ECOLOGICAL CHARACTER DESCRIPTION OF THE LAKE GORE RAMSAR SITE, ESPERANCE, WESTERN AUSTRALIA

A report by the Department of Environment and Conservation

Department of Environment and Conservation
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Acknowledgements

Funding for the development of this document was sourced jointly from the Natural Heritage Trust (NHT) and the State and Commonwealth contributions to the National Action Plan for Salinity and Water Quality (NAP). NHT and NAP are jointly administered by the Australian Government departments of Agriculture, Fisheries and Forestry and the Environment, Water, Heritage and the Arts and the WA Natural Resource Management Office. In-kind contributions were gratefully received from the organisations represented on the Technical Advisory Group.

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Cover photograph: Lake Gore (G. Watkins)
Internal photographs: B. Cook, G. Janicke, G. Watkins.

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Symbols in conceptual models courtesy of the Integration and Application Network <http://ian.umces.edu/symbols/>, University of Maryland Center for Environmental Science

To reference this document
Department of Environment and Conservation (2009). *Ecological Character Description of the Lake Gore Ramsar Site: A Report by the Department of Environment and Conservation*. Prepared by G.Watkins, Department of Environment and Conservation, Perth, Western Australia.

Introductory Note

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 EPBC Act, 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.

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GLOSSARY

(Definitions from DEWHA, 2008).

Administrative authority	The agency within each contracting party charged by the national government with oversight of implementation of the Ramsar Convention within its territory. **http://www.ramsar.org/about/about_glossary.htm**
Adverse conditions	Ecological conditions unusually hostile to the survival of plant or animal species, such as occur during severe weather like prolonged drought, flooding, cold, etc (Ramsar Convention, 2005b).
Assessment	The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities (as defined by Ramsar Convention, 2002).
Baseline	Condition at a starting point. For Ramsar wetlands it will usually be at the time of listing of a Ramsar site (Lambert & Elix, 2006).
Benchmark	A standard or point of reference A predetermined state (based on the values that are sought to be protected) to be achieved or maintained (Lambert & Elix, 2006).
Benefits	Benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as “the benefits that people receive from ecosystems” (Ramsar Convention, 2005a). See also “Ecosystem Services”.
Biogeographic region	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (Ramsar Convention, 2005b).
Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is based largely on the one contained in Article 2 of the Convention on Biological Diversity (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	Is defined as the human induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention, 2005a).
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).
Community composition	All the types of taxa present in a community (ANZECC and ARMCANZ, 2000a).

Community structure	All the types of taxa present in a community and their relative abundances (ANZECC and ARMCANZ, 2000a).
Conceptual model	Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Gross, 2003).
Contracting Parties	Are countries that are Member States to the Ramsar Convention on Wetlands; 153 as at September 2006. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialised agencies, or the International Atomic Energy Agency, or is a party to the Statute of the International Court of Justice. **http://www.ramsar.org/key_cp_e.htm**
Critical stage	Meaning stage of the lifecycle of wetland-dependant species. Critical stages being those activities (breeding, migration, stopovers, moulting etc) which if interrupted or prevented from occurring may threaten long-term conservation of the species (Ramsar Convention, 2005b).
Ecological Character	Is the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as “the benefits that people receive from our ecosystems” (Ramsar Convention, 2005a). 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	Are naturally occurring group of species inhabiting a common environment, interacting with each other especially through food relationships and 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 (2005a), ecosystems are described as the complex of living communities (including human communities) and nonliving 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).
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).
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 nonliving environment, that 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	Are the benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food and water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational) and supporting (e.g. nutrient cycling, ecological value) (Millennium Ecosystem Assessment, 2005b). See also "Benefits"
Limits of Acceptable Change	The variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the values for which the site was Ramsar listed (Phillips, 2006).
Monitoring	The collection of specific information for management purposes in response to hypothesis derived from assessment activities and the use of these monitoring results for implementing management (Ramsar Convention, 2002). Is based on surveillance and is the systematic collection of data or information over time in order to ascertain the extent of compliance with a predetermined standard or position (Hellawell, 1991).
Ramsar	Is a city in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Conventions short title, "Ramsar Convention on Wetlands. **http://www.ramsar.org/about/about_glossary.htm**
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/about/about_glossary.htm**
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. **http://www.ramsar.org/index_very_key_docs.htm**
Ramsar Information Sheet (RIS)	The form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological and socioeconomic issues among others, ownership and jurisdictions and conservation measures taken and needed. **http://www.ramsar.org/about/about_glossary.htm**
Ramsar List	The List of Wetlands of International Importance. **http://www.ramsar.org/about/about_glossary.htm**
Ramsar Sites	Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria.

	http://www.ramsar.org/about/about_glossary.htm
Wetlands	Are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention, 1987).
Wetland types	As defined by the wetland classification system. **http://ramsar.org/ris/key_ris.htm#type**
Wise use of wetlands	Is the maintenance of their ecological character, achieved through the implementation of the ecosystem approaches [1], within the context of sustainable development [2] (Ramsar Convention, 2005a). 1. Including inter alia the Convention on Biological Diversity's "Ecosystem Approach" (CBD COP5 Decision V/6) and that applied by HELCOM and OSPAR (Declaration of the First Joint Ministerial Meeting of the Helsinki and the OSPAR Commissions, Bremen, 25-26 June 2003). 2. The phrase "in the context of sustainable development" is intended to recognise that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the convention, and it is not appropriate to imply that 'development' is an objective for every wetland.

ABBREVIATIONS

AASS	Actual Acid Sulfate Soils
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CALM	Department of Conservation and Land Management (now DEC)
CAMBA	China Australia Migratory Bird Agreement
CMS or Bonn	Convention on the Conservation of Migratory Species of Wild Animals
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation (Western Australia)
DEWHA	Department of Environment, Water, Heritage and the Arts (Commonwealth)
DoW	Department of Water (Western Australia)
ECD	Ecological Character Description
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GIS	Geographical Information Systems
IUCN	International Union for Conservation of Nature and Natural Resources
JAMBA	Japan Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change
NRM	Natural Resource Management
PASS	Potential Acid Sulfate Soils
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SWWMP	South West Wetlands Monitoring Programme

Photo: Lake Gore (G. Watkins, 2008)

EXECUTIVE SUMMARY

The Lake Gore Ramsar Site is located in Esperance, on the south coast of Western Australia and was designated as a Wetland of International Importance under the Ramsar Convention on the 5th January 2001. The Ramsar Convention formally, *The Convention on Wetlands of International Importance, especially as Waterfowl Habitat,* currently has 158 contracting parties. The signatories of the treaty agree to cooperate on an international basis for the conservation and wise use of wetlands and their resources, which includes managing a Ramsar site to maintain its "ecological character".

The Ramsar Convention (2005a) defines ecological character as "*the combination of the ecosystem components, processes and benefits / services that characterise the wetlands at a given point in time".* Describing the ecological character (through an ecological character description [ECD]) of a wetland is crucial for identifying changes, or potential changes and provides a baseline or benchmark for future management and planning actions.

This report represents the first ECD for the Lake Gore Ramsar Site and was prepared using the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of the National Guidelines for Ramsar Wetlands - Implementing the Ramsar Convention in Australia*. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra (see: DEWHA, 2008).

The objectives of this ECD were to:

- Provide an overall description of the Lake Gore Ramsar Site;
- Describe the critical ecosystem components, processes, benefits and services of the Ramsar site;
- Describe any changes in ecosystem components, processes, benefits and services of the Ramsar site since listing and the current ecological character;
- Develop and provide conceptual models that describe the critical ecosystem components, processes, benefits and services of the Ramsar site;

- Identify threats to the ecological character of the site;
- Set limits of acceptable change for the critical ecosystem components and processes;
- Identify gaps in knowledge of the Lake Gore Ramsar Site;
- Identify monitoring requirements for the Lake Gore Ramsar Site; and
- Identify critical communication, education and public awareness messages that will enhance awareness and knowledge of the ecological values and threats of this system.

The Lake Gore Ramsar Site is situated in the South-West Coast Australian Drainage Division within the Esperance Sandplain Biogeographic Region. The site is located in the Shire of Esperance, approximately 34 km west of the Esperance townsite and covers an area of 4,017 ha. The Ramsar site provides significant waterbird habitat and refuge, and waterbird species listed under the international migratory agreements CAMBA, JAMBA, ROKAMBA and CMS have been observed at Lake Gore. The site also supports thousands of Australian Shelduck (*Tadorna tadornoides*), which utilise Lake Gore as a sanctuary during their moulting period. The numbers of Shelduck along with Banded Stilt (*Cladorhynchus leucocephalus*), Chestnut Teal (*Anas castanea*) and Hooded Plover (*Thinornis rubricollis*) recorded at the site have been significant exceeding 1% of their respective population thresholds (see: Wetlands International, 2006). The Hooded Plover is considered “Near Threatened” under the International Union for Conservation of Nature and Natural Resources (IUCN) Red List and in some regions it has become locally extinct (BirdLife International, 2006; Raines, 2002). The Hooded Plover is listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as “Marine” and is listed by the Western Australian Department of Environment and Conservation (DEC) as a Priority Four species (taxa in need of monitoring).

The Lake Gore Ramsar Site currently meets the following two Ramsar Criteria:

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.
Justification: Lake Gore regularly supports thousands of moulting Australian Shelducks (*Tadorna tadornoides*) and is therefore an important aspect of their life cycle, providing a refuge during this vulnerable period. The Lake is also used as a drought refuge by large numbers of other waterbirds (Jaensch & Watkins, 1999).

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
Justification: Lake Gore has, until relatively recently, supported more than 1% of the Western Australian population of Hooded Plover (*Thinornis rubricollis* [1% last recorded in 2002]) and more than 1% of the Australian population of Banded Stilt (*Cladorhynchus leucocephalus* [1% last

recorded in 1998]). The available data suggests that these population thresholds may again be met in the future.

The 1% population threshold is also met for the Australian Shelduck (*Tadorna tadornoides*) and the Chestnut Teal (*Anas castanea*). Regular counts exceeding the 1% population estimates (see: Wetlands International, 2006) have occurred at Lake Gore.

A summary of the critical ecosystem components, processes, benefits and services, and threats of the Lake Gore Ramsar Site is provided in Table E1.

Table E1. Summary of the critical ecosystem components, processes, benefits and services, and threats of the Lake Gore Ramsar Site.

Category	Summary
Critical ecosystem component / process	
Climate	• Mediterranean - warm, dry summers, cool wet winters • Evaporation exceeds rainfall most months with annual average rainfall approximately 620 mm and average annual evaporation rate 1657 mm • During the years 1999, 2000 and 2007 Esperance has received unseasonal episodic rainfall events • January and February (summer) averaging approximately 26 ˚C. The lowest temperatures are experienced in July (winter) with an average of approximately 8 ˚C
Geomorphology	• The Lake Gore Ramsar Site is confined by a granite escarpment to the north and by Quaternary dunes to the south • Lake Gore bathymetry ranges from approximately 15 - 20 m Australian Height Datum. However, the bathymetry is comparatively consistent with heights not usually varying by more than 2 m, resulting in a broad shallow basin
Hydrology	• Mainly surface water fed from the Dalyup catchment • Some groundwater influence (unquantified) • Shallow < 2 m and perennially inundated (Lake Gore) • Hydrological regime has provided habitats for a diversity of waterbirds i.e. wading to deeper feeding species • Altered hydrological regime has caused increases in the extent and duration of water inundation threatening waterbird habitats and riparian vegetation
Water quality (physico-chemical)	• Salinity concentrations saline to hypersaline • Alkaline pH • Nutrient enriched • Algal blooms recorded
Physical Processes	• Sedimentation occurring at an accelerated rate since catchment clearing • Sedimentation has possible implications on the bathymetry and hydrological regime of Lake Gore
Wetland Soils	• Clay based units • Alkaline sediments • Elevated nutrient concentrations • Potential acid sulfate soils maybe present

Category	Summary
Biota	• Waterbirds - Highest waterbird count > 20, 000 (1988) - 53 species of waterbirds recorded - 25 EPBC Act listed waterbirds: 24 "Marine" ,14 "Migratory" species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA and CMS) - Notable species (exceeding 1% population thresholds): Australian Shelduck, Banded Stilt, Chestnut Teal and Hooded Plover (listed as a Priority Four species by DEC and listed "Near Threatened" under the IUCN Red List) • Fish - Western Trout Minnow (*Galaxias truttaceus hesperius*), Blue Spotted Gobi (*Ellogobius olorum*) and Black Bream (*Mylio Butcheri*) have been recorded at Lake Gore, though not recently confirmed - Western Trout Minnow is listed as critically endangered under the EPBC Act. - Hardy Head (*Leptatherina wallacei*) and the Swan River Gobi (*Pseudogobius olorum*) have been recorded in the lower Dalyup River where it terminates at Lake Gore • Aquatic invertebrates - Low richness due to high salinities - Species composition has been variable • Vegetation - Lake Gore has fringing vegetation consisting of *Melaleuca cuticularis* - High water mark of Lake Gore consists of *Schoenus brevifolius* and *Gahnia trifida*, samphire species (*Suaeda australis* and *Sarcocornia quinqueflora*) and the grass species *Sporobolus virginicus* and herb *Samolus repens* - *Melaleuca cuticularis* is replaced by *Acacia* sp. as the elevation increases on the northerly side of Lake Gore - The majority of the riparian vegetation of the Lake Gore catchment is dead or declining due to an altered hydrological regime
Critical ecosystem benefits and services	
Provisioning Services	• Genetic resource • Human health
Regulating Services	• Pollution control and detoxification
Cultural Services	• Recreation • Science and education • Cultural heritage and identity / Spiritual and inspirational • Aesthetic amenity
Supporting Services	• Hydrological processes • Nutrient cycling • Biodiversity • Physical habitat • Priority wetland species • Ecological connectivity
Threats to the ecological character	
Agricultural activities in the Dalyup and Coobidge Creek catchments	• Altered hydrology • Pollution • Altered fire regimes

Category	Summary
	• Acid sulfate soils
Non - native and alien species	• Weeds • Exotic mammal species • *Phytophthora cinnamomi*
Climate change	• Altered hydrological regimes • Altered temperatures • Altered rainfall • Negative affects on flora an fauna
Recreation	• Spread of weeds and *Phytophthora* Dieback • Direct and indirect impacts on flora and fauna

Figure E1 conceptualises the interactions of the critical ecosystem components, processes, benefits and services that define the ecological character of the Lake Gore Ramsar Site, along with the existing and potential threats.

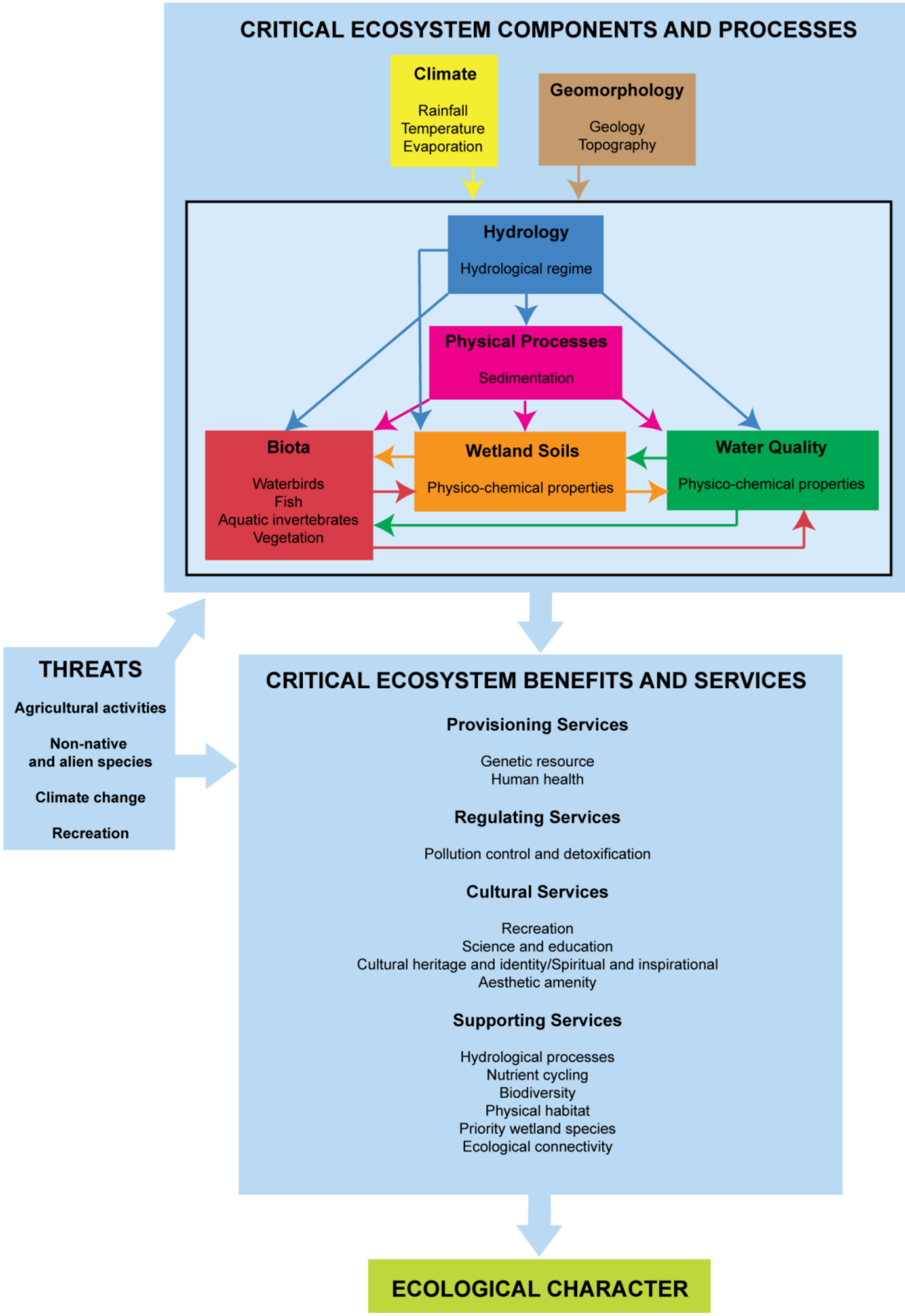


Figure E1. Conceptual model of the interaction of the critical ecosystem components, process, benefits, services of the Lake Gore Ramsar Site, Esperance, Western Australia and the determination of ecological character. Threats influence changes in ecological character (adapted from DEWHA, 2008).

Changes to the ecological character of the Lake Gore Ramsar Site have been identified prior to and since listing. An altered hydrological regime is the overarching change to the ecological character of the Lake Gore Ramsar Site. Catchment clearing due to agriculture, combined with the exacerbating affects of increased unseasonal episodic rainfall events, have resulted in the altered hydrological regime at Lake Gore (i.e. increased extent and duration of inundation). It appears that waterbird species composition is changing, with increases in ducks and allies that require deeper open water habitat, and decreases in those species that require an exposed shore zone and wading habitat. The altered hydrological regime has exceeded the natural inundation thresholds of the riparian vegetation of the Lake Gore catchment. This has resulted in death and decline of a large percentage of the riparian vegetation.

Limits of acceptable change (LAC) for the Lake Gore Ramsar Site have been addressed in the ECD based on the requirements for the maintenance of the ecosystem critical components, processes, benefits and services which define the ecological character of the site. Human induced changes in the negative context outside these limits may constitute a change in ecological character. Management triggers have also been provided to land managers as an Annex to this report. Management trigger values are a precautionary alert purposely set below LAC so that an adaptive management response can occur prior to the LAC being reached. It is anticipated that LAC and management triggers are adapted and revised once more information is available and the knowledge gaps outlined in the ECD are addressed.

Monitoring to support the ecological character and to address the knowledge gaps outlined have been acknowledged in the ECD. These form the basis of future management and a monitoring programme for the Lake Gore Ramsar Site.

1.0 INTRODUCTION

The Convention on Wetlands of International Importance, especially as Waterfowl Habitat, commonly referred to as The Ramsar Convention on Wetlands was signed in Ramsar, Iran in 1971 and came into force in 1975. The signatories of the treaty agree to cooperate on an international basis for the conservation and wise use of wetlands and their resources. The Ramsar Convention currently has 158 Contracting Parties and as at 30th January 2009, the treaty covered 1,831 wetland sites throughout the world. Australia has a total of 65 listed Ramsar sites covering approximately 7.5 million hectares (ha), 12 of which are located in Western Australia (see: Australian Government, 2008).

In addition to promoting the conservation and wise use of wetlands, Contracting Parties accept a number of other responsibilities, including managing a Ramsar site to maintain its "ecological character". Understanding and describing ecological character, and presenting this information in the form of an ecological character description (ECD), is an essential step in maintaining the ecological character of a Ramsar site. This report details the first ECD for the Lake Gore Ramsar Site in Esperance, Western Australia.

1.1 SITE DETAILS

The Lake Gore Ramsar Site is located in Esperance, on south coast of Western Australia and was designated as a Wetland of International Importance under the Ramsar Convention on the 5th January 2001. Table 1 provides a summary of the details of the Lake Gore Ramsar Site.

Table 1. Summary of the site details of the Lake Gore Ramsar Site, Esperance, Western Australia.

Site Name	Lake Gore Ramsar Site
Location in coordinates	33º47'S 121º29'E
General location	The Lake Gore Ramsar site is located on the south coast of Western Australia approximately 34 km west of the Esperance townsite.
Area	4,017 ha
Date of Ramsar site designation	5 January 2001
Ramsar criteria met	Ramsar Criteria 4 and 6
Management authority	Esperance District (based in Esperance) of the Department of Environment and Conservation.
Date the ECD applies	5 January 2001
Status of description	This report represents the first ECD of the site.
Date of compilation	February 2009
Name(s) of compiler(s)	Gareth Watkins of the Department of Environment and Conservation (DEC) all enquiries to Michael Coote, DEC, 17 Dick Perry Avenue, Technology Park Kensington, WA 6983, Australia, (Tel: +61-8-9219-8714; Fax: +61-8-9219-8750; email: Michael.Coote@dec.wa.gov.au).
References to the Ramsar Information Sheet (RIS)	Lake Gore Ramsar Site RIS compiled by Roger Jaensch, Wetlands International - Oceania, on behalf of the Western Australian Department of Conservation and Land Management (CALM), in 1998. Updated by CALM staff in 2000 and 2003. Updated by Gareth Watkins, DEC in 2009.
References to the management plan	A management plan including the Lake Gore Ramsar Site (Esperance and Recherche Parks and Reserves Management Plan) is currently being prepared by DEC.

1.2 PURPOSE OF AN ECOLOGICAL CHARACTER DESCRIPTION

The Ramsar Convention (2005a) defines ecological character as follows:

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

And a change in ecological character is defined as:

"The human induced adverse alteration of any ecosystem component, process and or ecosystem benefit / service".

Wetland ecosystems are dynamic and are therefore subject to "natural" variability. Changes in ecological character are recognised as the human-induced changes beyond "natural" variability. Human induced alteration to ecosystem components and processes are both direct and indirect and can vary in intensity. They include, though are not limited to: altered hydrological regimes; pollution (nutrients and other); secondary salinity; physical alteration and/or loss of habitat; and introduced flora and fauna.

Describing the ecological character of a wetland is crucial for identifying changes, or potential changes, and an ECD provides a baseline or benchmark for future management and planning actions. The implementation of a management plan along with an appropriate monitoring programme allows early recognition of changes to ecological character.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides the legislation which helps ensure that the ecological character of Ramsar sites within Australia is maintained. This includes the environmental impact assessment (EIA) of any proposed actions that may impact on the ecological character of a Ramsar site.

When a Ramsar site is designated, a Ramsar Information Sheet (RIS) is prepared; however, this is insufficient in describing the ecological character of a site. To ensure a consistent approach in developing ECD's, the Australian Government, state and territory governments, have developed the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of the National Guidelines for Ramsar Wetlands - Implementing the Ramsar Convention in Australia*. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra (see: DEWHA, 2008). The Australian Government requires an ECD and a management plan to accompany any new Ramsar site nominations.

An ECD is a central component to management, legislative compliance and other processes that promote the conservation and wise use of a Ramsar wetland (Figure 1). McGrath (2006) outlines the purpose of an ECD:

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
b) to formulate and implement planning that promotes:
i) conservation of the wetland
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, to 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.

1.2.1 OBJECTIVES OF THE LAKE GORE RAMSAR SITE ECOLOGICAL CHARACTER DESCRIPTION

The objectives of this ECD are to:

- Provide an overall description of the Lake Gore Ramsar Site;
- Describe the critical ecosystem components, processes, benefits and services of the Ramsar site;
- Describe any changes in ecosystem components, processes, benefits and services of the Ramsar site since listing and the current ecological character;
- Develop and provide conceptual models that describe the critical ecosystem components, processes, benefits and services of the Ramsar site;
- Identify threats to the ecological character of the site;
- Set limits of acceptable change for the critical ecosystem components and processes;
- Identify gaps in knowledge of the Lake Gore Ramsar Site;
- Identify monitoring requirements for the Lake Gore Ramsar Site; and
- Identify critical communication, education and public awareness messages that will enhance awareness and knowledge of the ecological values and threats of this system.

Additionally, this ECD will provide an important reference in the development of the Esperance and Recherche Parks and Reserves Management Plan (Figure 1), which includes the Lake Gore Ramsar Site. This draft of the management plan is currently being prepared by DEC.

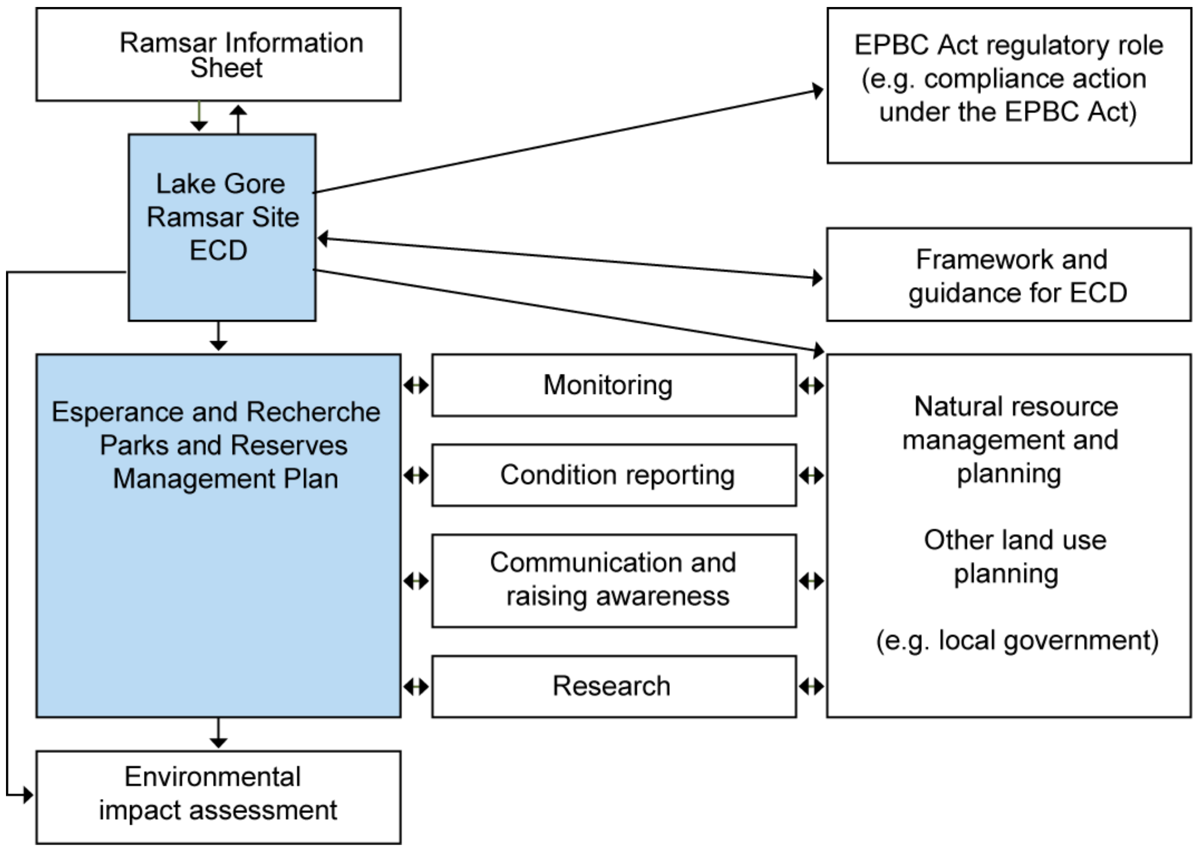


Figure 1. The relationship of the Lake Gore Ramsar Site ecological character description with the Esperance and Recherche Parks and Reserves Management Plan, legislation and other documents (adapted from DEWHA, 2008).

1.3 RELEVANT TREATIES, LEGISLATION AND REGULATIONS

The following section details the treaties, legislation and regulations that are relevant to the Lake Gore Ramsar Site. Additional state and local legislation that relate to a specific management perspective of the Lake Gore Ramsar Site will be outlined in the Esperance and Recherche Parks and Reserves Management Plan.

1.3.1 INTERNATIONAL AGREEMENTS/CONVENTIONS

Ramsar Convention

The Ramsar Convention formally, *The Convention on Wetlands of International Importance, especially as Waterfowl Habitat* is an intergovernmental treaty first adopted in Ramsar, Iran in 1971, coming into force in 1975. Its signatories are committed to the conservation and wise use of wetlands and their resources. Nomination and selection of Ramsar listed wetlands is based on their level of international significance taking into consideration the ecology, botany, zoology, limnology and or hydrology.

Convention on the Conservation of Migratory Species of Wild Animals

The CMS or Bonn Convention is a multilateral, intergovernmental treaty which aims to conserve all migratory species (terrestrial, marine and avian) throughout their range and prevent them from becoming endangered.

JAMBA, CAMBA, ROKAMBA

Australia has three bilateral agreements that are relevant to the waterbird species that have been recorded at the Lake Gore Ramsar Site. These agreements are for conservation of migratory bird species.

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;

CAMBA - The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1986; and

ROKAMBA - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds in Danger of Extinction and their Environment, 2006.

1.3.2 NATIONAL LEGISLATION

***The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)**

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

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act 1999 s335) which are set out in Schedule 6 of the Environment Protection and Biodiversity Conservation Regulations 2000. These principles are

intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention. Some matters protected under the EPBC Act are not protected under local or state/territory legislation, and as such, many migratory birds are not specifically protected under State legislation (though they are in Western Australia). All species listed under international treaties, JAMBA, CAMBA, ROKAMBA and CMS are covered by the Act. Threatened species and communities listed under the EPBC Act may also occur, or have habitat in the Ramsar site. The Regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site, and the community consultation process
(http://www.environment.gov.au/epbc/matters/Ramsar.html).

