Australian Government

Coongie Lakes

Ramsar Site

Ecological Character Description

May 2011

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Introductory Notes

This Ecological Character Description (ECD Publication) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

This ECD Publication is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

Disclaimer

Note: There may be differences in the type of information contained in this ECD Publication, to those for other Ramsar wetlands.

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Glossary

Definitions of words associated with ecological character descriptions (DEWHA 2008 and references cited within).

Benefits	Benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005, Resolution IX.1 Annex A). See also "Ecosystem Services".
Biogeographic region	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (Ramsar Convention 2005).
Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is largely based on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005).
Change in ecological character	Defined as the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005, Resolution IX.1 Annex A).
Community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000).
Community Composition	All the types of taxa present in a community (ANZECC and ARMCANZ 2000).
Conceptual model	Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Gross 2003).
Contracting Parties	Countries that are Member States to the Ramsar Convention on Wetlands; 159 as at March 2010. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialised agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice.
Critical stage	Meaning stage of the life cycle of wetland-dependent species. Critical stages being those activities (breeding, migration stopovers, moulting etc.) which if interrupted or prevented from occurring may threaten long-term conservation of the species. (Ramsar Convention 2005).
Ecological character	The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.
Ecosystems	The complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services). (Millennium Ecosystem Assessment 2005).
Ecosystem components	Include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (Millennium Ecosystem Assessment 2005).
Ecosystem processes	The changes or reactions which occur naturally within wetland systems. They may be physical, chemical or biological. (Ramsar Convention 1996, Resolution VI.1 Annex A). They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002).
Ecosystem services	The benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food and water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational), and supporting (e.g nutrient cycling, ecological value). (Millennium Ecosystem Assessment 2005). See also "Benefits".
Essential elements	A component or process that has an essential influence on the critical CPS of the wetland. Should the essential element cease, reduce, or is lost, it would result in a detrimental impact on one or more critical CPS. Critical CPS may

	depend in part or fully on essential elements, but an essential element is not in itself critical for defining the ecological character of the site.
Fluvial geomorphology	The study of water-shaped landforms (Gordon et al. 1999).
Geomorphology	The study of the evolution and configuration of landforms.
Indigenous species	A species that originates and occurs naturally in a particular country (Ramsar Convention 2005).
Limits of Acceptable Change	The variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed' (modified from definition adopted by Phillips 2006).
List of Wetlands of International Importance ("the Ramsar List")	The list of wetlands which have been designated by the Ramsar Contracting Party in which they reside as internationally important, according to one or more of the criteria that have been adopted by the Conference of the Parties.
Permanent wetland/waterholes	Within the context of this ECD permanent waterholes are defined by Silcock (2009) as those which have not dried since European settlement. Permanent wetlands are those which hold water 9 years out of 10, during extreme droughts these wetlands may dry (after Boulton and Brock 1999).
Semi permanent waterholes	Within the context of this ECD semi-permanent waterholes are defined as having variable frequency and duration of inundation, but typically have water for greater than 70 percent of the time (Silcock 2009). This would equate to intermittent in Ramsar terms.
Ramsar	City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, "Ramsar Convention on Wetlands".
Ramsar Criteria	Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values.
Ramsar Convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used.
Ramsar Information Sheet (RIS)	The form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed.
Ramsar List	The List of Wetlands of International Importance.
Ramsar Sites	Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria.
Temporary wetlands	Within the context of this ECD temporary wetlands include ephemeral, episodic, intermittent and seasonal wetlands.
Waterbirds	"birds ecologically dependent on wetlands" (Article 1.2). This definition thus includes any wetland bird species. However, at the broad level of taxonomic order, it includes: • penguins: *Sphenisciformes*. • divers: *Gaviiformes*; • grebes: *Podicipediformes*; • wetland related pelicans, cormorants, darters and allies: *Pelecaniformes*; • herons, bitterns, storks, ibises and spoonbills: *Ciconiiformes*; • flamingos: *Phoenicopteriformes*: • screamers, swans, geese and ducks (wildfowl): *Anseriformes*; • wetland related raptors*: *Accipitriformes* and *Falconiformes*; • wetland related cranes, rails and allies: *Gruiformes*; • Hoatzin: *Opisthocomiformes*;

	• wetland related jacanas, waders (or shorebirds), gulls, skimmers and terns: *Charadriiformes;* • coucals*: Cuculiformes;* and • wetland related owls: *Strigiformes*. * Hale (2010) documents wetland dependent species from the Lake Eyre Basin, in this assessment only two raptors are considered wetland dependent (see Section 2.2).
Wetlands	Are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987).
Wetland types	As defined by the Ramsar Convention's wetland classification system [http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-31-105^20823_4000_0__#B].

List of Abbreviations

CAMBA	China Australia Migratory Bird Agreement
CEPA	Communication, Education, Participation and Awareness
CMS	The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention)
CPS	Components, processes and services
DEWNR	Department of Environment, Water and Natural Resources, South Australia
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth) (now DSEWPaC)
DERM	Department of Environment and Resource Management, Queensland
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth) (formerly DEWHA)
DIWA	Directory of Important Wetlands in Australia
ECD	Ecological Character Description
EPBC Act	*Environment Protection and Biodiversity Conservation Act*, 1999 (Commonwealth)
IUCN	International Union for Conservation of Nature
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
JAMBA	Japan Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SARDI	South Australian Research and Development Institute

Executive Summary

The Coongie Lakes Ramsar site is located in the north east corner of South Australia near the town of Innamincka approximately 1046 kilometres north of Adelaide (Figure E1). The boundary of the site is a triangle and includes the Cooper Creek system from the South Australian – Queensland border downstream to Lake Hope (Lake Pando), the northwest branch of Cooper Creek, the northern overflow and their many waterholes and terminal lakes covering an area of over two million hectares. The site was listed as a Ramsar site in 1987.

Figure E1: Location of the Coongie Lakes Ramsar site (map supplied by Science Resource Centre, DENR South Australia).

A significant issue regarding the maintenance of ecological character of this site is the lack of information across the majority of the site. Most research and survey effort has focused on the more permanent lakes and waterholes and as such there is a distinct bias in the level of detail presented in describing the character of the Ramsar site. The majority of information pertains to the northwest branch, Coongie Lakes and the main branch from Cullyamurra to Embarka Swamp which represents only about a third of the site. It is critical that future effort be directed at redressing this significant knowledge gap. Despite this, the information that is available is of high quality and provides a strong basis for this Ecological Character Description.

The Coongie Lakes Ramsar site meets the following Ramsar criteria:

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

The Coongie Lakes Ramsar site lies within the Lake Eyre Basin Drainage Division bioregion. The site encompasses a wide diversity of wetlands that are representative of wetlands of the Channel Country. Cooper Creek is one of the largest unregulated river systems remaining in Australia and is recognised internationally as a significant inland river system. Wetland types found within the site include permanent waterholes, near permanent lakes, intermittently filled flood outs and channels, fresh and saline wetlands, and interdunal wetlands and swamps. Geomorphically the site is unique; with the broad fan that emanates downstream of Innamincka giving rise to the unique array of lakes and interconnecting channels which are in turn influenced by the regional parallel dune fields of the Strzelecki Desert. The lower Cooper Creek floodplain meets two of the attributes for meeting hydrological importance: it is a major natural floodplain, and is also important in retaining water for other wetland systems downstream including Lake Eyre.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

The Coongie Lakes site supports eight nationally or internationally listed species of conservation significance – six fauna and two flora species. The Australian painted snipe (*Rostratula australis*) is a wetland dependent species that is listed as endangered both under the EPBC Act and on the IUCN Red List. Reid (1988b) and Reid et al. (2004) provide three records of the Australian painted snipe in Lake Toontoowaranie. The Ramsar site is highly likely to support this cryptic species on a frequent basis however there are few records from the site as this species not likely to be recorded in aerial surveys. Other nationally or internationally listed species that have been recorded at the site are the greater bilby (*Macrotis lagotis*), dusky hopping-mouse (*Notomys fuscus*), plains rat (*Pseudomys australis*), woma python (*Aspidites ramsayi*), fawn hopping-mouse (*Notomys cervinus*), yellow swainson-pea (*Swainsona pyrophila*) and Mt Finke grevillea (*Grevillea treueriana*).

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

The Coongie Lakes site exhibits a concentration of arid zone biodiversity due to the presence of water on a semi regular basis. Water is present long enough and in sufficient quantities to sustain wetland dependent species, including obligate aquatic species. Species richness is comparatively high for most biota, with 83 wetland dependent bird species, 10 frog species, at least 12 native fish species, over 350 plants and one wetland dependent mammal recorded from within the site (DEHAA 1999). Coongie Lakes is one of the most species diverse systems in the Lake Eyre Basin in terms of wetland dependent species (Hale 2010). The site supports a number of wetland types (nine Ramsar wetland types), land systems and vegetation communities that are characteristic of the bioregion. The site is considered to be of high value for the fish and large numbers of waterbirds it supports in an arid environment. In addition, the diversity of terrestrial species is high, as species concentrate along the waterways to take advantage of the water supply and habitat. For example, dryland bird species richness (especially for raptors) is high and provides an outstanding example of a diverse and abundant riparian woodland bird community in the Lake Eyre Basin bioregion.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Coongie Lakes supports a significant number of migratory species including 18 species listed under international migratory species treaties (e.g. JAMBA, CAMBA, ROKAMBA) and a further 22 species that are listed as migratory or marine under the EPBC Act (see Appendix B). In addition, the site is important for the critical life stage of breeding. The site supports substantial breeding of waterbirds with 55 species having been recorded breeding at the site since listing. The most significant breeding events (in terms of numbers) occur after large scale floods. For example, a record 50 000 Australian pelican nests were recorded on the islands of Lake Goyder in 1990/91.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

Most bird counts represent only a portion of the site; however, they illustrate the importance of the Coongie Lakes Ramsar site for supporting a diversity and abundance of waterbirds. The site supports large numbers of birds all year round, with peaks in abundance following extensive inundation. Data from 1987 to 2004 has more than 20 000 waterbirds recorded for each survey event.

Criterion 6: A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of waterbird.

The site regularly supports one percent of the population of two species: pink-eared duck (*Malacorhynchus membranaceus*) and red-necked avocet (*Recurvirostra novaehollandiae*).

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Coongie Lakes supports fish populations which breed and undergo migration within the site. Other wetlands depend on these populations as colonists. Due to the unregulated hydrological regime and persistence of permanent waterholes, the dryland river system and its native fish fauna are largely intact for the lower Cooper Creek in South Australia. Fish respond to flood events to migrate and breed within different habitat areas of the site, and are also a source of colonists for Lake Eyre in large flood events. This is supported by the presence of a commercial fishery at Lake Hope in the lower reaches of the site. Lake Hope only receives water 1 in 4.5 years (Kingsford et al. 1999) but once full can retain water for up to four years (Kingsford et al. 1999). In the period May 1992 to March 1994, 309 tonnes of Lake Eyre callop (*Macquaria ambigua* sp. B) was harvested (DEHAA 1998). This fishery is supported by colonists from upstream within the site.

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Components and processes that are considered to be essential (but not necessarily critical) elements of the site's ecological character include climate, water quality, algae and invertebrates. Rainfall within the Ramsar site is highly variable and the seasons are considered to be a key driver of biotic responses. The wetlands are predominantly fresh, highly turbid and support high productivity. There are spatial differences in water quality, with in-channel wetlands having lower salinity than the floodplain lakes and wetlands. There are some saline wetlands within the site. Data on algae indicate low levels of endemic species, but comparatively high diversity compared to other river systems in the Lake Eyre Basin, with community composition being related to flood magnitude and to a lesser degree, salinity. The high level of similarity in community composition of algae has been attributed to the high level of hydrological connectivity across the site. Zooplankton exhibits high species richness and productivity across all major groups, with invertebrates in general having a high proportion of temporary wetland specialists, those adapted to a drying period.

Components and processes which are considered critical to the ecological character of the site include geomorphic setting, hydrology, primary productivity, vegetation, fish, and waterbirds. The site has a unique geomorphic setting which, combined with the hydrological regime, provides the physical template for the site. The Innamincka dome constrains Cooper Creek from the Queensland – South Australia border to Innamincka. It is in this reach that Cullyamurra waterhole, the deepest waterhole in the system is found. The distinctive morphology of the lower Cooper wetlands largely reflects the interplay of the regional gradient towards Lake Eyre and drainage capture by the linear dunes of the Strzelecki Desert. Permanent and semi-permanent waterholes predominantly occur from the border to the Coongie Lakes, with some semi permanent waterholes also occurring on the main branch of the Cooper. Several semi permanent waterholes also occur in the upper reaches of the main branch after it splits from the northwest branch. Cullyamurra is the largest and deepest of the waterholes in the site, and in the Lake Eyre Basin.

The hydrology of the site is one of the most variable in the world, and is linked to El Niño–Southern Oscillation (ENSO) events and the fact that the upper catchment area of the Lake Eyre Basin lies on the southern edge of the tropical zone. Floodwaters are predominantly generated in the headwaters of the catchment, but flooding from local rainfall events can also occur. Peak flows typically occur in late summer into autumn, with annual inflows into the Coongie Lake wetlands, the majority of which terminate within these wetlands. The lakes of the Ramsar site often fill sequentially, being highly connected via a complex series of distributary channels. The large floods which inundate Coongie Lakes, northern overflow and wetlands downstream ultimately feed into Lake Eyre and occur, on average, one in seven to eight years. Duration of dry periods can extend from a couple of months to years, depending on the position of the wetland within the site. Persistent waterholes do not occur downstream of the Coongie Lakes area on the northern overflow but do occur on the main branch.

Vegetation mapping is only available for a portion of the Ramsar site, with associations reflecting position in the landscape and frequency of inundation. Records exist for 795 species, 135 of which are considered to be wetland dependent. The site has a low fish species richness compared to other major river basins in Australia, such as the Murray-Darling Basin, with only 12 (possibly 13) native species. Nonetheless, the native species that do occur at the site account for over 90 percent of all fish caught. Permanent and semi-permanent wetlands support the highest species richness with decreasing richness with distance downstream. The fish populations are highly productive and large fish biomasses have been recorded within the site.

Waterbirds are a distinctive and spectacular feature with 83 species recorded at the site, 55 of which breed at the site. Species richness varies across the site, reflecting inundation patterns. Large numbers are often supported with more than 20 000 birds being recorded on a regular basis. The Coongie Lakes Ramsar Site exhibits the boom and bust ecology typical of arid zone environments and as such it is considered that productivity is a critical process for the site. There are no data on primary productivity within the site, however the biomass of fish and waterbirds supported by the site are indicative of a highly productive system.

The critical services identified for the Ramsar site are all supporting services. Cooper Creek has a natural hydrological regime and as such supports a suite of near natural wetland types, which in turn provides a range of physical habitat especially for waterbird breeding. The wetlands often sequentially fill and can remain hydrologically and ecologically connected for different periods of time depending on the magnitude of the floods. On recession of floodwaters the presence of permanent waterholes provides critical drought refuges and maintains populations of obligate aquatic species. Central to the character of the site is the unique geomorphic setting, especially the waterholes. The waterholes are critical refuges that are strongholds for aquatic species and allow for recolonisation when the wetlands become inundated. The waterholes are the focal points for biodiversity at the local and regional scale.

The site has high productivity and supports a high proportion of the regional biodiversity. Associated with the boom and bust ecology and diversity of habitats, the site supports a range of food webs and a mosaic of habitats, both spatially and temporally. Terrestrial biodiversity is also high as species congregate around the regular water supply and take advantage of wetland vegetation and habitats.

The site supports a number of threatened species including five terrestrial species that are listed under the EPBC Act and 38 species of conservation significance in South Australia (wetland dependent and terrestrial). The site also supports the Australian painted snipe (*Rostratula australis*) which is listed as endangered under the EPBC Act and 18 priority wetland species that are listed under various international treaties.

The relationship between essential and critical components, processes and services and how they relate to the listing criteria are shown conceptually in Figure E2.

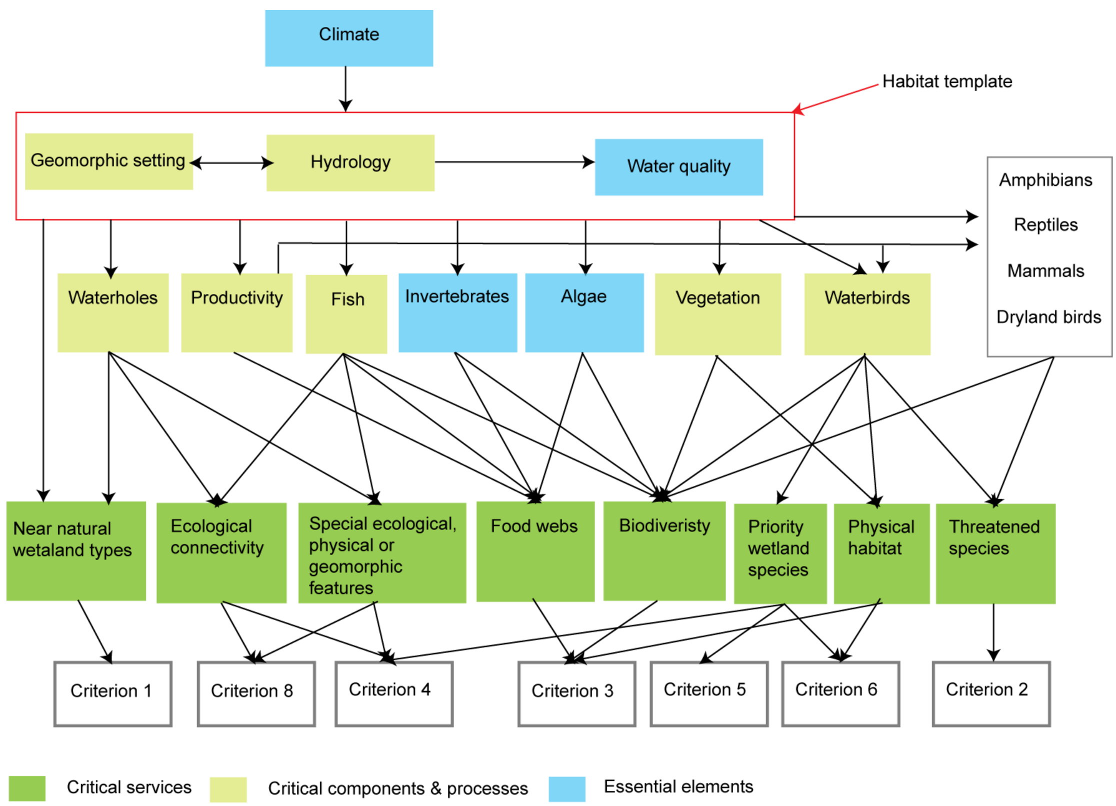


Figure E2: Relationships between components and processes; benefits and services and the listing criteria which the site meets.

Limits of Acceptable Change (LACs) are used to describe what is known about the natural variability of the site. This information can be used to help ensure that the ecological character of a site is maintained, as the exceedence of any particular LAC can indicate when an assessment of possible change in ecological character is required. The LACs for the Coongie Lakes Ramsar site (summarised in Table E1) have been proposed for critical components, processes and benefits and services based on existing data and guidelines.

Table E1: Proposed LAC for Coongie Lakes Ramsar site.

Component / Process/ Service for the LAC	Limit of Acceptable Change
Hydrology	Coongie Lake receives inflows no less than eight times in any ten year period, with no dry period lasting longer than 12 consecutive months. Lake Goyder receives inflows no less than six times in any ten year period, with no dry period lasting longer than 30 consecutive months. Large flood events (as defined by Costelloe 2008) occur no less than four times in any 30 year period.
Waterholes	No drying of any permanent waterholes. No drying of semi-permanent waterholes to less than 70 percent of time inundated over any 20 year time period.
Geomorphic setting	No direct LAC has been developed and instead the critical component will be assessed indirectly through changes in hydrology and in waterholes, see LACs above.
Primary productivity	Data insufficient – No direct LAC has been developed and instead the critical process will be assessed indirectly through changes in hydrology see LAC above.
Vegetation	Data insufficient – No direct LAC has been developed and instead the critical component will be assessed indirectly through changes in hydrology see LAC above.
Fish	No less than eight of 13 native species recorded from any three of five comprehensive sampling events (assumes seasonal sampling) from the main branch and northwest branch from the Queensland border downstream to Coongie Lakes and Embarka Swamp including Cullyamurra waterhole.
Waterbirds/abundance	In any 12 year period, a minimum of 34 000 waterbirds in two out of every three years in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008).
Waterbirds/supports 1% of populations	Greater than one percent of the Australian population (based on the most recent population estimates by Wetlands International) of red-necked avocet (1100) and pink-eared duck (10 000) in two years in every three in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008). Note this is based on 2010 population estimates: if estimates are changed the LAC needs to reflect those changes.
Waterbirds/ breeding	Data deficient – baseline must be established before LAC can be determined.
Waterbirds/species richness	A minimum of 45 species during peak inundation in two out of three years in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008). To be assessed over any 15 year period.
Near natural wetland ecosystem	See LAC for hydrology and waterholes.
Physical habitat	See LAC for hydrology.
Ecological connectivity	See LAC for hydrology and waterholes.
Food webs.	See LAC for hydrology.
Special ecological, physical or geomorphic features	See LAC for waterholes.
Priority wetland species	See LAC for waterbirds/abundance and species richness.
Threatened species – Australian painted snipe	Data deficient – baseline must be established before LAC can be determined.
Biodiversity	See LAC for hydrology and waterholes.

Additional explanatory notes for Limits of Acceptable Change:

1. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.

2. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.

3. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

4. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.

5. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

There are a number of potential and actual threats that may impact on the ecological character of Coongie Lakes Ramsar site; although overall the site is considered to be relatively unimpacted. Threats include water resource development leading to the loss of the naturally variable water regime and loss of permanent water. Climate change could lead to increased temperatures and evaporation leading to increased length of dry periods and reduced inundation. Invasive species impacts are poorly understood, however feral pigs are considered a problem within the site as is the potential for invasion by cane toads. There is a low likelihood of pollution associated with petroleum exploration and production which could lead to a loss of biota due to exposure to toxicants/hydrocarbons and changed connectivity due to barriers. Recreation and tourism impacts are increasing in the region, with concern over concentrated impacts occurring at permanent waterholes such as Cullyamurra. Removal of firewood leading to loss of groundcover and potentially increased invasive species is a noticeable impact in areas of high recreational use. Over-grazing is not considered to be a major threat to the site; however, impacts such as loss of vegetation may be concentrated around waterholes.

Despite having a lack of data for many of the wetlands in the site, there is clear evidence that there have been no significant impacts or change to the character of the site since listing. The ecology of the site is intact and is an excellent example of a large near natural arid zone floodplain system. Knowledge gaps have been identified relating to geomorphic setting in particular mapping of wetland types and extents, groundwater surface water interactions and importance in maintaining waterholes. Primary productivity, the role of egg and seed banks in sustaining productivity, and the importance and ecological values of rain fed wetlands. Vegetation mapping needs to be extended across the whole site and the presence of cryptic species established. The reproductive success of waterbirds and the role of flooding as a trigger for fish spawning are also poorly understood within the site. Information required includes setting baselines against which to measure change in ecological character as well as providing a better understanding of wetland functioning. Elements requiring monitoring have been identified; this will help to address knowledge gaps and allow for better assessment against LACs.

1. Introduction

1.1 Site details

Coongie Lakes Ramsar site was listed as a Wetland of International Importance in 1987 and at the time of listing covered an area of approximately 1 980 000 hectares. This ECD describes the site at the time of listing. Further site details for this Ramsar wetland are provided in Table 1.

Table 1: Site details for Coongie Lakes Ramsar site taken from the Ramsar Information Sheet (1998).

Site Name	Coongie Lakes
Location in coordinates	Latitude: (approx) 28º36'S to 26º18'S; Longitude: (approx) 139º00'E to 141º 00'E
General location of the site	Innamincka – Far Northeast of South Australia
Area	Approximately 1 980 000 hectares
Date of Ramsar site designation	Designated 15th June 1987
Ramsar/DIWA Criteria met by wetland	1, 2, 3, 4, 5, 6, 8
Management authority for the site	Department of Environment, Water and Natural Resources, South Australia, National Parks and Wildlife
Date the ECD applies	1987
Status of Description	This represents the first ECD for the site
Date of Compilation	May 2011
Name(s) of compiler(s)	Rhonda Butcher and Jennifer Hale on behalf of the Australian Government Department of Sustainability, Environment, Water, Population and Communities.
References to the Ramsar Information Sheet (RIS)	Coongie Lakes Ramsar Site RIS compiled DEH SA National Parks and Wildlife Service. Updated by Rhonda Butcher on behalf of the Australian Government Department of Sustainability, Environment, Water, Population and Communities 2011.
References to Management Plan(s)	Department for Environment, Heritage and Aboriginal Affairs (1999) Coongie Lakes Ramsar Wetlands: A plan for wise use. Draft for public consultation, November 1999. Prepared by North Region, Heritage & Biodiversity Division Department for Environment, Heritage and Aboriginal Affairs

1.2 Statement of purpose

The act of designating a wetland as a Ramsar site carries with it certain responsibilities, including managing the site to retain its ‘ecological character’ and having procedures in place to detect if any threatening processes are likely to, or have altered the ‘ecological character’. Thus, understanding and describing the ‘ecological character’ of a Ramsar site is a fundamental management tool for signatories and local site managers which should form the baseline or benchmark for management planning and action, including site monitoring to detect negative impacts.

The Ramsar Convention (Ramsar 2005) has defined ‘ecological character’ and ‘change in ecological character’ as:

‘Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetlands at a given point in time’

And

‘…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service.’

In order to detect change it is necessary to establish a benchmark for management and planning purposes. Ecological Character Descriptions (ECDs) form the foundation on which a site management plan and associated monitoring and evaluation activities are based. The legal framework for ensuring the ecological character of all Australian Ramsar sites is maintained is the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) (Figure 1).

A Ramsar Information Sheet (RIS) is prepared at the time of designation. However, whilst there is some link between the data used for listing a site (based on the various criteria), the information in a RIS does not provide sufficient detail on the interactions between ecological components, processes and functions to constitute a comprehensive description of ecological character. To assist with the management of Ramsar sites in the face of insufficient detail, the Australian and state/territory governments have developed a *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of Australian National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia* (DEWHA 2008). This ECD Publication has been prepared in accordance with these national guidelines.

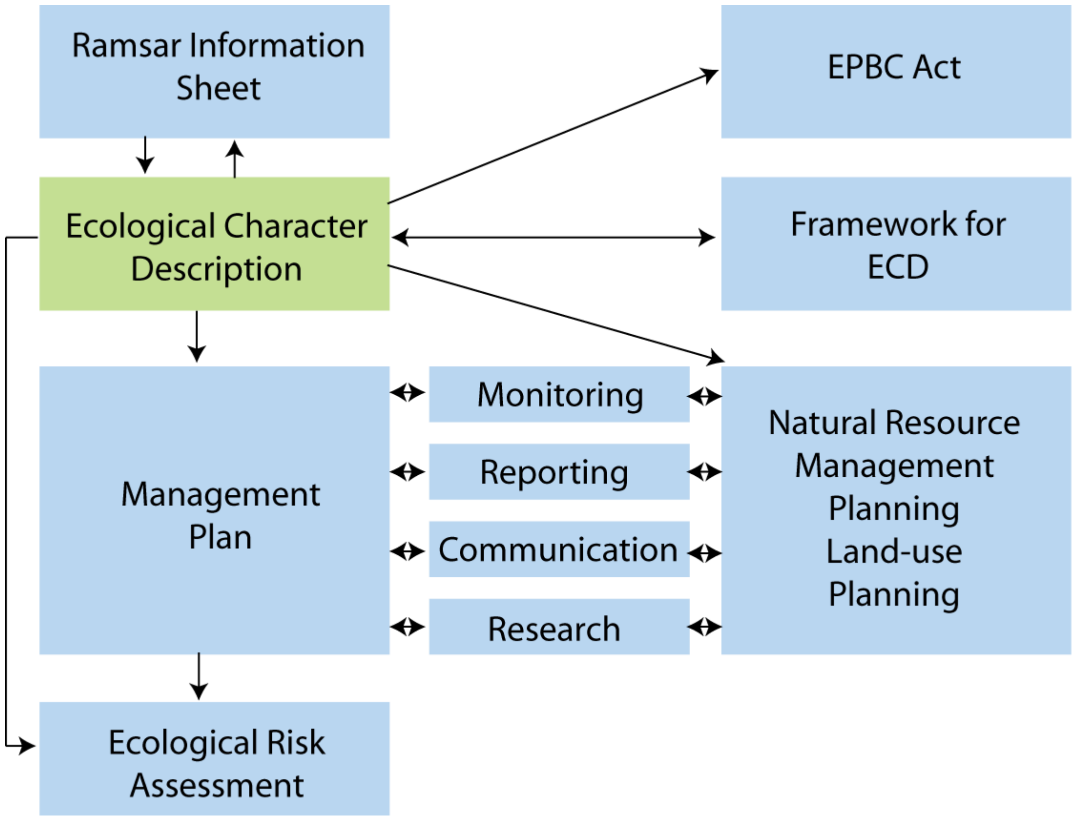


Figure 1: The ecological character description in the context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).

The framework emphasises the importance of describing and quantifying the ecosystem components, processes and benefits/services of the wetland and the relationship between them. It is also important that information is provided on the benchmarks or ecologically significant limits of acceptable change that can be used to indicate when the ecological character may have changed or is likely to change.

McGrath (2006) detailed the general aims of an ECD as follows:

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations 2000* (Commonwealth):
    a) To describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
    b) To formulate and implement planning that promotes:
        i) Conservation of the wetland; and
        ii) Wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.
2. To assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.

4. To assist the administration of the EPBC Act, particularly:
   a) To determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or
   b) To assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.
5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

1.3 Relevant treaties, legislation and regulations

This section provides a brief listing of the legislation and policy that is relevant to the description of the ecological character of the Ramsar site.

International

Ramsar Convention
The Convention on wetlands, otherwise known as the Ramsar Convention, was signed in Ramsar Iran in 1971 and came into force in 1975. It provides the framework for local, regional and national actions, and international cooperation, for the conservation and wise use of wetlands. Wetlands of International Importance are selected on the basis of their international significance in terms of ecology, botany, zoology, limnology and or hydrology.

Migratory bird bilateral agreements and conventions
Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds, which are relevant to Coongie Lakes Ramsar site. The bilateral agreements are:

- *JAMBA (Japan Australia Migratory Bird Agreement)* – The agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974;
- *CAMBA (China Australia Migratory Bird Agreement)* – The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986;
- *ROKAMBA (Republic of Korea Australia Migratory Bird Agreement)* – The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006; and
- *The Bonn Convention on Migratory Species (CMS)* – The Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

National legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
The EPBC Act regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (EPBC Act 1999 s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and approval under the EPBC Act. An 'action' includes a project, a development, an undertaking or an activity or series of activities (http://www.environment.gov.au/epbc/index.html).

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act 1999 s335), which are set out in Schedule 6 of the *Environment Protection and Biodiversity Conservation Act Regulations*

2000. These principles are intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention. Some matters protected under the EPBC Act are not protected under local or state/territory legislation, and as such, many migratory birds are not specifically protected under some state legislation. Species listed under international treaties (JAMBA, CAMBA, ROKAMBA and CMS) have been included in the List of Migratory species under the Act. Threatened species and communities listed under the EPBC Act may also occur, or have habitat in the Ramsar site; some species listed under state legislation as threatened are not listed under the EPBC Act as threatened, usually because they are not threatened at the national (often equivalent to whole-of-population) level. The Regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site, and the community consultation process.

Other important national strategies and legislation that confer protection of values associated with systems such as the Coongie Lakes Ramsar site include:

- National Framework for Management and Monitoring of Australia's Native Vegetation (2001) (http://www.environment.gov.au/land/publications/nvf/index.html);
- The National Strategy for the Conservation of Australia's Biological Diversity (1996) (http://www.environment.gov.au/biodiversity/publications/strategy/index.html)
- *The Native Title Act* (1993) (http://www.austlii.edu.au/au/legis/cth/consol_act/nta1993147/);
- The National Water Quality Management Strategy (1992) (http://www.environment.gov.au/water/quality/nwqms/)

State and regional legislation, strategies and plans

A significant body of state and regional legislation, natural resource management strategies and plans are relevant to or have the potential to affect the management of the Coongie Lakes site, including (listed chronologically):

- The Arid Lands Regional NRM Plan (2010) http://www.saalnrm.sa.gov.au/PolicyPlanning/RegionalNRMPlan/RegionalNRMPlanadopted.aspx
- The Lake Eyre Basin Agreement (2009)
- South Australian Arid Lands Biodiversity Strategy: Volume 2 Channel Country Conservation priorities. http://www.environment.sa.gov.au/Conservation/Ecosystem_conservation/Biodiversity_strategy_-_SA_Arid_Lands
- No Species Loss – A Nature Conservation Strategy for South Australia 2007-2017. State nature conservation strategy (2007), and South Australian Strategic Plan (2007)
- *The Fisheries Management Act (2007)* (http://www.legislation.sa.gov.au/LZ/C/A/FISHERIES%20MANAGEMENT%20ACT%202007.aspx)
- The South Australian State Natural Resources Management (NRM) Plan (2006) (http://www.nrm.sa.gov.au/SAStateNRMPlan/tabid/1356/Default.aspx)
- *Fire and Emergency Services Act* (2005) (http://www.legislation.sa.gov.au/LZ/C/A/FIRE%20AND%20EMERGENCY%20SERVICES%20ACT%202005.aspx)
- The *Natural Resources Management Act (2004)* (http://www.legislation.sa.gov.au/LZ/C/A/NATURAL%20RESOURCES%20MANAGEMENT%20ACT%202004.aspx)
- The Wetlands Strategy for South Australia (DEH and DWLBC 2003)
- The *Environment Protection Act (1993)* (http://www.austlii.edu.au/au/legis/sa/consol_act/epa1993284.txt)
- *The Development Act (1993)* (http://www.legislation.sa.gov.au/LZ/C/A/DEVELOPMENT%20ACT%201993.aspx)

- The *Native Vegetation Act (1991)* (http://www.legislation.sa.gov.au/LZ/C/A/NATIVE%20VEGETATION%20ACT%201991.aspx)
- *The Aboriginal Heritage Act (1988)* (http://www.legislation.sa.gov.au/LZ/C/A/ABORIGINAL%20HERITAGE%20ACT%201988.aspx)
- *National Parks and Wildlife Act (1972)* (http://www.legislation.sa.gov.au/LZ/C/A/NATIONAL%20PARKS%20AND%20WILDLIFE%20ACT%201972.aspx)
- *The Mining Act (1971)* (http://www.legislation.sa.gov.au/LZ/C/A/MINING%20ACT%201971.aspx)
- *Petroleum and Geothermal Act 2000* (http://www.legislation.sa.gov.au/LZ/C/A/PETROLEUM%20AND%20GEOTHERMAL%20ENERGY%20ACT%202000.aspx)

1.4 Preparing the ECD

The method used to develop the ECD for the Coongie Lakes Ramsar site is based on the twelve-step approach provided in the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (DEWHA 2008) illustrated in Figure 2. A more detailed description of each of the steps and the outputs required is provided in the source document.

This ECD was developed primarily through a desktop assessment and is based on existing data and information. A stakeholder advisory group was formed to provide input and comment on the ECD. Details of members of this group and more details of the method are provided in Appendix A.

1. Introduction to the description
Site details, purpose of the description, relevant legislation

2. Describe the site
Site location, climate, maps and images, tenure, criteria and wetland types

3. Identify and describe the critical components, processes, benefits and services
3.1 Identify all possible components, processes, benefits and services
3.2 Identify the critical components, processes benefits and services responsible for determining the ecological character of the site
3.3 Describe each of the critical components, processes, benefits & services

4. Develop a conceptual model of the wetland
Depict the critical components & processes of the wetland and their interactions

5. Set limits of acceptable change (LAC)
Determine LAC for critical components, processes and services

6. Identify threats to the ecological character of the site
Identify the actual or likely threats to the site

7. Describe changes to ecological character
Describe changes to the ecological character since the time of listing
Include information on the current condition of the site

8. Summarise knowledge gaps
Use information from Steps 3 - 7 to identify knowledge gaps

9. Identify site monitoring needs
Use information from Steps 3 - 8 to identify monitoring needs

10. Identify communication and education messages
Identify any communication & education messages highlighted during the development process

11. Compile the description of ecological character

12. Prepare or update the Ramsar Information Sheet
Submit as a companion document to the ecological character description

Figure 2: Twelve step process for developing an ECD (adapted from DEWHA 2008).

2. General Description of Coongie Lakes Ramsar Site

2.1 Location

The Coongie Lakes Ramsar site is located in the north east corner of South Australia near the town of Innamincka, approximately 1046 kilometres north of Adelaide (Figure 3). The boundary of the site is a triangle (demarcated by Lake Moorayepe in the north, Marion Hill in the south and the South Australia/Queensland border on the east). The site includes the Cooper Creek system from the South Australia/Queensland border downstream to Lake Hope (Lake Pando), the northwest branch of Cooper Creek, the northern overflow and their many waterholes and terminal lakes covering an area of over two million hectares. The site captures a large proportion of the wetlands in the South Australian part of the Cooper system, but the boundary does not reflect any political, landform or hydrological boundary – its shape was dictated by the choice of three points which demarcate its extent.

Cooper Creek feeds into Lake Eyre and is one of the three river systems that collectively make up the Channel Country of the Lake Eyre Basin (White 2001). The Channel Country refers to the middle and lower reaches of the Cooper, Diamantina and Georgina Rivers (White 2001). The Cooper Creek is an anatomising river which encompasses vast areas of floodplain with interconnecting channels, wetlands, lakes, and interdunal waterways. The Cooper Creek enters South Australia near Innamincka with the catchment area being 236 700 square kilometres at this point in time (Kotwicki 1986 cited White 2001).

2.2 Overview of the site

The Coongie Lakes site was listed as a Wetland of International Importance in 1987. Following the listing of the Coongie Lakes Ramsar site, part of the site (and area outside the site) was declared as the Innamincka Regional Reserve in 1989 under the *National Parks and Wildlife Act 1972*. Amendment to the Act in 1987 allowed for multiple use reserves to be designated (DEHAA 1998). In June 2005, the Coongie Lakes National Park was declared, covering an area of 266 square kilometres within the Innamincka Regional Reserve and Ramsar site, in recognition of the outstanding biodiversity and cultural values of the perennial lakes and wetlands in the area (Wainwright et al. 2006). The Coongie Lakes National Park has significant Indigenous and European values and places (see Section 4.4). Tourism is an increasing industry for the region, particularly when Lake Eyre floods.

The Coongie Lakes Ramsar site includes a vast array of temporary and near permanent wetlands spanning over two million hectares. The site plays an important role in hydrological functioning of wetlands in the region and supports significant ecological values. The drivers of the character of the Ramsar site are climate, geomorphic setting and hydrology. The ecology is driven by periods of boom, associated with the arrival of floodwaters from the upstream catchment and through local rainfall events, followed by the bust period of extreme aridity (Kingsford et al. 1999). Flooding events trigger a spectacular concentration of waterbirds which reflects the incredible productivity of the wetlands and the availability of abundant food resources as well as habitat. The bust period, when the wetlands dry, can result in large numbers of fish and waterbird deaths (Kingsford et al. 1999).

The key feature of the site is the high variability in the hydrological regime which switches on different wetlands and areas of floodplain at different times and scales according to the season, flood frequency, magnitude and duration of floods and intervening periods of dry. The history of wetting and drying for each wetland is distinctive and influences the ecology of each wetland. Biota are adapted to this variability with many species being temporary wetland specialists capable of dispersing or setting seeds and eggs into the sediments to await the next flood.

Figure 3: Location of Coongie Lakes Ramsar site (map produced by Science Resource Centre, DENR South Australia).

A significant challenge in preparing this ECD is the lack of data for the vast majority of wetlands within the site. Most research and survey effort has focused on the more permanent lakes and waterholes. As such there is a distinct bias in the level of detail presented in the ECD with a focus on the northwest branch, Coongie Lakes and the main branch from Cullyamurra to Embarka Swamp which represents only about a third of the site. It is critical that the future effort be directed at redressing this significant knowledge gap. There is no information for the majority of wetland areas within the site other than a broad assessment of frequency of inundation and some vegetation data.

The site can be roughly broken down into four broad landscape units (Figure 4). These are not accurately mapped but reflect broad groupings based on general flow patterns, frequency of inundation and water source. The four units are briefly described below. There is some overlap between these units and land systems, but they are not a direct match (see Section 3.3.1 for more detail on the land systems).

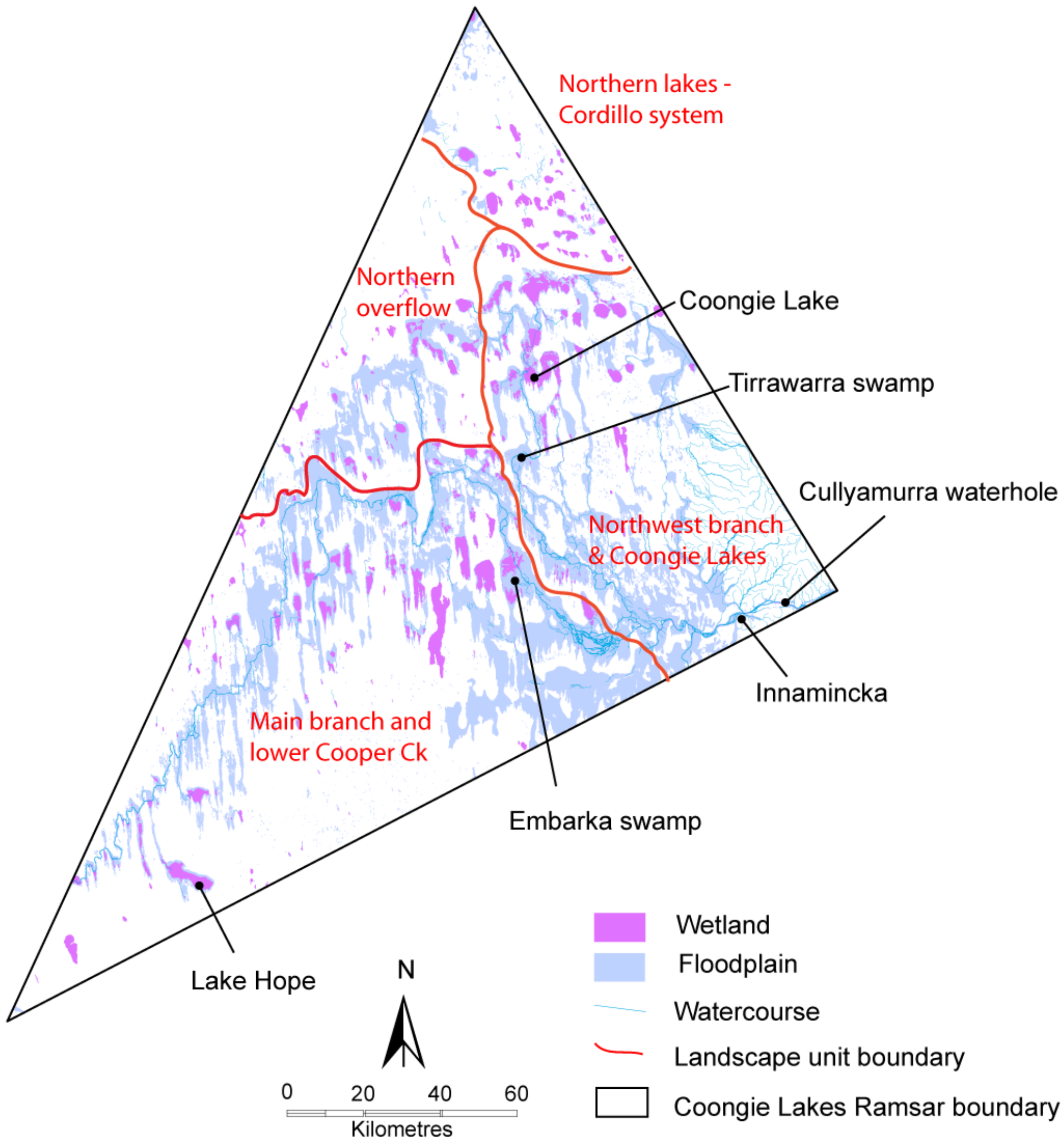


Figure 4: Ramsar boundary showing broad wetland types (not Ramsar wetland types) and broad landscape units.

