Australian Government





Western District Lakes

Ramsar Site

Ecological Character Description

April 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.

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

Cover photos: B Hale, J Clarke, J Mollison.

Table of Contents

Glossary

Definitions of words associated with ECDs (DEWHA 2008 and references cited within).

Benchmark	A standard or point of reference (ANZECC and ARMCANZ 2000b). A predetermined state (based on the values that are sought to be protected) to be achieved or maintained (Lambert and Elix 2006). In this ECD Publication, benchmarks are related to the baseline description at the time of listing (1982) of a Ramsar site.
Benefits	Benefits here refer to the economic, social and cultural benefits that people receive from ecosystems (Ramsar Convention 2005a, Resolution IX.1 Annex A). These benefits often rely on the underlying ecological components and processes in the wetland. See also 'Ecosystem services'.
Bioregion/ Biogeographic region	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type and vegetation cover (Ramsar Convention 2005b).
Catchment	The total area draining into a river, reservoir or other body of water (ANZECC and ARMCANZ 2000a).
Change in ecological character	Human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005a, 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 2000a).
Contracting Party	Country that is a Member State to the Ramsar Convention on Wetlands (http://www.ramsar.org/cda/en/ramsar-about-parties/main/ramsar/1-36-123_4000_0__).
Diversity (biological)	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 a part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity) and of ecological processes. This definition is based largely on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005b).
Ecological character	The combination of the ecosystem components, processes, and benefits and services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (ecosystem services). The phrase 'at a given point in time' refers to Resolution VI.1 paragraph 2.1, which states that, 'It is essential that the ecological character of a site be described by the Contracting Party concerned at the time of designation for the Ramsar List, by completion of the Information Sheet on Ramsar Wetlands (as adopted by Recommendation IV. 7).'
Ecological communities	Any naturally occurring group of species inhabiting a common environment that interacts with each other, especially through food relationships, and that is relatively independent of other groups. Ecological communities may be of varying sizes and larger ones may contain smaller ones (Ramsar Convention 2005b).
Ecosystems	Within the Millennium Ecosystem Assessment, ecosystems are described as 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) (Ramsar Convention 2005a, Resolution IX.1 Annex A).
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) (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Ecosystem processes	Dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment, which result in existing ecosystems and that bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological.

Ecosystem services	Benefits that people receive or obtain from an ecosystem (Ramsar Convention 2005a, Resolution IX.1, Annex A). The components of ecosystem services include (Millennium Ecosystem Assessment 2005): • provisioning services – such as food, fuel and fresh water; • regulating services – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation; • cultural services – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and • 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 in the long-term. See also 'Benefits'.
Ecological vegetation class (EVC)	An EVC is a native vegetation classification based on a combination of its floristics, life form and ecological characteristics, and through an inferred fidelity to particular environment attributes (DSE 2004).
Essential element	An essential element is a component or process that has an essential influence on the critical components, processes and services/benefits of the wetland. Should the essential element cease, reduce, or become lost, it would result in a detrimental impact on one or more critical component, process and services/benefits. Critical components, processes and services/benefits depend in part or fully on an essential element, but an essential element is not in itself critical for defining the ecological character of the site.
Limits of acceptable change	Variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (modified from definition adopted by Phillips 2006).
Ramsar	City in Iran where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, 'Ramsar Convention on Wetlands' (http://www.ramsar.org/cda/en/ramsar-about/main/ramsar/1-36_4000_0__).
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 (http://www.ramsar.org/cda/en/ramsar-about-sites-criteria-for/main/ramsar/1-36-55%5E20740_4000_0__).
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)' and 'Ramsar Convention' are more commonly used (http://www.ramsar.org/cda/en/ramsar-sept13-homeindex/main/ramsar/1%5E26292_4000_0__).
Ramsar Information Sheet (RIS)	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 (http://www.ramsar.org/cda/en/ramsar-documents-info/main/ramsar/1-31-59_4000_0__).
Ramsar site	The area of Western District Lakes situated within the Ramsar site boundary.
Wetlands	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=1-26-76%5E21235_4000_0__).

List of Abbreviations

AAV	Aboriginal Affairs Victoria
ARI	Arthur Rylah Institute
AWSG	Australian Wader Studies Group
AVW	Atlas of Victorian Wildlife
BOCA	Bird Observation and Conservation Australia
BOM	Bureau of Meteorology
CAMBA	China-Australia Migratory Birds Agreement
CMA	Catchment Management Authority
CMS	The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now Department of the Environment) (Australian Government)
DIWA	Directory of Important Wetlands in Australia
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment (now Department of Environment and Primary Industries) (Victorian Government)
ECD	Ecological Character Description
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EWA	Environmental Water Allocation
FFG Act	*Flora and Fauna Guarantee Act 1988* (Victoria)
FIS	Flora Information System
G-MW	Goulburn-Murray Water
JAMBA	Japan-Australia Migratory Birds Agreement
KBR	Kellogg Brown & Root Pty Ltd
LAC	Limit of Acceptable Change
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
RAOU	Royal Australian Ornithological Union
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea-Australia Migratory Birds Agreement
VWSG	Victorian Wader Studies Group

Executive Summary

The Western District Lakes Ramsar site is located in the west of Victoria, within the Southeast Coast Drainage Division (bioregion). The site covers approximately 33 000 hectares and lies within the Shires of Corangamite, Colac Otway and Surf Coast. The site comprises nine separate lakes, which lie to the west, north and east of the town of Colac (population in 2006; 11 000). The Western District Lakes are within the landlocked Lake Corangamite catchment, which covers approximately 4200 square kilometres. Lakes dominate surface water in the catchment and the only significant river, the Woady Yallock River, drains into Lake Corangamite. There are a large number of wetlands within the catchment nine of which comprise the Ramsar site: Lakes Beeac, Bookar, Colongulac, Corangamite, Cundare, Gnarpurt, Milangil, Murdeduke and Terangpom (Figure E1).

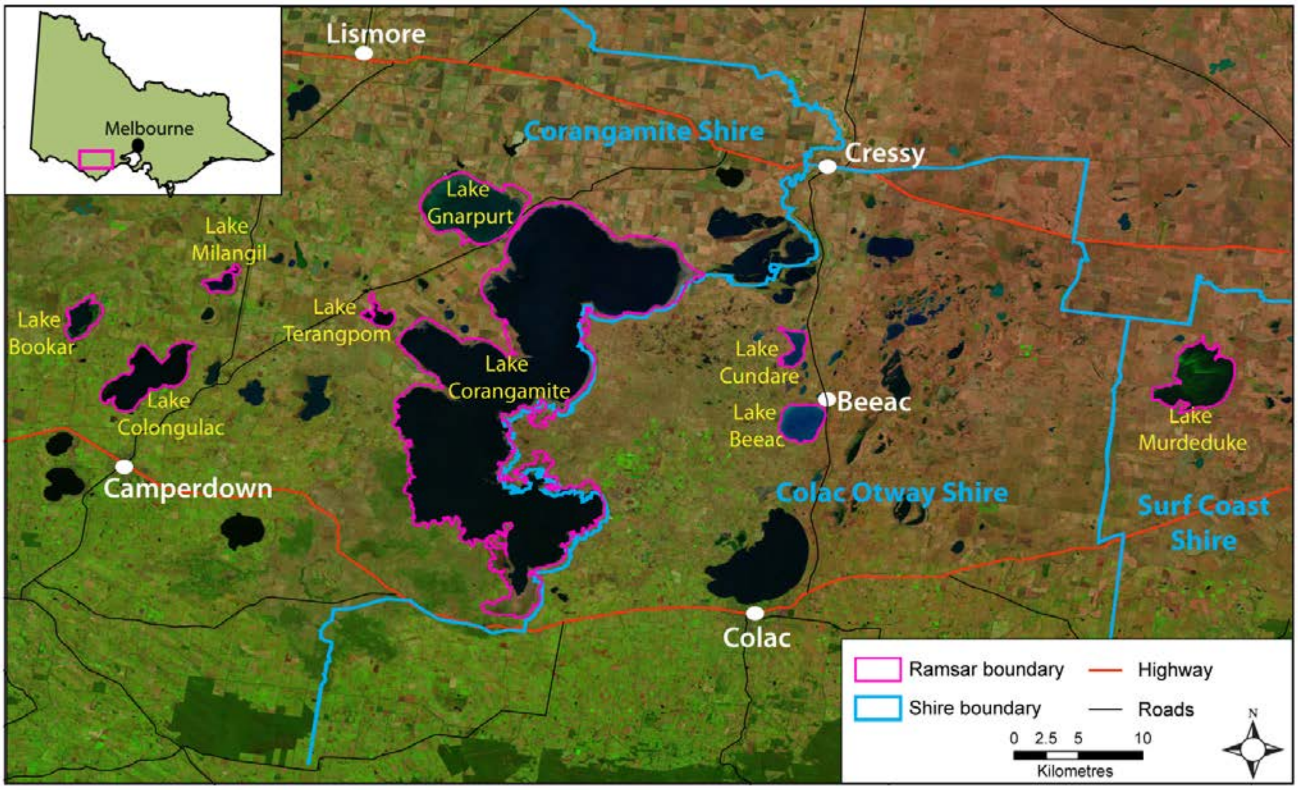


Figure E1: Location of the Western District Lakes Ramsar site (data supplied by DSE).

The Western District Lakes Ramsar site was listed in 1982 and this is the point in time captured by the ECD. The site met the following five criteria under conditions at the time of listing:

Criterion 1: Lake Corangamite was the largest inland permanent saline lake in Australia (Timms 2002) and therefore within the bioregion. In addition, at the time of listing it was considered to be a good representative example (arguably the best) of a permanent saline lake within the bioregion (based on the combined knowledge of the steering committee for this project).

Criterion 2: There were two nationally threatened species supported by the wetlands within the Western District Lakes Ramsar site:

- Salt-lake tussock-grass (*Poa sallacustris*) is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). It occurred at Lake Corangamite and Lake Terangpom (Carter and Walsh 2006).
- Spiny peppercress (*Lepidium aschersonii*) is listed as vulnerable under the EPBC Act and occurred at Lake Corangamite and Lake Beeac (DSE unpublished).

Criterion 4: The basic description of this criterion implies a number of common functions/roles that wetlands provide including supporting fauna during migration, providing drought refuge and supporting breeding and moulting in waterfowl. The Ramsar site provided a number of these functions and clearly met this criterion.

Criterion 5: Comprehensive bird survey data for the Western District Lakes Ramsar site are not available. Existing counts are often for a subset of wetlands within the site only and/or have not been undertaken regularly. Counts of total waterfowl for some areas within the Ramsar site were reported by the Royal Australasian Ornithologist Union (RAOU) from 1987 to 1992. These data do not consistently cover all wetlands in the Ramsar site and do not include other waterbirds such as herons, ibis and shorebirds, so they are likely to be an underestimate. However, there is sufficient evidence that the Western District Lakes Ramsar site met this criterion, with consistent records over of more than 20 000 waterbirds over six years.

Criterion 6: Within the Ramsar site, there were maximum counts for 12 species of waterbirds that were over the one percent population threshold. While there is insufficient evidence that the site regularly supported over one percent of the population of all of these species, there is strong evidence for a number of waterfowl species including the Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot. The one percent population threshold was exceeded for these four species in seasons for which data were available (1987 to 1992). For other species (such as banded stilt), the very large numbers that occur at the site periodically contribute to the Ramsar site currently meeting this criterion, with the average number (over more than five seasons) exceeding the one percent threshold.

* * *

A summary of the components and processes important to the ecological character of the Western District Lakes Ramsar site is provided in Table E1 and illustrated conceptually in Figure E2. This includes those that are considered essential elements as well as those identified as critical to the ecological character of the site and for which Limits of Acceptable Change (LACs) have been developed. Critical components and processes and essential elements were selected on the basis of their role in maintaining the ecological character of the site, the ecosystem services they support (Table E2) and the Ramsar criteria for which the site was listed.

Ecosystem benefits and services are defined by the Millennium Ecosystem Assessment 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 provision of food/water resources, as well as indirect ecological benefits.

Benefits and services of the Western District Lakes Ramsar site are summarised in Table E2. This includes provisioning services (products obtained from ecosystems); cultural services (benefits people obtain through spiritual enrichment, recreation, education and aesthetics) and supporting services (services that underpin other services and have indirect benefits to humans). Water supply, together with the four supporting services (physical habitat, biodiversity, priority wetland species and distinct wetland species) were identified as critical to the ecological character of the Ramsar site.

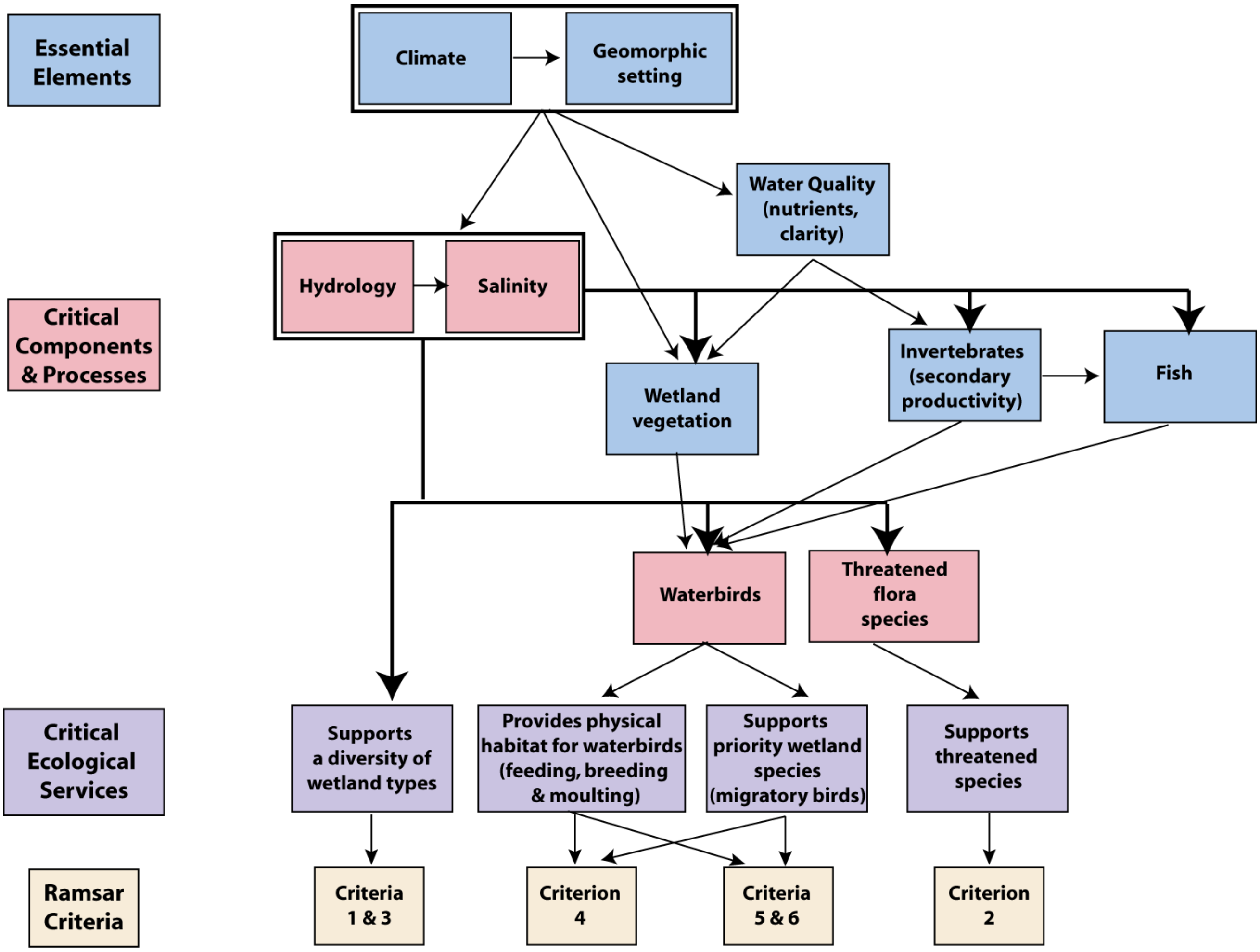


Figure E2: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a Wetland of International Importance.

Table E1: Summary of components and processes important for maintaining the ecological character of the Western District Lakes Ramsar site.

Component / process	Description
Essential elements	
Climate	• Located in temperate climatic zone with warm summers and cool winters. • Rainfall occurs year round but is higher in winter months. • On average, rainfall exceeds evaporation from April to October.
Geomorphic setting	• Located on the Victorian Volcanic Plains. • Lakes are all shallow, with flat bottoms and high surface area to volume ratios. • A number of lakes have lunettes on the eastern shore.
Water clarity and nutrients	• All lakes are turbid, with high levels of nutrients.
Wetland vegetation	• Most of the lake margins are bare, with less than 20 percent of the littoral zone vegetated. • A total of five submerged aquatic plant species have been recorded.
Fish	• Data deficient. • At the time of listing, a number of the lakes were stocked with short-finned eels and supported commercial fisheries. • A total of six native species of fish have been recorded within the lakes.
Invertebrates	• Species composition varies with salinity. • Molluscs dominate most saline and mesosaline lakes. • Lake Colongulac is dominated by oligochaetes.
Critical components and processes	
Hydrology	• At the time of listing, six of the lakes were considered permanent (not drying in the past 100 years), one (Lake Colongulac) was near permanent (drying on occasion in the last 100 years) and two were seasonal or intermittent. • All lakes are connected to saline, surficial groundwater. • The major water source is direct rainfall and most water is lost via evaporation. • All lakes except Beeac and Cundare are groundwater flow-through lakes, discharging to groundwater down-gradient. • Lakes vary in water level on seasonal cycles.
Salinity	• Salinity of the lakes is variable seasonally and with longer term climate patterns. • Lakes Bookar, Colongulac, Gnarpurt, Milangil and Murdeduke are considered mesosaline. • Lake Corangamite is saline. • Lakes Beeac and Cundare are hypersaline. • Lake Terangpom is freshwater / brackish.
Vegetation	• Supports two nationally threatened plant species: spiny peppercress and salt-lake tussock-grass.
Waterbirds	• Seventy species of waterbird including 20 international migratory species have been recorded in the site. • Abundances are high, with greater than 20 000 waterbirds recorded annually. • The site regularly supports greater than one percent of the population of four species of waterbird. • Breeding has been recorded for 11 species.

Table E2: Summary of the benefits and services of the Western District Lakes Ramsar site (critical services are shaded green).

Category	Description
Provisioning services	
Commercial fishing	At the time of listing a number of lakes within the Ramsar site, including Lake Corangamite and Gnarpurt were stocked with short-finned eels and used for commercial production of this species.
Cultural services	
Recreation and tourism	At the time of listing Lake Murdeduke was popular for recreational fishing. Lakes Bookar and Murdeduke are game reserves and used for duck hunting.
Spiritual and inspirational	The region is spiritually and culturally significant for the Djargurd Wurrung and Gulidjan Peoples. The site was significant for provision of food and there are a number of important archaeological sites.
Regulating services	
Flood control	The lakes within the Ramsar site receive drainage water from the surrounding landscape and play an important role in flood mitigation of adjacent agricultural landscapes.
Supporting services	
Diversity of wetland types	The Ramsar site contains a diversity of wetland types.
Physical habitat	The Ramsar site provides habitat for feeding, breeding and moulting waterbirds.
Priority wetland species	The Ramsar site supports 20 species of shorebird listed under international migratory bird treaties.
Threatened species	The Ramsar site supports two flora species listed under the EPBC Act.

Limits of Acceptable Change (LACs) are defined as 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 that may lead to a reduction or loss of the criteria for which the site was Ramsar listed. LACs for the Western District Lakes Ramsar site have been determined for critical components, processes and benefits and services based on existing data and guidelines (see Table E3).

Table E3: Limits of Acceptable Change for the Western District Lakes Ramsar site.

Component/Process Benefit/Service	Limit of Acceptable Change
Hydrology	*No change in wetland hydrological type for any given wetland. That is, the following hydrological regimes maintained:* • *Lakes Beeac and Cundare – intermittent wetlands drying seasonally but having water for at least a few months of each year;* • *Lake Colongulac – near permanent wetland drying for no more than twelve months in any five year period;* • *Lakes Bookar, Corangamite, Gnarpurt, Milangil, Murdeduke and Lake Terangpom – permanent wetlands not drying for more than two months in any five year period.*
Salinity	*No change in salinity category for any given wetland. That is, the following salinity regimes maintained:* • *Lakes Beeac and Cundare – hypersaline (greater than 50 parts per thousand);* • *Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke – saline (5 to 50 parts per thousand)* • *Lake Terangpom – fresh / brackish (less than three parts per thousand).*
Threatened flora	*Presence of spiny peppercress and salt-lake tussock-grass within the Ramsar site at least one year in any five year period.*
Waterbirds	*Total waterbird numbers not less than 28 000 during summer in a minimum of three years in any five year period.*
	Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot – greater than one percent of population (from latest Wetlands International population estimates) recorded at least once in every five year period.
	Presence of curlew sandpiper, red-necked stint and sharp-tailed sandpiper within the Ramsar site at least once in every five year period.
Diversity of wetland types	*See LACs for hydrology and salinity.*
Physical habitat	*See LACs for hydrology, salinity and waterbirds.*
Priority wetland species	*See LACs for waterbirds.*
Threatened species	*See LACs for threatened flora.*

Additional explanatory notes on LACs

LACs are a tool by which ecological change can be measured. However, ECDs are not management plans and LACs do not constitute a management regime for the Ramsar site.

Exceeding or not meeting LACs 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 LACs 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 ECD and define LACs 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 LACs 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 ECD and carefully evaluate the suitability of the information for their own purposes.

LACs 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 threats that could significantly impact on the ecological character of the Ramsar site. However, many of these (such as pollution and biological resource use (fishing and hunting)) could be considered minor in nature. The most significant threat to the ecological character of the Ramsar site is climate change (EPA 2010) and this has already had a dramatic impact on the site. A description of each of the threats is provided in Table E4.

Table E4: Summary of threats to the ecological character of the Ramsar site.

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or services	Location	Likelihood[1]	Timing[2]
Climate change – reduced rainfall	Lower water levels leading to increasing salinity.	All	Certain	Current
Water resource development	Reduced water levels leading to increased salinity levels through evaporation and concentration effects.	Lake Corangamite and Gnarpurt	Certain	Current
		Lake Murdeduke	Certain	Long term
Pollution	Eutrophication and toxic effects.	All	Certain	Current
Agricultural impacts	Grazing impacts	All	Certain	Current
	Salinity impacts due to land clearing.	All	Low	Long-term
Invasive species	Increased competition and loss of diversity.	All	Certain	Current
Resource utilisation	Fishing and duck hunting leading to disturbance of habitat and waterbirds.	Fishing - Colongulac, Gnarpurt and Murdeduke. Duck hunting - Bookar, Colongulac, Corangamite, Gnarpurt, and Murdeduke	Certain	Current

[1] Where Certain is defined as known to occur at the site or has occurred in the past; and Low is defined as theoretically possible, but not recorded at this or similar sites.
[2] Where Current is defined as happening at the time of writing (2010); Long-term is defined as greater than 10 years.

It has been over a quarter of a century since the Western District Lakes Ramsar site was designated as a Wetland of International Importance. As such, changes to the system are to be expected. However, there is strong evidence to suggest that there have been significant changes to the ecological character of this site, primarily as a result of drought and climate change. An assessment of current conditions against the LACs has been made (Table E5).

Table E5: Assessment of current conditions against LACs for the Western District Lakes Ramsar site.

Component /Process	Limit of Acceptable Change	Current conditions
Hydrology	*No change in wetland hydrological type for any given wetland. That is the following hydrological regimes maintained:* • *Lakes Beeac and Cundare – intermittent wetlands drying seasonally but having water for at least a few months of each year;* • *Lake Colongulac – near permanent wetland drying for no more than twelve months in any five year period;* • *Lakes Bookar, Corangamite, Gnarpurt, Milangil, Murdeduke and Lake Terangpom – permanent wetlands not drying for more than two months in any five year period.*	Lakes Bookar, Gnarpurt, Milangil and Terangpom have all dried completely on a number of occasions in the past decade. They are no longer permanent. **LAC has been exceeded.**
Salinity	*No change in salinity category for any given wetland. That is the following salinity regimes maintained:* • *Lakes Beeac and Cundare – hypersaline (greater than 50 parts per thousand);* • *Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke – saline (5 to 50 parts per thousand);* • *Lake Terangpom –fresh / brackish (less than three parts per thousand).*	Salinity has increased to greater than 50 parts per thousand at Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke; and greater than three parts per thousand at Terangpom. **LAC has been exceeded.**
Vegetation	*Presence of spiny peppercress and salt-lake tussock-grass within the Ramsar site,*	Spiny peppercress and salt-lake tussock grass remain within the Ramsar site.
Waterbirds	*Total waterbird numbers not less than 28 000 during summer.*	Total summer waterbird numbers were less than 28 000 from 2005 to 2010 inclusive. **LAC has been exceeded.**
	Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot - greater than one percent of population (from latest Wetlands International population estimates) recorded at least once in every five year period.	The one percent population thresholds for two of these four species have not been reached in five consecutive years (2007 to 2011) and the one percent threshold for Australian shelduck was reached on only one occasion in this time, in 2011. **LAC has been exceeded.**
	Presence of curlew sandpiper, red-necked stint and sharp-tailed sandpiper within the Ramsar site at least once in every five year period.	There have only been regular counts of shorebirds at the site in recent times in three years (2008 to 2010) and as such there is insufficient data to assess this LAC.

In addition, an assessment of current conditions at the site against the relevant Ramsar listing criteria indicates that the site no longer meets Criteria 1, 5 and 6:

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.

This criterion was considered to be met on the basis that Lake Corangamite was the largest permanent saline wetland in the bioregion and considered to be a good representative of the type with respect to condition and values. Given the changes to Lake Corangamite (declining water levels, increased salinity, loss of submerged vegetation and fish, and a decrease in waterbird abundance and diversity), it is difficult to make a case for the site still including good representative examples of the wetland types in the bioregion. Moreover, there is evidence to suggest that other wetlands in the region (for example, Lake Purrumbete and Bullen Merri) have retained better ecological values and are expected to be more resilient to climate change (EPA 2010).

The Ramsar site no longer meets this criterion.

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

This criterion was considered to be met on the basis of two threatened flora species: salt-lake tussock-grass (*Poa sallacustris*) and spiny peppercress (*Lepidium aschersonii*). These species are still present within the Ramsar site (Hose 2008).

The Ramsar site continues to meet this criterion.

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.

This criterion was considered to be met on the basis of supporting breeding of waterbirds, waterfowl during moult and moderate to large numbers of migratory shorebirds. However, there have been no observations of nesting or juvenile birds recorded during annual waterfowl counts in the past five years (2006 to 2010). In addition, there have also been no observations of moulting in that timeframe. The site has supported only very low numbers of international migratory shorebirds in the past ten years. On the other hand, there were over 2500 sharp-tailed sandpiper recorded in February 2010 at Lake Corangamite (AWSG unpublished) and the site therefore continues to support international migratory bird species.

The Ramsar site continues to meet this criterion.

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

The site did not support more than 20 000 waterbirds in summer from 2007 to 2010 inclusive (DSE Colac unpublished, Birds Australia unpublished). However, there were over 100 000 banded stilts at Lake Corangamite in August 2006 and 40 000 waterfowl in February 2011. Despite this one very large count, the application of the rule “regularly supports” indicates that the site no longer meets this criterion.

The Ramsar site no longer meets this criterion.

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.

There are maximum count records from the last decade that exceed the one percent population threshold. For example, the 112 000 banded stilts in August 2006 represents over 20 percent of the estimated total population and in February 2011 there were 32 000 Australian shelducks on Lake Corangamite. However, these are isolated incidents and the site no longer “regularly supports” over one percent of the population of any individual waterbird species.

The Ramsar site no longer meets this criterion.

* * *

Knowledge gaps have been identified (Table E6) and monitoring to address knowledge gaps and assess against LAC recommended (Table E7).

Table E6: Knowledge gaps relevant to the ecological character of the Ramsar site.

Knowledge Gap	Recommended Action
Threatened flora (spiny peppercress and salt-lake tussock grass) – abundance, trends and effects of altered water and salinity regimes.	Long term monitoring of known populations.
Total waterbird abundance and diversity – most counts are for select groups of birds only.	Expand current annual monitoring to include all waterbirds at the lakes.
The value of the site for waterbird breeding remains unknown.	Recording of nesting and breeding behaviours during annual counts.
The value of the site for international migratory shorebirds.	Continued biannual monitoring of shorebirds within the site.
The potential for the system for recovery. Given a few years where rainfall returns to averages of 750 millimetres per year will the system recover some of its values and biota?	Annual assessments of hydrology, water quality and flora to complement waterbird and threatened species monitoring.
Seed and egg bank viability following extensive dry/hypersaline conditions.	Seed and egg bank study of sediments from affected lakes.
Effect of 2010 rains and increased water levels on threatened plant species. Will they be able to migrate to higher ground?	Monitoring of threatened species at known locations in 2011 and 2012.

Table E7: Recommended monitoring for the Western District Lakes Ramsar site.

Component/ Process	Purpose	Indicator	Locations	Frequency	Priority
Hydrology	Assessment against LAC	Water level (gauges)	Each wetland	Monthly	Moderate
Water quality	Assessment against LAC and threat indicator	Salinity	Each wetland	Monthly	Moderate
Threatened plant species	Assessment against LAC	Location, abundance	Lakes Beeac, Corangamite and Terangpom	Annual	High
Aquatic Invertebrates	Knowledge gap	Community composition, abundance	Entire Ramsar site	Once in five years during spring	Moderate
Waterbirds	Assessment against LAC	Abundance and species identifications, breeding observations	Entire Ramsar site	Winter and summer	High
Vegetation (weeds)	Threat indicator	Location, extent	Lakes Beeac, Corangamite and Terangpom	Annual	High
Pest animals (foxes, rabbits)	Threat indicator	Abundance	Entire Ramsar site	Annual	Moderate

1. Introduction

1.1 Site details

The Western District Lakes Ramsar site is located in the western volcanic plains region in Victoria, approximately 15 kilometres west, north and east of the town of Colac. It was originally nominated as a Wetland of International Importance under the Ramsar Convention in 1982. Site details for this Ramsar wetland are provided in Table 1.

Table 1: Site details for the Western District Lakes Ramsar site.

Site Name	Western District Lakes
Location in coordinates	Latitude: 38° 00' S to 38° 20' S Longitude: 143° 07' E to 143° 55' E
General location of the site	The Western District Lakes Ramsar site is located in the Colac - Otway, Surf Coast and Corangamite Shires in Victoria. Drainage Division 2: Southeast Coast (Australia's River Basins, Australian Water Resources Council 1987).
Area	32 898 hectares
Date of Ramsar site designation	Designated on 15 December 1982
Ramsar Criteria met by wetland	At the time of listing (1982) – Ramsar Criteria 1, 2, 4, 5 and 6. Currently (2010) – Ramsar Criteria 2 and 4.
Management authority for the site	The Lakes are managed by Parks Victoria.
Date the ECD applies	1982
Status of Description	This represents the first Ecological Character Description (ECD) for the site.
Date of Compilation	April 2011
Name(s) of compiler(s)	Jennifer Hale and Rhonda Butcher on behalf of the Department of Sustainability, Environment, Water, Population and Communities.
References to the Ramsar Information Sheet (RIS)	RIS compiled by Parks Victoria in 1999. Updated by Jennifer Hale on behalf of SEWPaC in 2010.
References to Management Plan(s)	Department of Natural Resources and Environment, 2002, Western District Lakes Ramsar site: Strategic Management Plan, Victoria.

1.2 Statement of purpose

The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to retain its 'ecological character' and to have 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, and should form the baseline or benchmark for management planning and action, including site monitoring to detect negative impacts.

The Ramsar Convention has defined "ecological character" and "change in ecological character":

"Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetlands at a given point in time" (Ramsar 2005).

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) (see Figure 1).

A Ramsar Information Sheet (RIS) is prepared at the time of designation. However, 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. In response to this short fall, 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* (the National Framework) (DEWHA 2008).

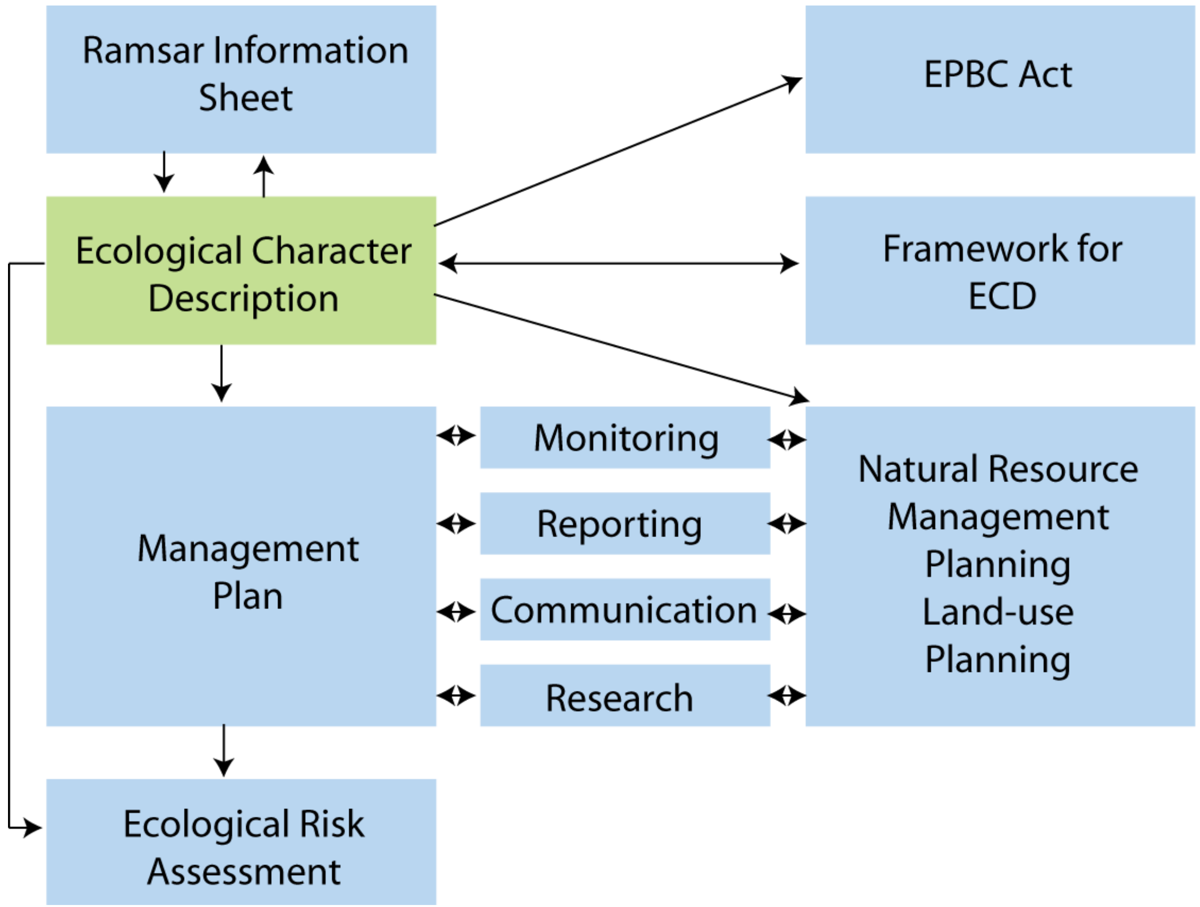


Figure 1: The ecological character description in the context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).

The National 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 would indicate when the ecological character has 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. There is a significant amount of legislation, particularly at the state/local level, relevant to the management of the site, which is documented more fully in the management plan for the site and as such is not repeated here.

International

Ramsar Convention

The Convention on Wetlands of International Importance, 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 listed 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 the Western District Lakes Ramsar site. The bilateral agreements are:

- *Japan-Australia Migratory Bird Agreement (JAMBA)* – 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;
- *China-Australia Migratory Bird Agreement (CAMBA)* – 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;
- *Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)* – 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 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 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.

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

Some matters protected under the EPBC Act are not protected under local or state/territory legislation, and as such, some migratory birds are not necessarily protected under state legislation. Species listed under JAMBA, CAMBA, ROKAMBA and CMS have been included in the List of Migratory species under the EPBC Act. Threatened species and communities listed under the EPBC Act may also occur, or have habitat within 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 EPBC 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.

Victorian state policy and legislation

*Crown Land (Reserves) Act 197*8

This Act provides the framework for the administration and management of Crown land reserves including nature conservation reserves. The Act also deals with the making of regulations, committees of management and leasing and licensing.

The Environment Protection Act 1970

This Act establishes the Environment Protection Authority and makes provision for the Authority's powers, duties and functions. These relate to improving the air, land and water environments by managing waters, control of noise and control of pollution. State Environment Protection Policies (SEPPs) are subordinate legislation made under the provisions of the Act. *State Environment Protection Policy* (Waters of Victoria) sets water quality objectives to protect the beneficial uses of inland waters.

Fisheries Act 1995

The *Fisheries Act* provides a framework for the regulation, management and conservation of Victorian fisheries. It deals with commercial and recreational licences, fish culture, noxious aquatic species, research and development, the declaration and management of fisheries reserves and the preparation of management plans for individual fisheries, declared noxious aquatic species and fisheries reserves.

Flora and Fauna Guarantee Act 1988

This Act provides a legislative and administrative framework for the conservation of biodiversity in Victoria. It provides for the listing of threatened taxa, communities and potentially threatening processes. It requires the preparation of action statements for listed species, communities and potentially threatening processes and sets out the process for implementing interim conservation orders to protect critical habitats. The Act also seeks to provide programs for community education in the conservation of flora and fauna and to encourage co-operative management of flora and fauna.

Water Act 1989

The *Water Act* establishes rights and obligations in relation to water resources and provides mechanisms for the allocation of water resources. This includes the consideration of environmental water needs of rivers and wetlands as well as for human uses such as urban water supply and irrigation.