1.3.3 WESTERN AUSTRALIA STATE LEGISLATION

Aboriginal Heritage Act 1972

This Act provides protection for Aboriginal sites (places and objects) which are significant in Aboriginal culture. These sites exist in the Dalyup catchment and around the Esperance region.

Environmental Protection Act 1986

This Act is for the prevention, control and abatement of pollution; also for the prevention control and abatement of environmental harm; and for the conservation, preservation, protection, enhancement and management of the environment. The Act covers any matters that are incidental to or connected with any of these.

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

Defines wetlands listed under the Ramsar Convention as environmentally sensitive areas. The clearing provisions of the *Environmental Protection Act 1986* prohibit clearing of native vegetation, unless a permit is granted by DEC or the clearing is for an exempt purpose. Exemptions do not apply in environmentally sensitive areas or within 50 metres of the boundary.

Conservation and Land Management Act 1984

This Act is administered by DEC and covers all public conservation lands managed by DEC including National Parks, State Forests and Nature Reserves. The Act provides for a better provision for the use, protection and management of certain public lands and the flora, fauna and waters within them.

Rights in Water Irrigation Act 1914

The Act provides for the management of water resources in Western Australia where a licence is required prior to any disturbance of a wetland and/or to take water from wetlands. New legislation is currently in preparation to replace the current Act in order to meet the requirements under the National Water Initiative signed by the Western Australian State Government in 2006.

Wildlife Conservation Act 1950

The Act provides for the protection and conservation of all wildlife (flora and fauna) in Western Australia. It provides the framework regarding the licensing for possessing and removal of flora and fauna and also offences and penalties in relation to the protection and conservation of them.

2.0 DESCRIPTION OF THE LAKE GORE RAMSAR SITE

2.1 LOCATION

The Lake Gore Ramsar Site is located on the south coast of Western Australia approximately 730 km south east of the capital, Perth. It is within the Shire of Esperance, approximately 34 km west of the Esperance townsite and covers an area of 4,017 ha. The Lake Gore Ramsar Site is situated in the South-West Coast Australian Drainage Division within the Esperance Sandplain Biogeographic Region. The Lake Gore Ramsar Site is the receiving body of the Dalyup catchment which consists of the Dalyup and West Dalyup Rivers and covers approximately 82,607 ha. The catchment is surrounded by the Coobidge Creek catchment to the west, Mortijinup Lake catchment to the south east and Coramup Creek catchment to the north east. The southerly flowing Dalyup River has a mean annual flow of 11,000 mega litres (ML), delivering brackish water into Lake Gore (Pen, 1999). The majority of the Dalyup catchment (80 - 90%) has been cleared and is dominated by broad acre agriculture (Beeston & Hopkins, 2001; Gee & Simons, 2002; Pen, 1999).

2.2 LAND TENURE AND LAND USE

The Lake Gore Ramsar Site comprises of Nature Reserve 32419 (Lake Gore) for the purpose of “Water and conservation of flora and fauna” and the eastern part of Nature Reserve 26885 for the “Conservation of flora” (Figure 2). These Reserves are both vested in the Conservation Commission. The southern boundary of the site extends to the high tide mark of the Southern Ocean (Figure 2).

Adjacent to Lake Gore are Lakes Carbul, Kubitch and Gidong and to the south on Nature Reserve 30672 is Lake Quallilup (Figure 2). These lakes are all external to the Ramsar boundary and also support waterbird populations. Further investigation into feasibility of including these wetlands as part of the Ramsar site is required.

The land tenure adjacent to the Lake Gore Ramsar Site includes Nature Reserve, freehold land and unallocated Crown Land (Figure 2). The majority of the land use surrounding the Lake Gore Ramsar Site is dedicated to agriculture of some form or another. Oats, wheat, barley, canola and lupins are the major crop types grown. Other forms of agriculture in the surrounding catchment include grazing for lamb, beef and wool production. Some farm forestry and hobby farming also exists.

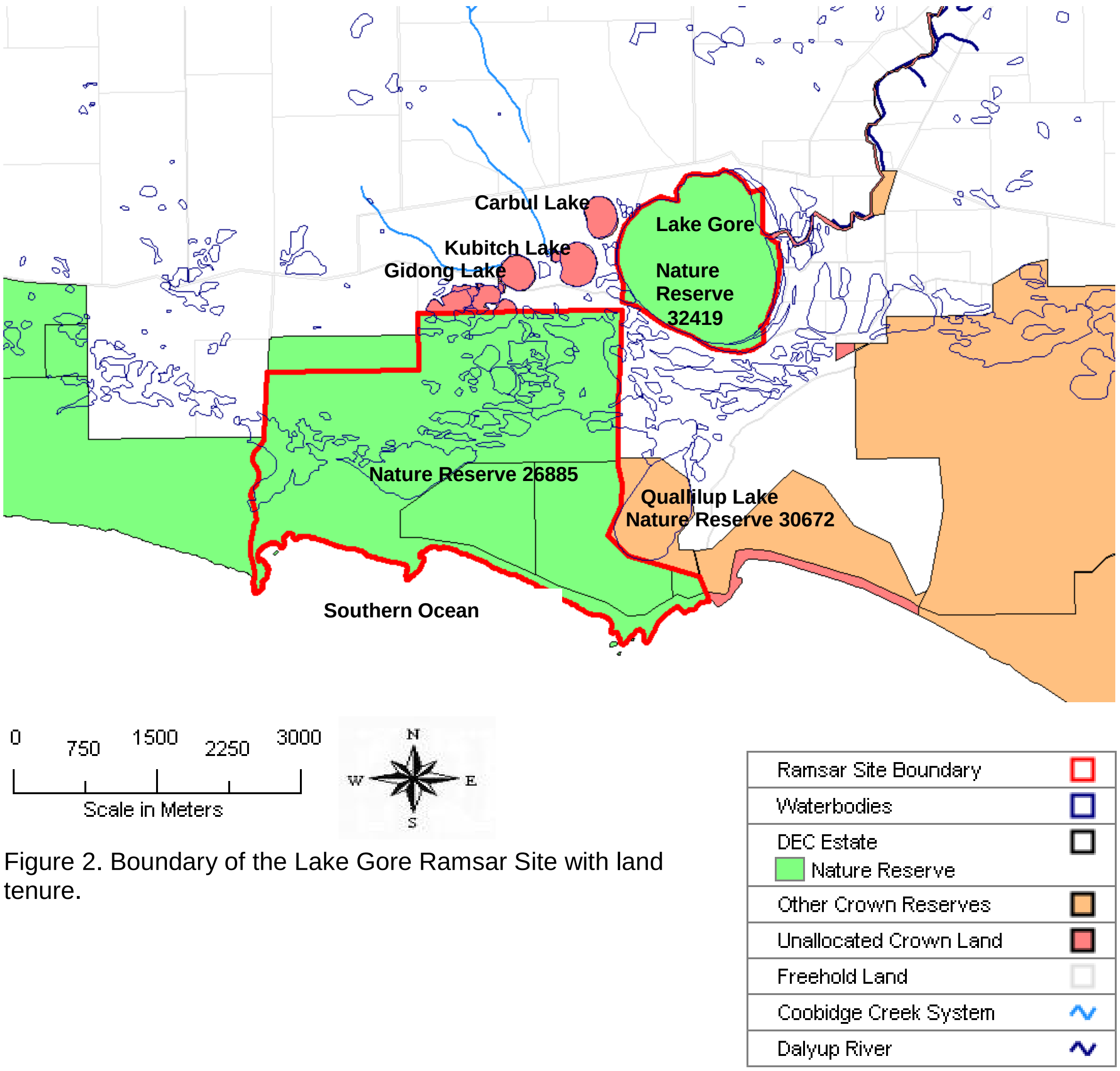


Figure 2. Boundary of the Lake Gore Ramsar Site with land tenure.

2.3 CULTURAL HERITAGE

2.3.1 ABORIGINAL HERITAGE

Lake Gore and the Dalyup and West Dalyup Rivers have been used historically by the traditional owners in the Esperance region and they are still regarded as significant areas for food gathering and fishing (Henry Dabb, South Coast NRM, pers. comm., 2008).

2.3.2 EUROPEAN HERITAGE

Esperance Bay was named after the French ship *Espérance* that took shelter there in December 1792, with the town of Esperance later named in 1893 (CALM, 1999). The Dempster brothers ran sheep through the majority of the Esperance area from the 1860’s and were the original European settlers of the region (CALM, 1999). Remnants of their woolshed are located within the Woody Lake Nature Reserve which is closer to the town of Esperance within the Esperance Lakes Nature Reserves and the Lake Warden System Ramsar Site (CALM, 1999).

Also amongst the first settlers were Mr F.J Daw (1895) in the Dalyup area, followed by the Stewart family in 1897, who established property adjacent to Lake Gore (Water and Rivers Commission, 2002). Early clearing of vegetation for farming and the installation of infrastructure such as roads is associated with these early settlements.

2.4 CLIMATE

Climate is an important ecosystem component and driver of wetland ecology (see: Section 3.0). The climate of Esperance is Mediterranean, with warm dry summers (December to February) and cool, wet winters (June to August). This climatic pattern is the result of northwest cloud bands that originate in the Indian Ocean and account for 25% - 40% of the rainfall received by Esperance (Burgess, 2001; Water and Rivers Commission, 2002). Wet winter days are characterised by southerly winds from the Southern Ocean and summer is dominated by northerly winds. Temperatures are highest in January and February (summer) averaging approximately 26˚C (Figure 3). The lowest temperatures are experienced in July (winter) with an average of approximately 8˚C (Figure 3).

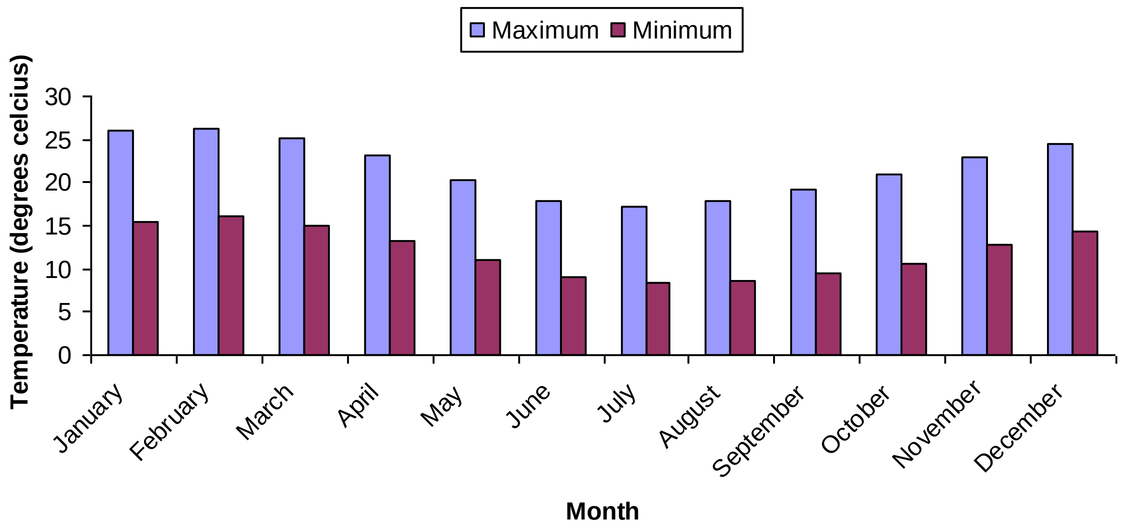


Figure 3. Mean maximum and minimum temperatures (1969 - 2008) for Esperance, Western Australia (data from Bureau of Meteorology, 2008).

The majority of the rainfall at Esperance falls between April and October, with the month of July receiving the most rainfall, averaging approximately 96 mm (Figure 4). The average annual evaporation rate at Esperance is approximately 1,657 mm (Bureau of Meteorology, 2008), with evaporation generally exceeding rainfall (Figure 4). From 1969 to 2008 the months May, July and September have been the most variable in terms of rainfall (Figure 5). Annual average rainfall at Esperance is approximately 620 mm, although it has varied over the years ranging in the order of 400 mm to > 860 mm (Figure 6). The years 1971, 1989, 1992, 1999 and 2007 have been amongst the wettest years with approximately > 800 mm being recorded (Figure 6). The annual rainfall for the years 1983, 1991, 1994, 2002 and 2006 has been notably lower at < 500 mm (Figure 6).

The Dalyup catchment receives an annual average rainfall of 484 mm of rain and 76% of this amount falls between April and October (Burgess, 2001; Water and Rivers Commission, 2002). Annual rainfall across the Dalyup catchment is variable with the northern part of the catchment receiving an average of 368 mm of rain, while the southern end of the catchment which is 40 km away receives a higher amount of rainfall with an annual average of 590 mm (Burgess, 2001; Water and Rivers Commission, 2002).

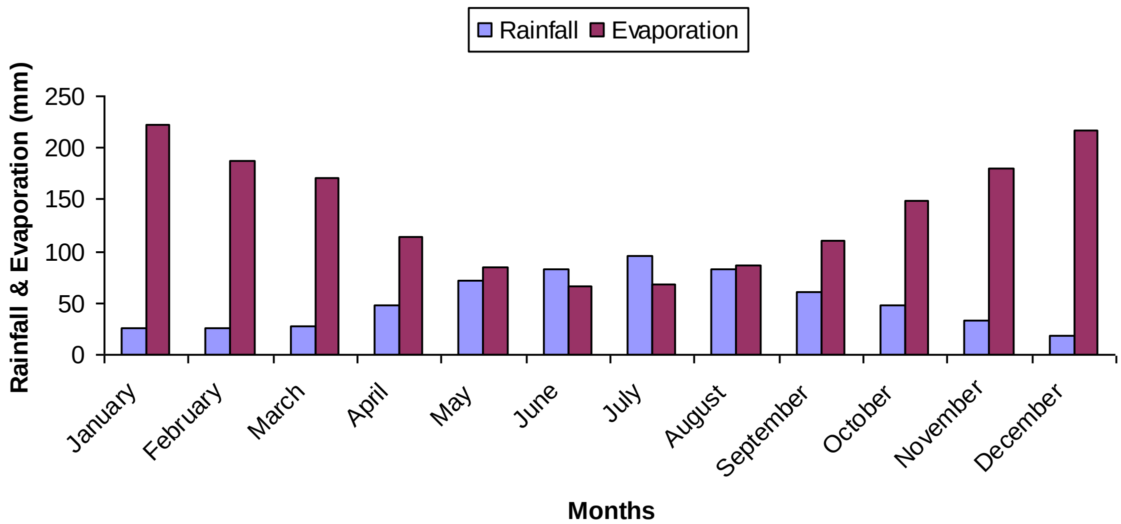


Figure 4. Average monthly rainfall and evaporation (1969 - 2008) for Esperance, Western Australia (data from Bureau of Meteorology, 2008).

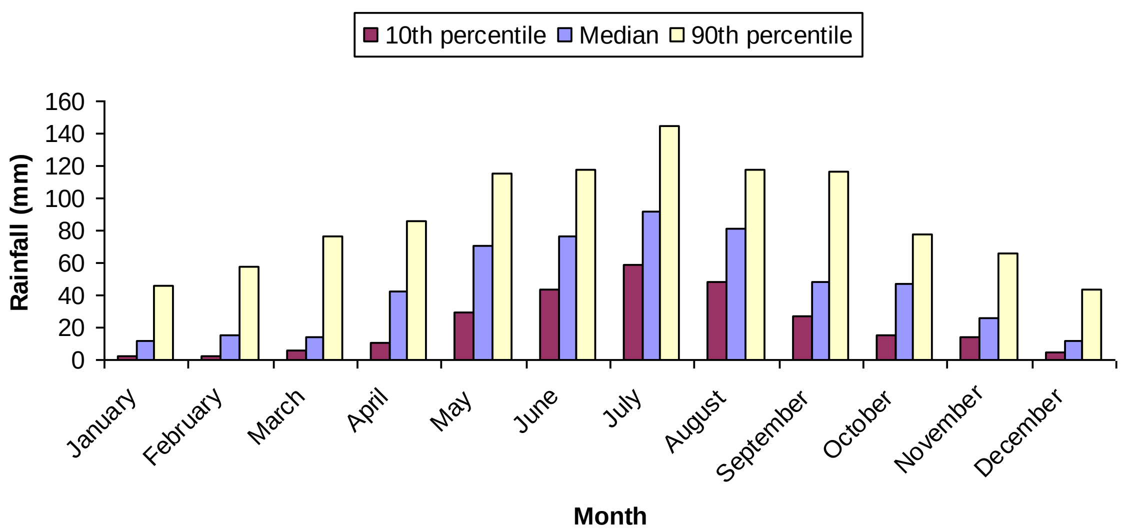


Figure 5. Median (10th and 90th percentile) monthly rainfall (1969 - 2008) for Esperance, Western Australia (data from Bureau of Meteorology, 2008).

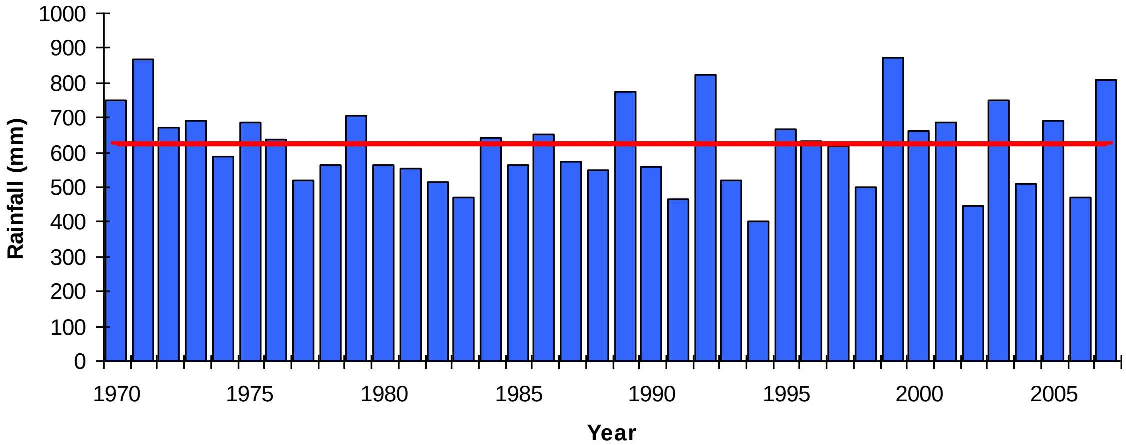


Figure 6. Annual rainfall (1970 - 2007) for Esperance, Western Australia together with long term average in red (data from Bureau of Meteorology, 2008).

Recent analysis of rainfall data from the south west of Western Australia indicates that there has been between a 5% to 10% increase in annual rainfall in the Esperance region (Figure 7). This is a contrast to the drier conditions experienced throughout the majority of the south west of Western Australia (Figure 7). During the years 1999, 2000 and 2007 Esperance has received unseasonal episodic rainfall events. In January 1999, over 107 mm of rain fell within a 24 hour period, contributing to the highest recorded monthly rainfall of 223.8 mm for Esperance (see: Bureau of Meteorology, 2008), and resulting in widespread flooding in the catchments surrounding Esperance. In March 2000, cyclone “Steve” delivered another extreme rainfall event causing flooding greater in magnitude than the previous year (Water and Rivers Commission, 2002). In January 2007, ex-tropical cyclone “Isobel” delivered a record 153 mm in a 24 hour period, again causing mass flooding and resulting in 196 mm of rainfall for the month (see: Bureau of Meteorology, 2008), well above the average generally expected for January.

These episodic, unseasonal rainfall events would not usually be experience more than once in a 50 to 100 year period (Janicke, 2000) and have therefore affected the hydrological regime of Lake Gore (see: Section 3.1.2 Hydrology). The widespread flooding from these events also caused massive erosion in the Dalyup catchment resulting in sediment deposition throughout the catchment and Lake Gore (see: Section 3.1.4 Physical Processes).

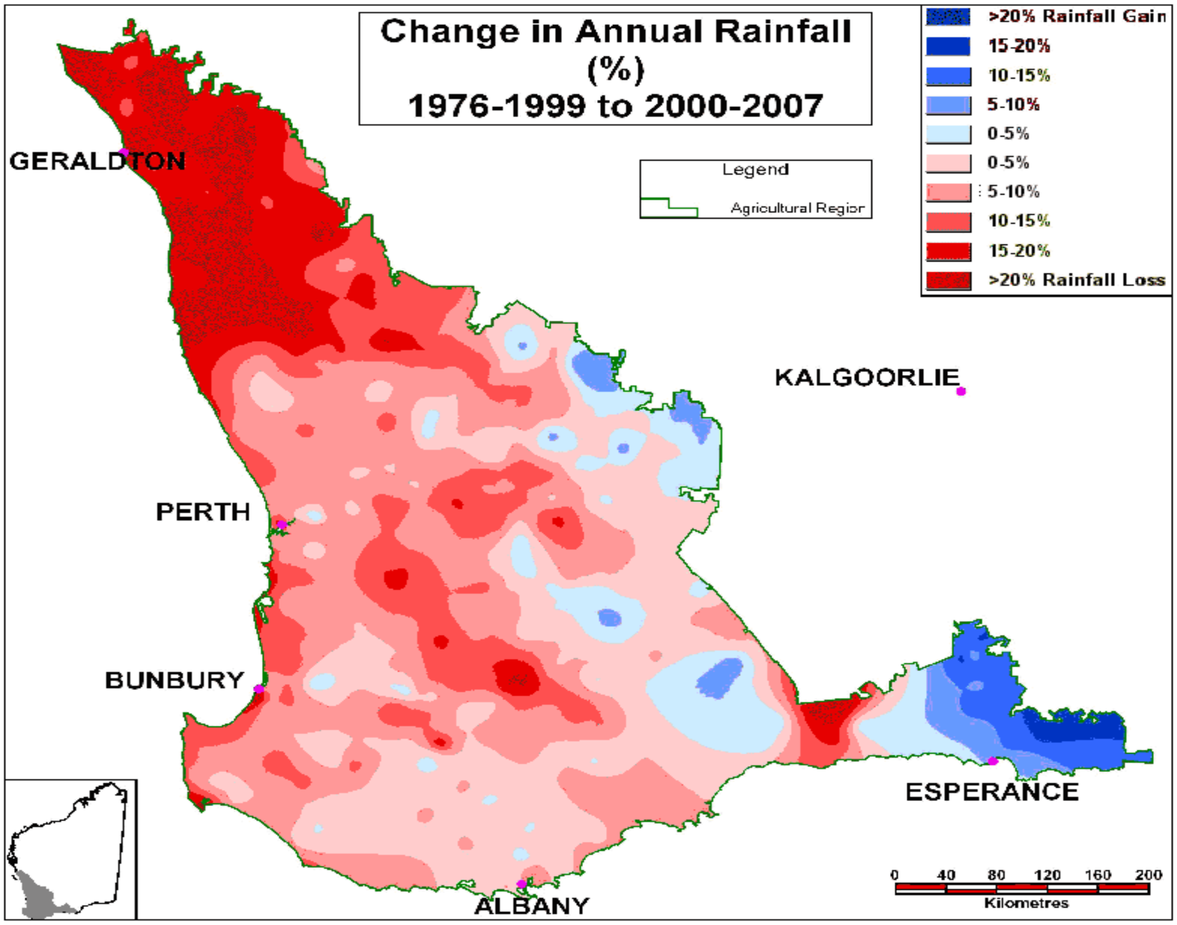


Figure 7. Rainfall in the south west of Western Australia comparing 1976 - 1999 with 2000 - 2007 (from George et al., 2008).

2.5 WETLAND TYPES

The Lake Gore Ramsar Site is an inland wetland system containing the wetland types Q, R and Ss as recognised by the Ramsar classification system. The wetland types within the Ramsar site have not been formally mapped or classified into types, however, a review of the Ramsar Information Sheet (2003) and satellite imagery suggest that these wetland types exist at the Lake Gore Ramsar Site.

Inland wetlands

Q permanent saline/brackish/ alkaline lakes and flats

R seasonal saline/brackish/ alkaline lakes and flats

Ss seasonal/ intermittent saline/ brackish/alkaline marshes/ pools

All of the wetlands on the site are of natural origin and cover a broad area they include a large lake (Lake Gore) and a downstream system of interconnected lakes, flats, marshes and pools of various extents (Figure 8).

Lake Gore (Q) is the main receiving body of the surrounding catchments and covers an area of approximately 740 ha, depending on the extent of inundation. Permanent / seasonal lakes, flats, marshes and pools (Q.R,Ss) are fed partly by Lake Gore itself, and the seasonally flowing Coobidge Creek catchment. These wetlands cover an area of approximately 1,433 ha (Figure 8).

The Ramsar Information Sheet updated in 2003 describes Lake Gore as R (seasonal/intermittent) as recognised by the Ramsar wetland classification system. During the preparation of this ECD water level data was analysed and since the time of listing no seasonal drying of Lake Gore has occurred. Lake Gore remains inundated and is therefore considered to be a permanent waterbody consistent with Q under the Ramsar wetland classification system.

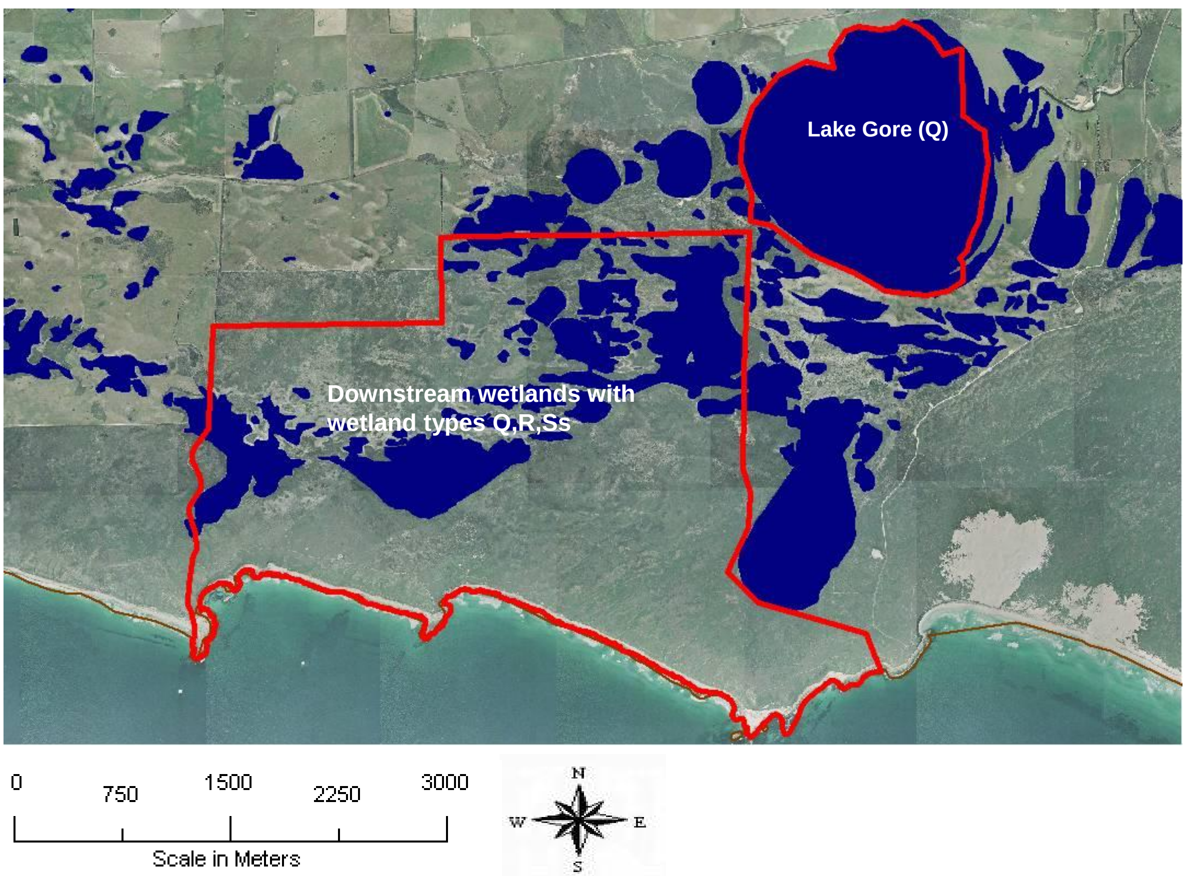


Figure 8. Wetland types at the Lake Gore Ramsar Site, Esperance, Western Australia. Note: Ramsar boundary in red.

2.6 RAMSAR CRITERIA

In order to be identified as a Wetland of International Importance a wetland must meet at least one of the nine Ramsar Criteria (Ramsar Convention, 2005b).

2.6.1 RAMSAR CRITERIA UNDER WHICH THE SITE WAS DESIGNATED

At the time Lake Gore was nominated as a Ramsar site there were eight Ramsar Criteria against which the site could qualify and Lake Gore was considered to meet three of these Ramsar Criteria (criteria 4, 5 and 6 [Table 2]). Table 2 provides the justification used in meeting these Ramsar Criteria at the time of nomination (see: Ramsar Information Sheet, 2003).

Table 2. Ramsar Criteria for identifying Wetlands of International Importance at the time of listing (from Ramsar Convention, 1999). Note: Ramsar Criteria for which the Lake Gore Ramsar Site was listed is highlighted in grey; (from Ramsar Information Sheet, 2003).

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	
Criteria based on species and ecological communities	**Criterion 2:** 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 biographic 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. **Justification:** Lake Gore regularly supports moulting by thousands of Australian Shelducks (*Tadorna tadornoides*). It is one of the most important moulting sites for shelducks in south Western Australia (Jaensch & Watkins, 1999). The Lake is also used as a drought refuge by large numbers of waterbirds (Jaensch & Watkins, 1999).
Specific criteria based on waterbirds	**Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds. **Justification:** More than 29,000 waterbirds have been counted at Lake Gore (Halse et al., 1990). The number of individual waterbirds that use the lake each year probably exceeds 20,000 and the annual data on water depth suggest conditions are suitable for use by 20,000 waterbirds at least several times within a 25 year period; in the context of wetland availability in Western Australia this is considered sufficient evidence of regular use by 20,000 waterbirds (Jaensch & Watkins, 1999).
	Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. **Justification:** Lake Gore supports up to 1600 Hooded Plover (*Thinornis rubricollis*) (Newbey, 1996), which constitutes more than 1% (almost one third) of the global population (Rose & Scott, 1997). Lake Gore is the single most important wetland for this species (Newbey, 1996). The 1% criterion is also met for Banded Stilt (*Cladorhynchus leucocephalus)*, thousands occur regularly and counts of up to 20,000 (Jaensch et al., 1988), which is approximately 10% of the population (Rose & Scott, 1997), have been recorded .
Specific criteria based on fish	**Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/ or values and thereby contributes to global biological diversity.
	Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/ or migration path on which fish stocks, either within the wetland or elsewhere, depend.