Northwest branch and Coongie Lakes

This includes the main branch of the Cooper Creek and the northern distributaries, including the northwest branch. The main branch and northwest branch, which splits from the main channel approximately 25 kilometres downstream of Innamincka (White 2001), are the dominant flow paths for water moving through the site. The river channel from the Queensland and South Australian border downstream to Tirrawarra Swamp is characterised by a number of semi-permanent and permanent waterholes, Cullyamurra being the deepest. This section of the site receives annual flow, which typically terminates in the Coongie Lakes. Coongie Lakes includes a number of very large wetlands including Lake Coongie, Lake Goyder (Coolangire), and Lake Marrocoolcannie among others. The wetlands of Coongie Lakes fill sequentially, but there is a lag time between each one filling, as each wetland can take several months to fill before overflowing into the next wetland (depending on the magnitude of events). These wetlands represent the group of wetlands which are most frequently inundated (Wainwright et al. 2006) and the most studied (see Section 3 and 4 for more details). The Coongie Lake wetlands are approximately 130 kilometres downstream from Cullyamurra waterhole. To the east of the northwest branch and north of Innamincka there are also some rain fed wetlands, for example the Marqualpie interdunal wetlands; however, the majority wetlands in this unit are floodplain wetlands, including 19 named lakes.

Northern overflow

This unit includes floodplain wetlands that receive flow in large events when water overflows from Apanburra channel and a single defined channel is replaced by a series of shallow intermittent wetlands, often referred to as flood-outs (Reid 1988b). Flow paths are dynamic and variable over time in response to flood magnitudes and shifting drainage lines. Water moves almost parallel to the main branch of the Cooper via a series of connected wetlands, with two main flow paths, Christmas Creek and the northern overflow channel further west, reconnecting flow back to the main branch in the lower section of the site. The majority of these floodplain wetlands are inundated only rarely. Rain-fed wetlands occur in this unit as well; however the most numerous wetlands are associated with the Cooper Creek floodplain.

Northern lakes – Cordillo system

There are no floodplain wetlands in this unit, with rainfall and local drainage feeding inflows to the wetlands. Included among these are several large intermittent saline wetlands. While there are some waterbird data for these wetlands from 2008, these could not be sourced. Overall there is very little known about these wetlands and this remains a key knowledge gap for understanding the character of the site. However it is believed that these wetlands may be important for dispersing aquatic organisms, most notably waterbirds. The wetlands lack fish and are therefore trophically and functionally different from the floodplain wetlands associated with the Cooper Creek (J. Reid, pers. comm.). The wetlands in this area also have cultural links to the Coongie Lakes. Included in this part of the site are playa lakes, or claypan lakes, also filled by rainfall and local drainage. These lakes are characterised by a specific invertebrate community dominated by crustaceans adapted to a drying period, a lack of macrophytes and high turbidity. Claypan wetlands may also be scattered throughout the rest of the site in the non floodplain areas, for example Kidman Claypan on the eastern boundary of the Ramsar site, however this wetland type has not been mapped.

Main branch and lower Cooper Creek

The upper reaches of the main branch receive annual inflows along with the northwest branch. The relative proportion of flow in the northwest branch and the main branch is not well known, but the majority of the flow is believed to move north, not along the main branch. The amount of water moving down each branch is variable depending on flood magnitudes and the amount of water in Coongie Lakes. Once flows from the northern overflow have rejoined the main branch, the Cooper Creek reforms into a single channel and ultimately flows into Lake Eyre. Downstream to Deparanie Waterhole on the Main Branch (and Lake Apanburra on the North West Branch), most of the river's course is along well defined channels and waterholes. However, downstream of Deparanie Waterhole (as with the lower reaches of the Northern Overflow) there is a distinct regime change and a novel riverine morphology is expressed. Short sections of well defined channels and waterholes with dense fringing riparian vegetation are followed by floodouts (temporary wetlands) with little channel definition, followed by a further small section of channel/waterhole, with or without lateral connections to a lake, and this sequence is repeated multiple times. This change in character presumably reflects subtle topographic variations and smaller flows to these lower reaches. The areas of floodout, at least in the northern half of this unit, are frequently characterised by extensive areas of lignum shrubland which are important breeding habitat for a wide range of waterbirds in big floods (J. Reid pers. comm.).

Notable wetlands within this unit include Embarka Swamp in the upper reach and Lake Hope in the lower reach. In general, the majority of wetlands in this part of the site are less frequently inundated, only filling in medium to large flood events.

Overview of fauna and flora

One hundred and ninety-eight species of bird have been recorded within the Coongie Lakes Ramsar site, 83 of which are wetland birds. Fifty five species of waterbird have been recorded breeding within the site (Appendix B). The Australian painted snipe (*Rostratula australis*), which is listed as endangered under the EPBC Act, occurs at the site. Eighteen species are listed under international treaties such as JAMBA and CAMBA and 39 species are listed as migratory or marine under Australian legislation. The Coongie Lakes Ramsar site supports a significant number of raptors with 18 species reported in the region, 16 of which breed at the site (DEHAA 1999). The night parrot (*Pezoporus occidentalis*) is known to have occurred at the site in the past but not recently (DEHAA 1998).

The terrestrial bird fauna present within the site is considered to represent a species rich dryland fauna for an arid zone area (Reid 1988b; Reid et al. 1990). Many arid zone birds require drinking water, particularly in the warmer months. Numbers and diversity of dryland bird decrease with distance from water (Reid 1988b), although this decline in diversity has more to do with habitat changes than the need to drink. Of the dryland species, Reid (1988b) reported 44 species breeding within the site in a nine month study, and many more species than this are known to breed in the site (Reid et al. 1990).

The river red gum riparian woodland is important habitat for the dryland birds and is a notable stronghold for breeding populations of several raptors, including black falcon (*Falco subniger*), grey falcon (*Falco hypoleucos*), Australian hobby (*Falco longipennis*) whistling kite (*Haliastur sphenurus*), black-breasted buzzard (*Hamirostra melanosternon*), little eagle (*Hieraaetus morphnoides*) and letter-winged kite (*Elanus scriptus*) (Reid 1988b). The diurnal raptors of the Ramsar site are not considered ecologically dependent on the wetlands. A preliminary list of wetland dependent species, including birds, was developed for the Lake Eyre Basin High Conservation Value Aquatic Ecosystem project (Hale 2010). There were 108 species identified in this list but only two of the raptors, white-bellied sea eagle and swamp harrier, were considered wetland dependent (Hale 2010). Raptors benefit from the wetlands being present and make use of the riparian vegetation but they are not solely reliant on it.

Eleven of the dryland bird species are listed as vulnerable within South Australia. The barking owl (*Ninox connivens*), listed as rare in South Australia, is considered a wetland dependent species as its core nesting habitat is river red gum woodlands lining the upper reaches of the Cooper Creek in South Australia.

Puckridge (2000) lists 15 species of fish from 10 families and two introduced species occurring in the Cooper Creek system, with 12 of these recorded in the site plus two introduced species (DEHAA 1999; Puckridge et al. 2010). Native species dominate the fish fauna representing 99 percent of the catch. The Cooper Creek catfish (*Neosiluroides cooperensis*) is considered rare in South Australia (Hammer et al. 2009). The catfish is one of only three relatively sedentary native species, remaining in waterholes, the other species are highly mobile, migrating up and downstream and sometimes moving onto floodplains to breed (Puckridge and Drewien 1998).

Ten species of frogs have been recorded within the Coongie Lakes Ramsar site, none of which are listed as threatened at the national level, but two are listed at the state level as rare: knife-footed frog (*Cyclorana cultripes*) and small-headed toadlet (*Uperoleia capitulata*). The frog community is considered one of the richest in central Australia (Morton et al. 1995). Fifty-six reptile species occur within the site, three of which are listed at the state level: the rare woma python (*Aspidites ramsayi*), the black-soil skink (*Proablepharus kinghorni*) and the vulnerable Cooper Creek turtle (*Emydura macquarii emotti*).

The Cooper Creek turtle is adapted to the boom and bust ecology of dryland rivers, utilising permanent waterholes as refugia (White 2002). The turtles are able to survive these conditions, having evolved a number of life history strategies, including having a large body size, delaying sexual maturity and in determinant growth in order to cope with the harsh unpredictable environment. Adult turtles dominate the permanent waterholes, with juveniles and smaller adults found in semi permanent waterholes in low numbers and densities (White 2002; Marshall 2005). Large adult turtles have been collected from deeper waterholes of the northwest branch of the Cooper Creek as well as at Cullyamurra Waterhole (Figure 5). Cullyamurra is the deepest waterhole and supports a large turtle population (White 2004).

Figure 5: Cooper Creek turtle (© Justin Costelloe).

Twenty-eight species of native mammal have been recorded within the site. Of these, only the water rat (*Hydromys chrysogaster*) is associated with wetland habitats and is abundant in the upper reaches of the site. Five mammal species are listed as vulnerable under the EPBC Act: the dusky-hopping mouse (*Notomys fuscus*), golden bandicoot (*Isoodon auratus auratus*), greater bilby (*Macrotis lagotis*), plains rat (*Pseudomys australis*) and the kowari (*Dasycercus byrnei*), noting that the two bandicoot species are regionally extinct. Yellow-bellied sheathtail bats (*Saccolamus flaviventis*) and fawn hopping mouse (*Notomys cervinus*) are listed as threatened in South Australia and also occur at the site.

Of the 795 plants recorded at the site approximately 135 could be considered wetland dependent, two are listed under the EPBC Act: the yellow swainson-pea (*Swainsona pyrophila*) and Mt Finke grevillea (*Grevillea treueriana*). An additional 15 species are listed as threatened in South Australia. There are also several state-listed threatened ecological communities within the Ramsar site including *Eucalyptus camaldulensis* woodland on levees and channel banks of regularly inundated floodplains in semi-arid areas (vulnerable), and Freshwater wetlands e.g. *Triglochin procerum* Herbland (endangered) (DEH 2005).

Aquatic invertebrates and algae have been sampled in a number of surveys revealing low level of endemic species but relatively high species diversity and abundance, particularly in response to flooding events leading to peak productivity. These groups form the basis of the food webs which support very large numbers of fish and waterbirds.

2.3 Land tenure

Three dominant land tenures occur within the site: Crown land-pastoral lease, Crown land-National Park and regional reserve as well as land covered by petroleum exploration licences (Figure 6). Lands managed by the South Australian National Parks and Wildlife Service account for 38 percent of the site and petroleum leases cover 15 percent of the site. Landuse includes cultural heritage, cattle grazing, oil and gas exploration and production and in recent times, recreation and tourism (DEHAA 1999; RIS 1998). Pastoral leases have been in effect in the region for the past 100 years (DEHAA 1999) (see Section 4.4 for more detail on cultural heritage of the region). Pastoralism is the dominant landuse within the site with 97 percent of the site covered by leases, and has been since the early 1870s. Sheep were initially stocked in the region but have been completely replaced with cattle (Reid 1988a), with grazing occurring over the entire site except for the Coongie Lakes National Park and an area surrounding Cullyamurra waterhole. Gas and oil exploration began in the 1950s with production beginning in the late 1960s. The majority of production has been focused around Moomba which lies just outside of the Ramsar site (Reid 1988a); however there is a legacy of tracks throughout the region associated with the exploration. Two major reserves fall within the boundary of the Ramsar site, the Coongie Lakes National Park in its entirety and just over half of the Innamincka Regional Reserve. In addition two small areas of the Strzelecki National Park also fall within the Ramsar site. The high proportion of reserve within the site reflects the high natural and conservation values of the area.

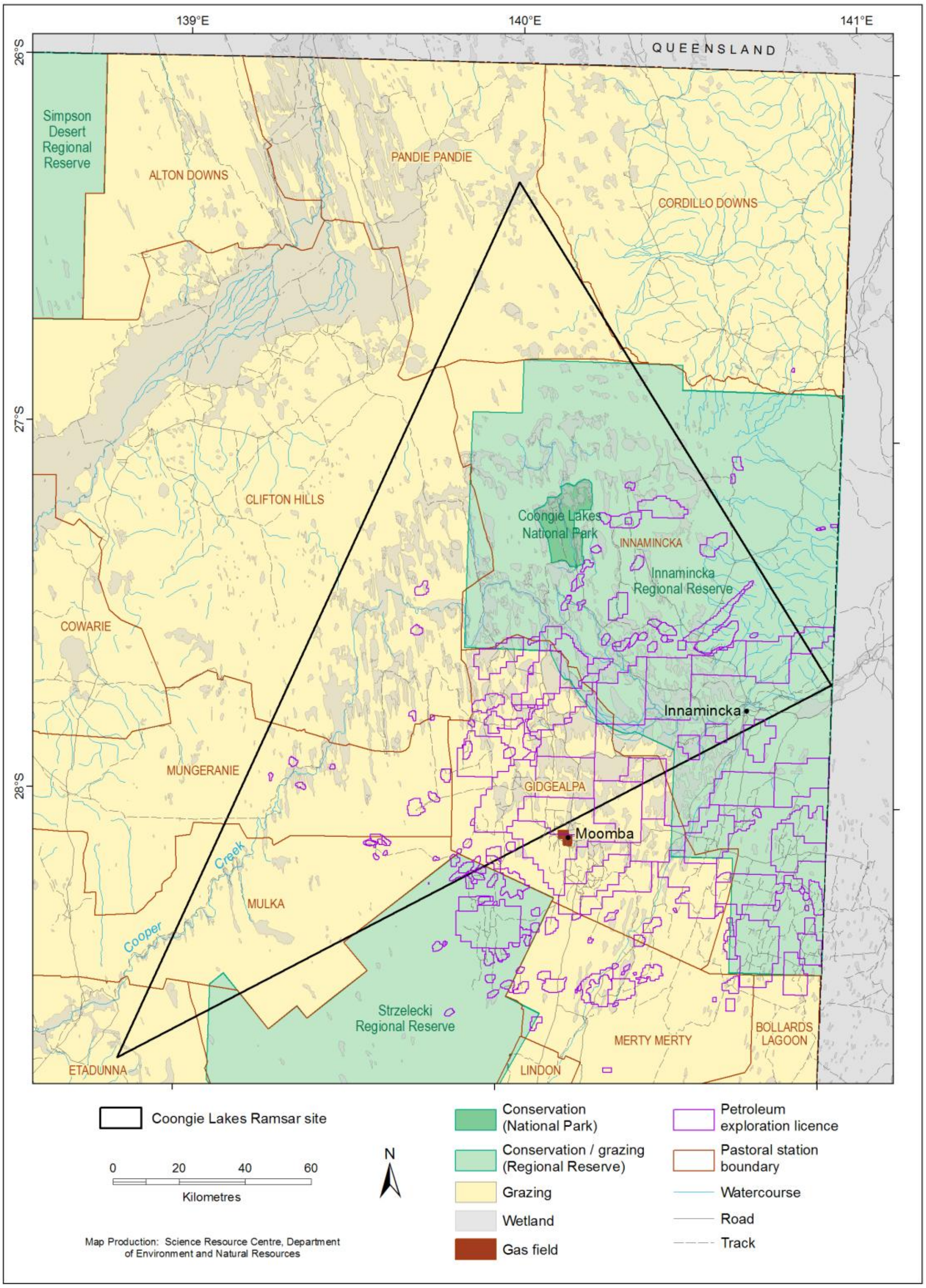


Figure 6: Land tenure within and surrounding the Coongie Lakes Ramsar site (map produced by Science Resource Centre, DENR South Australia).

2.4 Wetland types and extent

Classification of wetlands into discrete types is a difficult exercise and an inexact science. Clear boundaries are difficult to define or delineate and multiple wetland types could be considered to apply to the same wetland. DENR South Australia provided a wetland map layer that was based on multi-temporal satellite imagery and also uses 250K Geo-topographic mapping by GeoScience Australia. This mapping placed wetlands into three main categories:

wetlands (including the majority of permanent and near permanent lakes and wetlands), floodplain and watercourses (which include Cooper Creek, distributary channels and waterholes) (Figure 7). Whilst waterholes are riverine features, they are described as ‘wetlands’ as opposed to ‘watercourses’ for the purposes of this ECD as they have traits which are characteristic of lentic systems under cease-to-flow conditions. The potential Ramsar wetland categories have been applied against the DENR categories and extents have been estimated (Table 2).

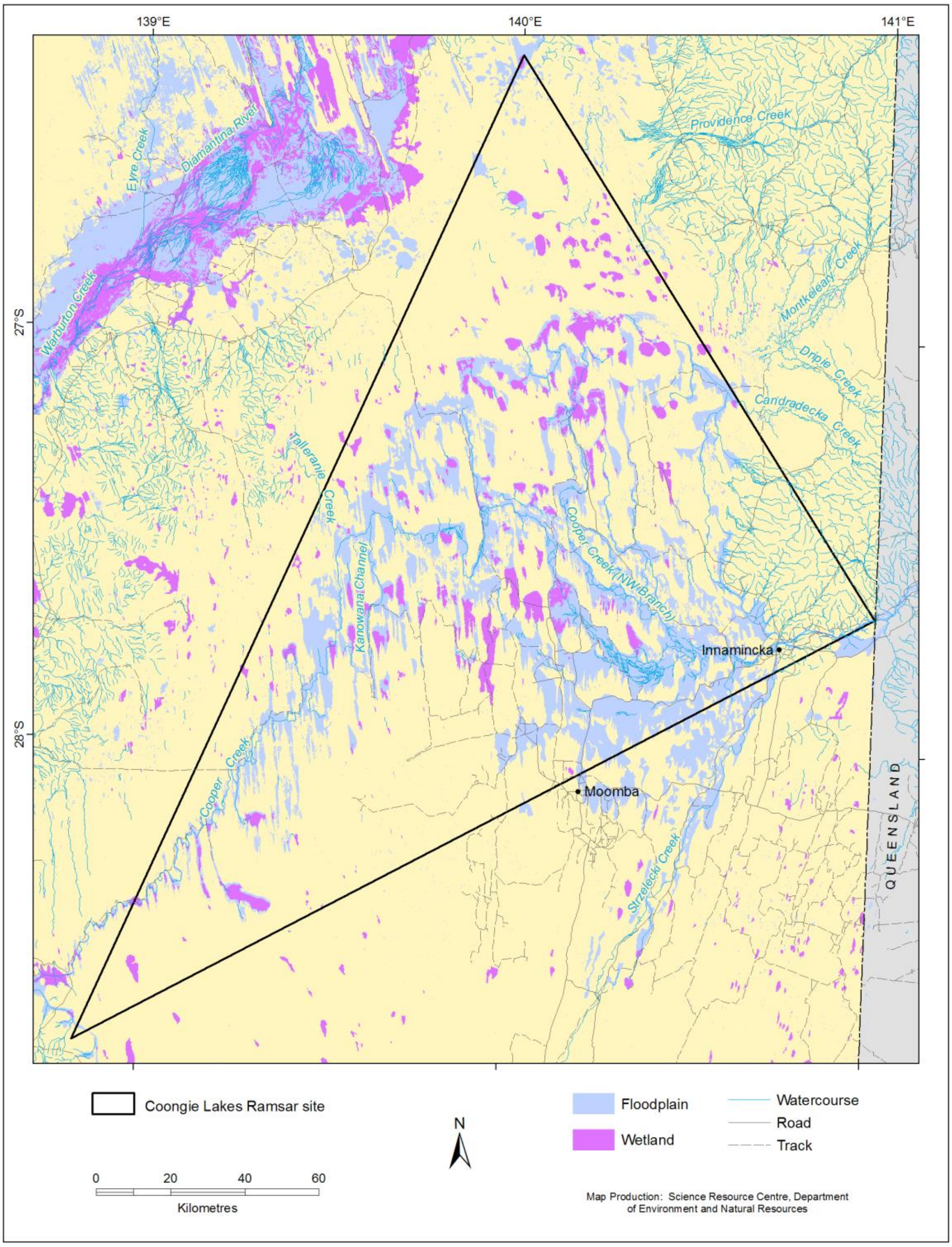


Figure 7: Wetland extent, by broad wetland types, within the Coongie Lakes Ramsar site (data supplied DENR South Australia).

Table 2: Wetland type and extent in the existing and proposed Coongie Lakes Ramsar site boundaries (data from GeoScience Australia). ND = not determined. *All identified in Channel Country Remote Sensing Frequency of Inundation Project 2008

Wetland type	Water regime	Probable Ramsar wetland types	Area (ha)	Examples
Wetland (includes waterholes)	Perennial	O: Permanent freshwater lakes (over 8 ha); includes large oxbow lakes.	889	Cullyamurra waterhole, Mollichuta waterhole, Yantandana waterhole, Coonyeeninna waterhole, Coongie Lake.
		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.		Minkanoranie soak well, Kuenpinie waterhole, Chillimookoo waterhole, Bookabourdie waterhole.
	Non-perennial	P: Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes.	91 698	Lake Marroocoolcannie, Lake Marrooculchanie, Lake Goyder, Lake Toontoowaranie.
		Ts: Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes		Most are unnamed; Lake Warrakalanna, Queerbidie Waterhole.
		R: Seasonal/intermittent saline/brackish/alkaline lakes and flats	ND	Lake Talinnie.
		Ss: Seasonal/intermittent saline/brackish/alkaline marshes/pools	ND	Mostly unnamed.
	Unknown*	O, Tp, P, Ts – As above.	9420	
Floodplain	Not specified (but assumed non-perennial)	Ts: As above	439 600	Mostly unnamed.
		W: Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.		Tirrawarra Swamp, Embarka Swamp.
		Xf: Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils		Tirrawarra Swamp, Embarka Swamp.
Watercourses	Unknown	Tp, Ts: As above	340	
	Non-perennial	N: Seasonal/intermittent/irregular rivers/streams/creeks.	2750	Cooper Creek and associated flow paths, Ellar Creek, Browne Creek.

2.4.1 Permanent lakes and waterholes greater than eight hectares (Ramsar type O)

Permanent wetlands in the Coongie Lakes Ramsar site include the deep waterholes along the Cooper Creek and Coongie Lake. Cullyamurra waterhole falls within this category and is the deepest waterhole in the Lake Eyre Basin with a cease to flow depth of at least 18 metres (Silcock 2009). Cullyamurra waterhole occurs in a reach where the Cooper Creek is confined, thus greatly increasing the scouring properties of floods which lead to its formation (see Section 3.3.1) (Figure 8 to Figure 10). Silcock (2009) only reported permanent waterholes upstream of the Coongie Lakes area; however there may be some in the upper sections of the main branch such as Embarka waterhole (J. Costelloe, pers. comm.). Waterholes play important cultural, social and economic roles as well as ecological roles, as they provide a water supply for stock and, increasingly, areas of tourism and recreation. Coongie Lake (Figure 11 and Figure 12) receives annual inflows and whilst it can undergo short periods of drying, is considered permanent.

Figure 8: End of Cullyamurra waterhole in cease to flow conditions (© Justin Costelloe).

Figure 9: Cullyamurra water hole (© Paul Wainwright)

Figure 10: Minkie waterhole (© Justin Costelloe).

Figure 11: Coongie Lake, full (© Paul Wainwright).

Figure 12: Coongie Lake, drying (© Justin Costelloe).

2.4.2 Permanent waterholes/ponds less than eight hectares (Ramsar type Tp)

No information regarding this wetland type has been sourced; however these are likely represented by the smaller waterholes, such as Chillimookoo and Bookabourdie waterholes, upstream of Coongie Lakes on both the northwest and main branches of the Cooper. These wetlands/waterholes would have areas of open water with fringing sedges, lignum and trees so are not typical marsh type habitats, but are more typically pond like. They have been placed into this category based on their permanency and size.

2.4.3 Seasonal intermittent lakes greater than eight hectares (Ramsar type P)

Many of the wetlands in the Coongie Lakes area fall into this category, including Lakes Toontawarrnie (Figure 13), Apanburra, Marroocoolcannie, and Marrooculchanie.

Figure 13: Lake Toontoowaranie (© Justin Costelloe).

2.4.4 Seasonal intermittent marshes (Ramsar type Ts)

Many of the wetlands that fall within this category are unnamed. They are characterised by shallow depth and variable patterns of wetting and drying. They include the shallow flood-out features on the edges of lake margins (Figure 14), which are particularly characteristic of the lakes in the northern parts of the site (e.g. Goyder Lake). Flood-outs are broad flat areas into which water can overflow, from either lakes or channels, and generally lack a defined channel (Reid 1988a).

Figure 14: Floodout on edge of Coongie Lake (© Paul Wainwright).

2.4.5 Shrub dominated wetlands (Ramsar type W)

Two major swamps representative of this type of wetland are Tirrawarra Swamp on the northwest branch and Embarka Swamp on the main branch of the Cooper Creek. Tirrawarra Swamp is a temporary wetland that floods and dries annually. It is densely vegetated with lignum (*Muehlenbeckia florulenta*) (Figure 15 and Figure 16) and river coobah (*Acacia stenophylla*) (Reid 1988b). Embarka Swamp is mainly vegetated with lignum, but less dense than Tirrawarra Swamp, as well as supporting areas of open water. The ponds within the Swamp are the result of gas and oil development (Reid 1988b). Reid (1988b) reports similar habitat between Innamincka and the swamps on both branches of the Cooper. Reid (2004) shows these shrub dominated (and similar tree dominated) wetlands are important colonially nesting waterbird breeding sites.

Figure 15: Lignum swamp Tirrawarra Swamp (© Paul Wainwright).

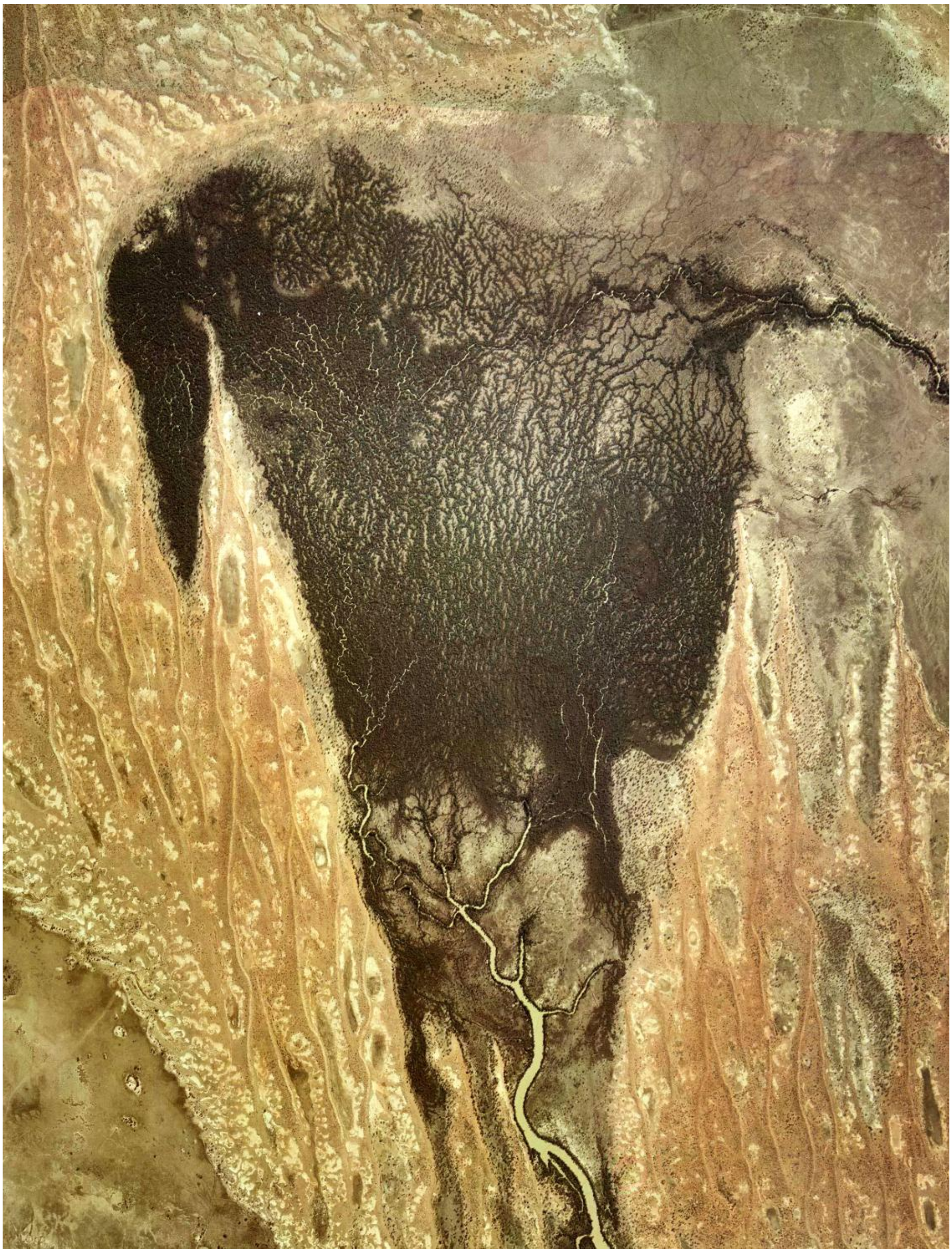


Figure 16: Tirrawarra Swamp (supplied DENR South Australia).

2.4.6 Freshwater tree dominated wetlands (Ramsar type Xf)

Backwaters are flat short channels connected to the distributaries and main branch of Cooper Creek, Ellar and Browne Creeks, and receive water on a regular basis as water levels rise in the Cooper. In periods of heavy local rainfall they can act as tributaries, transporting local runoff into the Cooper (Reid 1988a). A striking feature of the site is the large Interdunal wetlands which are connected to some of the Coongie Lakes on their southern and eastern sides. Large orange dunes extend right to the shorelines of some lakes and in times of high water the interdunal corridors are inundated forming south-south-easterly extensions to the lakes. Interdunal wetlands also occur on the south side of the Cooper. Backwaters and interdunal wetlands are often lined or dominated by trees including coolabahs and tall wattles

(Reid 1988a). An excellent example of this type of wetland is the large series of interdunal wetlands off the northwest branch upstream of Tirrawarra Swamp called Mudrangie Swamp which is an important waterbird breeding site (Figure 17 and Figure 18).

Figure 17: Tree dominated, interdunal wetlands, Mudrangie Swamps upstream of Tirrawarra waterhole on the northwest branch (© Paul Wainwright).

Figure 18: Tree dominated interdunal wetlands, Mudrangie Swamps upstream of Tirrawarra waterhole on the northwest branch. The wetland is in the swale an the dune crest on the left with another wetland running parallel on the other side of the dune crest (© Paul Wainwright).

2.4.7 Seasonal/intermittent river, streams, creeks (Ramsar type N)

This includes the Cooper Creek and associated distributary channels including the northwest branch, Ellar Creek, Browne Creek, Apanburra channel and the northern overflow channels. The channels are of variable width, depth and definition but most are shallow and less than 100 metres in width. The northwest branch is lined with a narrow strip of river red gum which provides critical habitat to a range of desert species, especially raptors and other dryland birds (Figure 19 to Figure 21).

Figure 19: Northwest branch of Cooper Creek feeding into Coongie Lake. Note narrow band of river red gums along the banks (© Paul Wainwright).

Figure 20: Northwest branch Cooper Creek (© Justin Costelloe).

Figure 21: Brown Creek during dry period (© Justin Costelloe).

2.4.8 Seasonal/intermittent saline wetlands (Ramsar type R & Ss)

No specific data on saline systems have been sourced and this remains a knowledge gap for the site. In the Coongie Lakes study, only one saline system visited had water – Lake Talinnie (Reid 1988b). Lake Talinnie is located to the west of Lake Toontoowarnie and is fed by rainfall and also from large floods along the northern overflow, such as the 2010 event. This wetland type is not considered a common.

2.5 Ramsar criteria

2.5.1 Criteria under which the site was designated

The listing criteria for the identification of internationally important wetlands have changed a number of times since the first set were established at the first COP in 1980. They were subsequently updated in 1987, 1990, 1999 and 2005. The 1999 criteria included the first criteria specifically aimed at fish and in 2005 a further criterion was added which covered wetland-dependent non-avian animal species (Ramsar 2009). The criteria for which Coongie Lakes was originally listed in 1987 are based on the 1980 set and are shown in Table 3. The RIS (1998) states the site met nine sub-criterion using the 1990 set of criteria (Table 4). However, no specific justification for any of the criteria was provided in the RIS reviewed. Table 5

Table lists the criteria met using the current, 2005, set of criteria.

Table 3: Original criteria for identifying Wetlands of International Importance as at listing date (RIS 1987). Criteria for which Coongie Lakes Ramsar site has been listed are shaded.

Basis	Number	Description
Specific criteria based on waterfowl	1a	It regularly supports 10 000 ducks, geese and swans; or 10 000 coots or 20 000 waders.
	1b	It regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.
	1c	It regularly supports 1% of the breeding pairs in a population of one species or subspecies of waterfowl.
General Criteria based on plants and animals	2a	It supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal.
	2b	It is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna.
	2c	It is of special value as the habitat of plants or animals at a critical stage of their biological cycle.
	2d	It is of special value for one or more endemic plant or animal species or communities.
Criteria for representative or unique wetlands	3	It is a particularly good example of a specific type of wetland characteristic of its region.

Table 4: Listing criteria met based on 1990 set of criteria (RIS 1998). Criteria for which Coongie Lakes Ramsar site has been listed are shaded.

Basis	Number	Description
Criteria for representative or unique wetlands	1a	It is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region.
	1b	It is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region.
	1c	It is a particularly good representative example of a wetland, which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially where it is located in a trans-border position.
	1d	It is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.
General Criteria based on plants and animals	2a	It supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.
	2b	It is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna.
	2c	It is of special value as the habitat of plants or animals at a critical stage of their biological cycle.
	2d	It is of special value for one or more endemic plant or animal species or communities.
Specific criteria based on waterfowl	3a	It regularly supports 20 000 waterfowl.
	3b	It regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.
	3c	Where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

Table 5: Criteria for Identifying Wetlands of International Importance as at listing date, 1987 using 2005 criteria. Criteria met by Coongie Lakes Ramsar site are shaded.

Number	Basis	Description
Group A. Sites containing representative, rare or unique wetland types		
Criterion 1		A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B. Sites of international importance for conserving biological diversity		
Criterion 2	Species and ecological communities	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3	Species and ecological communities	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4	Species and ecological communities	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Criterion 5	Waterbirds	A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.
Criterion 6	Waterbirds	A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of waterbird.
Criterion 7	Fish	A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8	Fish	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9	Other taxa	A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

2.5.2 Assessment based on current information and Ramsar criteria

There have been a few developments since the site was nominated in 1987 that influence the application of the Ramsar criteria to wetland sites this includes:

- Refinements and revisions of the Ramsar criteria as discussed above.
- Revision of population estimates for waterbirds (Wetlands International 2006; Bamford et al. 2008), which influences the application of criterion six.
- A decision with respect to the appropriate bioregionalisation for aquatic systems in Australia, which for inland systems are now based on drainage divisions and for marine systems the interim marine classification and regionalisation for Australia (IMCRA). This affects the application of criteria one and three.
- Updating of threatened species listings, which affects criterion two.

An assessment against each of the criteria for Coongie Lakes Ramsar site is as follows:

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

The application of this criterion must be considered in the context of the bioregion within which the site is located. The Coongie Lakes Ramsar site lies within the Lake Eyre Basin Drainage Division bioregion. The site encompasses a range of wetlands which is representative of the Channel Country. Cooper Creek is one of the largest unregulated river systems remaining in Australia and is recognised internationally as a significant inland river system. Wetland types found within the site include permanent waterholes and near permanent lakes, intermittently filled flood-outs and channels, fresh and saline wetlands, and interdunal wetlands and swamps. Geomorphically the site is unique; with the broad fan that emanates downstream of Innamincka giving rise to the unique array of lakes and interconnecting channels which are in turn influenced by the regional parallel dune fields of the Strzelecki Desert.

Linked to the diversity of wetland types, the Coongie Lakes Ramsar site also meets criterion one for its hydrological importance. One of the objectives for establishing a Ramsar list is to establish national networks of Ramsar sites in each Contracting Party which fully represent the diversity of wetlands and their key ecological and hydrological functions (Ramsar 2009). In order to achieve this sites that play a substantial ecological or hydrological role in the natural functioning of a major river basin should be included on national lists. Coongie Lakes Ramsar site clearly meets this objective. The lower Cooper Creek floodplain meets two of the attributes for meeting hydrological importance: it is a major natural floodplain, and is also important in retaining water for other wetland systems downstream including Lake Eyre.

This criterion was met at the time of listing and continues to be met.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

In the Australian context, it is recommended that this criterion should only be applied with respect to nationally or internationally threatened species/communities, listed under the EPBC Act or the International Union for Conservation of Nature (IUCN) Red List (IUCN 2009). Many South Australian state-listed species (see Section 2.2 above) have been recorded from the site but these do not meet the requirements for this criterion.

A number of threatened species listed at the national and/or international level have been recorded within the boundary of the Coongie Lakes Ramsar site – six fauna and two flora species. Of particular importance to this criterion, the Australian painted snipe (*Rostratula australis*) is a wetland dependent species that is listed as endangered both under the EPBC Act and the IUCN Red List. Reid (1988b) and Reid et al. (2004) provide three records of the Australian painted snipe in Lake Toontoowaranie. The Ramsar site is highly likely to support this cryptic species on a frequent basis however there are few records from the site as the Australian painted snipe not likely to be recorded in aerial surveys.

Other nationally or internationally listed species that have been recorded at the site are the greater bilby (*Macrotis lagotis*), dusky hopping-mouse (*Notomys fuscus*), plains rat (*Pseudomys australis*), woma python (*Aspidites ramsayi*), fawn hopping-mouse (*Notomys cervinus*), yellow swainson-pea (*Swainsona pyrophila*) and Mt Finke grevillea (*Grevillea treueriana*). These terrestrial species are not considered to be reliant on aquatic habitats for foraging, reproduction or other key parts of their lifecycle but are nonetheless supported by habitats within the Ramsar site.

Whilst this criterion was said to be met at the time of listing, the relevant species were not nominated. It is likely that the listing of the site under the then criterion 2a (see Table 3) was made on the basis of species with regional and or state conservation significance. In a review of the available species data, one wetland dependent species listed at the national and international level (the Australian painted snipe) was identified. As such this criterion is deemed to be currently met.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Like criterion one, application of this criterion must be taken in the context of the appropriate bioregion, in this instance the Lake Eyre Basin Drainage Division. Guidance from the Convention indicates that this criteria should be applied to "hotspots" of biological diversity, centres of endemism, sites that contain the range of biological diversity (including habitat types) occurring in a region; and/or support particular elements of biological diversity that are rare or particularly characteristic of the biogeographic region.

The site is neither a hotspot for biodiversity nor a centre of endemism within the Lake Eyre Basin; however it does contain a concentration of arid zone biodiversity due to the presence of water on a semi regular basis. Water is present long enough and in sufficient quantities to sustain wetland dependent species. Species richness is comparatively high for most biota, with 83 wetland dependent bird species, 10 frog species, at least 12 native fish species, over 350 plant species and one wetland dependent mammal species recorded from within the site (DEHAA 1999). Put into a bioregional perspective, it was ranked amongst the most species diverse system in the Lake Eyre Basin in terms of wetland dependent species (Hale 2010). The site supports a number of wetland types (nine Ramsar wetland types), land systems and vegetation communities that are characteristic of the bioregion. The site is considered to be of high value for its fish fauna as well as for supporting large numbers of waterbirds in an arid environment. In addition the diversity of terrestrial species is high, as species concentrate along the waterways taking advantage of the water supply and habitat. For example, dryland bird species richness (in particular raptor species richness) is particularly high and is an outstanding example of a diverse and abundant riparian woodland bird community in the Lake Eyre Basin bioregion.

This criterion was met at the time of listing and continues to be met.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

The long term intention of this criterion is to ensure wetlands within the Ramsar estate include those which are vital for providing habitat during critical life stages and or in period of adverse conditions (Ramsar 2009). The Coongie Lakes system is formally recognised as a highly significant refuge for biological diversity in arid and semi arid Australia (Morton et al. 1995). The presence of perennial water in an arid environment provides critical refuge for water dependent species including significant numbers of migratory species, notably waterbirds. The Cooper Creek turtle (*Emydura macquarii emmotti*) is found at the site and research indicates that only long term permanent waterholes provide the critical refugia required to sustain populations. Fish use the permanent waterholes as critical refuges in the Cooper Creek system and all Lake Eyre Basin rivers (Puckridge 1999; Timms 2001; McNeil and Schmarr 2009), with Cullyamurra waterhole is a critical refuge for fish in the lower Cooper and Ramsar site.

The also site provides for large scale waterbird breeding. Notable breeding records from the Ramsar site include (Reid and Puckridge 2000; Reid 2004):

- more than 50 000 nests of Australian pelican in summer 1990/91;
- more than 10 000 nests of grey teal and the same number of pink-eared duck in spring/summer 1988;
- thousands of nests of black-tailed native hen in spring/summer 1988, summer 1989/90 and summer 1990/91;

- thousands of nests of hardhead in spring / summer 1988, summer 1989/90 and summer 1990/91;
- 1300 nests of pied cormorant in summer 1990/91; and
- 1700 great cormorant nests in May 2004.

This criterion was met at the time of listing and continues to be met.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

Given the size, complexity and inaccessibility of much of the Ramsar site, it is not surprising that complete counts of waterbirds are rare. As such, most of the available abundance data are for a portion of the Ramsar site only, with a few more comprehensive ground and aerial surveys. Even though most bird counts represent only a portion of the site, they illustrate the importance of the Coongie Lakes system for supporting a diversity and abundance of waterbirds. The site supports large numbers of birds year round (Figure 22), with peaks in abundance following extensive inundation. It is clear from this data that the site meets criterion five, having in excess of 20 000 waterbirds record for each survey event.