Wildlife Act 1975

The *Wildlife Act* ensures procedures are in place to protect and conserve Victoria's wildlife and prevent any taxa of wildlife from becoming extinct. The Act also provides for the establishment of State Game Reserves. Regulations under the Act ensures that the consumptive use or other interactions with flora and fauna in Victoria do not threaten the sustainability of wild populations, while facilitating cultural and recreational pursuits in a humane, safe, ethical and sustainable manner.

Catchment and Land Protection Act 1994

This Act sets up a framework for the integrated management and protection of catchments. It establishes processes to encourage and support community participation in the management of land and water resources and provides for a system of controls on noxious weeds and pest animals.

Aboriginal Heritage Act 2006

This Act provides for the protection and management of Victoria's Aboriginal heritage. It establishes the Victorian Aboriginal Heritage Council to advise the Minister in the management of cultural heritage and registered Aboriginal parties. It also deals with cultural heritage management plans, cultural heritage permits and agreements. The Act also includes enforcement provisions and processes for handling dispute resolution. This includes the review of certain decisions through the Victorian Civil and Administrative Tribunal.

Securing our natural future: A white paper for land and biodiversity at a time of climate change (November 2009)

The Land and Biodiversity White Paper is a long-term, strategic framework to secure the health of Victoria's land, water and biodiversity in the face of ongoing pressures and a changing climate over the next fifty years. The framework for action is based on three inter-related elements:

- Building ecosystem resilience across Victoria;
- Managing flagship areas to maintain ecosystem services; and
- Improving connectivity in areas identified as biolinks.

The Draft Western Region Sustainable Water Strategy (Western Region SWS) 2010

The Western SWS covers the majority of the Ramsar site (excluding Lake Murdeduke which is covered by the Central Region SWS 2006). The strategy aims to identify and understand threats to water availability and quality over the next 50 years, and outlines policies and actions to manage the consequences of prolonged drought and climate change.

1.4 Method

The method used to develop the ECD for the Western District Lakes Ramsar site is based on the twelve-step approach provided in the National Framework (DEWHA 2008), illustrated in Figure 2. A more detailed description of each of the steps and 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 steering committee was formed to provide input and comment on the ECD.

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

2. General Description of the Western District Lakes Ramsar site

2.1 Location

The Western District Lakes Ramsar site is located in the west of Victoria, within the Southeast Coast Drainage Division (bioregion). The site covers approximately 33 000 hectares and lies within the Shires of Corangamite, Colac Otway and Surf Coast. The site comprises nine separate lakes, which lie to the west, north and east of the town of Colac (population in 2006; 11 000) (Figure 3).

The Western District Lakes are within the landlocked Lake Corangamite catchment, which covers approximately 4200 square kilometres. Lakes dominate surface water in the catchment and the only significant river, the Woady Yallock River, drains into Lake Corangamite. There are a large number of wetlands within the catchment, nine of which make up the Ramsar site:

Lake Beeac	672 hectares	Lake Gnarpurt	2513 hectares
Lake Bookar	480 hectares	Lake Milangil	246 hectares
Lake Corangamite	25 232 hectares	Lake Murdeduke	1495 hectares
Lake Colongulac	1516 hectares	Lake Terangpom	220 hectares
Lake Cundare	301 hectares		

2.2 Land tenure

Land tenure within the Western District Lakes Ramsar site comprises a combination of conservation and natural features reserves. Land tenure (as described in the Strategic Management Plan for the Ramsar site; NRE 2002) is provided in Table 2.

Table 2: Land tenure and management within the Western District Lakes Ramsar site (data supplied by DSE).

Lake	Land Tenure	Legal Status	Management
Beeac	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Bookar	State Game Reserve	*Wildlife Act 1975*	Parks Victoria
Colongulac	Natural Features Reserve – Lake Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Corangamite	Natural Features Reserve – Lake Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria Committee of management
Cundare	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Gnarpurt	Natural Features Reserve – Lake Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria Committee of management
Milangil	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Murdeduke	State Game Reserve	*Wildlife Act 1975*	Parks Victoria
Terangpom	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria

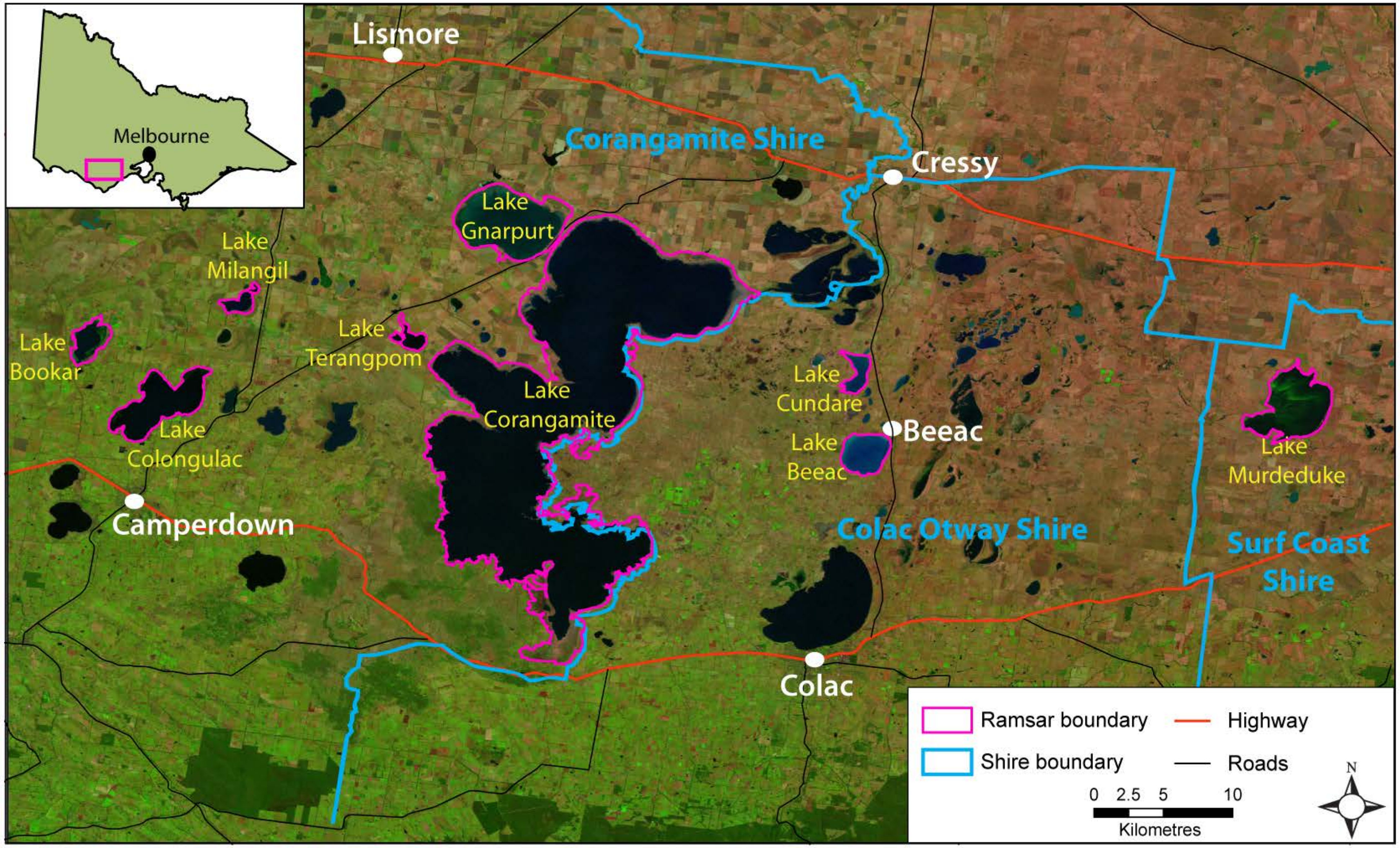


Figure 3: Local government boundaries relevant to the Western District Lakes Ramsar site (data supplied by DSE).

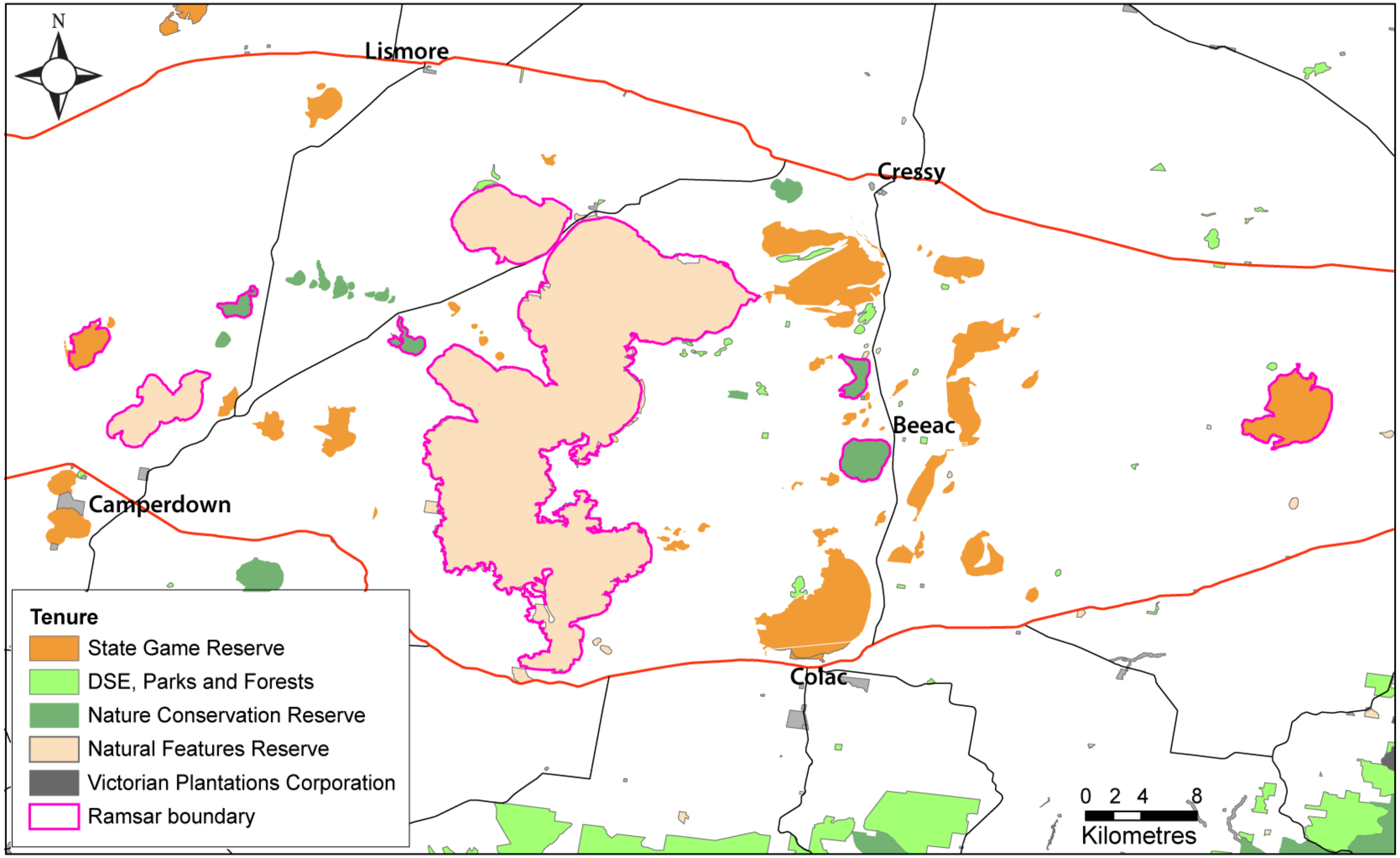


Figure 4: Land tenure within and adjacent to the site (data supplied by DSE).

2.3 Wetland types

There are four wetland types, according to the Ramsar wetland classification, within the Western District Lakes Ramsar site. In order of dominance, these are:

- Q – Permanent saline/brackish/alkaline lakes;
- R – Seasonal/intermittent saline/brackish/alkaline lakes and flats;
- O – Permanent freshwater lakes (over 8 hectares); and
- Tp – Seasonal / intermittent freshwater marshes.

Victorian wetlands have been mapped and classified according to the system developed by Corrick and Norman (1980), which for inland wetland systems can be approximated to Ramsar wetland types (Table 3 and Figure 5). It should be noted that the wetland classification adopted in Victoria defines "permanent" as wetlands that hold water for at least 12 months, although they can have periods of drying, especially during prolonged drought. With respect to the Western District Lakes, the "permanent" wetlands at the time of listing had all held water for prolonged periods (greater than 10 years) and so best equate to types O (permanent freshwater lakes) and Q (permanent saline lakes) under the Ramsar classification system, as they were not seasonal or intermittent. Nevertheless, the longer hydroperiod cycles are an important feature of the Ramsar site and have been considered in the description of character and setting of limits of acceptable change.

Table 3: Extent (hectares) of wetland types within the Western District Lakes Ramsar site mapped under Victorian inland wetland system for each lake (NRE 2002).

Victorian wetland type	Freshwater meadow	Shallow freshwater marsh	Permanent open freshwater	Permanent saline	Semi-permanent saline
Equivalent Ramsar wetland type	**Seasonal /intermittent freshwater marshes (Tp)**		**Permanent freshwater lakes (O)**	**Permanent saline lakes (Q)**	**Seasonal/ intermittent saline lakes (R)**
Beeac					647
Bookar				470	
Colongulac				1497	
Corangamite	12	3		24 096	226
Cundare					227
Gnarpurt				2403	
Milangil				228	
Murdeduke				1678	
Terangpom			190		14
Total extent	**12**	**3**	**190**	**30 372**	**1166**

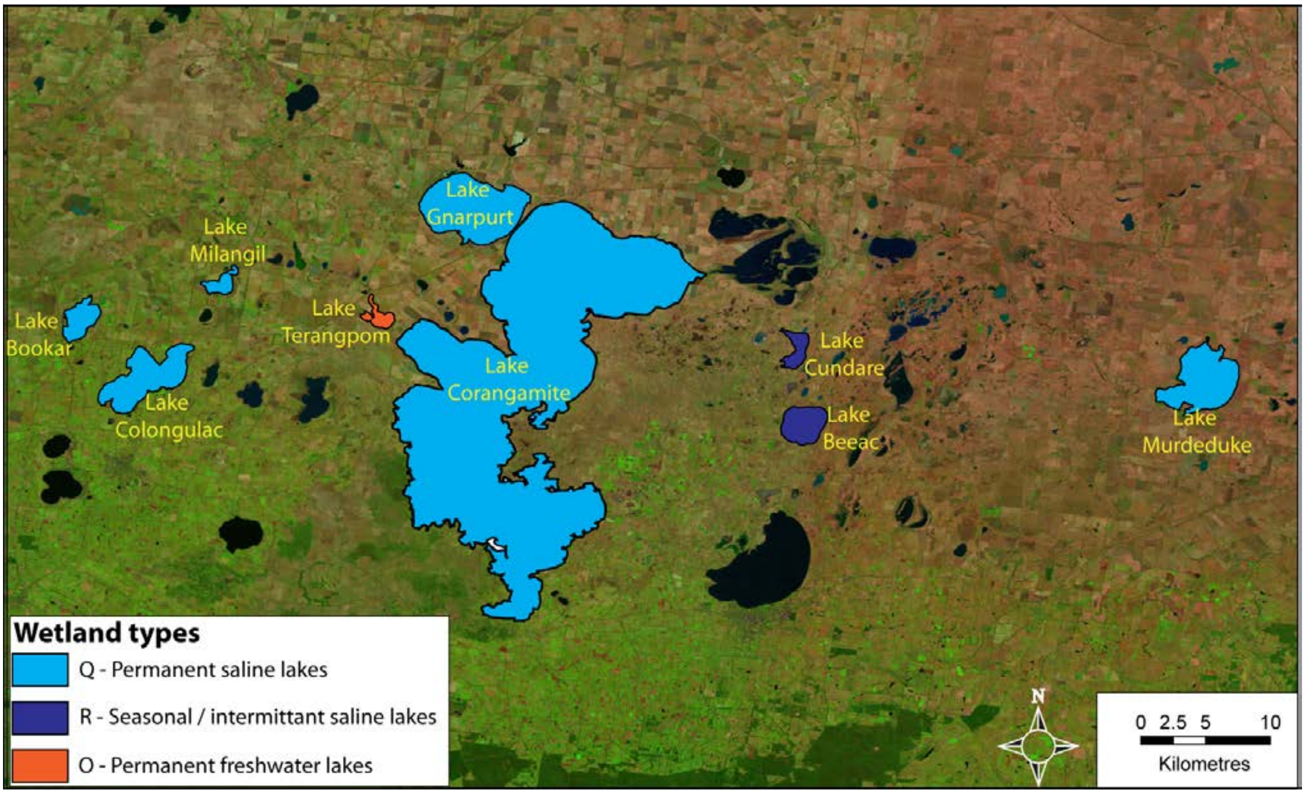


Figure 5: General location of dominant wetland types in the Western District Lakes Ramsar site (note that types with extents of less than 15 hectares are too small to show on the map, but the areas of seasonal/intermittent freshwater marsh are in the south west corner of Lake Corangamite).

Lakes within the Ramsar site (with the exception of Lake Terangpom) are large saline wetlands, dominated by open water. The boundary of the Ramsar site is roughly equivalent to the high water mark at each lake and therefore excludes most of the surrounding vegetation. Examples of wetland types are provided in Figure 6, Figure 7 and Figure 8.

Figure 6: Example of wetland type Q (permanent saline lakes) – Lake Corangamite (photo B. Hale; 2010).

Figure 7: Example of wetland type R (seasonal / intermittent saline lakes) – Lake Beeac (photo B. Hale; 2009).

Figure 8: Example of wetland type O (permanent freshwater lakes) – Lake Terangpom (photo B. Hale; 2010).

2.4 Ramsar criteria

2.4.1 Criteria under which the site was designated

At the time the Western District Lakes were first nominated as a Ramsar site, the criteria for identifying wetlands of international importance were the “Cagliari criteria”, adopted at the first Conference of the Contracting Parties in Cagliari in 1980. The original nomination documentation for the Western District Lakes Ramsar site considered that the site met two of these criteria, as shown in Table 4. However, no specific justification for these criteria was provided.

Table 4: Criteria for Identifying Wetlands of International Importance at the time of listing, 1982. Criteria met by Western District Lakes are shaded green.

Basis	Number	Description
Criteria for 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
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.
Criterion based on representative wetlands	3	it is a particularly good example of a specific type of wetland characteristic of its region.

The 1999 RIS assessed the site against the eight criteria adopted at the seventh Conference of Contracting Parties in San Jose in 1999, four of which the Western District Lakes Ramsar site was considered to meet. Justification against the criteria (as contained in the 1999 RIS) was 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.

Western District Lakes are a particularly good example of permanent saline, moderately saline and brackish lakes in the Victorian Volcanic Plains biogeographic region.

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.

Large numbers of Eurasian coots utilise the Western District Lakes Wetlands: 10 900 have been recorded on Lake Bookaar, 9700 on Lake Colongulac, 3100 on Lake Milangil, 10 015 on Lake Corangamite and 19 670 on Lake Murdeduke. The lakes also support very high numbers of ducks: Australian shelduck, Australasian shoveler and pink-eared duck. Banded stilts have been recorded at Lake Beeac (up to 50 000), Lake Corangamite and Lake Cundare (2895).

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

The Western District Lakes regularly support well over 20 000 waterfowl. Species and groups that regularly occur in high numbers include Eurasian coots (see below), ducks (Australian shelduck, Australasian shoveler and pink-eared duck in particular), banded stilts, grebes, ibis and cormorants.

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.

Lake Beeac is very significant for banded stilts and red-necked avocets and has supported internationally significant numbers of these species. Lake Corangamite has also supported internationally significant numbers of banded stilts. Five percent of the Victorian population of the black swan and Australasian shoveler have occurred at Lake Colongulac. Lake Milangil has supported five percent of the Victorian population of the pink-eared duck and chestnut teal.

2.4.2 Assessment based on current Ramsar criteria

There have been a number of developments in the past two decades that influence the application of the Ramsar criteria to wetland sites. These include:

- Refinements and revisions of the Ramsar criteria since 1999. A ninth criterion was added at the ninth Ramsar Conference in Uganda in 2005.
- Revision of population estimates for waterbirds (Wetlands International 2006; Bamford et al. 2008), which influences the application of criterion six.
- A decision regarding 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 criterion one and three.
- Updating of threatened species listings, which affects criterion two.

Therefore an assessment of the Western District Lakes Ramsar site against the current nine Ramsar criteria has been undertaken (Table 5). In deciding if the site qualifies under criteria five and six (regularly supports one percent of the individuals in a population of one species of waterbird), an approach consistent with the Ramsar Convention has been adopted (Text Box 1). This represents an assessment of the conditions at the time of listing with respect to the current criteria. An assessment of current conditions against the Ramsar criteria is provided in Section 7.

Table 5: Criteria for Identifying Wetlands of International Importance (adopted by the 6th (1996) and 9th (2005) Meetings of the Conference of the Contracting Parties). Criteria for which the Western District Lakes Ramsar site qualified at the time of designation are highlighted in green.

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		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		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		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.

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).

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

Criterion 1: The application of this criterion must now be considered in the context of the newly adopted bioregionalisation for aquatic systems, which is based on drainage divisions. The site lies within the South-east Coast drainage division, which extends from the edge of the Murray Darling Basin in South Australia to the NSW/Qld border. There is no comprehensive wetland inventory for this bioregion. As such the application of the terms “representative” and “rare” are difficult. In terms of “representative”, advice from the Convention (Ramsar 2009) is that contracting parties should select the “best examples” of each wetland type within a bioregion.

Lake Corangamite is the largest inland permanent saline lake in Australia (Timms 2004) and therefore within the bioregion. In addition, at the time of listing it was considered to be a good representative example (arguably the best) of a permanent saline lake within the bioregion (based on the combined knowledge of the steering committee for this project).

Criterion 2: In the Australian context, it is recommended that this criterion should only be applied with respect to nationally and/or internationally threatened species/communities, listed under the EPBC Act or the International Union for Conservation of Nature (IUCN) Red List. A number of threatened species listed at the national and/or international level have been recorded within the Western District Lakes Ramsar site. However, central to the application of this criterion are the words “a wetland” and “supports”. Guidance from Ramsar (Ramsar 2005) in applying the criteria indicates that the wetland must provide habitat for the species concerned. For this reason, vagrant species (such as the single record from Lake Murdeduke for the fairy prion, *Pachyptila turtur* in 1987; the growling grass frog, *Litoria raniformis* at Lake Gnarpurt in 1905 and the undated record for the Yarra pygmy perch, *Nannoperca obscura* at Lake Corangamite; DSE unpublished) have not been considered to contribute to the meeting of this criterion. In addition, while there is some evidence that the Corangamite water skink (*Eulamprus tympanum marnieae*) may occur within the site, core habitat for this species and over 90 percent of its population are within other lakes in the region. As such, this species is not considered to contribute to this criterion.

There are two threatened species supported by the wetlands within the Western District Lakes Ramsar site:

- Salt-lake tussock-grass (*Poa sallacustris*) listed as vulnerable under the EPBC Act 1999 occurs at Lake Corangamite and Lake Terangpom (Carter and Walsh 2006).
- Spiny peppercress (*Lepidium aschersonii*) listed as vulnerable under the EPBC Act 1999 occurs at Lake Corangamite and Lake Beeac within the Ramsar site (DSE unpublished).

Criterion 3: Like criterion one, application of this criterion must be taken in the context of the revised bioregionalisation for aquatic systems. A lack of data across the bioregion (which spans three states) makes application of this criterion difficult. In the absence of any species unique to the Ramsar site, or evidence that this site is substantially more species rich or diverse than other comparable areas, it is not possible to definitively state that this criterion is met. In addition, the site was not originally listed under this criterion in 1982, but the criterion was added in the 1999 revision of the Ramsar Information Sheet (RIS) based on numbers of waterfowl. Waterfowl abundance is covered by Criteria 5 and 6 and should not be used as the sole support for Criterion 3. Therefore, this criterion was most likely never met by the site and should not be considered here.

Criterion 4: The basic description of this criterion implies a number of common functions/roles that wetlands provide including supporting fauna during migration, providing drought refuge, supporting breeding and moulting in waterfowl. There is not a strong argument for the Western District Lakes acting as refuge for fauna. There are a number of other permanent, freshwater lakes in the region that provide this function. However the lakes within the Ramsar site clearly support wetland fauna during critical lifecycles (as described below) and clearly meet this criterion.

<u>The critical life stage of migration</u>

Lakes within the Ramsar site (most notably Lake Murdeduke and Corangamite) support large numbers of migratory shorebirds (GFNC 1993 – 2008; Birds Australia unpublished). This includes 20 species listed under international migratory bird agreements (Bonn, CAMBA, JAMBA, ROKAMBA).

<u>The critical life stage of breeding</u>

The Western District Lakes Ramsar site supports breeding of at least 11 species of waterbird (Appendix B).

<u>The critical life stage of moulting</u>

There is evidence that waterfowl such as hardheads and Australian shelduck use the large expanses of open water at Lakes Corangamite and Murdeduke during times of moult (GFNC 1993 – 2008).

Criterion 5: Comprehensive bird survey data for the Western District Lakes Ramsar site are lacking. Existing counts are often of a subset of wetlands within the site only and/or have not been undertaken regularly. Counts of total waterfowl for some areas within the Ramsar site were reported by the Royal Australasian Ornithologist Union (RAOU) from 1987 to 1992 (Table 6). These data do not consistently cover all wetlands in the Ramsar site and does not include other waterbirds such as herons and ibis and shorebirds; as such, total counts are likely to be higher. However, it is clear that there is sufficient evidence to state that the Western District Lakes Ramsar site meets this criterion, with consistent numbers over six years greater than 20 000.

Table 6: Summer total waterfowl counts from locations within the Western District Lakes Ramsar site (data from RAOU Reports). Blank cells indicate no count reported.

Location	1987[1]	1988[2]	1989[3]	1990[4]	1991[5]	1992[6]
Beeac	619					
Bookar	1488	2488	150		604	807
Colongulac		15 706	9777	6303	12 652	6253
Corangamite	17 810	29 654	21 865	5320	6738	8066
Gnarpurt	1042	902				
Milangil	954	6004	4911	5213	13 731	12 196
Murdeduke	14 451	9328	4886	12 667	8295	4840
Terangpom	909	16 650	6906	2281	5352	3208
Total	**37 233**	**80 732**	**48 495**	**31 784**	**47 372**	**35 370**

Criterion 6: Assessment of the Western District Lakes Ramsar site against this criterion has been made using the latest Waterbird Population Estimates (Wetlands International 2006) and by considering bird counts from within the site boundary only. Large numbers of birds have been regularly recorded from Lake Martin / Cundare Pool, which is adjacent to the north east corner of Lake Corangamite. However, this wetland is not within the boundary of the Ramsar site and birds observed in this wetland have been excluded from the analysis. Species for which maximum counts have exceeded the relevant one percent population thresholds are provided in (Table 7). Given the lack of consistent count data, an application of the principle “regularly supports” is difficult. While there is insufficient evidence for the majority of the species in Table 7, there is strong evidence for a number of waterfowl species including Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot, for which one percent population thresholds were exceeded in at least two thirds of seasons, or for which one percent population thresholds were exceeded by the mean of the maximum counts taken over five years, in years for which data is available (1987 to 1992 inclusive; see Section 3.3.4).

[1] Martindale 1988
[2] Hewish 1988
[3] Peter 1989
[4] Peter 1990
[5] Peter 1991
[6] Peter 1992

Table 7: Waterbirds species for which maximum counts in the Western District Lakes Ramsar site exceed one percent of the relevant population (those with sufficient evidence to meet the provision of "regularly supports" are shown highlighted). Note that the benchmark period for assessing populations at listing is 1987 to 1992.

Common name	Species name	Population (one percent)	Maximum count	Years with counts above threshold
Australasian shoveler	*Anas rhynchotis*	Australian (1000)	3552 February 1991 combined count[5]	1988, 1989, 1990, 1991, 1992, 1999, 2003, 2004
Australian shelduck	*Tadorna tadornoides*	Australian (10 000)	22 950 February 1988 at Lake Corangamite[2]	1983. 1987, 1988, 1989, 1999, 2002, 2004, 2006
Banded stilt	*Cladorhynchus leucocephalus*	Australian (2100)	112 000 August 2006 at Lake Corangamite[7]	1983, 1984, 1987, 1996, 2000, 2002, 2003, 2006, 2007
Black swan	*Cygnus atratus*	Australian (10 000)	10 000 February 2001 at Lake Murdeduke[7]	1983, 1987, 1989, 2001
Blue-billed duck	*Oxyura australis*	Australian (100)	1560 February 1999 at Lake Milangil[8]	1991, 1992, 1999, 2003
Chestnut teal	*Anas castanea*	Australian (1000)	4558 March 1999 at Lake Corangamite[9]	1989, 1990, 1991, 1992, 1999, 2002
Eurasian coot	*Fulica atra*	Australian (10 000)	20 000 March1996 at Lake Milangil[9]	1981, 1987, 1988, 1991, 1992, 1997, 1998, 2000, 2002
Freckled duck	*Stictonetta naevosa*	Australian (250)	730 January 1983 at Lake Murdeduke[9]	1981, 1983, 2002
Glossy ibis	*Threskiornis spinicollis*	Australian (10 000)	90 000 Jan 1974 at Lake Corangamite[9]	1974
Great crested grebe	*Podiceps cristatus*	Australian (250)	2000 July 1980 at Lake Colongulac[9]	1979, 1980
Hoary-headed grebe	*Poliocephalus poliocephalus*	Australian (3000)	4000 Feb 1998 at Lake Corangamite[9]	1998
Musk duck	*Biziura lobata*	Australian (250)	1000 Jan 1983 at Lake Corangamite[9]	1983

Criterion 7: Guidance from the Ramsar Convention (Ramsar 2009) 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 percent) or by having a high degree of biodisparity in the fish community. However, as only six native species of fish have been recorded from within the site, this criterion is unlikely to apply.

Criterion 8: Guidance from the Convention indicates that this criterion is about providing a network of sites that maintain fish populations as they migrate during their lifecycle. Western District Lakes are isolated from the sea and most flowing environments. It is unlikely that this criterion has ever been met at the site.

[7] GFNC 1993 - 2008
[8] Birds Australia unpublished
[9] DSE unpublished

Criterion 9: The application of this criterion relies on estimates of the total population of non-bird species. In the case of Western District Lakes this would require population estimates of frog or fish species. As there are no reliable population estimates for any of the relevant species it is not possible to determine if the site supports one percent of any population. Based on available information, this criterion is not met.

3. Critical Components and Processes

This description of the ecological character of the Western District Lakes Ramsar site is for conditions at the time of listing (1982). In order to capture temporal variation in components and processes, the following description is focussed on data spanning the decade before listing and the decade after (i.e. 1972 – 1992). However, in some instances, where data from around the time of listing could not be sourced, more recent information has been used and clearly indicated in the text. Changes since listing are discussed in Section 7.

3.1 Identifying critical components and processes

The basis of an ECD is the identification, description and where possible, quantification of the critical components, processes, benefits and services of the site at the time of listing. Wetlands are complex ecological systems and the complete list of physical, chemical and biological components and processes for even the simplest of wetlands would be extensive and difficult to conceptualise. It is not possible, or in fact desirable, to identify and characterise every organism and all the associated abiotic attributes that are affected by, or cause effect to, that organism to describe the ecological character of a system. This would result in volumes of data and theory but bring us no closer to understanding the system and how to best manage it. What is required is to identify the key components, the initial state of the systems and the basic rules that link the key components and cause changes in state (Holland 1998). Thus, we need to identify and characterise the key or critical components, processes, benefits and services that determine the character of the site. 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 that the minimum components, processes, benefits and services that should be included in an ECD are those:

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

In addition to critical components and processes are characteristics of the site, which are not critical (that is, if they were to change, they would not lead directly to a change in character) but are still important in the ecology of the system. These are termed "essential elements" and include some of the characteristics of the site, which may act as early warning indicators of a potential change in character and therefore should be considered in management planning for the site.

In distinguishing between critical components and processes and essential elements, the role that components and processes play in the provision of critical ecosystem services should also be considered. To this end, the linkages between essential elements, critical components, processes, benefits and services and the criteria under which the site was listed are illustrated conceptually in Figure 9. Note that cultural services such as recreation and tourism are not shown, but are underpinned by all critical components and processes and all other services.

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. In addition, they are important in providing the benefits and services that the site provides.

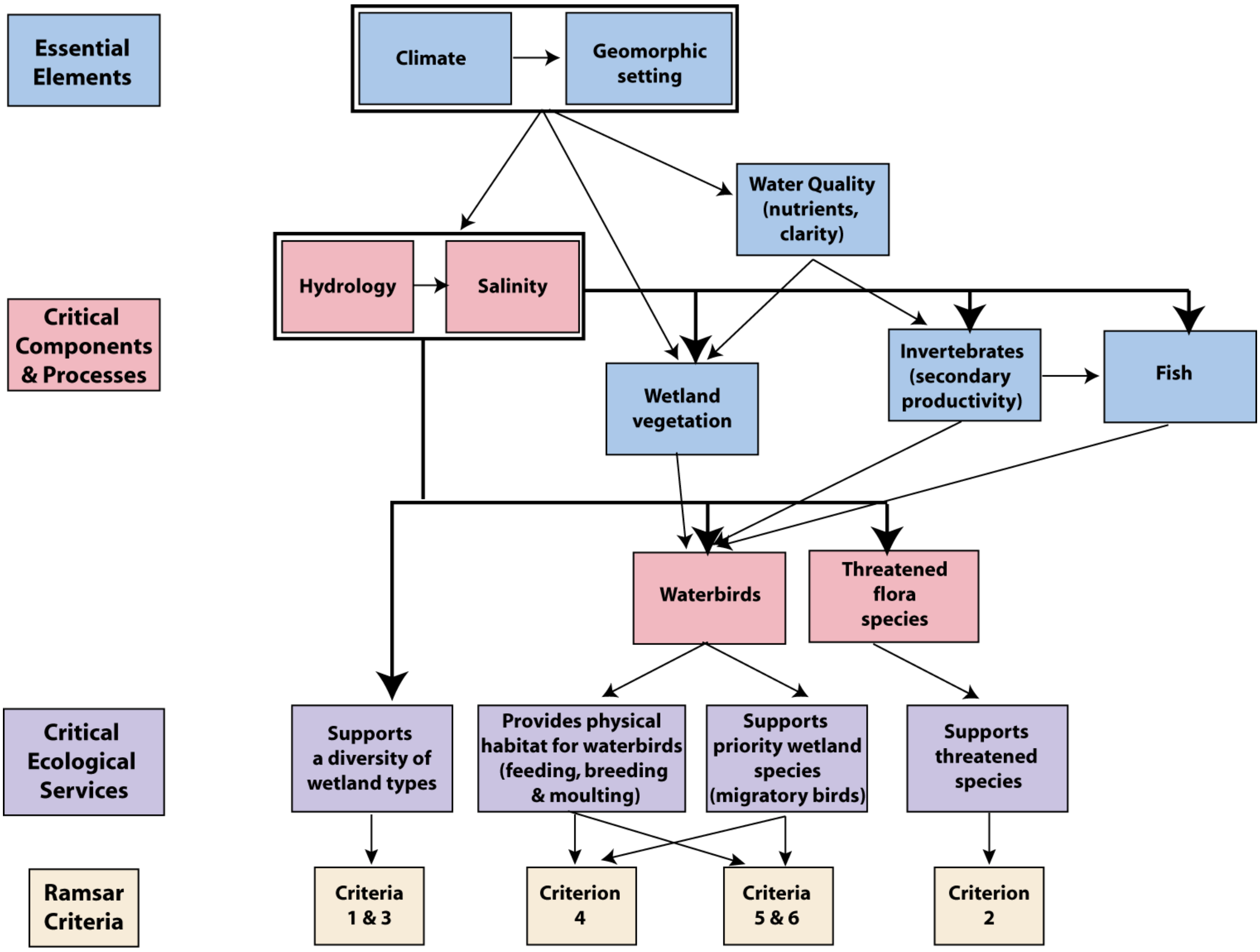


Figure 9: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a wetland of international importance.

The identified essential elements for the Western District Lakes Ramsar site are:

- climate
- geomorphic setting
- water clarity and nutrients
- wetland vegetation
- fish
- invertebrates.

The identified critical components and processes of the Western District Lakes Ramsar site are:

- hydrology
- salinity
- threatened flora species
- waterbirds.

It is difficult to separate components (physical, chemical and biological parts) and processes (reactions and changes). For example, aspects of geomorphology such as bathymetry and topography may be considered as components, while other aspects of geomorphology such as sediment transport and erosion could be considered processes. Similarly the species composition of birds at a site may be considered a component, but feeding and breeding are processes. In the context of this ECD, a separation of the ecology of wetlands into components and processes is an artificial boundary and does not add clarity to the description. As such, components and processes are considered together. The interactions between components and processes, the functions that they perform and the benefits and services that result are considered in detail in Section 4.

3.2 Essential elements

The essential elements of the Western District Lakes Ramsar site that are considered important in supporting the critical components, processes, benefits and services of the site are described briefly below and summarised in Table 8.

Table 8: Summary of essential elements within the Western District Lakes Ramsar site.

Essential elements	Description
Climate	• Located in temperate climatic zone with warm summers and cool winters. • Rainfall occurs year round, but is higher in winter months. • On average rainfall exceeds evaporation from April to September.
Geomorphic setting	• Located on the Victorian Volcanic Plains. • Lakes are all shallow, with flat bottoms and high surface area to volume ratios. • A number of lakes have lunettes on the eastern shore.
Water clarity and nutrients	• All lakes are turbid, with high levels of nutrients.
Wetland vegetation	• Most of the lake margins are bare, with less than 20 percent of the littoral zone vegetated. • A total of five submerged aquatic plant species have been recorded.
Fish	• Data deficient. • At the time of listing a number of the Lakes were stocked with short-finned eels and supported commercial fisheries. • A total of six native species of fish have been recorded within the Lakes.
Invertebrates	• Species composition varies with salinity. • Molluscs dominated most saline and mesosaline Lakes. • Lake Colongulac was dominated by oligochaetes.