2.6.2 CURRENT RAMSAR CRITERIA

The Ramsar Criteria have been reviewed since Lake Gore was designated as a Ramsar site in 2001 and a ninth criterion was added in 2005 after the 9^{th} Meeting of the Conference of the Contracting Parties. Table 3 details the Ramsar Criteria currently met by the Lake Gore Ramsar Site. During the preparation of this ECD an analysis of the historical and recent waterbird survey data was conducted in order to ascertain if the Lake Gore Ramsar Site still meets the Ramsar Criteria that it was originally nominated for and whether any changes to waterbird species richness and abundance has occurred. Waterbird experts from Wetlands International provided authoritative advice as part of this process.

Analyses of the waterbird data indicates that Ramsar Criteria 4 and 6 are still met by the Lake Gore Ramsar Site with the addition of two waterbird species; the Australian Shelduck (*Tadorna tadornoides*) and the Chestnut Teal (*Anas castanea*) under Ramsar Criterion 6. Ramsar Criterion 5 is not considered to be currently met at the Lake Gore Ramsar Site and its application at the time of nomination has been reassessed as part of the preparation of this ECD. These conclusions are in consideration of the most recent global waterbird population estimates (see: Wetlands International, 2006) and the Ramsar guidelines for applying Ramsar Criteria 5 and 6 including the definition of "regularly" under these Criteria (see: Text Box 1). As part of the preparation of this ECD the RIS has also been updated to reflect these changes. Sub-section 2.6.2.1 provides a description of the assessment against each of the Ramsar Criteria.

Table 3. Current Ramsar Criteria for identifying Wetlands of International Importance (from Ramsar Convention, 2005b). Note: Ramsar Criteria for which Lake Gore Ramsar Site currently meets is highlighted in grey.

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	
Criteria based on species and ecological communities	**Criterion 2:** 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 biographic 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. **Justification:** Lake Gore regularly supports thousands of moulting Australian Shelducks (*Tadorna tadornoides*) and is therefore an important aspect of their life cycle, providing a refuge during this vulnerable period. The Lake is also used as a drought refuge by large numbers of other waterbirds (Jaensch & Watkins, 1999).
Specific criteria based on waterbirds	**Criterion 5:** 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 1% of the individuals in a population of one species or subspecies of waterbird. **Justification:** Lake Gore has, until relatively recently, supported more than 1% of the Western Australian population of Hooded Plover (*Thinornis rubricollis* [1% last recorded in 2002]) and more than 1% of the Australian population of Banded Stilt (*Cladorhynchus leucocephalus* [1% last recorded in 1998]). The available data suggests that these population thresholds may again be met in the future. The 1% population threshold is also met for the Australian Shelduck (*Tadorna tadornoides*) and the Chestnut Teal (*Anas castanea*). Regular counts exceeding population estimates (see: Wetlands International, 2006) have occurred at Lake Gore.
Specific criteria based on fish	**Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/ or values and thereby contributes to global biological diversity.
	Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/ or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Specific criteria based on other taxa	**Criterion 9:** A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependant non- avian animal species.

The definition of “regularly” under Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands (Ramsar, Iran,1971) Third edition, as adopted by Resolution VII.11 (COP7, 1999) and amended by Resolutions VII.13 (1999), VIII.11 and VIII.33 (COP8, 2002), and IX.1 Annexes A and B (COP9, 2005) (Ramsar Convention, 2005b):

Regularly (Ramsar 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. **http://www.ramsar.org/key_guide_list2006_e.htm**.

Text Box 1. Definition of “regularly” in the application of Ramsar Criteria 5 and 6.

2.6.2.1 Assessment against each of the Ramsar Criteria for the Lake Gore Ramsar Site

Criterion 1. Other wetlands within the South-West Coast Drainage Division and the Esperance Plains Biogeographic Region (for example, the Lake Warden System Ramsar Site) are considered to be more representative of a natural or near-natural wetland type found within the bioregion than the Lake Gore Ramsar Site .

Criterion 2. The Fairy Tern (*Sterna nereis*) which is listed as "Vulnerable" under the International Union for Conservation of Nature and Natural Resources (IUCN) Red List has been recorded at Lake Gore. However, as there are only 3 records (January 1985 [4], July 2001 [12], May 2002 [12]) of Fairy Tern at Lake Gore (see: Birds Australia, 2008b; Jaensch et al., 1988), it is anticipated that the site is not important in supporting populations of Fairy Tern and the numbers recorded to date suggests that it is an occasional visitor.

Additionally, Lenanton (1974) refers to the existence at Lake Gore of the EPBC Act listed critically endangered Western Trout Minnow (*Galaxias truttaceus hesperius*). This information has not been confirmed under the Priority Fauna Database of Western Australia or the EPBC Protected Matters Database and therefore further research is required to ascertain the existence of this species at Lake Gore.

It is therefore concluded that the Lake Gore Ramsar Site does not support vulnerable, endangered or critically endangered species or threatened ecological communities.

Criterion 3. No species of flora or fauna are supported solely by the Lake Gore Ramsar Site, nor is it considered to contribute significantly to the biodiversity of the bioregion and therefore this criterion is not met.

Criterion 4. This criterion was met at the time of listing of the Lake Gore Ramsar Site and continues to be met.

Historically, thousands of Australian Shelducks (*Tadorna tadornoides*) have used Lake Gore as a sanctuary during the moulting stage of their lifecycle. Thousands are still recorded regularly and the site is therefore considered to be still providing an important refuge during this vulnerable period as the birds are flightless.

At the time of listing, the site was also used as a drought refuge by large numbers of other waterbirds (Jaensch & Watkins, 1999). This is still considered to remain the case as Lake Gore itself has not had any distinct drying periods since the time of listing.

Criterion 5. This criterion was considered to be met at the time of nomination and therefore at the time of listing of the Lake Gore Ramsar Site. Analysis of the waterbird data from 1981 to 2008 indicates that 20,000 or more waterbirds have been recorded only once over this period. In March 1988, over 29,000 waterbirds were counted at Lake Gore and this one count was used as justification to support Criterion 5 at the time of listing. Single counts are used at some sites where little information is known to establish the importance of the site for a species, particularly if the areas are remote or there are other constraints in undertaking regular waterbird surveys (see: **http://www.ramsar.org/key_guide_list2006_e.htm**). However, in this case, there are a sufficient number of waterbird surveys to apply the Ramsar definition of "regularly" under this criterion. The existing waterbird data for the site does not support the Ramsar definition of "regularly".

The original justification for Criterion 5 provided in the 2003 RIS stated that "annual data on water depth suggest conditions are suitable for use by 20,000 waterbirds at least several times within a 25 year period" (Ramsar Information Sheet, 2003). Analysis of 27 years of waterbird data indicates that the Lake Gore Ramsar Site has only been utilised by over 20,000 waterbirds on one recorded occasion (i.e. March 1988).

The waterbird count from March 1988 comprised of 20,000 individuals from a single species, the Banded Stilt (*Cladorhynchus leucocephalus*). Banded Stilt are a highly mobile and dispersive species, their behaviour is extremely nomadic and they will opportunistically use suitable habitats (Roshier 2003). This large, singular count in 1988 suggests that at this time, Lake Gore provided suitable habitat for considerable numbers of Banded Stilt while other wetlands within the region may have been dry or unsuitable for feeding and/or breeding opportunities. Comparable numbers of Banded Stilt have not been recorded at Lake Gore since 1988 (see: Bennelongia, 2008a; Bennelongia, 2008b; Birds Australia, 2008b; Buchanan, 2003; Clarke & Lane, 2003; Department of Environment and Conservation, 2008d; Halse, 2007; Halse et al., 1992; Halse et al., 1990; Halse et al., 1995; Halse et al., 1994; Jaensch et al., 1988).

While it is certainly beneficial to use a single count in the absence of available data to indicate the importance of a site for a species, it is not considered that the Lake Gore Ramsar Site originally met or currently meets Criterion 5. In particular, the application of the Ramsar definition of "regularly" discounts Criterion 5 at the Lake Gore Ramsar Site.

Criterion 6. Prior to listing of the site, Hooded Plover (*Thinornis rubricollis*) and Banded Stilt (*Cladorhynchus leucocephalus*) counts regularly exceeded the 1% population thresholds (see: Wetlands International, 2006). Although, the Banded Stilt and the Hooded Plover counts last exceeded the 1% population thresholds in 1998 and 2002 respectively, insufficient time has lapsed to suggest that these species will not meet the 1% population thresholds in the future (Roger Jaensch, Wetlands International - Oceania, pers. comm., 2008).

Two additional species, the Australian Shelduck (*Tadorna tadornoides*) and the Chestnut Teal (*Anas castanea*) now also meet Criterion 6. These two species were not included under this criterion at the time of listing as appropriate population estimates for these species were not available. The latest waterbird population estimates (see: Wetlands International, 2006), in comparison with historical and current waterbird surveys, indicate that the counts exceed the 1% population thresholds for these two species "regularly" (see: Bennelongia, 2008a; Bennelongia, 2008b; Birds Australia, 2008a, 2008b; Buchanan, 2003; Clarke & Lane, 2003; Department of Environment and Conservation, 2008d; Halse, 2007; Halse et al., 1992; Halse et al., 1990; Halse et al., 1995; Halse et al., 1994; Jaensch et al., 1988; Newbey, 1996; Singor, 1999; Weston & Elgar, 2000).

Criterion 7, 8 & 9. These criteria are not considered to be applicable to the Lake Gore Ramsar Site.

3.0 LAKE GORE RAMSAR SITE: CRITICAL ECOSYSTEM COMPONENTS, PROCESSES, BENEFITS AND SERVICES

3.1 CRITICAL ECOSYSTEM COMPONENTS AND PROCESSES

Ecosystem components and processes include the physical, chemical and biological parts of a wetland and include habitat, species and genes (Ramsar Convention, 2005a). Climate and geomorphology are overarching ecosystem components and processes as they strongly influence the ecology of wetlands (Mitsch & Gosselink, 2007). Climate and geomorphology affect other ecosystem components and processes such as the physico-chemical environment, wetland biota and hydrology (Mitsch & Gosselink, 2007). Collectively, ecosystem components and processes contribute in determining the ecological character of a wetland. Figure 9 provides an overview of ecosystem components and processes and their interactions.

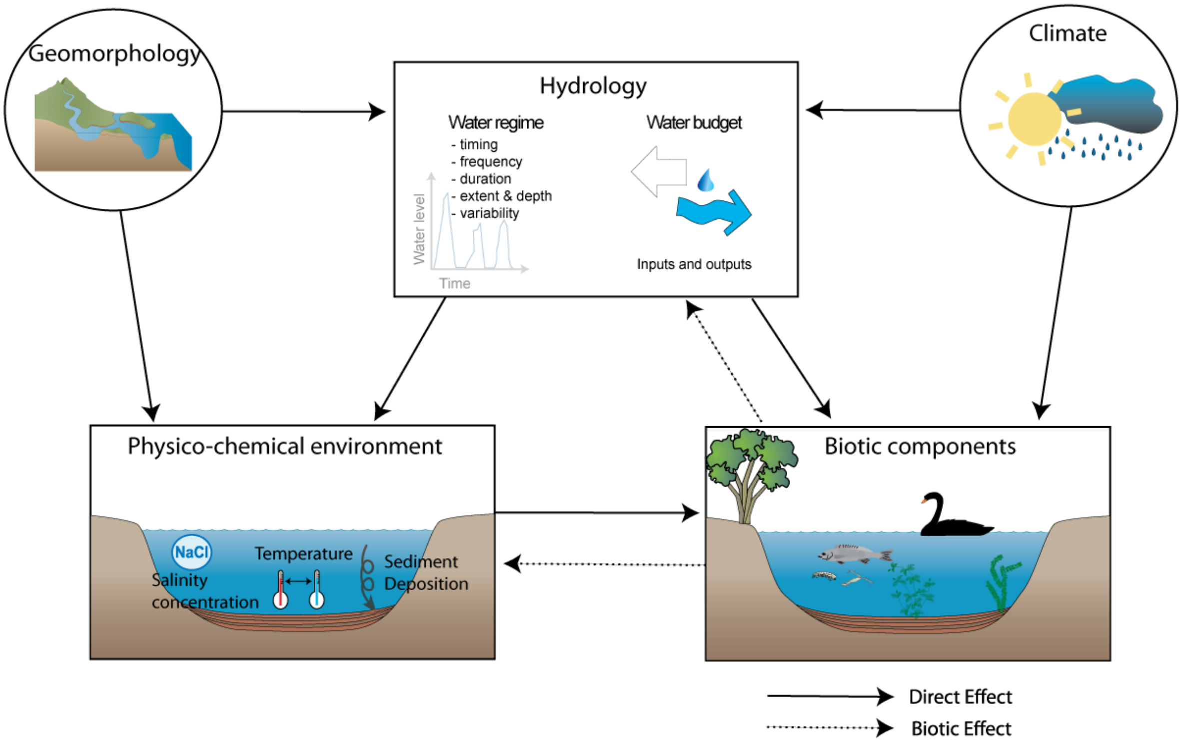


Figure 9. An overview of ecosystem components and processes and their interactions (adapted from DEWHA, 2008; Mitsch & Gosselink, 2007).

Alterations to any of the ecosystem components and processes may result in a change to the ecological character of a wetland system (see: Section 5.0 Changes to Ecological Character). This section will identify and describe the critical ecosystem components and processes that most strongly influence or determine the ecological character of the Lake Gore Ramsar Site. Ideally, the critical ecosystem components and processes should be quantified so if changes do occur they are both measurable and comparable in the future. However, in some instances knowledge gaps exist and quantification is difficult (see: Section 7.0 Knowledge Gaps).

Identifying and describing critical ecosystem components and processes will contribute towards setting limits of acceptable change, determining knowledge gaps and recommending monitoring requirements for the Lake Gore Ramsar Site, as detailed in later sections of this ECD. Any changes to the components and processes identified here will also be discussed in Section 5.0 Changes to Ecological Character.

Table 4 provides a summary of the critical ecosystem components and processes of the Lake Gore Ramsar Site.

Table 4. Summary of the critical ecosystem components and processes of the Lake Gore Ramsar Site, Esperance, Western Australia.

Critical ecosystem component/ process	Summary
Climate see: Section 2.4	• Mediterranean - warm, dry summers, cool wet winters • Evaporation exceeds rainfall most months with annual average rainfall approximately 620 mm and average annual evaporation rate 1657 mm • During the years 1999, 2000 and 2007 Esperance has received unseasonal episodic rainfall events • January and February (summer) averaging approximately 26 ˚C. The lowest temperatures are experienced in July (winter) with an average of approximately 8 ˚C
Geomorphology	• The Lake Gore Ramsar Site is confined by a granite escarpment to the north and by Quaternary dunes to the south • Lake Gore bathymetry ranges from approximately 15 - 20 m Australian Height Datum. However, the bathymetry is comparatively consistent with heights not usually varying by more than 2 m, resulting in a broad shallow basin
Hydrology	• Mainly surface water fed from the Dalyup catchment • Some groundwater influence (unquantified) • Shallow < 2 m and perennially inundated (Lake Gore) • Hydrological regime has provided habitats for a diversity of waterbirds i.e. wading to deeper feeding species • Altered hydrological regime has caused increases in the extent and duration of water inundation threatening waterbird habitats and riparian vegetation
Water quality (physico-chemical)	• Salinity concentrations saline to hypersaline • Alkaline pH • Nutrient enriched • Algal blooms recorded
Physical Processes	• Sedimentation occurring at an accelerated rate since catchment clearing • Sedimentation has possible implications on the bathymetry and hydrological regime of Lake Gore
Wetland Soils	• Clay based units • Alkaline sediments • Elevated nutrient concentrations • Potential acid sulfate soils maybe present
Biota	• Waterbirds - Highest waterbird count >20, 000 (1988) - 53 species of waterbirds recorded - 25 waterbirds listed under the EPBC Act: 24 “Marine” ,14 “Migratory” species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA and CMS) - Notable species (exceeding 1% population thresholds): Australian Shelduck, Banded Stilt, Chestnut Teal and Hooded Plover (listed as Priority Four species by DEC and listed “Near Threatened” under the IUCN Red List) • Fish - Western Trout Minnow (*Galaxias truttaceus*

Critical ecosystem component/ process	Summary
	hesperius), Blue Spotted Gobi (*Ellogobius olorum*) and Black Bream (*Mylio Butcheri*) have been recorded at Lake Gore, though not recently confirmed - Western Trout Minnow is listed as critically endangered under the EPBC Act. - Hardy Head (*Leptatherina wallacei*) and the Swan River Gobi (*Pseudogobius olorum*) have been recorded in the lower Dalyup River where it terminates at Lake Gore • Aquatic invertebrates - Low richness due to high salinities - Species composition has been variable • Vegetation - Lake Gore has fringing vegetation consisting of *Melaleuca cuticularis* - High water mark of Lake Gore consists of *Schoenus brevifolius* and *Gahnia trifida*, samphire species (*Suaeda australis* and *Sarcocornia quinqueflora*) and the grass species *Sporobolus virginicus* and herb *Samolus repens* - *Melaleuca cuticularis* is replaced by *Acacia* sp. as the elevation increases on the northerly side of Lake Gore - The majority of the riparian vegetation of the Lake Gore catchment is dead or declining due to an altered hydrological regime

Rationale for selection of the critical ecosystem components and processes

The identification and description of the critical components and processes of the Lake Gore Ramsar Site is based on the minimum requirements set by DEWHA (2008). The critical ecosystem components and processes have been selected on the basis that:

- They are important determinants of the site's unique character;
- They are important for supporting the Ramsar Criteria under which the site was listed;
- Changes to components and processes are likely to occur over short or medium time scales (<100 years); and
- Significant negative consequences will be the result of changes to the components and processes.

Climate and Geomorphology: Climate and geomorphology are the overarching ecosystem components (Mitsch & Gosselink, 2007), and should be considered as part of the critical components and processes of any ecosystem.

Hydrology: Hydrology is a fundamental determinant of the ecological character of this site. The hydrological regime directly influences biota including vegetation, waterbirds and invertebrates and is important in supporting the Ramsar criteria for which the site was listed. Changes in the hydrological regime of Lake Gore would have significant negative consequences for the ecological character of the site.

Water quality: Water quality is important in relation to the biotic composition of an ecosystem and is critical in any wetland. Changes in the water physico-chemical environment of Lake Gore will impact waterbirds and may affect the ability of the Lake Gore Ramsar Site to support the Ramsar criteria for which it was listed.

Physical Processes: Sedimentation is an important process influencing the ecological character of the site. Sedimentation directly alters the bathymetry of Lake Gore itself, which has subsequent impacts on components of the hydrological regime.

Wetland Soils: It is the physico-chemical attributes that make the wetland soils a critical component. The wetland soils affect water quality and also partly determine the vegetation of the site. Essentially a product of hydrology, geomorphology and climatic processes, as with water quality, wetland soils influence the biotic composition of the site.

Biota: The biotic components form the foodweb and are a critical determinant of the ecological character of the Lake Gore Ramsar Site. As waterbirds are part of the foodweb, any changes to the biota will affect the ability of the site to support the Ramsar criteria for which it was originally nominated.

3.1.1 GEOMORPHOLOGY

Geomorphology is second to climate as one of the most important factors in the ecology of wetlands (Mitsch & Gosselink, 2007). The basement geology of the Esperance area which includes the Dalyup catchment is made up of Proterozoic rocks of the Albany-Fraser Orogen consisting of granite and gneisses formed approximately 2300 - 1800 million years ago (CALM, 1999; Short, 2000). This bedrock was overlain by Tertiary sediments of the Plantagenet Group during periods of sea level change approximately 40 million years ago (CALM, 1999; Short, 2000). These Tertiary sediments overlay the in-situ weathered bedrock and together form the regolith which is highly influential on the hydrology of the Dalyup catchment (see: Section 3.1.2 Hydrology).

Approximately 30 million years ago, during the Oligocene period, the Darling Plateau began to rise and as a result the southern coastline tilted toward the south, forming the Ravensthorpe Ramp (Short, 2001). As a consequence, the older east-west flowing river systems were partly rejuvenated and began to flow in a southerly direction (Short, 2001). Over the past two million years during the Quaternary period, sediments consisting of sand and limestone have been deposited over the area (Short, 2000).

The regolith in the river valleys and slopes of the catchment, and the wetlands of the Ramsar site, are overlain by alluvial, colluvial, aeolian and lacustrine deposits from streams and the erosion of the nearby escarpments (Simons, 2001; Street & Abbott, 2005). The basement geology underlying the Lake Gore Ramsar Site is Archean crystalline basement of the Biranup complex.

Topography

The Lake Gore Ramsar Site is confined by a granite escarpment to the north and by Quaternary dunes to the south. The Quaternary dunes consist of coastal sand dunes and a limestone ridge. Lake Gore itself covers an area of approximately 740 ha within the 4,017 ha Ramsar site.

The bathymetry of Lake Gore ranges from approximately 15 - 20 m Australian Height Datum (AHD). However, the bathymetry is comparatively consistent with heights not usually varying by more than 2 m, resulting in a broad shallow basin (Figure 10). This means that water depth is also fairly constant over Lake Gore and a small change in water level can influence the extent of inundation and therefore the area of exposed shore zone (see: Section 3.1.2 Hydrology). Additionally, changes to the bathymetry of Lake Gore (e.g. from sedimentation) may also result in an increase in the extent of inundation (see: Section 3.1.4 Physical Processes).

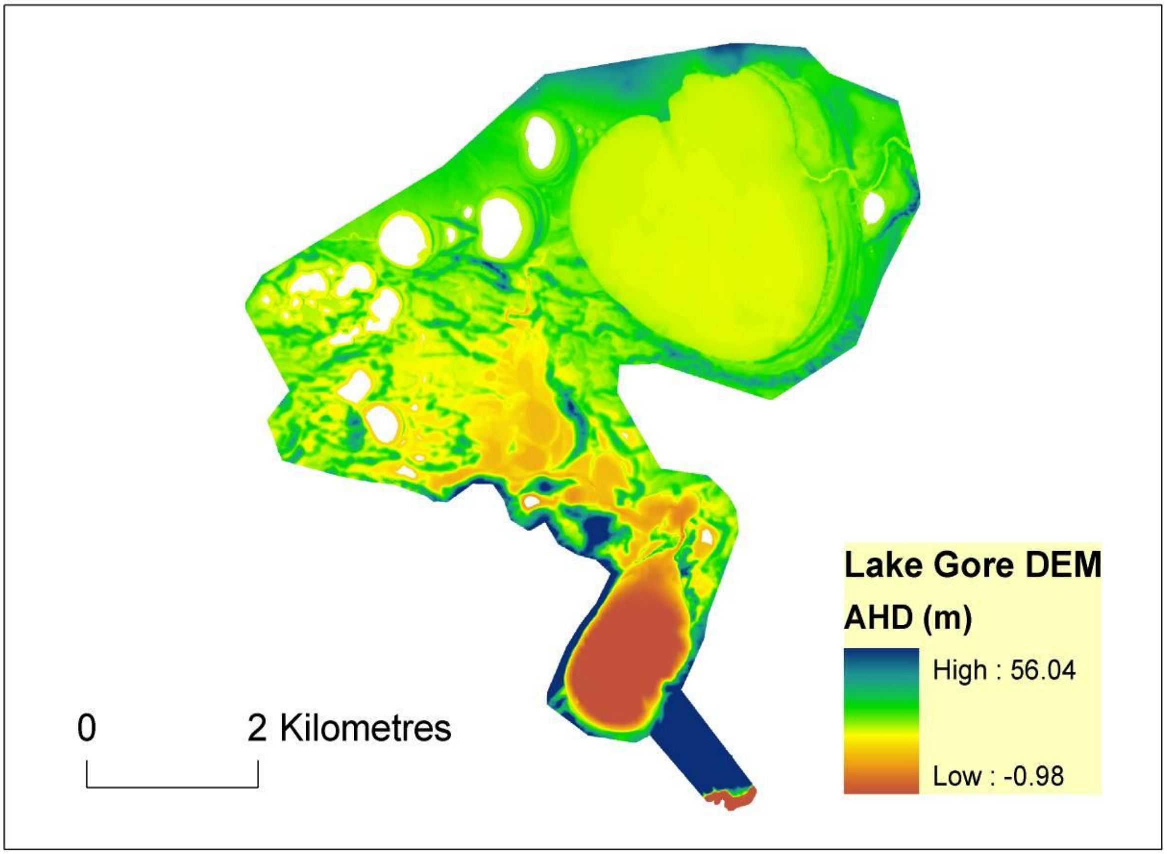


Figure 10. Digital Elevation Model (DEM) of Lake Gore, Esperance, Western Australia (from Massenbauer, 2008a).

3.1.2 HYDROLOGY

The hydrology of a wetland is directly influenced by climate and geomorphology (Mitsch & Gosselink, 2007). Hydrology and particularly the hydrological regime of a wetland affects biodiversity through the direct modification of the physico-chemical environment (Mitsch & Gosselink, 2007).

The components of a hydrological regime include timing, frequency, duration, extent and depth, and variability (Boulton & Brock, 1999). The interactions of surface and groundwater both contribute to the hydrological regime. Recording the water depth of a wetland on a seasonal basis assists in describing the hydrological characteristics or hydroperiod of a wetland. The hydroperiod (expressed in a hydrograph) represents the timing, frequency, duration and depth components of the hydrological regime. It is a major determinant of wetland processes and can vary, sometimes dramatically, both seasonally and annually (Mitsch & Gosselink, 2007).

Hydrological regime strongly influences the waterbird species composition of Lake Gore. The water depth along with the extent of inundation and the subsequent habitat created is an important ecosystem component for the Lake Gore Ramsar Site. Hydrological flux at Lake Gore is particularly influential on waterbird species richness and behaviour (Robertson & Massenbauer, 2005; Weston & Elgar, 2000). For example, too much water (resulting in increases in depth and extent of inundation) will reduce wading waterbird habitat.

The main hydrological input for Lake Gore is the Dalyup catchment, which has an annual flow of approximately 11,000 ML (Pen, 1999). The Dalyup catchment consists of the Dalyup and West Dalyup Rivers and their confluence is approximately 8 km north of Lake Gore (Figure 11). Other hydrological inputs for Lake Gore are derived from the Coobidge Creek catchment, which flows into Lake Gore through Carbul, Kubitch and Gidong Lakes (Figure 11). Coobidge Creek has an annual flow of approximately 3800 ML (Brearley, 2005). There is also some groundwater seepage from aquifers surrounding the Ramsar site including a perched aquifer in the Quaternary dunes to the south, however, the amounts are not quantified (Street & Abbott, 2005). Rainfall contributes directly to the water budget of the site and also indirectly via the surrounding landscape through runoff from the northern granite escarpment and the surrounding catchments.

An inter-connected system of seasonal wetlands within the Ramsar site are fed by Lake Gore and the seasonally flowing Coobidge Creek catchment (Figure 11). When Lake Gore fills, it over flows via “Overflow Swamp” into Quallilup Lake, which is outside the Ramsar boundary (Figure 11). In extreme flood events, overflow from the Lake Gore and Coobidge Creek catchments merge westward via an ill-defined watercourse, from the “Overflow Swamp” to Barkers Inlet approximately 12 km away and then to the Southern Ocean.

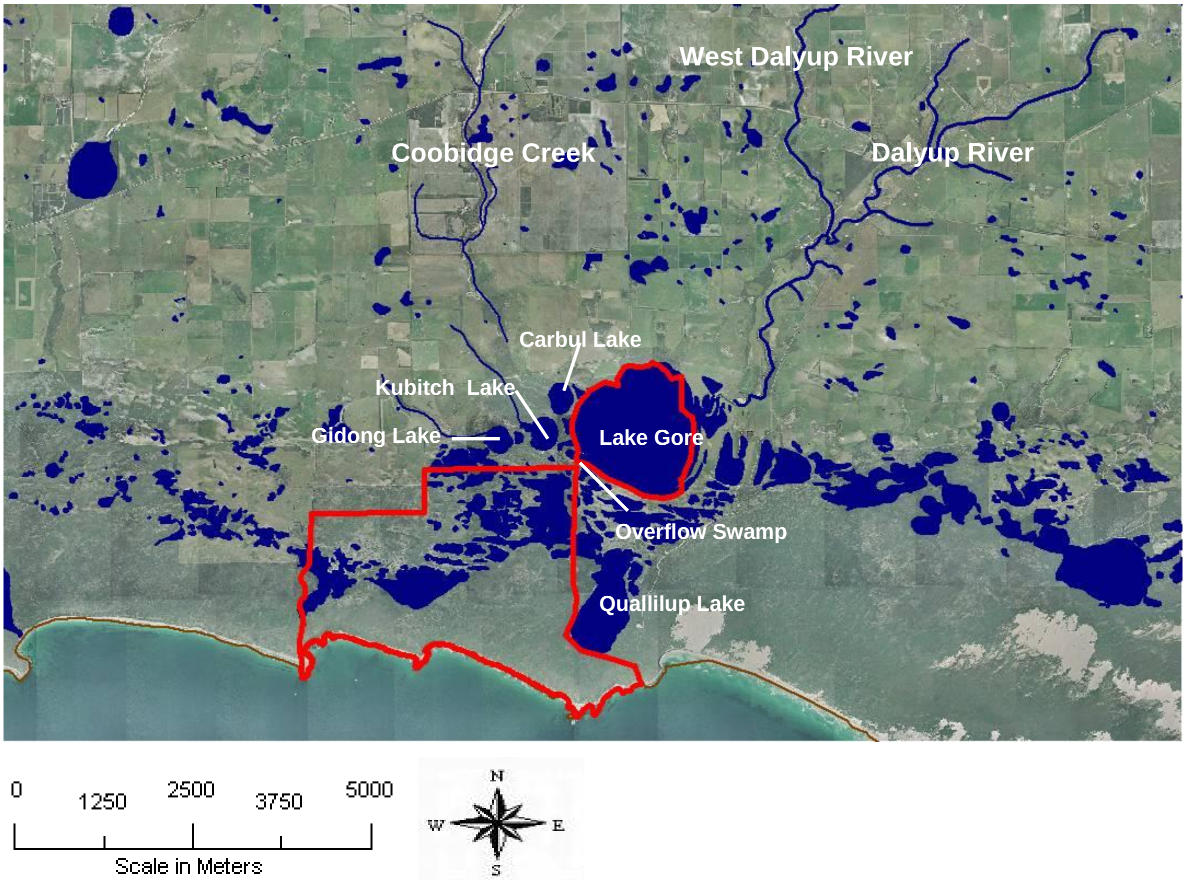


Figure 11. Lake Gore Ramsar Site and surrounding waterbodies, Esperance, Western Australia. Note: Ramsar boundary in red.