This criterion was not listed as met in the original listing (Table 3), however based on the data assessed it is likely it was met at the time of listing and continues to be met.

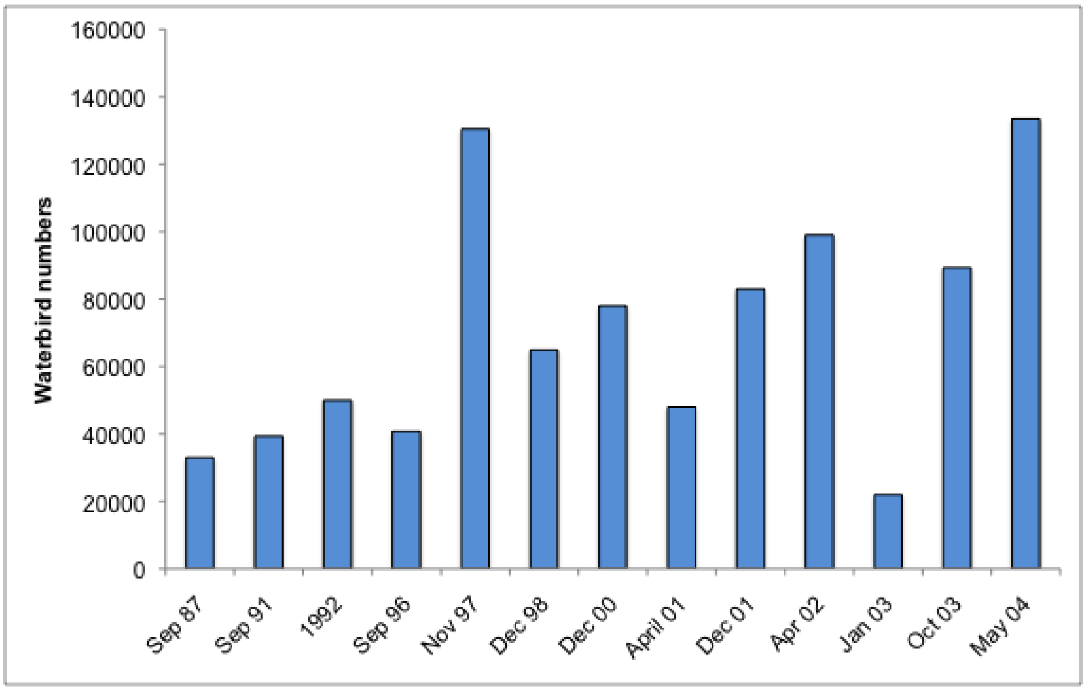


Figure 22: Total waterbird numbers from the Coongie Lakes Ramsar site (data from Birds Australia unpublished; Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999 and Reid et al. 2004). Note that several counts represent a portion of the site only (for example, October 2003 was a count of Lake Hope only).

Criterion 6: A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of waterbird.

The varied count data makes the concept of "regularly supports" (see Text Box 1) difficult to apply, especially for small species that are hard to identify in aerial surveys. Available data from published surveys (Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999; Reid and Jaensch 2004; Reid et al. 2004) provide good evidence to support the claim that the Ramsar site "regularly" supports greater than one percent of the population of pink-eared duck (*Malacorhynchus membranaceus*). The one percent population threshold was exceeded in ten separate surveys spanning two decades (Figure 23).

Regularly (Criteria 5 & 6) – as in supports regularly – a wetland regularly supports a population of a given size if:

i. the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available, the total number of seasons being not less than three; or
ii. the mean of the maxima of those seasons in which the site is internationally important, taken over at least five years, amounts to the required level (means based on three or four years may be quoted in provisional assessments only).

In establishing long-term 'use' of a site by birds, natural variability in population levels should be considered especially in relation to the ecological needs of the populations present. Thus in some situations (e.g., sites of importance as drought or cold weather refuges or temporary wetlands in semi-arid or arid areas – which may be quite variable in extent between years), the simple arithmetical average number of birds using a site over several years may not adequately reflect the true ecological importance of the site. In these instances, a site may be of crucial importance at certain times ('ecological bottlenecks'), but hold lesser numbers at other times. In such situations, there is a need for interpretation of data from an appropriate time period in order to ensure that the importance of sites is accurately assessed.

In some instances, however, for species occurring in very remote areas or which are particularly rare, or where there are particular constraints on national capacity to undertake surveys, areas may be considered suitable on the basis of fewer counts. For some countries or sites where there is very little information, single counts can help establish the relative importance of the site for a species.

The International Waterbird Census data collated by Wetlands International is the key reference source.

Text Box 1: Definition of regularly supports (Ramsar 2009).

There are seven counts above the one percent threshold for red-necked avocet (Figure 24), which includes four of the five comprehensive surveys that have been conducted across the entire Ramsar site as well as during the 1997 partial count (Reid and Puckridge 2000) and during 1983 and 1992, where the extent of survey is unknown. This meets the Ramsar definition of "regularly supports" with the one percent population threshold exceeded in more than two thirds of surveys (for which adequate data are available).

This criterion was met at the time of listing and continues to be met.

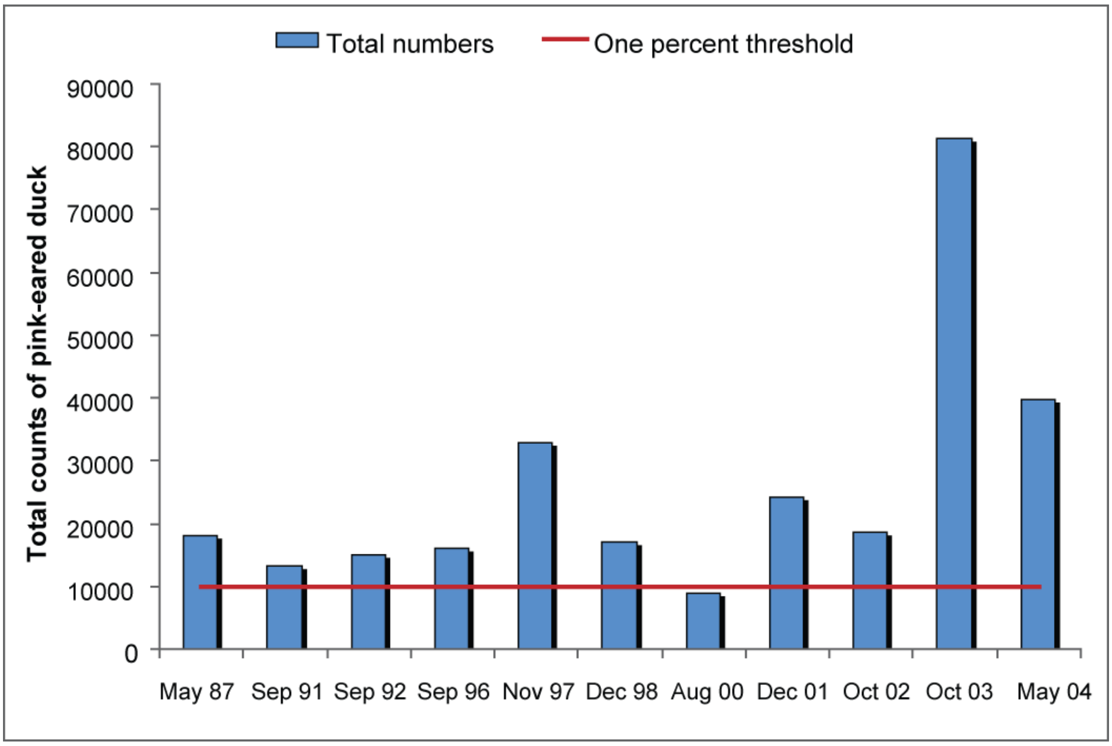


Figure 23: Abundance of pink-eared duck in the Coongie Lakes Ramsar site (Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999; Reid et al. 2004). Note that data for 2002 and 2003 are for Lake Hope only and 1997 represents a partial survey of the site.

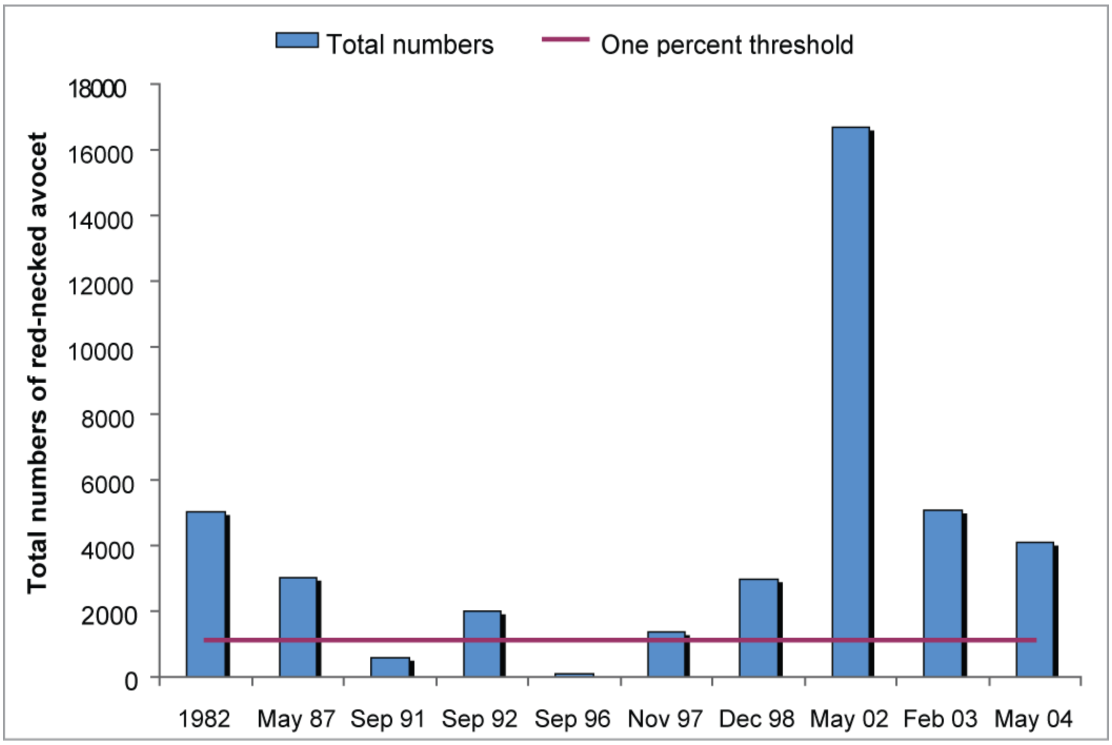


Figure 24: Abundance of red-necked avocet in the Coongie Lakes Ramsar site (Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999; Reid and Jaensch 2004; Reid et al. 2004). Note that the figure for 1992 was provided as “several thousand” and November 1997 represents a partial survey only.

Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

Guidance from the Ramsar Convention (Ramsar Convention 2009) on the application of this criterion indicates that in order to meet this criterion, a site should have a high degree of endemism or biodisparity in fish communities. This criterion is very difficult to apply. A site can potentially qualify based on the proportion of fish species present that are endemic to the site (must be greater than ten per cent) or by having a high degree of biodisparity in the fish community. Assemblages of fish found in internally draining catchments such as the Lake Eyre Basin rarely meet this criterion as they do not exhibit the variety of reproductive strategies shown by assemblages which have access to the sea. In addition, there is no evidence to suggest that the Coongie Lakes supports fish species that are endemic to the site. For example, samples collected during eight surveys (March 2000 to March 2003) did not collect any endemic fish with all species recorded within the Coongie Lakes also found in other streams within the bioregion (Pritchard et al. 2004).

This criterion is not considered to be met either at listing or currently.

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

The application of this criterion relates to sites which provide important food sources for fish, or are spawning grounds, nursery areas and/or on their migration path on which fish stocks, either within the site or elsewhere, depend. Guidance from the Ramsar Convention (Ramsar Convention 2009) suggests that sites can meet this criterion based on the fact that within a system fish migrate from deeper, more permanent waters to shallow temporarily inundated areas for spawning. Wetlands, even apparently insignificant ones in one part of a river system, may therefore be vital for the proper functioning of extensive river reaches upstream or downstream of the wetland (Ramsar Convention 2009). At the Coongie Lakes Ramsar site, the combination of permanent waterholes with an intermittent connection to an extensive floodplain ensures an intact, species rich, fish population for the lower Cooper. Flood history has been shown to be an important influence on fish abundance, with nine of the 13 species recorded at the site being highly mobile and responsive to floods for either breeding or migration (Puckridge et al. 2010). Species richness is correlated with water permanence (Puckridge et al. 2010) with the waterholes providing key habitat for sustaining fish populations in an arid environment (see Criterion 4). In addition, the hydrological variability is believed to contribute to the high proportion of native species compared with exotic species. Data from the ARIDFO project demonstrate 30 863 (99 percent) natives and only 325 exotic fish from two species (Pritchard et al. 2004).

Overall, the unregulated hydrological regime and persistence of permanent waterholes supports a largely intact dryland river native fish fauna for the lower Cooper Creek in South Australia. Fish respond to floods to migrate and breed within different habitats within the site. Fish within the site are also a source of colonists for Lake Eyre in large flood events. This is supported by the presence of a commercial fishery at Lake Hope in the lower reaches of the site. Lake Hope only receives water 1 in 4.5 years (Kingsford et al. 1999), but once full can retain water for up to four years (Kingsford et al. 1999). In the period May 1992 to March 1994 309 tonnes of Lake Eyre callop (*Macquaria ambigua* sp. B) was harvested (DEHAA 1998). This fishery is supported by colonists from upstream within the site.

This criterion is considered to be met both at listing and currently.

Criterion 9: A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

The application of this criterion relies on estimates of the total population of non-avian wetland dependent species. For the Coongie Lakes Ramsar site this would mean reliable population estimates for invertebrates, mammals, fish and turtles. The Cooper Creek turtle (*Emydura macquarii emotti*) occurs in large numbers inside the Ramsar site, however there are no estimates of population size at the national level (A. Georges, University of Canberra, pers. comm.) and so this criterion can not be assessed for the turtle. The water rat (*Hydromys chrysogaster*) occurs within the site, but there are no data on numbers. Population data on fish and invertebrates are unavailable.

This criterion is not considered to be met either at listing or currently.

3. Critical Components and Processes

3.1 Identifying critical components and processes

Ecological Character Descriptions (ECDs) identify, describe and where possible, quantify the critical components, processes and services of the site which determine the wetland's character and ultimately allow detection and monitoring of change in that character. These are the aspects of the ecology of the wetland, which, if they were to be significantly altered, would result in a significant change in the system.

DEWHA (2008) suggest the minimum components, processes, benefits and services, which should be included in an ECD are those:

1. that are important determinants of the site's unique character;
2. that are important for supporting the Ramsar or DIWA criteria under which the site was listed;
3. for which change is reasonably likely to occur over short to medium time scales (less than 100 years); and/or
4. that will cause significant negative consequences if change occurs.

The role that components and processes play in the provision of critical ecosystem services should also be considered in the selection of critical components and processes. The linkages between components, processes, benefits and services and the criteria under which the site was listed are illustrated conceptually in Figure 25. This simple conceptual model for the Coongie Lakes Ramsar site shows not only the components, processes and services that are critical to the ecological character of the site, but also but also the essential elements which are important in supporting these.

It is difficult to separate components (physical, chemical and biological parts) and processes (reactions and changes). For example, aspects of hydrology such as rainfall and water regime may be considered as components, while other aspects of hydrology such as groundwater flow and connectivity could be considered processes. Similarly the species composition of fish at a site may be considered a component, but breeding and migration are processes. In the context of this ECD, a separation of the ecology of wetlands into nouns (components) and verbs (processes) is an artificial boundary and does not add clarity to the description. As such components and processes are largely considered together.

Each of the identified critical components and processes meet the four criteria provided by DEWHA (2008) in that they are central to the character of the site, are directly linked to the Ramsar criteria for which the site was listed, could potentially change in the next 100 years and for which change would result in negative consequences and a change in the ecological character of the site.

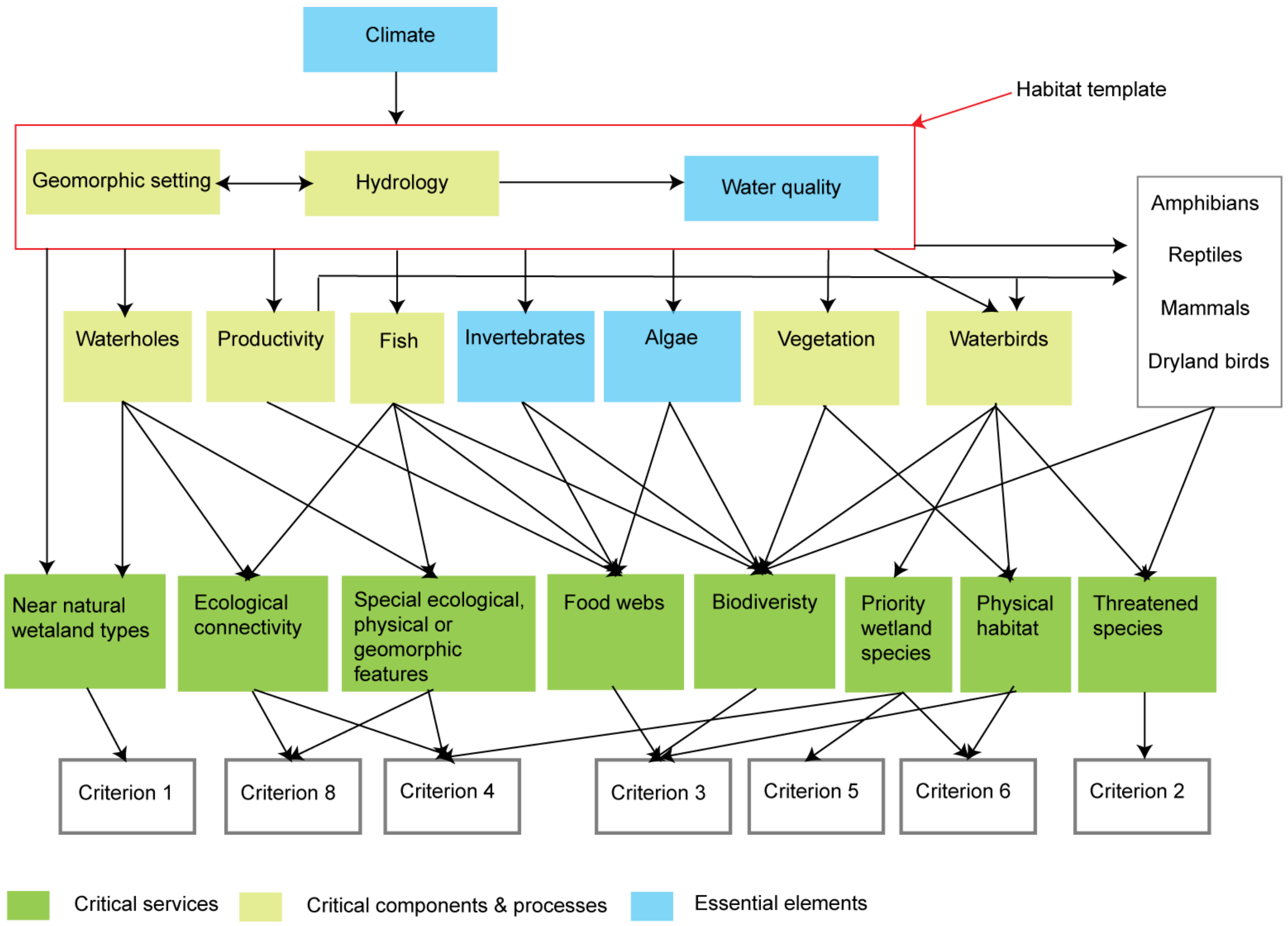


Figure 25: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a wetland of international importance.

Several of the remaining components and process identified in Figure 25, are important in supporting the critical components and processes, benefits and services but are not considered critical as a change in these components and process, in isolation (that is without a corresponding biological response) would not result in a change in the ecological character of the site. Essential elements (climate, water quality, algae and invertebrates) have been identified as components which support the critical components, processes and services and are important in managing the site to maintain ecological character and some may provide early warning indicators of change. The remaining components (reptiles, mammals, dryland birds and amphibians) contribute to the biodiversity value of the site and include a number of threatened species, but do not support the critical components, processes or services. These groups are briefly described in Section 2.2 and listed in Appendix C. Section 3.2 provides a description of the essential elements that are important in supporting the ecological character of the site:

- Climate
- Water quality
- Algae
- Invertebrates

3.2 Essential elements

The components and processes of the Coongie Lakes Ramsar site that are considered important in supporting the critical components, processes, benefits and services of the site (termed "essential elements") are described briefly below and summarised in Table 6.

Table 6: Summary of essential elements within Coongie Lakes Ramsar site.

Component / process	Description
Climate	• Highly variable annual and inter annual rainfall. • Season is considered a key driver of biotic responses.
Water quality	• Predominantly fresh, highly turbid and supports high productivity. • In channel and floodplain water quality differ, with wetlands filled from the Cooper Creek having higher salinity than the Cooper Creek itself – which is linked to the wetting and drying phases of the wetlands. • Water quality of the rain fed wetlands is a knowledge gap.
Algae	• Low endemism. • Comparatively high diversity compared to other river systems in the Lake Eyre Basin, related to flood magnitude and lesser role of salinity in structuring community composition • High degree of similarity across sites due to high degree of hydrological connectivity.
Invertebrates	• High species richness of zooplankton and productivity (all major groups). • High component of temporary wetland specialists, those adapted to a drying period.

3.2.1 Climate

Coongie Lakes are situated in the desert region of north-eastern South Australia. The climate is arid with hot dry summers and cold winters. Rainfall is highly variable both inter-annually (between years) and intra-annually (within a year). The aspects of climate that most directly affect wetland ecology are rainfall (both local and in the catchment), temperature and evaporation as these all fundamentally affect wetland hydrology and the water budget. The nearest weather station is at Moomba near the southern border of the Ramsar site.

Rainfall is very low year round with median monthly rainfall generally less than 13 millimetres. However, there is considerable variability in rainfall as evidenced by the 10th and 90th percentiles, which range from no rainfall in a month (recorded at least once in each month from 1973 to 2005) to more than 430 millimetres per month in January 1974 (Figure 26).

Annual average rainfall at Moomba is in the order of 200 millimetres per year. However, there is high inter-annual variation with annual rainfalls ranging from less than 50 millimetres to more than 800 millimetres in the past 30 years (Figure 27).

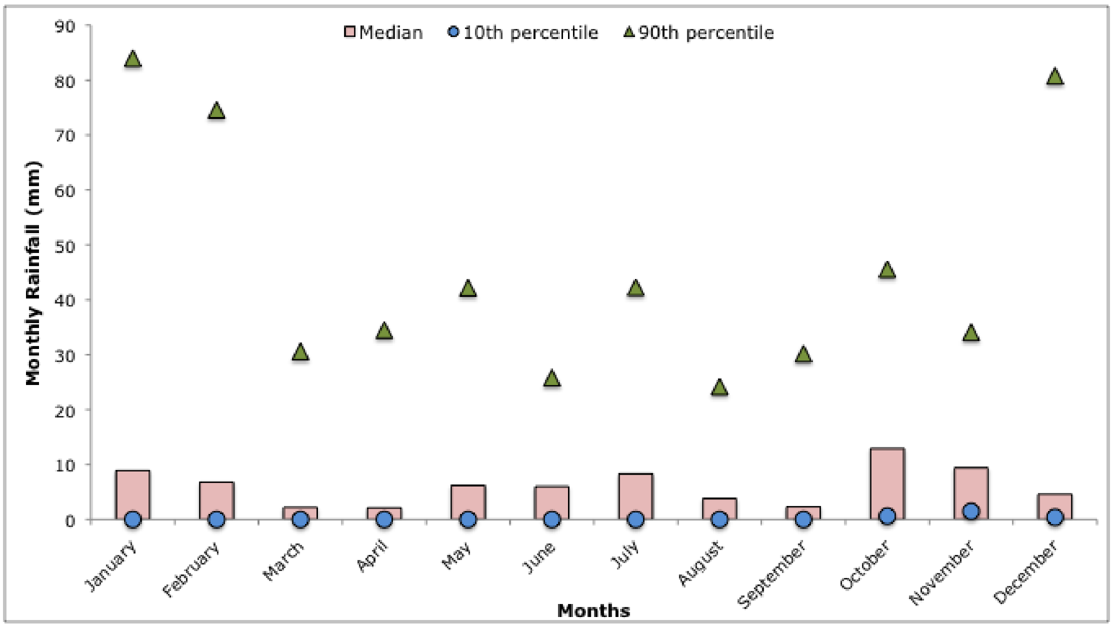


Figure 26: Median (10th and 90th percentile) monthly rainfall at Moomba, 1973 to 2005 (data from Bureau of Meteorology 2010).

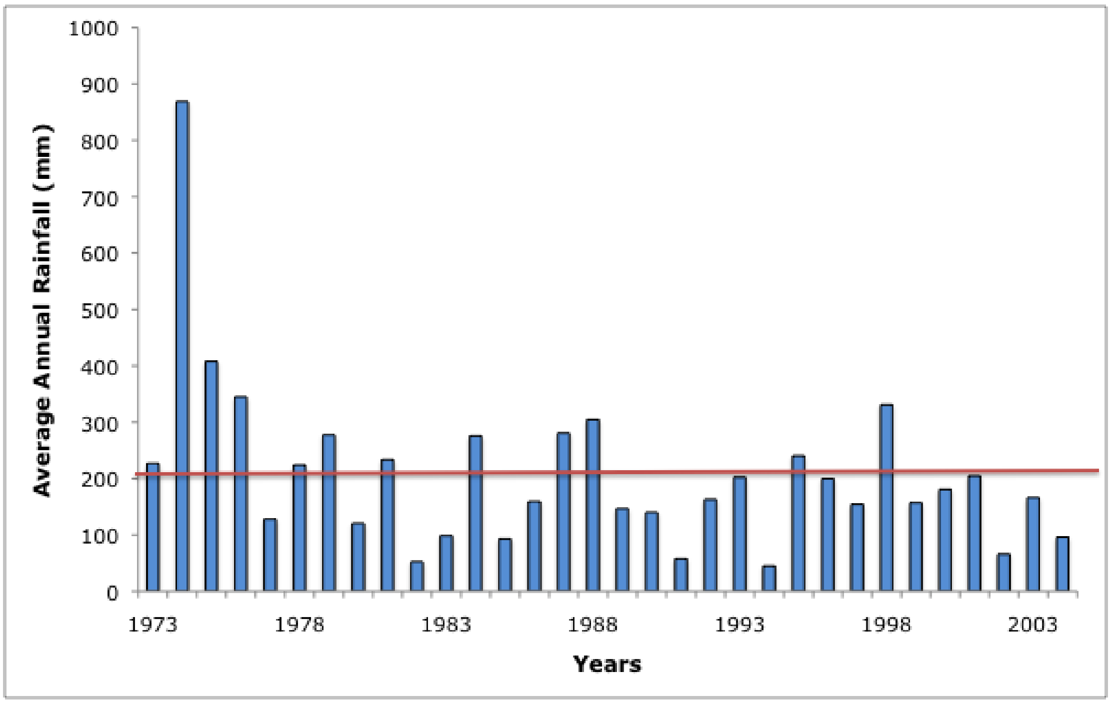


Figure 27: Average annual rainfall at Moomba, 1973 to 2005 (data from Bureau of Meteorology 2010).

Temperatures range from warm to hot year round, with average summer maximum temperatures between 34 and 37 degrees Celsius and average monthly minimum temperatures between 21 and 23 degrees Celsius. During winter average maximum temperatures are cooler (19 to 22 degrees Celsius). June and July are the coolest months with average maximum temperatures around 19 degrees Celsius and average minimum temperatures of approximately 6 to 7 degrees Celsius (Figure 28).

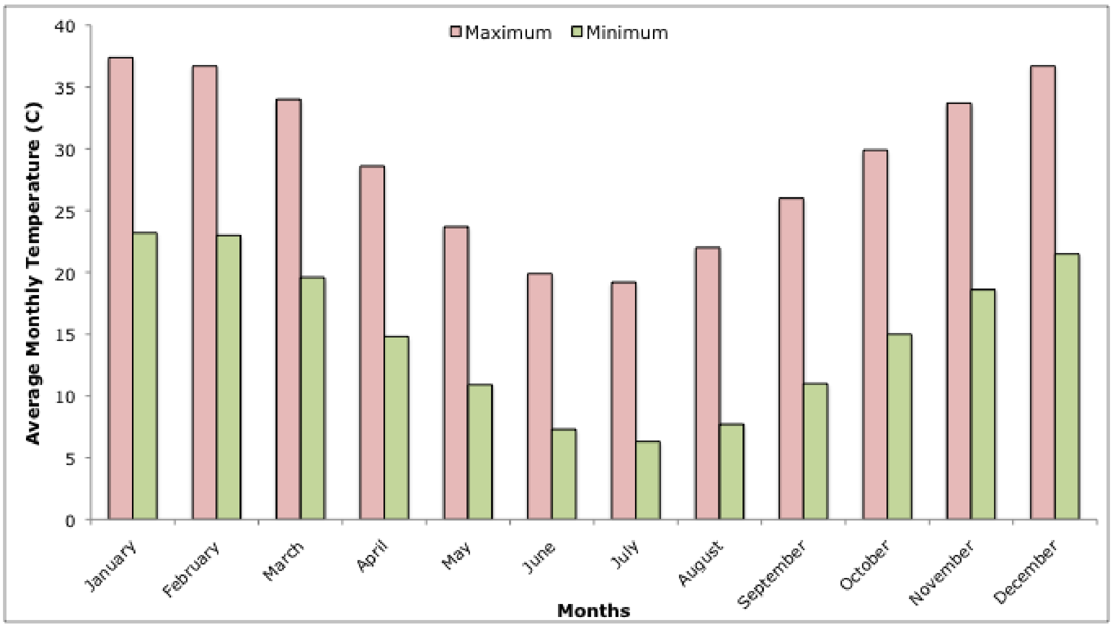


Figure 28: Average monthly maximum and minimum temperatures at Moomba, 1973 to 2005 (data from Bureau of Meteorology 2010).

Relative humidity is very low, ranging from 18 percent in the summer to 40 percent in the winter. This, combined with the high temperatures, produces evaporation rates that greatly exceed rainfall year round (Figure 29).

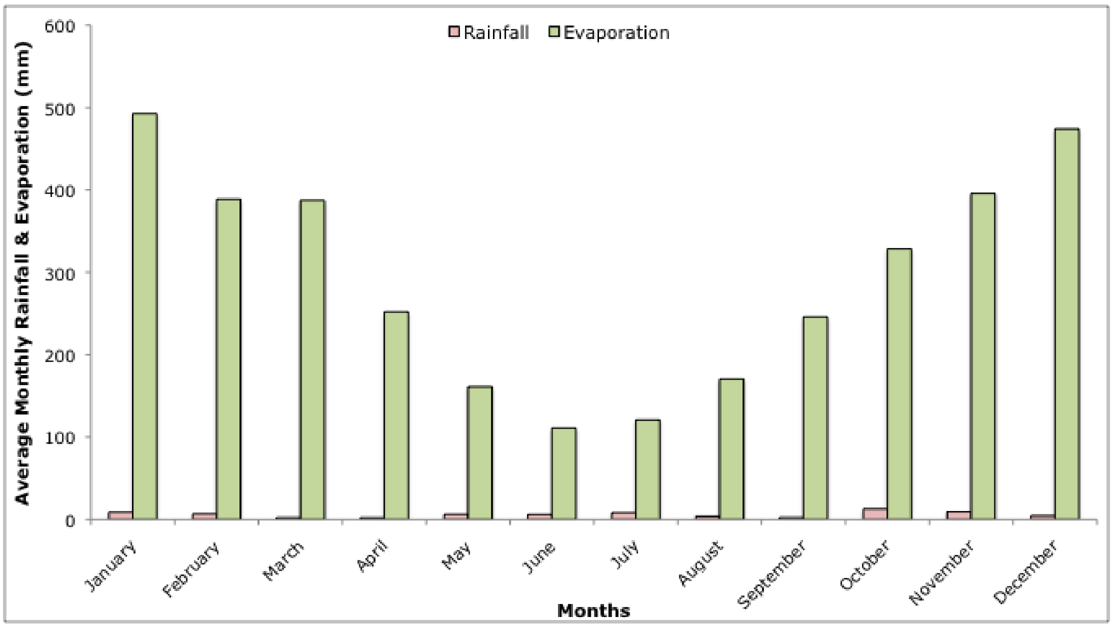


Figure 29: Average monthly rainfall and evaporation at Moomba, 1973 to 2005 (data from Bureau of Meteorology 2010).

Season has a strong influence on the biota and ecology of the Ramsar site with winter minima being correlated with low fish activity and reduced algal growth, two key factors in the productivity of the site. Costelloe et al. (2004a) showed that season was a key driver of biotic responses in the ARIDFLO project, particularly with regards to temperature. Rising water temperatures in spring and summer corresponded to increased fish activity including seasonal breeding and increased algal growth rates and abundance. Inter-annual variability in the intensity and onset timing of seasons and summer flows also affects breeding extent and success, food availability, and habitat availability resulting in different ecological responses between years (Costelloe et al. 2004a).

3.2.2 Water Quality

Water quality in the Coongie Lakes system has been described as predominantly fresh (although salinity fluctuates in river channels and some wetlands in response to wetting and drying), turbid and highly productive (Roberts 1988; Puckridge 2000; Timms, 2001). Although comprehensive data are not available for the whole system, available data suggests different water quality in river channels as opposed to non-flowing wetlands (Roberts 1988; Timms 2001). No data were sourced for the rain fed wetlands in the northern lakes and Cordillo system landscape unit.

Historical data from the Cullyamurra waterhole gauging station on the Cooper Creek provides an indication of in-channel water quality over time. Salinity (as indicated by electrical conductivity) remains fresh, but ranges from less than 100 microSiemens per centimetre to over 800 microSiemens per centimetre (Figure 30). Turbidity is high and highly variable with an average of 380 NTU ± 240 NTU (mean ± standard deviation). From 1974 to 2007, turbidity ranged from less than 5 NTU to more than 1000 NTU (Figure 31). Temperature fluctuates seasonally and is typically very warm (more than 25 degrees Celsius) in summer months (Figure 32). This leads to strong diurnal temperature stratification (Puckridge 2000). High turbidity can also influence water temperature, in extreme conditions leading to increased water loss through evaporation (Costelloe et al. 2007). Nutrient (nitrogen and phosphorus) and dissolved organic carbon concentrations are also high and vary in response to flooding (Figure 33, Figure 34 and

Figure 35). Typically flood waters bring nutrients from the catchment and stimulate the release of dissolved nutrients from the sediments (Puckridge 2000).

To put the water quality of the Cooper Creek within the Ramsar site into context, Puckridge (2000) described it comparatively with conditions in the River Murray at Morgan. Typically, the Cooper Creek has one quarter the salinity, five times the turbidity, three to four times more soluble and total phosphorus and higher concentrations of all forms of nitrogen.

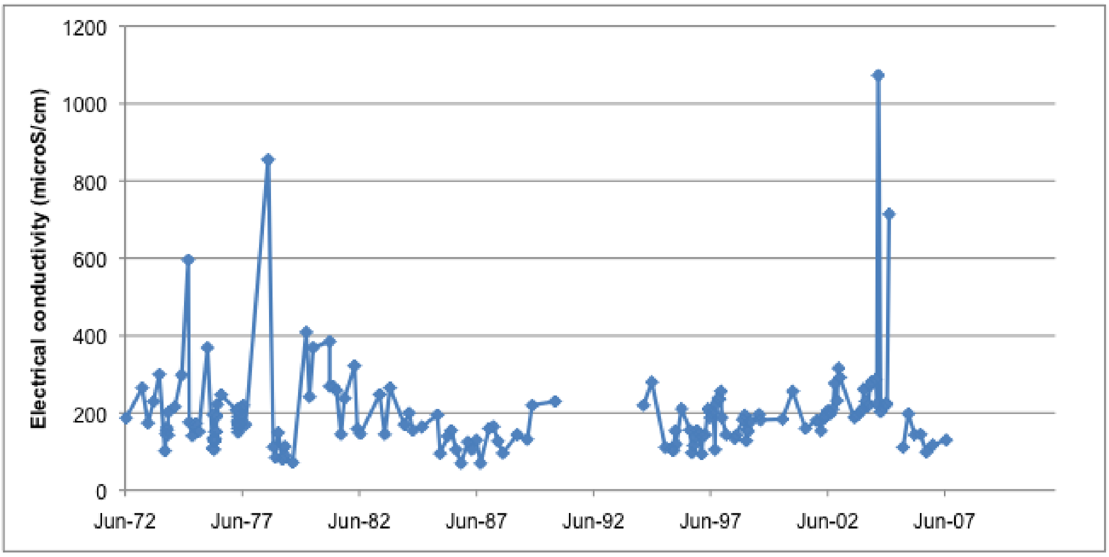


Figure 30: Electrical conductivity at Cullyamurra Waterhole 1972 to 2007 (data from EPA 2010).

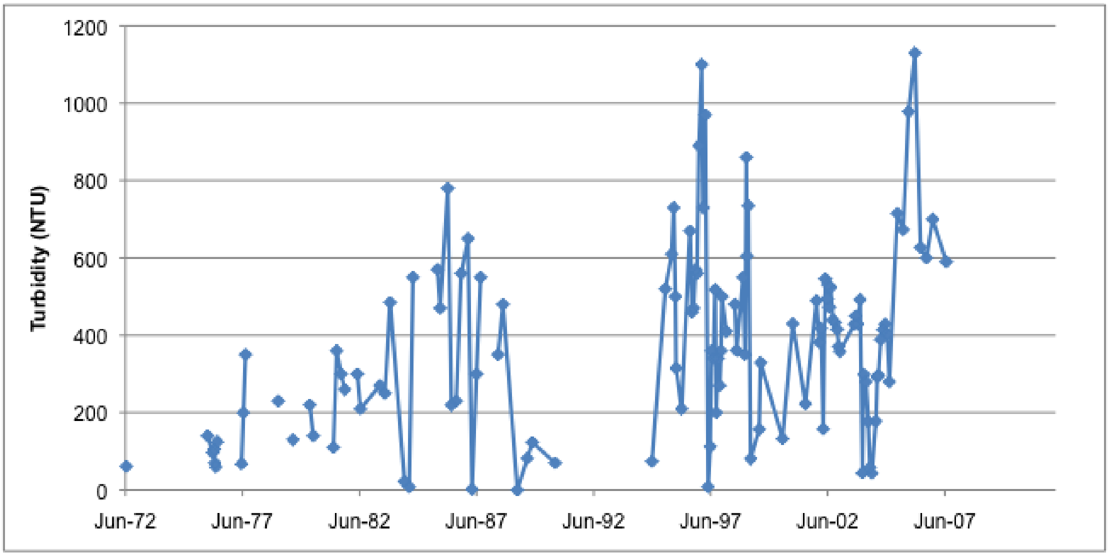


Figure 31: Turbidity at Cullyamurra Waterhole 1972 to 2007 (data from EPA 2010).

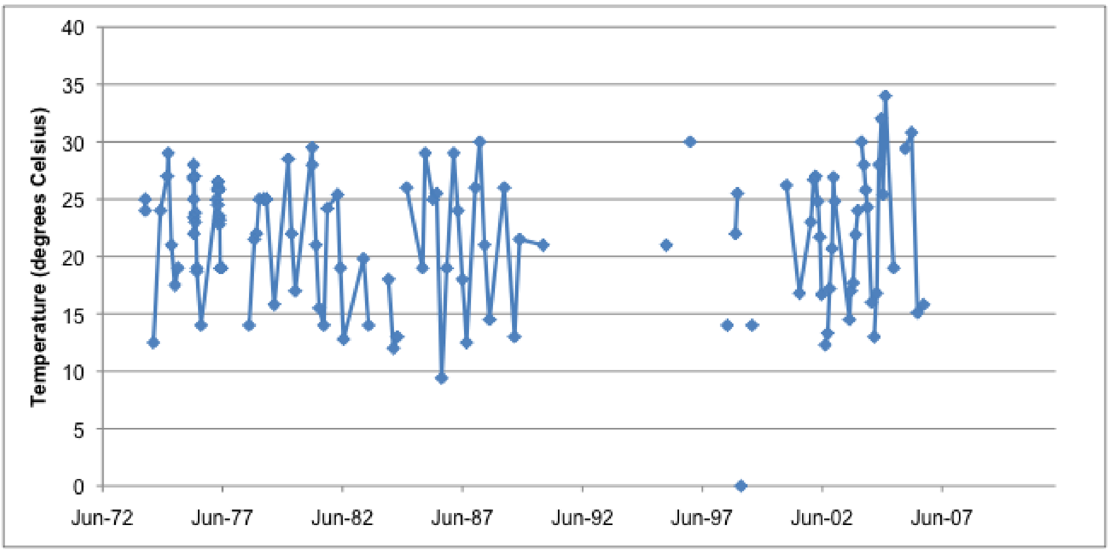


Figure 32: Temperature at Cullyamurra Waterhole 1972 to 2007 (data from EPA 2010).

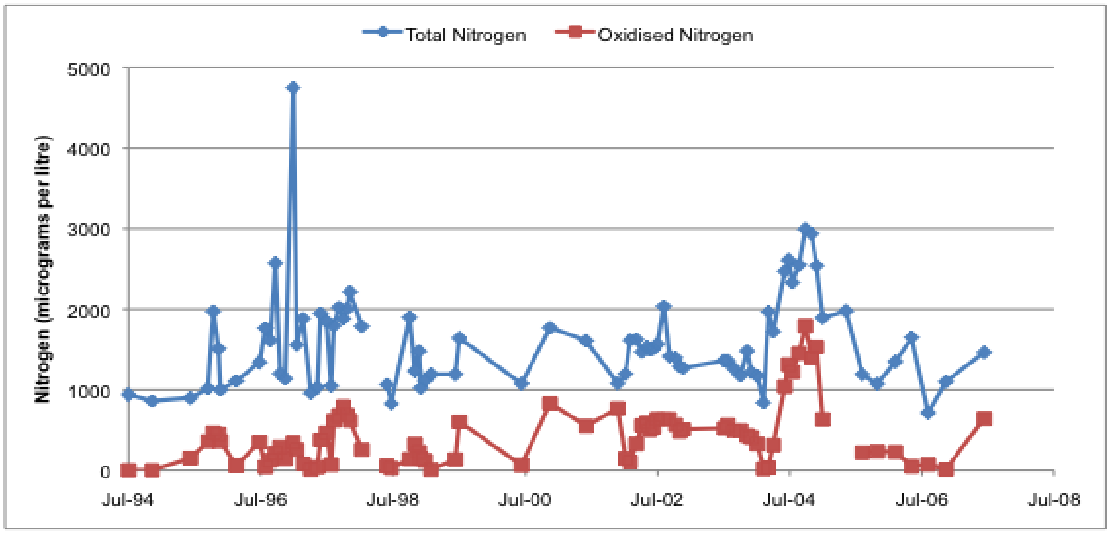


Figure 33: Nitrogen at Cullyamurra Waterhole 1994 to 2007 (data from EPA 2010).