3.2.1 Climate

Western District Lakes are situated within the temperate climatic zone of south eastern Australia (Bureau of Meteorology 2010). The general climatic pattern is cool winters and warm summers, with rainfall occurring year round. The three aspects of climate that most directly affect wetland ecology are rainfall (both local and in the catchment), temperature and (to a lesser extent in temperate systems) relative humidity as these all fundamentally affect wetland hydrology and the water budget. In addition, wind speed and direction can play an important role due to its effect on evaporation and lake turbidity.

Rainfall, on average, occurs year round with highest monthly average rainfall in August (87 millimetres) and lowest in February (35 millimetres). There is some degree of variability in rainfall as evidenced by the 10th and 90th percentiles, which range from less than 10 millimetres per month to greater than 130 millimetres per month (Figure 10). However, this is considerably more stable than rainfall in arid and topical zones within Australia (Bureau of Meteorology 2010).

Annual average rainfall at Colac is in the order of 750 millimetres per year. Once again, although there is some degree of variability in annual rainfall (ranging from less than 400 millimetres to more than 1000 millimetres in 40 years of records from this site) (Figure 11) the variability is relatively low compared to other areas in Australia.

Temperatures range from cool to warm (Figure 12), with average summer maximum temperatures around 26 degrees Celsius and average minimum temperatures around 11 degrees Celsius. During winter, average maximum temperatures are considerably cooler (12 to 13 degrees Celsius) as are average minimum temperatures (four to five degrees Celsius). Average relative humidity ranges from 46 percent during summer to 75 percent during winter months. This combined with the relatively low winter temperatures results in rainfall exceeding evaporation from April to September, but the reverse situation for the remainder of the year.

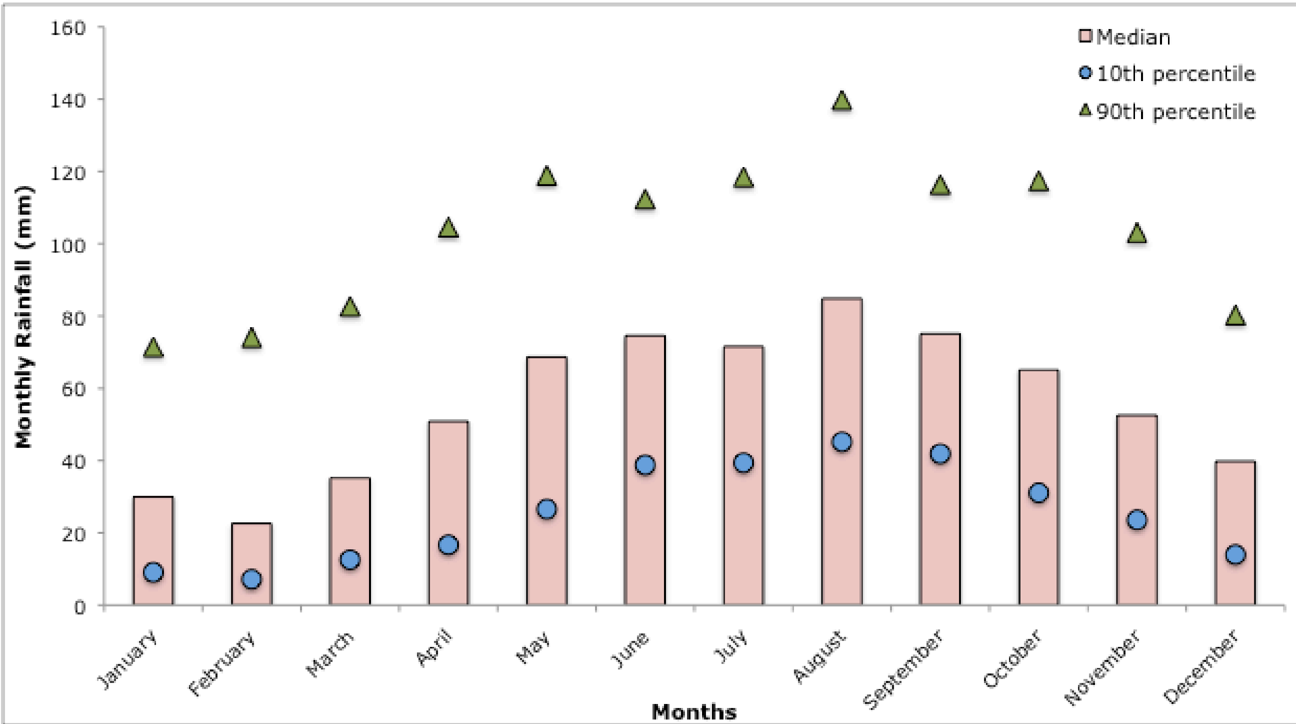


Figure 10: Median (10th and 90th percentile) monthly rainfall at Colac (1898 – 2009; Bureau of Meteorology).

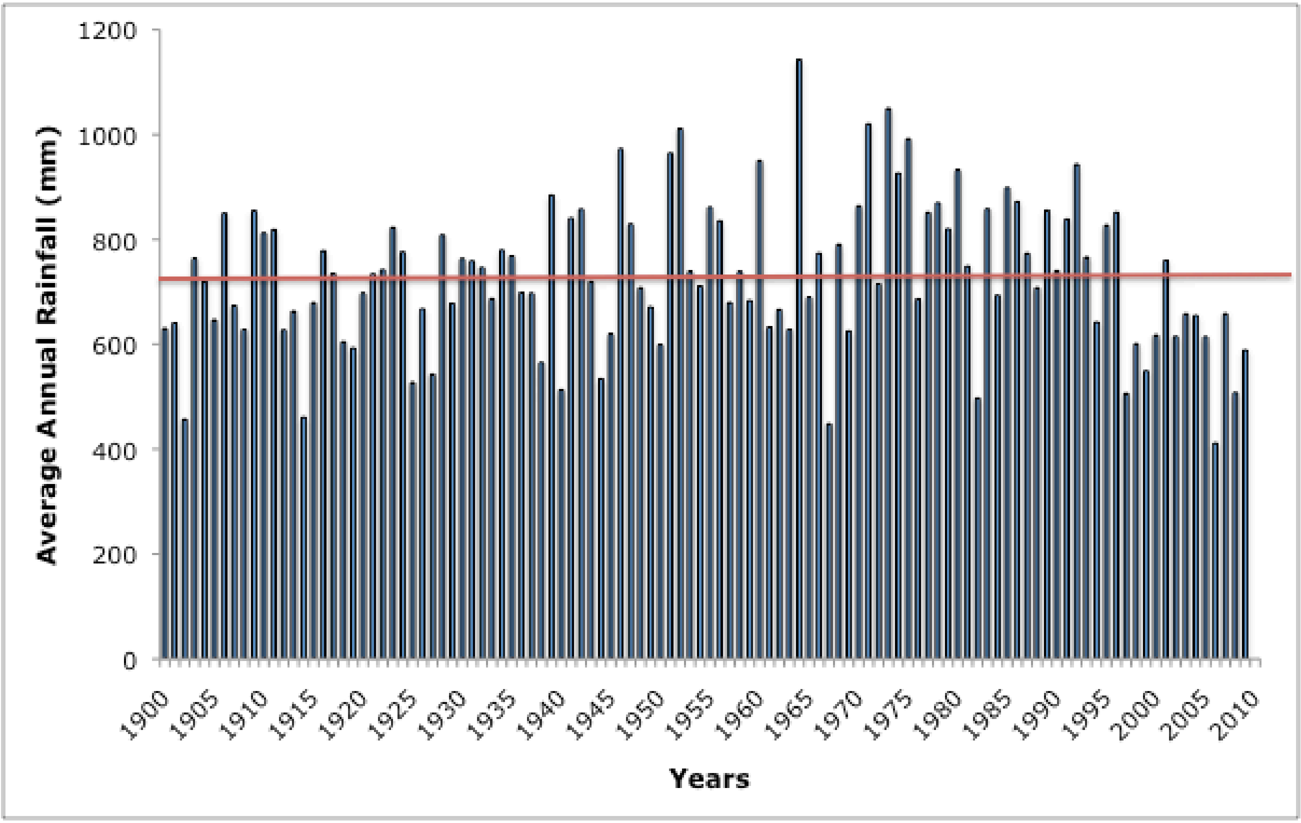


Figure 11: Average annual rainfall at Colac (1900 – 2009; Bureau of Meteorology). Note horizontal line shows long term average.

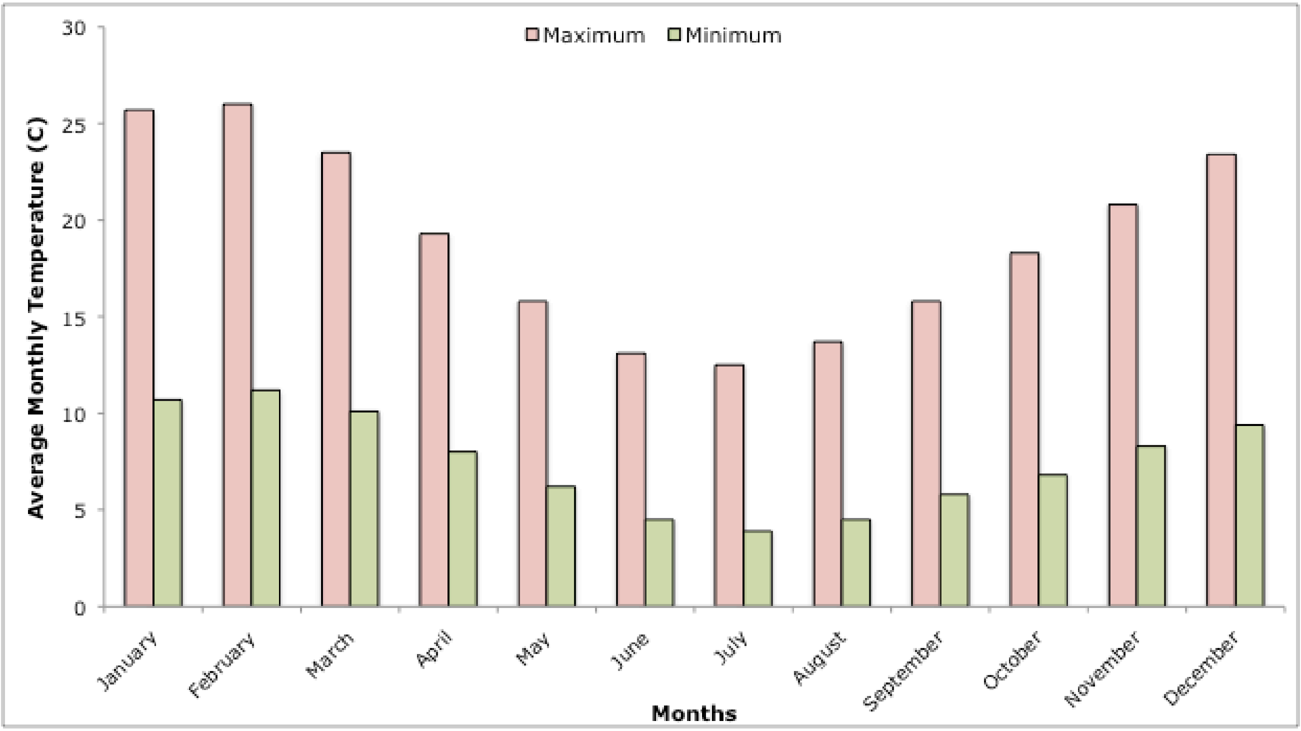


Figure 12: Average monthly maximum and minimum temperatures at Colac (1998 – 2009; Bureau of Meteorology).

3.2.2 Geomorphic setting

Western District Lakes are located on the Victorian Volcanic Plains, an area characterised by low relief and poorly integrated drainage resulting in a large number of lakes and few rivers (Decker and Last 1989). The geology of the area contains a handful of formations (Figure 13). Tertiary deposits of marine origin (Gellibrand marl) underlie the region. Overlaying this are more recent basalts of volcanic origin, and on the eastern margins of many lakes are lunettes of aeolian clays and softer sediments of Quaternary origin (Coram 1996).

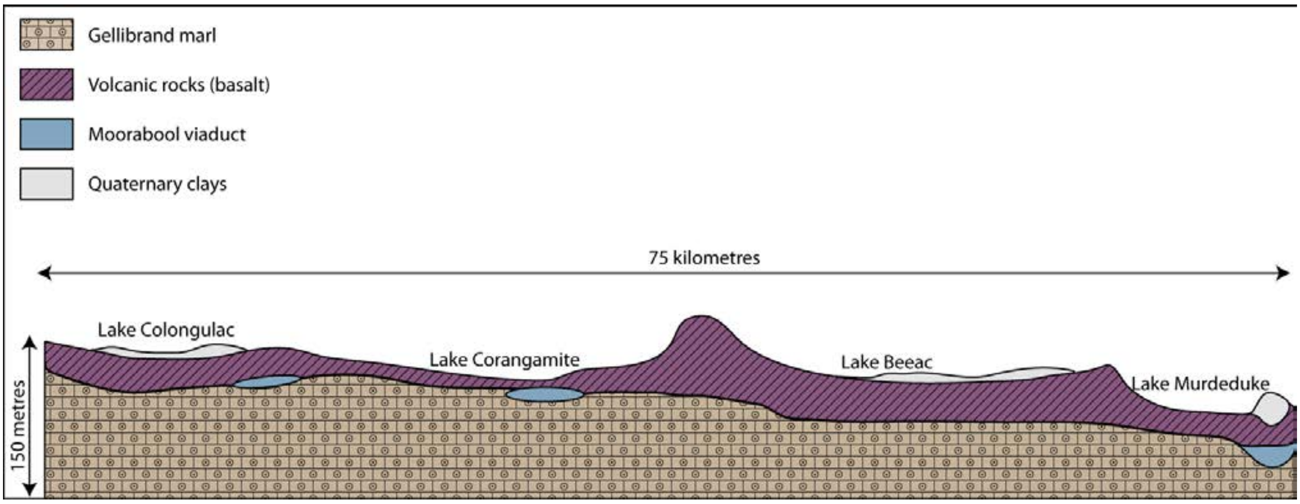


Figure 13: Geology of the western volcanic plains (adapted from Coram 1996).

Across the region there are two types of lake systems (De Decker and Last 1989):

1. Volcanic maar lakes – deep (greater than 10 metres), circular lakes located within volcanic craters; and
2. Playas – shallow flat bottomed depressions on the volcanic landscape, with a wide range of shoreline morphologies.

All the lakes within the Western District Lakes Ramsar site are playa lakes and were formed in low lying areas as a result of interruptions in individual lava flows (Coram 1996). The shallow nature of the lakes results in a large surface area to volume ratio (Table 9). A number of the lakes have lunettes of carbonate and clay that are considered evidence of fluctuating water levels for the past 40 000 years. These lunettes form when lake levels are low and sediments dry and are wind-blown onto the eastern margins of the lake where they accumulate in a crescent dune formation (Coram 1996).

Table 9: Summary of morphologies of the lakes within the Western District Lakes Ramsar site (Water Technology 2010). Note that all values are approximate.

Lake	Maximum depth (metres)	Mean depth (metres)	Area (hectares)	Volume (megalitres)	Surface area to volume ratio
Beeac	3	0.5	660	19 500	0.3
Bookar	2.5	0.5	480	10 000	0.5
Colongulac	4	2.2	1500	31 500	0.5
Corangamite	6	6	25 000	1 150 000	0.2
Cundare	2.5	0.6	300	8000	0.4
Gnarpurt	3	2.6	2500	95000	0.3
Milangil	3.5	1	230	5000	0.5
Murdeduke	5	5	1600	68 000	0.2
Terangpom	2.5	1	220	4500	0.5

The shapes of each of the lakes vary. Some, such as Lakes Corangamite and Bookar have islands within them and others, such as Lake Milangil have complex shorelines with spits (Gippel et al. 2002). Lakes Beeac and Gnarpurt have simple shapes and uncomplicated shorelines in comparison to the remainder of the lakes (Gippel et al. 2002) and this affects the complexity of physical habitats within these systems.

3.2.3 Water clarity and nutrients

The lakes within the Ramsar site are predominantly turbid with low transparency (Table 10). This has been attributed to the shallow water, large surface areas and clay substrate that is easily mobilised by the action of wind and waves (Hose et al. 2008). De Decker and Williams (1988) noted that turbidity did not follow a seasonal pattern and water transparency remained low year round.

Total nutrient concentrations within each of the lakes for which data exists are comparatively high and indicative of eutrophic conditions. Mean nitrogen concentrations at the six lakes for which quantitative data could be sourced range from 1900 micrograms per litre at Lake Gnarpurt to nearly 8000 micrograms per litre at Lake Corangamite (Figure 14). The percentage of nitrogen in bioavailable form (ammonium and/or nitrate-nitrite) ranges from less than 5 percent to up to 30 percent varying temporally and spatially, but with no discernible pattern (De Decker and Williams 1988).

Table 10: Turbidity (NTU) and Secchi depth (metres) at each of the lakes within the Western District Lakes Ramsar site.

Lake	Turbidity (NTU)	Secchi depth (metres)	Date of record	Reference
Beeac	130	0.06	1972	Hose et al. 2008
Bookar	9 – 115	0.07 – 1	1979 – 80	De Decker and Williams 1988
Colongulac	7 – 93	0.17 – 0.56	1979 – 80	De Decker and Williams 1988
Corangamite	4 – 67	0.41 – 1	1979 – 80	De Decker and Williams 1988
Cundare	145 – 350	0.06	1972	Hose et al. 2008
Gnarpurt	18 – 104	0.18 – 0.33	1979 – 80	De Decker and Williams 1988
Milangil	No data			
Murdeduke	4 – 36	0.13 – 0.8	1993 – 95	DSE 2010
Terangpom	12 – 78	No data	2005 – 09	DSE 2010

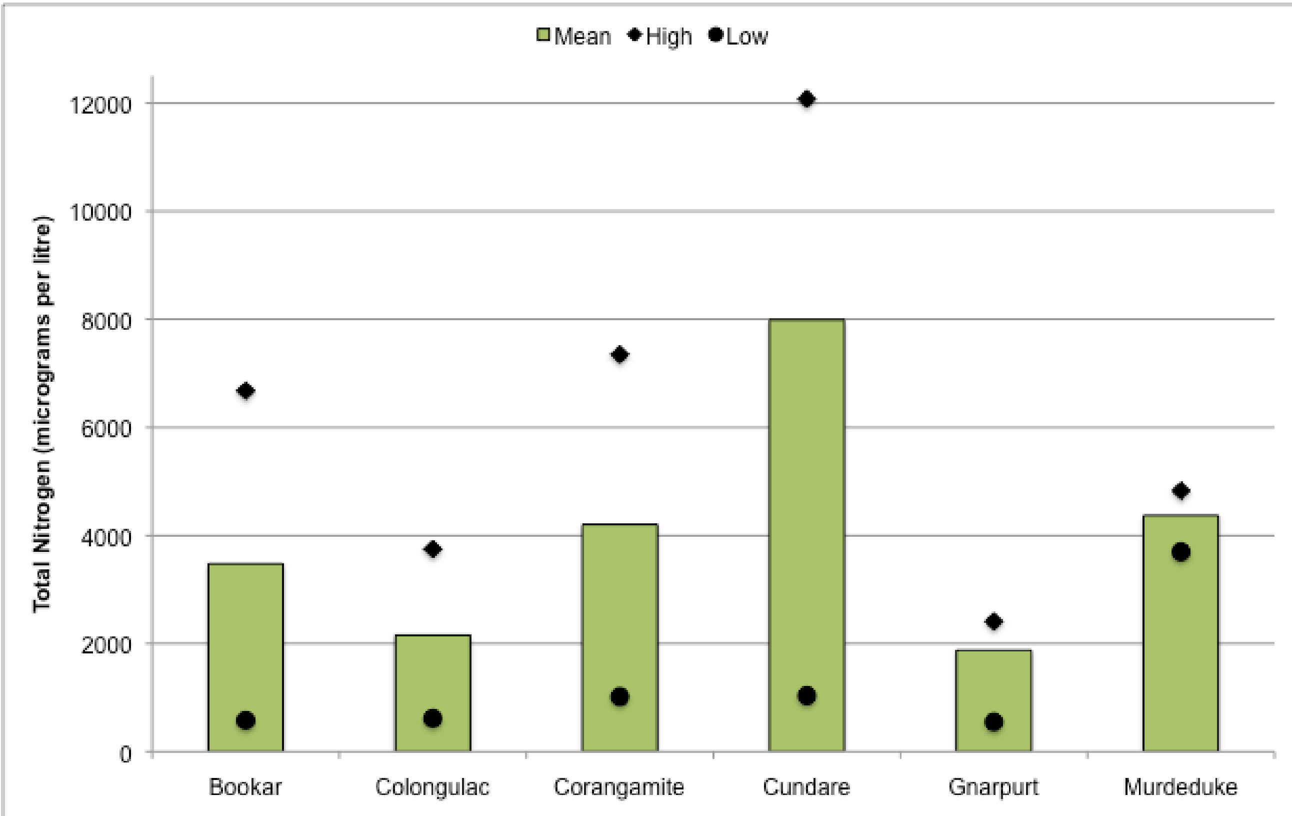


Figure 14: Mean (and range) of total nitrogen concentrations at six lakes within the Western District Ramsar Site. Lakes Bookar, Colongulac, Corangamite and Gnarpurt data from 1979 (De Decker and Williams 1988); Lakes Cundare and Murdeduke data from 1993 to 1995 (Victorian Water Resources Data Warehouse, DSE 2010).

Mean total phosphorus concentrations range from 120 micrograms per litre at Lake Murdeduke to over 5000 micrograms per litre at Lake Colongulac (Figure 15), the latter of which at the time of listing received sewage water discharge (Decker and Williams 1988). Although total phosphorus concentrations are lower at

Lakes Bookar, Corangamite, Gnarpurt and Murdeduke compared to Lakes Colongulac and Cundare, all are indicative of eutrophic conditions according to the Organisation for Economic Co-operation and Development (OECD) accepted trophic classification of Wetzel (1983), which suggests that mean total phosphorus concentrations greater than 85 micrograms per litre could be considered eutrophic.

The percentage of bioavailable phosphorus (dissolved inorganic phosphorus) was recorded as low at most lakes (less than 10 percent) but very high at Lake Colongulac (approximately 90 percent); again reflecting the wastewater discharge into this lake at the time of listing.

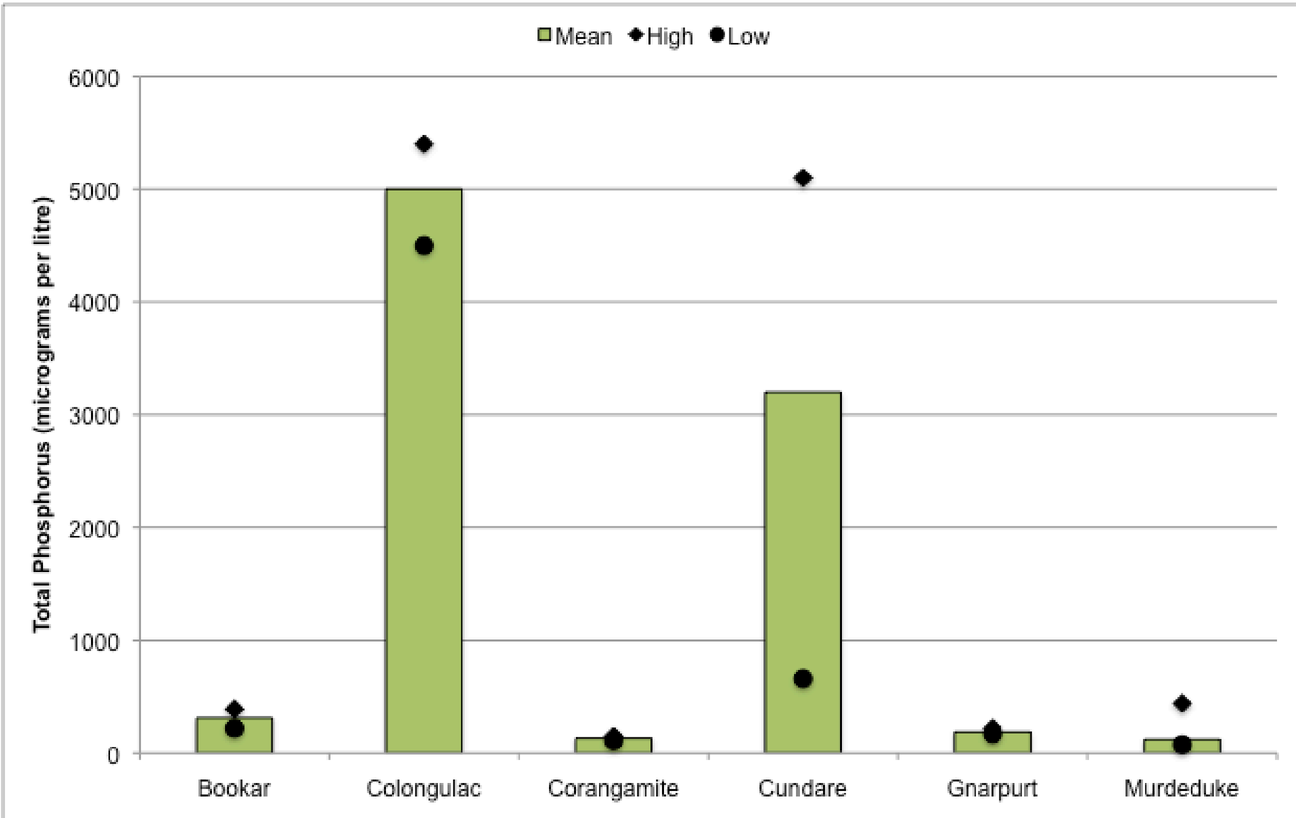


Figure 15: Mean (and range) of total phosphorus concentrations at six lakes within the Western District Ramsar Site. Lakes Bookar, Colongulac, Corangamite and Gnarpurt data from 1979 (De Decker and Williams 1988); Lakes Cundare and Murdeduke data from 1993 to 1995 (Victorian Water Resources Data Warehouse, DSE 2010).

Chlorophyll-a concentrations are high in all lakes and indicative of eutrophic conditions (mean greater than 14 micrograms per litre; Wetzel 1983). Mean chlorophyll-a concentrations ranged from 23 micrograms per litre at Lake Murdeduke to 70 micrograms per litre at Lake Corangamite (Figure 16). Data are insufficient to determine seasonal patterns with any confidence but it s likely that highest concentrations occur during summer when temperatures and light are at a maximum and drive primary productivity.

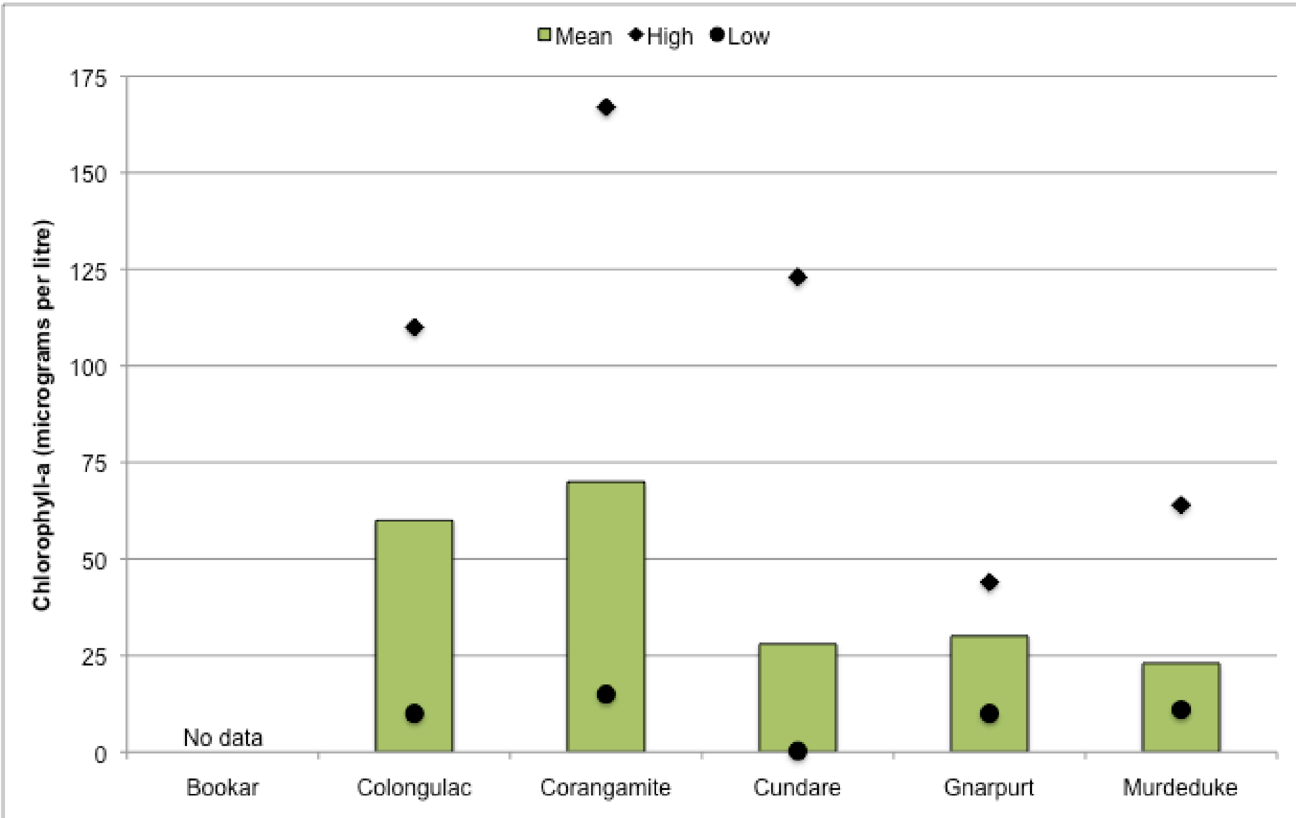


Figure 16: Mean (and range) of chlorophyll-a concentrations at six lakes within the Western District Ramsar Site. Data from 1993 to 1995 (DSE 2010).

The high levels of nutrients within the lake, coupled with high turbidity resulted in frequent algal blooms, most commonly of cyanobacteria that formed thick surficial layers to maximise light availability. Williams (1992) indicated that blooms of *Nodularia spumigena* were common in Lake Bookar and described the water as having the appearance of “thick pea soup” during blooms. This species is also known to bloom in Lakes Corangamite and Gnarpurt, where, at the time of listing (and for a number of decades prior) it was present in more or less bloom proportions most of the time (Williams 1992).

3.2.4 Wetland vegetation

Vegetation within the Western District Lakes Ramsar site is limited. Only 10 to 20 percent of lake margins are vegetated (DNRE 2002) and this is mostly with saltmarsh communities in a patchy distribution (Figure 17). Common species include beaded glasswort (*Sarcocornia quinqueflora*), Austral seablite (*Suaeda australis*) and creeping boobialla (*Myoporum parvifolium*).

At the time of listing a number of the lakes within the Ramsar site supported submerged macrophytes. The most common of these was large-fruit tassel (*Ruppia megacarpa*), which was present at Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke (Williams, 1992; Gippel et al. 2002). The site also contained the charophyte *Lamprothamnium macropogon* which was present at Lakes Bookar, Colongulac, Gnarpurt, Milangil and Murdeduke (Garcia 1999) and also at Lake Corangamite (Timms 2004).

Macrophyte diversity was highest at the freshwater/brackish Lake Terangpom, where five species of submerged macrophyte were recorded (Gippel et al. 2002):

- Fennel pondweed (*Potamogeton pectinatus*)
- Hooded water milfoil (*Myriophyllum muelleri)*
- Lake water milfoil (*Myriophyllum salsugineum*[10])
- Large-fruit tassel (*Ruppia megacarpa*)
- Slender water mat (*Lepilaena preissii*)

Macroalgae have also been recorded in some of the lakes prior to listing with *Enteromorpha* and *Cladophora* occurring in Lake Corangamite in 1918 and 1969 (Williams 1992).

Figure 17: Saltmarsh dominated by beaded glasswort along the shores of Lake Milangil (photo by B. Hale).

3.2.5 Fish

There is little information on fish within the Western District Lakes Ramsar site and no quantitative data could be sourced. Up until the mid 1990s, Lakes Bookar, Corangamite, Gnarpurt and Murdeduke were stocked with short-finned eels (*Anguilla australis*). Several of these lakes including Corangamite and Gnarpurt supported a commercial eel fishery (McKinnon 2006).

[10] Formerly *Myriophyllum elatinoides.*

There are records of seven native and six introduced species of fish from within the Ramsar site from around the time of listing (Table 11). Lake Murdeduke was popular for recreational fishing but it is likely that the target fish were the introduced species – brown trout (*Salmo trutta*) and Chinook salmon (*Oncorhynchus tshawytscha*).

Table 11: Fish species recorded within the Western District Lakes prior to 1996 (data supplied by Arthur Rylah Institute and from Williams 1992).

Common name	Species name	Locations
Native species		
Australian smelt	*Retropinna semoni*	Lakes Murdeduke and Terangpom
Common galaxias	*Galaxias maculatus*	Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Murdeduke and Terangpom
Flat-headed gudgeon	*Philypnodon grandiceps*	Lakes Corangamite and Terangpom
Short-finned eel	*Anguilla australis*	Lakes Bookar, Colongulac, Corangamite, Gnarpurt and Murdeduke
Small-mouthed hardyhead	*Atherinosoma microstoma*	Lake Corangamite
Southern pygmy perch	*Nannoperca australis*	Lake Corangamite
Yarra pygmy perch	*Edelia obscura*	Lake Corangamite
Introduced species		
Rainbow trout	*Oncorhynchus mykiss*	Lakes Murdeduke and Gnarpurt
Tench	*Tinca tinca*	Lakes Murdeduke and Terangpom
Carp	*Cyprinus carpio*	Lakes Murdeduke and Terangpom
Brown trout	*Salmo trutta*	Lakes Corangamite, Mudeduke and Terangpom
Redfin	*Perca fluviatilis*	Lakes Corangamite, Mudeduke and Terangpom
Chinook salmon	*Oncorhynchus tshawytscha*	Lakes Gnarpurt and Murdeduke

3.2.6 Invertebrates

Fresh and inland saline waters often have gross similarities in the invertebrate fauna, in that most groups found in freshwater will also have representatives in saline waters at different taxonomic levels. Salt lakes with salinities above three parts per thousand tend to have an increasingly different suite of taxa compared to freshwater systems (Williams 1999). Williams (1992) reports on the biological features of all of the lakes in the Ramsar site and includes discussion on invertebrate species richness and composition, which represents the most comprehensive description of the invertebrate communities present within the lakes at the time of listing. The Victorian EPA undertook a significant survey of the Western District lakes in 2009, including several of the lakes from the Ramsar site. Invertebrate data was combined with Williams (1992) showing a clear decline in species richness as salinity increases (Figure 18).

At the time of listing Lake Terangpom was fresh, Lakes Bookar, Colongulac, Gnarpurt, Milangil and Murdeduke were mesosaline, Lake Corangamite was saline, and Lakes Beeac and Cundare were hypersaline. Lake Beeac and Cundare were the only two lakes to have brine shrimp (*Parartemia*) and completely lacking insects. Brine shrimp were the dominant taxa in these lakes (Geddes 1976; Williams 1992). The five mesosaline lakes have a similar range of fauna with representatives from the copepods, cladocera, ostracods, amphipods, molluscs and insects across all lakes, although Lakes Milangil and Murdeduke had less species. This was attributed to less sampling effort compared to the other hyposaline lakes (Williams 1992). The dominant species in the hyposaline lakes are the amphipod *Austrochiltonia subtenuis* (*Austrochiltonia australis* in Lake Milangil) and snail *Coxiella* species, considered characteristic of the medium salinity lakes in the region (Williams 1992). Up until 1980, these two species were also the dominant invertebrates in Lake Corangamite. The invertebrate fauna of Lake Corangamite changed around 1980 as salinity increased. Five invertebrate species have been lost from Lake Corangamite since 1980 and a new species, *Australocypris robusta*, a halophile ostracod occurs only post 1980 (Williams 1992).

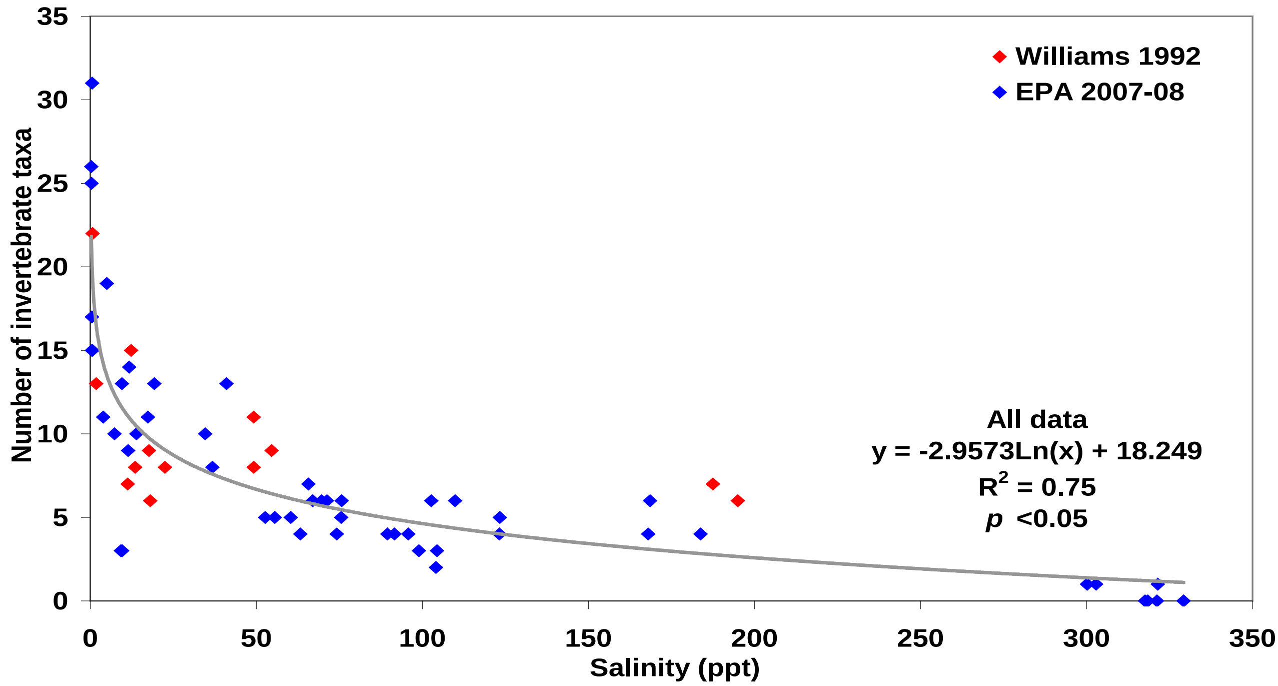


Figure 18: Relationship between invertebrate diversity and salinity in a merged EPA and Williams (1992) dataset for lakes in the Western District (EPA in press). Note this dataset represents more lakes than just the Ramsar site.