Lake Gore has no confirmed direct hydrological connection with the Southern Ocean and is therefore described as a sub-terminal basin. However, it is possible that some palaeodrainage features exist east of Lake Gore and are a likely output to the Southern Ocean (Street & Abbott, 2005). Figure 12 provides a conceptualised water budget for Lake Gore.

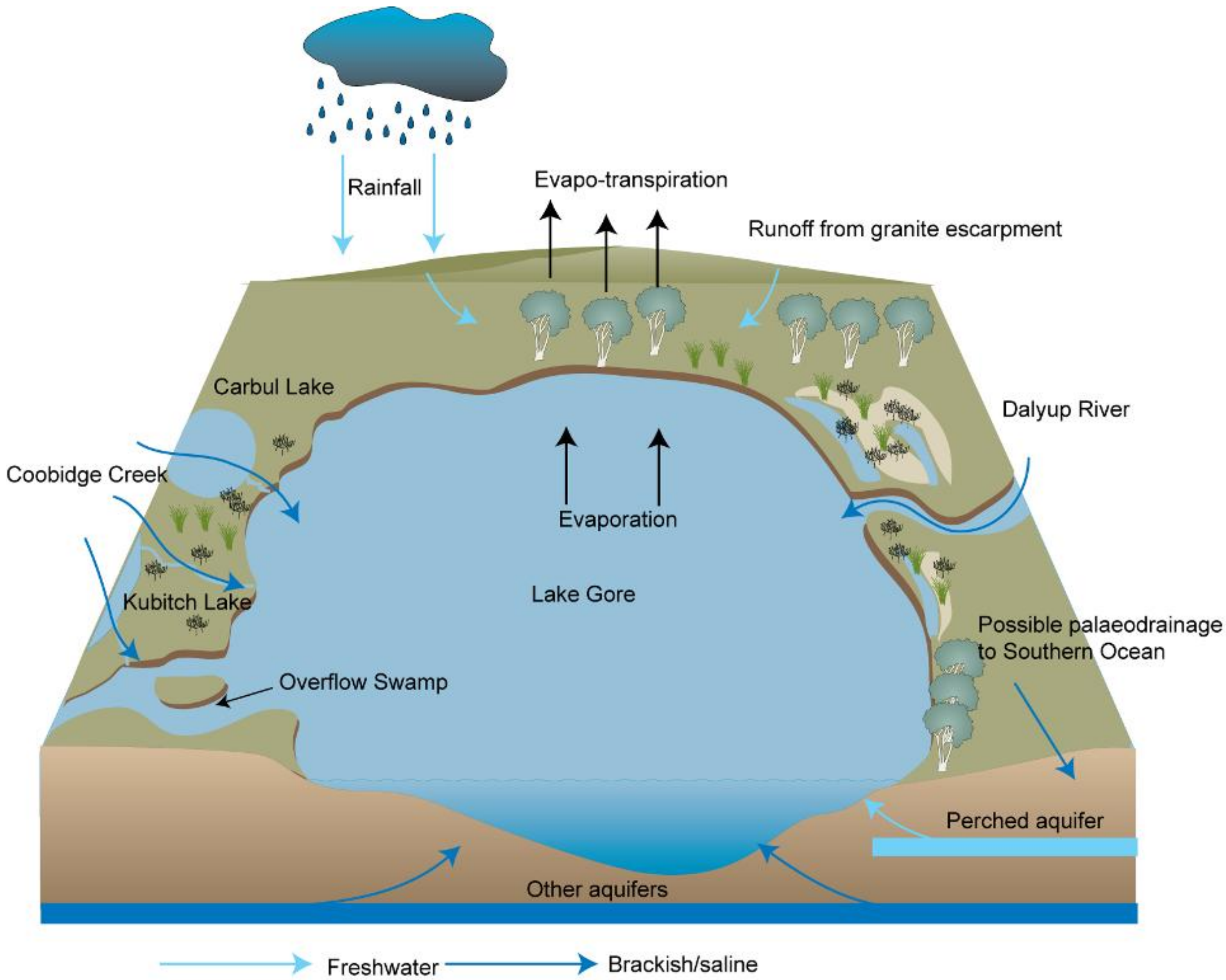


Figure 12. Conceptual water budget for Lake Gore, Esperance, Western Australia (constructed from information contained in Street & Abbott, 2005).

The regolith of the Dalyup catchment and its ability to store and transmit water, strongly influences the hydrological aspects of the catchment and subsequently the Lake Gore Ramsar Site (Simons, 2001). The Dalyup and West Dalyup Rivers are described as ephemeral systems flowing mainly after winter rains with summer baseflows the result of groundwater influences (Parker & Field, 2001). However, the clearing of vegetation in the Dalyup catchment for agriculture has resulted in an altered hydrological regime (Comer et al., 2001; Komarzynski, 2001). Clearing has altered surface and subsurface water processes causing rising groundwater levels and increased surface water runoff (Komarzynski, 2001). Hydrological changes within the Dalyup catchment are amplifying (and in some instances causing) the extent and incidence of secondary salinisation, water erosion, siltation, sedimentation, flooding, acidity (ground and surface water) and waterlogging (Comer et al., 2001; Komarzynski, 2001; Water and Rivers Commission, 2002).

The Dalyup River has flooded on average, once every 10 years with the first damaging flood occurring in 1968 / 1969 (Water and Rivers Commission, 2002). Since this flood in the 1960's, Lake Gore has rarely dried, whereas previously locals remember Lake Gore drying regularly (Water and Rivers Commission, 2002). Other major floods have occurred in 1979, 1989, 1999 and 2000 with corresponding high levels experienced at Lake Gore (Water and Rivers Commission, 2002). The most recent flooding of the Esperance region occurred in 2007. The flood of 2007 and the 1999 and 2000 floods were associated with unseasonal episodic rainfall events (see: Section 2.4 Climate). These flood events and the changes in the catchment have contributed to the altered hydrological regime of the Lake Gore Ramsar Site.

Due to hydrological changes the flow in the Dalyup River has now become more perennial, with increased annual discharge and flood peaks (Callow, 2007). It has been estimated that peak discharges are significantly higher and flow has increased from 20% to 80% of the year since clearing (Callow, 2007). In most parts of the catchment natural bankful discharge would occur every 1:10 years to 1:20 years and in some parts > 1:40 years (Callow, 2007). Since clearing, bankful discharge rates are now occurring 2 - 4 times a year depending on catchment location (Callow, 2007).

Lake Gore hydrological regime

Water depth has been recorded since 1977 in selected wetlands (including Lake Gore) of the south west of Western Australia by DEC, as part of the South West Wetland Monitoring Programme (SWWMP). Water depth has been recorded at Lake Gore from 1979 as part of the SWWMP (see: Lane, 2008; Lane et al., 2004). Initially, between 1979 and 1985 water depth was recorded every two months, then from the end of 1985 water depth was recorded biannually during September and November only (see: Lane, 2008). Since December 2006, DEC Esperance District Office have recorded the water depth at Lake Gore on a monthly basis (see: Department of Environment and Conservation, 2008b). The most comprehensive long term data appropriate for statistical analysis is the spring period (i.e. September and November records). It should be noted that the spring records represent Lake Gore at its maximum water depth.

The depth trend at Lake Gore prior to listing was of higher water levels during spring and lower water levels during the summer/autumn period (Figure 13). This trend is the typical pattern of water depth reflected in some other wetlands of the south west of Western Australia (Halse & Jaensch, 1989). The highest water depth recorded at Lake Gore prior to listing was in November 1992 with 2.84 m and the lowest was in March 1984 where Lake Gore was dry, with zero metres recorded (Figure 13). A dry period occurred from 1982 to 1984 when seasonal water levels recorded for Lake Gore were at their lowest and mostly below 1 m (Figure 13).

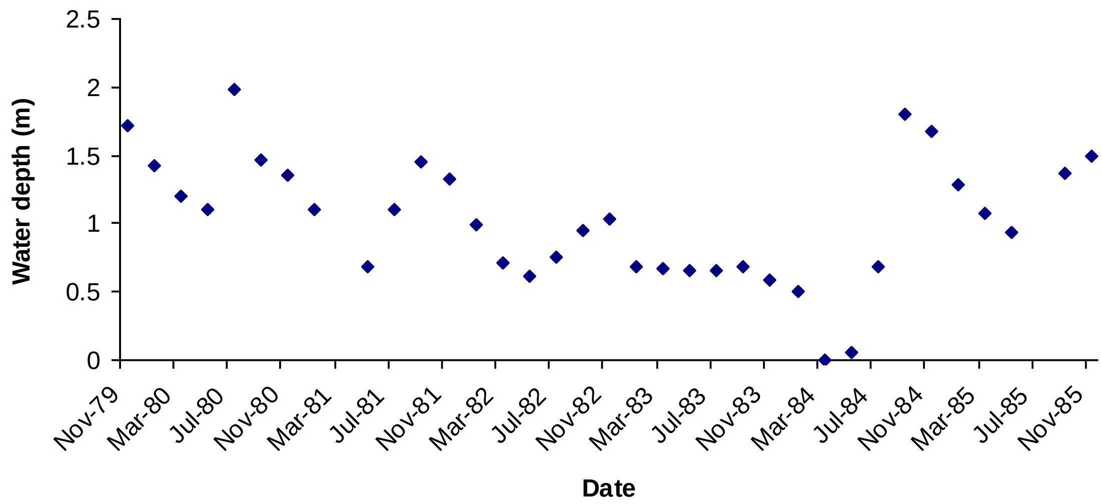


Figure 13. Seasonal water depth from November 1979 to November 1985 (prior to listing) at Lake Gore, Esperance, Western Australia (data from Lane, 2008).

The highest water depth recorded post listing at Lake Gore was 2.24 m in January 2007 (Figure 14). This high water depth is not usual during this time of year and was due to flooding as a result of an unseasonal episodic rainfall event (see: Section 2.4 Climate). The lowest water depth post listing was 0.68 m recorded in April 2001 (Figure 14). The most recent monthly water depth data (i.e. from 2006 – 2008) indicates that Lake Gore is remaining inundated throughout the year with an average depth of 1.5 m (n=36) (Figure 14). This change in ecological character is discussed further in Section 5.2 Changes to Critical Components and Processes.

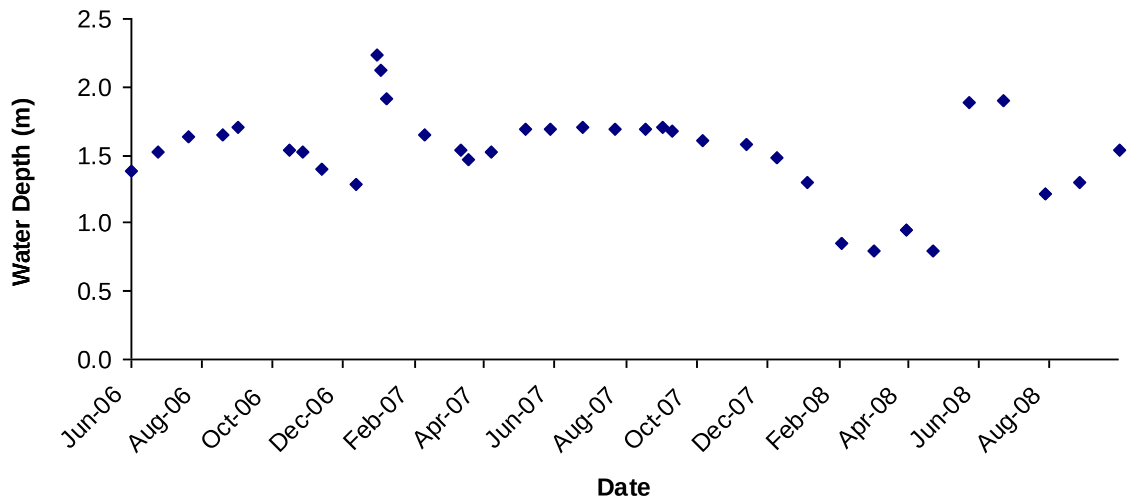


Figure 14. Monthly water depth from June 2006 to October 2008 (post listing) at Lake Gore, Esperance, Western Australia (data from Department of Environment and Conservation, 2008b; Lane, 2008).

The mean (± standard deviation) water depth for September 1980 to 2000 and November 1979 to 2000 (prior to listing) was 1.49 m (± 0.40) and 1.44 m (± 0.45) respectively (Figure 15). No statistically significant trends in the September and November water levels from 1979 - 2000 were found (Gupta & Collinson, 2008; Lane et al., 2004).

The mean (± standard deviation) water depth for September 2001 to 2008 and November 2001 to 2008 (post listing) was 1.6 m (± 0.24) and 1.5 m (± 0.23) respectively (Figure 15). This indicates that post listing, the September and November mean water depths are slightly higher with less variability. However, no statistically significant trends in the water levels from September and November 2001 to 2008 were found (Gupta & Collinson, 2008). Additionally, no significant trends in September and November water depths were apparent from 1979 to 2008 (Gupta & Collinson, 2008).

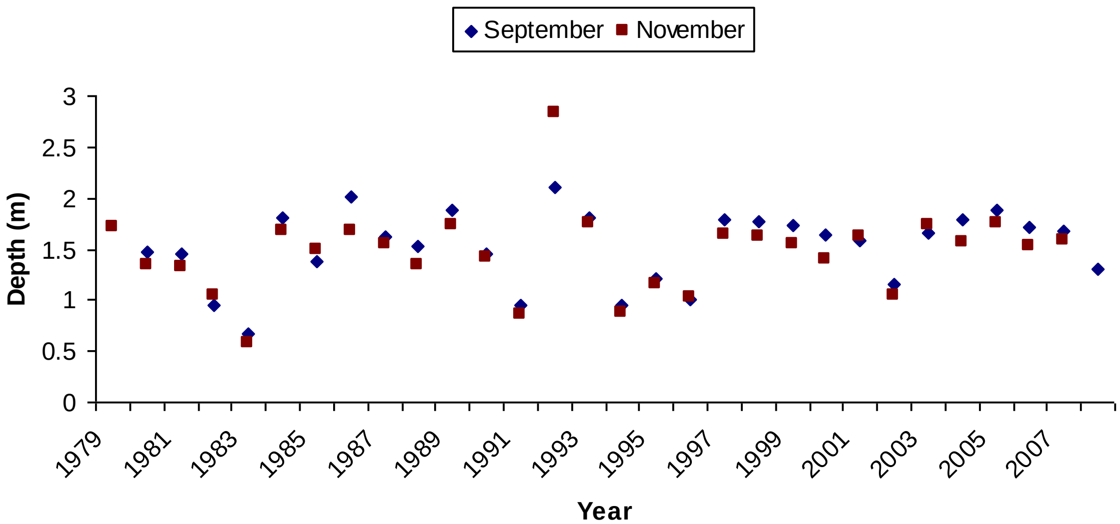


Figure 15. Biannual water depths recorded during September (1980 - 2007) and November (1979 - 2008) for Lake Gore, Esperance, Western Australia (data from Department of Environment and Conservation, 2008b; Lane, 2008).

The September and November records from 1979 to 2000 (prior to listing) indicate an annual rate of rise of 0.007 m and the September and November records from 2001 to 2008 (post listing) indicate an annual rate of rise of 0.013 m (Gupta & Collinson, 2008). However, these rates of rise are not statistically significant (see: Gupta & Collinson, 2008).

Although there are no statistically significant trends in water depth at Lake Gore, describing water depth only explains part of the “story”. As Lake Gore has a comparatively broad, uniform bathymetry (see: Section 3.1.1 Geomorphology) small increases in water depth may result in a larger area than usual, being inundated. Observations of Lake Gore suggest that the altered hydrological regime has caused increases in the extent and duration of water inundation (Tilo Massenbauer, Recovery Catchment Officer, DEC, pers. comm., 2008). Optimal wading waterbird habitats have been reduced and the riparian zone has been impacted, resulting in vegetation death (mainly *Melaleuca cuticularis*) and condition decline (Tilo Massenbauer, Recovery Catchment Officer, DEC, pers. comm., 2008).

The current and optimum exposed shore zone area (as a result of extent of inundation) have been calculated for Lake Gore using geographical information systems (GIS), bathymetry volume calculations, and historic and current lake depth data (see: Massenbauer, 2008b; Robertson & Massenbauer, 2005). The optimum minimum and maximum exposed shore zone area for Lake Gore is 45 ha - 200 ha and is based on historical ranges (Massenbauer, 2008b; Robertson & Massenbauer, 2005). During the current hydrological regime the minimum and maximum exposed shore zone area at Lake Gore has been reduced to 0 ha - 90 ha (Massenbauer, 2008b; Robertson & Massenbauer, 2005). Thus the optimum minimum and maximum shore zone areas have been reduced by 45 ha and 110 ha respectively. This change in ecological character is discussed further in Section 5.2 Changes to Critical Components and Processes.

Groundwater trends

Mean depth to groundwater within the Dalyup catchment from 1990 to 2000 has ranged from 1.3 - 2.2 m (Simons, 2001). Data collected by the Department Agriculture and Food Western Australia (DAFWA) from groundwater monitoring sites on the Dalyup catchment indicates that groundwater levels increased from 1990 to 2000 at a rate of between 0 cm and 35 cm per year (George et al., 2008). The trend from 2000 to 2007 indicates similar rises in groundwater level (George et al., 2008). However, some groundwater areas in the Dalyup catchment appear to be stagnant with little increase; these groundwater aquifers are close to full capacity and are unable to store any significant amounts of additional water (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008).

The hydrograph from observation bores installed around Lake Gore in 2003 to monitor groundwater influences, indicates a seasonal trend, with depth to groundwater increasing in the summer months and decreasing in the winter months (Figure 16). The groundwater data indicates that the majority of the groundwater surrounding Lake Gore is less than 2.5 metres from the surface (Figure 16). The groundwater levels recorded from these observation bores suggest that the aquifers surrounding Lake Gore have reached full capacity (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008). Although seasonal fluctuations are apparent, the increases in depth to groundwater during summer months is most likely due to the effects of evapo-transpiration (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008).

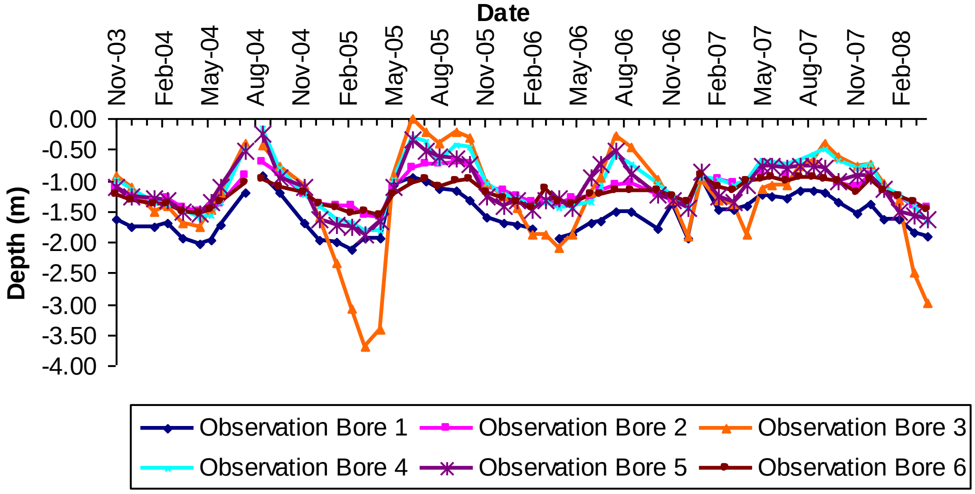


Figure 16. Depth to groundwater records November 2003 to April 2008 for observation bores located at Lake Gore, Esperance, Western Australia (data from Department of Environment and Conservation, 2008c).

The consistently high groundwater levels reflect the current altered hydrological regime experienced by the Lake Gore Ramsar Site and the surrounding catchments. The result is that soil pore spaces are full of water and waterlogging occurs, increasing surface water runoff and causing anaerobic conditions for the roots of vegetation. Constant waterlogging as a result of high groundwater levels also increases the incidence of secondary salinisation which is a threatening processes at the site (Comer et al., 2001).

3.1.3 WATER QUALITY

The measurement of water quality involves sampling a suite of physico-chemical parameters such as pH, salinity, metal and nutrient concentrations, which aids in understanding the physical and chemical processes that occur in wetlands.

The physico-chemical suite recorded for the Lake Gore Ramsar Site has been limited to Lake Gore itself. It includes pH and the concentration of salinity, nitrogen and phosphorus. As with water depth these parameters have all been recorded as part of the SWWMP (see: Lane, 2008).

Salinity concentrations at Lake Gore were measured at the same time as water depth, with seasonal data recorded every two months to the end of 1985, and then biannually in September and November only (see: Lane, 2008). The recording of pH began in 1981 with intermittent seasonal measurement continuing until the end of 1985, then biannually in September and November (see: Lane, 2008).

The concentrations of total phosphorus (TP) and soluble reactive phosphorus (SRP) have been recorded at Lake Gore biannually (September and November) since 1991 (see: Lane, 2008). However, seasonal TP concentrations were recorded during a limited period in 1984 / 1985 (see: Lane, 2008). Total nitrogen (TN) and total soluble nitrogen (TSN) have also been recorded at Lake Gore biannually (September and November) since 2000 (see: Lane, 2008).

In 2006, DEC Esperance District Office began recording conductivity as a measure of salinity, and pH on a monthly basis (see: Department of Environment and Conservation, 2008b). The pH, salinity and nutrient concentrations continue to be recorded biannually (September and November), as part of the SWWMP (see: Lane, 2008). The spring data from the SWWMP is the most comprehensive to describe pH, salinity and nutrient concentrations at Lake Gore.

3.1.3.1 Lake Gore water physico-chemical properties

Salinity concentrations

The salinity of a wetland can be influenced by geology, precipitation and evaporation. Salinity has a major affect on aquatic invertebrate species composition with increasing salinities reducing aquatic invertebrate species richness (Blinn, 2004; Pinder et al., 2004). However, some saline wetlands are also amongst the most productive wetlands for plants, birds, fish and invertebrates.

The salinity at Lake Gore has remained relatively stable during September and November from 1979 to 2007 (Figure 17). Mean (± standard deviation) salinity concentrations for September from 1979 to 2007 were 44.2 (± 29.4) parts per thousand (ppt) and for November they were 53.5 (± 44.3) ppt. Salinities have generally been saline to hypersaline (Figure 17) with sea water being on average 35 ppt (ANZECC and ARMCANZ, 2000b). In 1983, there was a peak in the salinity concentrations for September and November with 160 ppt and 250 ppt recorded respectively (Figure 17). These coincide with the lowest water levels recorded for Lake Gore which occurred from 1982 to 1984 (see: Section 3.1.2 Hydrology). Seasonal salinity data indicates the highest salinity concentrations recorded for Lake Gore occurred during 1982 to 1984, with salinity concentrations ranging from 90 ppt to 342 ppt (see: Lane, 2008). A strong inverse relationship between water depth and salinity has been noted at Lake Gore with a dramatic increase in salinity observed as water levels approach zero metres (Lane et al., 2004). The lowest salinity concentration recorded for Lake Gore was in November 1989 at 6.5 ppt (Figure 17).

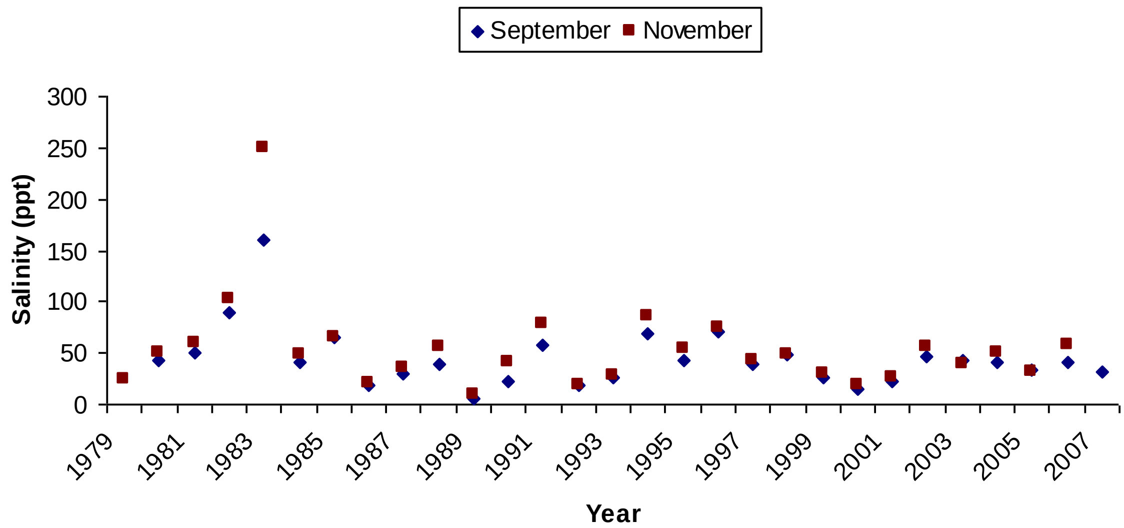


Figure 17. Salinity concentrations recorded in September and November from 1979 - 2007 at Lake Gore, Esperance, Western Australia (data from Lane, 2008).

As salinity concentrations are influenced by the volume of water, the measurement of salinity loads entering Lake Gore from the surrounding catchments would aid in the assessment of any trends in salinity.

pH

Recording pH is important, apart from the information it provides in terms of alkalinity or acidity, pH fluctuations can also affect metal toxicity. For example low pH or acidic conditions increase the solubility of metals which can increase their concentrations. Metals such as aluminium and iron have recognised negative impacts on fish resulting in kills (Sammut et al., 1995; Stephens & Ingram, 2006). Acidic conditions also provide a poor environment for vegetation and generally only a few fauna species such as mosquitoes can survive acidic water conditions. The pH conditions therefore have a strong influence on the composition of biota and any changes in pH could dramatically affect food webs.

The pH levels recorded at Lake Gore in September and November from 1982 to 2007 were generally alkaline (i.e. pH > 7) and no changes in pH since listing are apparent (Figure 18). Seasonal data also indicates that no trends in pH since listing are apparent (see: Department of Environment and Conservation, 2008b; Lane, 2008). The highest pH was recorded in November 1999 at 9.8 and the lowest pH was recorded in September 1995 at 6.8 (Figure 18).

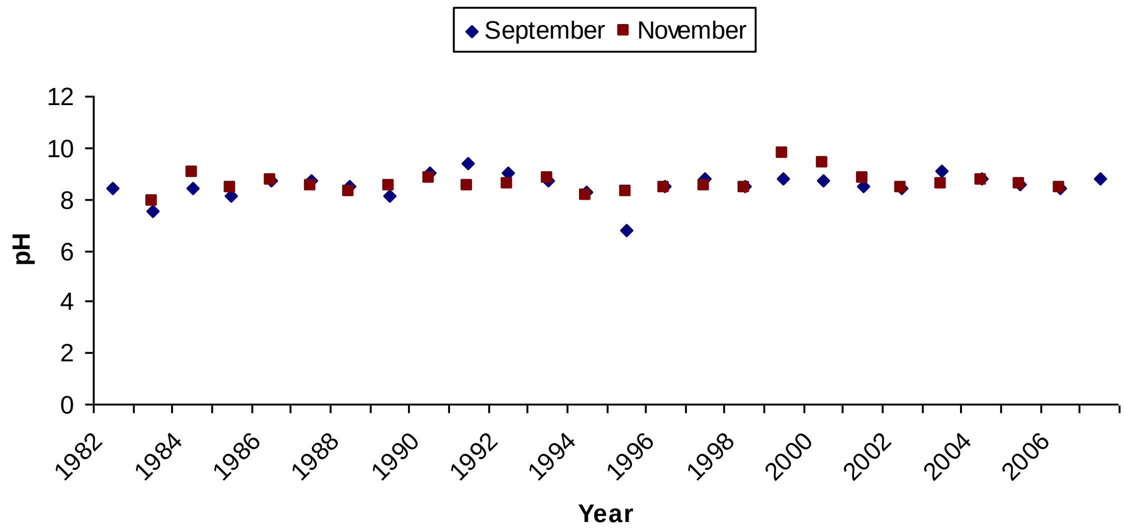


Figure 18. pH recorded in September and November from 1982 - 2007 at Lake Gore, Esperance, Western Australia (data from Lane, 2008).

Nutrient and chlorophyll *a* concentrations

The macronutrients nitrogen and phosphorus are often considered to be “limiting nutrients” as excessive amounts of these nutrients (i.e. eutrophication) can cause a dramatic increase in algal growth within a wetland (Boulton & Brock, 1999). Conversely, a wetland that is oligotrophic or nutrient poor is unproductive as it contains little nutrients to sustain an abundance of plant and animal life. Nutrient sources can be both natural (e.g. internal cycling of nutrients within an ecosystem) and artificial (usually anthropogenic sources e.g. fertilisers). Both natural and artificial sources have the potential to cause eutrophication.

The presence of algae or in particular chlorophyll *a* concentrations within the water are used as a surrogate indicator for nutrient pollution (ANZECC and ARMCANZ, 2000b). Excessive algal growth and subsequent death can reduce dissolved oxygen levels, increase turbidity and therefore affect the water quality. This causes distress to other biota with invertebrates, fish and waterbirds impacted by low oxygen concentrations and the toxic affects of algal blooms (Balla, 1994). Major algal blooms have occurred at Lake Gore which have been associated with agricultural fertilisers applied on the Dalyup catchment (Water and Rivers Commission, 2002). However, waterbird populations could also be a contributing factor in eutrophication, as waterbird excrement has been found to promote eutrophication of water bodies (Mukherjee & Borad, 2001). Waterbird excrement could be a synergist to the diffuse nutrient input from the Dalyup catchment (Figure 19).