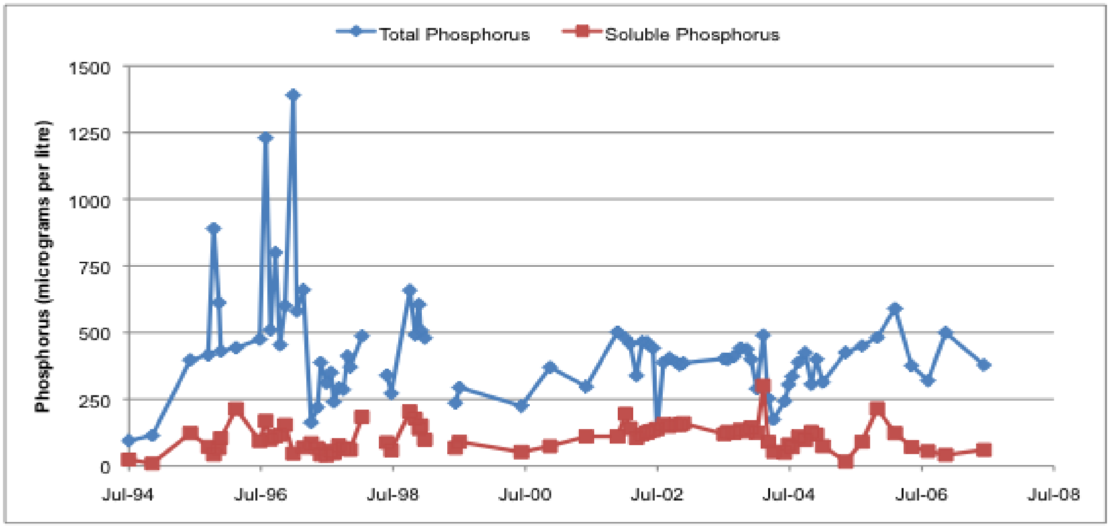


Figure 34: Phosphorus at Cullyamurra Waterhole 1972 to 2007 (data from EPA 2010).

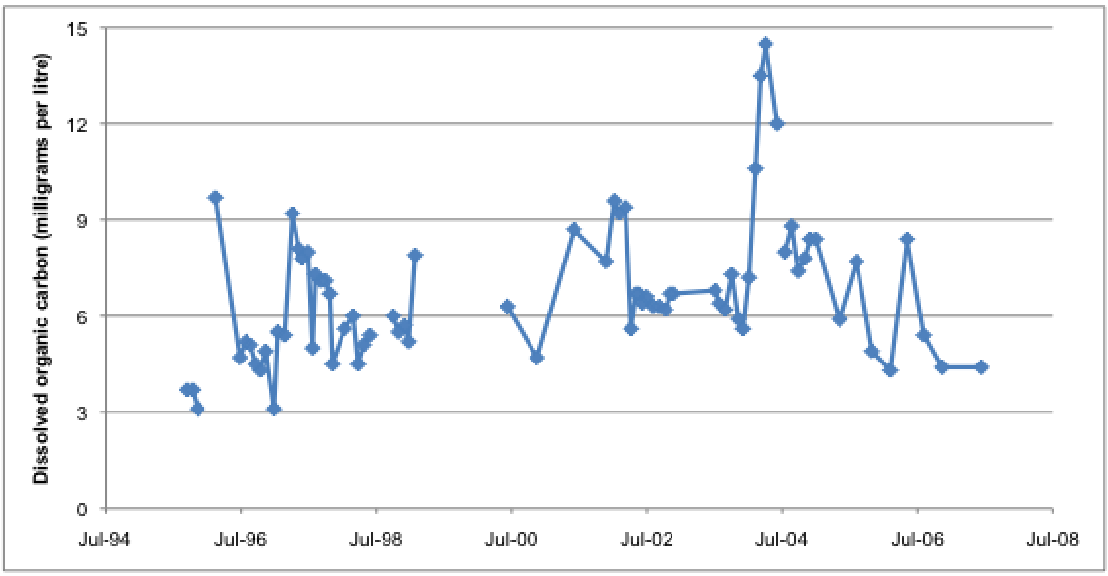


Figure 35: Dissolved organic carbon at Cullyamurra Waterhole 1972 to 2007 (data from EPA 2010).

Water quality in non-flowing environments can be characterised by data collected from 1987 to 1992 at five lake sites: Coongie Lake, Lake Apanburra, Lake Marroopootanie, Lake Goyder and Lake Tootoowaranie (Puckridge 2000). This may be indicative of a range of wetlands on the Cooper Creek floodplain but provides no indication as to the water quality in the rain fed systems located within the Ramsar site but outside the floodplain.

Water quality in these non-floodplain systems remains a knowledge gap. Some of the rain fed wetlands may have less turbid water, although this is not necessarily the case across all the rain fed wetlands. Claypan wetlands, for example, can be highly turbid. Hancock and Timms (2002) investigated the ecology of a series of arid zone claypan wetlands in the Paroo system, finding very high turbidity which increased as the wetlands dried. This was attributed to resuspension of sediments via wave/wind action rather than a concentration of suspended sediments as the wetlands dried (Hancock and Timms 2002). Claypans characteristically have no vegetation, which in other situations can help reduce turbidity. Williams (1985) states that many of the South Australian arid zone temporary wetlands are turbid, due to their shallow depth, with secchi disc readings of less than one centimetre common. However, turbidity is not necessarily persistent and there can be considerable variation in turbidity levels (Williams 1985).

Salinity (as indicated by electrical conductivity) is generally higher in lakes than channels (Puckridge 2000). Salinity increases as lake systems dry and lakes with lower inundation frequency and extent (for example Lake Marroopootanie) experience the greatest range in salinity (Figure 36). Costelloe et al. (2009) showed that the salinity of surface sediments in dry lake beds also increased as the frequency of drying increased. For example, salinity in the sediments of Lake Apanburra was higher than in Lake Goyder (Coolangire) and both were an order of magnitude higher than Toontoowaranie (Costelloe et al. 2009). Lake Toontoowaranie is a flow through lake, whereas Lake Apanburra is a terminal lake and Goyder is semi-terminal. The solute store in the sediments would influence the salinity of the surface waters when inundated and also influence seed and egg bank viability.

Similar to channel sites, lakes are generally very turbid with low clarity and narrow photic zones. From February 1987 to February 1992, water clarity (as indicated by secchi depth) was generally between five and ten centimetres at all five lake sites. This increased to a maximum of 30 centimetres some months after inundation (Puckridge 2000). Water temperatures in lakes are similar to that in channels and reaches maximums of more than 25 degrees Celsius in summer, which can lead to temperature stratification.

Importantly, these floodplain wetlands, although variable in inundation frequency and water quality over time, are "reset" during a large flood event, when water moves across the floodplain and water quality in all lakes is similar (Puckridge 2000). This is illustrated in Figure 36, where conductivity at all five lakes is between 200 and 300 microSiemens per centimetre following inundation in mid 1990. This does not apply to the non-floodplain wetlands within the Ramsar site, which may vary considerably in water quality both spatially and temporally. In general, arid zone temporary wetlands display considerably more variation in their physico-chemical natures than any other inland wetland type and therefore can be quite stressful environments for biota (Williams 1985).

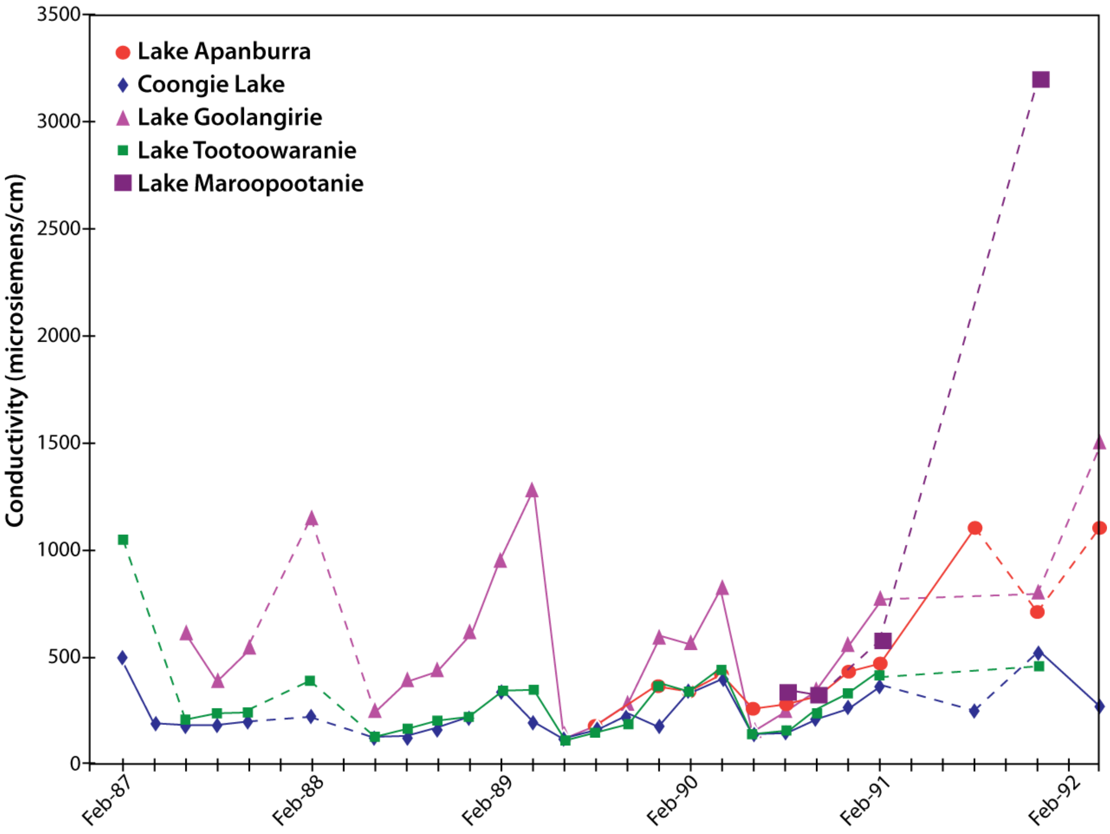


Figure 36: Electrical conductivity at five lake sites within the Coongie Lakes Ramsar site from February 1987 to March 1992 (Puckridge 2000).

3.2.3 Algae

The algal community of the lower Cooper is distinctive and supports high diversity when compared to other rivers within the Lake Eyre Basin at both the reach and individual waterbody scale (Costelloe and Powling 2004; Costelloe et al. 2005) (Table 7 and Figure 37). However, overall, there are relatively low levels of endemism within the rivers assessed in the ARIDFLO project, including within the Ramsar site. There was a high degree of similarity across all sites sampled within the Coongie Lakes system. This has been attributed, in part, to the hydrological connectivity of the system with sequentially filling wetlands (see Section 3.3.2), and also the fact that salinity is believed to have a lesser role in governing community structure compared to other systems in the bioregion (Costelloe et al. 2005). Diversity appears to be linked to magnitude/extent of hydrological events, with the ARIDFLO project recording peak diversity post a large flood in 2000, with a lower diversity recorded on the back of a smaller flood in 2001. The 2000 flood inundated a larger area of dry wetlands, floodplain and river channel than the 2001 event (Costelloe and Powling 2004; Costelloe et al. 2005).

Table 7: Generic richness of algae by phylum collected in the ARIDFLO project 2000 – 2003 (from Costelloe and Powling 2004). Lower Cooper represents data collected from the Ramsar site.

	Lower Cooper		Neales		Lower Diamantina	
Phylum	**Genera**	**Unique**	**Genera**	**Unique**	**Genera**	**Unique**
Cyanophyta	18	1	16	0	16	0
Heterokontophyta	7	0	5	1	8	1
Cryptophyta	2	0	2	0	1	0
Dinophyta	3	0	3	0	4	1
Euglenophyta	6	0	6	0	6	0
Cholorpyhta	39	1	37	7	43	5
Baciiiariphyta	25	1	29	3	25	3
All taxa	**100**	**3**	**98**	**11**	**103**	**10**

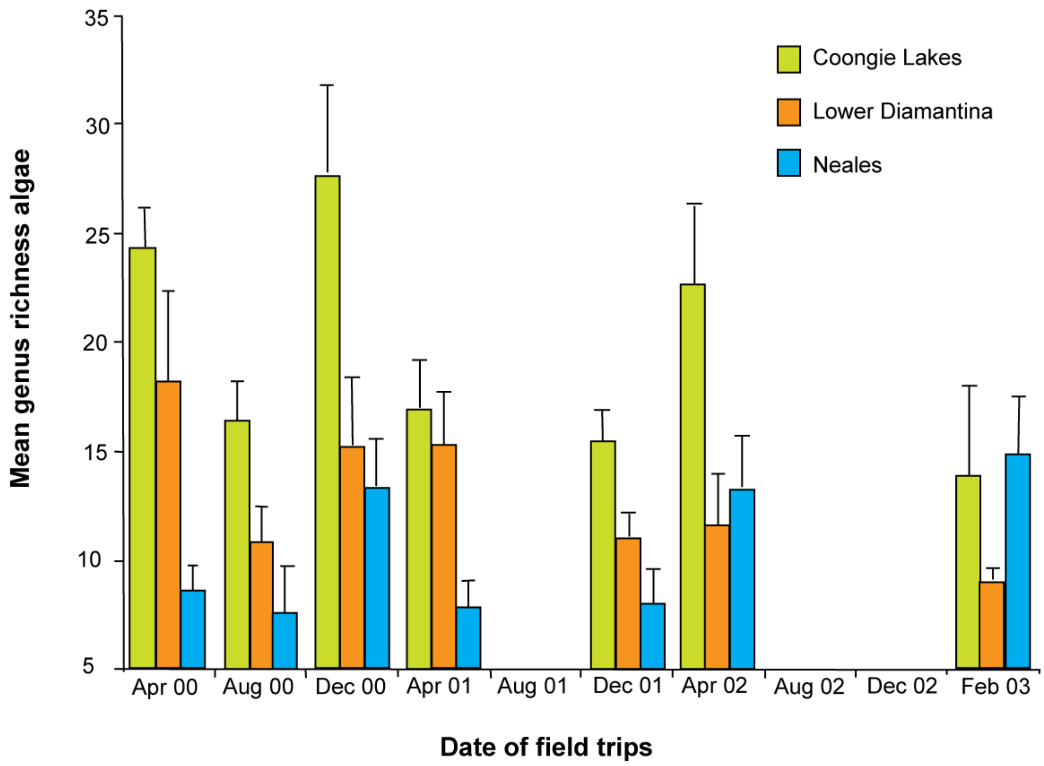


Figure 37: Mean genus richness of algae collected during the ARIDFLO project 2000 – 2003 showing high richness at Coongie Lakes (from Costelloe and Powling 2004). Coongie Lakes represents data collected from the Ramsar site.

Algae are considered essential elements of the site as they contribute to the boom and bust cycle, being the main elements in primary productivity and the bases of the food web of the floodplain (see Section 3.3.4 for further discussion on primary productivity).

3.2.4 Invertebrates

Zooplankton/microinvertebrates

Data collected during the ARIDFLO project showed mean taxon richness was comparable to the Lower Diamantina and higher than the Neales River at the Ramsar site (Shiel et al. 2006) (Table 8 and Figure 38). In general, rotifers were the most abundant, followed by microcrustacea and protists. Percentage rotifer taxa were shown to increase during or immediately following flood events in autumn with a corresponding decrease in microcrustacea. Opposite trends were observed in summer and winter with few rotifers and more microcrustacea (Costelloe and Shiel 2004; Shiel et al. 2006). Rotifers are better able to cope with flowing conditions than microcrustaceans (Costelloe and Shiel 2004) which may partially explain the season/flow related patterns observed. As with the algal abundances, Costelloe and Shiel (2004) postulated that increased zooplankton abundance was linked to flood magnitude. Reduced predation by juvenile fish, predominantly present in summer, may also contribute to the patterns in zooplankton dominance associated with season (Costelloe and Shiel 2004; Shiel et al. 2006). Zooplankton peaks in diversity coincided with peaks in algal diversity and combined these two elements contribute significantly to productivity and form the basis of the boom of higher trophic groups typical of boom bust ecologies (Shiel et al. 2006) (see Section 3.3.4). Puckridge (2000) showed that the low pulse phase of the hydrological cycle was important in terms of being biologically distinctive.

Table 8: Taxon richness of zooplankton collected in the ARIDFLO project 2000 – 2003 (from Costelloe and Shiel 2004). Lower Cooper represents data collected from the Ramsar site.

	Lower Cooper		Neales		Lower Diamantina	
	Taxa	Unique	Taxa	Unique	Taxa	Unique
Protista	55	10	35	5	55	9
Rotifera	150	44	109	20	160	40
Microcrustacea	51	12	32	6	72	32
Other	4	0	3	1	4	1
All taxa	**260**	**66**	**291**	**32**	**179**	**82**

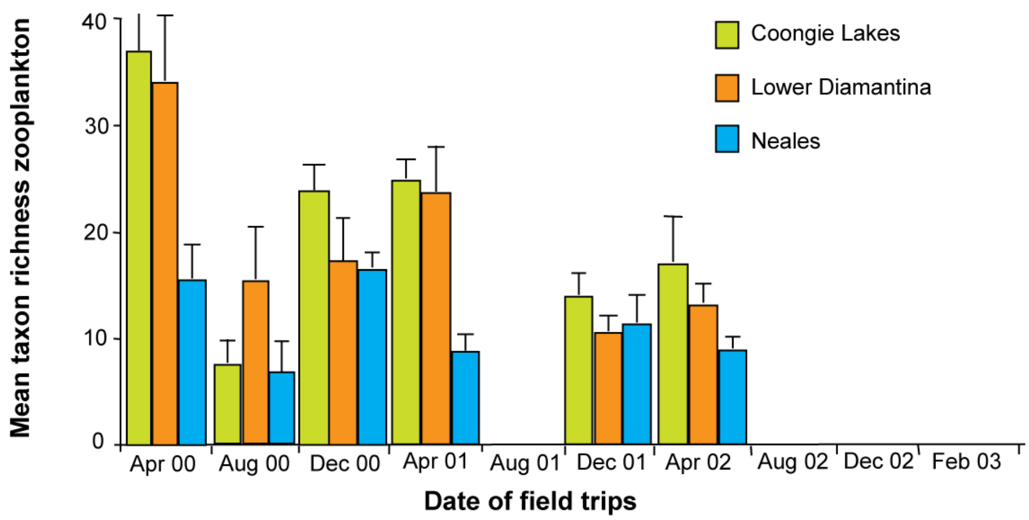


Figure 38: Mean taxon richness of zooplankton collected during the ARIDFLO project 2000 – 2003 (from Costelloe and Shiel 2004). Coongie Lakes represents data collected from the Ramsar site.

Macroinvertebrates

A number of investigations into the macroinvertebrate fauna of various wetlands and waterholes in the Coongie Lakes Ramsar site have been undertaken (Puckridge 2000; Sheldon et al. 2002; Hudson 2004). Direct comparisons between datasets are difficult as different sampling techniques and taxonomic resolutions provide variable results. As with most of the investigations undertaken within the site, the emphasis has been on the Coongie Lakes along the northwest branch of the Cooper. Most aquatic macroinvertebrates are ubiquitous throughout the arid zone of Australia (Timms 2001) and as with the algae and zooplankton there is low endemism at the bioregion scale. Hydrology, especially duration and frequency of inundation, as well as water source (river versus rainfall) influence the invertebrate fauna present. Temporal and spatial variation in community structure also reflects different successional stages, with the fauna of the rain fed wetlands being different to that of the floodplain lakes and main channel habitats. Abundance, in general, fluctuates in response to the variable hydrology, turbidity and salinity (Timms 2001). Sheldon et al. (2002) investigated different waterbodies finding interconnecting channels supported the greatest taxon richness and abundances of macroinvertebrates.

Of the macroinvertebrates, hemipterans and coleoptera are common in open water, with caddisflies, dragon and damselflies found more frequently in the more structurally complex littoral zone of the deeper lakes. Chironomids, midges, are common in the benthos of newly inundated areas. Molluscs are reasonably well represented in the system, many showing habitat preferences (Timms 2001). Large crustaceans recorded from the site include the shrimp, *Macrobrachium australiense*, the common yabbie *Cherax destructor* and the crab *Holthuisana transversa* all of which rely on the permanent waterholes as refuges (Timms 2001). Permanent waterholes are important strongholds for shrimp and freshwater mussels.

With regards to regional diversity, Sheldon et al. (2002) report a similar diversity at Coongie Lakes and the lower Cooper compared to other dryland rivers in Australia, with 70 taxa being recorded in the single sampling event in 1991. These data along with those collected by Puckridge (2000) represent the best dataset nearest to the time of listing for the Ramsar site. During the ARIDFLO project, macroinvertebrate sampling indicated that sites sampled in the Coongie Lakes Ramsar site were the second most species rich in terms of average number of taxa caught per waterbody (Hudson 2004). Overall the Coongie Lakes had 83 taxa, which equates to 61 percent of the total taxa encountered in the project across all systems sampled.

Mean sample taxon richness at the reach scale exhibited significant variation among trips and among reaches, with a decline in numbers over the length of the project (Figure 39) (Hudson 2004). Species richness was greatest associated with structurally complex habitats, and those that were inundated more frequently such as lignum, *Polygonum* and *Cyperus* (Hudson 2004) (Figure 40).

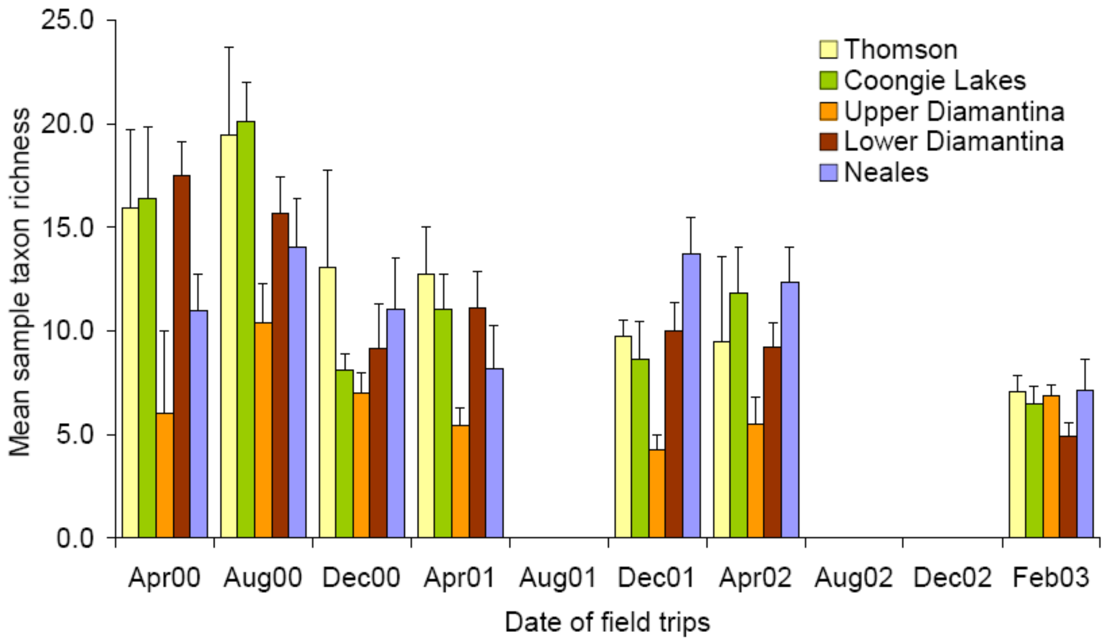


Figure 39: Mean sample taxon richness of macroinvertebrates by reach collected during the ARIDFLO project 2000 – 2003 (from Hudson 2004). Coongie Lakes represents data collected from the Ramsar site.

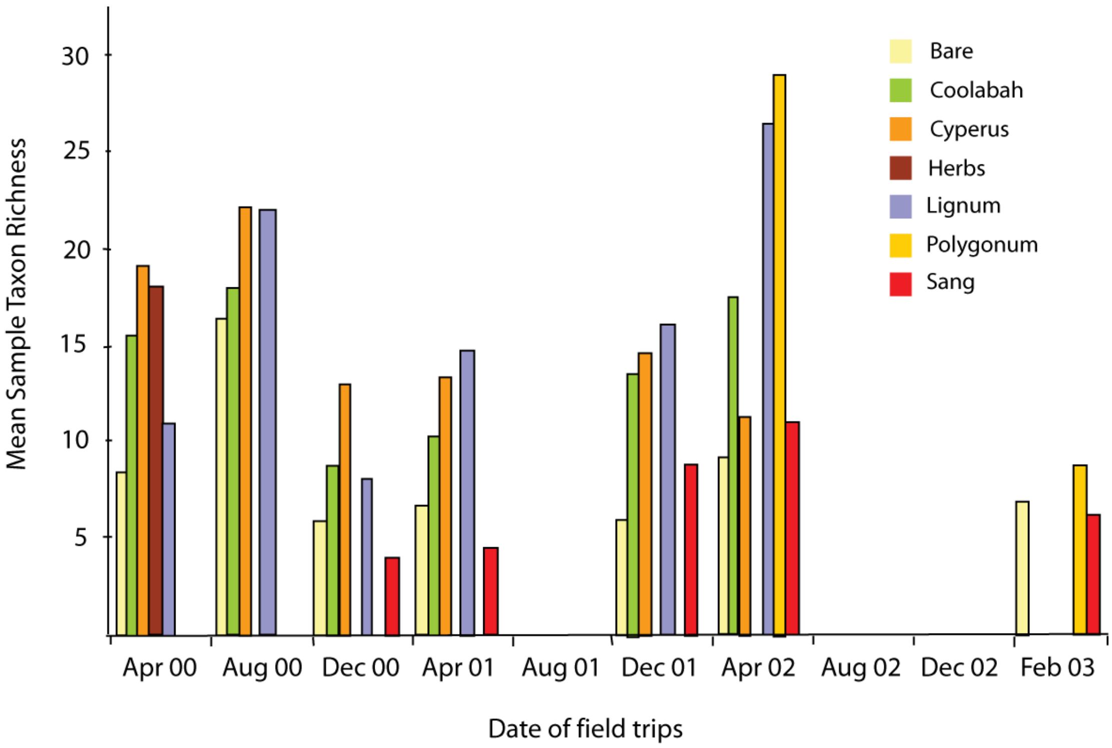


Figure 40: Mean sample taxon richness of macroinvertebrates associated with different structural habitats collected during the ARIDFLO project 2000 – 2003 at Coongie Lakes (from Hudson 2004).

Ecologically, invertebrates include primary and secondary consumers and are key elements in the food chain as a major food resource for fish and many species of waterbirds.

Rain fed wetland invertebrate fauna

There are no data on the invertebrate fauna of the rain red wetlands in the site. The greatest concentration of these wetlands occurs in the northern lakes section of the site, but they also occur on the eastern side of the site. These wetlands will have a distinctive fauna characterised by species adapted to a drying cycle. Claypan wetlands in the site will be dominated by crustaceans such as brine and fairy shrimp, species which have eggs resistant to desiccation. Opportunistic insects, those that can disperse, as well as those which are adapted to drying periods will also be present (Wiggins et al. 1980; Williams 1985; Hancock and Timms 2002). These systems can be incredibly productive and are believed to provide important resources for certain waterbirds at different temporal scales to the floodplain wetlands along the Cooper Creek. As claypans are typically highly turbid, only touch-feeding waterbirds, such as pink-eared duck, can take full advantage of the invertebrate biomass supported by these wetlands. Salinity, which will be highly variable, will influence the community structure of the invertebrate fauna of the rain fed wetlands. Turbidity may or may not affect community structure (Hancock and Timms 2002). The lack of data on the ecology of the rain fed wetlands is a major knowledge gap.

3.3 Critical components and processes

The attributes and characteristics of each of the critical components and processes of Coongie Lakes Ramsar site are described below. Where possible, quantitative information is used in the description of each component or process; however, as with many ecological character descriptions, there are significant knowledge gaps relating to the key characteristics of this site (see Section 8). A summary of the critical components and processes within the Coongie Lakes Ramsar site is provided in Table 9.

Table 9: Summary of critical components and processes within the Coongie Lakes Ramsar site.

Component / process	Description
Geomorphic setting	• Innamincka dome constrains Cooper Creek from the Queensland/ South Australia border to Innamincka. It is in this reach that Cullyamurra waterhole, the deepest waterhole in the system is found. • The distinctive morphology of the lower Cooper wetlands largely reflects the interplay of the regional gradient towards Lake Eyre and drainage capture by the linear dunes of the Strzelecki Desert. • Permanent and semi-permanent waterholes predominantly occur from the border to the Coongie Lakes, with some semi permanent waterholes also occurring on the main branch of the Cooper. • The lakes of the Ramsar site fill sequentially and are highly connected via a complex series of distributary channels.
Hydrology	• Highly variable hydrological regime – one of the most variable in the world – linked to ENSO events. • Floodwaters predominantly originate in the headwaters of the catchment, but also receive input from local rainfall. • Peak flows typically occur in late summer into autumn. • Annual inflows into the Coongie Lake wetlands, the majority of which terminate within these wetlands. • Large floods which inundate Coongie Lakes, northern overflow and wetlands downstream, ultimately feeding into Lake Eyre occur on average one in seven to eight years. • Duration of dry periods can extend from a couple of months to years depending on the position of the wetland within the site. • Persistent waterholes do not occur downstream of the Coongie Lakes area on the northern overflow but do occur on the main branch.
Waterholes	• The majority of permanent waterholes occur mainly between the Queensland/ South Australia border downstream to Coongie Lakes along the northwest branch. • Several semi permanent waterholes also occur in the upper reaches of the main branch after it splits from the northwest branch. • There are a few semi permanent waterholes which are sustained via groundwater (saline) in the lower reaches of the site. These are fresh during and immediately after flooding but then become saline (F. Badman pers. comm.). • Cullyamurra is the largest and deepest of the waterholes in the site.
Primary productivity	• Significant knowledge gap; however as the wetland system has a boom and bust ecology this is supported by high primary productivity.
Vegetation	• 795 species, 135 of which are wetland dependent. • Vegetation associations reflect position in landscape and frequency of inundation.
Fish	• At least 12 native species and 2 exotics. • Natives are favoured over exotics due to natural flooding regime. • Diversity decreased as you progress downstream within the site.
Waterbirds	• 83 waterbird species recorded at the site. • 54 waterbirds breed at the site. • Species richness is variable between survey reflecting different flood responses as well as survey techniques. • Large numbers regularly supported, site support greater than 20 000 on a regular basis.

3.3.1 Geomorphological setting

The Cooper Creek catchment has low relief and stream gradients of 0.1– 0.2 metres per kilometre. The lower Cooper is located on a complex sequence of nested, gently warped basins and associated near-horizontal sedimentary sequences that date from the Early Palaeozoic to the Cenozoic Lake Eyre (geological) Basin (Nanson et al. 2008; Cohen et al. 2010). As the Cooper Creek enters South Australia, and the Ramsar site, it passes along the southern side of the Innamincka Dome which is located near Nappa Merrie. In this reach, the river is constrained by bed rock with floods being restricted, in places, from a few hundred metres to one kilometre (Nanson et al. 2008; Cohen et al. 2010). Once the Cooper passes the Innamincka Dome it emerges onto the Cooper Creek Fan immediately downstream of Innamincka, into the Strzelecki Desert where linear dunes interrupt the path of the Cooper (Cohen et al. 2010).

The Cooper Creek Fan is approximately 30 by 20 kilometres, alluvial, and with a maximum westward regional slope of 0.00027 metres per metre, which is almost twice the slope of the adjacent alluvial plains (Cohen et al. 2010). East–west trending source-bordering dunes located on the northern margins of abandoned watercourses and contemporary floodways are a characteristic feature of the fan. Flow moves along distributary channels including the Cooper Creek channel which meanders westward with the northwest branch draining to Coongie Lakes. The second major distributary channel is Strzelecki Creek which flows southward on the western margin of the fan and ultimately feeds into Lake Blanche and Lake Frome. Strzelecki Creek only flows during high flows (gauge height of nine metres at Cullamurra gauge), which is approximately a one in ten year event (Cohen et al. 2010). Floodplain morphology within the fan is extremely flat with low relief gilgai occurring in areas with shrink-swell clays. The dunes, which are mainly spaced 400 to 600 metres apart, are linear dunes with some isolated irregular shaped dunes. The linear dunes reach 15 to 20 metres above the floodplain and are sparely vegetated (Cohen et al. 2010).

The northwest branch of the Cooper Creek is also influenced by dunes, with the dunes in this part of the Ramsar site trending north-northwest. Costelloe (2004) suggests the lakes along the northwest branch may have formed in the dune swales as they widened over time. As discussed in Section 3.3.2 the small to medium floods terminate in the Coongie Lakes with flows passing into the northern overflow only during large flood events (Costelloe 2004).

Distributary floodplain channels connect the lakes allowing them to fill sequentially. The channels are typically narrow, being less than 100 metres wide in the deeper sections, but in floods can expand considerably (Costelloe 2004). The lakes are described as having similar shallow saucer shaped forms and range from 2 to 2.5 metres in depth (Costelloe 2004).

As the wetlands within the Ramsar site are sub-terminal with the occasional overflow into Lake Eyre during very large flood events, the wetlands remain predominantly fresh, as salts are flushed from the system on a regular basis (Timms 2001). Thus the geomorphic setting has a significant influence on water quality within the wetlands.

Land systems

The landscape of the Ramsar site is of low relief with the underlying geology reflecting the major forces that shaped the land, with a dominance of alluvial / fluvial sediments on the floodplain systems and sediments of aeolian origins surrounding the floodplain (Figure 41). Land systems mapping incorporates aspects of soils, geology, geomorphology and vegetation. The land systems mapping for the Coongie Lakes Ramsar site indicates that the site is dominated by floodplain and dune fields (Figure 42) (Table 10).

Table 10: Land systems within the existing and proposed Coongie Lakes Ramsar boundaries (data supplied by DENR South Australia).

Land system description	Area (hectares)
Channels, lakes, swamps and crabhole flats of Cooper Creek floodplain. Main channels with coolibah, river red gum (upstream channels only), beantree, river cooba, river emubush, Broughton willow and lignum; swamps with Queensland bluebush, canegrass, old man saltbush, samphire and lignum; lakes lined with coolibah, river couch and rushes; crabhole flats with copperburrs and herbs; pale dunes and sandplains with whitewood/ sandhill wattle and sandhill canegrass; red longitudinal dunes with sandhill wattle and sandhill canegrass; interdune flats with variable soils and vegetation.	1 088 200
Dune Fields of Strzelecki Desert (generally non-wetland landsystem) in the south east of the district. Red dunes with whitewood, mulga, sandhill wattle, sandhill canegrass and lobed spinifex; sandy interdune flats with colony wattle, straggly corkbark over copperburrs and annual grasses; clay swales with Mitchell grass, neverfail and plate grass.	227 011
Dune Fields, swamps and lakes of Pandie Pandie, western Cordillo Downs and northern Innamincka. Long red dunes with lobed spinifex, sandhill canegrass and scattered sandhill wattle and narrowleaf hopbush; variable interdune flats with blackbush, starbush and neverfail on clay flats and lobed spinifex on sandy flats; swamps with canegrass and lignum; lakes fringed with samphire and copperburrs on lake beds.	147 800
Gently undulating gibber plains with Mitchell grass, katoora and bladder saltbush. Run on depressions and swamps with Queensland bluebush, cottonbush, canegrass and neverfail; scattered long red sand dunes with sandhill canegrass and desert cynanchum; drainage lines with coolibah, plum bush, river emubush and river cooba.	95 570
Gibber tableland and mesas of eastern Innamincka (generally non-wetland landsystem). Tableland and low hills with Mitchell grass, neverfail and copperburrs; mesas with emubushes, gidgee and mulga over bladder saltbush; drainage lines with red mulga, gidgee and river red gum; alluvial plains with Mitchell grass, copperburrs and forbs.	97 470
Jumbled dunes, sandplains, channels and swampy flats abutting tableland country on Cordillo Downs and surrounding Innamincka (Marqualpie Land System). Red dunes with sandhill wattle, sandhill spider flower and rattlepods over dense spinifex; a variety of flats with lignum, canegrass, Queensland bluebush, neverfail, Mitchell grass and coolibah on the channels and deeper depressions; sandplains with mulga;dead finish and bloodwood over woolybutt, spinifex and annual grasses.	13 370
Irreguarly flooded overflow from Cooper Creek to the north and west. Has atypical longitudinal dunes and swales and broad floodout areas of clayey soils. Dunes have Accacia ligulata tall shrubland and zygochloa paradoxa hummock grasslands. On the flats, diverse clenopod species of annual and perennial types.	503 205
Saltlake county often with pale dunes on lake margines. Large margins of bladder saltbush and samphire; Cobbler Desert with nitrebush, samphire, native myrtle and canegrass.	4 011
Undulating gibber tableland country. Tableland with gilgais supporting barley and curly Mitchell grass and cottonbush. Samphire, bladder saltbush. Mesas with feathered mulga and low blue-bush, large creeks with river red gum.	2 110

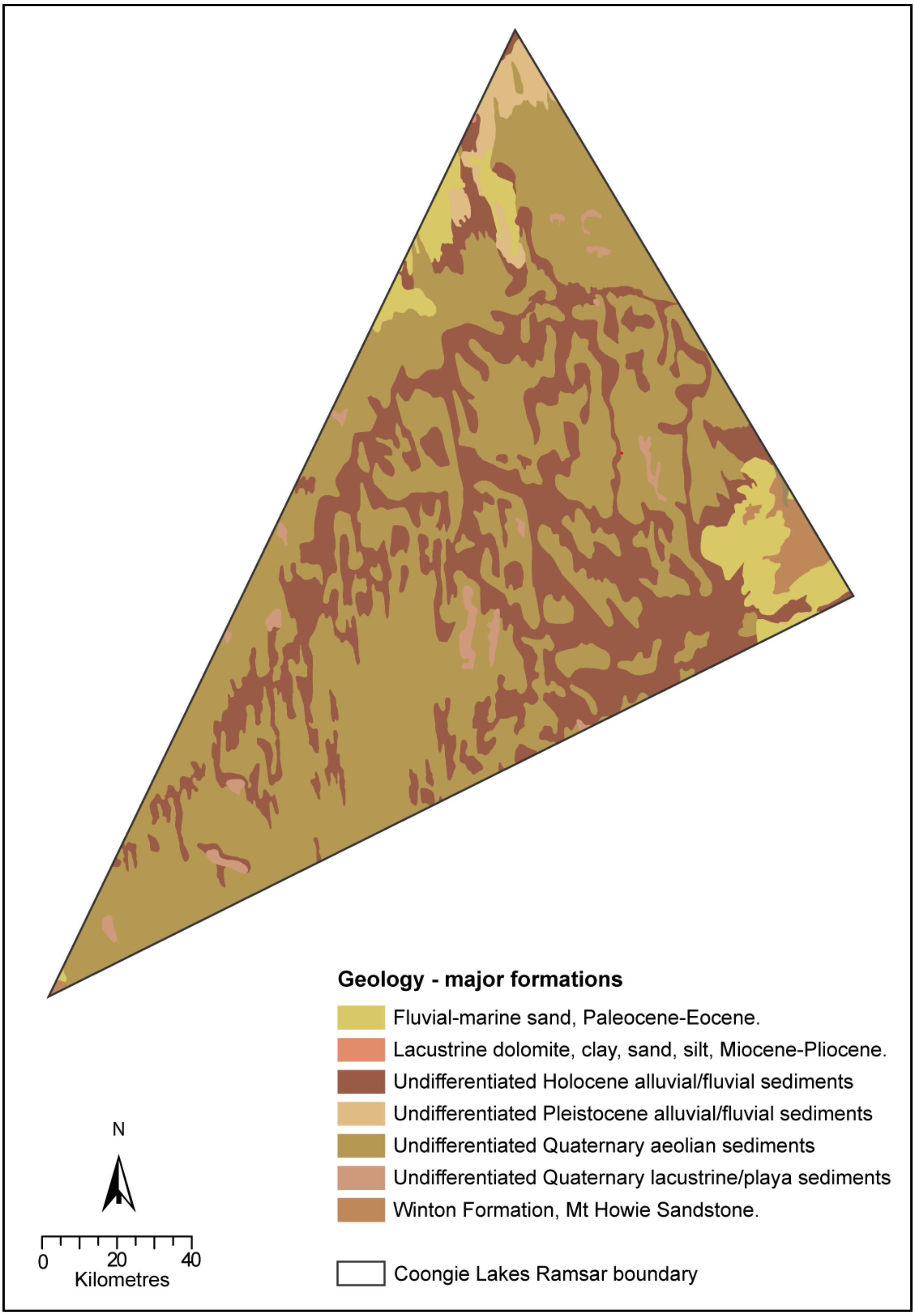


Figure 41: General geology in the Coongie Lakes Ramsar site (data supplied by DENR, South Australia).

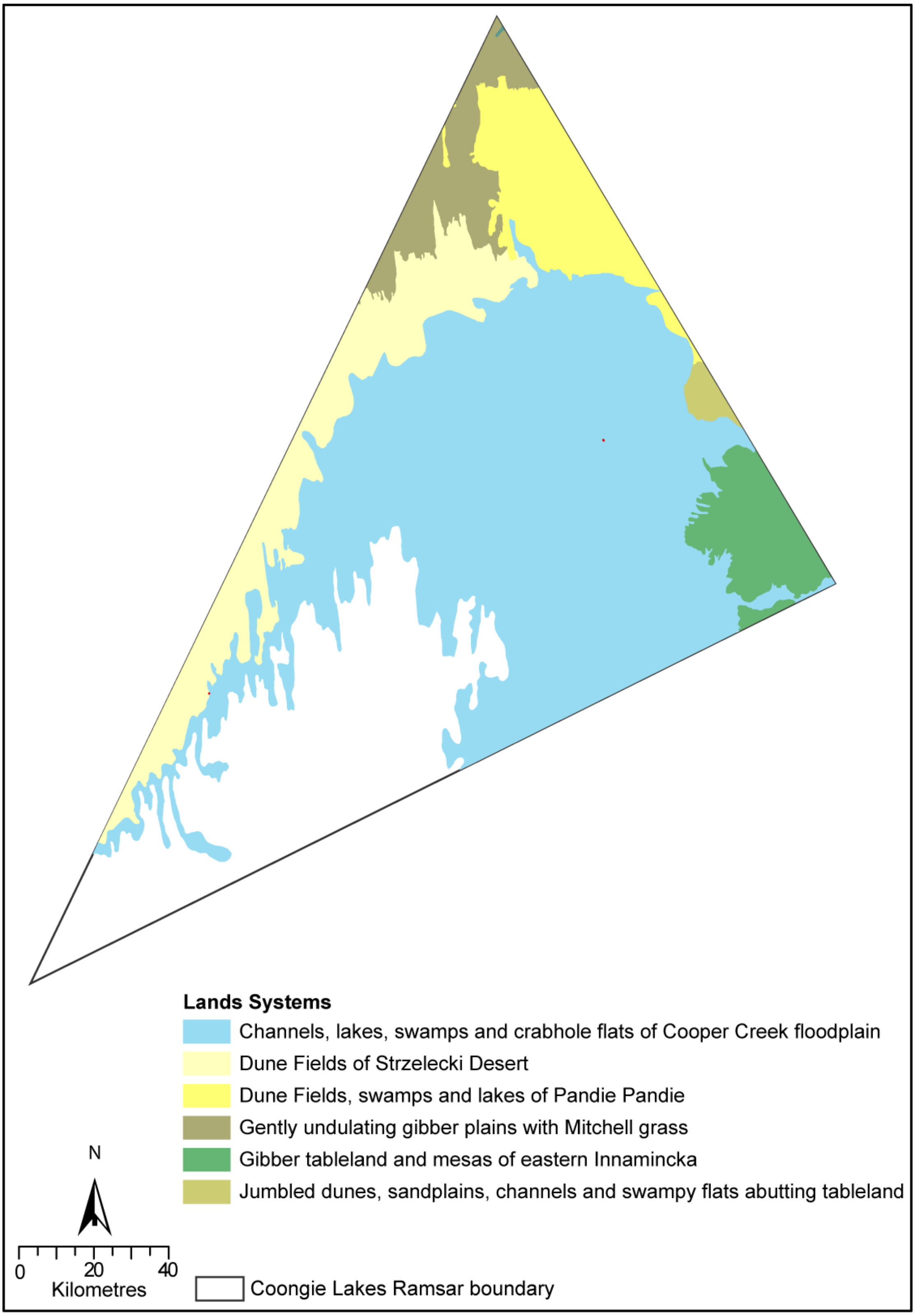


Figure 42: Land systems (data supplied DENR, South Australia). White area is unmapped.