Timms (1983) sampled benthic invertebrates only at 21 lakes from the region, including Lakes Bookar, Colongulac, Gnarpurt and Corangamite. He reported different dominance patterns in the benthic fauna reflecting different salinities as well. In freshwater to salinities less than 15 parts per thousand, oligochaetes are important and typically dominate the range six to 11 parts per thousand. Crustaceans dominate above 38 parts per thousand; chironomids can span the whole salinity range but are typically only dominant at the lower salinity ranges (less than 13 parts per thousand). Insects in general never dominate the benthic invertebrate fauna in saline lakes (Timms 1983). Timms (1983) found that molluscs were important in the range of 10 to 30 parts per thousand.

Timms (1983) reported moderately high standing crops of benthos in the study, attributing this fact to many of the lakes studied being eutrophic. The percentage contributions of the major groups of invertebrates to the standing crop recorded in the Ramsar site lakes assessed are presented in Table 12. Timms (1983) shows that *Coxiella* (Figure 19) was clearly dominant in the benthos of Lake Corangamite in January 1980 when the samples were collected. Invertebrates are important in the Western District Lakes Ramsar site for their role in food webs and secondary production.

Table 12: Percentage contribution to standing crop of major taxonomic groups at four of the lakes within the Ramsar site (data from Timms 1983).

Lake	Salinity parts per thousand	Taxonomic group				Mean weight grams per cubic metre	
		Oligochaetes	Crustacea	Chironomids	Molluscs	Wet	Dry
Bookar	13.3	-	29.4	43	27.6	18.6	2.79
Colongulac	9.7	86	1.7	2.1	10.2	29.1	3.78
Corangamite	30.4	0.1	0.8	17.5	82.5	14.2	2.13
Gnarput	11.1	-	24.5	20.6	54.9	1.6	0.26

Figure 19: *Coxiella* shells from Lake Corangamite (photo B. Hale).

3.3 Critical components and processes

The attributes and characteristics of each of the identified critical components and processes of the Western District Lakes Ramsar site are described below. Where possible, quantitative information is included. However, as with many ecological character descriptions, there are significant knowledge gaps (see Section 8). A summary of the critical components and processes within the Western District Lakes Ramsar site is provided in Table 13.

Table 13: Summary of critical components and processes within the Western District Lakes Ramsar site.

Component / process	Description
Hydrology	• At the time of listing six of the lakes were considered permanent (not drying in the past 100 years), one (Lake Colongulac) was near permanent drying on occasion in the last 100 years and two seasonal or intermittent. • All lakes are connected to saline, surficial groundwater. • The major water source, however, is direct rainfall and most water is lost via evaporation. • All except Beeac and Cundare are groundwater flow-through lakes, discharging to groundwater down gradient. • Lakes vary in water level on seasonal cycles.
Salinity	• Salinity of the lakes is variable seasonally and with longer term climate patterns. • Lakes Bookar, Colongulac, Gnarpurt, Milangil and Murdeduke are considered mesosaline. • Lake Corangamite is saline. • Lakes Beeac and Cundare are hypersaline. • Lake Terangpom is freshwater / brackish.
Vegetation	• The site supports two threatened plant species: spiny peppercress and salt-lake tussock-grass.
Waterbirds	• Seventy species of waterbird including 20 international migratory species have been recorded in the site. • Abundances were high, with greater than 20 000 waterbirds recorded annually. • The site supported greater than one percent of the population of 11 species of waterbird. • Breeding has been recorded for 11 species.

3.3.1 Hydrology

The water sources of the lakes of the Western District Lakes Ramsar site include a mixture of natural and human modified surface water as well as groundwater and direct rainfall. Hydrology is considered in terms of surface water sources, groundwater and water balances for the lakes.

Surface water

Surface water enters the lakes via precipitation, overland flow, a small number of minor natural creeks and drainage lines as well as an extensive constructed drainage network designed to divert water from adjacent agricultural land. In terms of surface water, all of the lakes within the Ramsar site are terminal basins, without natural surface water discharge (Coram 1996).

Surface water inflows from drainage and overland flow are from individual catchments that range in both absolute and relative size (Table 14). The lake areas range from just one percent of their catchment (for Lake Terangpom) to nearly one third of the catchment (Lake Cundare; Water Technology 2010).

Table 14: Catchment areas for each lake in the Western District Lakes Ramsar site (Water Technology 2010).

Lake	Lake area (hectares)	Catchment area (hectares)	Percentage of catchment covered by lake
Beeac	660	3500	19
Bookar	480	6400	7
Colongulac	1500	9300	17
Corangamite	25 100	125 300	20
Cundare	300	1100	29
Gnarpurt	2500	68 300	4
Milangil	230	4300	5
Murdeduke	1700	35 000	5
Terangpom	220	19 200	1

The major surface water source for Lake Corangamite is the Woady Yallock River which enters the lake via Lake Martin / Cundare Pools in the north (Figure 20). A major diversion scheme was constructed in the 1950s on the Woady Yallock River to reduce widespread flooding. The scheme diverts approximately 50 percent of flows from the Woady Yallock River to the Warrambine Creek to the east, and ultimately via the Barwon River to Bass Strait (Barton et al. 2008). There are numerous other constructed drains within the Ramsar site that were present at the time of listing and this includes a connection between Lake Gnarpurt and Lake Corangamite. This results in water from Lake Gnarpurt draining into Lake Corangamite.

Stream flow (and surface run off) is highly seasonal, with the majority of flow occurring in late winter and early spring. This is illustrated by flows in the Woady Yallock River upstream of the Ramsar site for a decade surrounding the time of listing (Figure 21). Winter and spring flows are up to an order of magnitude greater than those is summer. This pattern is also evident in other creeks and drainage lines that feed into the lakes. However, the inter-annual variability is greater in streams with smaller catchments (Coram 1996).

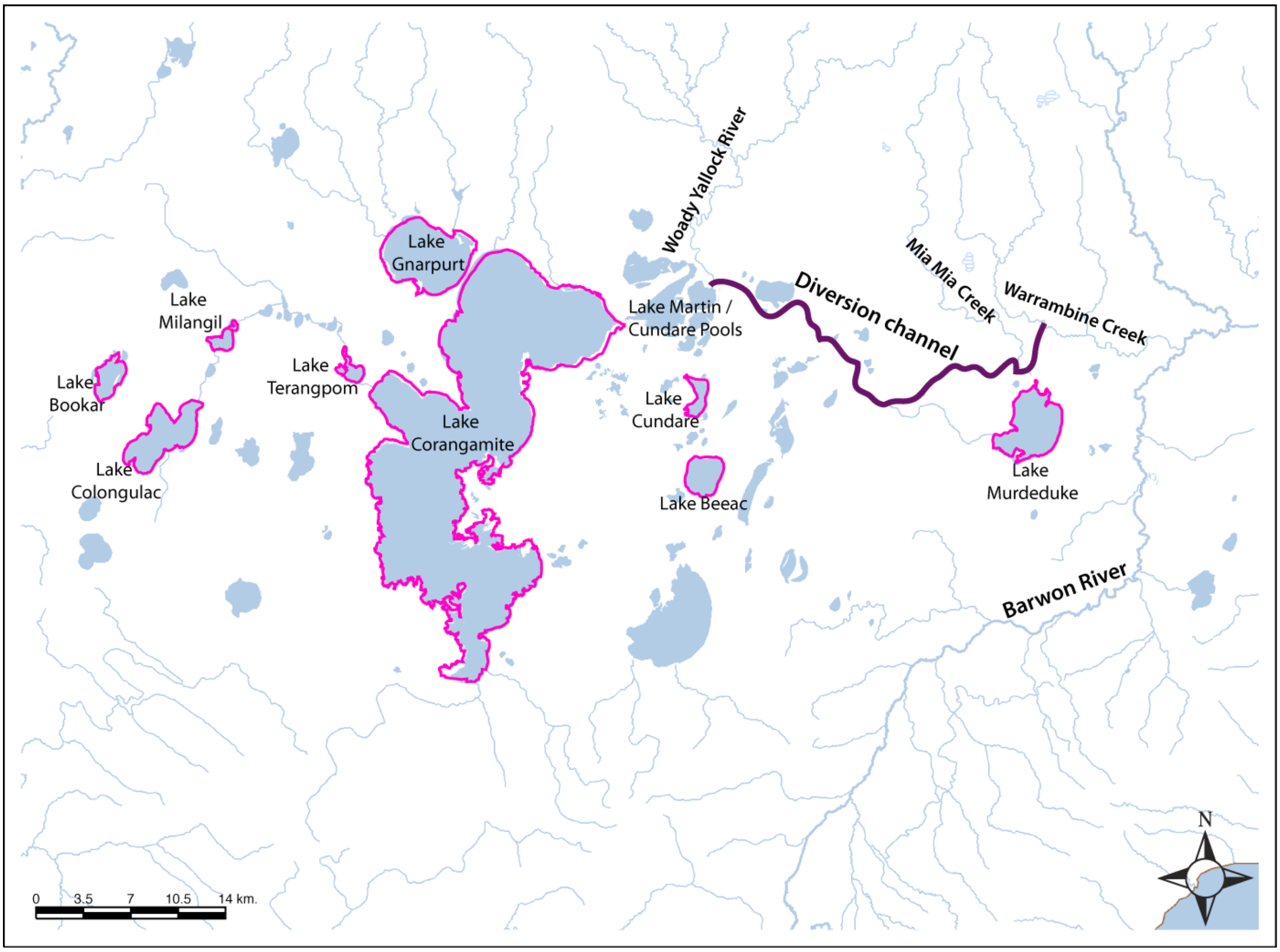


Figure 20: Major surface drainage around the Western District Lakes Ramsar site (data provided by DSE).

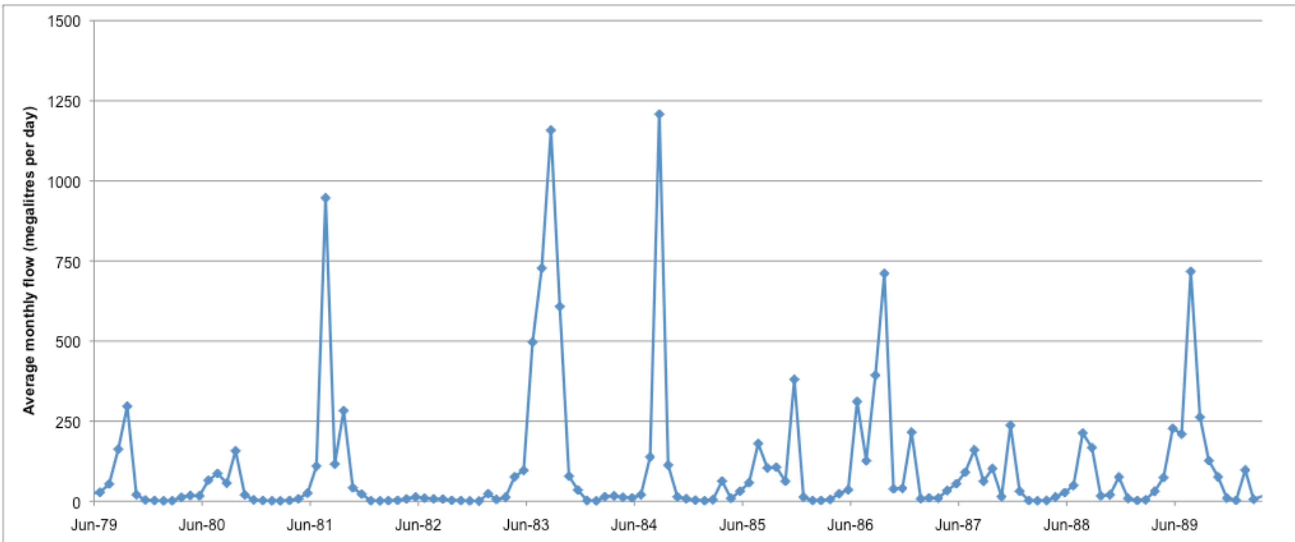


Figure 21: Average monthly flow (megalitres per day) in the Woady Yallock River from 1979 to 1989 approximately 20 kilometres up stream of Lake Corangamite (Victorian Water Resources Data Warehouse, DSE 2010).

In addition to drainage, at the time of listing, Lake Colongulac received treated wastewater from the Camperdown Treatment Plant (which ceased in 1999). The volume discharged varied seasonally and annually but contributed between 200 and 600 megalitres annually (Water Technology 2010).

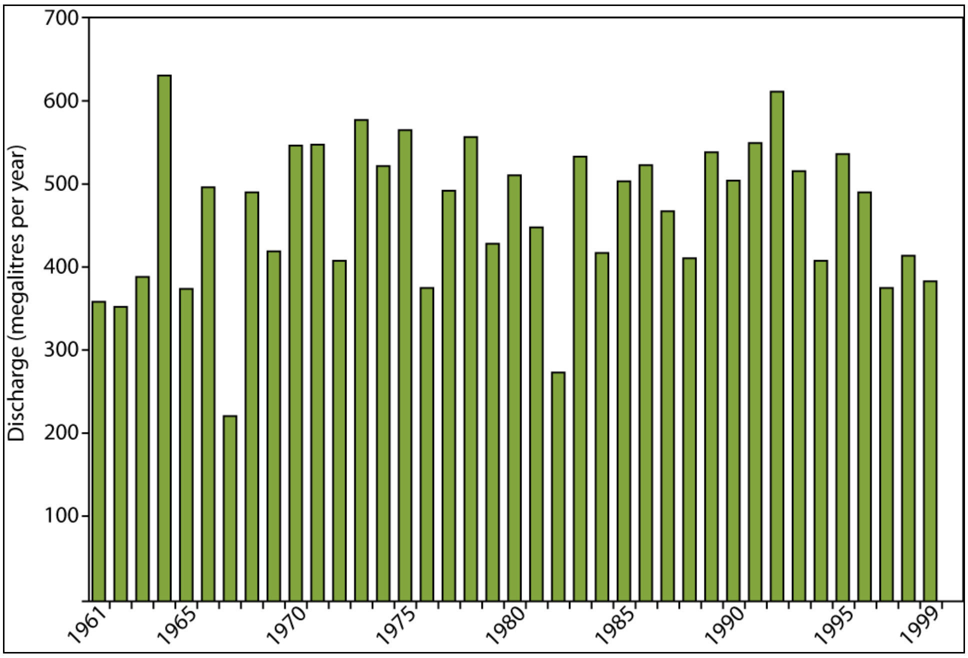


Figure 22: Camperdown treatment plant calculated outflows to Lake Colongulac (Water Technology 2010).

Groundwater

The groundwater sources for the lakes within the Ramsar site are local, surficial aquifers (Dalhouse 2008; Coram 1996). These local systems are described as follows (Dalhouse 2008).

- Groundwater flows occur over distances of less than five kilometres within small sub-catchments.
- Water tables rise rapidly in response to local runoff and rainfall.
- They have a low storage capacity.
- There is a mixture of saline and freshwater sources.
- They are shallow with water tables close to the surface of the plains.

Groundwater gradients in the regional aquifer indicate that movement is generally from west to east. However a localised groundwater recharge area to the immediate east of Lake Corangamite (Red Rocks) flows in a westerly direction to Lake Corangamite (Coram 1996; Figure 23). It should be noted that while the direction of flow has not changed since the time of listing, the groundwater levels shown in the contours in Figure 23 are indicative of current conditions and are lower than those at the time of listing by more than one metre (Tweed et al. 2009; see Section 7 for a complete description of changes since listing).

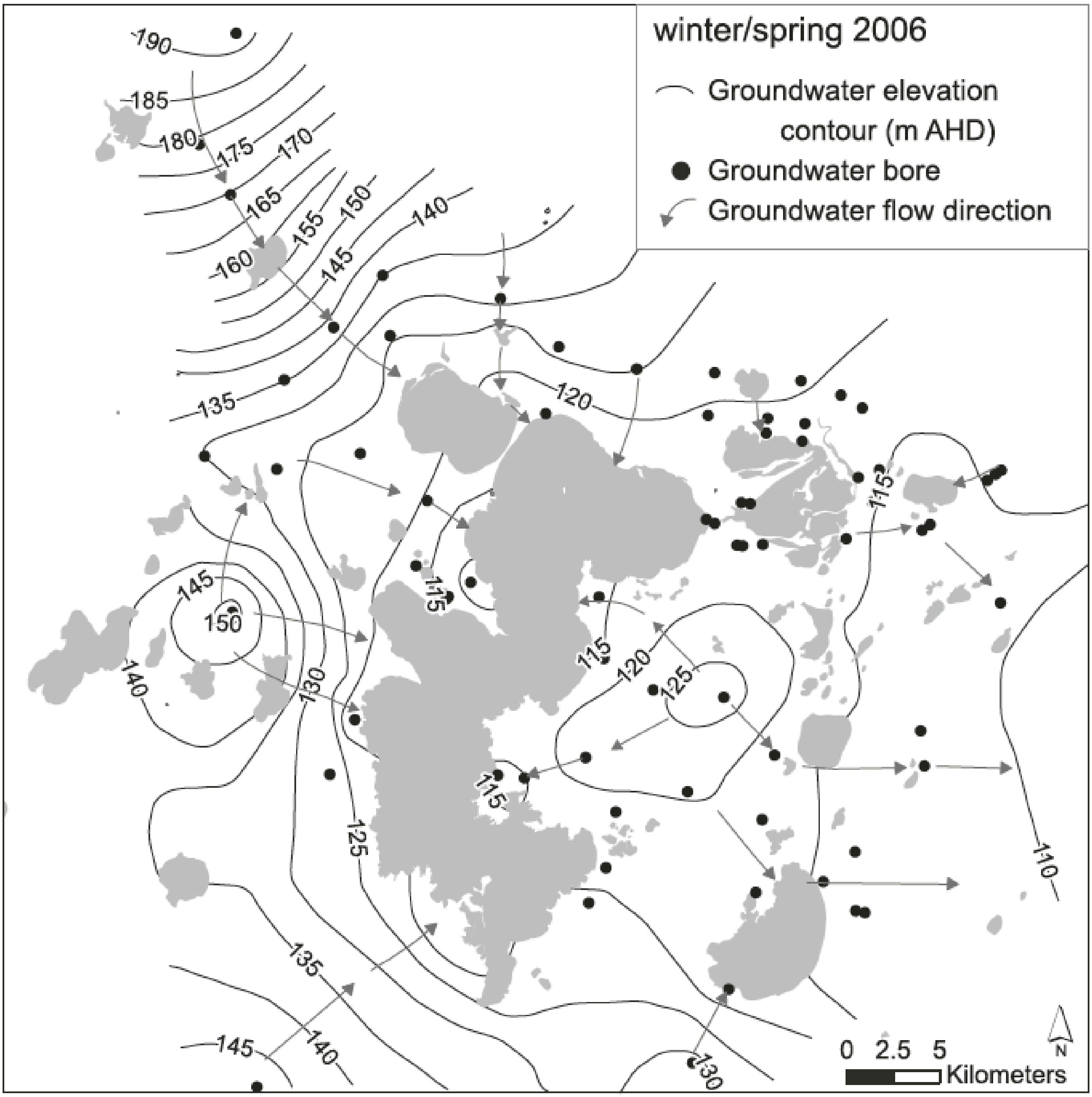


Figure 23: Groundwater flow directions for the shallow surficial aquifer in the Western Districts Lakes Ramsar site (Tweed et al. 2009).

Although the lakes are terminal basins with respect to surface water flow, the majority of the lakes within the system are considered to operate as groundwater "through flow" systems. That is, both receiving and discharging water (and dissolved salts) to the shallow groundwater aquifers (Coram 1996; Tweed et al. 2009). Lakes may also act as terminal basins for groundwater. Coram suggested that the presence of Quaternary clays around the down gradient margins of the lakes such as Beeac, limit groundwater discharge, resulting in retention of groundwater (and salts).

The categorisation of each of the lakes as "through flow" or terminal (with respect to groundwater) has not been consistent among various investigations (Barton et al. 2008; Coram 1996; Tweed et al. 2009). For example, Barton et al. (2008) indicated that Lakes Corangamite and Cundare were through flow systems, and Lake Murdeduke, less so with a long residence time and very little discharge to groundwater. Coram (1996) indicated that Lakes Bookar, Colongulac, Gnarpurt and Murdeduke were through flow systems, discharging significant amounts of water and salts through groundwater. Finally, Tweed et al. (2009) indicated that it was not possible to definitively determine if Lake Corangamite operated as a through flow system or a terminal basin with respect to groundwater. It is possible that the hydrology of these systems is variable in response to climate factors and groundwater levels. What is clear is that many of the lakes at one point in time act as through flow systems with respect to groundwater.

Surface expressions of fresh groundwater occur along the southern edge of Lake Corangamite through a series of springs of which McVean Springs are the best known and possibly most significant (Timms 2004). Although there is little documented about their hydrology, and they possibly contribute little to the overall water budget of the lake, these freshwater springs provide an important refugia and are responsible for the small area (15 hectares) of freshwater intermittent marsh in the large saline wetland system of Lake Corangamite.

Water balance and hydro-cycle

Water balance studies indicate that the majority of the water in each lake is supplied by direct rainfall and evaporation is the largest outflow (Coram 1996; Water Technology 2010). For example, at Lake Murdeduke, just five percent of inflows are from groundwater and over 60 percent from direct precipitation. Evaporation accounts for over 90 percent of water loss, with just seven percent discharging to groundwater (Coram 1996).

Table 15: Water balances (as percentages) for five of the wetlands within the Ramsar site (Coram 1996).

Lake	Inflows (percentage)			Outflows (percentage)	
	Surface run-off	Rainfall	Groundwater	Evaporation	Groundwater
Beeac	37	52	11	100	Negligible
Bookar	25	65	10	98	2
Colongulac	14	82	4	99	1
Gnarpurt	36	57	7	97	3
Murdeduke	30	65	5	93	7

Groundwater inflows at the time of listing (and for many years beforehand) were relatively constant both annually and inter-annually. Seasonal cycles were driven largely by patterns of rainfall and evaporation. Around the time of listing, lakes were highest in late winter, early spring and lowest at the end of summer and autumn (Figure 24). Lakes Beeac and Cundare were considered seasonal/intermittent lakes and they dried on an annual basis, filling again each winter. The remainder of the lakes were considered permanent and around the time of listing, water levels fluctuated in the order of one to two metres annually (Coram 1996).

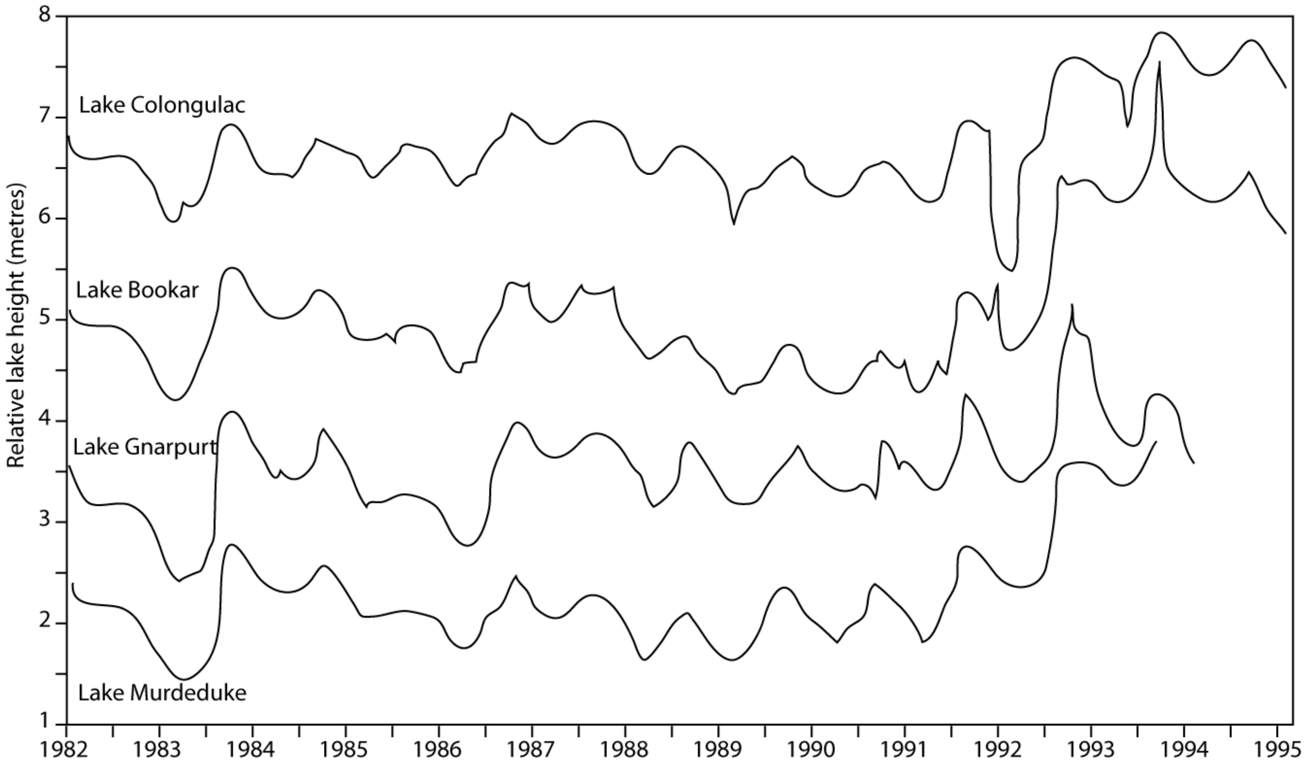


Figure 24: Relative surface levels of four lakes within the Western District Lakes Ramsar site. Note the values shown do not reflect actual height of lakes, but illustrate relative changes in surface water height over time (Coram 1996).

Longer term records indicate that many of the lakes within the Western District Lakes Ramsar site occasionally dried during periods of extended drought. While the presence of lunettes and Indigenous artefacts and oral history indicate that the lakes may have been dry for years at a time over periods of thousands of years (Dahlhaus et al. 2008), what is more relevant to the ecological character of the site at the time of listing is the more recent history and hydro-cycles.

Williams (1992) indicated that water levels fluctuated significantly at many of the lakes over the past 100 years, but considered only Colongulac (in addition to Beeac and Cundare which dry regularly) to have dried completely on occasions during this period. This is supported by the observations of early settlers, which indicate that the lakes held water of varying depths in response to climate, but have not dried for significant periods of time (Dahlhaus et al. 2008). The “permanence” of seven of the lakes within the Ramsar site was undoubtedly increased from the introduction of agriculture and drainage directing surface water into lakes during the mid 1800s (Dahlhaus et al. 2008).

Hydrological modelling undertaken by Water Technology (2010) supports the views of Williams (1992) and Dahlhaus (2008). Using historical climate to determine baseline hydrology at the lakes, their results indicated that there were no dry periods in Lake Murdeduke between 1889 and present (Figure 25). Over the same period of time Lake Colongulac could be expected to experience low water levels 98 times with an average duration of dry spells of 10 days and a longest dry period of 46 days. However all of these occurred prior to the inflow of wastewater from the Camperdown Wastewater Treatment Plant (Figure 26).

The long term water level record for Lake Corangamite indicates that the lake has not completely dried in the period 1955 to 1995 (Figure 27). However, there was a period from December 1967 to February 1968 where water was below the level of the gauge at Leslie Manor, indicating low water levels over summer.

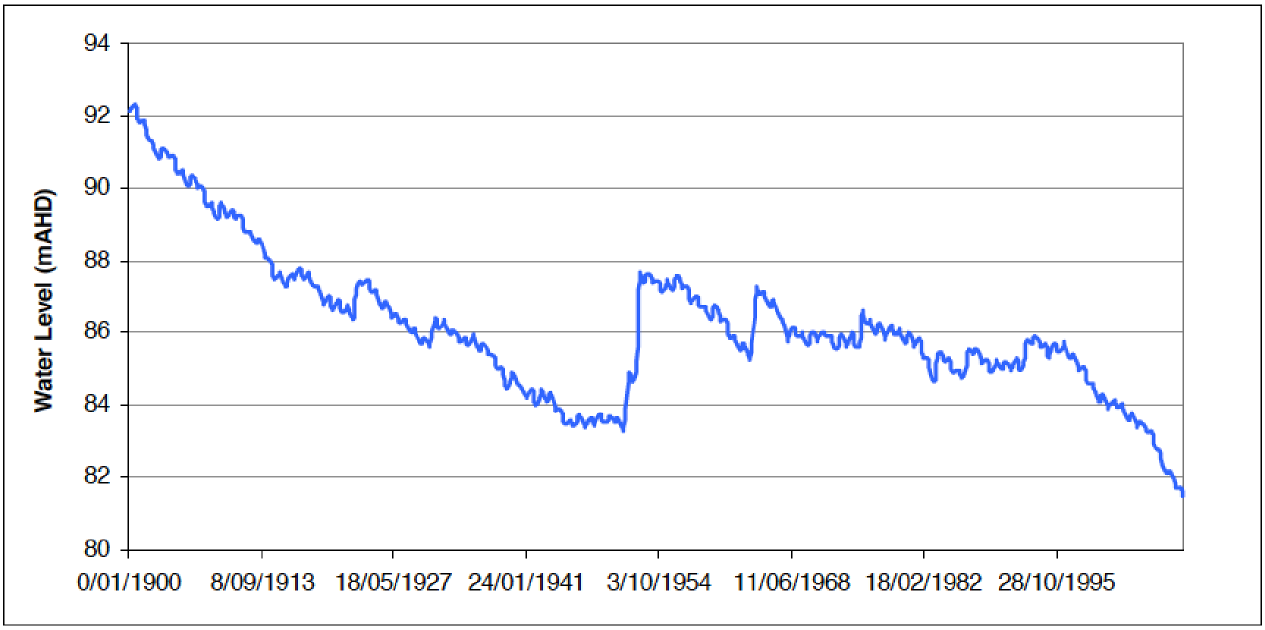


Figure 25: Murdeduke modelled mean seasonal water level (Water Technology 2010).

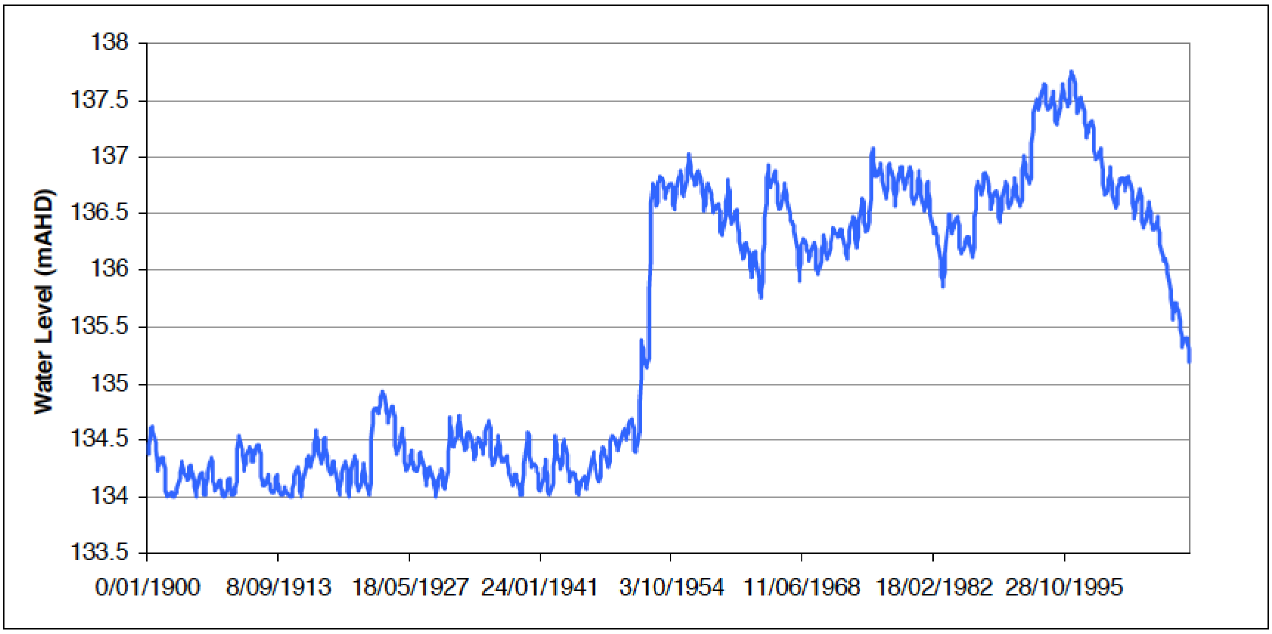


Figure 26: Colongulac modelled mean seasonal water level (Water Technology 2010).

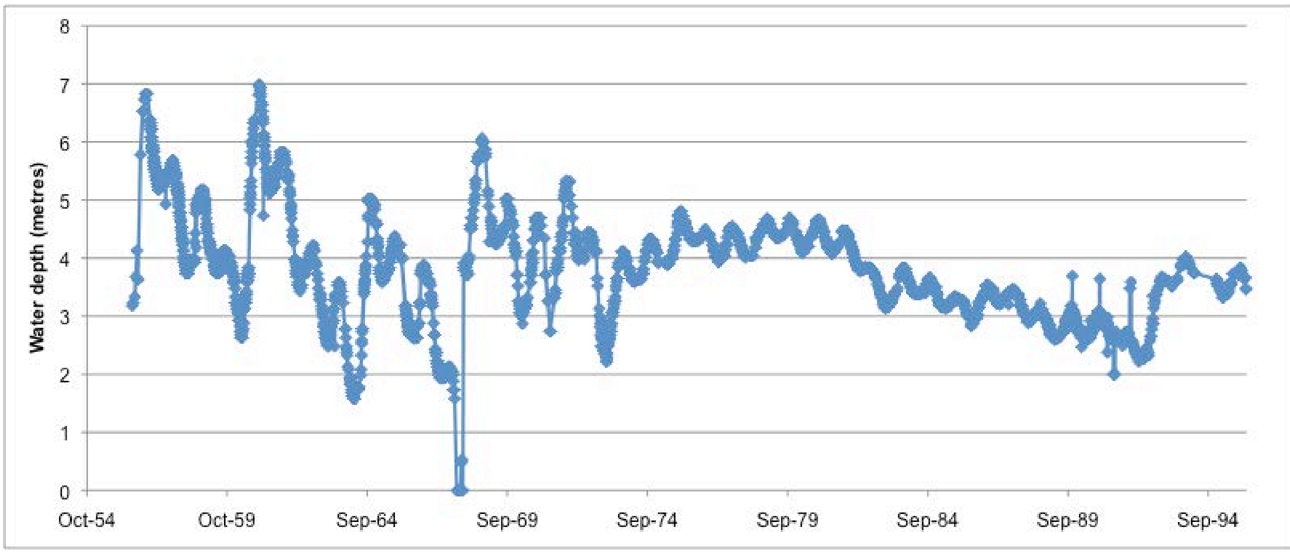


Figure 27: Water level in Lake Corangamite from 1955 to 1995 (data from Victorian Water Resources Data Warehouse, DSE 2010). Note that adjustments have been made to account for changes in gauge readings from values relative to lake bottom, to values relative to metres AHD.

3.3.2 Salinity

With the exception of Lake Terangpom, all the lakes within the Ramsar site were saline (salinity between 3 and 35 parts per thousand). However, salinity varies between lakes and seasonally within lakes. Data collected from four of the wetlands within the Ramsar site in 1979 to 1981 illustrate the variation both within and between wetlands (Figure 28). Salinity is lowest during winter and spring, when water levels are at their highest. In summer, evaporation results in concentration of salts and a corresponding rise in salinity.

Lake Corangamite at the time of listing had salinities close to seawater, while Bookar, Gnarpurt and Colongulac with lower salinity than Corangamite, could be considered mesosaline wetlands (Figure 28).

There is little data from the time of listing for other wetlands within the Ramsar site. More recent data (1993 to 1996) suggests that salinity at Lake Murdeduke was similar to that at Gnarpurt and Bookar ranging from 11 to 14 parts per thousand (Victorian Water Resources Data Warehouse, DSE 2010). Lake Milangil was also in this category with reported salinity of six to seven parts per thousand in 1996 (Garcia 1999). Data collected from 1993 to 1995 suggest that Lake Cundare was hypersaline, with salinities ranging from 56 to 122 parts per thousand (Victorian Water Resources Data Warehouse, DSE 2010) and Lake Beeac was also considered hypersaline with salinities ranging from 55 to greater than 300 parts per thousand (Hose et al. 2008).

Lake Terangpom is described as a freshwater playa (Parks Victoria 1999). However, the salinity in 1981 was around two parts per thousand (De Decker 1981), which would be considered to be brackish rather than fresh (ANZECC and ARMCANZ 2000). The salinity of each lake is summarised in Table 16.