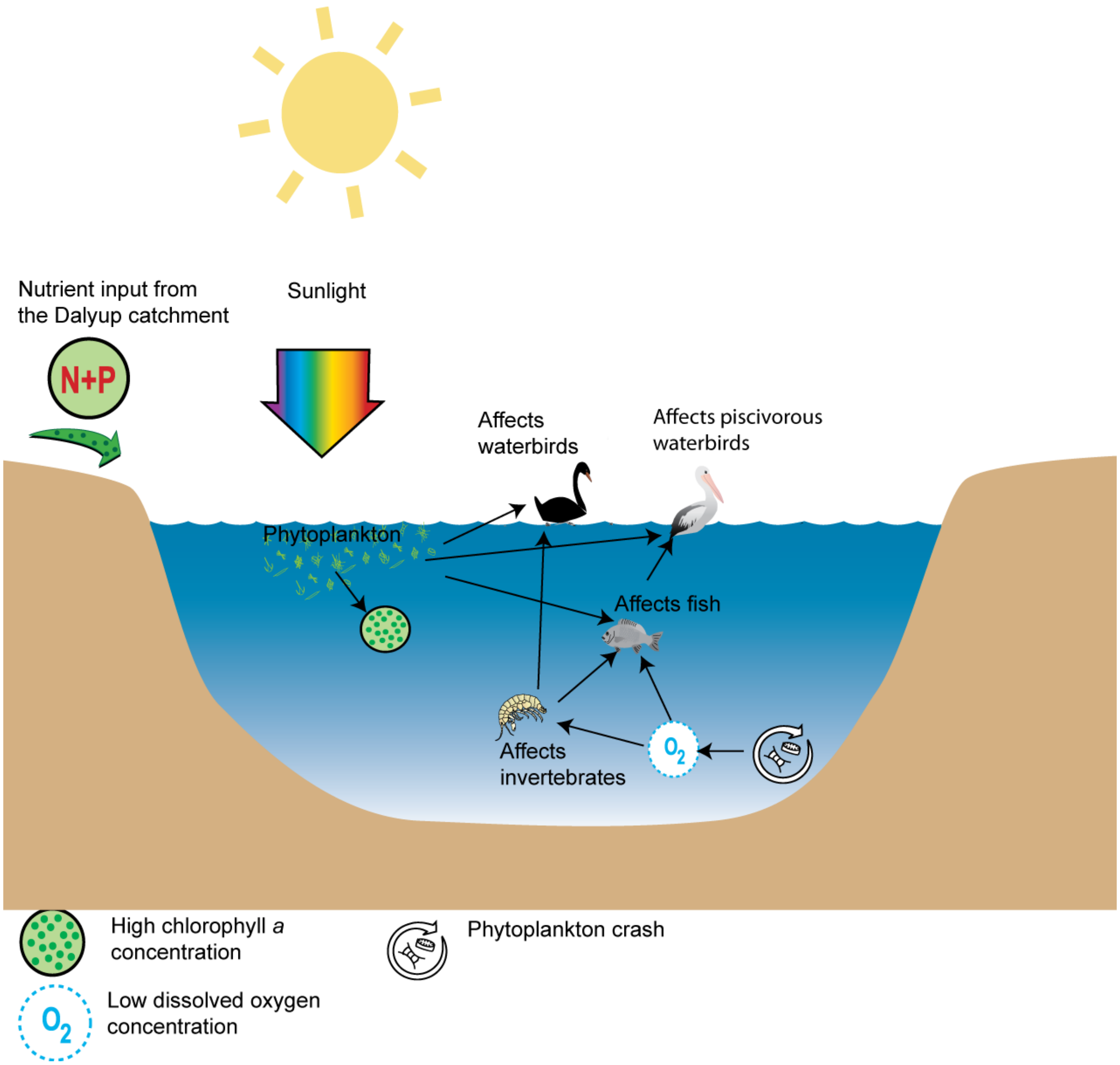
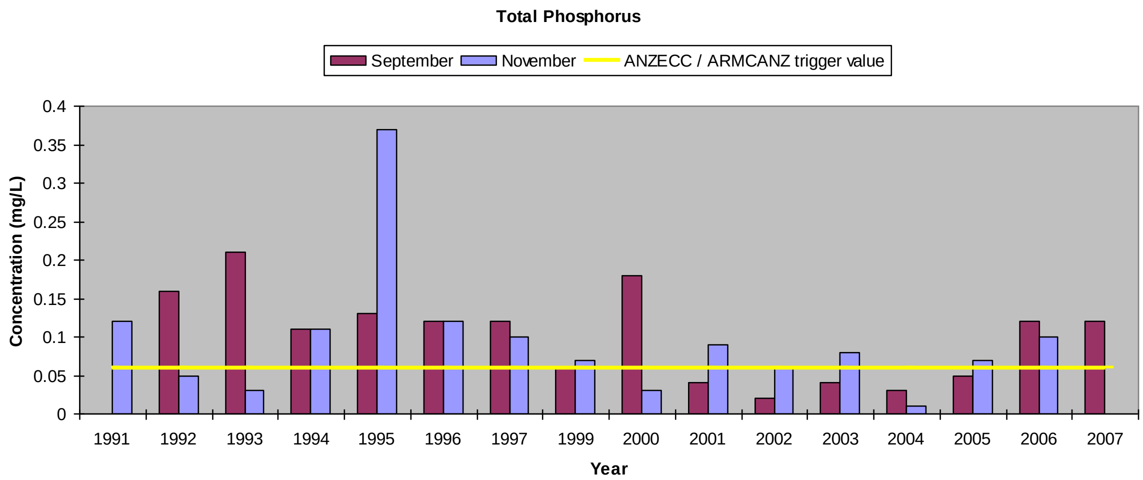


Figure 19. Conceptual model of the potential effect of nutrient enrichment combined with waterbird excrement at Lake Gore, Esperance, Western Australia.

The majority of TN and TP concentrations recorded for Lake Gore during spring (September and November) have exceeded the trigger values set by ANZECC and ARMCANZ (2000b) for wetlands of the south west of Western Australia (Figure 20). ANZECC and ARMCANZ (2000b) recommends trigger values for TP are to be compared against values that are recorded in summer. ANZECC and ARMCANZ (2000b) trigger values are derived from freshwater ecosystems and therefore in this instance they are used only as a guide.

There are no apparent trends in TN and TP concentrations, although they are notably lower between 1999 and 2005 with the exception of September 2000 (Figure 20), which could be attributed to dilution effects from large volumes of water received by Lake Gore during episodic rainfall events in January 1999 and March 2000 (see: Section 2.4 Climate).



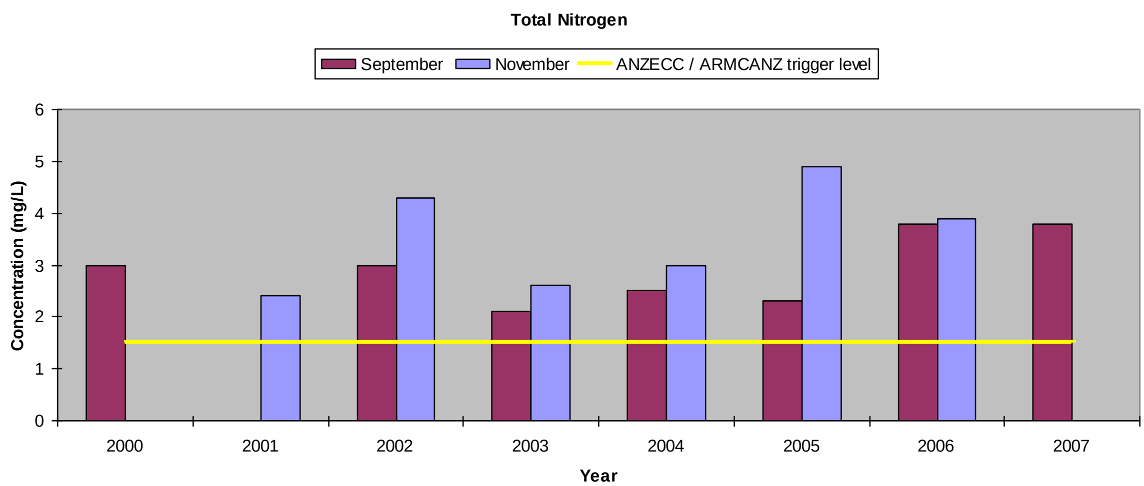
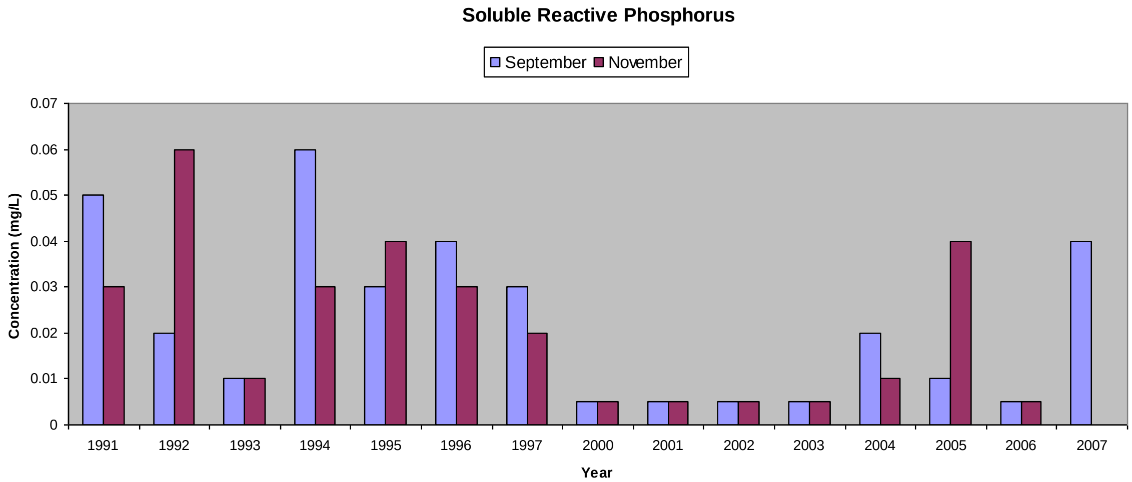


Figure 20. Total nitrogen 2000 - 2007 and total phosphorus 1991 - 2007 concentrations (September and November records) together with ANZECC and ARMCANZ trigger values at Lake Gore, Esperance, Western Australia (data from Lane, 2008). Note: Zero value indicates no record was taken.

There are no ANZECC and ARMCANZ (2000b) guideline trigger values for SRP or TSN for wetlands in the south west of Western Australia. Recording SRP and TSN concentrations gives an indication of the bioavailability of these nutrients. The concentration of SRP at Lake Gore ranged from 0.005 mg/L to 0.06 mg/L (Figure 21). There was a notable reduction in the concentration of SRP between 2000 and 2003 (Figure 21), which again may be the result of dilution effects after major storm events in 1999 and 2000 (see: Section 2.4 Climate).



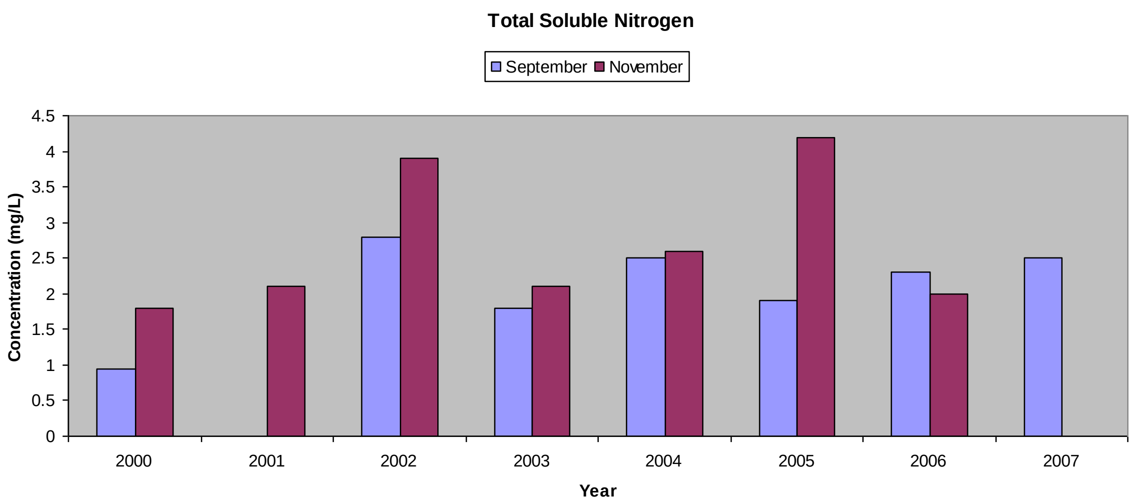


Figure 21. Total soluble nitrogen 2000 - 2007 and soluble reactive phosphorus 1991 - 1997 & 2000 - 2007 concentrations (September and November records) at Lake Gore, Esperance, Western Australia (data from Lane, 2008). Note: Zero value indicates no record was taken.

Chlorophyll *a* concentration was recorded during a single survey at 0.081 mg/L (see: Pinder et al., 2004), which indicated a hypereutrophic status (ANZECC and ARMCANZ, 2000b). This exceeded the trigger level of 0.03 mg/L for chlorophyll *a* concentrations in wetlands of the south west of Western Australia set by ANZECC and ARMCANZ (2000b).

The ANZECC and ARMCANZ (2000b) trigger levels are guidelines only and a more appropriate comparison of “natural” background conditions would be obtained from a reference site. Doombup Lake is located approximately 12 km east of Esperance and is also within the Esperance Plains Biogeographic Region. It is a hypersaline lake considered to be in “pristine” condition (Calvert & Randall, 2008). Doombup Lake will be considered here as a suitable reference site for Lake Gore.

Surveillance of Doombup Lake was undertaken in January, July and December of 2006 and in May 2007, for a number of water quality parameters including nutrient and chlorophyll *a* concentrations (see: Calvert & Randall, 2008). The concentrations for TP were below most of Lake Gore's concentrations, ranging from 0.033 mg/L to 0.046 mg/L (Calvert & Randall, 2008). The concentrations of SRP were also mostly below the concentrations of Lake Gore ranging from 0.005 mg/L to 0.011 mg/L (Calvert & Randall, 2008). The TN concentration ranged from 0.67 mg/L to 0.93 mg/L (Calvert & Randall, 2008), which were lower than those of Lake Gore. The chlorophyll *a* concentrations were also lower ranging from 0.004 mg/L to 0.005 mg/L (Calvert & Randall, 2008). In addition, the concentrations for Doombup Lake were consistently below the ANZECC and ARMCANZ (2000b) trigger levels.

The reasons for the low nutrient and chlorophyll *a* concentrations are thought to be due to a well vegetated catchment which is absorbing a large proportion of nutrients prior to entering Doombup Lake (Calvert & Randall, 2008). In comparison to Doombup Lake, the nutrient and chlorophyll *a* concentrations recorded at Lake Gore appear high. However, nutrient concentrations only reflect the capacity of the wetland to increase plant biomass with temperature, light and the ratio of nutrients also being limiting factors. The apparent elevated levels of nutrients recorded at Lake Gore are only a problem if they adversely affect the wetland, for example in the regular occurrence of algal blooms. Nutrient loads and the frequency of algal blooms are additional measurements that are required in order to ascertain if Lake Gore has a nutrient problem.

3.1.3.2 Catchment surface and ground water physico-chemical properties

Salinity concentrations

The salinity concentrations of the surface waters of the Dalyup catchment and the Coobidge Creek catchment range from saline to hypersaline, with concentrations decreasing down the catchment toward the coastal plain (see: Cook & Janicke, 2008; May, 2008). The same pattern is observed in the groundwater of the Dalyup catchment, where fresh to brackish water can be found on the sandplain and groundwater salinities further north in the catchment are hypersaline (Simons, 2001). Observation bores installed in 2003 indicate the groundwater in the vicinity of Lake Gore is brackish to saline (Department of Environment and Conservation, 2008c). To a large extent the groundwater in the Tertiary palaeochannels in the Esperance region often contains hypersaline water (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008).

It is likely that Lake Gore receives some fresh groundwater discharge from the dunes to the south of the site and from rainfall that runs off the northern granite escarpment, which would ameliorate the lake's salinity concentrations (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008). These discharges probably provide fresh to brackish water seeps around the edges of the lake, which may be important water sources for waterbirds and other wildlife that use the lake (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008).

pH

Recently there have been low pH (< 5) surface waters recorded in the upper Coobidge and Dalyup catchments (see: Cook & Janicke, 2008; Lillicrap & Simons, 2009). The lowest pH recorded were 3.4 in the Dalyup catchment and 3.59 in the Coobidge Creek catchment (Cook & Janicke, 2008; Lillicrap & Simons, 2009). Comparable low pH values have also been recorded in some groundwater in the Esperance Region (Steve Appleyard, Hydrogeologist DEC, pers. comm., 2008). These conditions are not evident lower in the catchment and are probably due to the mixing of groundwater discharging from the coastal dunes which is often slightly alkaline from the carbonate minerals found in aquifer sediments (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008). Data from observation bores surrounding Lake Gore, indicates that groundwater in the vicinity of Lake Gore generally has a pH > 7; although on occasions it has dropped below this, with the lowest pH of 4.29 recorded in October 2007 (Figure 22).

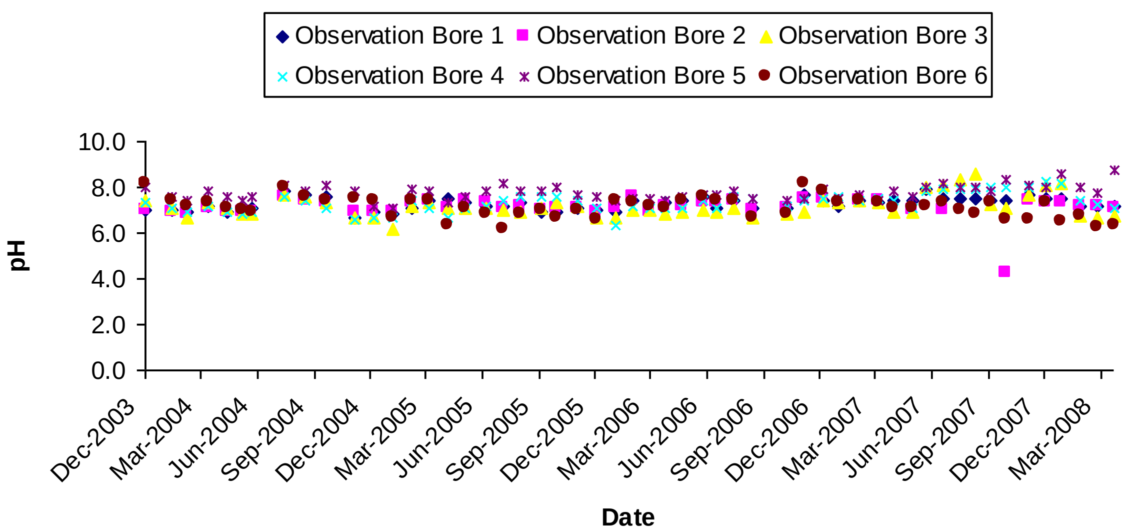


Figure 22. Recorded pH from December 2003 to April 2008 for observation bores located at Lake Gore, Esperance, Western Australia (data from Department of Environment and Conservation, 2008c).

Lake Gore is considered to be alkaline (> 7) (see: Section 3.1.3.1 Lake Gore Water Physico-chemical Properties) and the available data suggest that the lake has not been affected by acidity. The major buffering capacity within Lake Gore is probably being provided by the biogeochemical cycling of organic carbon in the wetland and to a lesser extent by the inputs of alkaline groundwater from dunes to the south of the wetland (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008).

Associated with the acidic surface waters recorded in the Dalyup catchment and the Coobidge Creek catchment there have been recordings of high metal concentrations (see: Lillicrap & Simons, 2009). Notably aluminium concentrations of up to 66 mg/L have been recorded in the Dalyup River (Lillicrap & Simons, 2009). The combination of low pH water and high aluminium concentrations have had documented negative affects on biota and in particular fish (Sammut et al., 1995; Stephens & Ingram, 2006). Figure 23 illustrates what is possibly the precipitation of aluminium oxide as a result of acidic water in the Dalyup River.

Figure 23. Possible aluminium oxide precipitating out of the acid water at the point of increased dissolved oxygen and turbulence in the Dalyup River (photo from Cook & Janicke, 2008).

A possible source of the acidity is from the Tertiary palaeochannels, which as well as containing hypersaline water are often acidic (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008). As the water table in the region is rising (see: Section 3.1.2 Hydrology), due to changes in water balances caused by land clearing, it is possible that rising water tables are allowing this acidic groundwater to discharge to surface drainages in the area (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008).

There is a significant risk that as a result of the groundwater rising in the catchments surrounding the site, that the quality of water inputs to Lake Gore will diminish with time and reduce the capacity of the lake to support wildlife (Steve Appleyard, Hydrogeologist DEC, pers. comm., 2008). The low pH surface waters of the catchments surrounding the Lake Gore Ramsar Site are potentially a significant threat to the ecological character of the site which requires further investigation. Discussion of this threat to the ecological character of the Lake Gore Ramsar Site will be included in Section 4.0.

Nutrient & chlorophyll *a* concentrations

Previous surveys of nutrient concentrations in the Dalyup River in 1995 and 1998 indicate levels exceeding the ANZECC and ARMCANZ (2000b) trigger values for rivers in the south west of Western Australia (Water and Rivers Commission, 1999).

More recent surveys of the Dalyup and Coobidge Creek catchments still indicate levels exceeding the ANZECC and ARMCANZ (2000b) guidelines. In December 2006 TN concentration on the Dalyup River West was recorded as high as 3 mg/L and on the Dalyup River 1.2 mg/L (Cook & Janicke, 2008). The concentrations of TP were recorded on the Dalyup River West and The Dalyup River at a maximum of 0.015 mg/L and 0.034 mg/L respectively (Cook & Janicke, 2008). The maximum TN and TP concentrations at Coobidge Creek were 2.9 mg/L and 0.034 mg/L respectively (Cook & Janicke, 2008). Chlorophyll *a* concentrations in the Dalyup catchment and Coobidge Creek catchment were below the ANZECC and ARMCANZ (2000b) guidelines (Cook & Janicke, 2008).

Surveillance of the Dalyup and the Coobidge Creek catchments from 2006 to 2008 recorded similar concentrations of TN and TP (see: May, 2008). The concentration of SRP was also recorded for these two catchments. The mean SRP concentration of Coobidge Creek was 0.007 mg/L whilst the mean concentration of SRP in the West Dalyup River and the Dalyup River was 0.014 mg/L and 0.026 mg/L (May, 2008).

Further quantification in terms of nutrient loads that are entering Lake Gore from surrounding catchments is required.

3.1.4 PHYSICAL PROCESSES

Sedimentation

Land clearing to make way for agriculture in the Dalyup and the Coobidge Creek catchments has resulted in a significant reduction in native vegetation. This has increased surface water runoff and reduced sediment entrapment, therefore increasing sediment transportation. These sediment loads subsequently make their way into the Dalyup River, depositing greater sediment loads than what would be expected in a vegetated catchment. Aerial photography shows plumes of sediment moving along the Dalyup and West Dalyup Rivers (Water and Rivers Commission, 1999). This has resulted in a clearly visible delta on the eastern side of Lake Gore consisting of sediment deposited from where the Dalyup River terminates (Water and Rivers Commission, 1999). Lake Gore on average has annually received 11,508 t / yr of sediment with a specific yield of 37.5 km^2 / yr (Callow, 2007). Studies on the rates of sedimentation conducted in the centre of Lake Gore suggest a 50 times increase in sedimentation rates since clearing of the Dalyup catchment (Street & Abbott, 2005). Pre-clearing sedimentation rates in Lake Gore were 8 mm per 100 years and post clearing (i.e. the last 50 years) sedimentation rates have been 400 mm per 50 years (Street & Abbott, 2005).

Flood events such as those of 1999, 2000 and 2007 also have a role to play in the sedimentation rates of Lake Gore. After the January 1999 floods, maximum flood erosion estimates were close to 10,000 m^3 / km of channel (Janicke, 2000). If this volume of sediment reached Lake Gore and was distributed over the bed of the lake it would have added a layer of between 30 mm and 45 mm deep resulting in ecological implications (Janicke, 2000). Nonetheless even reduced amounts of sediment could have adverse ecological affects.

The increased sedimentation rates pose a threat to the ecological character of the Ramsar site as it alters the bathymetry of the lake making it shallower. This displaces water and increases the extent of inundation while reducing the amount of exposed shore zone and wading waterbird habitat. In addition, wetland vegetation will be inundated by the saline waters of Lake Gore.

Further investigation on sediment loads and its affect on bathymetry need to be undertaken, in particular the spatial differences throughout Lake Gore.

3.1.5 WETLAND SOILS

Soil physico-chemical properties

Soils of the site are characterised as alkaline grey sandy duplex soils, pale deep sands and saline wet soils. The components of the lithology of the lacustrine sediments of Lake Gore itself consist of an upper marl unit of carbonate rich clay (0 - 98 cm); a middle gypsum/clay unit (98 - 233 cm); a carbonate nodule clay unit (233 - 239 cm); and a basal marl unit (239 - 274 cm) (Wilson, 2003).

The soil that is typically inundated (as described by: Lyons et al., 2004) has been recorded as having 0.18% organic carbon content; an average sand content of 94.35%; an average clay content of 5.25% and an average silt content of 0.4% (Lyons et al., 2004). The pH of inundated soil was recorded at 9.1 and 9.2. The concentration of TP of the inundated soil was recorded at 32 mg/L and 28 mg/L and TN concentration was recorded at 0.014 mg/L and 0.012 mg/L (Lyons et al., 2004). The elevated flat zone, which at the time of the study was considered to be inundated during extreme events, had a 1.8% organic carbon content; a 5.8% clay content; a 4.6% silt content; and a 89.7% sand content (Lyons et al., 2004). This study also included the recording of other soil physico-chemical attributes as well as the terrestrial soil (see: Lyons et al., 2004).

Core samples that have been taken from Lake Gore itself indicate an elevated amount of TP concentrations from 1955 onward, which coincides with superphosphate application on the Dalyup catchment (Wilson, 2003). Analysis of the surface sediments (≤ 10 cm) has indicated that TP was between 250 - 260 mg / kg (Wilson, 2003). This analysis also indicated landscape salinisation began approximately 6000 years ago.

The soils of the Gore system have been recognised with a high probability of having potential acid sulfate soils (PASS) (Massenbauer, 2007). However, if PASS are identified and remain undisturbed, they should not cause any adverse environmental conditions i.e. becoming actual acid sulfate soils (AASS) (see: Text Box 2).

The formation of AASS produces sulfuric acid, with the soil and surrounding waterways becoming acidic. While acidity alone may affect biota, acidic conditions also promote the release of metals from the sediments including potentially lethal quantities of heavy metals. Section 4.0 explains the threat of acid sulfate soils on the ecological character of the Lake Gore Ramsar Site.

Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils and sediments containing iron sulfides, most commonly pyrite. When ASS are exposed to air the iron sulfides in the soil react with oxygen and water to produce a variety of iron compounds and sulfuric acid. Initially a chemical reaction, the process is accelerated by soil bacteria. The resulting acid can release other substances, including heavy metals, from the soil and into the surrounding environment.

Potential acid sulfate soils

ASS which have not been oxidised by exposure to air are known as potential acid sulfate soils (PASS). While contained in a layer of waterlogged soil, the iron sulfides in the soil are stable and the surrounding soil pH is often weakly acid to weakly alkaline.

Potential acid sulfate soils:

- often have a pH close to neutral (6.5 - 7.5)
- contain unoxidised iron sulfides
- are usually soft, sticky and saturated with water
- are usually gel-like muds but can include wet sands and gravels
- have the potential to produce acid if exposed to oxygen.

Actual acid sulfate soils

When PASS are disturbed or exposed to oxygen, the iron sulfides are oxidised to produce sulfuric acid and the soil becomes strongly acidic (usually below pH 4). These soils are then called actual acid sulfate soils (AASS) - that is, they are already acidic.

Actual acid sulfate soils:

- have a pH of less than 4
- contain oxidised iron sulfides
- vary in texture
- often contain jarosite (a yellow mottle produced as a by-product of the oxidation process).

How are acid sulfate soils formed?

Although some ASS were formed millions of years ago and occur in ancient marine rocks, those of most concern were formed after the last major sea level rise - within the past 10,000 years (Holocene period). When the sea level rose and flooded the land, sulfate in the seawater mixed with land sediments containing iron oxides and organic matter. The resulting chemical reaction produced large quantities of iron sulfides in the waterlogged sediments. When exposed to air, these sulfides oxidise to produce sulfuric acid, hence the name acid sulfate soils.

Text Box 2. Acid sulfate soils (from Department of Environment and Conservation, 2008a).

3.1.6 BIOTA

3.1.6.1 Waterbirds

The diversity, abundance and distribution of waterbirds is dependant upon habitat characteristics. This includes the availability, distribution and density of food; size, shape and physico-chemical characteristics of the waterbody; and the availability of suitable sites for breeding and nesting (Goodsell, 1990; Halse et al., 1993; Wiens, 1989). Diversity and abundance of waterbirds may also change due to migration flux, birth and death rates.

Waterbird behaviour and functional morphology dictates which habitats birds occupy. For example, waterbirds occupy different water depths (habitats) within a wetland in order to satisfy their dietary requirements. Waterbirds are limited to certain habitats within a waterbody due to the size and function of their body parts such as the size and shape of their bill (Elner et al., 2005). Changes in habitat characteristics may affect the diversity and abundance of waterbird species that are able to use a wetland area. For example seasonal changes, such as the differences between summer and winter rainfall affecting water depth.

Waterbirds can occupy a series of guilds, which are groupings where the individuals share similar ecological requirements or have similar behaviours. Jaensch (2002) describes a series of waterbird guilds and this information has been combined with a literature review by Cowcher (2005) to organise the waterbird species recorded at the Lake Gore Ramsar Site into waterbird guilds and other ecological requirements (see: Appendix B).

Describing the ecological requirements of the waterbirds recorded at the Lake Gore Ramsar Site is an essential component of the ECD. If environmental conditions change outside of these requirements the resulting habitat may no longer be suitable for all of the waterbird species that have been recorded at the Lake Gore Ramsar Site. These ecological requirements therefore contribute to setting the limits of acceptable change for the Lake Gore Ramsar Site (see: Section 6.0 Limits of Acceptable Change).