3.3.2 Hydrology

The arid landscape of the Lake Eyre Basin Drainage Division is characterised by a large number of temporary wetland systems that are inundated from very short periods through to months and years (Roshier et al. 2001; Knighton and Nanson 1994). Between large flood events, surface water is limited across the landscape and permanent waterholes are critical as refuges for aquatic species (Sheldon et al. 2002; Carini et al. 2006).

The Cooper Creek has its headwaters in monsoonal Queensland and ultimately contributes approximately 16 percent of flows into Lake Eyre in South Australia (Nanson et al. 1998). However due to the extreme losses in the lower Cooper water only gets through to Lake Eyre every 12.5 years (Kingsford et al. 1999). The variability of rivers in the Lake Eyre Basin is double that of other arid zone rivers globally (McMahon et al. 2008). Specifically, the Cooper Creek is more variable than 53 other arid zone rivers in the world, as well as being more variable than the Diamantina and Paroo (Puckridge et al. 1998; Puckridge 1999 cited in Timms 2001). The variability characteristic of the Cooper Creek is related to El Nino Southern Oscillation (ENSO) events as well as having much of the northern part of the Lake Eyre Basin bordering the southern margin of the tropical zone (Allan 1988; Timms 2001). Whilst the main source of inflows to the Ramsar site is rainfall in the upper catchment, local rainfall events also contribute inflows, and not necessarily only in the monsoon season.

The lower Cooper Creek on-channel wetlands and lakes are distinctive in the Lake Eyre Basin as they often, but not always, fill sequentially due to the high degree of longitudinal and lateral connectivity via floodplain channels (see Section 3.3.1). Floodplain wetlands fill relative to their relative elevation in the landscape which contributes to the mosaic effect of habitat heterogeneity. Analysis of satellite imagery show some predictable and some unpredictable patterns, but overall there is a large amount of variability in the inundation patterns of floods of similar magnitudes (P. Wainwright, pers. comm.). Frequency of inundation is shown in Figure 43, which is reliant on both localised and non-localised flooding events (Wainwright et al. 2006). From this mapping it is clear that the wetlands within the northwest branch and Coongie Lakes and the upper section of the main branch landscape units are frequently inundated with the larger wetland basins in the northern overflow and lower Cooper Creek units receiving water less frequently. Across the whole site the majority of the wetlands only receive water every one to two years in five.

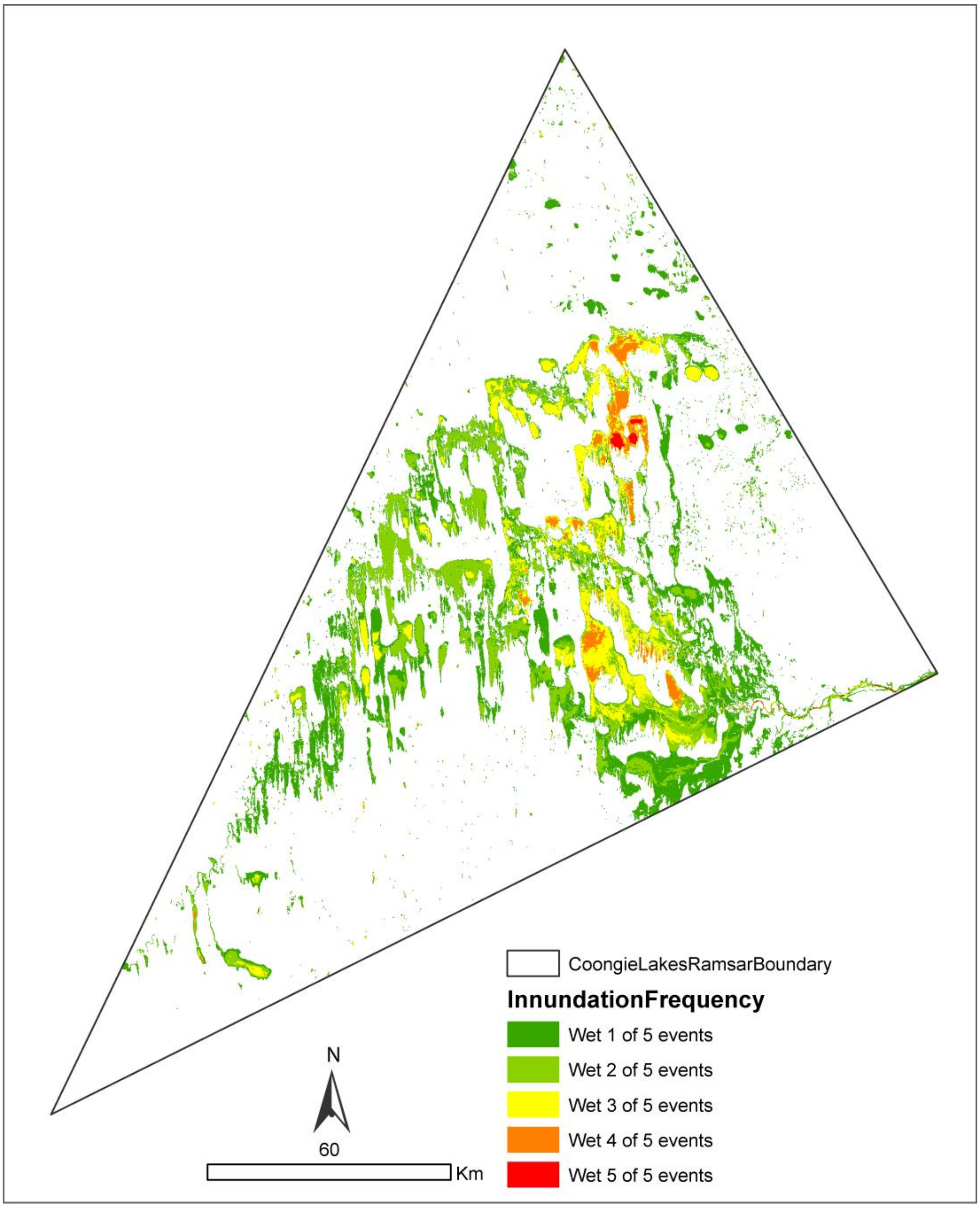


Figure 43: Frequency of inundation (data supplied by DENR South Australia).

The system has been subject to some very large events in 1974, 1990 and again in 2010 (see Figure 44) and based on discharge records at Cullyamurra waterhole, the only gauged site on the lower Cooper, the system receives flows in all years of the Cullamurra record (1973-2010). Groundwater interactions are limited with surface water inflows being the major water source of these wetlands (Costelloe et al. 2009; Puckridge et al. 2010).

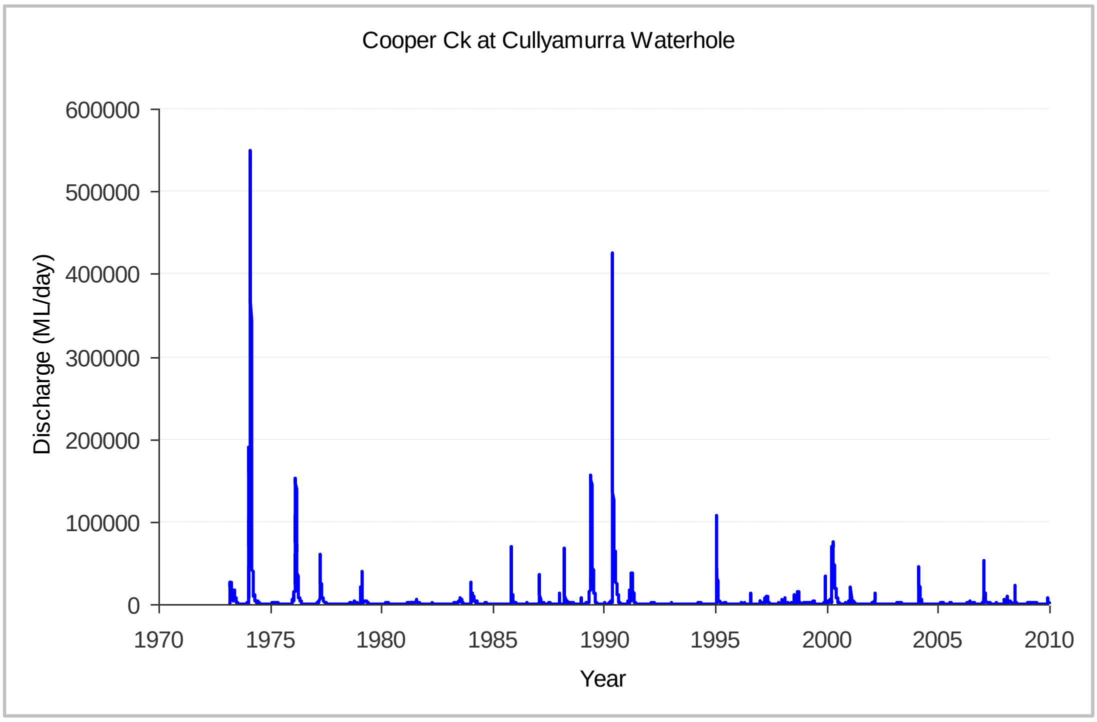


Figure 44: Stream discharge Cooper Creek at Cullyamurra waterhole for the period February 1973 to May 2010 (The Department of Water, South Australia 2010, accessed September 2010, http://e-nrims.dwlbc.sa.gov.au/SiteInfo/Default.aspx?site=A0030501.

Flow velocities in the Cooper Creek are very low and flow transmission tends to be long, occurring over several months. Peak discharge is typically in late summer (Figure 45) and transmission losses are generally high (Kotwicki 1986; Knighton and Nanson 1994; Puckridge 2000; Costelloe 2008) but can vary depending on the level of activation of secondary channels and the floodplain (Knighton and Nanson 1994). Data from the Cullamurra gauging station for the period 1973-2008 indicates peak in mean daily flows late summer to autumn (Costelloe 2008) (Figure 45). Costelloe (2008) reported that in the period 2000-2008 the peak flows were from April to August depending on the downstream position of the lake in question, with the winter dominance of flows in the Coongie Lakes reflecting their relative position and transmission times from Cullyamurra waterhole.

Puckridge et al. (2010) report that waterholes (see Section 3.3.3) from Cullyamurra to Coongie Lake received annual inflows over the period 1973 to 2008, a more frequent pattern of inundation than waterholes downstream of Coongie Lake and the lower sections of the Cooper Creek main branch. Most lakes sampled by Puckridge et al. (2010) had high to moderate flooding frequencies, the exception being Lake Marroopootanie, which only fills rarely (Puckridge et al. 2010) (Table 1). For wetlands further along the Cooper Creek which rely on the northern overflow from Coongie Lakes and the main branch of the Cooper for inflows, frequency of inundation would be less, however there is little to no information on the wetting and drying cycles of most of the wetlands downstream of the Coongie Lakes wetlands.

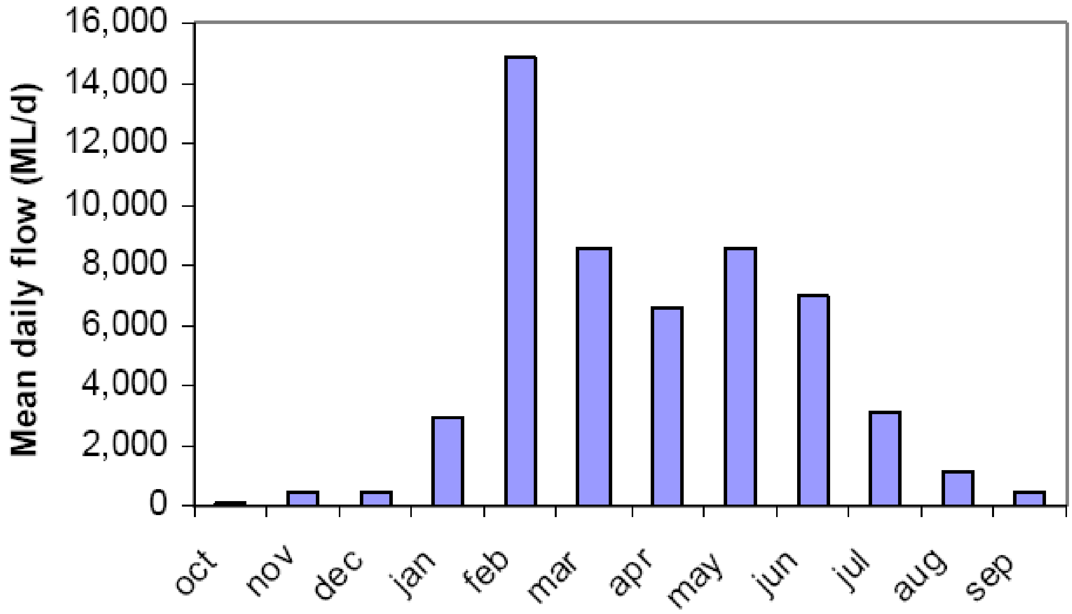


Figure 45: Mean daily flow for each month at Cullamurra gauging station (Cullyamurra waterhole) showing a broad seasonal spread between February to June. February peak is influenced by the large 1974 flood (from Costelloe 2008).

Table 11: Frequency of inundation and drying in sampled water bodies for the period 1973–2008 (W = waterhole channel site, L = Lake, I = delta) (from Puckridge et al. 2010).

Waterbody	Type	Frequency of inundation* %	Frequency of drying* %	Retention time (months)	Longest dry period (months)
Cullyamurra	W	100	0	Permanent	-
Queerbidie	W	100	1	24	-
Tirrawarra	W	100	1	24 - 36	-
Tirrawarra Swamp	I	100	2	8-12	<6
Northwest Branch	W	100	2	18 – 24	-
Coongie	L	100	4	12	< 2
Browne Creek	W	93	10	12 - 14	<17
Toontoowaranie	L	94	11	12 - 14	17
Ellar Creek	W	82	23	8 - 12	<18
Goyder	L	83	24	8 - 12	18
Apanburra Channel	W	57	53	12 - 18	<49
Apanburra	L	56	54	12 - 18	49
Marroopootanie	L	6	95	12 - 14	216

* Frequency expressed as percentages, i.e. how many years in a 100-year record would lakes receive floodwaters or dry between flood seasons.

Costelloe (2008) assigned three flow classes for the lower Cooper Creek as follows:

1. Large floods – floods sourced from the upper Cooper catchment that inundate the entire group of lakes in the Coongie Lakes and flow further downstream into the Northern Overflow. These floods also breach sand bars at the confluence of the Cooper Creek and Strzelecki Creek and flows are sent south along the latter. Larger volumes also flow along the main branch of the Cooper.
2. Terminal floods – Annual flows sourced from the upper catchment that terminates within the Coongie Lakes.
3. Local flows – flows derived mostly from convective thunderstorms that initiate flow along the Cooper main channel and are largely sourced from runoff around Innamincka. These flows generally only result in inflow to the most upstream lakes.

These flow classes are mostly specific to the Coongie Lakes and northern overflow. All three classes of floods can supply water into the main branch. Large floods will inundate most wetlands in the main branch and flow past Lake Hope and may reach Lake Eyre. Terminal floods will fill varying amounts of wetlands in the main branch. At the larger end of the scale, the 2004 flood went as far as putting some water into Lake Hope, while the smaller terminal flows may not get past Embarka Swamp. Local flows are most likely to only get as far as Embarka Swamp but some of the bigger ones might flow further downstream (J. Costelloe pers. comm.).

In the period 2000-2008 only the 2000 flood was considered large, the remaining events were all considered terminal floods (Table 12), with inflows terminating in the Coongie Lakes wetlands (Costelloe 2008) and into the main branch. All of the wetlands underwent a dry period one or more times over the 2002-2007 period. Localised rainfall in 2001, 2002, and 2007 in the area of Innamincka saw increased amplitude of peaks in flow compared to upstream flow pulses (Costelloe 2008). Flows take several months to move through the system, due mainly to the large capacity of the lakes along the northwest branch, for example in terminal floods water takes three to four weeks to reach Coongie Lake from Cullyamurra waterhole (Costelloe 2008).

Table 32: Flow events in the lower Cooper Creek 2000 – 2008 (from Costelloe 2008) (nr = no record).

Flow event	Type	Peak Cullyamurra Waterhole	Peak Northwest Branch	Peak Browne Creek	Peak Ellar Creek
2000	Large	08/04/00	nr	nr	18/08/00
2001	Terminal	18/03/01	13/04/02	14/04/01	05/05/01
2002	Terminal	25/02/02	20/03/02	nr	-
2003	Terminal	30/04/03	nr	nr	-
2004	Terminal	17/02/04	nr	02/04/04	19/06/04
2005	Terminal	24/02/05	nr	nr	-
2006	Terminal	11/06/06	nr	-	-
2007	Terminal	13/02/07	nr	nr	04/07/07

Duration of flow and commence to fill data for the Coongie Lakes wetlands has not been established due to the dampening effects of the lake volumes and the fact that the wetlands can continue to be hydraulically connected after flow has ceased (Costelloe 2008). Connectivity between wetlands in the Coongie Lakes is variable, with Costelloe (2008) reporting Coongie, Toontoowaranie and Goyder being connected over a 24 month period in 2000 to 2002, a nine month period in 2004, and at least a 15 month period in 2007 to 2008. This high degree of hydrological connectivity is unique to the lower Cooper system in the Lake Eyre Basin (see Section 4.3.6).

Puckridge et al. (2010) reports the Coongie Lakes wetlands have dry periods ranging from less than two months for Coongie Lake through to 49 months for Apanburra and 216 (18 years) for Lake Marroopootanie (Table 12 above). Costelloe (2008) reports a longer period of dry for lakes Toontoowaranie, Goyder and Apanburra of 21 months prior to receiving inflows in March 2004.

Puckridge (2000) showed that at the waterbody scale connectivity, permanence, inundation duration and flow durations were all important elements of the hydrological regime with regards to determining biotic responses. Flow history was also shown to play a major structuring role in aquatic communities, and that rare large flow events, can have a critical role in arid zone river and floodplain ecology (Puckridge 2000). However it is important to recognise that overbank flows are not the only driver of floodplain ecology in arid river systems, that duration of no-flow is also critical. During periods of no flow waterholes provide critical refugia and ensure populations of aquatic species are able to recolonise the floodplains during flood events.

3.3.3 Waterholes

Waterholes are self-maintaining scour features, or enlarged segments of a watercourse, where stream flow has become constricted (Silcock 2009). Waterholes are wider and deeper than the main channel, being typically two to five times wider and two to three times deeper. Most are greater than three metres deep and retain water after flow has ceased. Cullyamurra is the deepest in the Ramsar site, and in the Lake Eyre Basin, being more than 18 metres deep (Silcock 2009). Formation of waterholes is caused by a number of factors, including the sediment being subject to scour in areas of flow convergence or areas where flow turbulence is initiated, and as in the case of Cullyamurra waterhole at the Innamincka choke, being at the convergence of several anastomising channels (Silcock 2009).

Due to the low gradients of the arid zone rivers, once scouring begins the waterhole becomes self-perpetuating, concentrating flow further leading to enlargement (width, length and depth) of the waterhole (Silcock 2009). These geomorphic processes are dynamic and it is quite possible that new flow paths and waterholes could form during very large floods. The underlying geology of the waterholes is one of a surface layer of mud ranging in depths of two to nine metres underlain by a sand sheet. During floods the scouring can be significant, breaching the mud layer and resulting in the transport of large amounts of sand downstream of the waterhole. In some cases this movement of sediment can lead to a bifurcation of the waterhole (Silcock 2009).

Permanent waterholes are defined by Silcock (2009) as those which have not dried since European settlement. Semi-permanent waterholes vary in their frequency and duration of inundation, but are those which have water for greater than 70 percent of the time (Table 13). Within the site permanent and semipermanent waterholes are mainly found from Cullyamurra (just upstream of Innamincka) downstream along the northwest branch to Coongie Lake. They include Nappaoonie, Burke, Mulkonbar, Queerbidie, Minikie, Tlicha and Maapoo waterholes. Along the northwest branch are the almost permanent Scrubby Camp waterhole and the permanent Tirrawarra waterhole (Figure 46). Immediately south of Coongie Lakes is Kudriemitchie waterhole which is classed as an almost permanent waterhole (Silcock 2009).

There are no permanent waterholes for 340 kilometres along the Cooper downstream of Coongie Lake to Lake Eyre (Silcock 2009). Between Nappa Merrie and the junction of the northwest branch of the Cooper Creek there are 13 permanent and 28 semi-permanent waterholes.

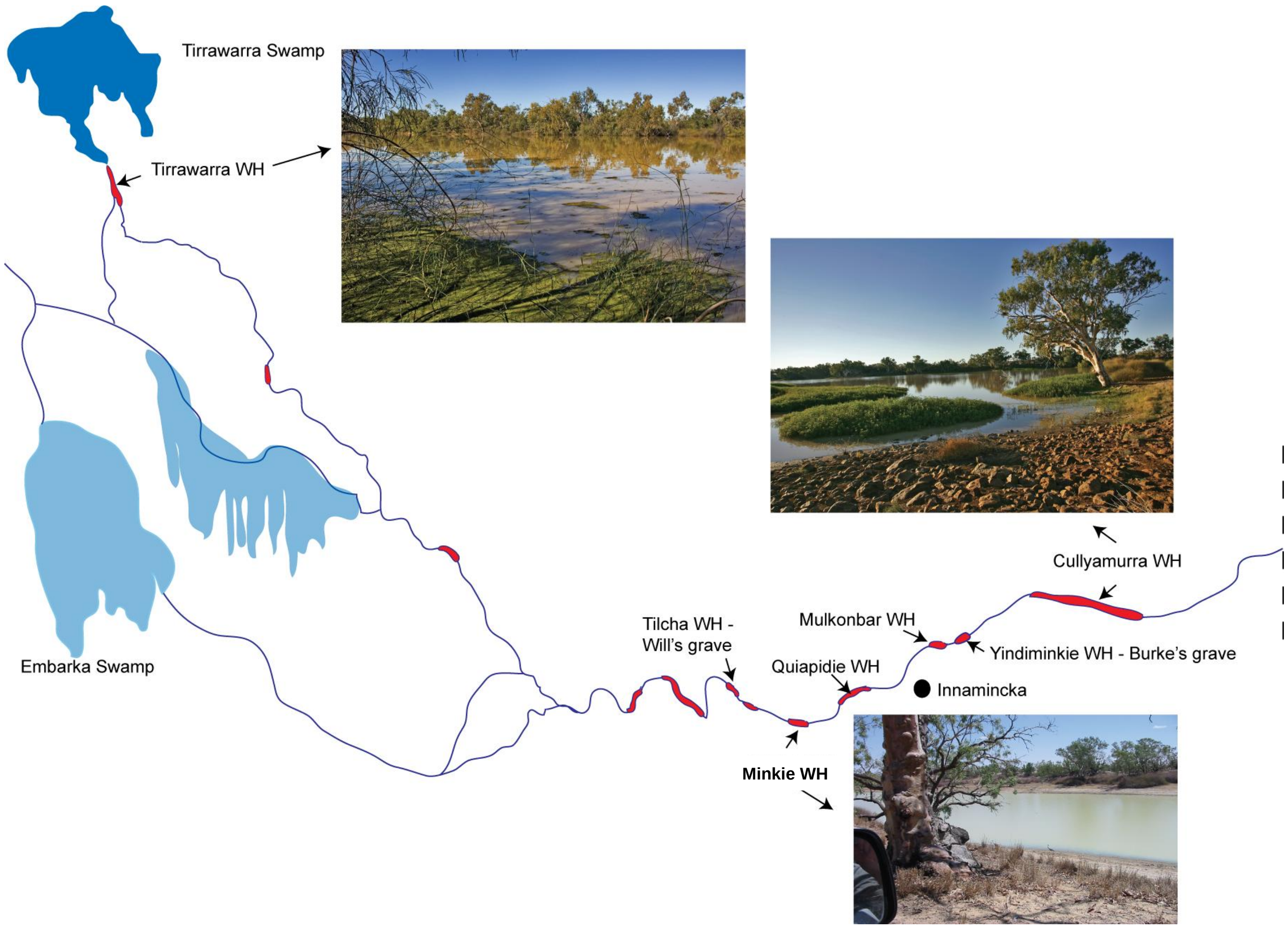


Figure 46: Approximate location of waterholes on the upper reach of the Cooper Creek and northwest branch. Waterholes not to scale.

Table 13: Waterhole and lake permanence categories (from Silcock 2009).

Category	Explanation	Amount of time with water (%)	Typical frequency of drying
Permanent (P)	Has not gone dry as far as could be ascertained through oral and written record; typically knowledge dates back to white settlement around 1870-1880 for most large permanent waterholes	100%	0/130-140
Almost permanent (AP)	Only dries out in the most severe droughts, in the order of once or twice in 50 years or less	97-99%	1-2/50 to 1/130
Infrequently dry (ID)	Goes dry during moderate droughts, once a decade or less	91-97%	1/10 to 3/50
Regularly dry (RD)	Dries out at least twice a decade on average	80-90%	2/10 to 3-4/10
Annually dry (AD)	Goes dry every year or nearly every year; will dry by end of the year in average seasons but last during good seasons	70-80%	1/1, 1/2 or 2/3

Permanence is directly influenced by the depth at cease to flow conditions. In the Lake Eyre Basin four metres has been identified as the minimum cease to flow depth for the waterhole to retain water for 24 months without any additional inflows. The loss from evapotranspiration from waterholes is expected to be between 1.5 to 2.5 metres per annum (Costelloe et al. 2007). Waterholes which are only two metres deep typically hold water between flood seasons, but will dry out in years without floods (Silcock 2009). The other main influences on permanency are location, with most permanent waterholes only occurring in main channels and hence receiving all flows in the reach, and loss processes (Silcock 2009). Some waterholes may receive groundwater discharge but there was not evidence of this in the Coongie Lakes area (J. Costelloe pers. comm.). However, this process hasn't been investigated along the Cooper Creek waterholes. The depth of Cullyamurra waterhole suggests that it quite likely extends below the water table but it is not known if the groundwater interaction is important. Limited data available during the 2000-2002 period suggest that it wasn't well connected (J. Costelloe pers. comm.).

Hydrological and geomorphic parameters of the waterholes studied in the ARIDFLO project are presented in Table 14.

Table 44: Hydrological and geomorphic parameters of waterholes in the Ramsar site (from Costelloe 2004).

Waterbody	Frequency of flooding	Frequency of drying	Cease-to-flow depth (m)	Bankfull depth (m)	Bankfull width (m)
Cullyamurra	Annual	Never	18.1	22.7	205
Queerbidie	Annual	Unknown	3.3	11.5	188
Minkie	Annual	Unknown	3.2	9.3	205
Tirrawarra	Annual	Unknown	3.6	5.9	105
Kudriemitchie	Annual	Unknown	3.0	4.6	82

Silcock (2009) reported that most waterholes show evidence of degradation due to increased total grazing pressure, impacts from recreational activities and invasive species. However the overall condition of waterholes within the Lake Eyre Basin and the Cooper in particular reflect the lower level of water resource development compared to other catchments throughout Australia (Silcock 2009).

3.3.4 Primary productivity

Primary productivity was not measured directly as part of the ARIDFLO project or any other investigations into the ecology of the site; however substantial work on productivity further upstream on Cooper Creek and other dryland rivers has been undertaken and reviewed (e.g. Bunn et al. 2003, 2006a, 2006b; Burford 2008; Leigh et al. 2010) providing an understanding of the role of primary productivity in boom and bust ecologies such as the Coongie Lakes Ramsar site.

In the bust phase, where water is contracted to permanent waterholes, primary productivity can be limited to a narrow band in the littoral zone where light penetrates. Despite this, productivity in this sort of environment can be among the highest in Australian rivers, remaining high in winter (Bunn et al. 2006a). Arid zone rivers are often highly turbid and have a very limited photic zones in which algae can flourish. In no flow conditions, waterholes have the majority of their productivity in the narrow photic zone, leaving behind ‘bath-tub rings’ of benthic algae when water levels drop (Bunn et al. 2003). Bunn et al. (2003) showed that this ring of algae production is a significant contributor to biomass carbon of a number of aquatic biota. In stable conditions algae are able to track the water level as it recedes due to evaporation, with some species postulated to be able to withstand short periods of desiccation (Bunn et al. 2006a). In flow pulse situations, where there is increased flow within the main channel, productivity can decrease as water levels rise and effectively raise the photic zone, or it can increase in response to increased nutrients (Bunn et al. 2006b). Bunn et al. (2006b) referred to flow pulses as the bits in between the boom and bust cycles.

Burford et al. (2008) investigated the role of floodplain sources to the productivity of a disconnected waterhole after flooding of adjacent floodplain (i.e. in the bust phase). The findings suggested that 50 percent of biomass of fish carbon in the waterhole was derived from the floodplain, and that the mass mortality of 80 percent of the fish population contributed to heterotrophic production in the waterhole (Burford et al. 2008).

During overbank floods, nutrients and sediment are carried onto the floodplain with the advancing floodwaters resulting in the booms in production (Bunn et al. 2006a; Leigh et al. 2010) which in turn supports primary and secondary consumers (Bunn et al. 2006b; Leigh et al. 2010). Bunn et al. (2006a) reported very large amounts of benthic algal production on the Cooper Creek floodplain, the equivalent of over 80 years of aquatic production in permanent waterholes during dry spells. Duration and magnitude of flooding are important in floodplain productivity.

Sequential flooding is believed to promote greater productivity (Puckridge et al. 2000; Leigh et al. 2010). In the Coongie Lakes, Puckridge et al. (2000) showed that a cluster of five floods over a four year period led to an increase in native fish populations. The pattern of repeated flooding increases ecological persistence of habitats and assemblages (Leigh et al. 2010), a pattern noted on several occasions within the Ramsar site (e.g. Puckridge et al. 2000; Costelloe et al. 2005).

3.3.5 Vegetation

Vegetation mapping provided by DENR South Australia shows a variety of wetland dependant vegetation communities within the Coongie Lakes Ramsar site (Figure 47). There are 11 wetland dependant vegetation communities within Coongie Lakes Ramsar site (Table 15).

Vegetation communities not found on the floodplain of the Cooper Creek, but which occur within the site include two chenopod shrublands (dominated by old man saltbush; *Attriplex nummalaria* and cotton bush; *Maireana aphylla*), a low shrubland (dominated by curious saltbush, *Dissocarpus paradoxus*) and cane grass grassland (*Eragrostis australasica*). Also the majority of the chenopod shrublands dominated by *Atriplex spongiosa* and *Atriplex vesicaria* are found in the non floodplain regions of the site.

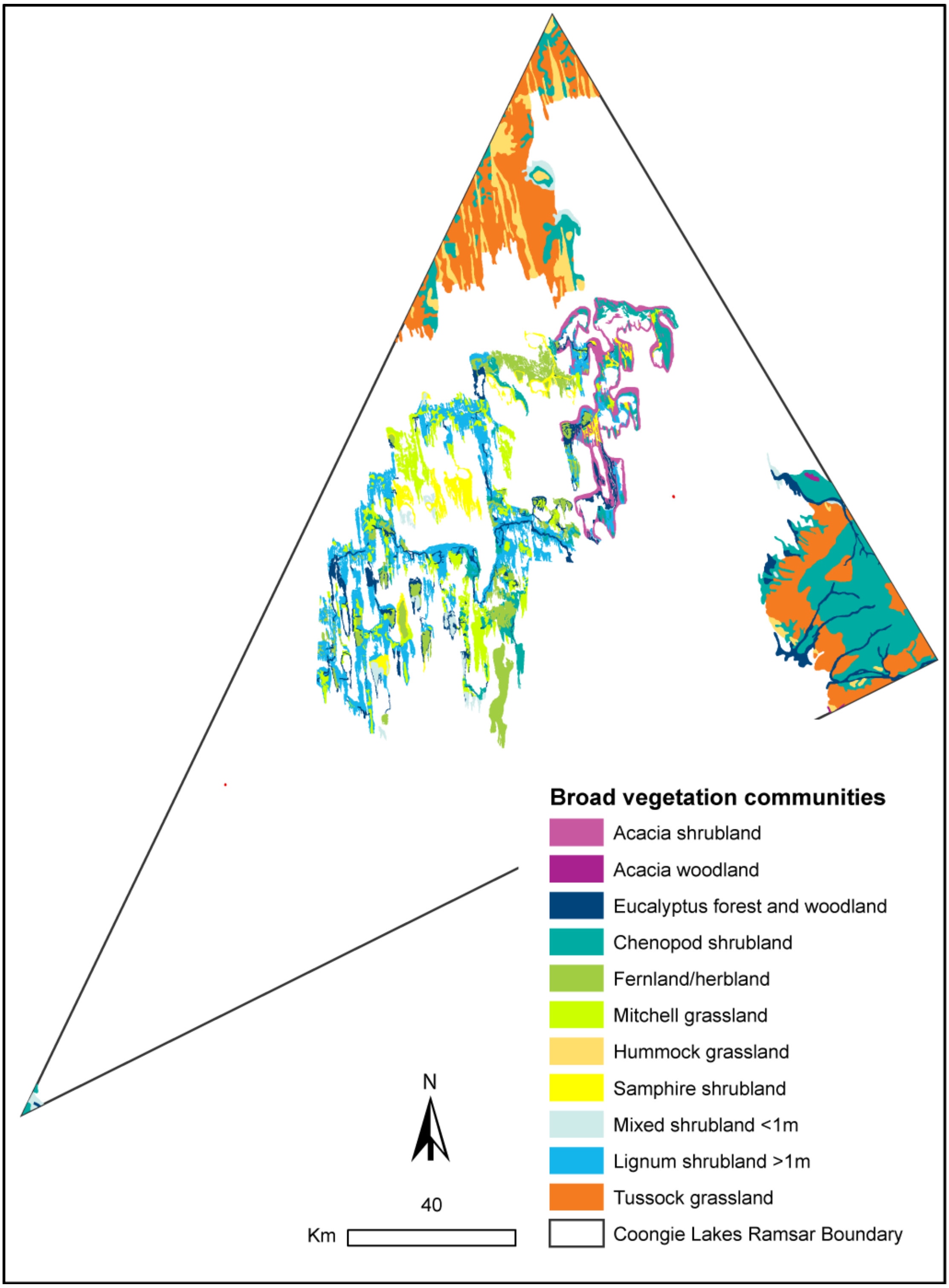


Figure 47: Broad vegetation communities within the Coongie Lakes Ramsar site (data supplied by DENR South Australia). White areas are unmapped.

There are 795 flora species that have been recorded within the site, of which approximately 135 could be considered wetland dependent[1].

Riparian associations fringing the river, channels and wetlands include coolibah (*Eucalyptus coolabah*), river red gum (*E. camaldulensis*), lignum (*Muehlenbeckia florulenta*), sedges (*Cyperus gymnocaulos*.) and the water primose (*Ludwigia peploides*) (Timms 2001). The narrow band of river red gum dominated riparian woodland along the northwest branch of the Cooper supports a very rich bird community notable in the district (Reid 1988b). Reid (1988b) suggests the importance of this habitat to woodland birds is threatened by increased pressure from recreational activities. Distribution of the riparian species reflects their water requirements, being influenced by water level and flow conditions. Coolibah occur on the higher elevations, often close to the bank tops, river red gum occurs lower down thus being inundated more frequently and lignum lower still (Costelloe et al. 2004a). *Cyperus gymnocaulos* and *Polygonum* occur below the lignum belt and the current water level. These two species have adaptations to deal with fluctuating water levels. *Cyperus* has rhizomes, capable of rapid growth, that traverse a wide band thus allowing plants to establish at different water levels and maintaining its position at the water's edge. *Polygonum* is also able to track water level rises and falls (Costelloe et al. 2004a).

The vegetation associations within the Ramsar site are intimately connected to movement of water across an arid landscape. There is a clear juxtaposition of wetland and desert vegetation which can be expressed abruptly over a very short distance, a matter of metres (Gillen and Reid 1988). The heterogeneity of the vegetation is extremely high both spatially and temporarily. Gillen and Reid (1988) identified five vegetation complexes. The Riverine complex included sites located well away from the margins of channels and could not be considered strictly riverine. This included stands of coolibah occupying a number of dry lake beds as well as occurring near the junction of the floodplain and dune fields. On the basis of landform such associations would typically be called floodplain rather than riverine (Gillen and Reid 1988). The importance of hydrological connectivity is also evident by the fact that the base-level vegetation of interdune lows did not group with the Interdune complex characterised by sany substrate, but rather with the Floodplain complex characterised by heavier soils (Gillen and Reid 1988). Soil nutrients are not considered as important in determining vegetation patterns as water, with response to local rainfall events and flooding being rapid and pronounced.

Assessment of aquatic macrophytes (defined as those adapted to growing in water, Roberts 1988) within the Ramsar site is limited. Roberts (1988) reported low diversity with only eleven species recorded during the December 1986 Coongie Lakes study. The species included two Charophytes (*Chara* sp*., Nitella* sp.) and two large green algae (*Spirogyra* sp. and *Hydrodictyon reticulatum*), as well as one introduced species and two amphibious grasses. Associations in the main channel and in the lakes were structurally distinct with the lakes being characterised more by robust generalists than the river habitat (Roberts 1988). Gillen and Reid (1988) recorded an additional 20 plus species which are considered aquatic or amphibious including several species of *Cyperus*, *Eleocharis*, *Triglochin, Isoplepis,* and *Fimbrostylis.*

[1] Based on the aquatic ecosystem dependent species list generated for the Lake Eyre Basin High Conservation Value Aquatic Ecosystem Pilot Project (Hale 2010).

Table 15: Area of broad vegetation communities within Coongie Lakes Ramsar site (data supplied by DENR South Australia).

Vegetation type	Area Existing Boundary (hectares)
Acacia shrubland	23 314
Acacia woodland	544
Eucalyptus forest and woodland	34 548
Chenopod shrubland	102 441
Fern/herbland	31 342
Mitchell grassland	33 389
Hummock grassland	28 405
Samphire shrubland	14 842
Mixed shrubland < 1 metre	9609
Lignum shrubland > 1 metre	62 848
Tussock grassland	111 669

3.3.6 Fish

Fish in the Lake Eyre Basin have high effective species richness, meaning all species are frequently encountered, more so than in other basins in Australia, despite having fewer native species (Pritchard et al. 2004). This may be attributed to the highly migratory nature of most species within the Lake Eyre Basin and reflect the unimpacted nature of the rivers (Pritchard et al. 2004). Another notable feature of the fish population at the bioregion scale is that the rivers of Lake Eyre Basin support very high productivity and biomass. Surveys have collected 103 869 native fish across five river reaches (Figure 48) contrasting with only 29 788 in a more intensive survey, the NSW Rivers Survey (Pritchard et al. 2004). Of the five systems sampled during the ARIDFLO project Coongie Lakes supported the number of native fish with a total of 30 863 native fish caught over eight sampling trips (Pritchard et al. 2004).

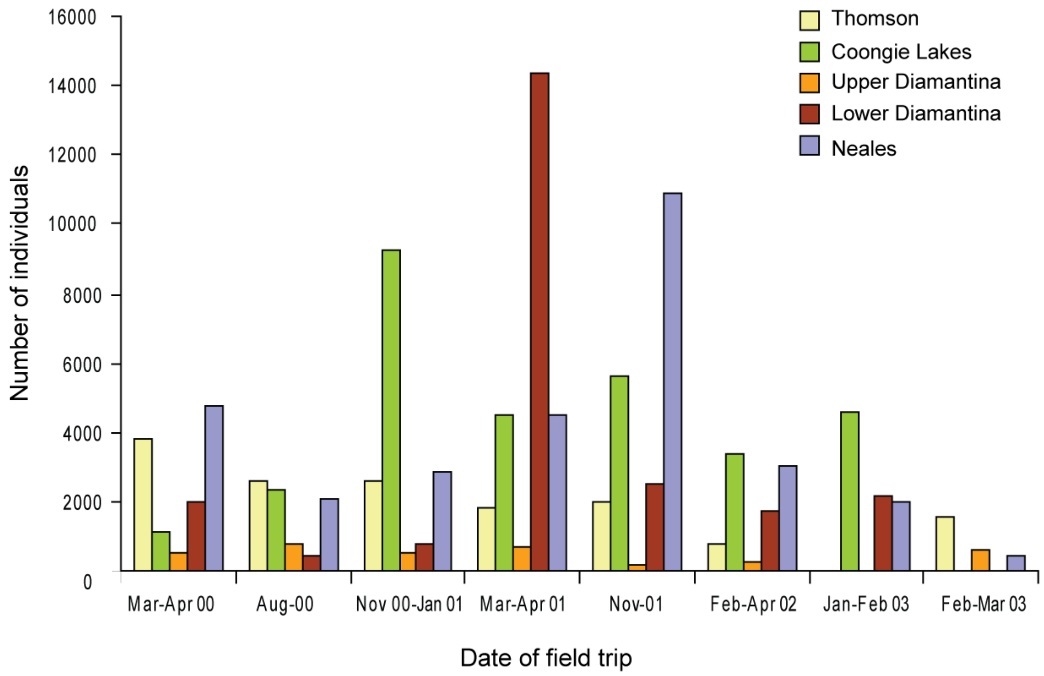


Figure 48: Number of individuals of native fish caught during ARIDFLO by reach and survey trip (all gears summed) (data from Pritchard et al. 2004).

Coongie Lakes has been studied to investigate ecological responses to the variable hydrological regime, including the responses of zooplankton, macroinvertebrates, fish and waterbirds (Puckridge 1999; Puckridge et al. 2010). Cooper Creek is an unregulated river system and as such the ecological responses to a varied water regime are considered to be largely intact (Puckridge et al. 2010).