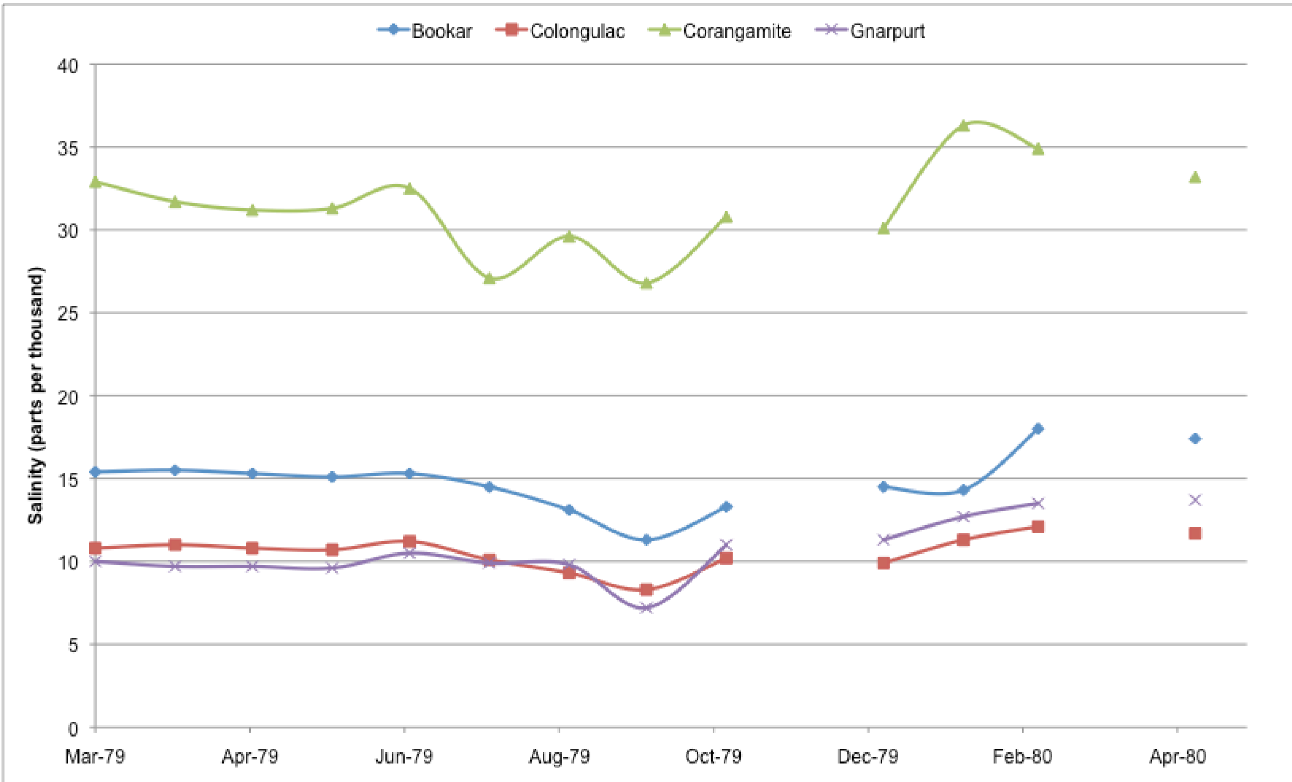


Figure 28: Salinity (parts per thousand) from four lakes within the Western District Ramsar Site in 1979 (data from De Decker and Williams 1988).

Table 16: Salinity (parts per thousand) of each of the lakes within the Western District Lakes Ramsar site.

Lake	Salinity range	Date of record	Category	Reference
Beeac	55 – 300	1972	Hypersaline	Hose et al. 2008
Bookar	11 – 17	1979 – 80	Mesosaline	De Decker and Williams 1988
Colongulac	8 – 12	1979 – 80	Mesosaline	De Decker and Williams 1988
Corangamite	27 – 36	1979 – 80	Saline	De Decker and Williams 1988
Cundare	77 – 347	1972	Hypersaline	Hose et al. 2008
Gnarpurt	7 – 14	1979 – 80	Mesosaline	De Decker and Williams 1988
Milangil	6 – 7	1996	Mesosaline	Garcia 1999
Murdeduke	11 – 14	1993 – 95	Mesosaline	DSE 2010
Terangpom	2	1981	Brackish	De Decker 1981

Ionic composition is similar at all wetlands within the Ramsar site and similar to seawater with sodium and chloride dominating and moderate amounts of carbonate (De Decker and Williams 1988; Barton et al. 2008). As a result of the carbonate, all lakes are alkaline and pH is usually between 7.5 and 9.5 at all lakes (De Decker and Williams 1988; Hose et al. 2008; Victorian Water Resources Data Warehouse, DSE 2010).

3.3.3 Threatened flora

The Western District Lakes Ramsar site supports two nationally threatened wetland dependent plant species: salt-lake tussock-grass (*Poa sallacustris*) and spiny peppercress (*Lepidium aschersonii*), both listed as vulnerable under the EPBC Act. These two plants are limited in distribution and within Victoria only occur on the Victorian Volcanic Plains. There are ten known populations of salt-lake tussock-grass, with a total abundance of 0.6 hectares. Two of these populations are within the Ramsar site at Lake Corangamite and Lake Terangpom (Carter and Walsh 2006).

There are 14 known populations of spiny peppercress in Victoria and a further 14 in New South Wales. Around the time of listing, over 1000 plants were recorded along the eastern lunette of Lake Beeac and 107 plants at Lake Corangamite (DSE 2009).

Figure 29: Spiny peppercress on shores of Lake Corangamite (photo B. Hale).

3.3.4 Waterbirds

At the time of listing the Western District Lakes Ramsar site supported a high diversity and abundance of waterbirds. A total of 70 species of wetland bird have been recorded within the site (Table 17, Appendix B). The list includes 20 species that are listed under international migratory agreements CAMBA, JAMBA, ROKAMBA and the Bonn Convention, and 26 species listed as migratory or marine under the EPBC Act.

Table 17: Number of wetland birds recorded within the Western District Lakes Ramsar site (Birds Australia unpublished; DSE unpublished; GFNC 1993 to 2008). See Appendix B for full list of species.

Bird group	Typical feeding requirements	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.	14
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).	10
Hawks, eagles	Shallow or deeper open water feeding mainly 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.	7
Shorebirds	Shallow water, bare mud and salt marsh. Feeding mainly on animals (invertebrates and some fish).	22
Gulls, terns	Terns, over open water feeding on fish and invertebrates; gulls, opportunistic feeders over a wide range of habitats.	5
Other	Non water birds that are reliant on wetlands for breeding or feeding (Clamorous Reed Warbler).	1
Total		**70**

Complete counts of the Ramsar site are very limited. There are no consistent count data for the years pre and post listing in 1982. The best dataset that may represent bird abundance at the time of listing is from the annual waterfowl counts from 1987 to 1992. These include all of the lakes within the Ramsar site, but only a subset of species (excluding waders, terns, herons, ibis, egrets and fish eating birds such as cormorants, darters and pelicans). The waterfowl counts indicate consistently large numbers of waterbirds from 1987 to 1992 (Figure 30). Although a relatively brief snap-shot in time, there is some evidence to suggest that this six year period is suitable for assessing conditions in the Western District Lakes at the time of listing. Results of large scale surveys of waterfowl across Australia indicate that 1987 to 1992 spans a period of various conditions and average waterfowl numbers (Porter et al. 2006). For example, 1987 to 1989 inclusive covered a period of low waterbird abundance in the interior of Australia and average waterfowl numbers in south-eastern Australia. While the ephemeral wetlands in central Australia were significant for waterfowl in 1990 to 1992, there were lower numbers of waterbirds in other wetlands (Kingsford et al. 1993). Taken together, 1987 to 1992 therefore covers a range of conditions and waterbird variability, taking into account larger, continental scale movements of birds.

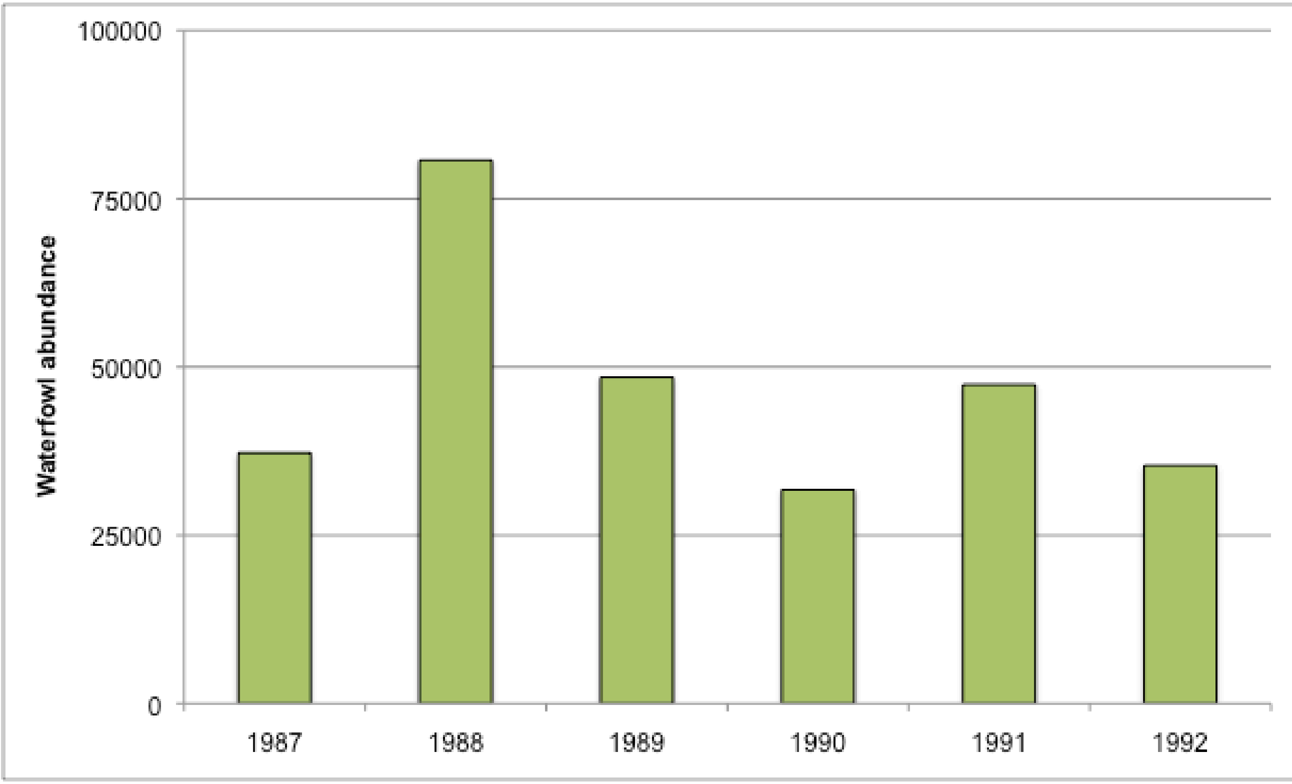


Figure 30: Summer total waterfowl counts from all lakes within the Western District Lakes Ramsar site (data from Martindale 1988; Hewish 1988 and Peter 1989 to 1992).

There is evidence that the site supports moderate to large numbers of shorebirds in addition to waterfowl. However, shorebird summer count data from within the Ramsar site from 1980 to 1999 indicates relatively modest numbers of shorebirds. Total counts range from just 480 birds in February 1982, to almost 10 000 birds in February 1983. The average for the period 1980 to 1999 was approximately 3900 (AWSG unpublished). However, it is likely that not all lakes within the site were consistently counted over this period. In addition, periodic large numbers of shorebirds, such as the 50 000 banded stilts in Lake Beeac in February 1987, are not included in the AWSG data.

Although 20 species of international migratory shorebirds have been recorded within the Western District Lakes Ramsar site, only three of these were regular visitors: curlew sandpiper, red-necked stint and sharp-tailed sandpiper. Shorebird counts for the site are less regular than those for waterfowl but bi-annual surveys were undertaken from 1981 to 1985 inclusive (AWSG unpublished). This indicates that the site regularly supported moderate to large numbers of these species during summer and moderate numbers of curlew sandpiper over winter (Figure 31).

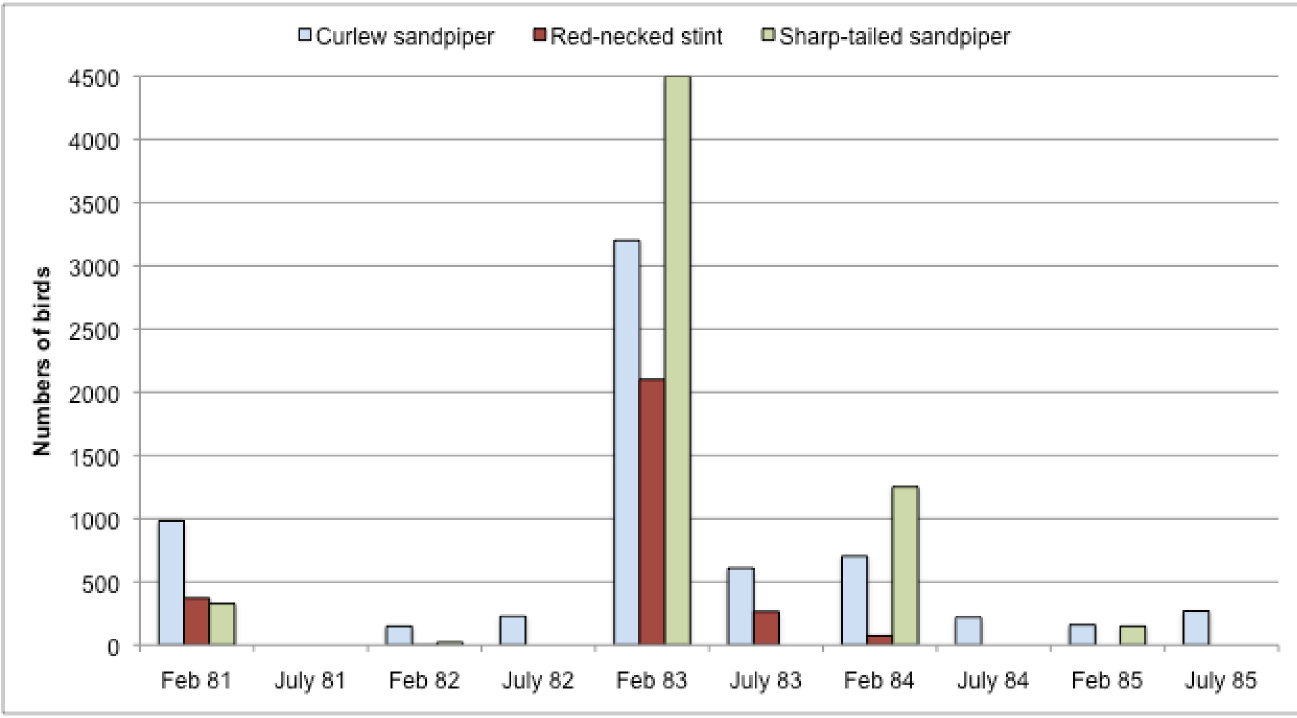


Figure 31: Numbers of curlew sandpiper, red-necked stint and sharp-tailed sandpiper in the Western District Lakes Ramsar site 1981 to 1985 (AWSG unpublished).

The Western District Lakes Ramsar site is also significant for the role it plays in supporting individual waterbird species. Maximum counts for 12 bird species exceed the one percent population thresholds (Wetland International 2006; Table 7). The limited count data makes application of the concept of "regularly supports" difficult. However, for data collected consistently from 1987 to 1992 (Martindale 1988; Hewish 1988 and Peter 1991 to 1992) it is evident that the site regularly supported more than one percent of the Australian populations of Australian shelduck (Figure 32), Australasian shoveler (Figure 33), chestnut teal (Figure 34) and Eurasian coot (Figure 35). The distribution of these three species was different, with Lake Corangamite supporting the greatest proportion of Australian shelduck and large numbers of chestnut teal. Lake Milangil supported large numbers of Australasian shoveler and chestnut teal and Lake Colongulac large numbers of Australasian shoveler and Eurasian coot.

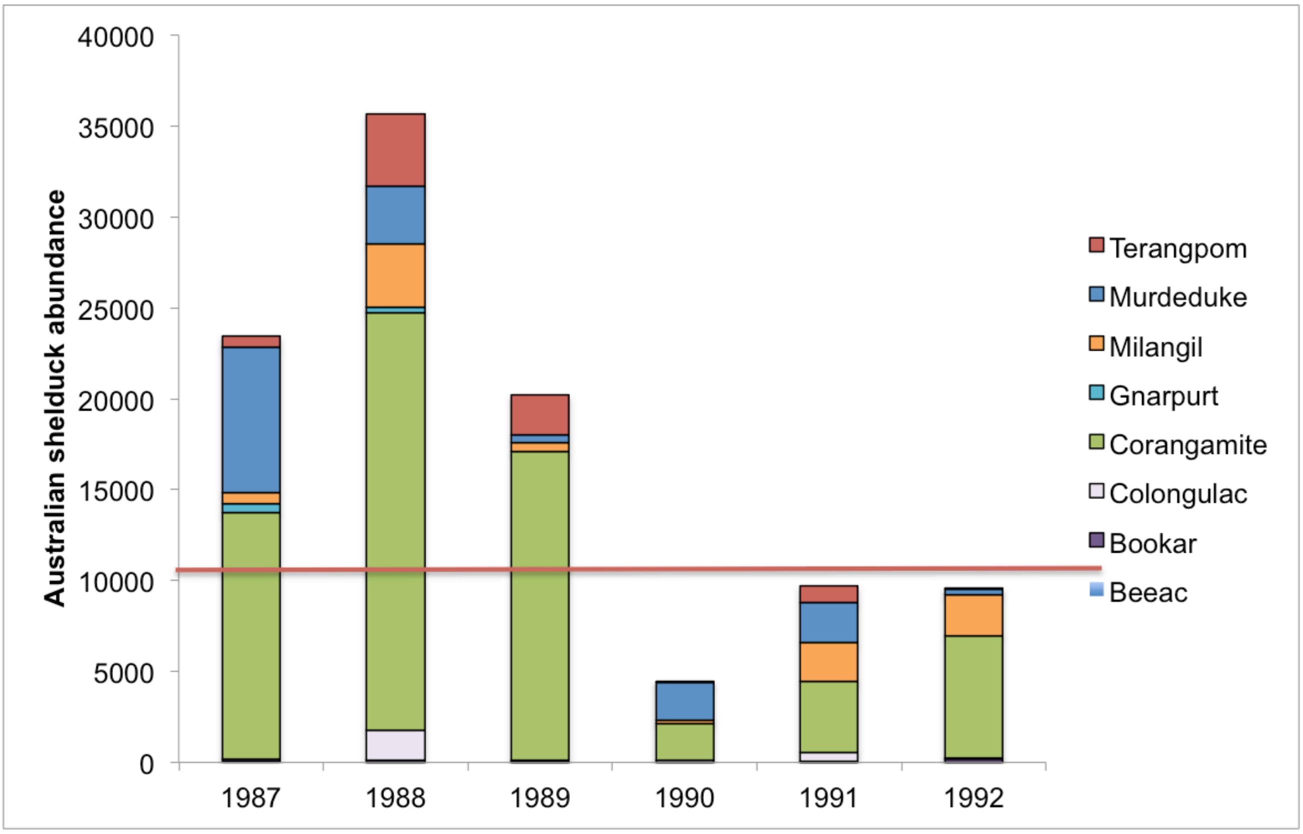


Figure 32: Abundance of Australian shelduck in the Western District Lakes Ramsar site from 1987 to 1992 (data from Martindale 1988; Hewish 1988 and Peter 1989 to 1992). Red line indicates one percent population threshold.

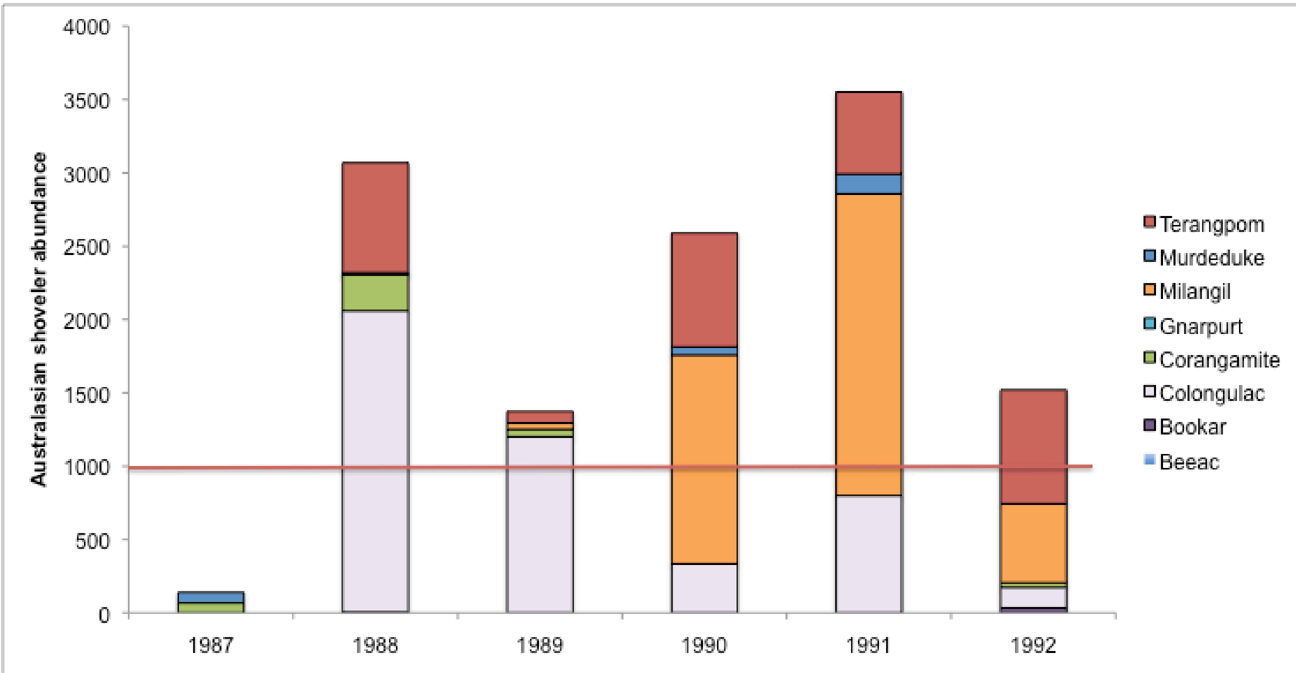


Figure 33: Abundance of Australasian shoveler in the Western District Lakes Ramsar site from 1987 to 1992 (data from Martindale 1988; Hewish 1988 and Peter 1989 to 1992). Red line indicates one percent population threshold.

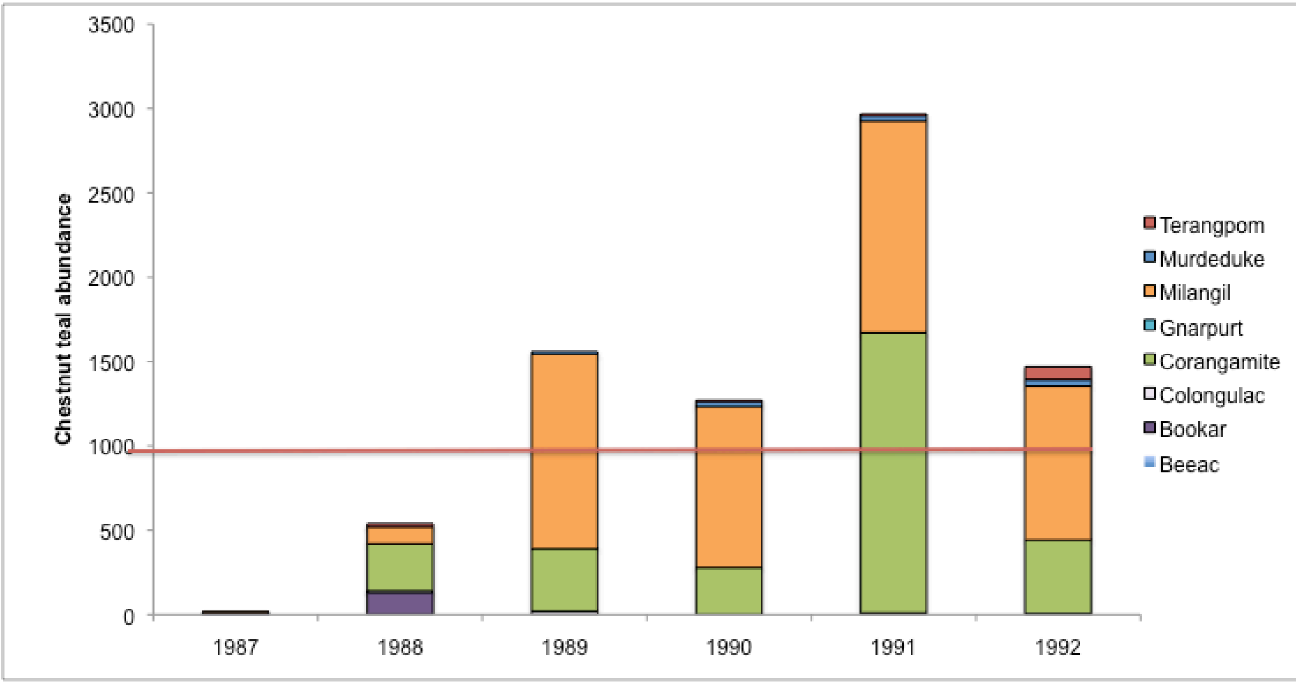


Figure 34: Abundance of chestnut teal in the Western District Lakes Ramsar site from 1987 to 1992 (data from Martindale 1988; Hewish 1988 and Peter 1989 to 1992). Red line indicates one percent population threshold.

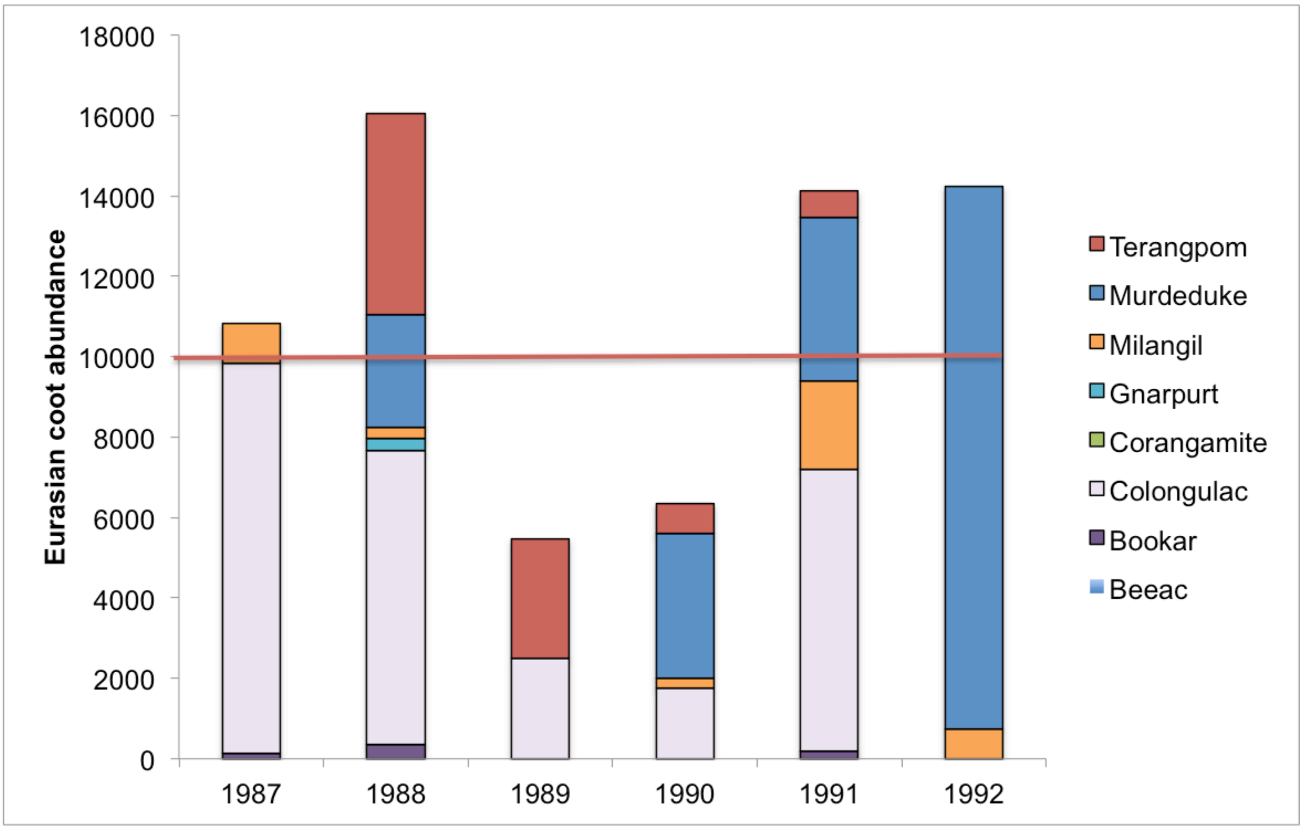


Figure 35: Abundance of Eurasian coot in the Western District Lakes Ramsar site from 1987 to 1992 (data from Martindale 1988; Hewish 1988 and Peter 1989 to 1992). Red line indicates one percent population threshold.

The Western District Lakes periodically supports very large numbers of banded stilts. However the data used for the benchmark period (1987 to 1992) to represent the time of listing only shows the banded stilt being present in one of these years (1987). While the large numbers recorded in that year would mathematically satisfy the five year average exceeding the 1% threshold, the lack of counts in the remaining five years of the benchmark period suggest that the intention of “regularly supports” is not really satisfied.

Available records indicate that the one percent population threshold of 2100 banded stilts (Wetlands International 2006) was exceeded on at least four occasions between 1980 and 1990 (DSE unpublished):

- February 1980 at Lake Beeac – 3000
- January 1983 at Lake Corangamite – 6000
- February 1984 at Lake Beeac – 3000
- February 1987 at Lake Beeac – 50 000

This provides an average for the decade (1980 to 1990) of 6200 birds, approximately three percent of the total population. In the years since listing there have been additional events which have seen over 100 000 banded stilts within the Ramsar site. This is considered further in the section on changes since listing (Section 7).

There are other isolated records of very large numbers of individual species (Table 7). However, there is no evidence that any of these species occur regularly in significant numbers.

Eleven species of waterbird have been recorded breeding within the Western District Lakes Ramsar site (Table 18). This includes nine species at Lake Corangamite, three at Lake Murdeduke and one each at Lakes Beeac and Colongulac (Table 18). However, given the patchiness of breeding records it is likely that this list and distribution is incomplete. Also, there is no quantitative information on breeding or nesting within the site.

Table 18: Waterbird breeding records for the Western District Lakes Ramsar site (Birds Australia unpublished, GFNC 1993 to 1008).

Common name	Species name	Locations where breeding
Australian Pelican	*Pelecanus conspicillatus*	Lake Corangamite
Australian Shelduck	*Tadorna tadornoides*	Lake Corangamite
Banded Lapwing	*Vanellus tricolor*	Lake Corangamite
Black Swan	*Cygnus atratus*	Lakes Colongulac and Corangamite
Brolga	*Grus rubicunda*	Lake Murdeduke
Cape Barren Goose	*Cereopsis novaehollandiae*	Lake Corangamite
Masked Lapwing	*Vanellus miles*	Lakes Corangamite and Murdeduke
Red-capped Plover	*Charadrius ruficapillus*	Lake Murdeduke
Straw-necked Ibis	*Threskiornis spinicollis*	Lake Corangamite
White-faced Heron	*Egretta novaehollandiae*	Lake Corangamite
White-necked Heron	*Ardea pacifica*	Lake Corangamite

Waterfowl undergo an annual moult and during the time when primary flight feathers are being replaced, individuals are flightless for a period of 2 – 4 weeks. There is evidence that the lakes within the Ramsar site provide habitat for this critical life stage. Large numbers of Australian shelduck (3200) have been recorded undergoing primary moult at Lake Murdeduke (GFNC 2006) and Lake Corangamite is considered to support roosting and moulting of Australian shelduck and chestnut teal (Parks Victoria 1999).

4 Ecosystem services

4.1 Overview of benefits and services

Ecosystem benefits and services are defined by the Millennium Ecosystem Assessment 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:

- **Provisioning services** – the products obtained from the ecosystem such as food, fuel and fresh water
- **Regulating services** – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation
- **Cultural services** – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics
- **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 Western District Lakes Ramsar site are outlined in Table 19.

Table 19: Ecosystem services and benefits provided by the Western District Lakes Ramsar site (those considered critical are shown shaded (see section 4.2).

Category	Description
Provisioning services	
Commercial fishing	At the time of listing a number of lakes within the Ramsar site, including Lake Corangamite and Gnarpurt were stocked with short-finned eels and used for commercial production of this species.
Cultural services	
Recreation and tourism	At the time of listing Lake Murdeduke was popular for recreational fishing. Lakes Bookar and Murdeduke are State Game Reserves and used for duck hunting.
Spiritual and inspirational	The region is spiritually and culturally significant for the Djargurd Wurrung and Gulidjan Peoples. The site was significant for provision of food and there are a number of important archaeological sites.
Regulating services	
Flood control	The lakes within the Ramsar site receive drainage water from the surrounding landscape and play an important role in flood mitigation of adjacent agricultural landscapes.
Supporting services	
Diversity of wetland types	The Ramsar site contains a diversity of wetland types.
Physical habitat	The Ramsar site provides habitat for feeding, breeding and moulting of waterbirds.
Priority wetland species	The Ramsar site supports 20 species of shorebird listed under international migratory bird treaties.
Threatened species	The Ramsar site supports two species of plant listed under the EPBC Act.

4.2 Identifying critical ecosystem services and benefits

The critical ecologically based ecosystem services and benefits of a Ramsar site have been identified using the same criteria provided by DEWHA (2008). They have been used as a guide for selecting critical components and processes; i.e. services:

- that at a minimum are important determinants of the site's unique character;
- that at a minimum are important for supporting the Ramsar Convention or A Directory of Important Wetlands in Australia (DIWA) criteria under which the site was listed;
- for which change is reasonably likely to occur over short or medium time scales (less than 100 years); and/or
- that will cause significant negative consequences if change occurs.

Using these criteria it was considered that all of the supporting services (that is, those that are ecologically based) could be considered "critical". While the site is undoubtedly beneficial in terms of cultural services, commercial fishing and flood control, these were not considered "critical" services in that a reduction in any of these services would not necessarily indicate a change in ecological character.

Therefore the critical ecosystem benefits and services of the Western District Lakes Ramsar site are:

- diversity of wetland types
- physical habitat
- priority wetland species
- threatened species.

4.3 Critical services

4.3.1 Supports a diversity of wetland types

As described in Section 2.3, at the time of listing, the Western District Lakes Ramsar site contains a range of wetland types, some of which can be considered significant in a bioregional context. The major wetland types and associated habitats that are considered critical to the ecological character of the site are:

- permanent saline wetlands – open water, submerged macrophyte beds
- seasonal/intermittent saline wetlands – open water, shallow mudflats
- permanent freshwater wetlands – open water, submerged macrophyte beds.

This diversity of habitat is brought about by the interactions between geomorphology, hydrology, water quality and vegetation (Figure 36). The critical components and processes and the interactions between them that result in these wetland habitats is described below.

<u>Permanent saline wetlands</u>

The permanent, saline wetlands within the Ramsar site are described as flow through systems that receive the majority of their water from surface water, but almost all their salts from the constant groundwater inflows (Coram 1996; Tweed et al. 2009). Ionic balance is maintained by the through flow of salts that are discharged to groundwater and the regular inflow or very low salinity surface water and rainfall.

At the time of listing, these systems had submerged macrophyte beds and seasonally inundated saltmarsh in the littoral zones, both of which provide habitat for waterbirds and other fauna. In addition, shoreline complexity and features such as islands in these systems increase habitat diversity.

<u>Seasonal intermittent saline wetlands</u>

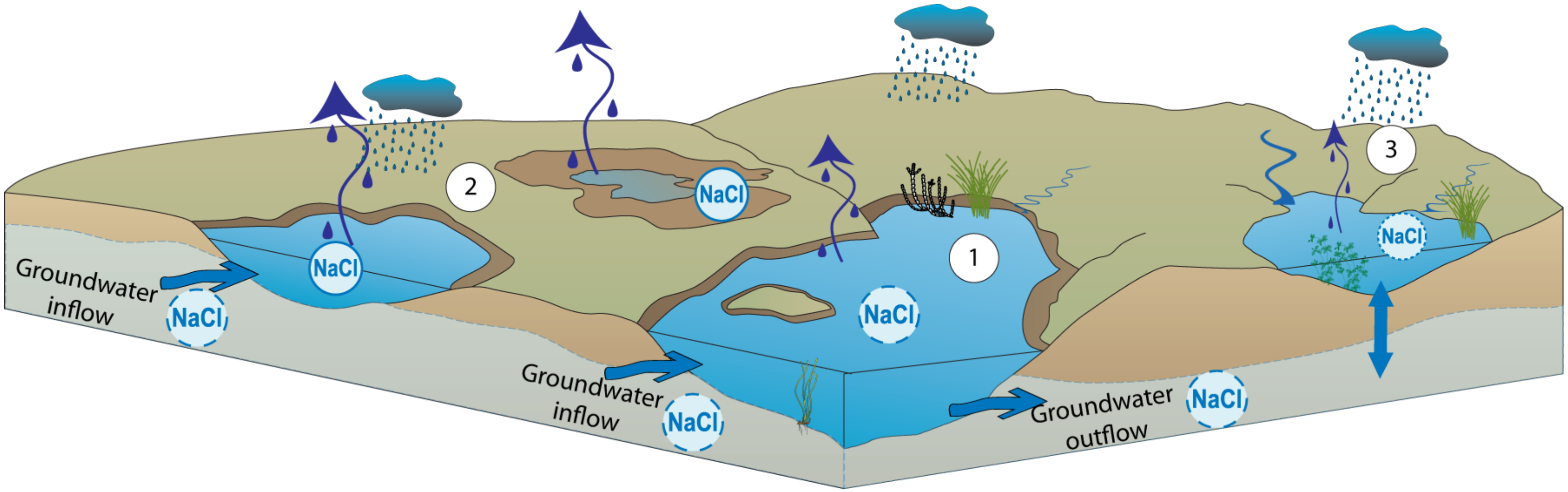
The seasonal/intermittent saline wetlands in the Ramsar site do not exhibit the flow through features of the permanent systems. These wetlands receive saline groundwater and fresh surface water and rainfall, but do not discharge a large proportion of water or salts to the groundwater down gradient (Coram 1996). As a consequence, salts concentrate in the wetland as water evaporates and hypersaline conditions prevail.