Waterbird surveys at the Lake Gore Ramsar Site have been conducted as part of various DEC projects (formerly Department of Conservation and Land Management [CALM]). Surveys include the CALM Water Birds in Nature Reserves Project; CALM Annual Waterfowl Counts and other CALM Aquatic Projects and were undertaken during 1981 - 1992 and 1998. The initial surveys (July 1981 - May 1988) under the CALM Water Birds in Nature Reserves Project were conducted by the Royal Australasian Ornithologists Union (see: Jaensch et al., 1988). From November 1988 to March

1992 the Annual Waterfowl Counts in South-west Western Australia Project was conducted by CALM staff, however, these surveys only recorded waterfowl, namely ducks, swans and coots (see: Halse et al., 1992; Halse et al., 1990; Halse et al., 1995; Halse et al., 1994).

In November 1998, a single waterbird survey was also conducted as part of the Biodiversity Survey of the Western Australian Agricultural zone (see: Keighery et al., 2004). Various waterbird surveys have also been conducted by Birds Australia, including specific Hooded Plover surveys during 1994 - 1998 and 2003, 2006 and 2007 as part of the Hooded Plover Project (see: Newbey, 1996; Singor, 1999).

Other single waterbird surveys were conducted in November 2002 and February 2003 (see: Buchanan, 2003; Clarke & Lane, 2003). Bennelongia Environmental Consultants have recently conducted aerial surveys in spring of 2006 and 2007 and in the summer of 2008 (see: Bennelongia, 2008a; Bennelongia, 2008b; Halse, 2007).

Species diversity and abundance

Waterbird surveys at Lake Gore have resulted in a total of 53 species being recorded for the site (Table 5). This includes 25 waterbirds listed under the EPBC Act, 24 are listed as “Marine” species and 14 species are listed as “Migratory” and are included under the international migratory agreements CAMBA (14), JAMBA (13), ROKAMBA (11) and CMS (12) (Appendix B, Table B1).

A total of 4 species listed under the IUCN Red List have been recorded at the site, 3 species “Near Threatened” and 1 species listed as “Vulnerable” (Appendix B, Table B1).

Table 5. Number of waterbird species recorded at the Lake Gore Ramsar Site, Esperance, Western Australia, together with their feeding requirements (feeding requirements from Cowcher, 2005).

Waterbird group	Families	Feeding requirements	No of species
Ducks and allies	Anatidae	Dryland to deep water > 1 m. Omnivores including plant/algae material, fish and invertebrates	12
Grebes	Podicipedidae	Deep open water > 1 m feeding on mainly fish but also insects and some vegetation	3
Pelicans, Cormorants, Darters	Pelecanidae, Phalacrocoracidae, Anhingidae	Deep open water > 1 m feeding on fish and invertebrates	5
Herons, Egrets, Ibises, Spoonbills	Ardeidae, Threskiornithidae	Shallow/wading or on mudflats feeding on a range of animals (invertebrates, reptiles and fish)	6
Hawks, Eagles	Accipitridae	Feeds on dryland to deep open water on a variety of animals including waterbirds and fish	1
Crakes, Rails, Water Hens, Coots	Rallidae	Shallow/wading or on mudflats with coots using deeper open water > 1 m. Omnivores including plant/algae material, fish and invertebrates	2
Shorebirds	Charadriidae, Recurvirostridae, Scolopacidae	Shallow/wading or on mudflats feeding on mainly fish and invertebrates and some vegetation	20
Gulls and Terns	Laridae, Sternidae	Gulls use a wide range of habitats and are omnivorous, feeding opportunistically. Terns feed over permanent, open waters eating mainly fish but also invertebrates	4
Total			**53**

The waterbirds recorded for Lake Gore have been grouped into four different guilds to illustrate their habitat feeding requirements (Figure 24 and Appendix B, Table B1). Feeding requirements have been based on the maximum depth required for feeding; however, some waterbirds may occupy or feed within any habitat up to their maximum feeding depth. Typically, the majority (approximately 60%) of the waterbird species that have utilised the Lake Gore Ramsar Site are shallow feeders or waders that generally require a habitat that is ≤ 0.5 m in depth (Figure 24 and Appendix B, Table B1) and they may also rely on an exposed shore zone. Approximately 34% of the species utilising the Lake Gore Ramsar Site require a habitat ≥ 1 m, they are the deeper feeders (Figure 24 and Appendix B, Table B1). The remaining 6% is occupied by shore feeders and aerial feeders (Figure 24 and Appendix B, Table B1).

Of the 14 species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA and CMS), 13 species occupy waterbird feeding Guild 2 indicating they are shallow feeding or wading waterbirds, which may also rely on an exposed shore zone (Figure 24 and Appendix B,

Table B1). These 13 species represent approximately 24% of all the waterbirds recorded at Lake Gore and comprise approximately 40% of waterbird feeding Guild 2.

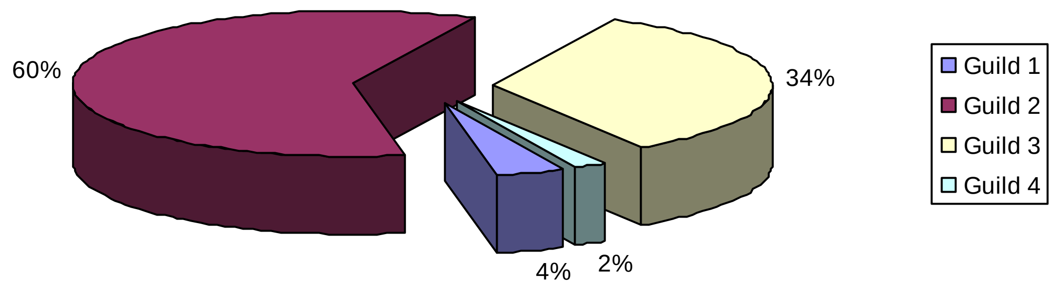


Figure 24. An illustration of the general percentage composition of the waterbird feeding guilds of the Lake Gore Ramsar Site, Esperance, Western Australia. Note: Guild 1 - Shore: Majority of feeding is on dry land; Guild 2 - Wading birds and shallow feeders: Feeding in water that is ≤ 0.5 m. Birds within this group may also feed within wet mud and guild 1; Guild 3 - Deep feeders: Requiring a water depth that is ≥ 1 m but can also occupy guilds 1 and 2; Guild 4 - Aerial feeders: Birds of prey; (data from Bennelongia, 2008a, 2008b; Birds Australia, 2008b; Buchanan, 2003; Clarke & Lane, 2003; Department of Environment and Conservation, 2008d; Halse, 2007); (guild information adapted from Cowcher, 2005; Jaensch, 2002).

The identification of waterbird feeding guilds indicates that the Ramsar site offers a diversity of feeding habitats and has been particularly important to wading and shallow feeding species, some of which are internationally recognised. In order for these species to continue using the site, it is essential that the diversity of waterbird feeding habitats is maintained.

The optimum hydrological thresholds for waterbirds at Lake Gore and other wetlands in the Esperance region have been calculated using GIS, bathymetry volume calculations, waterbird habitat preference literature, and historic and current lake depth data (see: Massenbauer, 2008b; Robertson & Massenbauer, 2005).

During the current hydrological regime the optimum minimum and maximum shore zone areas have been reduced by 45 ha and 110 ha respectively (Massenbauer, 2008b; Robertson & Massenbauer, 2005). Thus the maximum habitat area available for wading waterbirds has reduced from 400 ha to 60 ha and for diving waterbirds it has increased from 250 ha to 630 ha (Figure 25). To ensure waterbird diversity the exposed shore zone around Lake Gore should be between a minimum of 45 ha and a maximum of 200 ha, equating to a depth range between 15.8 and 16.6 m AHD (Figure

25). This change in ecological character is discussed further in Section 5.2 Changes to Critical Components and Processes.

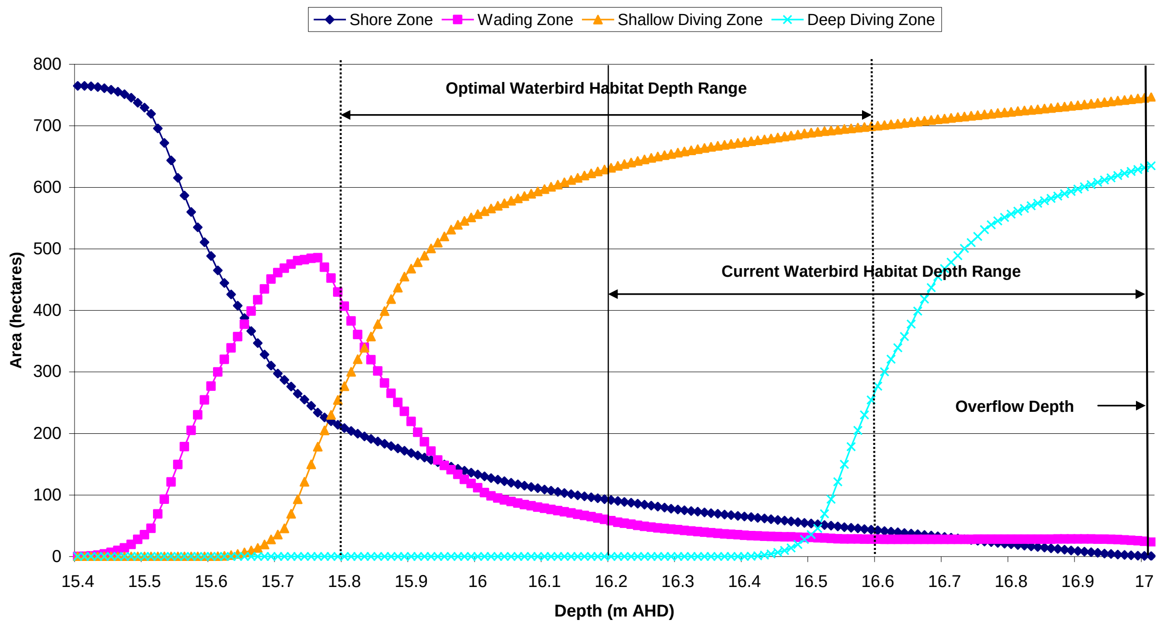


Figure 25. Relationship between water depth and waterbird habitats at Lake Gore, Esperance, Western Australia (from Massenbauer, 2008b; Robertson & Massenbauer, 2005).

Waterbird counts at Lake Gore have been highly variable in terms of species richness and abundance, with no particular trends apparent (Figure 26). Species richness is one aspect of diversity and has fluctuated at Lake Gore, with a maximum of 26 species (November 1984) recorded in a single survey (Figure 26). The lowest species richness recorded in a single survey is one species; recorded in March 1984, October 1985, March 2003 and September 2003 (Figure 26).

The highest number (abundance) of waterbirds counted at the Lake Gore Ramsar site was in March 1988 with 29,273 individuals (Figure 26). This particular count was used to support Ramsar Criterion 5 at the time of listing. At the time of listing the annual water depth data of Lake Gore was considered an indication that conditions would be suitable for use by 20,000 waterbirds at least several times within a 25 year period (Jaensch & Watkins, 1999). Analysis of 27 years of waterbird data indicates that this occasion (i.e. March 1988) was the only time when > 20,000 waterbirds were recorded at the Lake Gore Ramsar Site (Figure 26). Additionally, this count consisted of 20,000 individuals from one species, the Banded Stilt. Banded Stilt are a highly mobile and dispersive species known for their extremely nomadic behaviour (Roshier 2003). This large single count of Banded Stilt may be the result of an opportunistic gathering while other habitats within their home range were unsuitable.

As described in Section 2.6, it is not considered that the Lake Gore Ramsar Site originally met or currently meets Ramsar Criterion 5. In particular, the application of the Ramsar definition of “regularly” discounts Criterion 5 being supported at the Lake Gore Ramsar Site.

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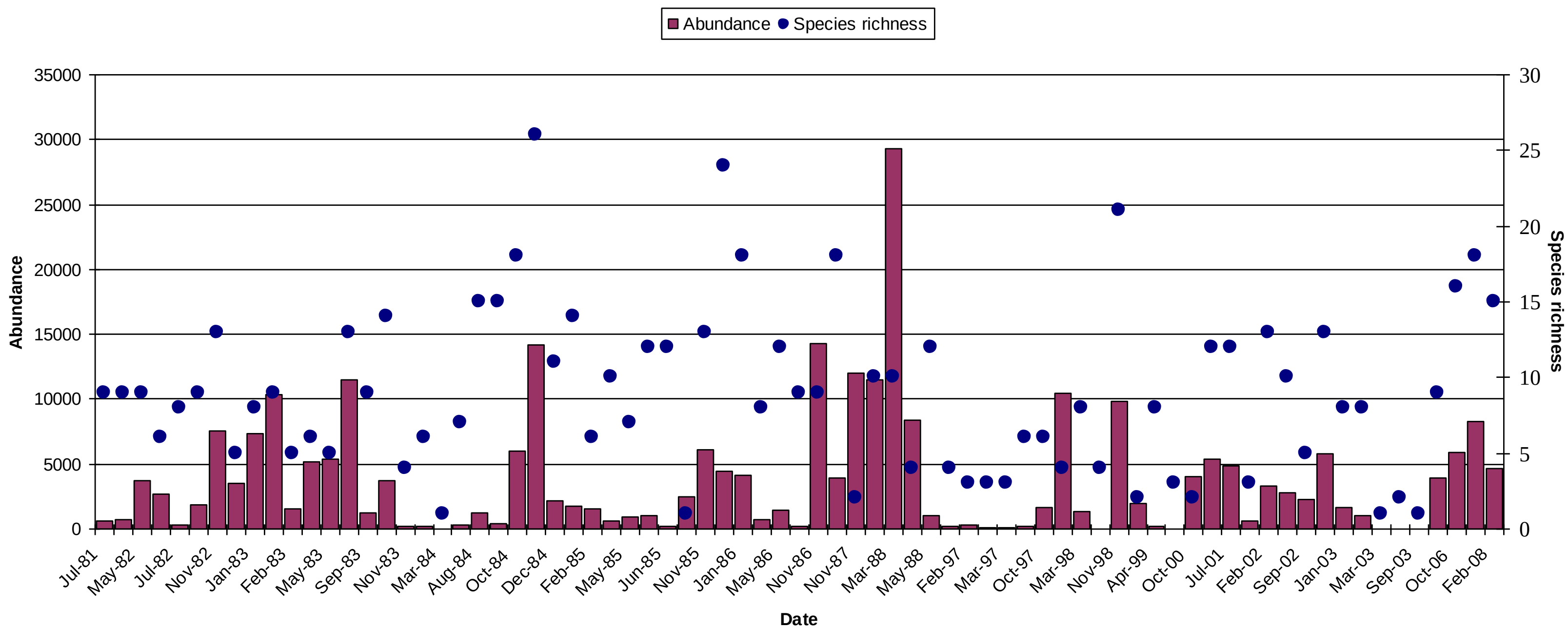

Figure 26. Waterbird species richness and abundance recorded from all waterbird surveys, 1981 - 2008 at the Lake Gore Ramsar Site, Esperance, Western Australia. Note: does not include annual waterfowl count data November 1988 - March 1992.

Generally, spring surveys have recorded greater numbers of waterbirds than summer surveys (Bennelongia, 2008a). However, there has been a noted increase in waterbird usage during the summer months which has been attributed to increases in water levels at Lake Gore (Bennelongia, 2008a). Abundant water is not always desirable, as a reduction in hydrological variability (natural flooding and drying disturbance) reduces biodiversity in waterbirds and other biota, and affects ecological processes (Kingsford et al., 2004).

The most abundant waterbird species recorded at the Lake Gore Ramsar Site are the Australian Shelduck (max 12,000 November 1986), Banded Stilt (max 20,000 March 1988), Black Swan (max 4,000 July 2001), Chestnut Teal (max 884 February 2008), Grey Teal (max 3,500 December 1987), Hoary Headed Grebe (max 1,000 March 1988) and the Hooded Plover (max 1,570 January 1995) Four of these species have been recorded at Lake Gore in numbers exceeded their 1% population thresholds (see: Wetlands International, 2006 for population thresholds), they are:

1. Australian Shelduck (Anatidae) 1% of the South-west Australian population = 2,400 birds
2. Banded Stilt (Recurvirostridae) 1% of the Australian population = 2,100 birds
3. Chestnut Teal (Anatidae) 1% of the South-west Australian population = 50 birds
4. Hooded Plover (Charadriidae) 1% of the Western Australian population = 60 birds

At the time of listing only the Banded Stilt and the Hooded Plover were considered to support Ramsar Criterion 6. At this time there were no population estimates for the Australian Shelduck or the Chestnut Teal. The latest waterbird population estimates (see: Wetlands International, 2006) and the waterbirds surveys from Lake Gore indicate that the Australian Shelduck and the Chestnut Teal have also exceeded the 1% population thresholds "regularly", as defined by the Ramsar Convention (Ramsar Convention, 2005b). Table 6 details the waterbird surveys that have taken place since 1981 and the number of times the Australian Shelduck, Banded Stilt, Chestnut Teal and the Hooded Plover have exceeded the 1% population thresholds.

Lake Gore is an important refuge during the moulting stage of Australian Shelduck, which takes place during spring and contributes to the species "regularly" exceeding the 1% population thresholds (Table 6). Thousands of moulting Australian Shelducks also contribute to the higher numbers of waterbirds recorded during the spring period (Bennelongia, 2008a).The rocky outcrops on the northern side of Lake Gore provide an important "loafing" site for the flightless Shelducks during the moulting period (Jaensch et al., 1988).

Early waterbird counts, particularly in the early 1980's, were dominated by Australian Shelducks and Banded Stilts, with low numbers of Musk Duck (Bennelongia, 2008a, 2008b; Halse, 2007; Jaensch et al., 1988). More recent waterbird counts have indicated decreases in Banded Stilt and increases in Chestnut Teal, Grey Teal and Musk Duck (Bennelongia, 2008a, 2008b; Halse, 2007). The reasons behind the increased numbers of Teal and Musk Duck are unknown and further investigation is required.

Bennelongia (2008b) suggest that the reduction in Banded Stilts recorded at Lake Gore may be attributed to higher water levels now experienced at Lake Gore. It should be noted that the periods in the 1980's when Banded Stilt were recorded exceeding the 1% population thresholds (Table 6), coincided with the lowest water levels recorded at Lake Gore (see: Section 3.1.2 Hydrology). Waders generally prefer an exposed shore zone and a shallow habitat (i.e. low water levels). A reduction in the Banded Stilt's habitat (through increases in extent, timing and depth of inundation) is likely to influence the numbers recorded at Lake Gore. Banded Stilt were last recorded exceeding the 1% population thresholds at Lake Gore in 1998 (Table 6).

Up to 400 Hooded Plover individuals were recorded in the early 1980's, with the highest numbers recorded during 1995 and 1996. (see: Birds Australia, 2008a; Birds Australia, 2008b; Department of Environment and Conservation, 2008d; Newbey, 1996; Singor, 1999; Weston & Elgar, 2000). Consequently, Lake Gore was considered the single most important wetland known for Hooded Plover throughout their range (Newbey, 1996). The highest count of 1,570 in January 1995 represented approximately 30% of the Western Australian population of Hooded Plover at the time (see: Rose & Scott, 1997). Since listing, Hooded Plover have only been recorded exceeding the 1% population thresholds on one occasion (87, November 2002 [Table 6]). Other surveys have recorded less than 5 individuals and sometimes none have been recorded (see: Bennelongia, 2008a; Bennelongia, 2008b; Birds Australia, 2008a; Buchanan, 2003; Clarke & Lane, 2003; Halse, 2007; Newbey, 1996; Singor, 1999; Weston & Elgar, 2000).

Table 6. Waterbirds recorded at the Lake Gore Ramsar Site that have exceeded the 1% population thresholds (see: Wetlands International, 2006). Note: X denotes the species was recorded exceeding the 1% population threshold; N.S: no survey undertaken.

Year	Australian Shelduck	Banded Stilt	Chestnut Teal	Hooded Plover
1981				
1982	X	X		X
1983		X	X	X
1984	X	X	X	X
1985	X			
1986	X			
1987	X	X		
1988	X	X		X
1989	X	N.S		N.S
1990	X	N.S		N.S
1991	X	N.S	X	N.S
1992	X	N.S		N.S
1993	N.S	N.S	N.S	X
1994	N.S	N.S	N.S	X
1995	N.S	N.S	N.S	X
1996	N.S	N.S	N.S	X
1997				X
1998	X	X	X	X
1999			X	
2000	X			
2001	X			
2002	X		X	X
2003				
2004	N.S	N.S	N.S	N.S
2005	N.S	N.S	N.S	N.S
2006	X		X	
2007	X		X	
2008	X		X	

The Hooded Plover is considered “Near Threatened” under the International Union for Conservation of Nature and Natural Resources (IUCN) Red List and in some regions it has become locally extinct (BirdLife International, 2006; Raines, 2002). The Hooded Plover is listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as “Marine” and is listed by the

Western Australian Department of Environment and Conservation (DEC) as a Priority Four species (taxa in need of monitoring). The main food source of Hooded Plover at Lake Gore is considered to be *Coxiella exposita* which have been observed on the beaches surrounding Lake Gore (Singor, 1999; Weston & Elgar, 2000). The Hooded Plover requires a wading habitat and an exposed shore zone, with the spit and shores to the north and northeast end of Lake Gore considered to be important habitat areas (Jaensch et al., 1988). Clarke & Lane (2003) suggest that there is a potential threat to the Hooded Plover's habitat as lake levels and the area of inundation increases, thus decreasing the wading habitat and shore zone.

The fluctuating numbers and an apparent reduction in the numbers of Hooded Plover over time, particularly since listing, could be attributed to habitat suitability. For example, it has been noted that Carbul, Gidong and Kubitch Lakes have also been important sites for Hooded Plover (see: Jaensch et al., 1988). These lakes are in close proximity to Lake Gore and Jaensch et al (1988) explains that it is likely that Hooded Plovers congregate at any one of these wetlands (i.e. Gore, Carbul, Gidong and Kubitch) at any given time, depending on which ever has the most suitable water level.

The altered hydrological regime and a subsequent loss of habitat may have reduced Hooded Plover numbers at Lake Gore. However, this is a cryptic species and could be missed due to a reduction in survey effort or different survey methods. Weston & Elgar (2000) conducted a 14 day intensive survey of Hooded Plover at Lake Gore and highlighted how variability in waterbird numbers can be attributed to species behaviour influenced by time of day and weather (Weston & Elgar, 2000). They found significant differences in Hooded Plover numbers. On some days the counts were relatively constant; other days there were higher numbers in the midday as opposed to evening; and on some days Hooded Plover numbers were higher in the morning and evening while lower at midday. It is acknowledged that cryptic species such as the Hooded Plover and also diving waterbirds, are missed during aerial surveys (Bennelongia, 2008a, 2008b; Halse, 2007).

Other IUCN listed species recorded at Lake Gore are the Darter (*Anhinga melanogaster* [Near Threatened]), the Black-tailed Godwit (*Limosa limosa* [Near Threatened]) and the Fairy Tern (*Sterna nereis* [Vulnerable]). Although the Fairy Tern has been recorded at Lake Gore their presence has been irregular and with low abundance. There are only 3 records (January 1985 [4], July 2001 [12], May 2002 [12]) of Fairy Tern at Lake Gore (see: Birds Australia, 2008b; Jaensch et al., 1988). With sufficient waterbird surveys conducted at Lake Gore it is anticipated that the site is not important in supporting populations of Fairy Tern and the numbers recorded to date suggests that it is an occasional visitor.

Breeding

Detailed breeding information of waterbirds at the Lake Gore Ramsar Site is limited. Chestnut Teal, Australian Shelduck, Pacific Black Duck, Australasian Shoveler, Red-capped Plovers and the Black Winged Stilt have all been found breeding at the site during the spring months (Jaensch et al., 1988). The Hooded Plover has also been recorded breeding at Lake Gore although records are limited (Birds Australia, 2008a; Newbey, 1996; Singor, 1999).

Historically, Lake Gore itself has been the only waterbody within the Ramsar site to be surveyed for waterbirds, as other smaller waterbodies within the site are surrounded by dense vegetation and are difficult to access. Breeding activity of waterbirds could therefore have been underestimated in the past. Additionally, it appears that some waterbird surveys have not differentiated between breeding and non-breeding waterbirds. In the future waterbird surveys that identify breeding birds may yield different results.

3.1.6.2 Fish

Fish satisfy the dietary requirements of many different waterbirds groups, particularly the deeper feeding species such as gulls, terns, grebes, pelicans and cormorants, which are piscivores (see: Appendix B, Table B2).

There is little reference to the presence of fish at the Lake Gore Ramsar Site although the area has been used for fishing by Indigenous peoples of the Esperance area (see: Section 3.2.3 Cultural Services). Lenanton (1974) refers to the existence of the Western Trout Minnow (*Galaxias truttaceus hesperius*), Blue Spotted Gobi (*Ellogobius olorum*) and Black Bream (*Mylio Butcheri*) at Lake Gore and the Dalyup River. The Black Bream is considered to be an estuarine species, although land locked populations do occur in Western Australia, including Lake Gore and the Dalyup River (Norriss et al., 2002).

The Western Trout Minnow is listed as critically endangered listed under the EPBC Act 1999, however, its presence at Lake Gore and the Dalyup River has not been confirmed under the Priority Fauna Database of Western Australia or the EPBC Protected Matters Database. It is possible that this species is no longer found in this area. Habitat changes and the introduction of the Mosquito Fish (*Gambusia holbrooki*) are the main threats to this species (Morgan et al., 1998).

More recently, the Hardy Head (*Leptatherina wallacei*) and the Swan River Gobi (*Pseudogobius olorum*) have been recorded in the lower Dalyup River where it terminates at Lake Gore (Cook & Janicke, 2008). These species may also exist at Lake Gore as they were recorded under similar salinity concentrations (see: Cook & Janicke, 2008), particularly the Swan River Gobi as it known to occur in freshwater and hypersaline lakes (Morgan et al., 1998).

It is unclear if the fish populations at Lake Gore are stable and how fluctuations in water quality affect them. Changes in fish populations may also impact the waterbirds using Lake Gore. Monitoring is required to identify the fish species at Lake Gore, particularly the EPBC listed Western Trout Minnow.

3.1.6.3 Aquatic invertebrates

The study of aquatic invertebrates of the Ramsar site has been limited to Lake Gore itself. The interaction of this critical ecosystem component with other ecosystem components such as waterbirds and fish at Lake Gore is not clear. However, the importance of aquatic invertebrates can be inferred through current knowledge on their role in wetland foodwebs.

Aquatic invertebrates are secondary producers and are a vital driver in wetland ecology, providing food sources to other biota such as fish and waterbirds. Aquatic invertebrates form two interconnected food chains; a grazing and a detrital food chain (Davis & Christidis, 1997). The organisms in the detrital food chain feed on dead and decaying plant and animal material, and are essential in the process of decomposition and the elemental cycling of plant and animal material (Davis & Christidis, 1997). The grazing food chain comprises of organisms that feed directly upon primary producers within the ecosystem such as the macrophytes and phytoplankton. Figure 27 details the grazing and detrital food chains of invertebrates in wetland ecosystems.

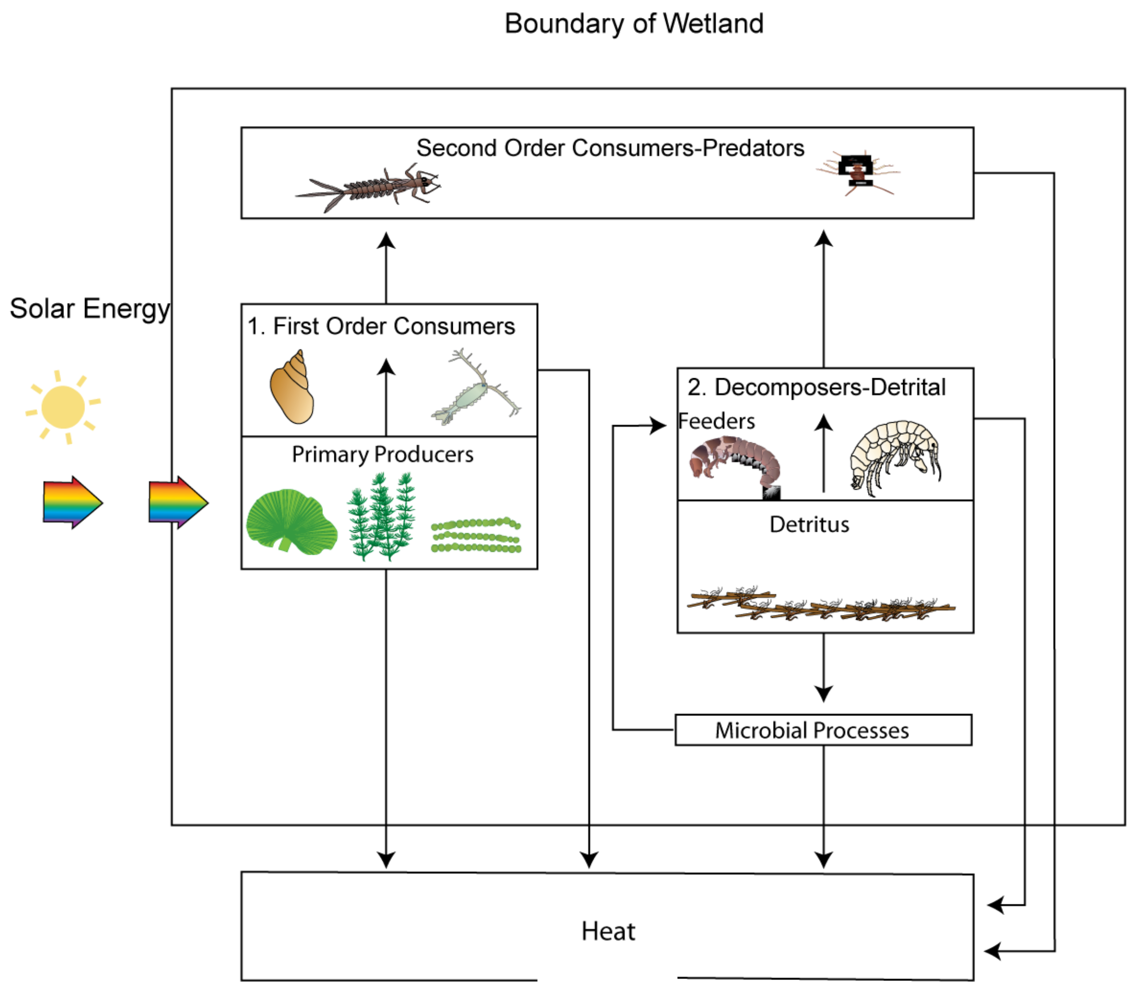

Figure 27. Grazing and detrital invertebrate food chains; Note: 1. Grazing food chain; 2. Detrital food chain; (adapted from Davis & Christidis, 1997).