Fish were collected from 13 sites, including five lakes, seven channels and an internal delta over the period 1986-1992, with this data representing a baseline for fish at the time of listing. Sampling was predominantly bi-monthly with a mixture of sampling methods utilised. During the sampling period there were a number of recurrent floods, increasing until 1990 which represented a greater than 1 in 25 year flood, resulting in progressively more dry sites being inundated over the life of the program (Puckridge et al. 2010).

Hydrological regime directly influences species diversity, with increased retention of water leading to increased fish diversity. In the ARIDFLO project abundance of native fish caught was highly variable, with some sites having no fish and others recording over 2000 fish. This variability in catch was attributed the highly variable water regime of the system (Pritchard et al. 2004). Increasing dominance by fish was reflected in corresponding decreases in macroinvertebrate dominance (Puckridge et al. 2010). The more mobile species are able to utilise the floodplain as habitat and food resources become available (Puckridge et al. 2010).

Puckridge et al. (2010) reported a high degree of 'nesting' in fish assemblages with species dropping out of assemblages in successive waterbodies from upstream to downstream (Figure 49) in an ordered sequence corresponding to decreasing frequencies of inundation and increasing frequencies of drying. Bony herring, a schooling detritivore/herbivore, were the dominant species accounting for 90.5 percent of the fish catch (Puckridge et al. 2010).

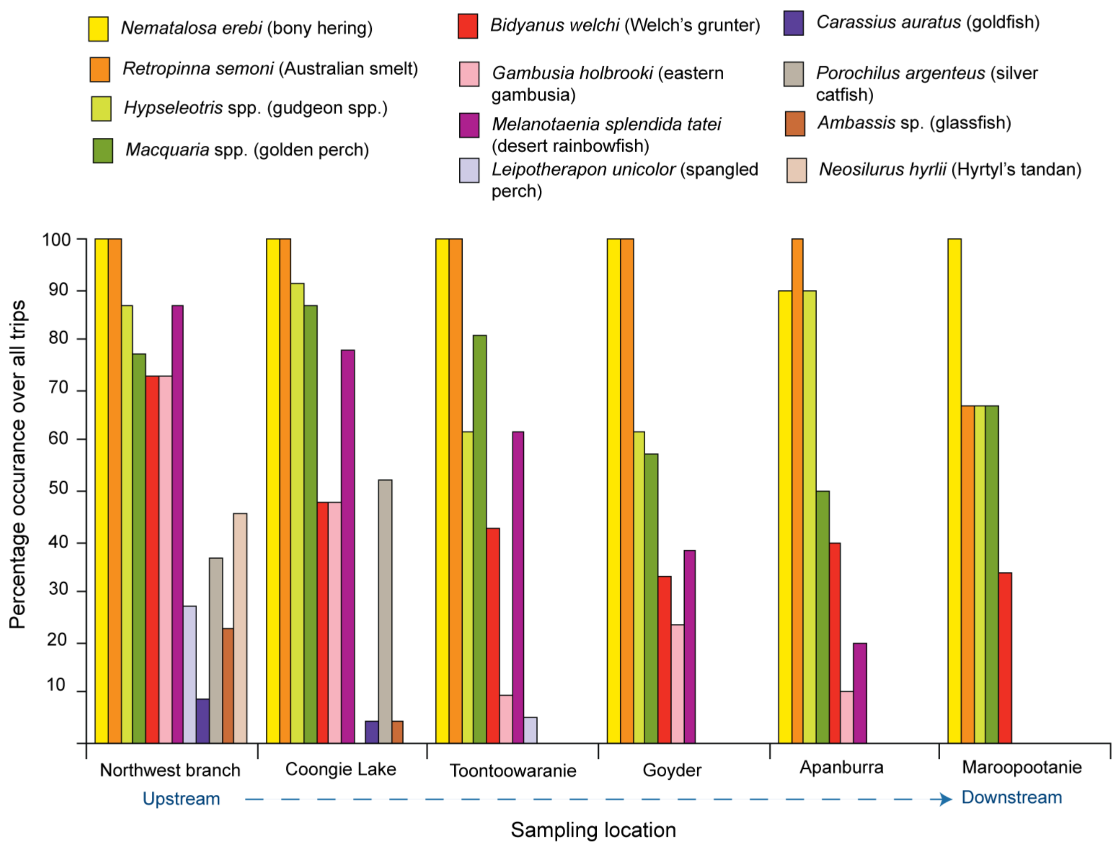


Figure 49: Percentage occurrence over all trips 1986-1992 of 12 fish species detected from all gear types at six waterbodies (data from Puckridge et al. 2010).

Twelve native fish species and two exotic species were found (Table 16), with a possible additional native species yet to be determined (Pritchard et al. 2004). The species are a mixture of northern and central Australia and Murray–Darling species (Timms 2001). The native species are able to out-compete the introduced species as they are favoured by the highly variable hydrological regime (Puckridge 1999; Costelloe et al. 2010; Puckridge et al. 2010). The key traits of the native fish fauna of the site is that they are dominated by species that are highly mobile able to colonise newly inundated habitat, and which use floods as cues for spawning. Diversity decreases downstream where filling of floodplain lakes and wetlands is more unpredictable. Trophically the native fish fauna sampled are dominated by carnivores.

Table 16: Fish species recorded within Coongie Lakes Ramsar site from Coongie Lakes, northwest and main branch of Cooper Creek indicating key traits (Pritchard et al. 2004).

Family	Species	Common name	Trophic group	Juvenile habitat	Adult habitat	Reproductive type*	Flood responders	Colonising ability
Ambasside	*Ambassis* sp	Glassfish	Microphagic carnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Flood cued spawning	Yes	High
Clupeidae	*Nematalosa erebi*	Bony herring	Detritivore (herbivore)	Littoral/pelagic pool dweller	Pelagic pool dweller	Seasonally cued	Yes	High
Elotridae	*Hypseleotris* spp.	Gudgeon species complex	Microphagic carnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Seasonally cued	No	Low
Melanotaeniidae	*Melanotaenia splendida tatei*	Desert rainbowfish	Microphagic omnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Seasonally cued	Yes	Moderate
Percichythyidae	*Macquaria ambigua* sp. B	Lake Eyre callop/golden perch, yellowbelly	Macrophagic carnivore	Littoral pool dweller	Benthic/littoral pool dweller	Flood cued spawning	Yes	High
Plotosidae	*Neosiluroides cooperensis*	Cooper Creek catfish	Macrophagic carnivore	Benthic pool dweller	Benthic pool dweller	Seasonally cued	No	Low
	Neosilurus hyrtlii	Hyrtl's tandan	Macrophagic carnivore	Benthic/pelagic pool dweller	Benthic pool dweller	Flood cued spawning	Yes	High
	Porochilus argentus	Silver catfish, moonfish	Macrophagic carnivore	Benthic/pelagic pool dweller	Benthic pool dweller	Flood cued spawning	Yes	High
Retropinnidae	*Retropinna semoni*	Australian smelt	Microphagic carnivore	Littoral/pelagic pool dweller	Pelagic pool dweller	Seasonally cued	No	Low
Terpontidae	*Bidyanus welchi*	Welch's grunter	Macrophagic carnivore	Littoral/pelagic pool dweller	Pelagic pool dweller	Flood cued spawning	Yes	High
	Leiopotherapon unicolor	Spangled grunter, spangled	Macrophagic carnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Seasonally cued	Yes	Very high

Family	Species	Common name	Trophic group	Juvenile habitat	Adult habitat	Reproductive type*	Flood responders	Colonising ability
		perch, bobby cod						
	Scortum barcoo	Barcoo grunter	Macrophagic omnivore	Littoral pool dweller	Benthic/littoral pool dweller	Flood cued spawning	Yes	High
	Scortum sp. (hydrid)		Macrophagic carnivore	Littoral pool dweller	Pelagic pool dweller	-	-	-
Cyprinidae*	*Carassius auratus*	Goldfish:	Microphagic omnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Seasonally cued	No	Moderate
Poeciliidae*	*Gambusia holbrooki*	Eastern gambusia	Microphagic carnivore	Littoral pool dweller	Littoral/pelagic pool dweller	Seasonally cued	No	High

* exotic species

Pritchard et al. (2004) report on increased abundances between the survey work in 1986-1992 and the ARIDFLO project 2000-2003. Glassfish (*Ambassis* spp.) are believed to have entered the Coongie system on floodwaters in a one in ten year event in 1991; however the arrival of this species can not account for the increased abundances recorded by in the ARIDFLO project, rather increases in four species already present were noted and attributed to different hydrological conditions. Whilst the period 1987-1991 was wetter than the 2000-2003, the pattern of flooding was different. The 1987-1991 period built up with a series of flood events in 1989-1991 while the 2000-2003 period started with a large flood and then floods progressively became smaller. Clusters of sequential floods (or multi-annual floods) are important in supporting the native fish fauna of the site, with greater numbers found in successive years (see Sections 3.3.4 and 4.3.6) due to persistence of aquatic habitats. Exotic species appear unable to take advantage of clusters of floods (Pritchard et al. 2004).

Overall species richness was greater in wetlands of the Ramsar site compared to sites sampled in the Diamantina and Neales River systems (
Figure 50). Species richness decreases as you travel downstream within the site, a reflection of decreasing frequency of inundation (Pritchard et al. 2004; Puckridge et al. 2010). Coongie Lakes Ramsar site is significant in that it supports migration of fish within the site (that is it meets Criterion 8). ARIDFLO results showed that migration of juveniles of native species occurred downstream in the channels but also laterally across floodplains (Pritchard et al. 2004). Peaks in abundance of juveniles have also been shown to be linked to inundation history, with peaks not necessarily associated with the largest floods but rather is associated with successive large floods reflecting a ramping of biological response to inundation over multiple years (Pritchard et al. 2004).

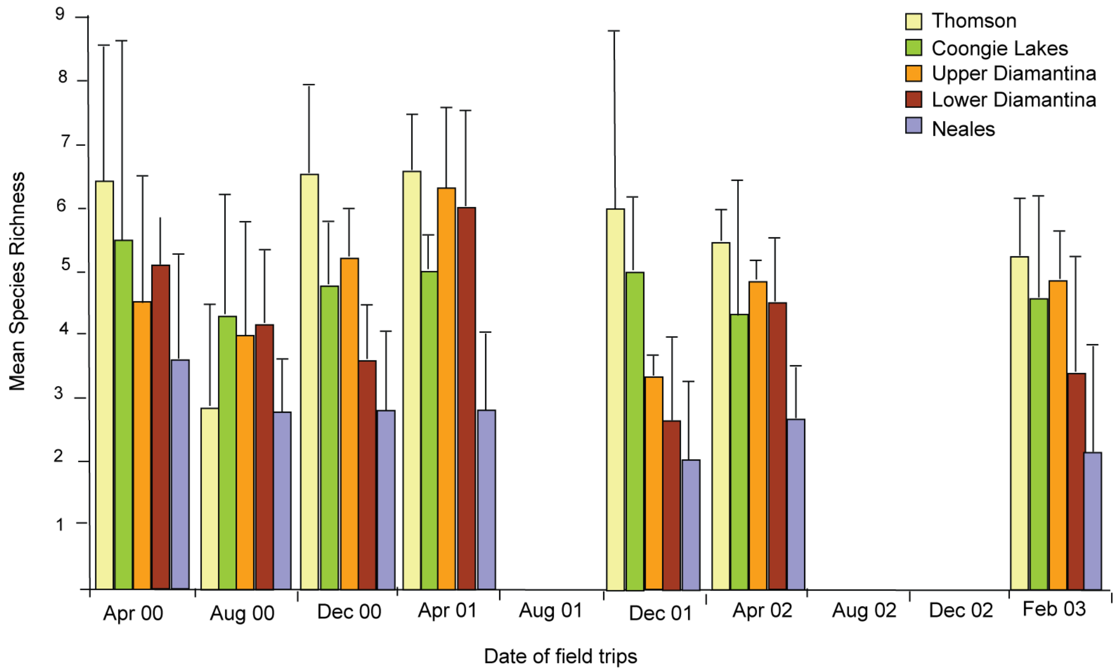


Figure 50: Mean number of native fish caught per waterbody per reach in ARIDFLO (from Pritchard et al. 2004).

Permanent waterholes have been identified as refuges for the fish in all Lake Eyre Basin rivers including the Cooper Creek (Puckridge 1999; Timms 2001; Puckridge et al. 2010; McNeil and Schmarr 2009). The fact that not all wetlands, including waterholes, dry at the same time and that occasional large floods reconnect isolated wetlands allowing migration or recolonisation, ensures the native fish population is maintained within the lower Cooper Creek (Pritchard et al. 2004). The fish in the permanent waterholes are often subject to harsh conditions as the waterhole dries down. Reasonable water quality in the waterholes is important to maintain source populations of fish species (McNeil and Schmarr 2009). Cullyamurra waterhole is a critical refuge for fish in the lower Cooper, with all waterholes considered essential to sustaining native fish biodiversity as it is the waterholes which support the greatest diversity (Pritchard et al. 2004).

Large-scale fish disease outbreaks are considered natural occurrences in the Cooper Creek system and other arid zone rivers in the Lake Eyre Basin. They occur following the disconnection phase after large floods, but are not considered an indication of poor ecological health but rather are a natural process in the wetting and drying of these systems (Pritchard et al. 2004).

Fish are considered critical to the ecology of the site, being an integral component of food web, both as consumers and also as prey for many piscivorous waterbirds in particular. They also contribute to the biodiversity value of the site.

3.3.7 Waterbirds

A total of 83 species of waterbird have been recorded within the Ramsar site, which contributes to the sites listing as a Wetland of International Importance (see Table 17and Appendix B). This includes 18 species that are listed under international migratory agreements Bonn (14), CAMBA (18), JAMBA (16) and ROKAMBA (14). A further 22 species are listed as marine or migratory under the EPBC Act. This includes records for the Australian painted snipe (*Rostratula australis*), listed as endangered under the EPBC Act, in Lake Toontoowaranie (Reid et al. 2004).

Table 57: Number of wetland birds recorded within the Coongie Lakes Ramsar site (Birds Australia unpublished; Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999; Reid et al. 2004). See Appendix B for full list of species.

Bird Group	Typical feeding habitat	Number of species
Ducks and allies	Shallow or deeper open water foragers. Vegetarian (for example Black Swan) or omnivorous with diet including leaves, seeds and invertebrates.	15
Grebes	Deeper open waters feeding mainly on fish.	3
Pelicans, Cormorants, Darters	Deeper open waters feeding mainly on fish.	6
Heron, Ibis, Spoonbills	Shallow water or mudflats. Feeding mainly on animals (fish and invertebrates).	12
Hawks, Eagles	Shallow or deeper open water on fish and occasionally waterbirds and carrion.	2
Cranes, Crakes, Rails, Water Hens, Coots	Coots in open water; others in shallow water within cover of dense emergent vegetation such as sedge. Some species vegetarian, others mainly take invertebrates, some are omnivores.	10
Shorebirds	Shallow water, bare mud and salt marsh. Feeding mainly on animals (invertebrates and some fish).	25
Gulls, Terns	Terns, over open water feeding on fish and invertebrates; gulls, opportunistic feeders over a wide range of habitats.	4
Other	Non waterbirds that are reliant on wetlands for breeding or feeding (e.g. clamorous reed warbler, barking owl).	6
Total		**83**

Species richness varies considerably between counts both as a reflection of the number of species within the site at any one time as well as counting techniques. Total species numbers from combined aerial and ground surveys from April 2000 to February 2003, averaged 51 (± 7 standard deviation). This ranged from 40 species in April 2000 when flooding had commenced but large numbers of birds had yet to arrive from elsewhere to 61 species in November / December 2000 (Figure 51). The potential effect of counting technique and coverage is illustrated by species richness in May 2004, which was just 38 species in the peak flood, but determined from aerial surveys only (Reid 2004).

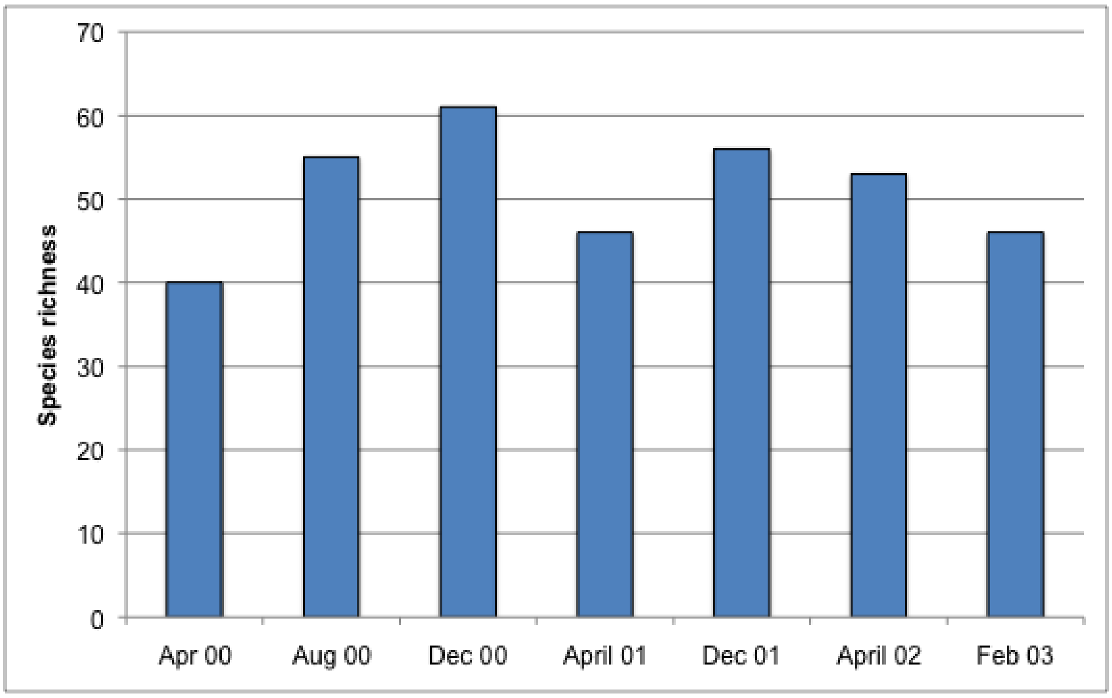


Figure 51: Species richness (total species number) of waterbirds in the Coongie Lakes Ramsar site from April 2000 to February 2003 from combined aerial and ground surveys (data from Reid et al. 2004).

As discussed in Section 2.5 the site regularly supports in excess of 20 000 waterbirds, and this data are based on incomplete survey effort. Coongie Lakes is also significant for the role it plays in supporting individual waterbird species. The site also regularly supports over one percent of the population of pink-eared duck and red-necked avocet (Figure 52). The evidence for other species is less strong. There are only single counts above the one percent population threshold for black-winged stilt, black-tailed native hen, hardhead, Australian pelican Australian pratincole and sharp-tailed sandpiper; two for grey teal and four for the freckled duck. In many other surveys numbers of these species were well below the respective thresholds.

Figure 52: Pink-eared duck and red-necked avocet (© I. Montgomery, Birdway).

Overall maximum counts for ten species exceed the one percent population thresholds (Wetlands International 2006; Table 18), but not all on a 'regular' basis. The list comprises predominantly Australian resident species, but includes the international migratory shorebird the sharp-tailed sandpiper (*Calidris acuminata*).

Table 68: Waterbird species for which more than one percent of the relevant population has been recorded in the Coongie Lakes Ramsar site.

Common name	Species name	Population (one percent)	Maximum count	Reference
Freckled Duck	*Stictonetta naevosa*	Australia 250	1988, Oct 2002	Kingsford et al. 2003
Grey Teal	*Anas gracilis*	Australia 20 000	32 282, May 2004	Reid et al. 2004
Hardhead	*Aythya australis*	Australia 10 000	24 963, May 2004	Reid et al. 2004
Pink-eared duck	*Malacorhynchus membranaceus*	Australia 10 000	81 306, Oct 2003	Porter et al. 2006
Australian pelican	*Pelecanus conspicillatus*	Australia 10 000	12 000, 1992	Reid and Puckridge 2000
Black-tailed native-hen	*Tribonyx ventralis*	Australia 10 000	44 750, Nov 1997	Reid and Puckridge 2000
Australian pratincole	*Stiltia isabella*	Australia 3000	3501, Nov 1997	Reid and Puckridge 2000
Black-winged Stilt	*Himantopus himantopus*	Australia 1750	2200, May 2004	Reid et al. 2004
Red-capped Plover	*Charadrius ruficapillus*	Australia 950	2000, 1982	Reid and Puckridge 2000
Red-kneed Dotterel	*Erythrogonys cinctus*	Australia 3000	7455, Nov 1997	Reid and Puckridge 2000
Red-necked Avocet	*Recurvirostra novaehollandiae*	Australia 1100	16703, May 2002	Reid and Jaensch 2004
Sharp-tailed Sandpiper	*Calidris acuminata*	EAAF 1600	4533, Nov 1997	Reid and Puckridge 2000

The Coongie Lakes Ramsar site is also important in terms of breeding of waterbirds. Fifty-four species of wetland bird have been recorded breeding within the site (Appendix B), which represents 65 percent of the wetland birds recorded at the site. Nesting abundance data are highly variable reflecting a combination of actual variability in breeding events and the difficulties in conducting ground surveys following heavy rain and inundation (Reid 2004). Notable breeding records from the Ramsar site include (Reid and Puckridge 2000; Reid 2004):

- more than 50 000 nests of Australian pelican in summer 1990/91;
- more than 10 000 nests of grey teal and the same number of pink-eared duck in spring/summer 1988;
- thousands of nests of black-tailed native hen in spring/summer 1988, summer 1989/90 and summer 1990/91;
- thousands of nests of hardhead on spring/summer 1988, summer 1989/90 and summer 1990/91;
- 1300 nests of pied cormorant in summer 1990/91; and
- 1700 great cormorant nests in May 2004.

Very large numbers of nesting pelicans and cormorants, gulls and terns and colonial nesting herons, egrets and ibis were observed in the period April 2000 to March 2001 (Reid et al. 2004). However, data are reported for the entire Channel Country, rather than the Ramsar site alone.

4 Critical Ecosystem Services

4.1 Overview of benefits and services

Ecosystem benefits and services are defined under the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems" (Ramsar Convention 2005, Resolution IX.1 Annex A). This includes benefits that directly affect people such as the provision of food or water resources as well as indirect ecological benefits. The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005) defines four main categories of ecosystem services:

1. **Provisioning services** - the products obtained from the ecosystem such as food, fuel and fresh water;
2. **Regulating services** – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation;
3. **Cultural services** – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and
4. **Supporting services** – the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

The ecosystem benefits and services of the Coongie Lakes Ramsar site are outlined in Table 19 below.

4.2 Identifying critical ecosystem services and benefits

The critical ecologically based ecosystem services and benefits of the Ramsar site have been identified using the same criteria provided by DEWHA (2008) for selecting critical components and services. These are services that:

1. are important determinants of the site's unique character;
2. are important for supporting the Ramsar or DIWA criteria under which the site was listed;
3. for which change is reasonably likely to occur over short or medium time scales (less than 100 years); and/or
4. that will cause significant negative consequences if change occurs.

Using these criteria it was considered that all of the supporting services (those that are ecologically based) could be considered "critical" (see Table 19).

Table 19: Ecosystem services and benefits provided by Coongie Lakes Ramsar site at the time of listing. Shaded services indicate those considered critical to the ecological character of the site.

Category	Description
Regulating services	
Maintenance and regulation of hydrological cycles and regimes	• Influence downstream passage of inflows into the downstream sections of the Ramsar site and ultimately inflows into Lake Eyre.
Provisioning services	
Stock watering	• Stock have access to many wetlands in the Ramsar site.
Provision of aquatic foods for human consumption	• Recreational fishing. • Commercial fishery at Lake Hope.
Cultural services	
Cultural heritage	• Presence of permanent water in an arid landscape means the site has significant cultural value both to Indigenous and European cultures.
Tourism and recreation	• Around 40 000 to 50 000 visit Cullyamurra waterhole annually (Silcock 2009). • Waterbird watching is a key activity, focusing on permanent waterbodies and major floods.
Supporting services	
Supports near-natural wetland types	• Cooper Creek is unregulated and the wetlands have a natural hydrological regime.
Provides physical habitat especially for breeding waterbirds	• During flood events the Coongie lakes Ramsar site provides a mosaic of habitats, both spatially and temporally, supporting large numbers of waterbirds from a range of feeding groups. • Fifty four species of waterbird have been recorded breeding at the site.
Biodiversity	• Permanent waterholes provide a focal point for regional biodiversity, with species richness and abundance declining with distance from permanent water. • Both aquatic and terrestrial diversity is considered high at the bioregion scale.
Food webs	• Primary productivity underpins the aquatic food webs of the system. • Hydrological regime drives the boom and bust periods.
Special ecological, physical or geomorphic features	• Permanent waterholes provide critical drought refuge.
Threatened wetland species, habitats and ecosystems	• Supports the Australian painted snipe (*Rostratula australis*) • Supports a number of threatened species including six terrestrial species listed under the EPBC Act and 38 species of conservation significance in South Australia (wetland dependent and terrestrial).
Priority wetland species	• Eighteen species of waterbirds which occur at the site are listed under JAMBA, CAMBA, ROKAMBA, Bonn.
Ecological connectivity	• The wetlands sequentially fill and can remain hydrologically and ecologically connected for different periods of time depending on the magnitude of the floods. • On recession of floodwaters the presence of permanent waterholes provides critical drought refuges and maintains populations of obligate aquatic species.

4.3 Critical supporting services

This section documents the critical supporting ecosystem services; it is important to note that these are often difficult to separate from functions or processes.

4.3.1 Natural or near natural wetland ecosystems

As detailed in Section 2.4, the Coongie Lakes Ramsar site contains a number of wetland types that by virtue of the remote location, limited access, terrain and protected status of the site, can be considered in near natural condition. Of particular importance is the fact that the Cooper Creek is unregulated and that the inflows are highly variable. The wetland types present in the site are brought about predominantly by interactions between geomorphology and hydrology. The hydrology is driven largely by monsoonal rainfall in the upper catchment of the Cooper Creek, although local rainfall can contribute to inflows. For example, Lake Deception and Salt Lake, which are north of the Coongie Lakes wetlands, fill from rare run-off events from the Cordillo Downs stony tablelands to the north east (Reid 1988b). The variable hydrology of the system has created a complex mosaic of highly connected wetlands in an arid environment which display the classic boom and bust ecology associated with periods of flooding.

4.3.2 Physical habitat for water bird breeding and feeding

Feeding

The major waterbird functional feeding groups (see Section 4.3.7) have different physical habitat requirements. The diversity of wetlands within the Coongie Lakes Ramsar site provides a spatial and temporal mosaic of habitats that support a diversity and abundance of waterbirds. Some of the general habitat requirements for species within each of the function feeding group classes are provided in Table 20.

Table 20: General habitat requirements of a number of waterbirds in the Coongie Lakes Ramsar site (Marchant and Higgins 1990 unless otherwise specified).

Species	Habitat characteristics
Piscivores	
Australian pelican	Colonial feeder, often working in groups to drive prey (small schools of fish) to shallow water. Feeds in shallow water by scooping water and fish into the pouch and discarding the water.
Pied cormorant	Roost in trees near water or on cliffs, offshore rocks. Diet consists mainly of small to medium size fish. Feed by pursuit diving.
Diving ducks	
Eurasian coot	Food is mainly obtained during underwater dives, lasting up to 15 seconds and ranging down to seven metres in depth. Birds also graze on the land and on the surface of the water. In Australia, Eurasian coots feed almost entirely on vegetable matter, supplemented with only a few insects, worms and fish.
Hardhead	Prefer larger lakes, swamps and rivers with deep, still water. Feed by diving deeply, often staying submerged for up to a minute at a time. They slip under the water with barely a ripple, simply lowering their heads and thrusting with their powerful webbed feet. Feed on a broad range of small aquatic creatures supplemented with aquatic plants.
Dabbling ducks	
Australasian shoveler	Prefer deep, large permanent waterbodies. Roost on open water or in low trees over water. Diet – plants and animals (molluscs and insect larvae). Foraging – filter feeder dabbling in mud or in surface water.
Freckled duck	Shallow productive inland wetlands. Roosts by day on banks.

Species	Habitat characteristics
	Diet of plants and animals. Filter feeds at night in soft mud or shallow water.
Pink-eared duck	Prefer inland, shallow turbid wetlands. Roost – rest on water, may roost in low branches of trees. Diet is mostly invertebrates (e.g. chironomids). Filter feeds mostly at surface taking planktonic invertebrates.
Grazing ducks	
Australian shelduck	Wide range of habitats but prefer shallow wetlands. No specific roosting pattern. Diet of vegetation and invertebrates. Foraging – opportunistic grazing, filter feeding.
Plumed whistling duck	Prefers deeper waters where aquatic plants and insects are plentiful. Foraging – feeds almost entirely on aquatic vegetation and seeds, but also on young grass, the bulbs of rushes and other herbage, insects and other small aquatic animals.
Non-diving rails	
Black-tailed native hen	Permanent or temporary wetlands in low rainfall areas. Diet – seeds, plant material and insects. Foraging – feeds on open ground near wetlands or at the edge of water and often feeds by running, then stopping, to stir up insects.
Purple swamphen	Wide range of habitats including open water, swamps, rivers and temporary wetlands. Diet of soft shoots of reeds and rushes and small animals (e.g. frogs and invertebrates), also known to predate on eggs of other waterbirds and ducklings. Feed on open ground near wetlands or at the edge of water.
Storks, cranes, ibis and spoonbills	
Brolga	Wide range of habitats including large open wetlands, grassy plains and mudflats. Uncommon in arid and semi-arid areas. Diet of vegetation and invertebrates. Forage in shallow water or wet mud.
Yellow Spoon-bill	Prefers inland, freshwater wetlands with shallow margins. Diet of predominantly invertebrates. Forage in shallow mud using the vibration detectors in its bill to detect movement of prey in the mud.
Waders (shorebirds)	
Sharp-tailed sandpiper	Forage on wet mud, preferring areas with short, surrounding vegetation to bare substrate (Collins and Jessop 1998). Diet is predominantly polychaetes, crustaceans and molluscs.
Red-necked Avocet	Forage in shallow water. Beak, leg and foot morphology are adapted to foraging in deeper water than some other wading species of bird (Loyn et al. 2001).

Waterbird functional feeding groups across a range of wetlands in the Ramsar site in 2004 (Reid 2004) illustrate the spatial differences as a result of different habitats (Figure 53). Piscivorous dominate the waterbird assemblage at permanent and intermittent systems, with open water at a depth of water sufficient to allow for feeding. Reid (1988) noted that these species preferred lake and channel habitats less than one metre in depth. At sites like Mudrangie Wooded Swamps, the piscivores were dominated by cormorants and darters, which utilise the trees and shrubs for roosting and nesting. In contrast this waterbird functional group was dominated by Australian pelicans at more open wetlands.

Diving and dabbling ducks were dominant at a range of wetlands, reflecting the high productivity at the time of the sampling and the wealth of food resources. These species have been observed favouring open water away from vegetated margins for foraging (Reid 1988b). Habitat for waders is provided at the receding margins of many wetlands and across more extensive areas of shallow, temporary systems such as the “unnamed lake northwest of Mollichuta Waterhole”. Some systems with a diversity of habitats, such as Embarka Swamp, with channels, deeper areas and a diversity of vegetation can support the full suite of waterbird functional groups.

It should be noted that there is also a temporal aspect to the habitat availability within the site (see Figure 54 below). Waterbirds move between the wetlands within the Ramsar site in response to filling and drying to match their foraging and dietary requirements (Reid 1988b). In addition, waterbirds may use different habitats for different needs such as nesting, foraging, roosting or during moult of their primary flight feathers.

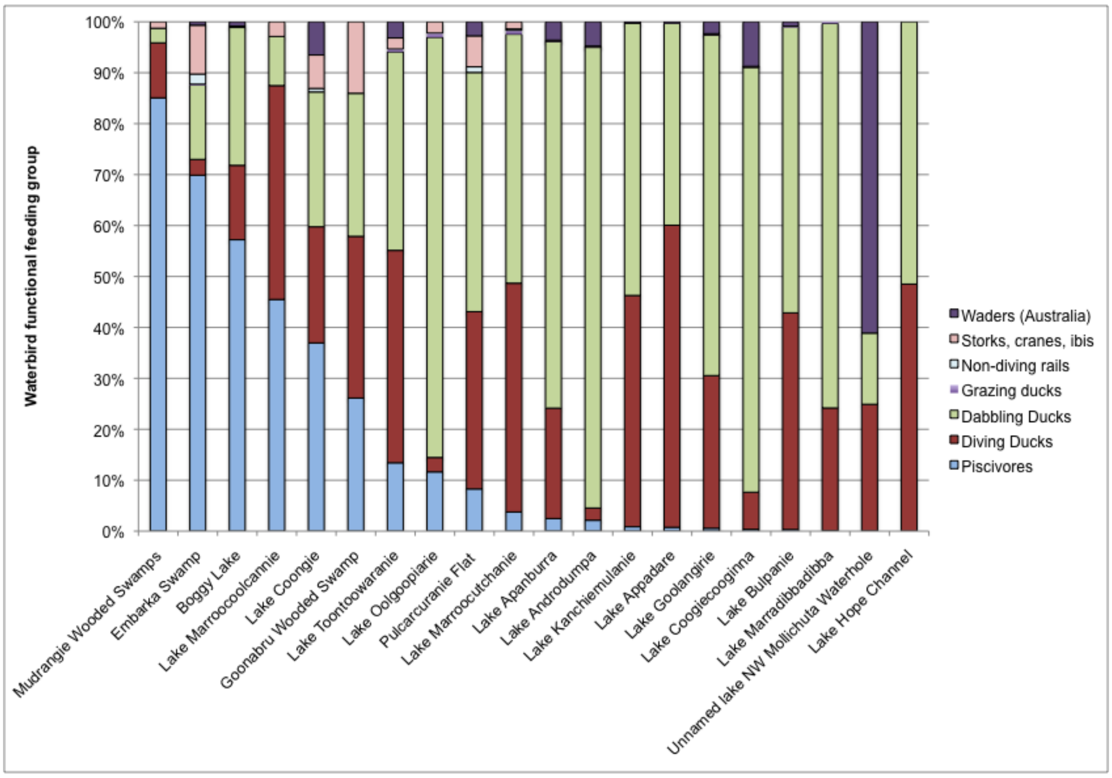


Figure 53: Proportion of waterbird functional groups at 20 wetlands within the Coongie Lakes Ramsar site in May 2004 (data from Reid 2004).

Breeding

Fifty five species of waterbird have been recorded breeding within the Coongie Lakes Ramsar site. Breeding records are not consistent and it is difficult to determine how many of these species regularly breed in the site. The species recorded breeding at the site utilise a range of different habitats within the system (Table 21). The most significant breeding of waterbirds (in terms of numbers) occurs following large scale flood events and includes the record of 50 000 Australian pelican nests on the islands of Lake Goyder in 1990/91.

Table 21: General habitat requirements of a number of waterbirds recorded breeding in the Coongie Lakes Ramsar site (Marchant and Higgins 1990 unless otherwise specified). Note that groups represent taxonomic groupings rather than functional feeding groups.

Species	Habitat characteristics
Ducks and allies	
Black swan	Nest mound built in open water, on an island, or in swamp vegetation. Within the Ramsar site known to breed in the emergent vegetation at Lake Toontoowaranie. Requires minimum water depth of 30–50 cm until cygnets are independent. First flight 20–25 weeks.
Pink-eared duck	Opportunistic breeder utilising a range of vegetation over water, including tree hollows stumps, shrubs. Commonly using old nests of other waterbirds. Ducklings leave the nest soon after hatching by dropping to the ground/water.
Pelicans, cormorants and darters	
Australian pelican	Colonial breeder with nests usually on islands with little or no vegetation. Within the Ramsar site often breeds on the islands at Lake Goyder. Adults can obtain food for their dependent young locally or from distant wetlands. Young leave nests to form crèche at about 3–4 weeks. First flight at 3 months.
Pied cormorant	Nests in horizontal branches and forks of trees (live or dead) in or over water. Colonial nester with multiple nests in single trees/shrubs. Requires water to remain until nestlings are independent. Hatchlings leave nest after 4 weeks, first flight at approximately 8 weeks.
Herons, ibis, egrets and spoonbills	
Australian white ibis	Nests in a wide variety of habitats including wooded swamps and dense emergent vegetation. Young leave nests after 48 days but dependent on parents for several weeks.
Straw-necked ibis	Commonly breed in mixed colonies with other ibis, egrets and herons. Nest in shrubs, reeds or trees over water, or on ground on islands. Fledge 4 weeks after hatching, fed for two weeks by parents after leaving nest.
Royal spoonbill	Nests in wooded swamps or reed beds. In the Ramsar site mostly in the coolibah lining channels and the margins of lakes. Requires inundation until young fledge.
Cranes, crakes and rails	
Black-tailed native-hen	Nests over water in shrubs or sturdy tussocks; breeds as dispersed pairs or in loose clusters. Young leave nest soon after hatching, but are dependent on adults for some time after.
Brolga	Nest constricted of a large mound of vegetation on a small island in a shallow waterway or swamp. Breeding rare in the Ramsar site. Young leave the nest after 1–2 days, first flight at 14 weeks, but may stay with parents for up to 11 months.
Shorebirds	
Red-capped plover	Nests in scrape made in sand or mud. Young leave nest within one day and self fed, require vegetation for cover.
Red-necked avocet	Nest in scrape in mud on an island, ridge or other elevated position.

Species	Habitat characteristics
Gulls and terns	
Gull-billed tern	Nest in a range of habitats including on top of inundated samphire and on low bare islets. Young may leave nest at 2–3 days old, but dependent on parents for 3 months.
Whiskered tern	Floating nests on inundated temporary wetland systems, often over grass, sedge, ribbon weed or samphire. Young may leave the nest at a few days and fledge in only 8–14 days.
Birds of prey	
Swamp harrier	Breed in swamps as well as terrestrial environments such as grasslands / croplands. Nest constructed from vegetation. Young fledge at 7 weeks.

4.3.3 Biodiversity

The Coongie Lakes Ramsar site's biodiversity value does not arise solely from high species richness, but rather from a unique combination of species and ecosystems and a boom and bust ecology which supports peaks and troughs in diversity and abundance of biota. The spatial and temporal variability in habitat availability combined with the range of habitats types forms a habitat template which supports the diversity and richness of the aquatic and terrestrial biota (Reid 1988b) (see Section 2.2). For most groups of biota the Ramsar site supports species rich communities (See section 3), often among the highest in the Lake Eyre Basin.

A key role in maintaining the biodiversity value of the site is the presence of permanent water. The waterholes act as critical aquatic habitat in periods of no flow and also provide drinking water for terrestrial species, with species richness and abundance decreasing with increasing distance from water.

4.3.4 Supports threatened species

The Coongie Lakes supports the endangered Australian painted snipe (*Rostratula australis*). This species is most commonly observed in freshwater, shallow inundated wetlands with areas of grasslands or dense low vegetation (Lane and Rogers 2000).
It forages at night on mudflats and shallow water, feeding on invertebrates (e.g. worms, snails) and seeds, resting during the day under the cover of low vegetation such as grasslands or sedges (Marchant and Higgins 1990). It is possibly nomadic or migratory, but movements are not well understood (Lane and Rogers 2000). Within the Ramsar site it has been observed at Lake Toontoowaranie (Reid et al. 2004), presumably in the lake's vegetated margins.

Species of conservation significance are an important element of biodiversity value and the Coongie Lakes supports six nationally listed species and at least 38 state listed species across all major groups of biota (see Section 2.2).

4.3.5 Special ecological, physical or geomorphic features

Waterholes are critical elements of the Cooper Creek system, and within the Ramsar site they occur from the Queensland South Australian border downstream to the Coongie Lakes. As discussed above (see Sections 2.4, 3.3.1, 3.3.2 and 3.3.3) the waterholes act as drought refuges, provide focal points for water supply for stock, are sites of cultural significance and are important in regional tourism and recreation.

White (2002, 2004) states that the permanent waterholes allow the persistence of the Cooper Creek turtle in an arid landscape. The turtles are believed to move onto the floodplain to take advantage of high productivity levels during floods, but return to the same waterhole when the floodplain dries. Genetics work in the Cooper Creek in Queensland has shown high site fidelity with limited migration between waterholes (White 2004). White (2004) postulates that the turtles exhibit trade-offs in relation to the permanency of waterholes. In permanent waterholes turtle densities are high and therefore competition for resources is high. In these situations the turtles have low to no recruitment, putting less energy into reproduction, and also slower growth rates. Sites such as Cullyamurra waterhole probably represent climax populations. In semi-permanent waterholes numbers of turtles are lower and therefore competition is less, however the security of the habitat is also less. In this type of waterhole there is enhanced recruitment and growth (White 2004).

4.3.6 Ecological connectivity

Floodplain systems are characterised by a mosaic of spatial and temporal habitats with varying degrees of hydrological and ecological connectivity (Leigh et al. 2010). In the Coongie Lakes Ramsar site, as with other complex large floodplain systems, this habitat mosaic is driven by the channel, waterhole, wetland geomorphology and hydrological regime.

The Coongie Lakes Ramsar site is unique in the Lake Eyre Basin as the lower Cooper and associated floodplain has a much higher level of hydrological connectivity than other river systems in the basin. The Ramsar site wetlands exhibit multi-annual periods of connectivity (Costelloe 2008) and reflects the high degree of connectivity between individual wetlands and the floodplain channels. The wetlands of the system fill sequentially, another feature unique to this system. As mentioned in Section 3.3.4 sequential flooding or multi-annual periods of connectivity leads to ecological persistence of aquatic habitats

4.3.7 Food webs

Waterbird functional feeding groups

Classification of waterbirds based on diet and foraging method was developed for arid Australian wetlands by Reid et al. (2004). The classification divides wetland bird species into the following categories:

- Piscivores – fish eating birds;
- Diving ducks – including coots and swans;
- Dabbling and filter-feeding ducks;
- Grazing ducks and geese;
- Non-diving rails;
- Storks, cranes, ibises and spoonbills;
- Waders (shorebirds) that breed in Australia; and
- Waders (migratory shorebirds) that do not breed in Australia.

The mean abundance of each of these groups was determined in the Coongie Lakes for the period April 2000 to February 2003 (Reid et al. 2004). Abundance and composition of waterbirds at the site varied considerably in response to hydrology and reflects the “boom and bust” cycle experienced by the wetlands in the Ramsar site (Figure 54). The period was characterised by a one in 10 year flood event commencing in early 2000, followed by a number of small, seasonal floods and then a drought period in mid 2002 to February 2003 at which point most of the floodplain and temporary wetlands had dried completely (Costello et al. 2004). The pattern of waterbirds indicates a lag between inundation and the arrival of large numbers of waterbirds from elsewhere in Australia. The pre-flood assemblage (as indicated by April 2000, when the area was flooded, but large numbers of waterbirds had yet to arrive from elsewhere) was limited to refuges, such as deep waterholes that hold fish, but not necessarily extensive areas of vegetation. This is reflected in the proportion of piscivores at that time.