The high salinity prevents the establishment of submerged macrophytes and these systems have lower habitat diversity within a single wetland. However, as the wetlands dry during summer periods, the shallow water and wet mud provide extensive foraging habitat for wading species of bird.

<u>Permanent freshwater wetlands</u>

Lake Terangpom is the only “freshwater” system within the Ramsar site. It receives the majority of its water from surface water inflows, which are generally less saline than the groundwater sources. The wetland acts as a flow through system and salts are discharged with outflowing groundwater, maintaining the ionic balance.

The lower salinity at this site makes it suitable for a wider range of wetland plants and at the time of listing it had the greatest diversity of aquatic macrophytes, providing habitat for a range of fauna.



1. Permanent saline wetlands:
- Highest proportion of inflowing water is from low salinity rainfall and surface water.
- Outflow of water and salts to groundwater maintains ionic balance and saline conditions.
- Inflows and outflows are seasonal and result in variable lake levels and some mudflat habitat at margins.
- Lakes with complex morphologies provide other habitats such as islands and vegetated margins.

2. Seasonal / intermittent saline wetlands:
- Surface water and rainfall are the major inflows, but they receive higher proportion of groundwater which brings in moderate amounts of salts.
- No or little outflow of water to groundwater and evaporation leads to concentration of salts and hypersaline conditions.
- No vegetation present due to high salinity and temporary inundation.
- As water evaporates large areas of shallow water and mudflat habitat are provided.

3. Permanent freshwater wetlands:
- Highest proportion of inflowing water is from surface water which brings in low amounts of salts.
- Outflow of water and salts to groundwater maintains freshwater conditions.
- Freshwater conditions allow for a higher diversity of aquatic plants.
- Inflows and outflows are seasonal and result in variable lake levels and some mudflat habitat at margins.

Figure 36: Conceptual model of wetland diversity and habitat types within the Western District Lakes Ramsar site.

4.3.2 Provides physical habitat for large numbers of waterbirds

The Western District Lakes provide a range of habitats that support large numbers of waterbirds in terms of moulting, feeding and, to a lesser extent, breeding.

Moulting

Waterfowl (with the exception of the magpie goose) undergo an annual moult of their primary flight feathers. Much of the information on moulting in waterfowl comes from the northern hemisphere where predictable patterns of moulting following breeding are related to predictable seasons and climatic patterns. The more variable climate in Australia may result in more variable patterns of moulting (Kingsford and Norman 2002).

During primary moult individuals are flightless for a period of two to four weeks, which makes them more vulnerable to predators. In addition, protein comprises greater than 80 percent of flight feathers and during moult birds have a high requirement for protein in their diets (Ringelman 1990). This includes green fodder for herbivores and invertebrates for carnivorous waterfowl.

The permanent open water of many of the lakes within the Ramsar site provides ideal habitat for moulting waterfowl, where they can congregate at distance from the shore and be safe from predators during their flightless period.

Feeding

The Western District Lakes Ramsar site supports large numbers of waterbirds. These are considered in terms of broad feeding/habitat guilds. Of note, different wetlands within the system provide feeding habitat for different types of birds. Combined count data from around the time of listing (1980 to 1999) illustrates the proportion of different feeding guilds within eight of the nine wetlands (Figure 37). Lake Beeac provides foraging habitat predominantly for waders, especially during late summer and autumn as the wetland dries down exposing large areas of shallow mudflats. Lakes Murdeduke, Bookar and Colongulac are dominated by diving species such as Eurasian coots, while grazing species such as Australian shelduck and black swans are the dominant feeding group at Lakes Corangamite and Gnarpurt.

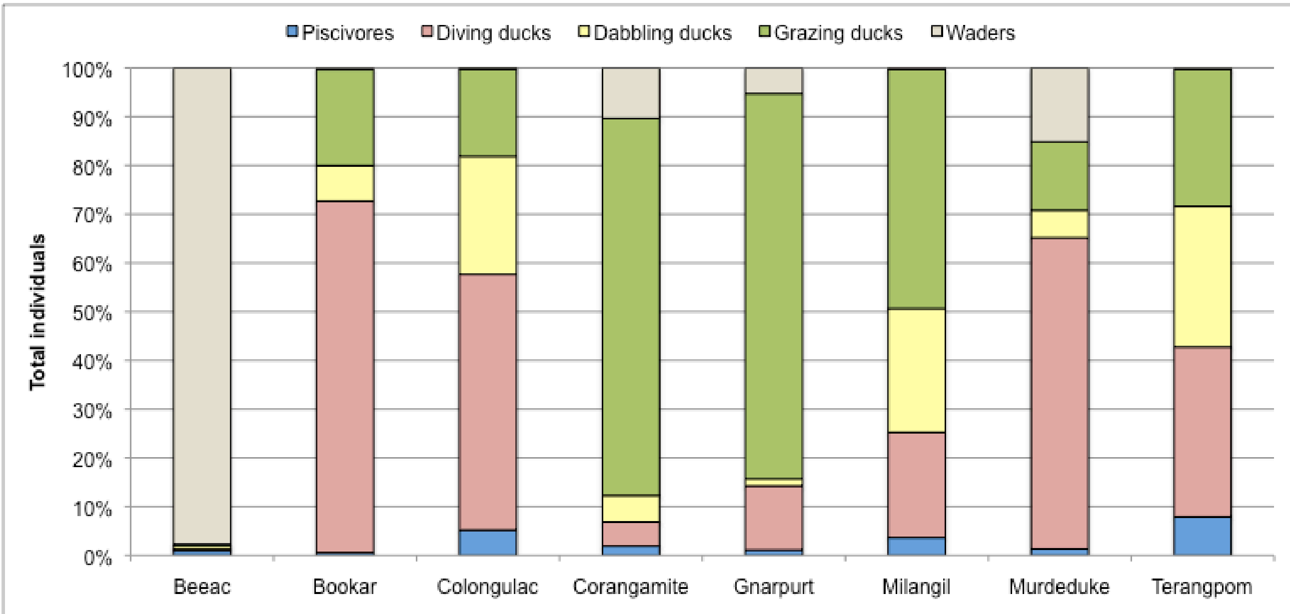


Figure 37: Proportion of birds from different feeding guilds within eight of the nine wetlands within the Ramsar site. Note that there was insufficient data to include Lake Cundare. Data represents total counts (based on maximum monthly counts where there was more than one count in a given month) from all sources (ARI unpublished; AWSG unpublished; Bird Australia unpublished; DSE unpublished; DSE Colac unpublished; GFNC 1993 – 2008).

<u>Piscivores</u>

At the time of listing, there were a number of waterbird species within the Ramsar site whose diet was wholly or mostly comprised of fish. This included the gulls and terns, cormorants and the Australian pelican. These fish eating birds were predominantly found at Lakes Corangamite, Gnarpurt and Murdeduke, where large numbers (greater than 1000 Australian pelicans and 4000 great cormorants) have been recorded (DSE unpublished). The general habitat requirements for a number of piscivorous waterbirds that occur within the Western District Lakes Ramsar site are provided in Table 20.

Table 20: General habitat requirements of a number of piscivorous waterbirds in the Western District Lakes Ramsar site (Marchant and Higgins 1990).

Species	Habitat characteristics
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	• Diet consists mainly of small to medium size fish. • Feed by pursuit diving via deep underwater dives.
Great cormorant	• Diet mainly of fish, but supplemented with crustaceans and frogs. • Feeds by capturing prey in shallow underwater dives, which often last for more than a minute.

Waterfowl and associated waterbirds (diving, dabbling and grazing)

This group includes not just ducks, swans and geese but also grebes, coots and waterhens. At the time of listing, the Ramsar site supported large numbers of waterfowl as a group and significant numbers (greater than one percent of the population) of Australian shelduck, Australasian shoveler and chestnut teal. There is a range of feeding strategies and foraging and roosting habitats for this group of waterbirds, some of which are described in Table 21.

Table 21: General habitat requirements of selected species of waterfowl within the Ramsar site (information from Marchant et al. 1994)

Species	Habitat characteristics
Eurasian coot	Prefers vegetated lagoons and swamps. In the Ramsar site large numbers have been recorded at all lakes except Lakes Beeac and Cundare. Diet – almost entirely vegetable matter (seeds and plant material). Foraging – 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.
Australasian shoveler	Prefer deep, large permanent waterbodies. In the Ramsar site, largest numbers have been recorded at Lakes Milangil and Terangpom. Roost on open water. Diet – plants and animals (molluscs and insect larvae). Foraging – filter feeder dabbling in mud or in surface water.
Australian shelduck	Wide range of habitats but prefer shallow wetlands. In the Ramsar site the largest numbers have been recorded at Lake Corangamite. Diet – vegetation and invertebrates. Foraging – opportunistic grazing, dabbling, etc.
Blue-billed duck	Prefer deep, large permanent open water. In the Ramsar site occasionally large numbers have been recorded at Lake Milangil. Roost – nocturnally usually on open water. Diet – seeds and leaves of aquatic plants and invertebrates (chironomids, caddis flies, dragonflies). Foraging – deep diving.
Chestnut teal	Prefer saline wetlands. In the Ramsar site largest numbers have been recorded at Lakes Colongulac, Corangamite and Milangil. Diet – seeds and insects. Foraging – dabbling at the water's edge or in bottom waters.
Pink-eared duck	Prefer inland, shallow turbid wetlands. Roost – rest on water, may roost in low branches of trees. Diet – mostly invertebrates (e.g. chironomids). Foraging – filter feeding mostly at surface taking planktonic invertebrates.
Black swan	Inland and estuarine shallow waters where floating, submerged or emergent vegetation is plentiful; in the Western District Lakes Ramsar site large numbers have been recorded at Lakes Colongulac, Corangamite and Murdeduke Roost – mostly over water, but occasionally on shore. Diet – herbivorous feeding on the shoots and leaves of aquatic plants including filamentous algae and seagrass. Foraging – grazers.

Waders

This group includes species in the two families, Ardeidae and Threskiornithidae, (herons, egrets, spoonbills and ibis) as well as the shorebirds (for international migratory species see Section 4.3.3 below). Wading species of bird feed in shallow water (usually less than 15 centimetres) and within the Ramsar site favour the shallow, mudflats of Lakes Beeac, Corangamite, Gnarpurt and to a lesser extent Lake Murdeduke. The foraging and feeding strategies of some of the wading species of birds found within the Ramsar site are provided in Table 22.

Table 22: General habitat requirements of selected species of waders within the Ramsar site (information from Marchant et al. 1994)

Species	Habitat characteristics
Black-winged stilt	Prefer inland freshwater and saline marshes. Diet – feed mainly on aquatic insects, but also crustaceans and molluscs. Foraging – wade in shallow water and seize prey at or near the surface, but occasionally taking sub-surface prey.
Brolga	Wide range of habitats including large open wetlands, grassy plains and mudflats. Diet – vegetation and invertebrates. Foraging – in shallow water or wet mud.
Red-capped plover	Prefers saline and brackish wetlands. Diet – mainly molluscs and small crustaceans, but also vegetation. Foraging – wading in shallow water / wet mud and saltmarsh.
Straw-necked ibis	Favours inland, freshwater or brackish wetlands. Feeds mainly on terrestrial invertebrates, but also frogs, small reptiles and mammals. It forages by probing in the mud or taking prey from the surface of shallow water.
Yellow spoonbill	Prefers inland, freshwater wetlands with shallow margins. Diet – predominantly invertebrates. Foraging – in shallow mud using the vibration detectors in its bill to detect movement of prey in the mud.

Breeding

Eleven species of waterbird have been recorded breeding within the Western District Lakes Ramsar site, with breeding recorded across all locations. Breeding records are not consistent and it is difficult to determine how many of these species regularly breed in the site, and the numbers of individuals that bred within the site. The species recorded breeding at the site utilise a range of different habitats within the system (Table 23). Some of these nesting habitats are not provided within the Ramsar site boundary, for example there are few (if any) trees within the Ramsar site. This may indicate that the site provides important feeding habitat for parents and young, rather than nesting habitat in some instances.

Table 23: Requirements of some of the waterbirds recorded breeding in the Western District Lakes Ramsar site (adapted from Marchant et al 1994 and Jaensch 2002).

Species	Breeding habitat and behaviour
Ducks and allies	
Australian shelduck	Usually in tree hollows, but have been known to nest in rabbit burrows. Given the lack of trees in the site, nesting must have been in the ground. Breed between July and December, incubation 33 days.
Black swan	Nest mound built in open water, on an island, or in swamp vegetation. Within the Ramsar site recorded breeding at Lakes Corangamite and Murdeduke. Requires minimum water depth of 30 – 50 centimetres until cygnets are independent. First flight 20 – 25 weeks.
Cape Barren goose	Usually nests in tussocks of open grasslands. Breeding season is July to September. Not reliant on inundation or water for breeding success (feed on terrestrial grasses).
Pelicans, Cormorants and Darters	
Australian pelican	Colonial breeder with nests usually on islands with little or no vegetation. Within the Ramsar site a large colony was recorded breeding at Vaughn Island and Wool Wool Rocks in Lake Corangamite. 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.
Herons, Ibis and Egrets	
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. Recorded breeding in saltmarsh at Lake Corangamite. Fledge 4 weeks after hatching, fed for two weeks by parents after leaving nest.
White-faced heron	Nest in trees, not necessarily associated with water. Young fledge six to seven weeks after hatching.
White-necked heron	Nests in vegetation over water, usually in trees. Requires inundation until young have fledged (at least six to seven weeks after hatching).
Cranes, Crakes and Rails	
Brolga	Nest constructed of a large mound of vegetation on a small island in a shallow waterway or swamp. In the Ramsar site within vegetation at Lake Murdeduke. Young leave the nest after 1 – 2 days, first flight at 14 weeks, but may stay with parents for up to 11 months.
Shore birds	
Banded lapwing	Nests in a scrape on the ground lined with dry grasses. In the Ramsar site, observed in the shores of Lake Murdeduke.
Masked lapwing	Nests in scrape on the ground away from vegetation cover (not necessarily near wetlands). Young hatch with full down and are independent within a few hours.
Red-capped plover	Nests in scrape made in sand or mud. In the Ramsar site observed on the mudflats at Lake Murdeduke. Young leave nest within one day and self fed; require vegetation for cover.

4.3.3 Priority wetland species – supports migratory birds

At the time of listing, the Western District Lakes supported moderate to large numbers of migratory shorebirds in the East Asian-Australasian Flyway. The majority of birds using this flyway migrate from breeding grounds in North-east Asia and Alaska to non-breeding grounds in Australia and New Zealand, covering the journey of 10 000 kilometres twice a year (Figure 38).

The lifecycle of most international migratory shorebirds involves (Bamford et al. 2008):

- breeding in May to August (northern hemisphere);
- southward migration to the southern hemisphere (August to November);
- feeding and foraging in the southern hemisphere (August to April); and
- northward migration to breeding grounds (March to May).

During both northward and southward migration, birds may stop at areas on route to rest and feed. These stopovers are referred to as “staging” areas and are important for the bird’s survival. In addition, birds on their first southward migration have not yet reached breeding maturity and may remain in Australia over the southern winter period.

The exception to this lifecycle pattern is the double-banded plover, which is the only species in the East Asian-Australasian Flyway that breeds in the southern hemisphere. This species breeds in New Zealand from September to December and then spends the winter in Australia (May to August).

Figure 38: East Asian-Australasian Flyway (adapted from Bamford et al. 2008).

Utilisation of foraging and feeding habitats by shorebirds is a complex interaction between factors such as trophic structure, food partition (Davis and Smith 2001), prey availability (Hubbard and Dugan 2003) and selectivity (Kalejta 1993; Backwell et al. 1998), predation risk (Cresswell 1994; Ydenberg et al. 2002) and abiotic factors such as water level (Recher 1966; Boettcher et al. 1995; Colwell and Dodd 1995; Cole et al. 2002), tidal cycle (Recher 1966; Burger et al. 1997) and substrate particle size (Danufsky and Colwell 2003).

There is a large body of literature describing the habitat requirements (with respect to feeding) of shorebirds based both on observational and experimental studies. In general terms, the habitat requirements of species which the Western District Lakes Ramsar site regularly supports in moderate to large numbers are described in Table 24.

Shorebirds within the Ramsar site are reliant on abundant food sources to build up reserves prior to the journey back to breeding grounds.

Table 24: Habitat requirements of migratory shorebirds which the Western District Lakes Ramsar site regularly supports (information from BirdLife International, 2009 unless otherwise specified).

Species	Lifecycle	Non-breeding habitat characteristics
Curlew sandpiper	East Asian-Australasian Flyway. Breeds in Siberia. Adults spend non-breeding season (September to March) in Australia. However, juveniles may remain in Australia for up to three years before returning to the northern hemisphere to breed.	Forage on mudflats and nearby shallow water. They usually wade, mostly in water 15–30 millimetres, but up to 60 millimetres, deep. On wet mud they forage by pecking and probing. They probe in shallow water, and jab at the edge of the water where a film of water remains on the sand. They may wade up to the belly, often with their heads submerged while probing. Feed on seeds and invertebrates.
Double-banded plover	Breeds in New Zealand in September – December. Birds then migrate to Australia in February or March and spend the winter feeding in Australian estuaries and shallow lakes.	Occurs on muddy, sandy, shingled or sometimes rocky beaches, bays and inlets. Forages in exposed mudflats, seagrass and shallow depressions at low tide. Also known to forage and roost in saltmarsh (Dann 2007).
Red-necked stint	East Asian-Australasian Flyway. Breeds in Siberia. Adults spend non-breeding season (September to March) in Australia. However, juveniles may remain in Australia for up to three years before returning to the northern hemisphere to breed.	Feeds in intertidal areas in wet mud or very shallow water. Due to its small size, occupies a different niche to the Curlew Sandpiper and most often feeds above the water's edge (Thomas and Dartnall 1971).
Sharp-tailed sandpiper	East Asian-Australasian Flyway. Breeds in Siberia. Adults spend non-breeding season (September to March) in Australia. However, juveniles may remain in Australia for up to three years before returning to the northern hemisphere to breed.	Forage on wet mud, preferring areas with short, surrounding vegetation to bare substrate (Collins and Jessop 1998).

4.3.4 Threatened wetland species

The Western District Lakes Ramsar site supports two nationally threatened species with limited distributions. The habitat requirements of these are described briefly in Table 25. There is also a single record of the nationally threatened Australian painted snipe (*Rostratula australis*) occurring at the site, in 1982.

Table 25: General habitat requirements of nationally threatened species within the Ramsar site.

Species	Habitat characteristics
Salt-lake tussock-grass *Poa sallacustris*	Occurs in grassland/herbfields on flat to slightly elevated sites at the verges of slightly to strongly saline lakes. Soils commonly are grey to black clays on basalt substrate. In the Ramsar site, the species occurs at Lake Terangpom on sandy clays with tuff and ironstone nodules, while at Lake Corangamite the population grows on soils comprising partly decomposed shell beds of the small aquatic snail *Coxiella striata* (Carter and Walsh 2006).
Spiny peppercress *Lepidium aschersonii*	Occurs mainly in or around swamps and salt marshes on heavy black or clay soils. The species requires some degree of soil water-logging or seasonal inundation and has been observed to survive complete submergence. Can tolerate a range of salinity conditions, from hypersaline at Lake Beeac to near fresh at other locations. Known to have specific germination and regeneration requirements that depend on a balance between climatic conditions and soil moisture levels (DSE 2009).

4.4 Non-critical services

4.4.1 Commercial fishing

Up until the mid 1990s, Lakes Colongulac, Gnarpurt and Murdeduke were annually stocked with short-fin eels. Elvers and glass eels were collected from nearby estuarine waters during their annual migration and transferred to the nutrient rich waters of the inland lakes to grow and later harvest (McKinnon 2002).

4.4.2 Recreation and tourism

The Western District Lakes Ramsar site attracts visitors who partake in a wide range of activities centred on the lakes including camping, fishing, boating, bird watching and duck hunting. Tour groups and individuals also commonly visit the scenic volcanic features of the Western District Lakes Ramsar site and the surrounding area (DNRE 2002). Lakes Murdeduke and Terangpom are popular fishing locations for recreational fishing and boating. In addition, at the time of listing, the shores of Lake Corangamite were used by local residents as an “inland beach” for swimming and other associated recreational activities (J. Clarke, Parks Victoria, pers. comm.)

4.4.3 Indigenous cultural values

The area within and surrounding the Western District Lakes Ramsar site is culturally significant to local Indigenous people. The area to the east of the eastern shore of Lake Corangamite, including Lakes Beeac and Cundare is attributed to the *Gulidjan* People. The area to the west of the eastern shore of Lake Corangamite, including Lake Corangamite, Gnarpurt, Milangil, Bookar, Colongulac and Terangpom, is considered the territory of the *Djargurd Wurrung* People and the area surrounding Lake Murdeduke is considered *Wathaurong* country (Corangamite CMA 2010).

There are a number of registered indigenous cultural heritage sites within the Western District Lakes Ramsar site, which reinforce the importance of the lakes within the Ramsar site to traditional owners. These include (Corangamite CMA 2010):

- two traditional burial mounds – located along the northern shores of Lake Corangamite and Lake Gnarpurt;
- numerous artefact scatters around all lakes within the site;
- the remnants of stone dwellings on the southern shores of Lake Corangamite (Figure 39); and
- fish trap sites at Lakes Beeac, Corangamite, Cundare and Terangpom (Figure 40).

Figure 39: Remnants of a stone house on Lake Corangamite (photo J. Clarke).

Figure 40: Stone fish trap on the shores of Lake Terangpom (photo J. Clarke).

The lakes in the Ramsar site represented a significant resource to indigenous people and the presence of permanent stone structures such as dwellings and fish traps is an indication of the more or less permanent water and food resources provided by the lakes. Indigenous people practised aquaculture in the lakes and built stone dwellings in “villages” on the shores of the more permanent systems.

There is evidence that Aboriginal people constructed elaborate channels to divert water (and fish) from streams to lakes and from one lake to another. In this manner, aquaculture of eels was made possible in Lakes such as Terangpom and Corangamite (John Clarke, Parks Victoria pers comm.). The different features associated with fish trapping and management are described in Text Box 2.

“***Stone traps*** *…were defined as stone features which had been constructed across a range of depression features in the landscape. Some traps occurred on slightly elevated land surface, between two areas of lower ground…Stone traps were also constructed across natural and artificial drainage lines, and across the edges of depression features, particularly lava sinkholes.*

Stone traps were differentiated from stone alignments, which also occur in similar positions in the landscape, by the presence of one or more gaps in the stone structure. Stone traps do not just consist of freestanding stone walls…but occur in a range of forms. There are structures which do consist of low (50 to 75 centimetre), free-standing, stone walls, but there are also traps which make use of natural basalt outcrops by adding short sections of piled stones to the existing geological formations. Other traps combine short sections of low walls with natural outcrops and small (up to one metre in diameter and 75 centimetres high) stone piles. The traps occur across landscape features which contain and direct water flow.

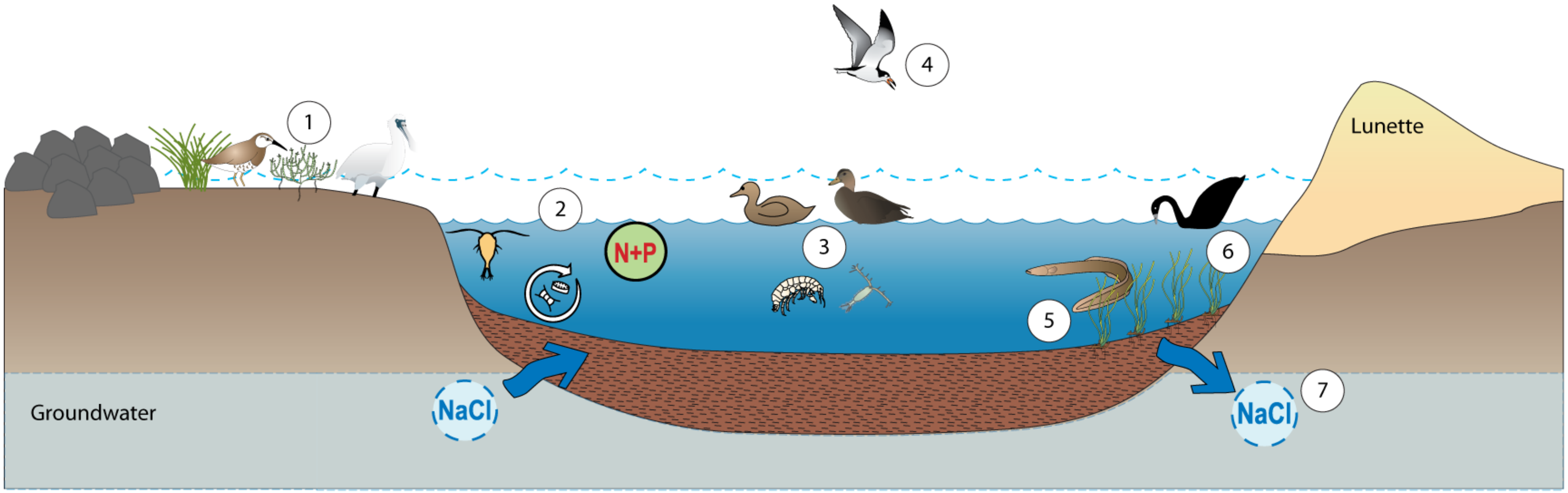
Channels *were defined as drainage lines whose edges were not defined by blocks of basalt. They were only recorded as sites where they were clearly in association with a stone trap or stone alignment. It is likely, given the topography, that these features are simply natural drainage lines running along the bottoms of the depressions. However, it is also possible that some may have been defined, or accentuated by some form of cultural modification.*

Stone-lined channels*…are…channels whose edges have been defined by lines of basalt blocks. Again, given their location within the depressions, they appear to be natural drainage lines which have been modified by the addition of rocks.*

Text Box 2: Description of stone fishing structures that occur within the Ramsar site (Clarke 1991, as cited by Lane 2009).

4.5 Conceptual model

A simple conceptual model of the Western District Lakes Ramsar site at the time of listing (Figure 41) presents an overview of how components and processes interact to provide the critical supporting services of the site. This highlights the variety of habitats within the site at the time of listing (see also Figure 36 above) and how these supported a diversity of species, particularly waterbirds.



1. Seasonally variable water levels result in mudflats during spring and summer months, which provides foraging habitat for wading birds. The variable water levels also provide habitat at lake margins for threatened plant species: spiny peppercress and salt tussock-grass.
2. Nutrients from inflowing waters stimulate productivity and provide food resources for invertebrates, fish and waterbirds.
3. Expanses of open water provide foraging habitat for diving and dabbling ducks as well as a refuge during primary moult.
4. Fish within the lakes and the open water environment provide foraging habitat for piscivorous birds.
5. A number of lakes were stocked with elvers adding to the food chain and supporting commercial fishing.
6. Submerged macrorphyte beds provide habitat for fish and macroinvertebrates, as well as foraging habitat for grazing waterfowl.
7. The balance between water sources and inflowing / outflowing water regulates salinity within the lakes.

Figure 41: Simple conceptual model of the Western District Lakes (at the time of listing) showing the major interactions between components, processes and services.

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 (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 driver or 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. For example, increased nutrients may be identified as a threat to lake ecology. However, management actions cannot be targeted at increased nutrients without some understanding of why the increase is taking place. By identifying the threatening activities that could contribute to increased nutrients (for example stormwater inflows, intensive agriculture) management actions can be targeted at these threatening activities and reduce the impact to the wetland.

There are a number of threats that could significantly impact on the ecological character of the site. The stressor model (Figure 42) illustrates the threats (threatening activities), stressors and resulting ecological effects on critical components, processes and services at the Western District Lakes Ramsar site. However, many of these such as pollution and biological resource use (fishing and hunting) could be considered minor in nature. The most significant threat to the ecological character of the Ramsar site is climate change (EPA 2010) and this has already had a dramatic impact on the site (see Section 7). As such threats are considered in two categories: Climate Change (and associated additive and synergistic factors) and local scale threats.

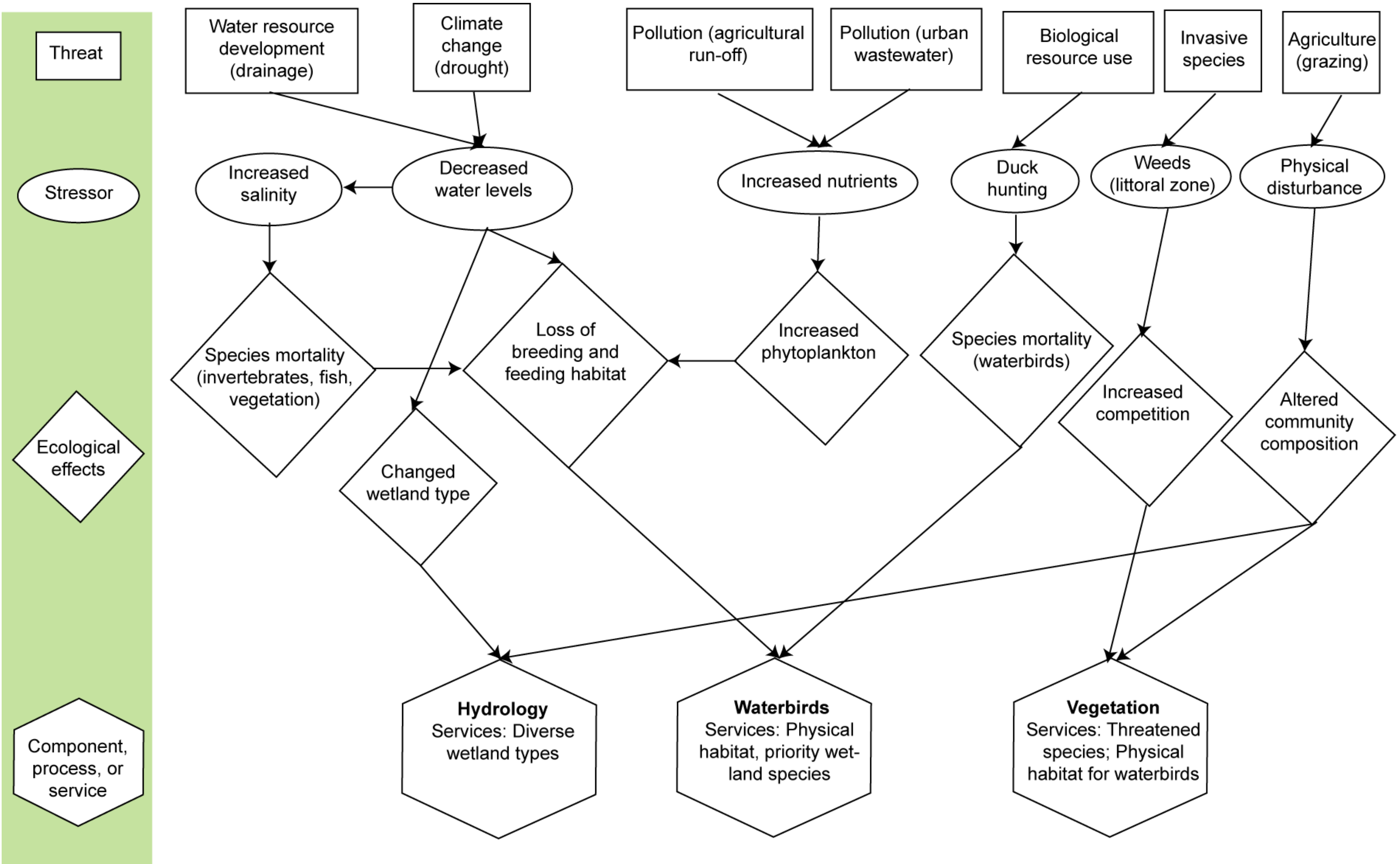


Figure 42: Stressor model of the Western District Lakes Ramsar site (after Gross 2003 and Davis and Brock 2008).

5.1 Climate change

Williams (1995) stated that salt lakes are more susceptible to impacts of climatic change and altered water regime than freshwater systems. The lakes of the Ramsar site are very susceptible to changes to the balance between inflows and evaporation (EPA 2010). Regional rainfall has declined by approximately 13 percent compared to the long term mean, averaging 680 millimetres from 1997 to 2008 (EPA 2010). The aerial distribution for the decades 1961 to 1990 and 1996 to 2005 are shown in Figure 43 and Figure 44.

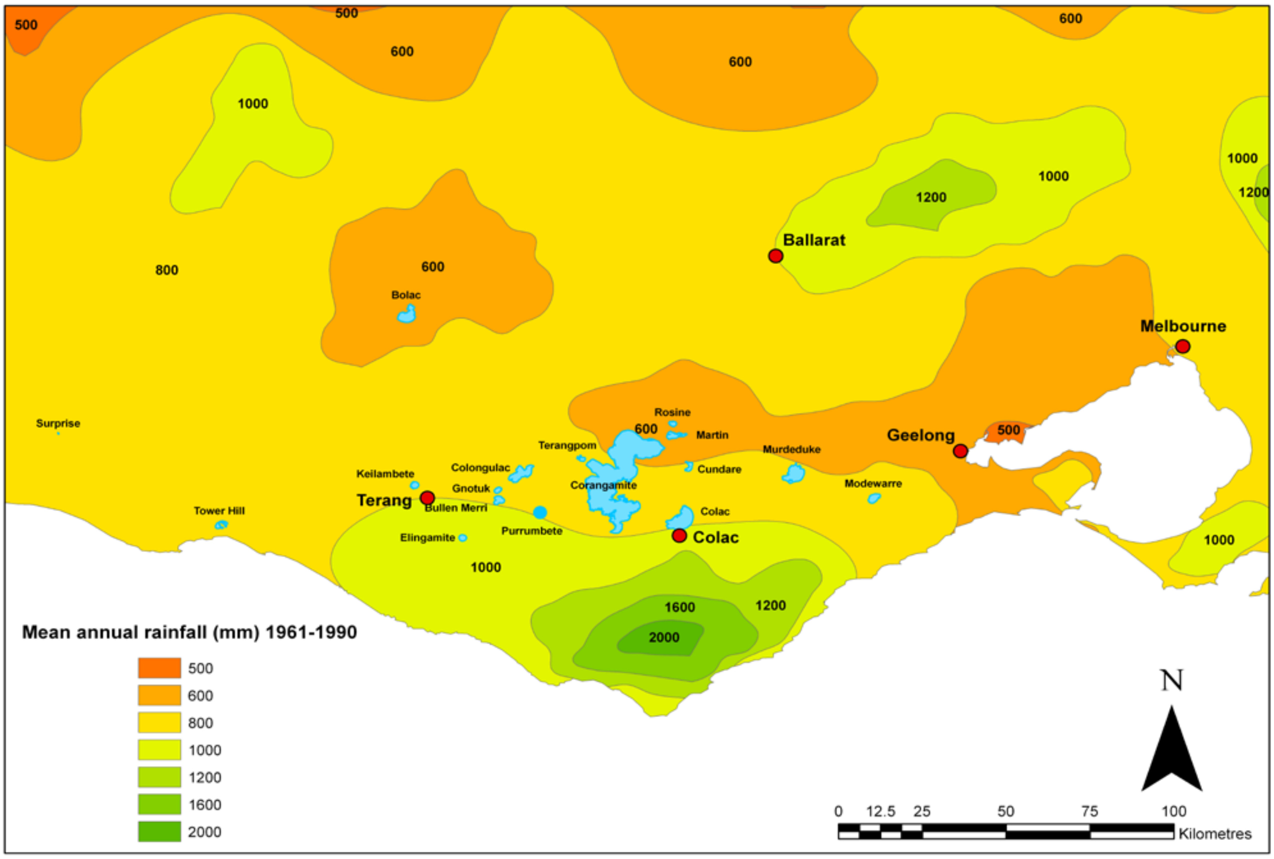


Figure 43: Aerial distribution of rainfall from 1961 to 1990 (from EPA 2010).

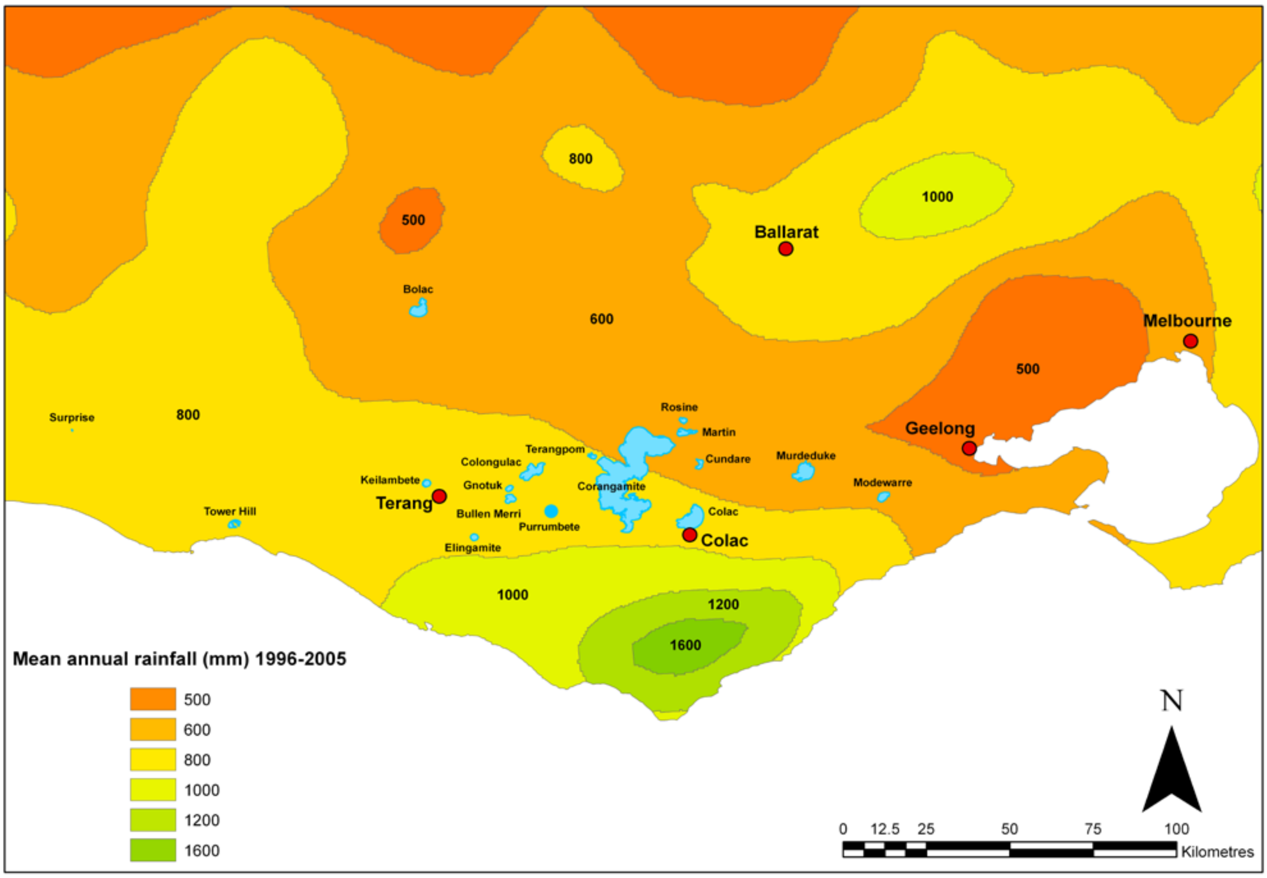


Figure 44: Aerial distribution of rainfall from 1996 to 2005 (from EPA 2010).