Invertebrates form functional feeding groups based on their feeding habits and can occupy either or both the detrital and grazing food chains. The broad functional feeding groups are:

- Shredders - feed on organic material mainly coarse particulate matter
- Collectors / filter feeders - feed on fine organic material
- Scrapers - graze on paraphytic algae
- Macrophyte piercers - feeding off living plants and algae
- Predators - feed off other invertebrates
- Parasites - parasitic

The composition of feeding groups can be used as an indicator for water quality and wetland health, particularly if there is a dominance of a particular group or species of aquatic invertebrates. For example, highly eutrophic wetlands often have a large abundance of nuisance species such as non-biting Chironomid midge (Davis et al., 1993). Chironomid are collectors feeding on small particles mostly consisting of unicellular algae (Armitage et al., 1995). Anthropogenic nutrient pollution provides favourable environmental conditions for algae growth. This increase in food source for midge larvae increases the carrying capacity of a wetland for Chironomid midge causing a dominance of this group.

Lake Gore is naturally saline, with this salinisation process beginning around 5,000 to 6,000 years ago (Wilson, 2003). Salinity at Lake Gore ranges from saline to hypersaline which affects the invertebrate assemblages. In non marine, saline aquatic environments such as Lake Gore, as the salinity level increases, aquatic invertebrate species richness declines (Blinn, 2004; Pinder et al., 2004). In hypersaline environments, the species richness is reduced even further into a subset of halophyte and halotolerent species such as the ostracods *Australocypris insularis, Diacypris compacta* and *Platycypris baueri* (Blinn, 2004). Pinder et al (2004) recorded these as the dominant species at Lake Gore just prior to listing in a biological survey of wetlands in the wheatbelt of the south west of Western Australian, conducted between 1997 and 2000.

The next most abundant aquatic invertebrates recorded by Pinder et al (2004) were; the copepod *Meridiecyclops bayly* which is tolerant of a wide range of saline environments (Blinn, 2004); a biting midge *Culicoides* sp. and the isopod *Haloniscus searlei*, which is pre adapted to life in saline environments (Ellis & Williams, 1970). The halotolerant beetle *Necterosoma penicillatus*, and individuals of the dipteran family Ephydridae were found in the lowest abundances (Pinder et al., 2004). A total of 8 species from 6 families were recorded during the survey by Pinder et al (2004).

Prior to this survey, Brock & Shiel (1983) recorded 10 taxa of zooplankton (to genus level) at Lake Gore, however, abundances were not measured. They recorded the following copepod genera: *Gladioferens*, *Microcyclops*, *Canthocampus and Mesochra*; the rotifera *Brachionus plicatilis*; four unidentified taxa from the order Ostracoda; and the cladoceran *Daphniopsis pusilla* (Brock & Shiel, 1983). This assemblage is unlike that identified by Pinder et al (2004) and could possibly be due to different sampling methods.

The red shelled mollusc *Coxiella* sp, thought to be *Coxiella exposita,* have been identified on the shore of Lake Gore. This species is able to survive environmental extremes (i.e. salinity and drying) and can reproduce repeatedly during optimum conditions (Williams & Mellor, 1991). The mollusc is considered an important food source for the Hooded Plover as they have been observed foraging on them. The shells of the mollusc have also been found in the faeces and stomach contents of Hooded Plover at Lake Gore and other wetlands (Singor, 1999; Weston & Elgar, 2000).

An invertebrate survey under the Resource Condition Monitoring Project (see: Department of Environment and Conservation, 2008e) was conducted in November 2008 (post listing). The species composition and richness identified during this survey was dissimilar to the previous surveys mentioned, which may be related to the lower salinity concentrations recorded in 2008 (Department of Environment and Conservation, 2008e). A total of 10 species from 7 families were recorded, with the dipteran *Culicoides* sp. the only previously recorded invertebrate (Department of Environment and Conservation, 2008e). All species were either halophilic or eurytolerant and included mostly dipterans identified as *Dicrotendipes pseudoconjunctus*, *Tanytarsus barbitarsus*, *Ephydrid* sp (x 2), *Muscid* sp (x 2) and an individual from the family Stratiomyidae (Department of Environment and Conservation, 2008e). The polychaete *Capitella* sp. and a species from the order Arcariformes were also recorded (Department of Environment and Conservation, 2008e). It is unusual for the polychaete (*Capitella* sp.) to be found in an inland lake such as Lake Gore, as it is from a marine group which has only been recorded previously in Western Australia in south coast saline streams (Department of Environment and Conservation, 2008e). As Lake Gore has no confirmed connection with the Southern Ocean seabirds may have translocated this species (Department of Environment and Conservation, 2008e).

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Fewer invertebrate groups have been recorded at Lake Gore in comparison with Doombup Lake, where 21 groups of invertebrates have been identified (see: Calvert & Randall, 2008). As mentioned previously (see: Section 3.1.3 Water Quality), Doombup Lake is another hypersaline wetland in the Esperance Plains Biogeographic Region, which is considered to be in pristine condition (Calvert & Randall, 2008). Comprehensive and regular monitoring of Lake Gore's invertebrates is required to correctly interpret the existing results. The differences to date may indicate a potential change in ecological character or may reflect the sampling methods and or environmental conditions.

3.1.6.4 Vegetation

The Lake Gore Ramsar Site is located in the South-West Botanical Province within the Fanny's Cove Vegetation System. The Fanny Cove Vegetation System occupies a narrow plain on top of the young Quaternary sands, silts and clays between the sea and the older sandplains of the Esperance System to the north. The coastal dune vegetation is dominated by *Scaevola crassifolia*, which occurs in front of the mallee *Eucalyptus angulosa* with an understorey of *Melaleuca*

pentagona (Beard, 1973). Further inland there are thickets of tall *Acacia*, *Melaleuca* or scrub heath dominated by *Banksia speciosa* (Beard, 1973).
Lake Gore's wetland vegetation has been described as having a fringing belt of *Melaleuca cuticularis* which is variable in width, with sedges (*Schoenus brevifolius* and *Gahnia trifida*) and samphire species (*Suaeda australis* and *Sarcocornia quinqueflora*) around the high water mark (Halse et al., 1993). *Melaleuca cuticularis* is replaced by *Acacia* sp. as the elevation increases on the northern side of the Lake (Halse et al., 1993). The grass species *Sporobolus virginicus* and herb *Samolus repens* were also recorded at the high water mark (Halse et al., 1993).

Halse et al. (1993) noted that many of the fringing *Melaleuca cuticularis* trees were dead or declining, with dead trees constituting approximately 20% of the area and 40% of the canopy cover. Waterbird studies in the early 1980's noted a living fringe of *Melaleuca cuticularis* with only some dead trees (Jaensch et al., 1988). Therefore, the decline appeared to begin in the 1980's to early 1990's and by the time of listing, death of the fringing vegetation was already recognised. Although Halse et al. (1993) and Jaensch et al. (1988) did not explain the reasons for the death of the *Melaleuca cuticularis* it may be due to prolonged inundation as a result of ongoing hydrological changes.

In 2003 the vegetation of the Lake Gore catchment (2800 ha), which includes the majority of the Lake Gore Ramsar Site, was surveyed and mapped (see: Massenbauer & Palmquist, 2006). The survey and mapping were undertaken using Digital Multi-Spectral Imaging (DMSI) combined with ground truthing to identify vegetation types within the Lake Gore catchment and to monitor vegetation condition (Massenbauer & Palmquist, 2006). The survey identified 15 vegetation community types for the Lake Gore catchment (Figure 28). In 2006 the survey was repeated and vegetation change over the three years was determined by comparing the DMSI data and a vegetation change detection image was produced.

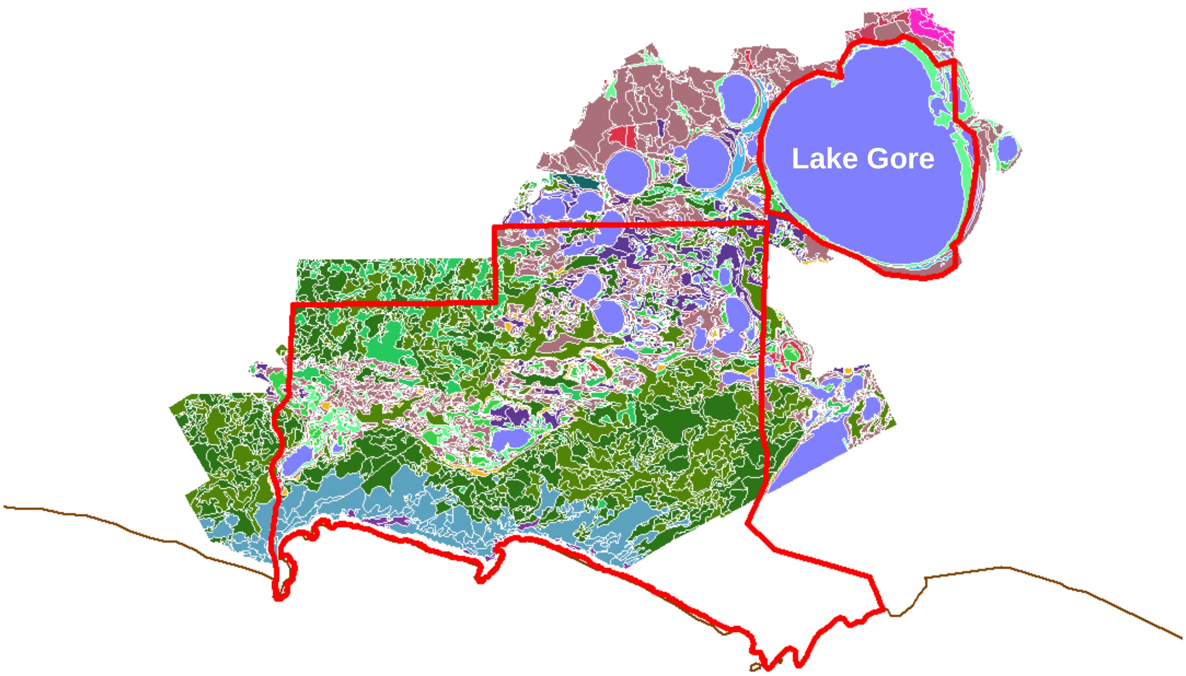

Figure 28. Vegetation communities surveyed at the Lake Gore catchment, Esperance, Western Australia.

The riparian vegetation covers approximately 1,720 ha of the Lake Gore catchment, 90% of which is paperbark plant communities (*Melaleuca cuticularis*) (Massenbauer & Palmquist, 2006). The vegetation surveys identified that at 2006, approximately 53% or 920 ha (between 15.9 and 17.5 m AHD) of the riparian vegetation of the Lake Gore catchment was either dead or degrading (Massenbauer & Palmquist, 2006). The decline in vegetation condition has been attributed to increases in the timing and extent of inundation of the riparian zone (Tilo Massenbauer, Recovery Catchment Officer, DEC, pers. comm., 2008). The inundation period has exceeded the inundation threshold for *Melaleuca cuticularis* and *Melaleuca brevifolia* (Massenbauer & Palmquist, 2006). Recovery and regeneration of vegetation was identified in areas > 17.5 m AHD, indicating that a new high water level was being established as regeneration was not occurring in the inundated and waterlogged areas (Massenbauer & Palmquist, 2006). Field observations also identified that some stands of *Banksia speciosa* close to riparian areas had died and were being replaced by the more salt and water tolerant *Melaleuca cuticularis*, indicating a change in hydrological regime (Massenbauer & Palmquist, 2006).

Figure 29 conceptualises changes in the hydrological regime of Lake Gore and its affects on fringing riparian vegetation and waterbird species composition**.**

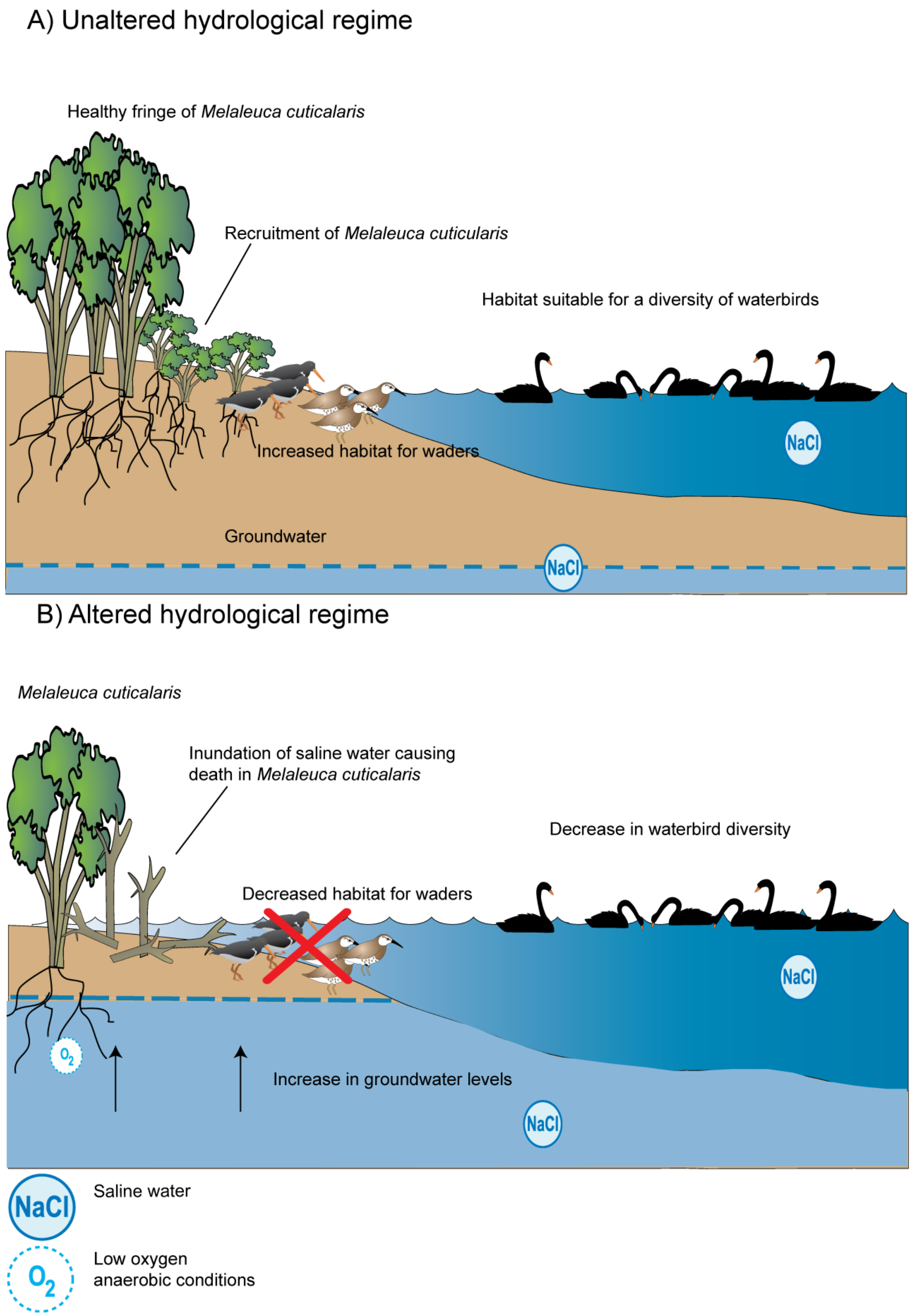

Figure 29. Conceptual changes in hydrological regime at Lake Gore, Esperance, Western Australia. A) Unaltered hydrological regime suitable habit for a diversity of waterbirds and healthy fringe of riparian vegetation; B) Altered hydrological regime resulting in a reduced diversity of waterbird habitats; and death of fringing riparian vegetation from low oxygen conditions and prolonged inundation of saline water..

3.2 CRITICAL ECOSYSTEM BENEFITS AND SERVICES

As well as describing the critical components and processes of an ecosystem, it is important to also understand the benefits and services they provide. Ecosystem benefits and services are defined by the Millennium Ecosystem Assessment as *"the benefits that people receive from ecosystems"* (Ramsar Convention, 2005a). Ecosystem benefits are both tangible and intangible and can be in the form of economic, social, health and cultural benefits.

Ecosystem benefits and services are derived directly from the ecosystem components and processes as a result of the interaction between them (Figure 30). There is therefore a correlation between the preservation of the ecosystem components and processes and the continuation of the benefits people receive from them. This focus is particularly prevalent in the Ramsar sites of developing countries, where the preservation of the critical ecosystem components and processes is directly related to the livelihood and health of people. This forms part of the reason why these Ramsar sites in developing countries have been nominated. The recognition of link between critical ecosystem benefits and services and the benefits and services they provide to people helps drive more sustainable practices. This sub-section provides a description of the critical benefits and services provided by the ecosystem of the Lake Gore Ramsar Site and the rationale for their identification.

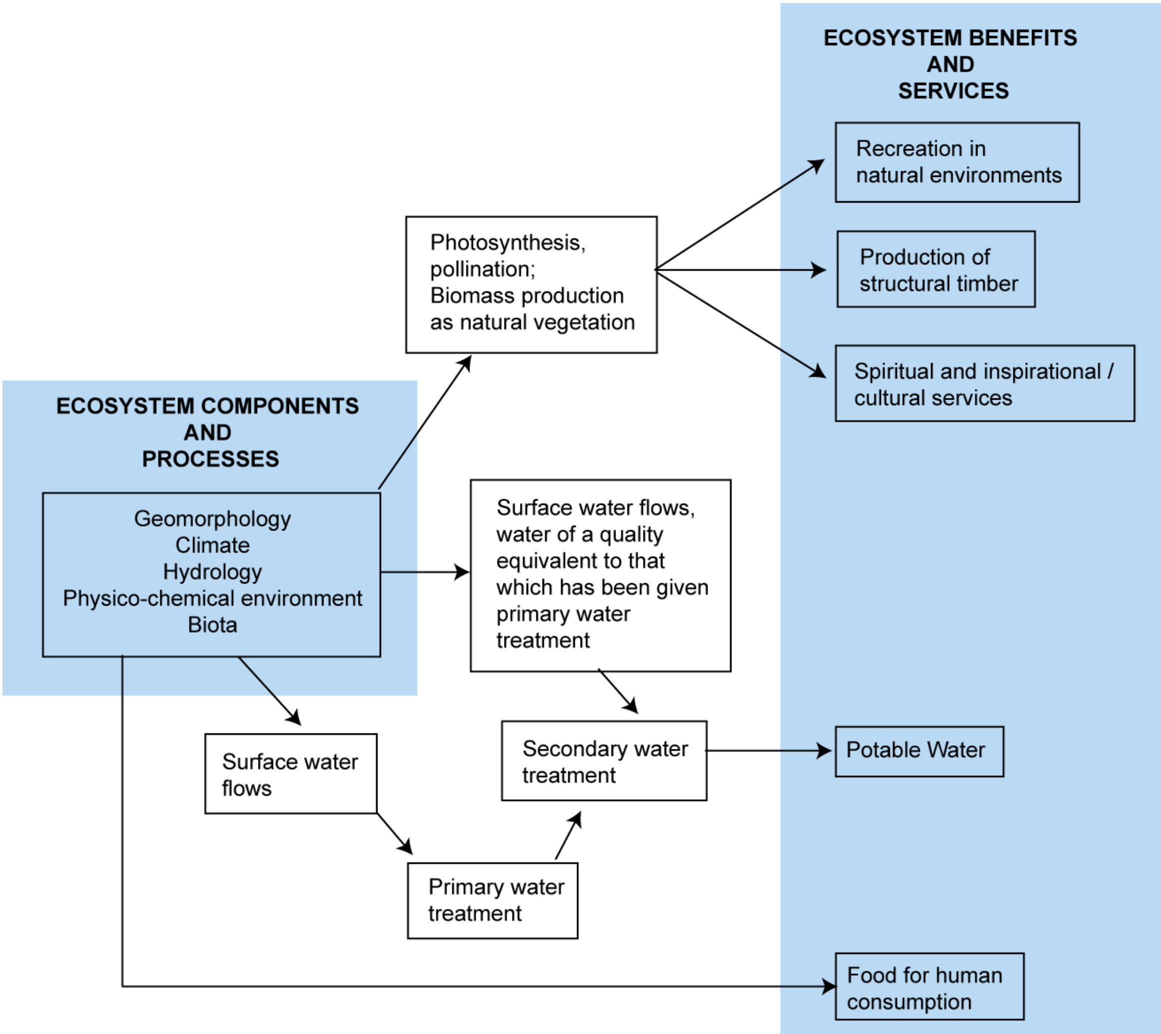

Figure 30. Conceptual model of wetland ecosystem components and processes and ecosystem pathways in delivering ecosystem benefits and services (adapted from Wallace, 2007).

The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005a, 2005b) identifies four main categories of ecosystem benefits and services:

1. ***Provisioning services*** *– the products obtained from the ecosystem such as food, fuel and freshwater;*
2. ***Regulating services –*** *the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation;*
3. ***Cultural services –*** *the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and*

4. ***Supporting services*** *– the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.*

Rationale for selection of the critical ecosystem benefits and services

The identification and description of the critical benefits and service of the Lake Gore Ramsar Site is based on the minimum requirements set by DEWHA (2008). The critical ecosystem benefits and services have been selected on the basis that:

- They are important determinants of the site’s unique character;
- They are important for supporting the Ramsar Criteria under which the site was listed;
- Changes to the benefits and services are likely to occur over short or medium time scales (<100 years); and
- Significant negative consequences will be the result of changes to the benefits and services.

The critical ecosystem benefits and services are related to the critical ecosystem components and processes of the Lake Gore Ramsar Site (see: Section 3.1 Critical Ecosystem Components and Processes). They also illustrate the values of the Lake Gore Ramsar across multiple audiences and not just from an ecological perspective.

Table 7 provides a summary of the critical ecosystem benefits and services of the Lake Gore Ramsar Site.

Table 7. Critical ecosystem benefits and services for the Lake Gore Ramsar Site, Esperance, Western Australia.

Category	Description
Provisioning Services *The material products provided directly from wetland ecosystems including food, fresh water, fibre, fuel, biochemical's and genetic material.*	
Genetic resource	Plausible but not yet confirmed.
Human health	Provides an environment conducive to the continuation of human physical and mental health.
Regulating Services *The material benefits obtained from the regulation of wetland ecosystem processes.*	
Pollution control and detoxification	Lake Gore is a sink for excessive nutrients, sediments and saline water discharges from the Dalyup catchment.
Cultural Services *The benefits people obtain through spiritual and Inspirational, enrichment recreation, education and aesthetic experiences.*	
Recreation	Low level passive recreation such as bird watching. Some active recreation; 4WD tracks exist.
Science and education	Long term recording of water depth and quality. Opportunities for science based management of threatening processes.
Cultural heritage and identity/ Spiritual and inspirational	Lake Gore is used by Indigenous people and provides "sense of place".
Aesthetic amenity	Provides scenic values to residents and visitors which are in addition to others in the scenically rich area.
Supporting Services *Those services necessary for the production of all other ecosystem services including soil formation and nutrient cycling.*	
Hydrological processes	Lake Gore supplies water to nearby Lake Quallilup and other smaller unnamed lakes and swamps in the Lake Gore wetland system.
Nutrient cycling	Lake Gore has a role in nutrient cycling although the scale at which this occurs is unknown.
Biodiversity	Supports waterbirds at a critical life stage. Supports 1% of the population of four waterbird species.
Physical habitat	Provides varied waterbird habitats and is a drought refuge during summer periods. Habitat varies within the Ramsar site from wetland to terrestrial, offering habitat for wetland and terrestrial dependant species. Also supports diversity of waterbird habitat from wading to deep water.
Priority wetland species	Supports the Hooded Plover which has a current management plan and is listed by DEC as a Priority Four species (taxa in need of monitoring). The Hooded Plover is also listed as "Near Threatened" under the IUCN Red List. Twenty five waterbird species listed under the EPBC Act have been recorded at Lake Gore.
Ecological connectivity	Forms part of an interconnected habitat of wetlands for waterbirds in the Esperance region.

3.2.1 PROVISIONING SERVICES

Genetic resource

The Lake Gore Ramsar Site, like other ecosystems contains genetic resources that require conserving in order to provide provisioning, regulating, cultural and supporting services in the future. Although not confirmed, it is plausible that if any genetic resources at the Lake Gore Ramsar Site are lost it would affect the ecosystem functioning in a way that would discontinue the provision of other benefits and services.

Human health

Human health both physically and mentally is attributed partly to the health of the environment. It is evident that a relationship exists between the decline in human health and a decline in environmental health. Dryland salinity illustrates such a relationship and has been attributed to multiple human health problems such as: respiratory health problems through increases in wind-borne dust; increases in the threat and incidence of the Ross River virus by altering the ecology of the mosquito-borne disease; and a decline in mental health (Jardine, 2007).

The health of an ecosystem such as the Lake Gore Ramsar Site and the surrounding catchment is therefore also important to human health. Although the contribution to human health that the Lake Gore Ramsar Site provides is difficult to quantify, it is nonetheless a valid benefit and service to people.

3.2.2 REGULATING SERVICES

Pollution control and detoxification

The Dalyup catchment has long standing issues, many of which are associated with the clearing of deep rooted vegetation to make way for agriculture. The result is that Lake Gore acts as a sink for excessive nutrients, sediments and saline water discharges from the Dalyup catchment (Parker & Janicke, 2001; Water and Rivers Commission, 2002). Although pollution is recognised as a threatening processes (see: Comer et al., 2001), Lake Gore also has a monetary benefit in supplying this regulating service. Particularly, as some of the saline water discharges are the result of the installation of deep drains on farms to alleviate problems associated with excessive rises in groundwater.

3.2.3 CULTURAL SERVICES

Recreation

The Lake Gore Ramsar Site is used mainly for low level passive recreation including camping and bird watching opportunities. The Esperance Bird Observers Group is an active community group and has been involved in many waterbird surveys at the site.

As the Ramsar boundary extends toward the high water mark of the Southern Ocean, recreation activities such as surfing and fishing (on Warrinup Beach) are associated with the site, mainly on Nature Reserve 26885. The site is difficult to access therefore 4WD tracks are located through the site and forms the basis of further recreational activities.

Science and education

Long term recording of water depth and water quality have occurred at Lake Gore and it has historically been used as an education tool for local schools (Ribbons of Blue Programme). The Ramsar site is also part of the Esperance Hooded Plover Management Region (see: Raines, 2002).

This site also has threatening processes associated with catchment land use and catchment clearing which provides an opportunity to apply science based management to alleviate these threats. The results can be then be applied to other similarly affected ecosystems.

Cultural heritage and identity/Spiritual and inspirational

Lake Gore is regarded as a important area for food gathering and fishing by Indigenous people (Henry Dabb, South Coast NRM, pers. comm., 2008). It also provides a “sense of place” for the community, contributing to wellbeing and spiritual values.

Aesthetic amenity

The Esperance area is scenically rich, known internationally and nationally for its beautiful beaches and coastline. It has many wetlands, which include another Ramsar site the Lake Warden System Ramsar Site. The Lake Gore Ramsar Site provides further scenic and aesthetic values to the Esperance region.

3.2.4 SUPPORTING SERVICES

Hydrological processes

Lake Gore forms part of a wetland system and provides a downstream system of marshes and pools within the Ramsar site. During extreme wet events such as floods, Lake Gore overflows, providing water to Lake Quallilup which lies external to the Ramsar boundary.

Nutrient cycling

Ecosystems have a role to play in the cycling of chemical elements from the abiotic parts of the environment into organic components. The details, such as nutrient loads and internal loading are unknown for Lake Gore.

Biodiversity

Lake Gore regularly supports thousands of Shelduck, which use the site during the critical moulting stage of their lifecycle. It also has regularly supported 1% or more of the Shelduck population, as well as the Banded Stilt, Chestnut Teal and the Hooded Plover (see: Wetlands International, 2006).

Physical habitat

The site provides a variety of habitats, from wetland to terrestrial and coastal heath scrub, supporting aquatic as well as terrestrial species. In particular, there are important sites such as the spit on the eastern side of Lake Gore where large number of waterbirds have been observed loafing (Jaensch et al., 1988). Large concentrations of Hooded Plover have been observed on the north-east and north shore of Lake Gore and the rock outcrops to the north side of the lake are important for moulting Shelducks (Jaensch et al., 1988).

The shores and vegetation surrounding Lake Gore and other small associated waterbodies within the site, have also supported breeding Shelduck, Pacific Black Duck, Australian Shoveler and the Black Winged Stilt (Jaensch et al., 1988). Red Capped Plovers and Hooded Plovers have also been found breeding on the shores of Lake Gore (Jaensch et al., 1988; Singor, 1999).

Lake Gore is a drought refuge for many waterbirds and also provides various waterbird feeding habitats, from wading to deeper feeding conditions.

Priority wetland species

Lake Gore supports the Hooded Plover, which has a current management plan aimed at conserving this species and its habitat (see: Raines, 2002). The Hooded Plover is listed by DEC as a Priority Four species (taxa in need of monitoring) and is considered as “Near “Threatened” under the IUCN Red List. Twenty five waterbird species listed under the EPBC Act have been recorded at Lake

Gore: 24 “Marine”,14 “Migratory” species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA and CMS) .

Ecological connectivity

Within the Esperance region there are multiple wetlands providing habitat to waterbird species. The Lake Gore Ramsar Site forms part of this interconnected habitat of wetlands for waterbirds in the Esperance region. There is potential for the site to become part of the south coast “macro-corridor” which is a near continuous strip of native coastal vegetation along the south coast between Albany and Esperance in Western Australia. These corridors allow movement of flora and fauna and connect various habitat types.

4.0 THREATS TO ECOLOGICAL CHARACTER

This section identifies actual or likely threats to the ecological character of the Lake Gore Ramsar Site. Table 8 provides a summary of the threats to the critical ecosystem components, processes, benefits and services at the Lake Gore Ramsar Site. It is anticipated that any threatening process acting on the critical ecosystem components and processes at the Lake Gore Ramsar Site will result in a reduced capacity of the site to provide critical ecosystem benefits and services. The threats also have the ability to cause a change in ecological character, which will be explored in Section 5.0 Changes to Ecological Character.

Table 8. Threats to the critical ecosystem components, processes, benefits and services of the Lake Gore Ramsar Site, Esperance, Western Australia.