During the peak inundation and productivity phases, the waterbird numbers reached their maximum and were comprised of the full component of function groups, but dominated by piscivores, diving and dabbling ducks. As wetlands began to dry, waterbirds from the region become concentrated in the last remaining inundated areas and the number of dabbling ducks increased. Similarly as wetland receded and areas of shallow mud were exposed, the numbers of waders (mostly Australian residents) increased. By February 2003 there was little water left in the system and numbers of all functional groups were in decline as waterbirds dispersed to other regions (Reid et al. 2004).

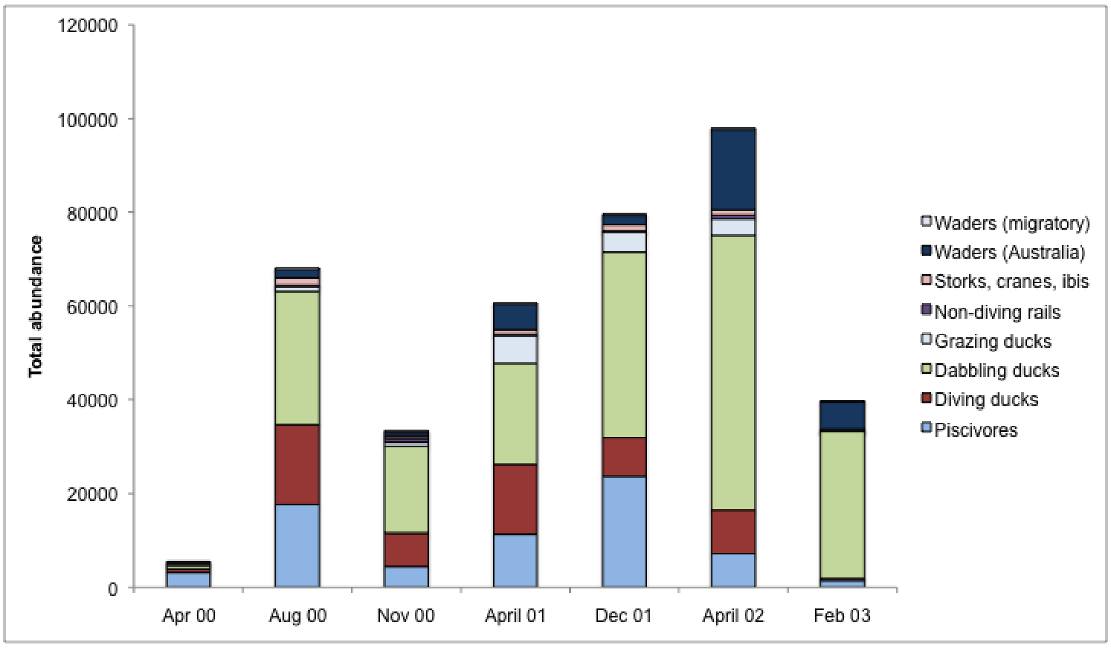


Figure 54: Abundance of waterbird functional feeding groups at Coongie Lakes from aerial surveys April 2000 to February 2003 (adapted from Reid and Jaensch 2004).

4.3.8 Priority wetland species

Priority wetland species and ecosystems are those which have been identified as having species management requirements, for example are threatened species with a recovery plan, or are listed under international treaties such as JAMBA, CAMBA, BONN and ROKAMBA. Coongie Lakes Ramsar site supports 18 waterbird species listed under these treaties (see Appendix B). This is considered significant number for an arid zone wetland system (P. Wainwright, pers. comm.).

4.4 Cultural services

Whilst not identified as critical, cultural services are considered important for Coongie Lakes Ramsar site and so have been briefly described below. Similarly tourism and recreation, although important services provided by the Ramsar site wetlands, are not considered critical to the ecological character of the site.

4.4.1 Cultural heritage

Across Australia water is pivotal to Indigenous culture, society and economy and water use and management is an integral part of traditional use of lands (Armstrong 2008). This is particularly the case in arid Australia where permanent water is the foci of human activity (Silcock 2010). Indigenous people in Australian consider themselves an integral part of their natural environment having both a close physical and spiritual connection to the landscape. Wetlands are often places of great significance as they are places with a high concentration of natural resources in an often arid landscape. Wetlands are often key places in stories and are evidence of the work of the ancestral creators (Ramsar Convention 2002). Aboriginal knowledge of waterbodies is predominantly held in oral tradition and anthropogenic reports, which in general are not in the public domain (Box et al. 2008), and so the significance of sites are often undervalued by the general public.

There are a number of Aboriginal groups, who have an association with the wetlands of the Ramsar site. Historic records indicate the region around Innamincka was densely populated with the focus being along the Cooper Creek and around permanent waterholes (DEHAA 1999). Movement through the landscape and use of resources were linked to flood events, maximising the productivity of the floodplain. Fish, turtles, mussels, waterbirds and frogs along with mammals and reptiles were all taken from the floodplain and river channels. Plant foods collected included seeds from grasses, acaia and nardoo (DEHAA 1999).

European heritage is also closely linked to the permanent water in the landscape. Captain Charles Sturt was the first European in the area in 1845 and named the Cooper system after Charles Cooper, South Australia's first Chief Justice. In 1861 the bodies of the explorers Burke and Wills were found by Howitt, who marked the spot by blazing nearby trees. Another search party, led by John McKinlay from Adelaide, discovered non-aboriginal human remains at Lake Massacre, north of the Cooper Creek area. These explorers were quickly followed by the establishment of the pastoral industry, and then by service industries and the settlement of Innamincka (DEHAA 1999).

Pastoral activities began in 1873 and Innamincka was surveyed as a town in 1890 and included a hotel, store, police station, blacksmith and an Australian Inland Mission Nursing Home. The town was effectively abandoned in 1952 but was re-established in 1971 and now acts as a staging place for tourism in the region (DEHAA 1999).

Listed Cultural Sites

There are a significant number of listed cultural sites in this Ramsar site, the majority being in the vicinity of Innamincka and Coongie Lakes. Within the Innamincka Regional Reserve, 127 sites are listed as being protected under the *Aboriginal Heritage Act 1988* including examples of archaeological sites (occupation sites), burials, art sites, ritually significant locations, tool manufacturing sites, grindstone quarries, remains of wiltjas, early historic campsites and stone arrangements (DEHAA 1999).

The significance of the European settlement of the area is recorded on the State Heritage register (SH) and the National Estate (NE). The places listed are (from DEHAA 1999):

1. The former AIM Nursing Home in Innamincka township (SH, NE). This building was renovated as the Regional Reserve office and reopened in 1994.
2. Gray's Tree, Lake Massacre (SH, NE). This tree is believed to mark the site of the death and burial of Charles Gray on 17 April 1861. It is one of only two known and tangible pieces of evidence in South Australia of the Burke and Wills Expedition.
3. Innamincka Cooper Creek State Heritage Area. Sites within this area related to the fate of Burke and Wills include:
   - Burke's Tree (SH, NE) near Innamincka marks the vicinity where Howitt found Burke's body buried. The body was later exhumed for a hero's burial in Melbourne in January 1863. Sand drift has covered the trunk of this tree bearing the large blaze.
   - The site of Wills' Tree (SH, NE) near which Wills died in a wurlie, and where King buried him with sand and rushes. Howitt's party collected the remains and interred them at this site. This tree does not appear to exist any longer.
   - A recently erected cairn, and tree blazed with King's name (a later event also) mark where King was discovered by Howitt (SH). This tree was broken and killed in a windstorm in 1987. The remains of the tree trunk were pieced together, mounted on a base, and reinstalled at the site in 1989.
   - The site of Howitt's camp (SH, NE) by Cullyamurra waterhole has been marked by a cairn erected on the basis of information from Howitt's Journal. 4. Innamincka Historic Reserve which includes Aboriginal rock engravings (NE), campsites and graves and the first gravesite of Burke.

4.5 Ecological character conceptual models

The hydrological diversity is a critical characteristic of the Coongie Lakes Ramsar site. The variable hydrology means that habitats are inundated and set at different times; drying rates vary which also affects the biota of the wetlands. The persistence and pattern of filling of many of the floodplain wetlands is significantly different to the non-floodplain wetlands in the northern lakes area of the site, which in turn elicit different ecological responses from biota. This results in a mosaic, or patchwork, of wetted areas across the larger site which are switched on, ecologically speaking, at different times. Reid (1988b) documented the movement of waterbirds between the main lakes of the Cooper and rain-fed wetlands within the Ramsar site. The results showed that many waterbirds use the greater system (i.e. not just the floodplain) in an integrated manner. The rain fed wetlands peripheral to the Cooper Creek floodplain have different trophic structure and dynamics, and as such are likely to be important to waterbirds that spend most of their time (when within the region) on the main Cooper-connected water bodies (J. Reid pers. comm.).

Whilst variability is a key characteristic of the site, hydrological persistence is also a critical feature. The presence of permanent waterholes and near permanent lakes such as Coongie Lake are the drivers of ecology of the site, allowing the persistence of wetland dependent species and providing critical refuge in dry times (Figure 55). Conditions within waterholes can vary considerably depending on the hydrological phase. When hydrologically connected biota move freely between the waterholes and the surrounding floodplain via the main and secondary channels. At the time of disconnection, when the waterholes become isolated, biota will contract into the waterholes to await reconnection. During disconnection water quality can decline as evaporation increases concentration of salts in the water. High competition for food resources within a relatively small area can lead to increased predation, starvation and death in some species. The waterholes may receive top ups from local rainfall events which may alleviate water quality problems in the short term. Permanent waterholes provide a critical refuge for aquatic species and provide the source of adult colonists when the system floods again.

In addition two landscape/floodplain conceptual models representing two aspects of the hydrological variability of the site, a large flood event and cease to flow conditions, are presented below (Figure 56 and Figure 57 respectively).

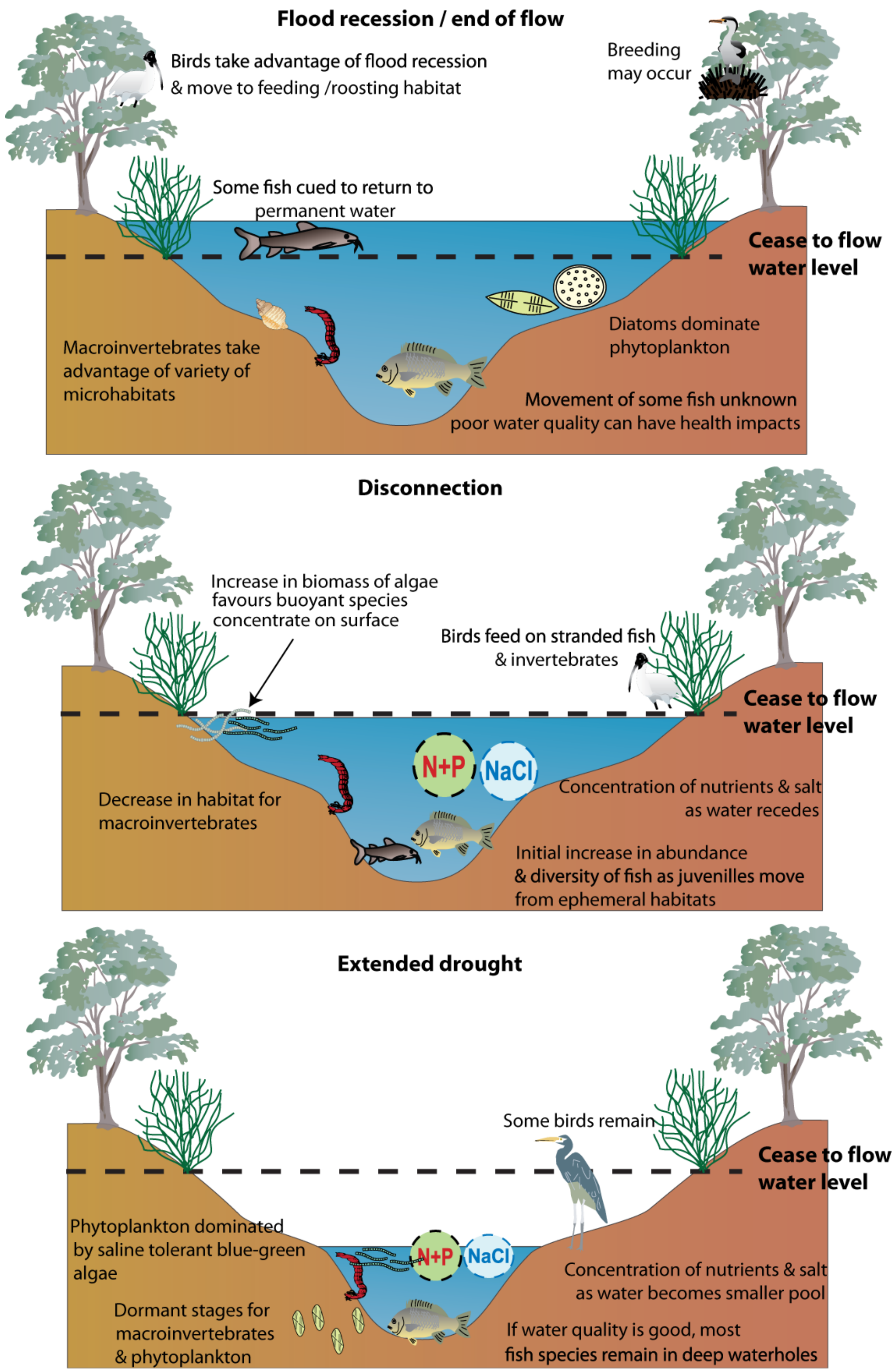


Figure 55: Conceptual model of permanent waterhole in three different hydrological states (based on models presented in Costelloe et al. 2004).


1d
1c
5
1b
2
6
3
4
7
1a

Components, processes, and services.

Water is fresh, however electrical conductivity is temporally and spatially variable. Turbidity levels can be moderate to high. Water quality is variable across the floodplain, with some areas having good water quality, others poor.

Sediments, dissolved nutrients and allochthonous material are transported into floodplain wetlands via channels in the floodplain and over land flows. Biota disperse into and out of floodplain wetlands with floodwaters.

1a to 1d

Hydrology. This model represents a large flood where the majority of the floodplain is inundated with significant lateral and longitudinal connectivity. Water arrives along via a major channel, either the main branch or northwest branch (1a) filling backwaters areas of the flood-plain (1b) as the water moves downstream. These areas can retain water for weeks to months. Water moves along the main flow path and fills large lakes (1c) sequentially. There are lag times involved with the movement of water through the system due to the large capacities of the wetlands and transmission loss (1d). The further downstream the water travels the shorter the inundation periods, with the lakes in the lower end of the site only being filled in very large events. Contributes to meeting criterion 1.

2 **Productivity** is high and the site exhibits a classic boom and bust ecology. On arrival of floodwaters primary productivity booms with a corre-sponding flush of zooplankton. Plankton arrive both arrive on floodwaters and emerge from the egg and seed bank. Larger invertebrates such as aerial insects arrive and provide an abundant food resource for secondary consumers such as fish. High productivity supports high biodi-versity values and contributes to meeting criterion 3.

3 **Native fish** species found on site are abundant many of which respond to floods by moving onto the floodplain. Several species have been recorded spawning on the floodplains in response to flooding with migration within the site potentially covering hundreds of kilometers. Contributes to meeting criteria 4 and 8.

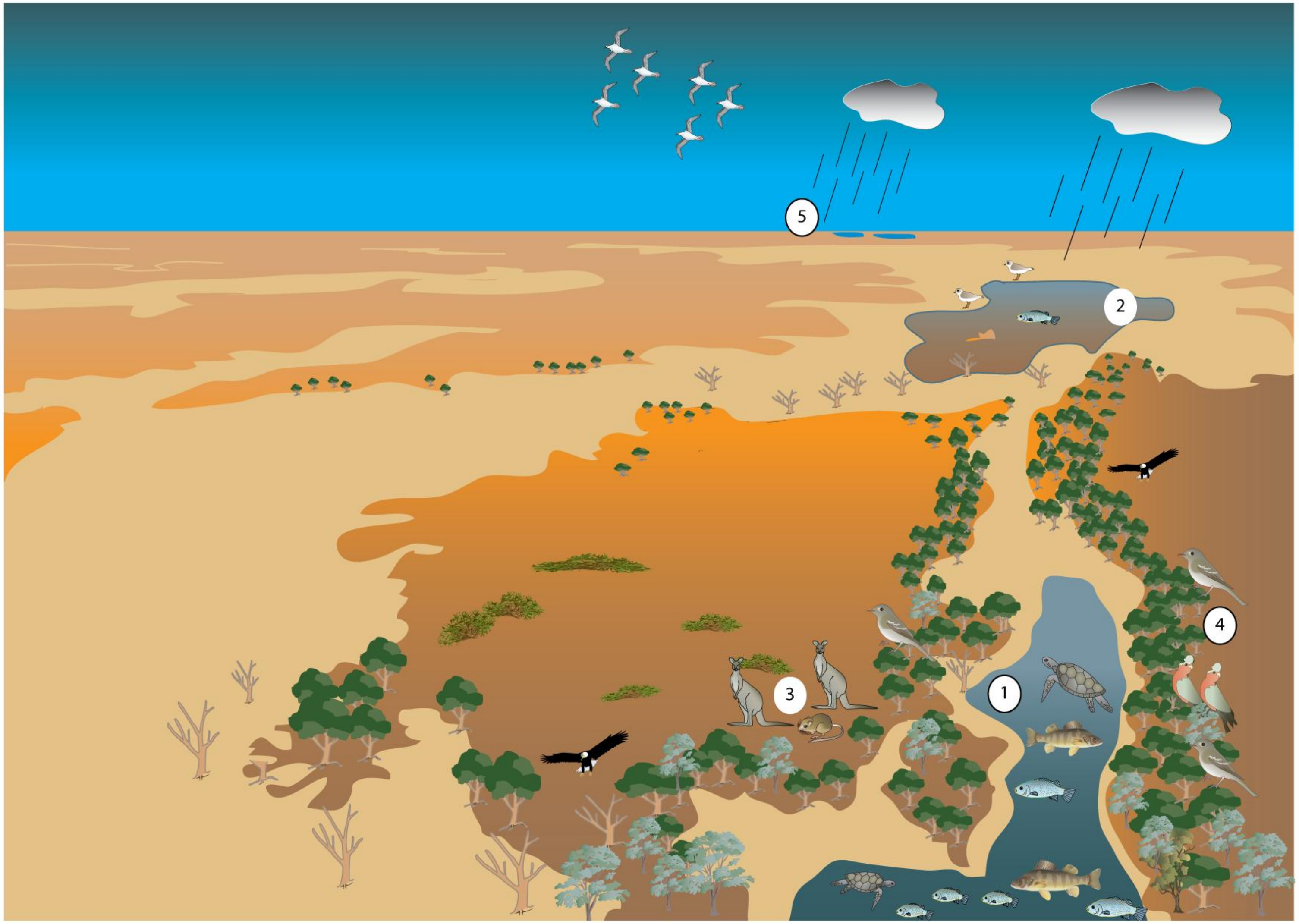
4 **Waterbirds**. In large flood events a vast floodplain is inundated which supports very large congregations of waterbirds. Eighty three species are recorded from the site, many of which breed at the site. Contributes to meeting criteria 4 and 5.

5 **Waterbirds - priority wetland species.** During large flood events the site supports 18 international and many national migratory species. The site also regularly supports 1% of two species of waterbirds: red-necked avocets and pink-eared duck. Contributes to meeting criteria 4 and 6.

6 7 **Supports biodiversity.** As well as supporting large numbers of waterbirds and other wetland dependent species, the site also supports high species richness of drland birds, mammals, amphibians and reptiles. During large flood events these species utilise a broad range of habitats across the inundated floodplain. Contributes to meeting criterion 3.

8 **Supports threatened species.** Seven nationally listed species and 38 state listed species are found within the site. Contributes to meeting criterion 2.

Figure 56: Conceptual model showing key elements of the ecological character of Coongie Lakes during a large flood event.


5
2
4
3
1

Components, processes, and services.

1 **Waterholes**. This model represents cease to flow conditions where the majority of the floodplain is dry and locations with water are disconnected. Biota retreat into permanent and semi-permanent waterholes and lakes, such as Coongie Lake. Fish populations can be very large initially, but will crash as conditions decline and resources become scarce. Adult Cooper Creek turtles also use permanent waterholes as a strong hold for maintaining the local populations and occur in very large numbers. The presence of permanent water in an arid environment is critical to the ecological character of the site as it allows obligate aquatic species to persist. This contributes to meeting criteria 1 and 4.

2 **Hydrology.** Some wetlands will retain water for months to years after a large flood event. Near permanent wetlands such as Coongie Lakes do not undergo significant periods of dry as they typically received annual inflows. However wetlands in the lower section of the site will eventually dry and lead to local extinctions of obligate aquatic species, which will have to recolonise in the next large flood. Local rainfall and run-off may increase the longevity of these hydrological disconnected wetlands. Contributes to meeting criterion 4.

3 4 **Biodiversity.** As water recedes to the permanent waterholes and wetlands these become the focus of both terrestrial and aquatic biodiversity as they represent the only secure source of water in an arid environment..

5 **Rain fed wetlands.** Scattered throughout the floodplain and concentrated in the northern lakes - Cordillo downs area of the site are rain fed wetlands. These fill from local storm events and run-off. They are isolated from the main floodplain wetlands and as such do not support fish. They are trophically different and often variable in their species composition according to their inundation history. Temporary wetland specialists dominate the invertebrate fauna, including many species which actually require a drying phase to complete their life cycles. These wetlands are 'available' at different spatial and temporal scales and are believed important in providing resources to dispersing waterbirds. Contributes to meeting criteria 1 and 3.

Figure 57: Conceptual model showing key elements of the ecological character of Coongie Lakes during cease to flow conditions.

5. Threats to Ecological Character

Wetlands are complex systems and an understanding of components and processes and the interactions or linkages between them is necessary to describe ecological character. Similarly threats to ecological character need to be described not just in terms of their potential effects, but the interactions between them. One mechanism for exploring these relationships is the use of stressor models (Gross 2003). The use of stressor models in ecological character descriptions has been suggested by a number of authors to describe ecological character (for example Phillips and Muller, 2006; Hale and Butcher 2008) and to aid in the determination of limits of acceptable change (Davis and Brock 2008).

Stressors are defined as (Barrett et al. 1976):

"*physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level*"

In evaluating threats it is useful (in terms of management) to separate the threatening activity from the stressor. In this manner, the causes of impacts to natural assets are made clear, which provides clarity for the management of natural resources by focussing management actions on tangible threatening activities.

There are a number of potential and actual threats that may impact on the ecological character of Coongie Lakes Ramsar site. The stressor model (
Figure 58) is a simple illustration of the threatening activities (boxes), stressors (ellipses) and resulting ecological effects (diamonds) on the components processes and services (hexagons) in Coongie Lakes Ramsar site. A brief description of each threat is provided below.

5.1 Water resource development

At present the Cooper Creek remains unregulated with relatively little water diverted from the system, as such biota, including waterbirds and fish, are not severely threatened by upstream water management practices compared to other basins such as the Murray-Darling Basin (Kingsford and Porter 2008). Irrigation agriculture is poorly suited to the area and as such the main agricultural activities are beef and sheep production (DNWR 2008). The Cooper Creek Water Resource Plan is currently being drafted and when completed will replace the Water Resource (Cooper Creek) Plan 2000. The plan will provide a framework for the allocation of licenses for water use in the Queensland section of the Cooper Creek catchment.

Wetland hydrology dictates the ecological signature of wetlands. In an arid environment water resource development, even relatively minor levels of development, has the potential to significantly change the ecological character of the Ramsar site.

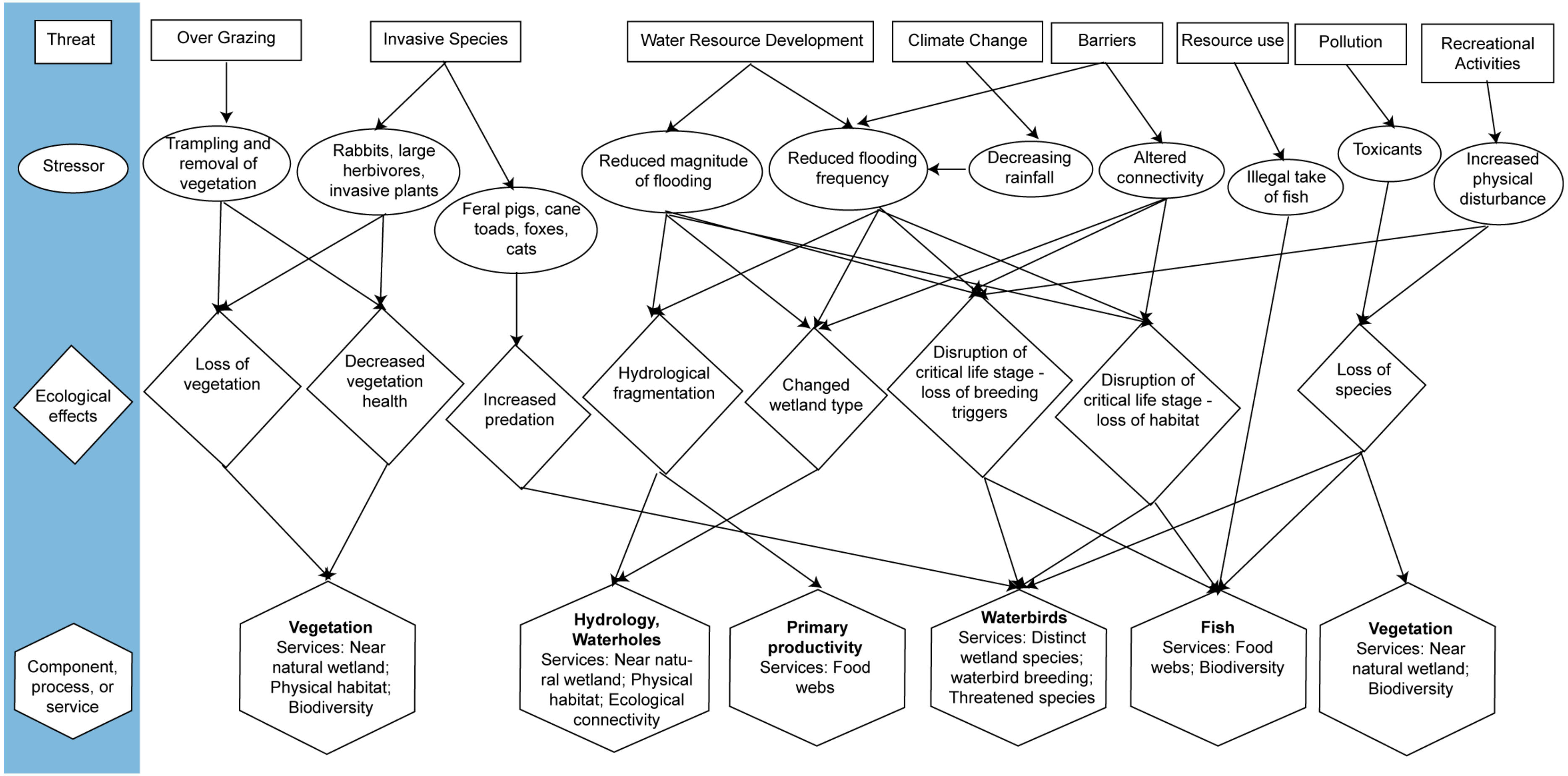


Figure 58: Stressor model of threats to ecological character of Coongie Lakes Ramsar site (after Gross 2003 and Davis and Brock 2008).

5.2 Climate change

Under the ClimateQ program, assessments of climate change have been produced for 13 regions across Queensland. Data from the Central and South West regions are relevant to the Cooper Creek catchment, however as they represent areas greater than the catchment these figures should be used with caution. In both regions increases in temperature and evaporation are predicted. Rainfall over the past decade has decreased in both regions, but is within natural variation (DERM 2009). Temperature is predicted to rise in the order of 3.5 degrees; evaporation will also increase in the order of three to 15 percent by 2070. Rainfall predictions are more varied with the ranges given for each region in the order of an annual increase of 20 percent to a decrease of 38 percent. A decline in rainfall is predicted under ‘best estimates’ for all emissions levels modelled (DERM 2009). It is unclear what impacts such changes would have on inflows, however the increased evaporation and reduced rainfall would most likely lead to shorter periods of inundation and longer dry periods.

Cobon and Toombs (2007) modeled the impacts from climate change on seasonal and annual flows in the Thomson River, a tributary of the Cooper. There results suggested impacts were likely to include reduced persistence of waterholes and connectivity during droughts, reduced magnitude of large events and an associated loss of habitat and biodiversity as less floodplain is inundated.

Waterbird populations may be affected by climate change if increased temperatures lead to increased evaporation and faster drying of wetlands (Kingsford and Porter 2008). Different species of waterbird require different lengths of inundation to complete their life cycles. Shorter lengths of inundation will decrease the number of successful breeding events in some species, with a likely decline in the number of waterbirds breeding at the site.

In small flood events, there was a significant decrease, 75 percent, in inundation extent which would also have significant impacts on riparian vegetation (Cobon and Toombs 2007). Whilst these results were modeled for a tributary the general impacts would cascade downstream and have the potential to significantly affect the hydrological persistence of wetlands within the Ramsar site.

Decreases in local rainfall and run-off as a result of climate change could have an impact on the persistence of waterholes in dry periods. Local rainfall events were shown to ‘top up’ shallower waterholes, retaining water for longer and diluting saline waterbodies (Costelloe et al. 2004b).

5.3 Pollution – gas and oil development

Exploration and development of gas and oil in the region has the potential to impact on the site in a number of ways. Development of roads and causeways can lead to increased localised erosion and barriers to hydrological and ecological connectivity (see Section 5.7). There is also the potential for oil spills from pipelines.

5.4 Invasive species

Roberts (1988) identified rabbits as a possible threat to the vegetation of the Coongie Lakes, suggesting that grazing pressure was evident in some areas fringing the lakes leading to simplified vegetation dominated by species which were not palatable to rabbits. Feral pigs are present within the site and have the potential to impact on waterbird breeding through predation and habitat degradation, and they pose safety risk to visitors to the region. Feral pigs are subject to ongoing management in the Innamincka regions through culling and baiting programs (DENR 2011). Feral cats and foxes also occur within the site. Of major concern is the possible extension of cane toads (*Bufo marinus*) into the site. Cane toads and their biological impacts are listed as a Key Threatening Process under the EPBC Act, and have the potential to enter the site from Queensland as free swimming tadpoles in large flood events (DENR 2011). DENR (2011) consider there is also potential for cross country dispersal into the site. Cane toads could have significant impact on native fauna should they reach the Ramsar site.

There are relatively few invasive plant species found within the site, approximately six percent of the species recorded within the site (DEHAA 1999). Several weeds of concern for the site include are Weeds of National Significance including Mesquite spp. (*Prosopis spp.*), Mexican poppy (*Argemone ochroleuca*), parkinsonia (*Paarkinsona* arculeta) and prickly acacia (*Acacia nilotica*) (DENR 2011).

Unlike many other wetlands within Australia the number of native fish species are greater than the introduced species. The highly variable natural hydrological regime is believed to favour native species over introduced species. Two invasive species have been recorded in the site, goldfish (*Carassius auratus*) and eastern gambusia (*Gambusia holbrooki*). However their numbers are extremely low compared to other river systems and as such Pritchard et al. (2004) suggest that high abundances of invasive fish species are a result, not the cause, of degraded river health.

A clear understanding of the relative impacts of the invasive species within the Ramsar site on the critical components, process and services is lacking and remains a knowledge gap. However, other than predation on waterbirds the impacts of invasive species are thought to be relatively minor and unlikely to lead to a change in ecological character.

5.5 Recreational activities

Tourism and recreational activities are increasing in the area. Aesthetic values of the region are appreciated by many different groups of people including photographers and artists. Bird watching is another activity linked to the presence of water. Impacts from recreation and tourism activities tend to be centered, although not restricted to, the permanent waterholes. People are naturally drawn to water in an arid landscape and as such they are subjected to concentrated pressure. This can include compaction of soil, loss of vegetation, introduction of pollutants and nutrients into the water. Of particular concern is the increasing pressure tourism is having on woody vegetation including coolabah and other long lived species which are targeted for firewood. Removal of firewood and leaf litter is considered a significant activity. Soil compaction around key waterholes and camping areas is also a problem. As the region becomes more accessible this type of impact will increase, with increased pressure placed on permanent waterholes such as Cullyamurra. Associated with increased visitors there is a higher risk of invasive species being introduced to the area and erosion. Recreational high use areas may be having an impact on water rat abundances at waterholes (DENR 2011). Overfishing in permanent waterholes which act as refuges for the native fish populations of the region is an emerging issue of concern associated with increased recreational activities.

5.6 Over grazing

Pastoral activities have long been established in the region, for decades prior to the site being listed. In recent times management of grazing practices has lead to reduced impacts on the site since listing (D. Wilson, pers. comm.). For example Cullyamurra waterhole and Coongie Lakes National Park are no longer grazed. The likelihood of overgrazing occurring and causing significant damage to the site is considered to be quite low. Grazing impacts are typically centred on permanent water sources and are caused by grazing stock, large introduced herbivores such as camels and horses, as well as native herbivores. Accumulation of manure in and around wetlands could result in localised build up of nutrients which may contribute to poor water quality and potentially to algal blooms; however this is also considered a low risk.

5.7 Barriers

Barriers to dispersal, in particular access to permanent waterholes or refuges, poses a considerable threat to the fish population of the Ramsar site. Seemingly small barriers can prevent species from reaching waterholes in which fish populations are maintained in dry periods. McNeil and Schmarr (2009) found differences in abundance and distribution of fish above and below the Innamincka causeway, with large adult fish of golden perch, bony herring, spangled perch, Hyrtl’s tandan and Barcoo grunters predominantly found downstream of the weir. Welch's grunter showed a reverse pattern, with large adult fish being dominant upstream of the causeway. Australian smelt and carp gudgeons do not appear to have their passage blocked as similar numbers and sizes were found upstream and downstream of the weir (McNiel and Schmarr 2009). Further investigations are underway as the potential need for a fish ladder to ensure passage upstream of the causeway.

Barriers in the form of causeways or roadways which alter the flow path of floodwaters could also impact on fish movement and access to resources and frequency of inundation and drying of areas of floodplain and wetlands. Embarka Swamp (Figure 59) has a series of causeways and roads which have changed the flow regime of the wetland as a result of gas and oil development. Tall embankments have led to water ponding to occur in some areas of the swamp. Areas where soil was removed to form the embankments have changed, becoming artificial expanses of open water (Reid 1988b).

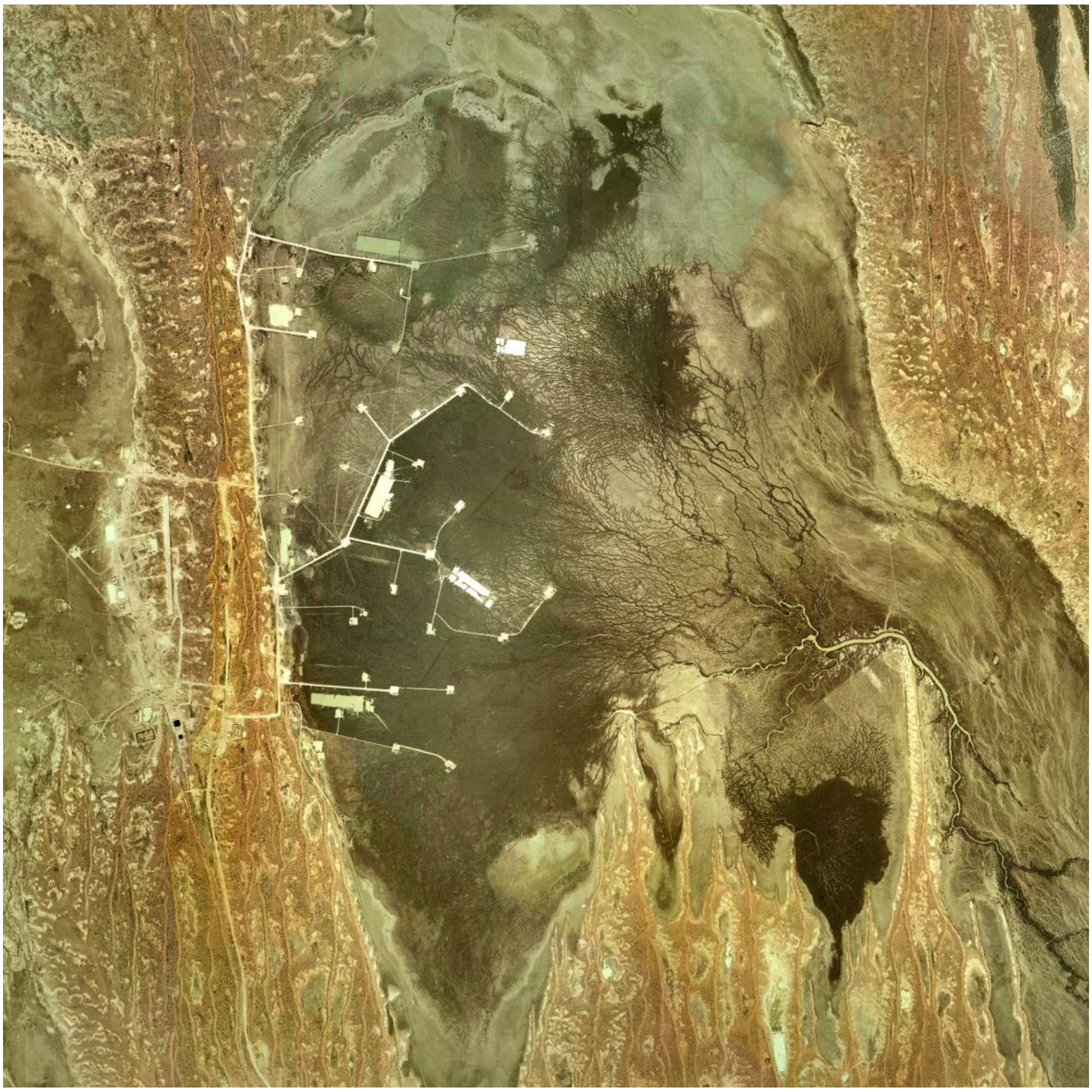


Figure 59: Embarka swamp (supplied by DENR South Australia).

5.8 Resource use

Resource uses include use of water for domestic and stock supply (particularly from waterholes during cease-to-flow conditions), recreational fishing, commercial fishing, and the removal of firewood (DEHAA 1999). Recreational fishing is often concentrated on permanent waterholes and it is not known what impact this is having on adult populations in the waterholes. Particularly during extended periods of dry this may have the potential to significantly reduce the viable fish population.

Illegal gill and drum netting for fish is a threat to the adult turtle populations in permanent waterholes. White (2002) suggested that illegal netting, used to catch yellow-belly *Macquaria ambigua* can drown turtles and has the potential to selectively reduce the adult population. Waterholes where netting has ceased for 15 years shows a recovering population, with a low adult juvenile ratio but a large number of sub-adults (White 2002). Overall, illegal fishing or take is not considered to be a significant threat to the site.

Removal of firewood is becoming a serious issue as recreational activities increase. The impact this is having on habitat is not known.

5.9 Summary of threats

Although a risk assessment is beyond the scope of an ECD, the DEWHA (2008) framework states that an indication of the impacts of threats to ecological character, likelihood and timing of threats should be included. The threats considered in the previous sections have been summarised for each location within the Ramsar site in accordance with the DEWHA (2008) framework Table 22.

Table 22: Summary of the main threats to the Coongie Lakes Ramsar site.

Actual or likely threat	Potential impact(s) to wetland components, processes and/or service	Likelihood[1]	Timing
Water resource development	• Loss of variable hydrological regime. • Loss of permanent water.	Medium	Current to short term
Climate change	• Increased temperatures leading to increased evaporation, leading to increased length of dry periods. • Reduced periods of inundation.	Medium	Short to long term
Invasive species	• Loss of vegetation on dunes – increased erosion.	Certain	Current
Pollution	• Loss of biota due to exposure to toxicants/ hydrocarbons.	Low	Current
Connectivity	• Changed connectivity by roads, barriers, pond, veg loss etc	Certain	Current
Recreation and tourism	• Disturbance of biota – waterbirds, dryland birds. • Degradation of habitat by trampling, 4wd.	Certain	Current
Resource use	• Illegal fishing loss of source population of adult fish from permanent waterholes. • Removal of firewood leading to loss of groundcover and potentially increased invasive species. • Loss of turtles as bycatch from illegal fishing.	Certain	Current (known to have happened in the past)
Over grazing	• Loss of vegetation around waterholes due to trampling/grazing Include mention of feral herbivores.	Medium	Current

[1] Where Certain is defined as known to occur at the site or has occurred in the past; Medium is defined as not known from the site but occurs at similar sites; and Low is defined as theoretically possible, but not recorded at this or similar sites.

6. Limits of Acceptable Change

6.1 Process for setting Limits of Acceptable Change (LACs)

Limits of Acceptable Change are defined by Phillips (2006) as:

"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed".

Limits of Acceptable Change and the natural variability in the parameters for which limits are set are inextricably linked. Phillips (2006) suggested that LACs should be beyond the levels of natural variation. Setting limits with consideration of natural variability is an important, but complex concept. Wetlands are complex systems and there is both spatial and temporal variability associated with all components and processes. Defining this variability such that trends away from "natural" can be reliably detected is far from straightforward.

Hale and Butcher (2008) considered that it is not sufficient to simply define the extreme measures of a given parameter and to set LACs beyond those limits. What is required is a method of detecting change in patterns and setting limits that indicate a distinct shift from natural variability (be that positive or negative). This may mean accounting for changes in the frequency and magnitude of extreme events, changes in the temporal or seasonal patterns and changes in spatial variability as well as changes in the mean or median conditions.

It should be noted that LACs are not synonymous with management values or "trigger levels". The LACs described here indicate potential changes in ecological character in absolute terms rather than detecting change prior to irrevocable changes in wetland ecology. Detecting change with sufficient time to instigate management actions to prevent an irrevocable change in ecological character is the role of wetland management. The management plan for a site must develop and implement a set of management triggers with this aim.

LACs have been set for the Coongie Lakes Ramsar site based on conditions at the time of listing. It is preferable to use site-specific information to statistically determine LACs. However, in the absence of sufficient site-specific data, LACs are based on recognised standards or information in the scientific literature that is relevant to the site. In these cases, the source of the information upon which the LAC is determined is provided. For Coongie Lakes, there is a very limited amount of site-specific data for most of the critical components, processes and services; therefore, qualitative LACs based on the precautionary principle are recommended and will require careful review as information is gained from future monitoring.

The columns in Table 3 contain the following information:

Component / Process	The component or processes for which the LAC is a direct measure.
Baseline / supporting evidence	Relevant baseline information (relevant to the time of listing) and any additional supporting evidence from the scientific literature and / or local knowledge.
Limit of Acceptable Change	The LAC stated as it is to be assessed against.
Confidence level	The degree to which the authors are confident that the LAC represents the point at which a change in character has occurred. Assigned as follows:

High – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measurable.