Declining rainfall and increased temperatures since 1996–2005 have led to declines in water levels and increases in salinity across many lakes in the Western District, particularly since 1998 (EPA 2010). Reconstruction of climatic data and lake water levels on a couple of lakes in the region has shown that there has been an ongoing decline in levels since 1841; however anthropogenic induced climate change is likely to severely exacerbate the situation (EPA 2010). The recent dry period (13 percent decline in rainfall) far exceeds the predicted decreases in rainfall for the region of two to five percent. Even with a return to wetter conditions it is likely that in the coming decades water levels will continue to decline, resulting in increasing salinity (EPA 2010).

The 1997–2009 drought has also had notable impacts on the groundwater tables of the region (Tweed et al. 2009). Water levels at Lake Corangamite have fallen 2.23 metres between October 1996 and October 2005 (Tweed et al. 2009). Pre-drought (1992) to drought (2006) data shows a decline in the water table levels during drought; 0.73 metres lower in summer/autumn and on average 1.24 metres lower in winter/spring. A decline in seasonal variation in the water table was also observed with the seasonal amplitude pre-drought being on average 0.55 metres compared to only 0.06 metres during the drought (Tweed et al. 2009). Tweed et al. (2009) prepared a water balance for Lake Corangamite which indicated that rainfall was the main source of water inputs to the system and that declines in rainfall were the main factor leading to lower water levels; evaporation did not increase at Lake Corangamite (EPA 2010; Tweed et al. 2009).

Overall, drought and climate change have had a significant impact on the lakes of the Ramsar site, evidenced by the severe and rapid changes observed at Lake Corangamite. Williams (1992) suggested the character of Lake Corangamite had undergone a change based on the impacts from diverting inflows from Woady Yaloak River. Tweed et al. (2009) state that the impact of the drought on Lake Corangamite far exceeds those caused by the surface water diversion which occurred over a 26 year period.

The potential effects of climate change on the hydrology of the lakes within the Ramsar site has been modelled by Water Technology (2010). The results indicate that there is likely to be a further decline in water levels and permanence with a greater incidence of dry periods. For example, the modelled hydrology for Lakes Colongulac and Murdeduke with climate change (2030 scenario of lower rainfall and increased temperatures) and under current conditions illustrate the dramatic nature of predicted impacts. Baseline conditions at Lake Murdeduke indicate there have been no incidents of complete drying in at least 100 years. However, under climate change scenarios, the reduced inflows from rainfall and overland flow, together with increased evaporation from predicted warmer temperatures, results in an increased net loss of water. As a result it is predicted that the lake would be dry 24 percent of the time, with 100 dry spells in 100 years averaging one month long, with a maximum dry period of 130 days (Figure 45; Water Technology 2010).

Similarly, the reduction in surface water inflows and increase in evaporation under climate change scenarios is predicted to result in a decline in water in Lake Colongulac. Although there were periods of dry conditions at this lake under baseline conditions, the frequency of these periods is predicted to increase substantially with water levels between dry periods remaining consistently low (Figure 46; Water Technology 2010). This situation is exacerbated at the lake by the change in operations of the Camperdown Wastewater Treatment Plant, which stopped discharging to Lake Colongulac in 1999 (Water Technology 2010).

Water Technology (2010) suggests that the effect on the other lakes within the Ramsar site will be similar.

Due to the strong linkages between salinity and hydrology at the lakes within the Ramsar site, impacts of climate change have and will continue to extend to altered salinity regimes. This is illustrated by recent observations of water level and salinity at Lake Corangamite (Figure 47). The continued loss of water by evaporation results in a concentration of salts in the remaining smaller volume of water. In the absence of significant freshwater inflows to dilute the salts, salinity continues to rise. This is consistent with the findings of Tweed et al. (2009) who indicated that impacts of the drought have increased lake salinity levels by approximately 2.8 times over a nine year period to 2006 (Tweed et al. 2009).

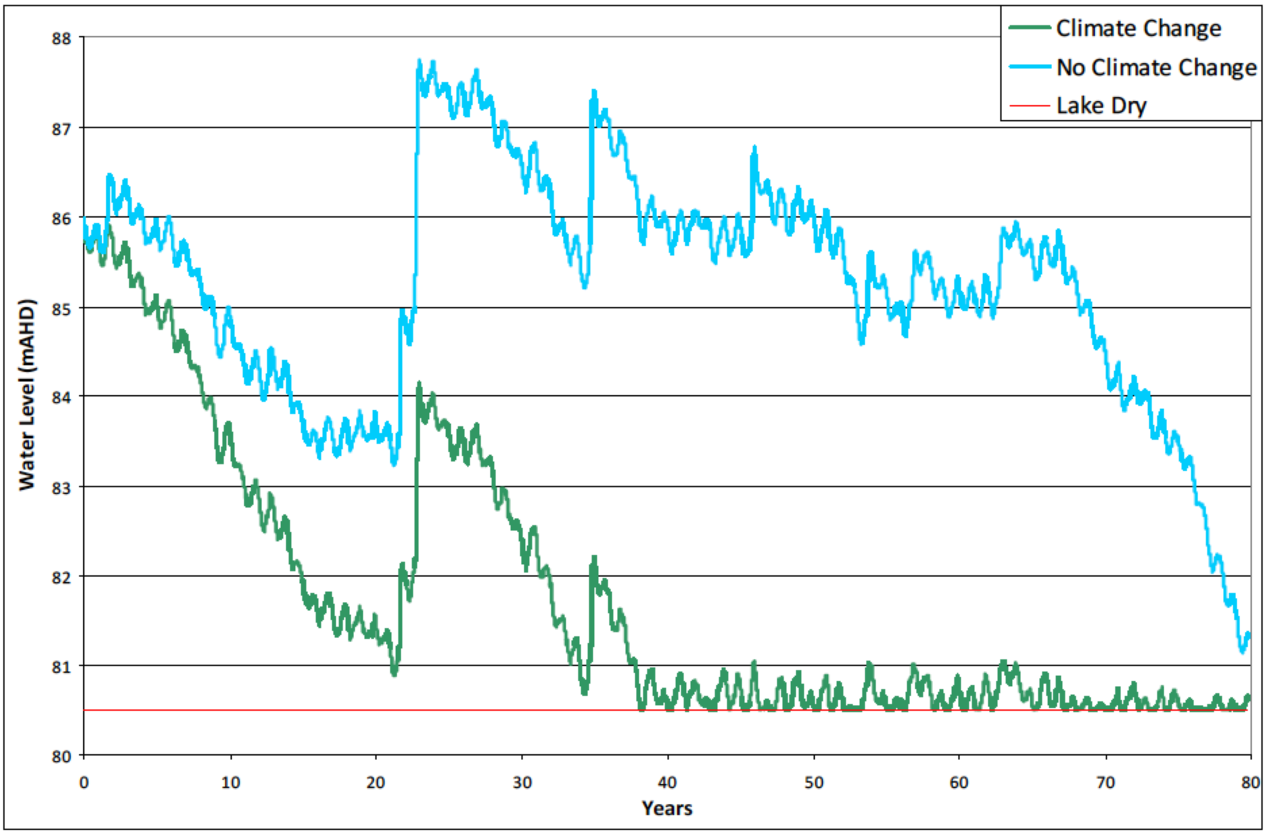


Figure 45: Predicted effect of climate change on water levels in Lake Murdeduke based on historical hydrology 1930 to 2010 (Water Technology 2010). Note: "no climate change" equates to current conditions.

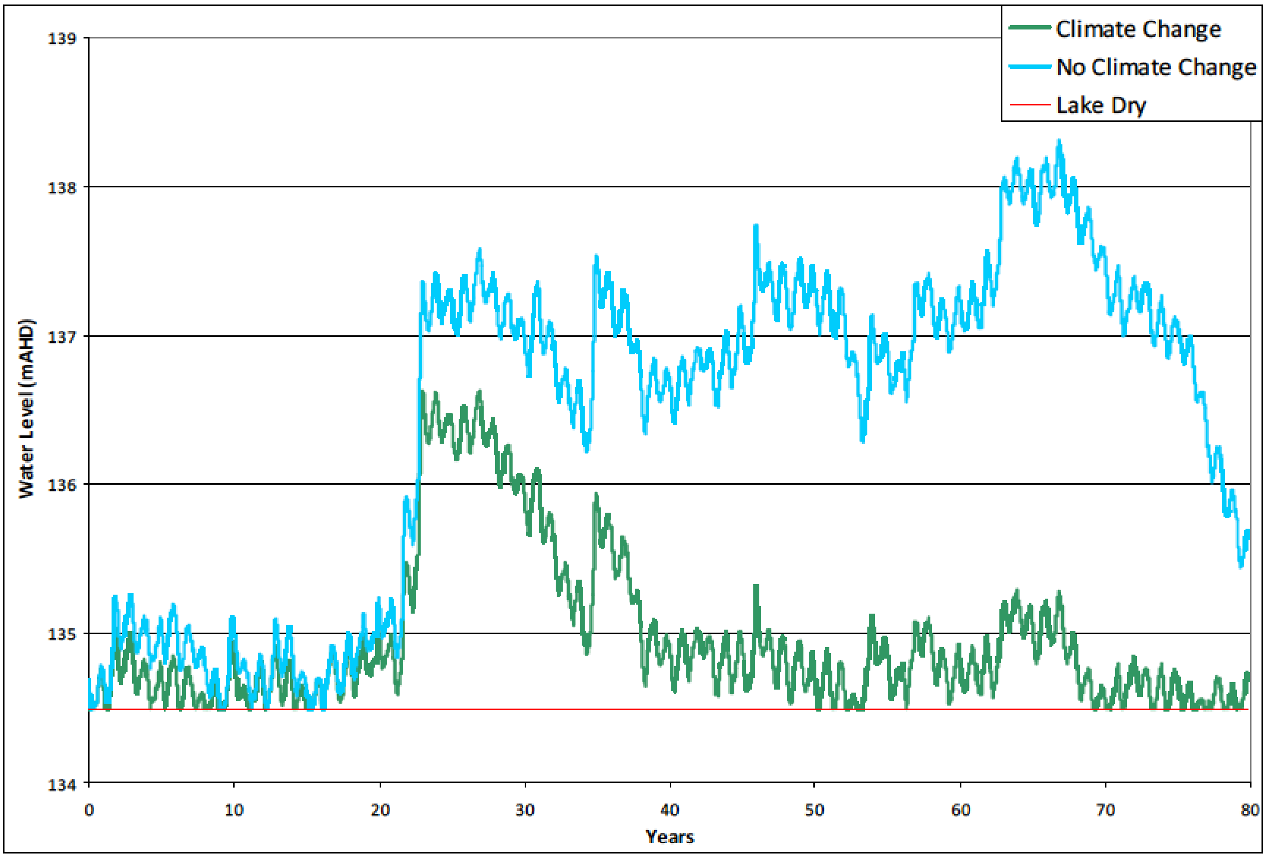


Figure 46: Predicted effect of climate change on water levels in Lake Colongulac based on historical hydrology 1930 to 2010 (Water Technology 2010). Note: "no climate change" equates to current conditions.

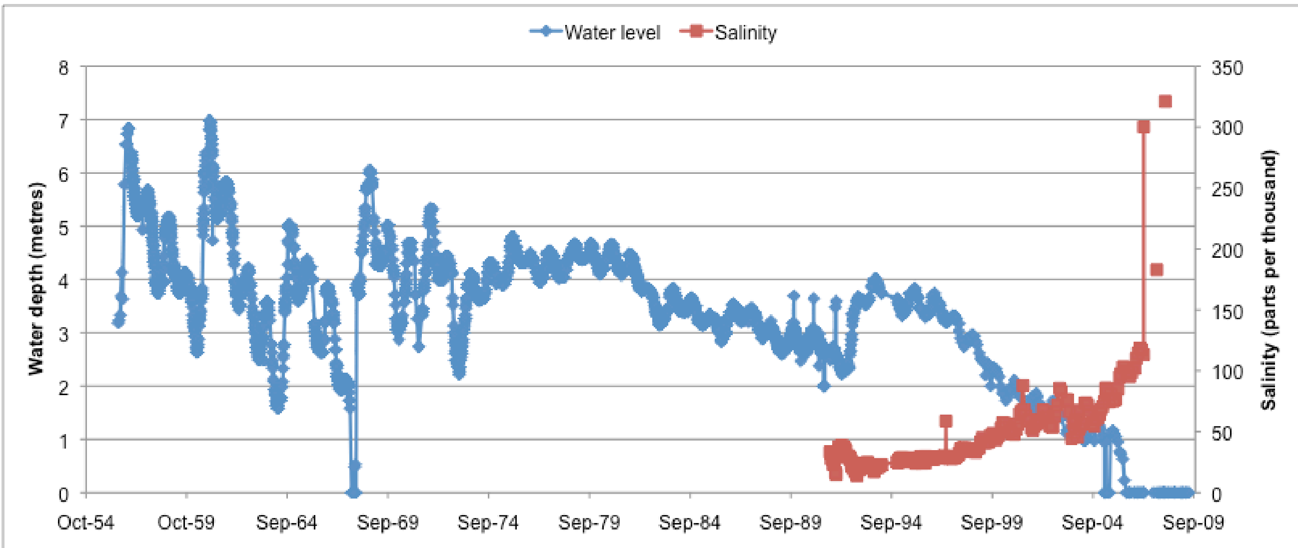


Figure 47: Salinity and water level in Lake Corangamite (adapted from EPA 2010).

5.2 Local scale threats

5.2.1 Water resource development

Water resource development as defined by the International Union for Conservation of Nature – Conservation Measures Partnership (IUCN-CMP) includes all activities that modify natural flow and so includes drainage and diversion as well as extraction. Drainage has been occurring within the Western District Lakes since the 1800s and so forms part of the ecological character of the site. The question of lag effects and effects on resilience however, remain. For example, this has been seen at Lake Corangamite where the Woady Yaloak diversion implemented in 1959 has led to a major shift in the limnology and biota of the lake (Williams 1992; DNRE 2002). Water levels in the lake have dropped by two metres and salinity increased to above 50 parts per thousand (Williams 1992, 1995; DNRE 2002), invertebrate and fish species have been lost and waterbird usage changed (Williams 1995; DNRE 2002). The fact that the diversion of inflows from the Woady Yaloak River commenced in 1959, but the biological responses were observed some 20 years later, indicates there is a time lag involved before critical thresholds are reached.

In terms of extraction, the area around Red Rock to the east of Lake Corangamite is included in the Warrion Water Supply Protection Area. This water supply area covers the surficial, unconfined aquifer that supplies part of the water for Lake Corangamite to the west and Lake Beeac to the east. The status of the water aquifer has been defined as declining, with current licensed entitlements equivalent to the PCV (permissible consumptive volume; DSE in press). Continued extraction at current license limits into the future (considering the likely impacts of climate change) could result in further decreased inflows to the lakes of the Ramsar site.

5.2.2 Pollution

Household sewage and urban wastewater

Urbanisation of the region has resulted in high levels of nutrients and toxins particularly from stormwater systems entering the waterways (Corangamite CMA 2003). Dumping of hard rubbish is also an issue at the Ramsar site. An old tip on the eastern shore of Lake Beeac has the potential to leach pollutants into the lake (including heavy metals) as wave action washes over part of the tip which extends into the lake (DNRE 2002).

At the time of listing Camperdown sewage treatment plant discharged secondary treated wastewater into Lake Colongulac leading to high levels of mercury. This is thought to have led to the closure of eel and fish stocking in the lake (DNRE 2002). In 1999, discharge of treated wastewater to the lake ceased (Water Technology 2010).

Agricultural run-off

Run off from surrounding landscapes subject to intense use has resulted in increased pollutants entering the waterways. As the lakes are terminal systems they are all sinks for pollutants. Nitrogen and phosphorous inputs to Lakes Milangil, Murdeduke, Colongulac, Corangamite and Gnarpurt from agricultural runoff and local drainage schemes are all likely to have contributed to nutrient enrichment of the lakes. Algal blooms are commonplace in the region with the frequency and severity of blooms increasing (DNRE 2002). Algal blooms have led to taste and odour problems, loss of scenic values and aesthetic appeal. Crashes in blooms can lead to sudden extreme reductions in oxygen levels leading to fish kills as was thought to have occurred at Lake Gnarpurt, a commercial fishery, in October 1999 (DNRE 2002). Recreational fishing and tourism are also affected by the increased presence of algal blooms (Corangamite CMA 2003).

A number of intensive farming activities occur right up to the margins of the Ramsar site at several lakes including a piggery on the shores of Lake Murdeduke (Figure 48), and dairy operations at Lakes Beeac and Colongulac. Sediment and nutrient runoff from these types of agricultural practices can lead to localised nutrient enrichment with associated changes in the aquatic biota.

Figure 48: Piggery on the shores of Lake Murdeduke (photo B. Hale).

5.2.3 Agriculture

Clearing of land for agriculture has long been held as a primary cause of increasing dryland salinity through rising groundwater for much of Australia. However, in the Corangamite region salinity has been a naturally episodic feature of the landscape throughout the Quaternary period (Dahlhaus 2004; Dahlhaus et al. 2008). Increased salinity in some waterbodies and landscapes has been recorded in the region, however there is no recorded evidence found which supports significant rises in groundwater following widespread land-use change (Dahlhaus et al. 2008). Grassland vegetation has been the dominant vegetation cover over much of the Basalt Plain, so that the leaching of salts into the environment has been underway for a greater period than in catchments, which are dominated by deep rooted woody vegetation (Corangamite CMA 2003).

Groundwater levels in many parts of the region, including the western plains and uplands, have not changed for hundreds of years (Dahlhaus et al. 2008). There are some areas of secondary salinisation in the region; however, an increase in salinity through rising groundwater tables at the Ramsar site is not considered a significant nor immediate threat. Direct alteration of inflows (see Section 5.1) has a much greater likelihood of impacting the salinity of the lakes.

Other agricultural impacts at the site include grazing the lake margins. Approximately 90 percent of the lake margins are grazed, and have been since settlement (DNRE 2002). Livestock have a tendency to concentrate at water sources, including wetlands, particularly in drier periods, thus increasing the effects of grazing and trampling (Jansen and Robertson 2001). The effects of grazing on wetland geomorphology, vegetation and water quality are well documented; however there has been relatively little investigation of the impacts of different stocking rates on catchment scale functions (Jansen and Robertson 2001).

Stock can trample vegetation affecting the height and density of wetland vegetation and overgrazing can reduce primary productivity in wetlands and lead to increased water turbidity and areas devoid of vegetation (Kantrud, 1990). The main impacts associated with grazing of wetlands are:

- soil compaction
- increased nutrient input
- changes in turbidity
- spread of weeds
- selective grazing and trampling of indigenous wetland vegetation
- erosion.

The relative severity of grazing impacts on the Ramsar site are not well documented; however, changes in vegetation have been noted, including reductions in native grassland, woodland and saltmarsh (DNRE 2002). Grazing has also been implicated in increasing the susceptibility of the lake margins to erosion (DNRE 2002).

5.2.4 Invasive species

Invasive plants, or weeds, in this context, are exotic plants that invade native vegetation communities and cause negative impacts to native flora (by competition and displacement) and fauna (by the loss of native food sources). Weeds that dominate much of the lake margins include tall wheat grass (*Lophopyrum ponticum)*, phalaris (*Phalaris aquatica*) and sweet vernal grass (*Anthoxanthum odoratum)* (DNRE 2002). Tall wheat grass is a saline tolerant species which is palatable to stock and as such it has been promoted as a valuable perennial grass pasture for areas affected by secondary salinity (DPI 2010). However, it is considered a serious weed when it gets into wetland environments where it can out-compete native species. Phalaris is considered a productive perennial grass which has a high degree of drought tolerance and is one of the most widely sown perennial grasses sown in Victoria. Sweet vernal grass is commonly found associated with seasonal freshwater wetlands.

Bathurst burr (*Xanthium spinosum*), variegated thistle (*Silybum marianum*) and ragwort (*Senecio jacobaea*) are also found in the Ramsar site along shorelines. Boxthorn provides habitat for invasive pest species including cats and foxes as well as reducing waterbird habitat by displacing native shoreline vegetation including the threatened hairy-tails and spiny pepper-cress at lakes Corangamite and Beeac (DNRE 2002).

Foxes and cats occur throughout the site and pose a predation risk to reptiles, including waterbirds that nest or feed on the ground near the lake margins. Waterbird breeding sites such as Wool Wool Rocks at Lake Corangamite are particularly susceptible to fox predation (DNRE 2002). DNRE (2002) list the following waterbirds as being particularly susceptible to predation by foxes: red-capped plover, straw-necked ibis, great cormorant, pied cormorant, Australian white ibis, black swan, Australian pelican, silver gull and gull-billed tern. Rabbits and hare are also found in the site and have contributed to loss of native species and localised erosion (DNRE 2002)

5.2.5 Resource utilisation

At the time of listing, duck hunting occurred and continues to occur on Lakes Bookar, Colongulac, Corangamite, Gnarpurt, and Murdeduke; however the impact of the activity has not been assessed (DNRE 2002). The main types of impacts from hunting, aside from taking of ducks, include accidental shooting of protected species and disturbance to the habitat and fauna (DNRE 2002).

5.3 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 major threats considered in the previous sections have been summarised for each location within the Ramsar site in accordance with the DEWHA (2008) framework in Table 26.

Table 26: Summary of the main threats to the Western District Lakes Ramsar site.

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or service	Location	Likelihood[1]	Timing[2]
Climate change - drought	Lower water levels leading to increasing salinity.	All	Certain	Current
Water resource development	Reduced water levels leading to increased salinity levels through evaporation and concentration effects.	Lake Corangamite and Gnarpurt.	Certain	Current
		Lake Murdeduke	Certain	Long term
Pollution	Eutrophication and toxic effects.	All	Certain	Current
Agricultural impacts	Grazing impacts	All	Certain	Current
	Salinity impacts due to land clearing.	All	Low	Long-term
Invasive species	Increased competition and loss of diversity.	All	Certain	Current
Resource utilisation	Fishing and duck hunting leading to disturbance of habitat and waterbirds.	Fishing - Colongulac, Gnarpurt and Murdeduke. Duck hunting - Bookar, Colongulac, Corangamite, Gnarpurt, and Murdeduke	Certain	Current

[1] Where Certain is defined as known to occur at the site or has occurred in the past; and Low is defined as theoretically possible, but not recorded at this or similar sites.
[2] Where Current is defined as happening at the time of writing (2010); Long-term is defined as greater than 10 years.

6. Limits of Acceptable Change

6.1 Process for setting Limits of Acceptable Change (LAC)

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".

LACs 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 in consideration with 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 straight forward.

Hale and Butcher (2008b) considered that it is not sufficient to simply define the extreme measures of a given parameter and to set LAC beyond those limits. What is required is a method of detecting change in pattern 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 represent what could infer a change in ecological character at the site in absolute terms with no regard for 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 and the management plan for a site must develop and implement a set of management triggers with this aim.

6.2 Limits of Acceptable Change for the Western District Lakes Ramsar site

LACs have been set for the Western District Lakes Ramsar site based on conditions at the time of listing (Table 27). Where possible, site specific information has been used to statistically determine LACs. 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 all these cases, the source of the information upon which the LAC has been determined is provided. However, it should be noted that for many of the critical components and processes there are limited quantitative data on which to set limits. In these instances, LACs have been recommended. These are qualitative, based on the precautionary principle, and will require careful review with increased information gained from future monitoring. It should be noted that:

- exceeding or not meeting a LAC does not necessarily indicate that there has been a change in ecological character; and
- while the best available information has been used to define LACs for threatened flora and waterbirds, only limited information and data are available and the LACs in Table 27 may not accurately represent the variability of the these services and benefits under the natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

LACs are required for all identified critical components, processes, benefits and services. However, due to the interrelated nature of components, processes and services a single LAC may in fact account for multiple components, process and services. For example, the LAC that addresses hydrology at Western District Lakes also covers the critical service of water provision and physical habitat. If hydrology were significantly altered this would lead to a loss of the services. In order to limit repetition in the LACs for Western District Lakes, a hierarchical approach has been adopted where LACs have been set for components, which in this case has also covered critical services.

The columns in Table 27 contain the following information:

Critical components, processes and services	The component, process or service of which the LAC is a 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.
Confidence level	The degree to which the authors are confident that the LAC represents the point beyond which a change in character is likely to occur. Assigned as follows: High – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measureable. Medium – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific literature; or informed expert opinion; LAC is objectively measureable. 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 LACs

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 27: Limits of Acceptable Change for the Western District Lakes Ramsar site.

Component, Process and Service	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Critical components and processes			
Hydrology	At the time of listing Western District Lakes comprised: • Six permanent wetlands that had not been known to dry completely in European history (Lakes Bookar, Corangamite, Gnarpurt, Milangil, Murdeduke and Terangpom); • One permanent wetland that dried on occasion in the last 100 years, for a maximum period of six weeks (Lake Colongulac); and • Two temporary wetlands that dried seasonally (Lakes Beeac and Cundare). Water levels varied seasonally in all lakes, with permanent wetlands changing in depth by approximately one metre annually (Coram 1996). LAC based on no change in hydrological type and local knowledge.	*No change in wetland hydrological type for any given wetland. That is the following hydrological regimes maintained:* • *Lakes Beeac and Cundare – intermittent wetlands drying seasonally but having water for at least a few months of each year;* • *Lake Colongulac – near permanent wetland drying for no more than twelve months in any five year period;* • *Lakes Bookar, Corangamite, Gnarpurt, Milangil, Murdeduke and Lake Terangpom – permanent wetlands not drying for more than two months in any five year period.*	High
Salinity	Salinity within the wetlands varied on annual and inter-annual cycles (Decker and Williams 1988; Hose et al. 2008): • Beeac 55 to 300 parts per thousand • Bookar 11 to 17 parts per thousand • Colongulac 8 to 12 parts per thousand • Corangamite 27 to 36 parts per thousand • Cundare 77 to 347parts per thousand • Gnarpurt 7 to 14 parts per thousand • Milangil 6 to 7 parts per thousand • Murdeduke 11 to 14 parts per thousand • Terangpom 2 parts per thousand LAC based on no change in salinity category (for example fresh to saline, saline to hypersaline).	*No change in salinity category for any given wetland. That is the following salinity regimes maintained:* • *Lakes Beeac and Cundare – hypersaline (greater than 50 parts per thousand);* • *Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke – saline (5 to 50 parts per thousand)* • *Lake Terangpom –fresh / brackish (less than three parts per thousand).*	High

Component, Process and Service	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level
Threatened flora	At the time of listing, the site supported two threatened wetland dependent plant species: Spiny peppercress – nine populations, total of 0.6 hectares (Carter and Walsh 2006); and Salt-lake tussock-grass - 97 plants were recorded along the eastern lunette of Lake Beeac and 107 plants at Lake Corangamite (DSE 2009). Variability in extent and population size is not known.	*Presence of spiny peppercress and salt-lake tussock-grass within the Ramsar site at least one year in any five year period,*	Low
Waterbirds	At the time of listing, the Western District Lakes supported large numbers of waterbirds annually (Martindale 1988; Hewish 1988; Peter 1989 to 1992). In an attempt to incorporate the level of variability in shorebird counts, limits are determined based on mean minus one standard deviation.	*Total waterbird numbers not less than 28 000 during summer in a minimum of three years in any five year period.*	Medium
	At the time of listing the Western District Lakes regularly supported greater than one percent of the population of Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot (see sections 3.3.4 and 2.4.2). Mean abundance (1987 to 1992) was close to the current one percent population thresholds for each species. LAC is based on percentage of population to account for changes in the wider population of these species to be reflected in the LAC into the future.	*Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot – not less than one percent of population (from latest Wetlands International population estimates) recorded at least once in every five year period.*	Medium
	The site supports 20 species of migratory shorebird that are listed under international migratory bird agreements. Of these, three occur regularly in the site: curlew sandpiper, red-necked stint and sharp-tailed sandpiper (AWSG unpublished). Abundance however, is highly variable and insufficient data is available to determine a quantitative LAC.	*Presence of curlew sandpiper, red-necked stint and sharp-tailed sandpiper within the Ramsar site in at least once in every five year period.*	Low
Critical Services			
Diversity of wetland types	Wetland types (intermittent saline, permanent saline and permanent freshwater) are maintained by hydrology and salinity.	*See LACs for hydrology and salinity.*	Not applicable
Physical habitat	Physical habitat for waterbirds is maintained through wetland types and can be indicated by the numbers of waterbirds supported by the site	*See LACs for hydrology, salinity and waterbirds.*	Not applicable
Priority wetland species	Priority species at the Western District Lakes Ramsar site are the 20 international migratory shorebirds.	*See LACs for waterbirds.*	Not applicable
Threatened species	The site supports two threatened plant species (spiny peppercress and salt-lake tussock-grass).	*See LACs for threatened flora.*	Not applicable

7. Current Ecological Character and Changes Since Designation

It has been over a quarter of a century since the Western District Lakes Ramsar site was designated as a Wetland of International Importance. As such, changes to the system are to be expected. However, there is strong evidence to suggest that there have been significant changes to the ecological character of this site, driven by climate change.

The major changes to the site since 1982 are described below, together with clear indication if the change has resulted in a breach of a LAC and therefore has resulted in a change in ecological character. Relative confidence levels (based on the extent and type of data available) have also been provided based on the following scale:

- High confidence – where there is sufficient data for statistical comparisons
- Medium confidence – where there is insufficient data for statistical analysis, but sufficient data to allow for considered expert opinion
- Low confidence – where there is little or no data, but judgements have been made on observations or opinion.

For a number of components and processes there was no quantitative information at the time of listing (e.g. extent and distribution of vegetation) and therefore only qualitative indications of change can be made.

7.1 Hydrology

Surface water inflows (as indicated by flow in the Woady Yallock River) have decreased dramatically since listing and particularly since 1996 (Figure 49). This can be largely attributed to the long term drought that affected the region (and much of eastern Australia) during the 2000s. While quantitative information on groundwater resources is not available, there is strong evidence to suggest that there has been a similar decline (Barton et al. 2008).

As previously stated, at the time of listing, seven of the lakes that comprise the Ramsar site were considered permanent wetlands. However, since that time, many have completely dried on at least one occasion and some have remained dry (or very low water levels) for a number of years. Information collected during annual summer waterfowl counts indicates that many Lakes were dry or had reduced water levels in recent years (Table 28). This is further illustrated by the aerial image from December 2007, which shows the extent of drying in the lakes (Figure 50).

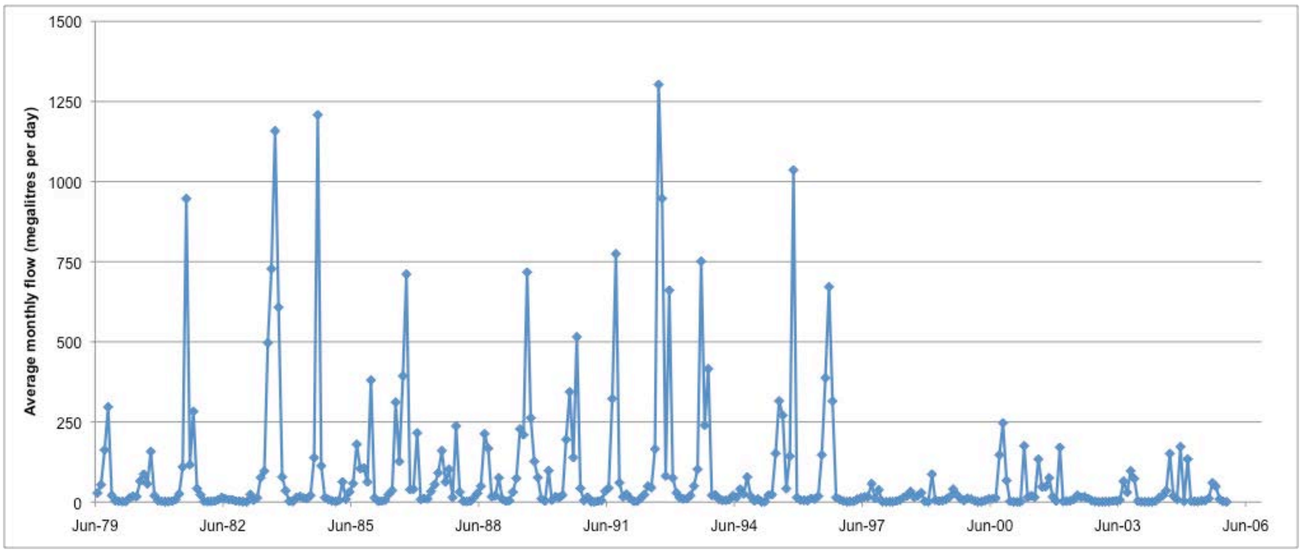


Figure 49: Average monthly flow (megalitres per day) in the Woady Yallock River from 1979 to 2006 approximately 20 kilometres up stream of Lake Corangamite (Victorian Water Resources Data Warehouse, DSE 2010).

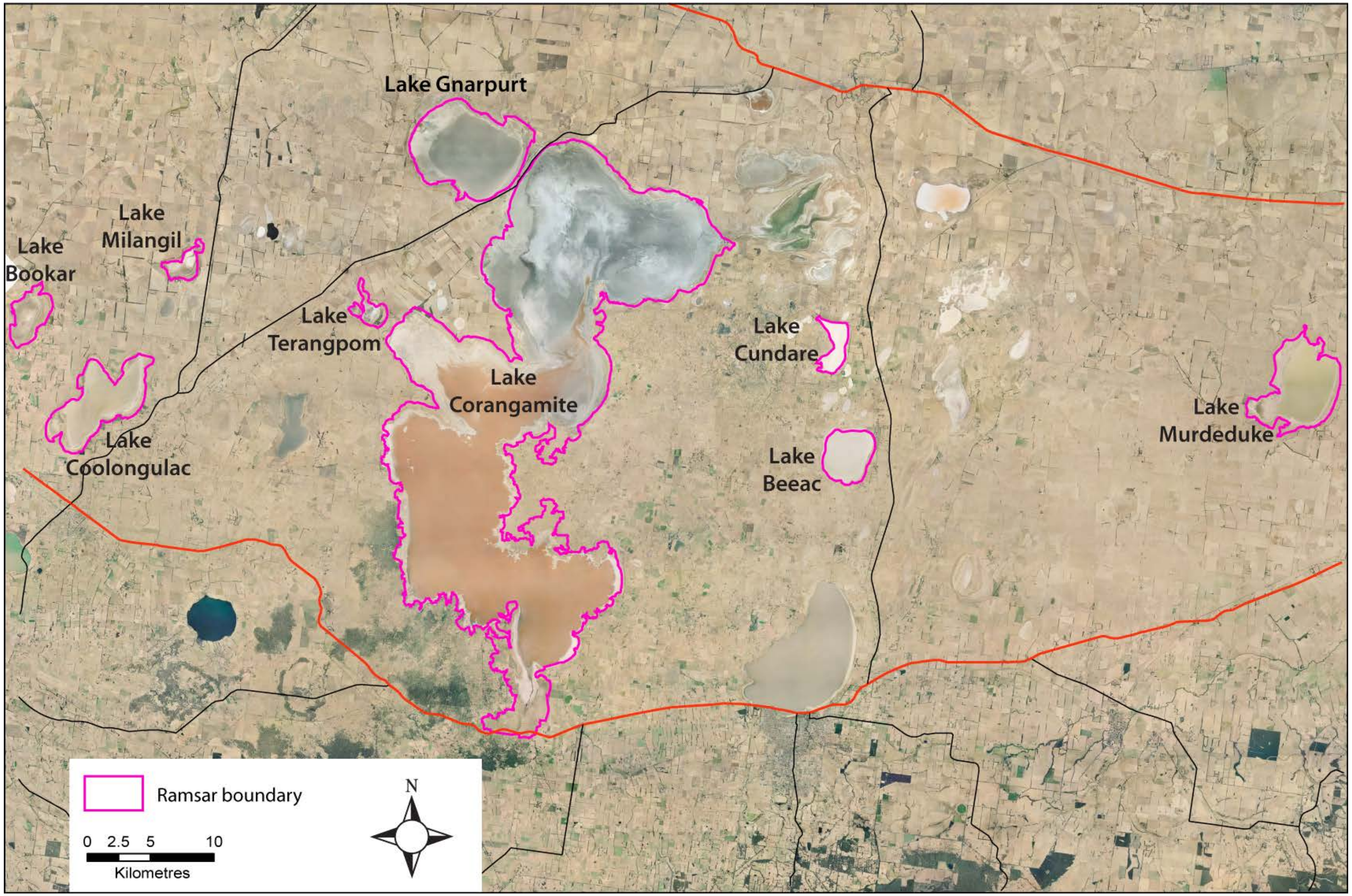


Figure 50: Western District Lakes in December 2007 showing Lakes Beeac, Bookar, Cundare Milangil and Terangpom completely dry and low water levels at Lakes Colongulac, Corangamite (northern half dry) and Murdeduke (imagery supplied by DSE).