Medium – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific literature; or informed expert opinion; LAC is objectively measurable.

Low – No site specific data or reliable evidence from the scientific literature or expert opinion, LAC may not be objectively measurable and/or the importance of the indicator to the ecological character of the site is unknown.

Additional explanatory notes for Limits of Acceptable Change

Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.

Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.

While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.

Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

Table 23: Proposed Limits of Acceptable Change (LACs) for Coongie Lakes Ramsar site.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Hydrology	Costello (2008) classified floods into three types: large, terminal and local flows. In the period 2000-2008 only one large event occurred, every other year the floods were terminal in nature. Approximately eight large events occurred between 1973 and 2000. Terminal floods, those that terminate in the Coongie Lakes, can vary considerably in magnitude. For this reason LACs have been set for key wetlands on the assumption that if their hydrological requirements are met then many other wetlands upstream will also have their flow regime met, and potentially along other sections of the Cooper Creek. LACs have been set for two wetlands within Coongie Lakes; however, it was generally considered that in an arid environment a 10 to 20 percent change in frequency of inundation would constitute a change in character. It should be noted that whilst terminal floods reach the Coongie Lakes, they also inundate the upper reaches of the main branch of the Cooper. Large floods, those that course through Coongie Lakes and into the northern overflow are rarer. During large flood events both the northern and main pathways are inundated and flows can reach downstream of Lake Hope to the end of the Ramsar site. LACs for the Coongie Lakes are based on frequency of inundation given in Puckridge et al. (2010). On average, at listing, Coongie Lake would receive annual inflows, so an extended dry period with no water lasting longer than 12 months, was considered to represent a potential tipping point in such an arid environment.	Coongie Lake receives inflows no less than eight times in any ten year period, with no dry period lasting longer than 12 consecutive months. Lake Goyder receives inflows no less than six times in any ten year period, with no dry period lasting longer than 30 consecutive months. Large flood events (as defined by Costelloe 2008) occur no less than four times in any 30 year period.	Medium.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Waterholes	Silcock (2009) identified a number of permanent and semi-permanent waterholes (those that had water more than 70% of the time) within the Ramsar site, mainly concentrated in the upper reaches of the main branch and northwest branch. Permanent waterholes are a critical feature of the site, acting as refuges for aquatic species during cease-to-flow conditions. In an arid landscape, any loss of permanent water or change in frequency of inundation for semi-permanent waterholes has significant impacts on the biota of the site – as such 'no change' has been used as the basis of the LAC.	No drying of any permanent waterholes. No drying of semi-permanent waterholes to less than 70 percent of time inundated over any 20 year time period.	Medium.
Geomorphic setting	The geomorphic setting is dynamic and heavily influenced by the hydrological regime, particularly the formation and maintenance of waterholes. Therefore it is assumed that the LACs for hydrology and waterholes would be suitable surrogates to account for changes in geomorphic setting (i.e. changing flow paths, creation and loss of waterholes).	No direct LAC has been developed and instead the critical component will be assessed indirectly through changes in hydrology and in waterholes, see LACs above.	Not applicable.
Primary productivity	Productivity in the boom, bust and bits in between (Bunn et al. 2006b) is predominantly driven by hydrology. As such maintenance of the natural, highly variable, hydrological regime should ensure the maintenance of this critical process. Therefore, without a direct baseline of productivity, it is assumed that the LACs for hydrology would be a suitable surrogate accounting for changes in productivity.	Insufficient data – no direct LAC has been developed and instead the critical process will be assessed indirectly through changes in hydrology, see LACs above.	Not applicable.
Vegetation	Mapping of vegetation associations are insufficient to set LAC. However, persistence of vegetation is evidence of no sustained loss of habitat over time, with vegetation associations closely reflecting inundation history. In an arid landscape any change in the frequency or extent of inundation across the floodplain has significant impacts on the vegetation of the Ramsar site; therefore the hydrology LACs are considered a suitable surrogate.	Data insufficient - No direct LAC has been developed and instead the critical component will be assessed indirectly through changes in hydrology, see LAC above.	Not applicable.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Fish	A total of 13 species of native fish have been recorded from the site (Puckridge et al. 2010). The majority of species are commonly encountered with standard assessment methods in the upper reaches of the site (upstream from Coongie Lakes). The exceptions are the Cooper catfish and glassfish, which are more rarely collected (D. McNeil, pers comm.). A complete understanding of the spatial coverage of fish species across the entire site is lacking. As such, the LAC is set for the upstream section of the main and northwest branch from Embarka Swamp and Coongie Lakes upstream to the Queensland border. A change of 20 percent is adopted as the basis of the LAC as fish populations can be quite variable spatially and temporarily and was selected based on expert opinion. The timeframe of assessment took into consideration that three years is the typical life span for many of the small bodied native fish. Sampling effort strongly influences determination of species diversity. Work is underway by SARDI to establish sampling effort required to adequately assess fish communities of the Ramsar site (D. McNeil, pers. comm.). Methods adopted for the LEB Rivers Assessment program should be considered the minimum required for fish sampling. In due course the ongoing LEB River Assessment monitoring program will provide information to refine the LAC (D. McNeil, pers comm.) Seasonal sampling is recommended, that is, pre (November) and post (April/May) flooding events for the assessment of fish populations (Balcombe and McNeil nd).	No less than eight of 13 native species recorded from any three of five comprehensive sampling events (assumes seasonal sampling) from the main branch and northwest branch, from the Queensland border downstream to Coongie Lakes and Embarka Swamp including Cullyamurra waterhole.	Medium.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Waterbirds/abundance	Large numbers of waterbirds occur at the site following significant inundation. However, complete counts are rare and numbers are highly variable. The mean abundance from 13 counts over the period 1987 to 2004 is 70 000 with a standard deviation of 36 000 (data from Birds Australia unpublished; Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999 and Reid et al. 2004). The LAC based on the mean, minus one standard deviation and two thirds of seasons in which the floodplain is inundated to account for variability.	In any 12 year period, a minimum of 34 000 waterbirds in two out of every three years in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008).	Medium.
Waterbirds/supports 1% of populations	The site is known to regularly support more than one percent of the Australian population of red-necked avocet and pink-eared duck. However, numbers are highly variable with the standard deviation close to or greater than the mean for both species as follows: Red-necked avocet: mean 4000, standard deviation 4700; Pink-eared duck: mean 26 000, standard deviation 21 000. However, for both species, the site supports greater than one percent of the population in at least two thirds of the years when inundation of the floodplain occurs (data from Birds Australia unpublished; Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999 and Reid et al. 2004). The LAC is therefore based on retaining abundance greater than the one percent population (allowing for Australian population changes) in two out of three years in which the floodplain is inundated.	Greater than one percent of the Australian population (based on the most recent population estimates by Wetlands International) of red-necked avocet (1100) and pink-eared duck (10 000) in two years in every three in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008). Note this is based on 2010 population estimates; if estimates are changed the LAC needs to reflect those changes.	Medium.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Waterbirds/ breeding	Fifty-four species of waterbird have been observed breeding within the site (Appendix B). However, quantitative data on nesting and breeding have not been consistently collected at the site and available data are limited to occasional observations (Reid 2004). As such a quantitative LAC cannot be set at this point in time.	Data deficient, baseline must be established before LAC can be determined.	Not applicable.
Waterbirds/species richness	The site supports a diversity of waterbirds with a total of 83 species recorded from the site. Over a flood period species richness ranged from 40 to 61 with an average number of waterbird species of 51 ± 7 (mean ± standard deviation) (data from Reid et al. 2004). The LAC is based on the mean, minus one standard deviation and two thirds of seasons in which the floodplain is inundated to account for variability. A time frame of 15 years is used to capture large flood events which occur every 3 to 4 years.	A minimum of 45 species during peak inundation in two out of three years in which there are sufficient inflows to inundate the floodplain (i.e. large floods as per Costelloe 2008). To be assessed over any 15 year period.	Medium.
Near natural wetland ecosystem	The Cooper Creek has a natural hydrological regime which in turn supports a vast a complex floodplain which forms the majority of the Ramsar site. The rain-fed northern lakes add to the hydrological and ecological complexity of the site. There are relatively few serious threatening activities and the ecological character of the site has been maintained since the time of listing.	See LACs for hydrology and waterholes.	Not applicable.
Physical habitat	Physical habitat for waterbird breeding is maintained through the natural hydrological regime.	See LACs for hydrology.	Not applicable.
Ecological connectivity	Hydrological connectivity ensures ecological connectivity within the site. Maintenance of fish, turtles and other obligate aquatic species are supported by the waterholes which act as refuges in dry periods.	See LACs for hydrology and waterholes.	Not applicable.

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Food webs	Primary productivity underpins the aquatic food webs of the system. Hydrological regime drives the boom and bust periods.	See LACs for hydrology.	Not applicable.
Special ecological, physical or geomorphic features	Presence of waterholes provides critical drought refuge in an arid landscape. This service is	See LAC for waterholes.	Not applicable.
Priority wetland species	The site supports 18 international migratory species. This service will be captured by the LAC for waterbird abundance and species richness.	See LAC for supporting large numbers of waterbirds.	Not applicable.
Threatened species	The site supports the Australian painted snipe (*Rostratula australis*) (Reid et al. 2004). Sightings of this species are limited and potentially reflect the fact that most surveys have not included targeted surveying for this species.	Data deficient, baseline must be established before LAC can be determined.	Not applicable.
Biodiversity	The biodiversity values of the site are a result of the natural hydrological regime and hydrological persistence in an arid environment. Both aquatic and terrestrial species utilise the wetland habitat and water supply.	See LAC for hydrology and waterholes.	Not applicable.

7. Current Ecological Character and Changes since Designation

Change in ecological character is defined as the human-induced adverse alteration of any ecosystem component, process and/or ecosystem benefit or service (Ramsar Convention 2005, Resolution IX.1 Annex A). Changes to the ecological character of the wetland outside natural variations may signal that uses of the site or externally derived impacts on the site are unsustainable and may lead to the degradation of natural processes and thus the ultimate breakdown of the ecological, biological and hydrological functioning of the wetland (Ramsar Convention 1996, Resolution VI.1). Guidance from the Australian Government indicates that positive change to ecological character should also be documented. Change should be established against the ecological character at the time a site was listed as a Ramsar site.

In preparing this ECD it is very evident that there have been no significant impacts or change to the character of the site, despite a lack of data for many of the wetlands within the system. The ecology of the site is intact and is an excellent example of a large near natural dryland river system. The hydrology, geomorphic setting and biota at Coongie Lakes have not changed since listing other than exhibiting the extremes typical of a highly variable and dynamic wetland ecosystem.

The ecological character of the site has not changed and the site continues to meet the six criteria for which it was listed as well as meeting Criterion 8 (see Section 2.5).

8. Knowledge Gaps

Throughout the Ecological Character Description for Coongie Lakes Ramsar site, mention has been made of knowledge gaps and data deficiencies for the site. While it is tempting to produce an infinite list of research and monitoring needs, it is important to focus on the purpose of an ecological character description and identify and prioritise knowledge gaps that are important for describing and maintaining the ecological character of the system.

Knowledge gaps that are required to be addressed so as to fully describe the ecological character of this site and enable rigorous and defensible Limits of Acceptable Change to be met are relatively few (Table 24). A major limitation in preparing this ECD is that the vast majority of information available relates only to the permanent waterholes, upper reaches of the Cooper Creek, northwest branch and Coongie Lakes. This represents a relatively small proportion of the wetlands within the site. In particular there is virtually nothing known on the extent and ecology of the rain fed wetlands in the northern lakes area of the site. These are believed to be limnologically distinct from the floodplain wetlands and warrant investigation.

Table 24: Knowledge gaps for Coongie Lakes Ramsar site

Knowledge Gap	Recommended Action
Mapping against Ramsar wetland types including fine scale mapping of intermittent rain fed systems.	Undertake mapping of wetland types using LiDAR or other remote sensed data.
Inundation frequency by Ramsar wetland types, including rates of drying.	Determine frequencies of inundation for each wetland type.
Flow paths of water movement across the site.	Map major flow paths.
Mapping of all waterholes, including those which have water for less than 70 percent of the time.	Silcock (2009) only mapped semi-permanent and permanent waterholes which held water for more than 70 percent of the time – map other waterholes within the site, in particular waterholes in the lower section of the site. Morphological and water quality measurements of waterholes would provide quantitative data to validate remote sensed data. Link to investigations of groundwater surface water interactions.
Ecological values and hydrological regime of rain fed wetlands.	Undertake baseline surveys of biota, water quality and hydrological regime.
Ecological connectivity – movement patterns of biota across wetland within the site.	Investigate pattern of wetland use by different biotic groups. Include consideration of seasonality.
Groundwater surface water interactions.	Hydrological investigations of groundwater surface water interactions, particularly in waterholes.
Interdependence of some ecological communities on groundwater.	Investigate linkages between groundwater influence on seed and egg banks, contributing to productivity and boom – bust cycles.
Spatial distribution of native fish in the temporary floodplain wetlands and waterholes, as well as lower Cooper Creek.	Expand survey work to encompass greater spatial range and diversity of habitats sampled.
Improved mapping of vegetation communities.	Undertake fine scale mapping of vegetation associations. Undertake condition assessment of major communities, river red gum in particular.
Presence of cryptic species of waterbirds, such as the Australian painted snipe.	Targeted on-ground surveys.

Knowledge Gap	Recommended Action
Reproductive success of waterbirds.	Monitor breeding events.
Importance, composition and longevity of seed and egg banks for sustaining productivity, in relation to hydrological regime and wetland type.	Survey seed and egg banks.
Understanding of sources of carbon and primary productivity within the river, floodplain and lakes.	Investigation of carbon sources for primary productivity and relationship to flood events.
Role of flooding as a trigger for spawning in fish species.	Establish relative importance of seasonal versus flood triggers for breeding within the site.
Genetic confirmation of fish species within the Ramsar site, most notably the hybrid species identified and carp gudgeons.	Genetic assessment of native fish species.
Impacts of invasive species.	Establish extent and severity of threat.
Potential of tropical invasive species to invade the site – e.g. cane toad, plant spp.	Implement proposed actions in North-east Deserts District Landscape Biodiversity Action Plan (DENR 2011).

9. Monitoring needs

As a signatory to the Ramsar Convention, Australia has made a commitment to protect the ecological character of its Wetlands of International Importance. Under Part 3 of the EPBC Act a person must not take an action that has, will have or is likely to have a significant impact on the ecological character of a declared Ramsar wetland. While there is no explicit requirement for monitoring the site, in order to ascertain if the ecological character of the wetland site is being protected a monitoring program is required.

A comprehensive monitoring program is beyond the scope of an ECD. What is provided is an identification of monitoring needs required to both set baselines for key components and processes and to assess against limits of acceptable change. It should be noted that the focus of the monitoring recommended in an ECD is an assessment against LAC and determination of changes in ecological character. This monitoring is not designed as an early warning system whereby trends in data are assessed to detect changes in components and processes prior to a change in ecological character of the site. This must be included in the management plan for the site.

The recommended monitoring to meet the obligations under Ramsar and the EPBC Act with respect to Coongie Lakes Ramsar site are provided in Table 75. There are a number of existing monitoring programs within Coongie Lakes Ramsar site and some of the monitoring recommended may already be contained in these existing programs.

Table 75: Monitoring needs for Coongie Lakes Ramsar site.

Component/ Process	Purpose	Indicator	Locations	Frequency	Priority
Waterholes	Assessment against LAC.	Inundation patterns.	Waterholes in upper reach.	Annual.	High.
Hydrology	Assessment against LAC.	Frequency of inundation, magnitude at Cullyamurra.	Coongie Lakes, Cullyamurra waterhole.	Annual.	High.
Water quality	Establishment of baseline in rain fed wetlands.	Turbidity, salinity, nutrients.	Northern lakes.	Event based.	Low.
Vegetation	Establish baseline across site.	Location, composition, condition.	Entire site at baseline then selected areas for ongoing assessment.	Once off.	Moderate.
Fish	Measure against LAC.	Identification and abundance.	Permanent waterholes, floodplain wetlands and main channel in northwest branch and main branch to Coongie Lakes and Embarka Swamp.	Seasonal – pre and post wet season.	Moderate.
Invertebrates	Establishment of baseline in rain fed wetlands.	Identification and abundance.	Rain fed wetlands.	Event based.	Low.
Waterbirds	Measure against LAC and establish use of rain fed wetlands.	Identification and abundance.	Entire site (aerial) and ground surveys in accessible areas.	Following inundation of the floodplain.	High.
Threatened species	Monitor against threats.	Location, abundance.	Entire site.	Annual.	Low.

10. Communication and Education Messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

a) The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management.
b) The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society.
c) The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

The management plan for the Coongie Lakes Ramsar site contains a number of key communication messages and a program for implementing community education. Key CEPA messages for Coongie Lakes Ramsar site arising from this ECD, which should be promoted through this program, include:

- Coongie Lakes is listed as a Wetland of International Importance under the Ramsar convention. At the time of listing in 1987, it met seven of the nine Ramsar Nomination criteria.

- Coongie Lakes constitutes the bulk of the lower Cooper Creek floodplain, from the Queensland border to just above the inflow to Lake Eyre. The Cooper Creek is one of the last unregulated rivers in Australia and has a natural hydrological regime.

- A key feature of the system is the hydrological persistence of waterholes and some permanent wetlands which allow the persistence of wetland dependent biota in an arid landscape.

- Permanent and semi-permanent waterholes and wetlands provide critical refuge during dry periods.

- Coongie Lakes has significant cultural heritage values, both indigenous and European, the focus of which has been on the permanent waterholes of the region.

- The site exhibits a boom and bust ecology with large flood events inundating the floodplain which has high productivity. Very large numbers of waterbirds congregate in large flood events with a large number of species breeding on site.

- Terrestrial biodiversity is concentrated along the waterways of the site, where water and habitat sustain populations in an arid environment.

- The site supports a significant number of threatened species including species listed at the national and state levels.

- Invasive species whilst present within the site are currently managed by regional staff of DENR South Australia, with little overall impact on the ecology of the site. Native fish dominate the fish populations with invasive species disadvantaged by the natural hydrological regime.

- Climate change has the potential to exacerbate the impacts of upstream water extraction through increased temperature and evaporation.

- This site is remote and limited research has been undertaken. Continued investigation into the ecology and function of this large and complex site will provide key information for the management of large dryland rivers.

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Appendix A: Methods

A.1 Approach

The method for compiling this ECD comprised of the following tasks:

Project Inception:
Consultant team leader Rhonda Butcher met with the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) project manager to confirm the scope of works and timelines as well as identifying relevant stakeholders that would be consulted.

Task 1: Review and compilation of available data
The consultant team undertook a thorough desktop review of existing information on the ecology of Coongie Lakes Ramsar site. In addition data was supplied by DECCW.

Task 2: Stakeholder engagement and consultation
A Steering Committee was formed for the preparation of Coongie Lakes Ramsar site ECD. This group was comprised of stakeholders with an interest in the ECD and management planning process, and included representatives of the following organisations:

- Department of Environment and Natural Resources, Adelaide and Innamincka, South Australia; and
- Department of Sustainability, Environment, Water, Population and Communities

Members of the Steering Committee provided verbal and written comments on drafts of the ECD.

Task 3: Development of a draft ECD
Consistent with the national guidance and framework (2008) the following steps were undertaken to describe the ecological character of Coongie Lakes Ramsar site.

Steps from the national draft (2008) framework	Activities
1. Document introductory details.	Prepare basic details: site details, purpose, legislation.
2. Describe the site.	Based on the Ramsar RIS and the above literature review describe the site in terms of: location, land tenure, Ramsar criteria and wetland types (using Ramsar classification).
3. Identify and describe the critical components, processes and services.	Identify all possible components, services and benefits. Identify and describe the critical components, services and benefits responsible for determining ecological character.
4. Develop a conceptual model of the system.	Two types of models were developed for the system: • A series of control models that describe important aspects of the ecology of the site, including feedback loops. Aiding in the understanding of the system and its ecological functions. • A stressor model that highlights the threats and their effects on ecological components and processes. Aiding in understanding management of the system.
5. Set Limits of Acceptable Change.	For each critical component process and service, establish the limits of acceptable change.
6. Identify threats to the site.	This process identified both actual and potential future threats to the ecological character of the wetland system.
7. Describe changes to ecological character since the time of listing.	This section describes in quantitative terms (where possible) changes to the wetlands since the initial listing in 2002.

Steps from the national draft (2008) framework	Activities
8. Summarise knowledge gaps.	This identifies the knowledge gaps for not only the ecological character description, but also for its management.
9. Identify site monitoring needs.	Based on the identification of knowledge gaps above, recommendations for future monitoring are described.
10. Identify communication, education and public awareness messages.	Following the identification of threats, management actions and incorporating stakeholder comments, a general description of the broad communication / education messages are described.

Task 4: Revision of the Ramsar Information Sheet (RIS)
The information collated during Task 1, together with the draft Ecological Character Description was used to produce a revised RIS in the standard format provided by Ramsar Convention.

Task 5 Finalising the ECD and RIS
The draft ECD and RIS were submitted to DSEWPAC, and the Steering Committee for review. Comments from agencies and stakeholders were incorporated to produce revised ECD and RIS documents.

A.2 Consultant Team

Rhonda Butcher (project manager)
Rhonda is considered an expert in wetland ecology and assessment. She has a BSc (hons) and a PhD in Wetland Ecology together with over twenty years of experience in the field of aquatic science. She has extensive experience in biological monitoring, biodiversity assessment, invertebrate ecology as well as wetland and river ecology having worked for CSIRO/Murray Darling Freshwater Research Centre, Monash University/CRC for Freshwater Ecology, Museum of Victoria, Victorian EPA and the State Water Laboratories of Victoria. Rhonda has worked on numerous Ramsar related projects over the past eight years, including the first pilot studies into describing ecological character. She has subsequently co-authored, provided technical input, and peer reviewed a number of Ecological Character Descriptions. She project managed the preparation of Ramsar nomination documents for Piccaninnie Ponds Karst Wetlands in South Australia, which included preparation of the ECD, RIS and Ramsar Management Plan, and the preparation of the ECD for Banrock Station Wetland Complex. Other ECD project's Rhonda has had technical input to include the Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Peel-Yalgorup, Eighty-mile Beach, Port Phillip Bay. Rhonda is currently project managing the Ramsar Rolling Review developing a framework for reporting the status of ecological character at all 65 Ramsar sites in Australia.

Jennifer Hale
Jennifer has over twenty years experience in the water industry having started her career with the State Water Laboratory in Victoria. Jennifer is an aquatic ecologist with expertise in freshwater, estuarine and near-shore marine systems. She is qualified with a Bachelor of Science (Natural Resource Management) and a Masters of Business Administration. Jennifer is an aquatic ecologist with specialist fields of expertise including phytoplankton dynamics, aquatic macrophytes, sediment water interactions and nutrient dynamics. She has a broad understanding of the ecology of aquatic macrophytes, fish, waterbirds, macroinvertebrates and floodplain vegetation as well as geomorphic processes. She has a solid knowledge of the development of ecological character descriptions and has been involved in the development of ECDs for Port Phillip Bay and Bellarine Peninsula (current), the Peel-Yalgorup, the Ord River Floodplain, Eighty-mile Beach, the Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Elizabeth and Middleton Reefs, Ashmore Reef and the Coral Seas Ramsar sites.

Halina Kobryn

Dr Halina Kobryn has over fifteen years of experience in applications of GIS and remote sensing in environmental applications. She is a GIS and remote sensing expert, specialising in natural resource assessment. Dr Kobryn has a BSc in Physical Geography and Cartography, Graduate Diploma in Surveying and Mapping and a PhD which explored impacts of stormwater on an urban wetland and explored GIS methods for such applications. She has worked at a university as a lecturer for over 15 years and taught many subjects including GIS, remote sensing, environmental monitoring and management of aquatic systems. She has developed the first course in Australia (at a graduate level) on Environmental Monitoring. She has been involved in many research and consulting projects and her cv outlines the breadth of her expertise. She has also supervised over 20 research students (honours, Masters and PhD). She has worked in Indonesia, Malaysia (Sarawak) and East Timor on projects related to water quality and river health.

An expert panel was established to contribute data, provide technical advice and to review draft versions of the ECD and RIS. The panel for this project included:

- Julian Reid, Australian National University – waterbird and arid zone ecology expert
- Justin Costelloe, University of Melbourne – hydrology and arid zone river expert
- Brian Timms, University of NSW – geomorphology and arid zone ecology expert

Appendix B: Wetland birds recorded in Coongie Lakes Ramsar Site

Listing status:
M = Migratory or marine under the EPBC Act; E = Endangered under the EPBC Act;
J = JAMBA; C= CAMBA; R = ROKAMBA, B = Bonn.

Species list compiled from Birds Australia Bird Atlas (Birds Australia unpublished); Kingsford et al. 1999; Kingsford et al. 2003; Porter et al. 2006; Reid and Puckridge 2000; Reid and Gillen 1988; Reid and Jaensch 1999 and Reid et al. 2004.

Scientific Name	Common Name	Breeding	EPBC Act Listing
Anhinga novaehollandiae	Australasian darter	Yes	
Tachybaptus novaehollandiae	Australasian grebe	Yes	
Anas rhynchotis	Australasian shoveler	Yes	
Rostratula australis	Australian painted snipe		E, C
Pelecanus conspicillatus	Australian pelican	Yes	M
Stiltia isabella	Australian pratincole	Yes	M
Acrocephalus australis	Australian reed-warbler	Yes	
Tadorna tadornoides	Australian shelduck	Yes	
Porzana fluminea	Australian spotted crake	Yes	
Threskiornis molucca	Australian white ibis		M
Chenonetta jubata	Australian wood duck	Yes	
Porzana pusilla	Baillon's crake		M
Vanellus tricolor	Banded lapwing	Yes	
Cladorhynchus leucocephalus	Banded stilt		
Ninox connivens	Barking owl	Yes	
Cygnus atratus	Black swan	Yes	
Elseyornis melanops	Black-fronted dotterel		
Ephippiorhynchus asiaticus	Black-necked stork		
Limosa limosa	Black-tailed godwit		M, B, C, J, R
Tribonyx ventralis	Black-tailed native-hen	Yes	
Himantopus himantopus	Black-winged stilt		M
Oxyura australis	Blue-billed duck	Yes	
Grus rubicunda	Brolga	Yes	
Gallirallus philippensis	Buff-banded rail		M
Burhinus grallarius	Bush stone-curlew		
Sterna caspia	Caspian tern	Yes	M, J,C
Anas castanea	Chestnut teal		
Tringa nebularia	Common greenshank		M, B, C, J, R
Actitis hypoleucos	Common sandpiper		M, B, C, J, R
Calidris ferruginea	Curlew sandpiper		M, B, C, J, R
Gallinula tenebrosa	Dusky moorhen	Yes	
Ardea modesta	Eastern great egret	Yes	M, C, J
Fulica atra	Eurasian coot	Yes	

Scientific Name	Common Name	Breeding	EPBC Act Listing
Amytornis goyderi	Eyrean grasswren	Yes	
Stictonetta naevosa	Freckled duck	Yes	
Plegadis falcinellus	Glossy ibis	Yes	M, B, C
Phalacrocorax carbo	Great cormorant	Yes	
Podiceps cristatus	Great crested grebe	Yes	
Amytornis barbatus diamantina	Grey grasswren	Yes	
Pluvialis squatarola	Grey plover		M, B, C, J, R
Anas gracilis	Grey teal	Yes	
Gelochelidon nilotica	Gull-billed tern	Yes	M
Aythya australis	Hardhead	Yes	
Poliocephalus poliocephalus	Hoary-headed grebe	Yes	
Ardea intermedia	Intermediate egret	Yes	M
Gallinago hardwickii	Latham's snipe		M, B, C, J, R
Tringa flavipes	Lesser yellowlegs		Vagrant
Phalacrocorax sulcirostris	Little black cormorant	Yes	
Egretta garzetta	Little egret	Yes	M
Megalurus gramineus	Little grassbird	Yes	
Microcarbo melanoleucos	Little pied cormorant	Yes	
Calidris subminuta	Long-toed stint		M, B, C, J, R
Anseranas semipalmata	Magpie goose	Yes	M
Tringa stagnatilis	Marsh sandpiper		M, B, C, J, R
Vanellus miles	Masked lapwing	Yes	
Biziura lobata	Musk duck	Yes	M
Nycticorax caledonicus	Nankeen night-heron	Yes	M
Anas clypeata	Northern shoveler		M, C, J, R
Charadrius veredus	Oriental plover		M, B, J, R
Anas superciliosa	Pacific black duck	Yes	
Pluvialis fulva	Pacific golden plover		M, B, C, J, R
Phalacrocorax varius	Pied cormorant	Yes	
Egretta picata	Pied heron		
Malacorhynchus membranaceus	Pink-eared duck	Yes	
Dendrocygna eytoni	Plumed whistling-duck	Yes	
Porphyrio porphyrio	Purple swamphen	Yes	M
Charadrius ruficapillus	Red-capped plover	Yes	M
Erythrogonys cinctus	Red-kneed dotterel	Yes	
Recurvirostra novaehollandiae	Red-necked avocet	Yes	M
Calidris ruficollis	Red-necked stint		M, B, C, J, R
Platalea regia	Royal spoonbill	Yes	
Todiramphus sanctus	Sacred kingfisher	Yes	M
Calidris acuminata	Sharp-tailed sandpiper		M, B, C, J, R
Chroicocephalus novaehollandiae	Silver gull	Yes	M
Porzana tabuensis	Spotless crake		M
Threskiornis spinicollis	Straw-necked ibis		M

Scientific Name	Common Name	Breeding	EPBC Act Listing
Circus approximans	Swamp harrier	Yes	M
Chlidonias hybrida	Whiskered tern	Yes	M
Haliaeetus leucogaster	White-bellied sea eagle	Yes	M
Egretta novaehollandiae	White-faced heron	Yes	
Ardea pacifica	White-necked heron	Yes	
Tringa glareola	Wood sandpiper		M, B, C, J, R
Platalea flavipes	Yellow-billed spoonbill	Yes	

Appendix C: Dryland birds, mammals, amphibians and reptiles recorded in Coongie Lakes Ramsar Site

Dryland bird species recorded within the site – data supplied by DENR South Australia.

Common name	Scientific name	EPBC	SA listing
Australasian pipit	*Anthus novaeseelandiae*		
Australian barn owl	*Tyto delicatula*		
Australian bustard	*Ardeotis australis*		V
Australian hobby	*Falco longipennis*		
Australian magpie	*Cracticus tibicen*		
Australian owlet-nightjar	*Aegotheles cristatus*		
Australian pratincole	*Stiltia isabella*		
Australian raven	*Corvus coronoides*		
Australian ringneck	*Barnardius zonarius*		
Australian ringneck, (Ring-necked Parrot)	*Barnardius zonarius barnardi (NC)*		
Banded whiteface	*Aphelocephala nigricincta*		
Black falcon	*Falco subniger*		
Black kite	*Milvus migrans*		
Black-breasted buzzard	*Hamirostra melanosternon*		R
Black-eared cuckoo	*Chalcites osculans*		
Black-faced cuckoo-shrike	*Coracina novaehollandiae*		
Black-faced woodswallow	*Artamus cinereus*		
Black-shouldered kite	*Elanus axillaris*		
Blue bonnet	*Northiella haematogaster*		ssp
Blue-winged parrot	*Neophema chrysostoma*		V
Bourke's parrot	*Neopsephotus bourkii*		
Brown falcon	*Falco berigora*		
Brown goshawk	*Accipiter fasciatus*		
Brown quail	*Coturnix ypsilophora*		V
Brown songlark	*Cincloramphus cruralis*		
Brown treecreeper	*Climacteris picumnus*		
Budgerigar	*Melopsittacus undulatus*		
Bush stone-curlew	*Burhinus grallarius*		R
Chestnut-crowned babbler	*Pomatostomus ruficeps*		
Chestnut-rumped thornbill	*Acanthiza uropygialis*		
Chirruping wedgebill	*Psophodes cristatus*		
Cinnamon quail-thrush	*Cinclosoma cinnamomeum*		

Common name	Scientific name	EPBC	SA listing
Cockatiel	*Nymphicus hollandicus*		
Collared sparrowhawk	*Accipiter cirrocephalus*		
Common bronzewing	*Phaps chalcoptera*		
Common starling	*Sturnus vulgaris*		
Crested bellbird	*Oreoica gutturalis*		
Crested pigeon	*Ocyphaps lophotes*		
Crimson chat	*Epthianura tricolor*		
Diamond dove	*Geopelia cuneata*		
Emu	*Dromaius novaehollandiae*		
Fairy martin	*Petrochelidon ariel*		
Fan-tailed cuckoo	*Cacomantis flabelliformis*		
Flock bronzewing	*Phaps histrionica*		R
Fork-tailed swift	*Apus pacificus*		
Galah	*Eolophus roseicapillus*		
Gibberbird	*Ashbyia lovensis*		
Golden-backed honeyeater	*Melithreptus gularis laetior*		R
Grey butcherbird	*Cracticus torquatus*		
Grey falcon	*Falco hypoleucos*		R
Grey fantail	*Rhipidura albiscapa*		
Grey shrike-thrush	*Colluricincla harmonica*		
Grey-fronted honeyeater	*Lichenostomus plumulus*		
Ground Cuckoo-shrike	*Coracina maxima*		
Horsfield's bronze-cuckoo	*Chalcites basalis*		
Horsfield's bushlark	*Mirafra javanica*		
House sparrow	*Passer domesticus*		
Jacky winter	*Microeca fascinans*		ssp
Letter-winged Kite	*Elanus scriptus*		R
Little button-quail	*Turnix velox*		
Little crow	*Corvus bennetti*		
Little eagle	*Hieraaetus morphnoides*		
Magpie-lark	*Grallina cyanoleuca*		
Masked owl	*Tyto novaehollandiae*		E
Masked woodswallow	*Artamus personatus*		
Mistletoebird	*Dicaeum hirundinaceum*		
Mulga parrot	*Psephotus varius*		
Nankeen kestrel	*Falco cenchroides*		

Common name	Scientific name	EPBC	SA listing
Night parrot	*Pezoporus occidentalis*	EN	E
Olive-backed oriole	*Oriolus sagittatus*		R
Orange chat	*Epthianura aurifrons*		
Pallid cuckoo	*Cacomantis pallidus*		
Peaceful dove	*Geopelia placida*		
Peregrine falcon	*Falco peregrinus*		R
Pied butcherbird	*Cracticus nigrogularis*		
Pied honeyeater	*Certhionyx variegatus*		
Red-backed kingfisher	*Todiramphus pyrrhopygius*		
Red-browed pardalote	*Pardalotus rubricatus*		
Red-capped robin	*Petroica goodenovii*		
Red-tailed black-cockatoo	*Calyptorhynchus banksii*		ssp
Red-winged parrot	*Aprosmictus erythropterus*		R
Restless flycatcher	*Myiagra inquieta*		R
Rufous songlark	*Cincloramphus mathewsi*		
Rufous whistler	*Pachycephala rufiventris*		
Singing honeyeater	*Lichenostomus virescens*		
Slaty-backed thornbill	*Acanthiza robustirostris*		
Southern boobook	*Ninox boobook*		
Southern whiteface	*Aphelocephala leucopsis*		
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*		
Spotted nightjar	*Eurostopodus argus*		
Square-tailed kite	*Lophoictinia isura*		E
Striated pardalote	*Pardalotus striatus*		
Stubble quail	*Coturnix pectoralis*		
Tawny frogmouth	*Podargus strigoides*		
Torresian crow	*Corvus orru*		
Tree martin	*Petrochelidon nigricans*		
Wedge-tailed eagle	*Aquila audax*		
Weebill	*Smicrornis brevirostris*		
Welcome swallow	*Hirundo neoxena*		
Whistling kite	*Haliastur sphenurus*		
White-backed swallow	*Cheramoeca leucosterna*		
White-breasted woodswallow	*Artamus leucorynchus*		
White-browed babbler	*Pomatostomus superciliosus*		
White-browed treecreeper	*Climacteris affinis*		R

Common name	Scientific name	EPBC	SA listing
White-browed woodswallow	*Artamus superciliosus*		
White-plumed honeyeater	*Lichenostomus penicillatus*		
White-winged fairy-wren	*Malurus leucopterus*		
White-winged triller	*Lalage sueurii*		
Willie wagtail	*Rhipidura leucophrys*		
Yellow-plumed honeyeater	*Lichenostomus ornatus*		
Yellow-throated miner	*Manorina flavigula*		
Zebra finch	*Taeniopygia guttata*		

Mammal species recorded within the site – data supplied by DENR South Australia.

Common name	Species name	EPBC	SA listing
Bilby (greater bilby)	*Macrotis lagotis*	VU	V
Cat (feral cat)	*Felis catus*		
Cattle (European cattle)	*Bos taurus*		
Desert mouse (brown desert mouse)	*Pseudomys desertor*		
Dingo	*Canis lupus dingo*		
Dog (domestic or feral)	*Canis lupus familiaris*		
Donkey (feral donkey)	*Equus asinus*		
Dusky hopping-mouse	*Notomys fuscus*	VU	V
Fat-tailed dunnart	*Sminthopsis crassicaudata*		
Fawn hopping-mouse	*Notomys cervinus*		V
Forrest's mouse	*Leggadina forresti*		
Fox (red fox)	*Vulpes vulpes*		
Giles' planigale (paucident planigale)	*Planigale gilesi*		
Golden bandicoot	*Isoodon auratus*	VU	E
Gould's wattled bat	*Chalinolobus gouldii*		
Horse (brumby)	*Equus caballus*		
House Mouse	*Mus musculus*		
Kowari	*Dasycercus byrnei*	VU	V
Kultarr	*Antechinomys laniger*		
Lesser long-eared bat	*Nyctophilus geoffroyi*		
Little broad-nosed bat	*Scotorepens greyii*		
Long-haired rat (plague rat)	*Rattus villosissimus*		
Long-tailed planigale	*Planigale ingrami*		
Narrow-nosed planigale	*Planigale tenuirostris*		

Common name	Species name	EPBC	SA listing
One-humped camel (dromedary, Arabian camel)	*Camelus dromedarius*		
Pig (feral pig)	*Sus scrofa*		
Plains mouse (plains pat)	*Pseudomys australis*	VU	V
Rabbit (European pabbit)	*Oryctolagus cuniculus*		
Red kangaroo	*Macropus rufus*		
Sandy inland mouse	*Pseudomys hermannsburgensis*		
Short-beaked echidna	*Tachyglossus aculeatus*		
Southern freetail-bats	*Mormopterus spp. (species complex)* (NC)		
Spinifex hopping-mouse	*Notomys alexis*		
Stripe-faced dunnart	*Sminthopsis macroura*		
Water-rat	*Hydromys chrysogaster*		
White-striped freetail-bat	*Tadarida australis*		
Wolf (Dog, Dingo)	*Canis lupus* (NC)		
Wongai ningaui	*Ningaui ridei*		
Yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*		R

Amphibian species recorded within the site – data supplied by DENR South Australia.

Common name	Species name	EPBC	SA listing
Broad-palmed frog	*Litoria latopalmata*		
Desert froglet	*Crinia deserticola*		
Desert tree frog	*Litoria rubella*		
Green tree frog	*Litoria caerulea*		
Knife-footed frog	*Cyclorana cultripes*		R
Small-headed toadlet	*Uperoleia capitulata*		R
Spencer's burrowing frog	*Opisthodon spenceri*		
Spotted marsh frog	*Limnodynastes tasmaniensis*		
Trilling frog	*Neobatrachus centralis*		
	Neobatrachus sp.		
Water-holding frog	*Cyclorana platycephala*		

Reptile species recorded within the site – data supplied by DENR South Australia.

Common name	Specie name	EPBC	SA listing
Adelaide snake-eye	*Morethia adelaidensis*		
Barking gecko	*Nephrurus milii*		
Beaded gecko	*Lucasium damaeum*		
Beaked gecko	*Rhynchoedura ornata*		
Black-headed goanna	*Varanus tristis*		
Black-necked snake-lizard	*Delma tincta*		
Blacksoil skink	*Proablepharus kinghorni*		R
Broad-banded sandswimmer	*Eremiascincus richardsonii*		
Burton's legless lizard	*Lialis burtonis*		
Bynoe's gecko	*Heteronotia binoei*		
Canegrass dragon	*Diporiphora winneckei*		
Central bearded dragon	*Pogona vitticeps*		
Central netted dragon	*Ctenophorus nuchalis*		
Centralian blind snake	*Ramphotyphlops endoterus*		
Centralian bluetongue	*Tiliqua multifasciata*		
Centralian coppertail	*Ctenotus leae*		
Channel dragon	*Amphibolurus burnsi*		
Common snake-eye	*Morethia boulengeri*		
Curl snake	*Suta suta*		
Desert skink	*Liopholis inornata*		
Desert wall skink	*Cryptoblepharus australis*		
Desert wall skink	*Cryptoblepharus cf plagiocephalus* (NC)		
Dwarf skink	*Menetia greyii*		
Eastern brown snake	*Pseudonaja textilis*		
Eastern desert ctenotus	*Ctenotus regius*		
Eastern two-toed slider	*Lerista labialis*		
Eyrean ctenotus	*Ctenotus taeniatus*		
Eyrean earless dragon	*Tympanocryptis tetraporophora*		
Eyrean wall skink	*Cryptoblepharus ochrus*		
Five-lined earless dragon	*Tympanocryptis lineata*		
Gidgee skink	*Egernia stokesii*		
Gwardar	*Pseudonaja mengdeni*		
Hooded scaly-foot	*Pygopus schraderi*		
Inland taipan	*Oxyuranus microlepidotus*		
Macquarie tortoise	*Emydura macquarii*		V

Common name	Specie name	EPBC	SA listing
Mulga snake	*Pseudechis australis*		
Narrow-banded sandswimmer	*Eremiascincus fasciolatus*		
Northern spiny-tailed gecko	*Strophurus ciliaris*		
Painted dragon	*Ctenophorus pictus*		
Pink-blotched gecko	*Lucasium byrnei*		
Purple dtella	*Gehyra purpurascens*		
Red-naped snake	*Furina diadema*		
Rough-nosed blind snake	*Ramphotyphlops bituberculatus*		
Saltbush ctenotus	*Ctenotus olympicus*		
Sand goanna	*Varanus gouldii*		
Sandplain ctenotus	*Ctenotus schomburgkii*		
Sandplain gecko	*Lucasium stenodactylum* (revised)		
Short-legged ctenotus	*Ctenotus strauchii*		
Smooth knob-tailed gecko	*Nephrurus levis*		
Smooth-snouted earless dragon	*Tympanocryptis intima*		
Southern spiny-tailed gecko	*Strophurus intermedius*		
Stimson's python	*Antaresia stimsoni*		
Tessellated gecko	*Diplodactylus tessellatus*		
Tree dtella	*Gehyra variegata*		
Western brown snake	*Pseudonaja nuchalis* (NC)		
Woma	*Aspidites ramsayi*		R
Yellow-tailed slider	*Lerista aericeps*		