Table 28: Observations of lake hydrology (percent inundation) of permanent wetlands from annual summer waterfowl counts conducted in February each year (DSE Colac unpublished).

Location	Percent inundation							
	2004	2005	2006	2007	2008	2009	2010	2011
Bookar	Dry	20	Dry	Dry	Dry	Dry	Dry	80
Colongulac	70	70	70	30	5	Dry	Dry	50
Corangamite	50	50	30	20	20	15	15	65
Gnarpurt	Dry	5	Dry	Dry	Dry	Dry	Dry	100
Milangil	30	50	Dry	Dry	Dry	Dry	Dry	50
Murdeduke	50	50	40	35	30	10	10	40
Terangpom	60	75	35	Dry	Dry	Dry	Dry	100

The impacts of reduced water inflows can also be seen in the long term hydrograph for Lake Corangamite (Figure 51). This shows a sustained decline in water levels in the lake since the beginning of the drought in 1997 and sustained levels below the height of the gauge since 2006. Similarly, the decline in inundation can be seen at Lake Murdeduke (Figure 52). Although neither of these two lakes has completely dried, water levels have declined significantly.

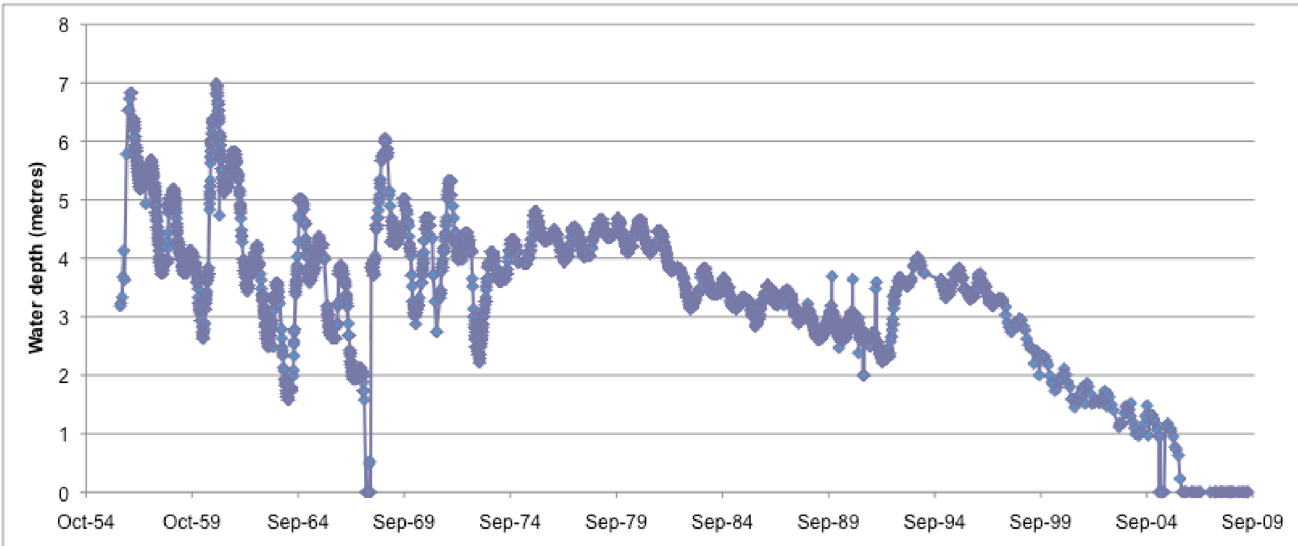


Figure 51: Long term water level at Lake Corangamite (adapted from EPA 2010). Note that zero represents the bottom of the gauge and approximately 15% inundation remains at this time.

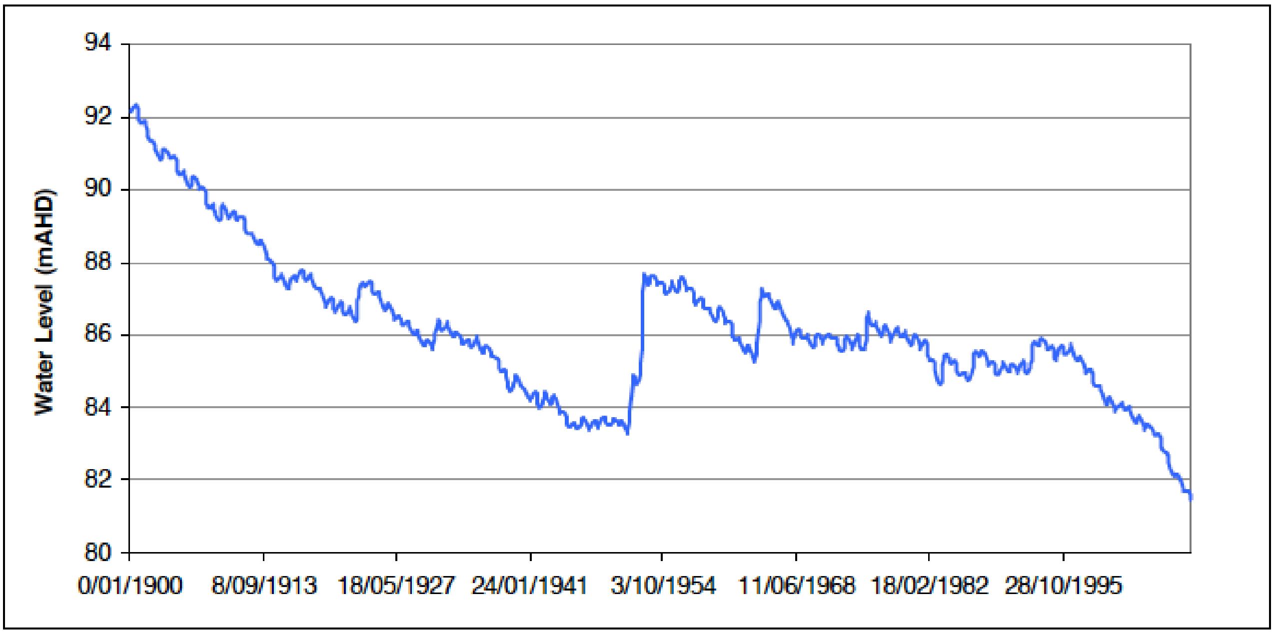


Figure 52: Water level at Lake Murdeduke (Water Technology 2010).

The LAC for hydrology (no change in wetland hydrological type for any given wetland) has been exceeded, with a change from permanent wetlands that have not been dry in European history to intermittent systems for Lakes Bookar, Gnarpurt, Milangil and Terangpom. This represents a potential change in ecological character at this site since the time of listing. Confidence level – High.

7.2 Salinity

There have been multiple effects from the altered water regimes in the Western District Lakes not the least of which has been increases in salinity. At the time of listing, salinity in Lake Corangamite was close to that of seawater at 29 – 35 parts per thousand. Since 2005, salinity has increased dramatically to an average of over 100 parts per thousand (Figure 53). A similar situation is evident at Lake Murdeduke, where salinity was around 10 parts per thousand at the time of listing, but since sampling recommenced in 2005, the average salinity is nearly 90 parts per thousand (Figure 54). At both lakes Murdeduke and Corangamite, the real salinity is likely to have far exceeded that in Figure 53 and 54 because of the methods used to calculate salinity. In 2007-08 at Lake Murdeduke and Corangamite, the salinity was similar to that of the Dead Sea, at over 300 parts per thousand, the upper limit for salt saturation in water (EPA 2010).

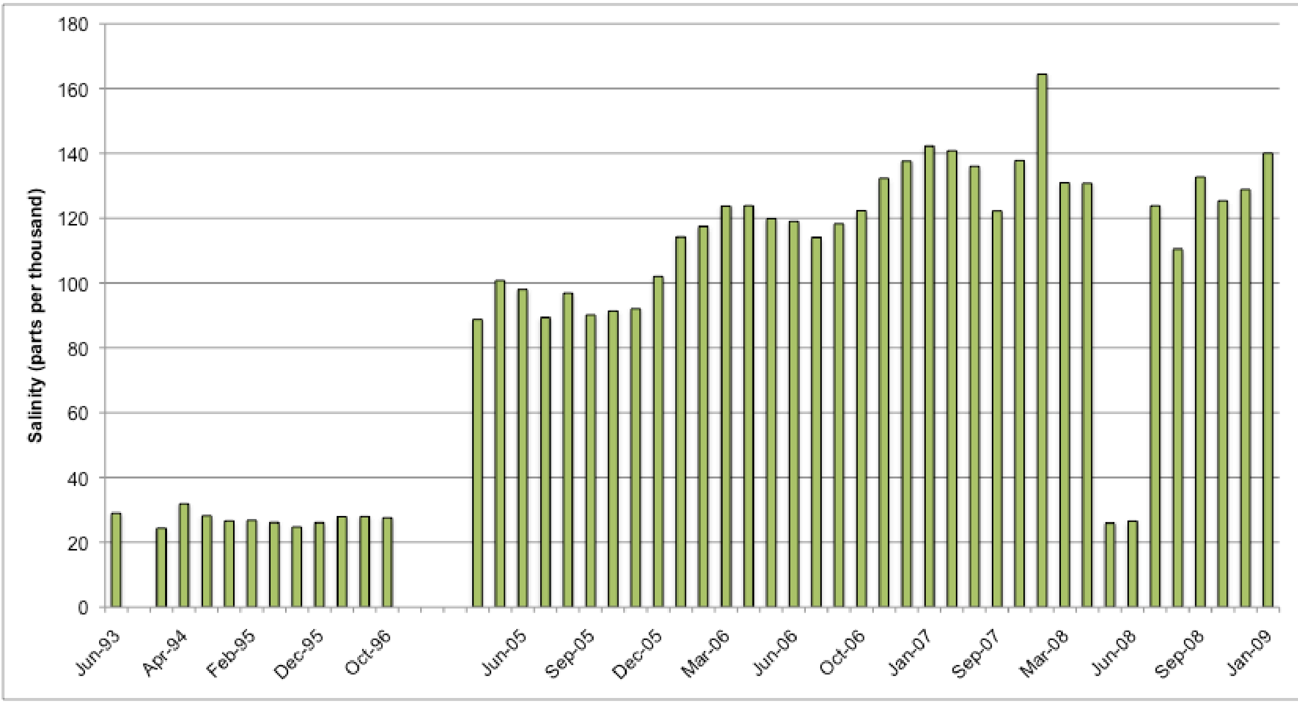


Figure 53: Salinity in Lake Corangamite: 1993 to 1995 (representative of conditions at the time of listing) and 2005 to 2009 (current conditions). Data from the Victorian Water Resources Data Warehouse, DSE 2010.

Similar increases have also been recorded at Lake Colongulac where salinity was around five to eight parts per thousand at the time of listing and jumped to over 100 parts per thousand in 2007 (DSE Victorian Data Warehouse). There is less information from other lakes in the Ramsar site but some evidence to suggest that salinity has increased at Lakes Bookar and Milangil where maximum salinities of over 100 parts per thousand have been recorded (Barton et al. 2008). In addition, Lake Terangpom which was freshwater / brackish at the time of listing (salinity of approximately two parts per thousand) may have become saline, with a salinity of more than 14 parts per thousand recorded in July 2006 (Barton et al. 2008) and 19 parts per thousand in November 2007 (EPA 2010). However, Lakes Beeac and Cundare were hypersaline at the time of listing and remain so currently (Hose et al. 2008).

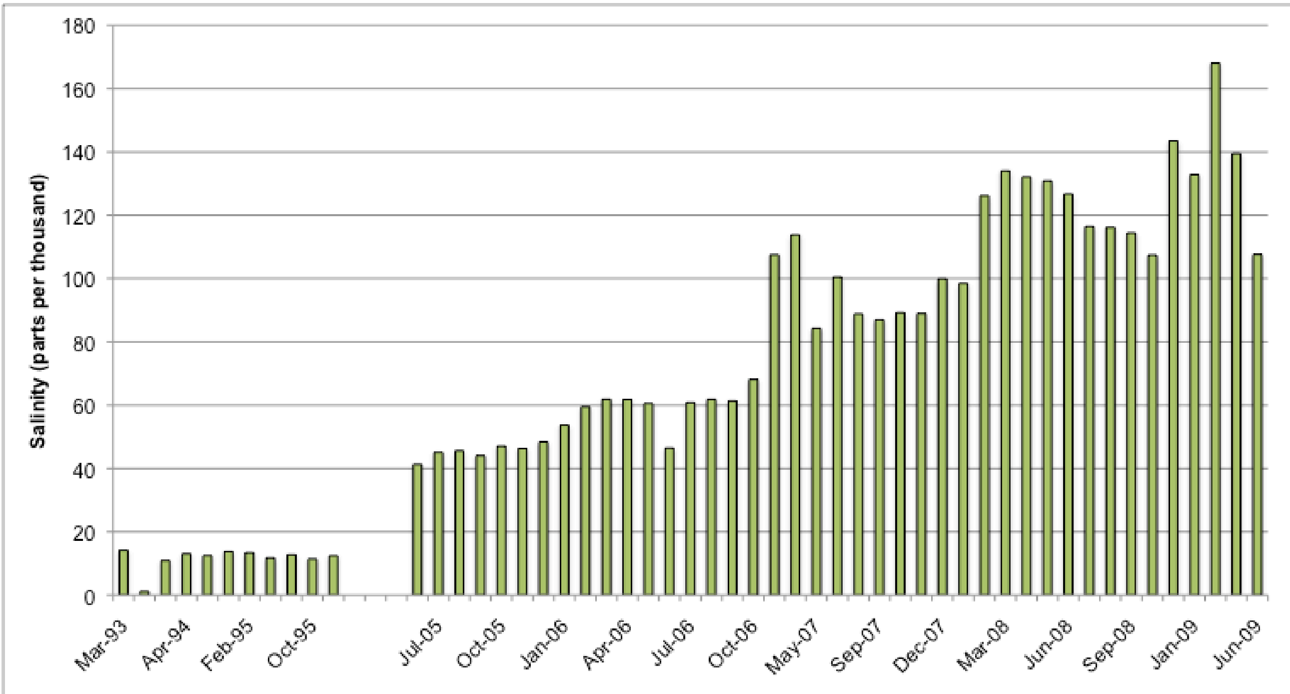


Figure 54: Salinity in Lake Murdeduke: 1993 to 1995 (representative of conditions at the time of listing) and 2005 to 2009 (current conditions). Data from the Victorian Water Resources Data Warehouse, DSE 2010.

Changes to hydrology and corresponding changes in salinity have been attributed to the persistent drought in the region (Barton et al. 2008). Of major concern is the lack of recovery of lakes following periods of increased rainfall. For example, above average rainfall in July and August of 2008 and 2009, did not result in any significant, sustained decrease in salinity in the lakes. The above average rainfall in spring 2010, however, did result in decreased salinity across the lakes, with salinity in Corangamite returning to 37 parts per thousand in September 2010 (Corangamite CMA, unpublished). However, the persistence of these conditions is not known.

The increase in salinity and decline in water levels are likely to have also affected fish populations within the site. The salinity of many of the lakes is now considerably higher than known tolerances for native species present (Table 29). In addition, the drying of these systems, with no surface water outlets, does not provide an escape route for native fish from the drying wetland, so fish within the lakes at the time of drying are trapped. Re-stocking would have to occur with inflow of surface waters in subsequent filling events.

Table 29: Known salinity tolerances of some of the native fish species recorded within the Western District Lakes Ramsar site.

Common name	Species name	Salinity tolerance
Native species		
Australian smelt	*Retropinna semoni*	Mortality at 50 to 60 parts per thousand (Williams 1987)
Common galaxias	*Galaxias maculatus*	Upper limit of 49 parts per thousand (Chessman and Williams 1975)
Small-mouthed hardyhead	*Atherinosoma microstoma*	Upper salinity of 70 parts per thousand, (Hart et al. 1989)
Southern pygmy perch	*Nannoperca australis*	Can survive 10 parts per thousand, but not able to breed (Kuiter et al. 1996)
Yarra pygmy perch	*Edelia obscura*	Fresh to brackish (Kuiter et al. 1996)

The LAC for salinity (no change in wetland salinity category) has been exceeded, with a change from saline to hypersaline conditions (salinity greater than 50 parts per thousand) for Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke; and a change from fresh / brackish to saline (salinity greater than three parts per thousand) at Lake Terangpom. This represents a potential change in ecological character at this site since the time of listing. Confidence level – High.

7.3 Vegetation

The changes in hydrology and salinity at the Western District Lakes Ramsar site have lead to changes in vegetation. Lakes Bookar, Corangamite, Gnarpurt, Murdeduke and Terangpom no longer support submerged aquatic vegetation (Muston 2001; Timms, 2002). However, the two threatened flora species remain within the Ramsar site, with recent records of spiny peppercress and salt-lake tussock-grass from the north-eastern shore of Lake Corangamite and around Lake Terangpom (Greening Australia unpublished and author's personal observation in August 2010).

The LAC for threatened flora (presence of spiny peppercress and salt-lake tussock-grass within the Ramsar site) has not been exceeded. Confidence Level – High.

7.4 Waterbirds

Changes to hydrology, salinity and vegetation described above have also impacted waterbirds at the site. Data from around the time of listing (1987 to 1992) indicated that the site regularly supported over 20 000 waterfowl. Recent data from the site indicates that numbers of waterfowl declined dramatically from 2005 to 2010. However, in February 2011 waterbird numbers increased to over 40 000 following above average rainfall in late 2010 / early 2011 (Figure 55).

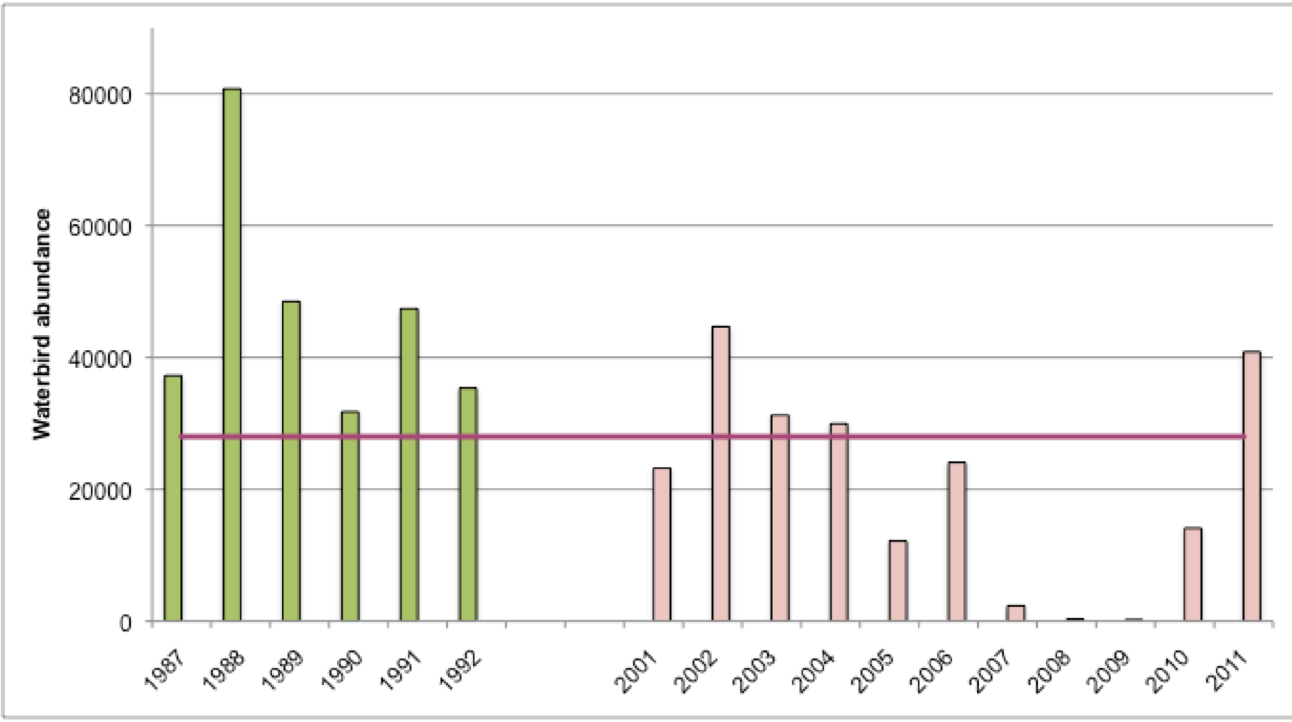


Figure 55: Annual waterfowl counts from around the time of listing (green) and current (pink). Red line indicates the abundance upon which the LAC is based.

Mean summer abundance of waterfowl from 1987 to 1992 was approximately 46 000. Data from counts conducted in 2001 to 2011, indicate a mean of 20 300, with this figure including other waterbirds such as shorebirds in the count (DSE unpublished). However, the average total number of birds in the past five years (2007 to 2011) was only 11 500. The loss of vegetation and fish, as well as open water during the second half of the 2000 decade, reduced habitat diversity and availability within the site, which led to a corresponding decline in waterbird numbers. The increase in numbers in 2011 indicates that the system can respond after periods of drought. However, it remains unknown if the system will recover over a long period of time.

While waterfowl numbers have declined, the site still periodically supports large numbers of shorebirds. In August 2006, over 100 000 banded stilts were recorded on Lake Corangamite (GFNC 2006). The drying lake provided a large expanse of shallow water / wet mud habitat for foraging.

At the time of listing the Western District Lakes Ramsar site supported significant numbers of at least four species of waterbird: Australasian shoveler, Australian shelduck, chestnut teal and Eurasian coot (see Section 3.3.4 above). While there were numbers above the one percent thresholds (and the LACs) recorded on occasion in the period 2000 to 2005, there have been no instances of counts above the thresholds for Australasian shoveler, chestnut teal and Eurasian coot in the past five years, and only a single instance (in 2011) of large numbers of Australian shelduck.

International migratory shorebirds within the site have not been assessed regularly. In recent years, there have been annual summer surveys of the Lakes in 2008, 2009 and 2010 (AWSG unpublished). Although this is an insufficient period to assess change in character with respect to the LAC (which is based on presence of curlew sandpiper, red-necked stint and sharp-tailed sandpiper in three out of any five year period) of note is the fact that curlew sandpiper and red-necked stint have not been recorded in the site in the past three years. In addition the sharp-tailed sandpiper was recorded in only one of the three counts to date (2010; AWSG unpublished). So although as yet the LAC for migratory shorebirds has not been exceeded, there are indications of a declining trend in numbers of these three species at the site.

Two of the three LAC for waterbirds have been exceeded (total abundance and numbers of Australasian shoveler, Australian shelduck and chestnut teal) and this represents a potential change in character at the site. Confidence level – High.

7.5 Overall change in ecological character

An assessment of current conditions with respect to LAC is provided in Table 30. This indicates that most LACs for which adequate data is available have been exceeded and is indicative of a potential change in ecological character at the site.

Table 30: Assessment of current conditions against LAC for the Western District Lakes Ramsar site.

Component / process	Limit of Acceptable Change	Current conditions	Confidence in LAC assessment
Hydrology	*No change in wetland hydrological type for any given wetland. That is the following hydrological regimes maintained:* • *Lakes Beeac and Cundare – intermittent wetlands drying seasonally but having water for at least a few months of each year;* • *Lake Colongulac – near permanent wetland drying for no more than twelve months in any five year period;* • *Lakes Bookar, Corangamite, Gnarpurt, Milangil, Murdeduke and Lake Terangpom – permanent wetlands not drying for more than two months in any five year period.*	Lakes Bookar, Gnarpurt, Milangil and Terangpom have all dried completely on a number of occasions in the past decade for extended periods of time. **LAC has been exceeded.**	High
Salinity	*No change in salinity category for any given wetland. That is the following salinity regimes maintained:* • *Lakes Beeac and Cundare – hypersaline (greater than 50 parts per thousand);* • *Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke – saline (5 to 50 parts per thousand);* • *Lake Terangpom –fresh / brackish (less than three parts per thousand).*	Salinity has increased to greater than 50 parts per thousand at Lakes Bookar, Colongulac, Corangamite, Gnarpurt, Milangil and Murdeduke; and greater than three parts per thousand at Terangpom. **LAC has been exceeded.**	High
Vegetation	*Presence of spiny peppercress and salt-lake tussock-grass within the Ramsar site at least one year in any five year period,*	Spiny peppercress and tussock grass remain within the Ramsar site.	High
Waterbirds	*Total waterbird numbers not less than 28 000 during summer in a minimum of three years in any five year period.*	Total summer waterbird numbers were less than 28 000 from 2005 to 2010 inclusive. **LAC has been exceeded.**	High
	Australian shelduck, Australasian shoveler, chestnut teal and Eurasian coot – not less than one percent of population (from latest Wetlands International population estimates) recorded at least once in every five year period.	The one percent population thresholds for two of these three species have not been exceeded in five consecutive years (2007 to 2011) and the threshold for Australian shelduck was exceeded on only one occasion in this time, in 2011. **LAC has been exceeded.**	High
	Presence of curlew sandpiper, red-necked stint and sharp-tailed sandpiper within the Ramsar site at least once in every five year period.	There have only been regular counts of shorebirds at the site in recent times in three years (2008 to 2010) and as such there is insufficient data to assess this LAC.	Not applicable.

7.6 Assessment of current conditions against Ramsar listing criteria

Given the extent of changes that have occurred within the site in recent times, an assessment of current conditions with respect to the Ramsar listing criteria is necessary. Conditions at the time of listing were such that five of the nine Ramsar criteria were considered to have been met (see Section 2.4). There is no evidence that there has been an increase in values at the site, such that additional criteria would be met. Therefore this assessment considers current conditions against the five criteria the site was considered to meet at the time of listing.

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.

This criterion was considered to be met on the basis that Lake Corangamite was the largest permanent saline wetland in the bioregion and considered to be a good representative of the type with respect to condition and values. Given the changes to Lake Corangamite such as declining water levels, increased salinity, loss of submerged vegetation and fish and decrease in waterbird abundance and diversity, it is difficult to make a case for the site still including good representative examples of the wetland types in the bioregion. In addition, there is evidence to suggest that other wetlands in the region (for example Lake Purrumbete and Bullen Merri) have retained better ecological values and are expected to be more resilient to climate change (EPA 2010).

The Ramsar site no longer meets this criterion under current conditions.

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

This criterion was considered to be met on the basis of two threatened species: salt-lake tussock-grass (*Poa sallacustris*) and spiny peppercress (*Lepidium aschersonii*). These species are still present within the Ramsar site (Hose 2008).

The Ramsar site continues to meet this criterion under current conditions.

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.

This criterion was considered to be met by the Western District Lakes Ramsar site on the basis of supporting breeding of waterbirds, waterfowl during moult and moderate to large numbers of migratory shorebirds. There have been no observations of nesting, or juvenile birds recorded during annual waterfowl counts in the past five years (2006 to 2010), in addition there have also been no observations of moulting in that time. The site has supported low numbers of international migratory shorebirds in the past ten years. However there were over 2500 sharp-tailed sandpiper recorded in February 2010 at Lake Corangamite (AWSG unpublished) and the site therefore continues to support international migratory bird species.

The Ramsar site continues to meet this criterion under current conditions.

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

The site did not support more than 20 000 waterbirds in summer from 2007 to 2010 inclusive (DSE Colac unpublished, Birds Australia unpublished). However, there were over 100 000 banded stilts at Lake Corangamite in August 2006 and 40 000 waterfowl in February 2011. Despite these counts, the application of the rule “regularly supports” (see Text Box 1) indicates that the site no longer meets this criterion.

The Ramsar site no longer meets this criterion under current conditions.

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.

There are maximum count records from the last decade that exceed the one percent population threshold. For example, the 112 000 banded stilts in August 2006 represents over 20 percent of the estimated total population and in February 2011 there were 32 000 Australian shelduck on Lake Corangamite. However, these are isolated incidents and the site no longer “regularly supports” over one percent of the population of any individual species of waterbirds.

The Ramsar site no longer meets this criterion under current conditions.

8. Knowledge Gaps

Throughout the Ecological Character Description for the Western District Lakes Ramsar site, mention has been made of knowledge gaps and data deficiencies for the site. While there is potentially a large list of research and monitoring needs for this wetland system, 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. As such, knowledge gaps that are required to fully describe the ecological character of this site and enable rigorous and defensible limits of acceptable change to be met are relatively few and listed in Table 31.

Table 31: Knowledge Gaps for the Western District Lakes Ramsar site

Knowledge Gap	Recommended Action
Threatened flora (spiny peppercress and salt-lake tussock-grass) – abundance, trends and effects of altered water and salinity regimes.	Long term monitoring of known populations.
Total waterbird abundance and diversity – most counts are for select groups of birds only.	Expand current annual monitoring to include all waterbirds at the lakes.
The value of the site for waterbird breeding remains unknown.	Recording of nesting and breeding behaviours during annual counts.
The value of the site for international migratory shorebirds.	Continued biannual monitoring of shorebirds within the site.
The potential for the system for recovery. Given a few years of average rainfall will the system recover some of its values and biota?	Annual assessments of hydrology, water quality and flora to compliment waterbird and threatened species monitoring.
Seed and egg bank viability following extensive dry / hypersaline conditions.	Seed and egg bank study of sediments from affected lakes.
Inundation regime thresholds for the survival of threatened plant species.	Monitoring of threatened species and inundation regimes at threatened species' locations.

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 three 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 critical 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 the Ramsar Convention and the EPBC Act with respect to the Western District Lakes Ramsar site are provided in Table 32.

Table 32: Monitoring needs for the Western District Lakes Ramsar site

Parameter	Purpose	Indicator	Locations	Frequency	Priority
Hydrology	Assessment against LAC	Water level	Each wetland	Monthly	Moderate
Water quality	Assessment against LAC and threat indicator	Salinity Nutrients	Each wetland	Monthly	Moderate
Threatened plant species	Assessment against LAC	Location, abundance, site hydrological conditions	Lakes Beeac, Corangamite and Terangpom	Annual	High
Aquatic Invertebrates	Knowledge gap	Community composition, abundance	Entire Ramsar site	Once in five years during spring	Moderate
Waterbirds	Assessment against LAC	Abundance and species identifications, breeding observations	Entire Ramsar site	Winter and summer	High
Vegetation (weeds)	Threat indicator	Location, extent	Lakes Beeac, Corangamite and Terangpom	Annual	High
Pest animals (foxes, rabbits)	Threat indicator	Abundance	Entire Ramsar site	Annual	Moderate

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.

There are a number of programs currently in place, which focus on communication and education of wetland values in the Western District Lakes Ramsar site. This includes interpretative boards explaining the international standing of the wetlands under the Ramsar Convention and the important aspects of ecological character. The local Waterwatch Victoria school program includes sessions on water quality and aquatic fauna within the lakes. In addition the Borrell-a-kandelop (indigenous expression for "resting place for water birds") program was established by Greening Australia in partnership with Parks Victoria, Corangamite CMA and the local community in 2001. The aims are to protect and rehabilitate the wetlands within the Western District Ramsar Site. Achievements are outlined below.

- Significant habitat restoration and protection works have been undertaken, including 150 km of fencing to exclude stock and over 210 000 plantings.

- Productive partnerships have been forged and broadscale community engagement has occurred. Greening Australia's Borrell-a-kandelop partners include local Aboriginal groups, over 100 local landholders, eight schools, Green Corps teams, international students and other volunteers.

- Education programs have been implemented, including a course on 'Managing Wetlands on Farms' and a successful school-based threatened species program initiative.

Key CEPA messages for the Western District Lakes Ramsar site arising from this ECD, which should be promoted through these programs, include:

- the Ramsar values of the site and the importance of the Ramsar site as a habitat for shorebirds and waterfowl to meet different needs in their lifecycles
- the significance of the site for international migratory birds; their journey through the East Asian-Australasian Flyway, the habitats they use within the site and the potentially significant consequences of disturbance by walking, boating, vehicles and domestic pets
- the significance of the site for threatened species, particularly salt-lake tussock-grass and spiny peppercress
- the potential impacts of climate change on the benefits and services of the Ramsar site and the vulnerability of aquatic ecosystems to multiple impacts exacerbated by climate change
- the need for cooperative and coordinated management across this complex site with the large number of stakeholders and bodies responsible for management.

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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 Jennifer Hale met with the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) 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 the Western District Lakes Ramsar site.

Task 2: Stakeholder engagement and consultation

A Steering Committee was formed for the Western District Lakes Ramsar site ECD. This group was comprised of representatives of the following stakeholder groups with an interest in the ECD and management planning process:

- Yvette Baker; Department of Sustainability and Environment
- John Clarke; Parks Victoria
- Frank Gleeson; Parks Victoria
- Janet Holmes; Department of Sustainability and Environment
- Grant Hull; Department of Sustainability and Environment
- Paul Leahy; Environmental Protection Authority
- Graham Mitchell; Department of Sustainability and Environment
- Jim Mollison; Department of Sustainability, Environment, Water, Population and Communities
- Donna Smithyman; Corangamite Catchment Authority

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 the Western District Lakes Ramsar site.

Steps from the national framework (DEWHA 2008)	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, 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 1990.
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 the Ramsar Convention secretariat.

Task 5 Finalising the ECD and RIS

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

A.2 Consultant Team

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 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.

Rhonda Butcher

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. Other Ramsar sites she has been involved with the development of ECD include Coongie Lakes, Banrock Station Wetland Complex, Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Peel-Yalgorup, Eighty-mile Beach, Narran Lakes, The Dales and Hosnies Spring on Christmas Island. Rhonda is currently project managing the Ramsar Rolling Review developing a framework for reporting the status of ecological character at all 64 Ramsar sites in Australia.

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.

Appendix B: Waterbirds

Species listing: M = Listed as migratory or marine under the EPBC Act; J = JAMBA; C= CAMBA; R = ROKAMBA, B = Bonn; V = Vulnerable nationally or internationally; E = Endangered nationally or internationally.

Species list compiled from DSE unpublished, Birds Australia unpublished, Geelong Field Naturalists Club 1993 to 2008.

Common Name	Species name	Breeding	Listing
Australasian darter	*Anhinga novaehollandiae*		
Australasian grebe	*Tachybaptus novaehollandiae*		
Australasian shoveler	*Anas rhynchotis*		M
Australian painted snipe	*Rostratula australis*		E (EPBC), C
Australian pelican	*Pelecanus conspicillatus*	Yes	M
Australian shelduck	*Tadorna tadornoides*	Yes	M
Australian white ibis	*Threskiornis molucca*		M
Australian wood duck	*Chenonetta jubata*		M
Baillon's crake	*Porzana pusilla*		M
Banded lapwing	*Vanellus tricolor*	Yes	
Banded stilt	*Cladorhynchus leucocephalus*		
Black swan	*Cygnus atratus*	Yes	M
Black-fronted dotterel	*Elseyornis melanops*		
Black-tailed native-hen	*Tribonyx ventralis*		
Black-winged stilt	*Himantopus himantopus*		M
Blue-billed duck	*Oxyura australis*		M
Brolga	*Grus rubicunda*	Yes	
Buff-breasted sandpiper	*Tryngites subruficollis*		M, J, R
Cape barren goose	*Cereopsis novaehollandiae*	Yes	M
Caspian tern	*Sterna caspia*		M, C, J
Cattle egret	*Ardea ibis*		M, C, J
Chestnut teal	*Anas castanea*		M
Clamorous reed-warbler	*Acrocephalus stentoreus*		
Common greenshank	*Tringa nebularia*		M, B, C, J, R
Curlew sandpiper	*Calidris ferruginea*		M, B, C, J, R
Double-banded plover	*Charadrius bicinctus*		M, B
Dusky moorhen	*Gallinula tenebrosa*		
Eastern great egret	*Ardea modesta*		M, C, J
Eurasian coot	*Fulica atra*		
Freckled duck	*Stictonetta naevosa*		M
Glossy ibis	*Plegadis falcinellus*		M, B, C
Great cormorant	*Phalacrocorax carbo*		

Common Name	Species name	Breeding	Listing
Great crested grebe	*Podiceps cristatus*		
Grey plover	*Pluvialis squatarola*		M, B, C, J, R
Grey teal	*Anas gracilis*		M
Gull-billed tern	*Gelochelidon nilotica*		M
Hardhead	*Aythya australis*		M
Hoary-headed grebe	*Poliocephalus poliocephalus*		
Latham's snipe	*Gallinago hardwickii*		M, B, C, J, R
Little black cormorant	*Phalacrocorax sulcirostris*		
Little curlew	*Numenius minutus*		M, B, C, J, R
Little pied cormorant	*Microcarbo melanoleucos*		
Magpie goose	*Anseranas semipalmata*		M
Marsh sandpiper	*Tringa stagnatilis*		M, B, C, J, R
Masked lapwing	*Vanellus miles*	Yes	
Musk duck	*Biziura lobata*		M
Nankeen night-heron	*Nycticorax caledonicus*		
Pacific black duck	*Anas superciliosa*		M
Pacific golden plover	*Pluvialis fulva*		M, B, C, J, R
Pectoral sandpiper	*Calidris melanotos*		M, B, J, R
Pied cormorant	*Phalacrocorax varius*		
Pink-eared duck	*Malacorhynchus membranaceus*		M
Purple swamphen	*Porphyrio porphyrio*		
Red knot	*Calidris canutus*		M, B, C, J, R
Red-capped plover	*Charadrius ruficapillus*	Yes	
Red-necked avocet	*Recurvirostra novaehollandiae*		M
Red-necked stint	*Calidris ruficollis*		M, B, C, J, R
Royal spoonbill	*Platalea regia*		
Ruddy turnstone	*Arenaria interpres*		M, B, C, J, R
Sharp-tailed sandpiper	*Calidris acuminata*		M, B, C, J, R
Silver gull	*Chroicocephalus novaehollandiae*		M
Spotless crake	*Porzana tabuensis*		M
Straw-necked ibis	*Threskiornis spinicollis*	Yes	M
Swamp harrier	*Circus approximans*		M
Whiskered tern	*Chlidonias hybrida*		M
White-bellied sea eagle	*Haliaeetus leucogaster*		M
White-faced heron	*Egretta novaehollandiae*	Yes	
White-necked heron	*Ardea pacifica*	Yes	
White-winged black tern	*Chlidonias leucopterus*		M, C, J, R
Yellow-billed spoonbill	*Platalea flavipes*		