Actual or likely threat or threatening activities	Potential and/or actual impact(s) to wetland components, processes, benefits and services	Likelihood	Timing of threat
Agricultural activities in the Dalyup and Coobidge Creek catchments have resulted in: • Clearing of native vegetation • Livestock grazing • General cropping and agricultural activities	• Altered hydrological regime - timing, frequency and extent of inundation • Introduction and establishment of weeds • Increased sedimentation • Increased salinisation (secondary salinisation) through changed hydrology (Comer et al., 2001) • Nutrient enrichment and subsequent algal blooms • Pollution, nutrient, sediment and salinity (Comer et al., 2001) • Reduction in waterbird habitat area and condition • Reduction in extent of native vegetation • Altered fire regimes • Changes to water and sediment chemistry • Disturbance of potential acid sulfate soils • Increasing fragmentation, loss of remnants and lack of	Certain/high	Immediate - long term

Actual or likely threat or threatening activities	Potential and/or actual impact(s) to wetland components, processes, benefits and services	Likelihood	Timing of threat
	recruitment (Comer et al., 2001) • Reduction in the capacity for the site to provide provisioning, regulating, cultural and supporting services		
Non native and alien species	• Competition with native flora and fauna reducing habitat area and condition • Loss of native species • Reduction in the capacity for the site to provide provisioning, regulating, cultural and supporting services	Certain/high	Immediate
Climate change • Changes in rainfall, temperature and wind regimes. • Increases in extreme episodic events.	• Altered catchment hydrological regimes - timing, magnitude and frequency of flows into Lake Gore • Altered hydrological regime of Lake Gore - timing, frequency and extent of inundation • Changes to flora and fauna distribution and condition • Increased non-native flora and fauna species • Increases in sedimentation • Reduction in the capacity for the site to provide provisioning, regulating, cultural and supporting services	High	Medium to long term (5 years to decades)
Recreation	• Introduction and establishment of weeds • Spread of alien species such as *Phytophthora cinnamomi* • Destruction of flora and fauna habitat • Increased fire risk • Direct impacts on flora and fauna (e.g. by vehicles, trampling, disturbing mating and nesting sites) • Reduction in the capacity for the site to provide provisioning, regulating, cultural and supporting services	Medium	Immediate to long term (decades)

4.1 AGRICULTURAL ACTIVITIES

4.1.1 ALTERED HYDROLOGY

Clearing of native vegetation within the Dalyup and Coobidge Creek catchments has resulted in rising groundwater levels and increased surface water runoff (Komarzynski, 2001). The altered hydrological regime is increasing the extent and incidence of secondary salinisation, water erosion, siltation, sedimentation, flooding, acidity (ground and surface water) and waterlogging in the catchments (Comer et al., 2001; Komarzynski, 2001; Water and Rivers Commission, 2002).

The hydrological changes in the Dalyup and Coobidge Creek catchment, along with the installation of deep drainage to alleviate rising ground water problems on farms have in turn changed the hydrological regime of Lake Gore. The seasonal salinity pattern within Lake Gore may also change due to increasing inputs of saline water from the Dalyup and Coobidge Creek catchments (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008). Lake Gore has therefore been designated as a tier one state biodiversity asset at risk of salinity and identified as part of a potential Natural Diversity Recovery Catchment (Department of Environment, 2003; Walshe et al., 2005).

Threat to flora

The altered hydrological regime in the catchment has resulted in increases in the water depth and the extent and duration of inundation at Lake Gore (Maunsell/Aecom, 2006; Water and Rivers Commission, 2002). The hydrological changes have been implicated in the death and decline of some components of the riparian vegetation of the Lake Gore catchment (Comer et al., 2001), mainly the fringing vegetation (*Melaleuca cuticularis*) of Lake Gore itself (Massenbauer & Palmquist, 2006). The threats to vegetation also include waterlogging of soil and increased inputs of saline to hypersaline water. *Melaleuca cuticularis* is tolerant of waterlogging and has been recorded withstanding salinities of up to 42 ppt (Carter et al., 2006; Froend & van der moezel, 1996). However, long term none can survive prolonged flooding as this deprives oxygen to their roots and in general trees are likely to die if they do not dry out every 1 to 2 years (Froend et al., 1987). The inundation threshold for *Melaleuca cuticularis* has been exceeded at Lake Gore (Massenbauer & Palmquist, 2006), resulting in tree deaths (Figure 31).

Figure 31. Tree death along the shoreline at Lake Gore, Esperance, Western Australia (photo G. Watkins, 2008).

Threat to fauna

The altered hydrological regime experienced at Lake Gore is also reducing waterbird habitat diversity, particularly wading waterbird habitat such as that suitable for the Hooded Plover (Clarke & Lane, 2003; Massenbauer, 2008b; Robertson & Massenbauer, 2005). There may also be a reduction and eventual loss of any existing fresh/brackish water seeps into Lake Gore, impacting waterbirds and other fauna (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008).

Acidity and heavy metal risk

The altered hydrological regime has resulted in low pH values and high concentrations of heavy metals, mostly in the upper Dalyup and Coobidge Creek catchments (see: Section 3.1.3 Water Quality). Lake Gore is the main receiving water body of the catchment and is therefore at a greater risk from acidity and heavy metals than the rest of the Ramsar site. Inputs of acidity and heavy metals at Lake Gore may result in:

- Increasing anoxia of benthic sediments due to the formation of iron monosulphide black oozes (MBO) caused by increasing sulfate inputs to Lake Gore. This could reduce the biodiversity and abundance of benthic macroinvertebrates;
- Increased eutrophication and associated algal blooms linked to increasing MBO formation and sulfate inputs. These factors cause phosphorus to be released from benthic sediments into the water column in wetlands. An increase in the frequency of algal blooms in the wetland are a threat to fauna (i.e. death) due to cyanobacterial toxins;
- Increasing soluble aluminium due to acid drainage entering the wetland. Aluminium is extremely toxic to macroinvertebrates, which are likely to form the base of local food webs that support waterbird populations in the wetland. Elevated levels of metal concentrations such as aluminium and iron have resulted in fish kills (Sammut et al., 1995; Stephens & Ingram, 2006). Additionally, increased levels of readily soluble aluminium may cause aluminium toxicity in the fringing vegetation of Lake Gore; and
- Increasing heavy metals levels in the benthic sediments of Lake Gore due to inputs from acid saline drainage. The heavy metal of most concern in the catchment is likely to be lead, due to its abundance in leachate from granitic rocks and due to the risk of this metal bioaccumulating in organisms and being biomagnified through local food webs (Steve Appleyard, Hydrogeologist, DEC, pers. comm., 2008). Figure 32 conceptualises the threat of acidity to Lake Gore.

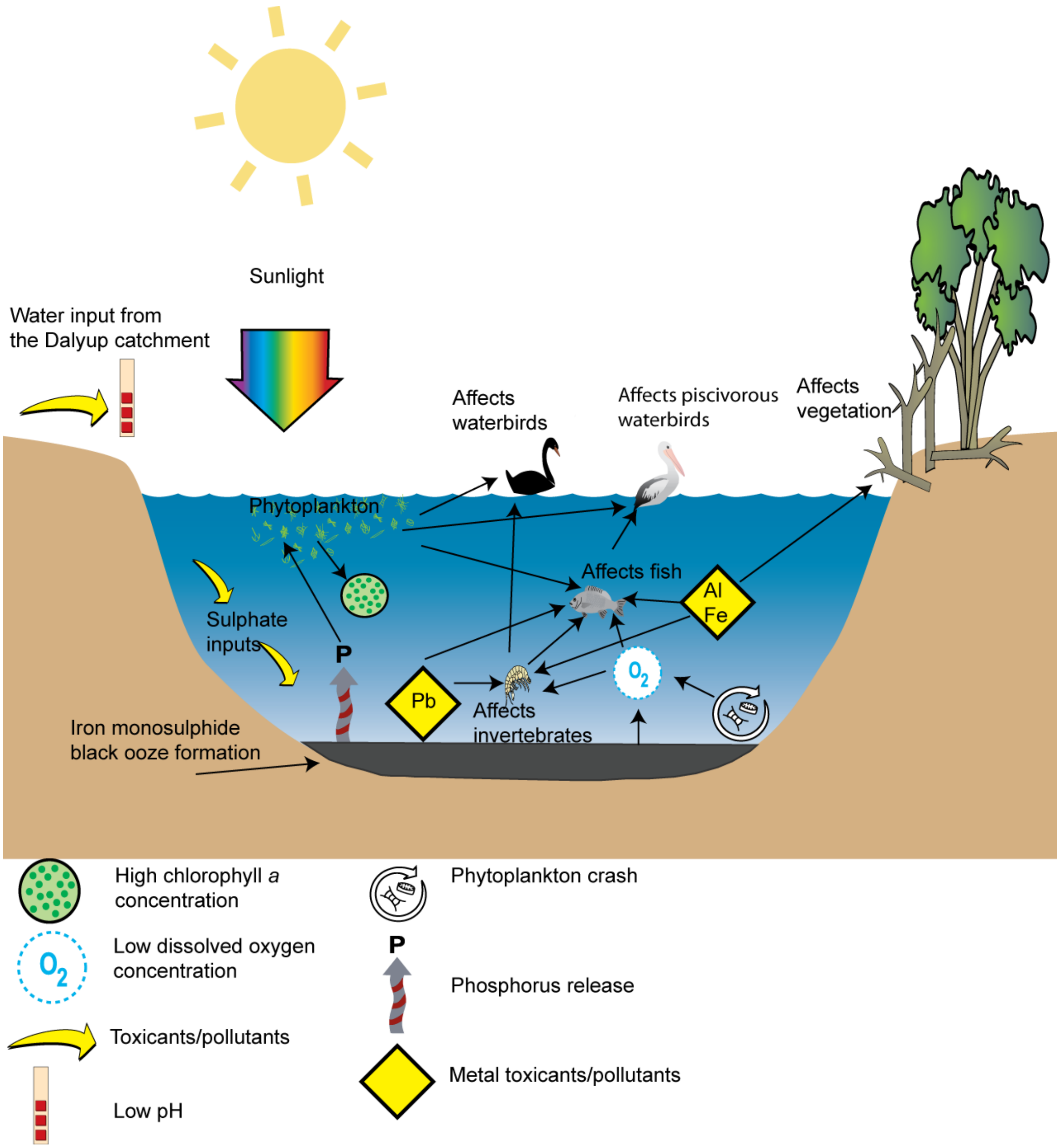

Figure 32. Conceptual model of the potential acidity threat to Lake Gore, Esperance, Western Australia.

4.1.2 POLLUTION

Pollution is recognised as a threatening process to the Lake Gore Ramsar Site (Comer et al., 2001) in the form of nutrients, sediments and saline water discharges from the deep drainage. Analysis of sediment cores taken in Lake Gore, have shown elevated nutrient levels occurring from the 1950's, coinciding with the beginning of agriculture and application of fertiliser in the catchment (Wilson, 2003). There have also been anecdotal reports of algal blooms occurring at Lake Gore. In addition, the levels of TP and TN recorded for Lake Gore are high when compared with ANZECC and ARMCANZ (2000b) suggesting that nutrient enrichment is a potential threat. The impact of these blooms on waterbird populations is unknown.

4.1.3 ALTERED FIRE REGIMES

Due to the surrounding land use fire and fire suppression are a potential threat to the ecological character of the site. Agriculture has the potential to increase the occurrence of fire due to the use of agricultural machinery and the growth of annual crops which provide dry fuel during summer periods. To protect human life fire is also suppressed. Fire is a naturally occurring form of disturbance in Australia and is essential for seed germination, dispersal and nutrient recycling within ecosystems (Australian Academy of Science, 1981). Depending on the intensity, disturbances such as fire can be associated with high species richness and diversity (Beard et al., 2000; Kimmins, 2004; Morrison, 2002). However, this is also dependant upon other factors such as fire frequency and timing (Morrison, 2002). Fire suppression leads to a build up of fuel, the ensuing fire may then burn too intense for flora and fauna to recover.

Another issue associated with fire is the introduction of weeds and weed infestation. Disturbance through fire provides the opportunity for weeds to replace the native species of the Lake Gore Ramsar Site. Fire can also cause hydrological changes through the removal of vegetation. Other threats resulting from fire include the attraction of feral animals to an area to feed on new growth that results post fire (Nikki Cowcher, Fire Operations Officer, DEC, pers. comm., 2008). For example, post fire there is often a concentration and abundance of rabbits which causes erosion and changes vegetation structure; more rabbits attracts more foxes which may also feed on native species (Nikki Cowcher, Fire Operations Officer, DEC, pers. comm., 2008).

4.1.4 ACID SULFATE SOILS

As the soils of the Gore system have a high probability of having PASS (Massenbauer, 2007), the agricultural activities in the surrounding catchment may disturb and expose these PASS. The potential threats as a result of exposing acid sulfate soils will be similar to those acidic conditions that have been caused due an altered hydrological regime.

4.2 NON-NATIVE AND ALIEN SPECIES

The Esperance Sand Plain Biogeographic Region is host to some of the typical exotic mammal species found in the Wheatbelt region of Western Australia including, the house mouse (*Mus domesticus)*, black rat (*Rattus rattus)*, red fox (*Vulpes vulpes)*, cat (*Felis catus)* and the European rabbit (*Oryctolagus cuniculus)* (Australian Government, 2007). Populations of wild deer have also been sighted at Lake Gore (Tilo Massenbauer, Recovery Catchment Officer, DEC, pers. comm., 2008).

Weed species are found within the Ramsar site and the surrounding catchments (Table 9), and can compete with native species for resources. Bridal Creeper and the Victorian Tea Tree are considered to be of significant threat to the Lake Gore Ramsar Site (Comer et al., 2001).

Table 9. Weeds recorded in the Dalyup catchment and the Lake Gore Ramsar Site, Western Australia (from Department of Environment and Conservation, 2008e; Massenbauer & Palmquist, 2006; Water and Rivers Commission, 1999). Note: * denotes species is present in the Lake Gore Ramsar Site.

Common Name	Taxa
African Lovegrass	*Eragrostic curvula*
Annual Veldt Grass	*Ehrharta longifolia**
Afghan Weed	*Solanum hoplopetalum*
Annual Ryegrass	*Lolium rigidum**
Barley Grass	*Hordeum sp**
Black berry Nightshade	*Solanum nigrum*
Blow Fly Grass	*Briza maxima**
Bridal Creeper	*Asparagus asparagoides*
Cape Weed	*Arctotheca calendula*
Common Sow Thistle	*Sonchus oleraceus**
Corn Spurrey	*Spergula salina*
Curled Dock	*Rumex crispus**
Doublegee	*Emex australis*
Flat Leaf Weed	*Hypochaeris* sp
Flaxleaf Fleabane	*Conzya bonariensis*
Geranium	*Erodium sp*
Great Brome	*Bromus diandrus**

Common Name	Taxa
Onion Grass	*Romulea rosea**
Oxalis	*Oxalis pes-caprae**
Prickly Paddy Melon	*Cucumis myriocarpus*
Stinkgrass	*Eragrostis minor*
Spear Thistle	*Cirsium vulgare*
Spiny Rush	*Juncus acutus*
Tall Wheatgrass	*Thinopyrum elongatum*
Tumbleweed	*Amaranthus albus*
Victorian Tea Tree	*Leptospermum laevigatum**
Wild Oats	*Avena fatua*
Winter Grass	*Poa annua**
Wireweed	*Polygonum aviculare*

Another threat to the ecological character of the Lake Gore Ramsar Site is *Phytophthora cinnamomi* which causes *Phytophthora* Dieback. *Phytophthora* Dieback is a pathogen introduced into Australia that kills plants by destroying root systems, leaving the plants unable to uptake nutrients and water. *Phytophthora* is a microscopic water mould that travels from plant to plant via soil, water or through root-to-root contact, and once established it can never be eradicated (Department of Environment and Conservation, 2007). Symptoms of infection include crown decline and death of vegetation, which can often be sudden.

As *Phytophthora* Dieback affects plants, it can cause the collapse of whole ecosystems, and fauna such as waterbirds, will lose their source of food and habitat (Department of Environment and Conservation, 2007). *Phytophthora* Dieback can also decrease biodiversity, for example resulting in the dominance of *Phytophthora* Dieback resistant species such as grasses (Department of Environment and Conservation, 2007).

4.3 CLIMATE CHANGE

Human induced climate change is a threat to the ecological character of the Lake Gore Ramsar Site. There has been a noted reduction in winter rainfall throughout much of the south west of Western Australia (Indian Ocean Climate Initiative, 2004), which may impact hydrological regimes. However, the Esperance Region has experienced an increase in rainfall, and unseasonal, episodic rainfall and flooding events (Callow, 2007; George et al., 2008). Although these are not confirmed climate change events, they have affected hydrological regimes. Climate change is a broad issue and controlling it is beyond the management scope for the site. However, the implications of climate change on the ecological character of the Lake Gore Ramsar Site need to be understood in order to effectively manage the site.

The Indian Ocean Climate Initiative (2002) states that the following changes have already occurred to the climate in the south west of Western Australia:

- Winter rainfall in the south west of Western Australia has decreased substantially since the mid-20th century. This has altered the perceptions of regional climate even though a similar, albeit less severe, dry sequence was experienced earlier in the century;
- The recent rainfall decrease was only observed in early winter (May - July) rainfall; late winter (August - October) rainfall has actually increased, although by a smaller amount;
- The winter rainfall sharply and suddenly decreased in the mid-1970s by about 15 – 20%. It was not a gradual decline but more of a switching into an alternative rainfall regime;
- The reduction in winter rainfall resulted in an even sharper fall in stream flow in the south west; and
- Temperatures, both day-time and night-time, have increased gradually but substantially over the last 50 years, particularly in winter and autumn.

4.4 RECREATION

Recreation has been identified as a critical ecosystem benefit/service, however, inappropriate recreational activities may adversely affect the site's ecological character. The Ramsar site hosts mainly passive forms of recreation such as bird watching; however, there are also four wheel drive tracks surrounding and within the Ramsar boundary. Surfing and fishing also occurs on nearby beaches at the southern boundary of the Ramsar site. Camping and bringing pets such as dogs onto the site is not authorised, although it is assumed that this does occur. Visitors to the Ramsar site may also inadvertently spread weeds and *Phytophthora* Dieback. The impacts of recreational activities at the Lake Gore Ramsar Site have not been measured and they remain potential impacts to the flora and fauna of the site.

Monaghan & Beale (2004) identify that human disturbance of waterbirds may reduce reproductive success by affecting behaviour or causing stress related behavioural changes, and may even delay breeding. For instance, it has been documented that human disturbance of Hooded Plovers, while they are away from the nest, results in a negative incubation response (Michael & Mark, 2007).

Human disturbance decreases nest attendance substantially more than any other source of disturbance.

5.0 CHANGES TO ECOLOGICAL CHARACTER

This section describes the current ecological character of the Lake Gore Ramsar Site and identifies any changes in ecological character. Although positive and negative changes can occur in ecological condition a change in ecological character is defined by Ramsar Convention (2005a) as:

"The human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/ service".

An ECD should identify any changes in a Ramsar site's ecological character since the time of listing (DEWHA, 2008). However, it should be recognised that a change in ecological character since listing may also reflect changes that began prior to listing. This section will discuss changes in ecological character prior to and since listing.

At the time of listing in January 2001, the Lake Gore Ramsar Site was already experiencing changes resulting from the threatening processes described in Section 4.0. Comer et al. (2001) acknowledged that the Lake Gore System, which includes Lake Gore, was in a fair condition with a declining trend.

Some changes can be easily identified (e.g. death and decline of riparian vegetation), however, other changes may not be statistically significant or experienced for decades. Determining if the changes to critical ecosystem components, processes, benefits and services are human induced and constitute a change in ecological character, is difficult. Cause and effect relationships are not always obvious and there are often multiple influences occurring simultaneously. As such a precautionary approach will be used when identifying changes to ecological character. If precaution is not used further adverse changes may result whilst additional evidence is being obtained.

5.1 INTERACTION BETWEEN THE CRITICAL ECOSYSTEM COMPONENTS, PROCESSES, BENEFITS, SERVICES AND THREATS

The interaction of the critical ecosystem components, processes, benefits and services determine the ecological character of the Lake Gore Ramsar Site. Threatening activities can have direct influences on critical ecosystem components, processes, benefits and services and therefore impact and change the ecological character of the Lake Gore Ramsar Site

There are interactions between the critical ecosystem components and processes, with climate and geomorphology the overarching drivers. It is important to understand that these critical ecosystem components and processes provide the critical ecosystem benefits and services of the Lake Gore Ramsar Site. They are inextricably linked and negative changes in the critical ecosystem components and processes may affect the capacity of the site to deliver critical ecosystem benefits and services, thus resulting in a change in ecological character. Figure 33 conceptualises the interaction between the critical ecosystem components, processes benefits, services and threats.

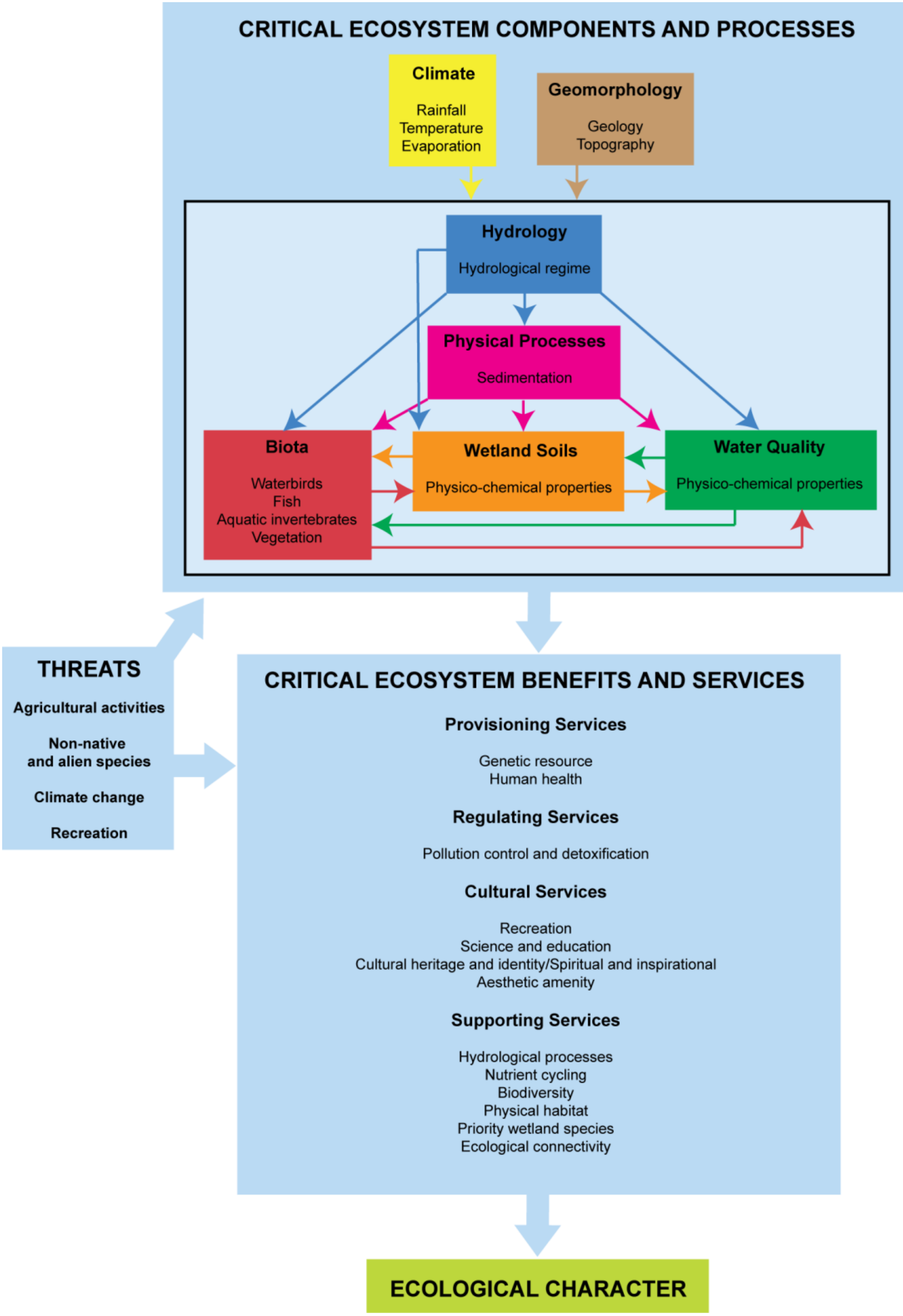

Figure 33. Conceptual model of the interaction of the critical ecosystem components, process, benefits and services of the Lake Gore Ramsar Site, Esperance, Western Australia and the determination of ecological character. Threats influence changes in ecological character (adapted from DEWHA, 2008).

5.2 CHANGES TO CRITICAL ECOSYSTEM COMPONENTS AND PROCESSES

The following is a summary of the changes to the critical ecosystem components and processes of the Lake Gore Ramsar Site:

Climate

- A 5% to 10% increase in annual rainfall in the Esperance region comparing 1976 - 1999 to 2000 - 2007 data (George et al., 2008); and
- Unseasonal, episodic rainfall events resulting in floods in 1999, 2000 and 2007.

Hydrology

- The Dalyup River has now become more perennial, with increased annual discharge and flood peaks (Callow, 2007);
- Estimated peak discharges are significantly higher and flow has increased from 20% to 80% of the year since clearing (Callow, 2007);
- Since catchment clearing, bankful discharge rates are now occurring 2 - 4 times a year depending on catchment location (Callow, 2007);
- An increase in the groundwater levels in the Dalyup catchment of between 0 cm and 35 cm per year since listing (George et al., 2008) with many groundwater aquifers close to full capacity (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008);
- An altered hydrological regime has caused increases in the extent and duration of water inundation at Lake Gore and has not dried out since listing The most recent monthly water depth data (i.e. from 2006 – 2008) indicates that Lake Gore is remaining inundated throughout the year with an average depth of 1.5 m (n=36);
- The current hydrological regime has resulted in the establishment of a new high water mark (> 17.5 m AHD);
- The minimum and maximum exposed shore zone areas at Lake Gore has been reduced from 45 ha - 200 ha (optimum) to 0 ha - 90 ha (Massenbauer, 2008b; Robertson & Massenbauer, 2005). Thus the optimum minimum and maximum shore zone areas have been reduced by 45 ha and 110 ha respectively; and
- A 50 times increase in sedimentation rates since clearing of the Dalyup catchment occurred (Street & Abbott, 2005).

Waterbirds

- A change in waterbird species composition i.e. decreases in Banded Stilt and increases in Chestnut Teal, Grey Teal and Musk Duck (Bennelongia, 2008a, 2008b; Halse, 2007); and

- During the current hydrological regime the maximum habitat area available for wading waterbirds has reduced from 400 ha to 60 ha and for diving waterbirds it has increased from 250 ha to 630 ha (Massenbauer, 2008b; Robertson & Massenbauer, 2005). This equates to a reduction of up to 340 ha of wading waterbird habitat and a gain of up to 380 ha of habitat for diving waterbirds depending on water depth and subsequent area of inundation.

Vegetation

- Much of the fringing *Melaleuca cuticularis* surrounding Lake Gore prior to listing was described as dead or declining (Halse et al., 1993); and
- In 2006, approximately 53% of the riparian vegetation in the Lake Gore catchment was either dead or declining (Massenbauer & Palmquist, 2006).

These changes to individual critical ecosystem components and processes are adverse and considered human induced as a result of catchment clearing prior to listing. Increases in unseasonal, episodic rainfall events have exacerbated the affects of catchment clearing, resulting in an altered hydrological regime at Lake Gore (i.e. increased extent and duration of inundation). It appears that changes to the hydrological regime have caused adverse changes to waterbirds and the vegetation of the Lake Gore Ramsar Site. Waterbird species composition appears to be changing with increases in ducks and allies that require deeper open water habitat and decreases in those species that require an exposed shore zone and wading habitat. A period of inundation longer than natural thresholds has resulted in the death of riparian vegetation.

These changes constitute a change in ecological character of the Lake Gore Ramsar Site. The change in ecological character began prior to listing and has continued post listing. The limited data available means that changes since the time of listing are not able to be quantified.

Lake Gore is yet to reach a hydrological equilibrium as groundwater aquifers in the surrounding catchments are still rising (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008). It is therefore anticipated that further changes to the ecological character of the Lake Gore Ramsar Site may occur.

5.3 CHANGES TO CRITICAL ECOSYSTEM BENEFITS AND SERVICES

Critical ecosystem benefits and services are not easily quantifiable and it is therefore difficult to measure changes. However, the changes identified in the critical ecosystem components and processes are likely to result in changes to the critical ecosystem benefits and services. This relates to the provisioning, regulating, cultural and supporting services provided by the Lake Gore Ramsar Site.

There has been a change in the physical habitat of Lake Gore itself which is a supporting service provided by the Ramsar site which constitutes a change in ecological character (see: Section 3.2 Critical Ecosystem Benefits and Services). The hydrological changes have reduced the diversity of waterbird habitat and the vegetation which they rely on. These changes to physical habitat constitute a change in ecological character.

It is anticipated that if threatening processes continue other critical ecosystem benefits and services will undergo adverse changes that would constitute a change in ecological character. Specifically it is likely that the following critical ecosystem benefits and services will undergo adverse changes:

- **Human health** - Physical and mental health may be affected caused by factors such as further degradation to land (e.g. increases in secondary salinisation);
- **Pollution control and detoxification** - Further pressures on the Lake Gore Ramsar Site and specifically Lake Gore to receive pollution from the surrounding catchment may result in collapse of the system. The systems capacity to deal with pollution will therefore be diminished and catchments, along with agriculture will be affected;
- **Recreation** - Bird watching experiences could be diminished, particularly if a reduction in waterbird species richness occurs;
- **Aesthetic amenity** - If further vegetation deaths occur, visual amenity will be reduced. Visual amenity may also be reduced if pollution threats continue resulting in an increase in algal blooms;
- **Biodiversity** - The habitats of the Ramsar site contribute to the biodiversity it attracts, particularly in relation to waterbird habitat. If the condition of these habitats is impacted biodiversity may be reduced; and
- **Priority wetland species** - A reduction in waterbird habitat has already occurred and this may affect the CAMBA, JAMBA, ROKAMBA and CMS species that visit Lake Gore. The majority of these waterbird species require a wading habitat (see: Section 3.1.6.1 Waterbirds). A reduction in Hooded Plover numbers may also occur.

6.0 LIMITS OF ACCEPTABLE CHANGE

Limits of acceptable change (LAC) 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 (Figure 34). In most cases, change is considered in a negative context, leading to a reduction in the values for which the site was listed".

LAC were originally conceived to deal with the issues of recreation carrying capacity in forested wilderness areas in the United States (Stankey et al., 1985), but has since been adopted by the Ramsar Convention (and in other contexts) to describe, identify and set limits within which change can be tolerated. Phillips (2006), explains that the limits of acceptable change should be set outside of natural variability (Figure 34).

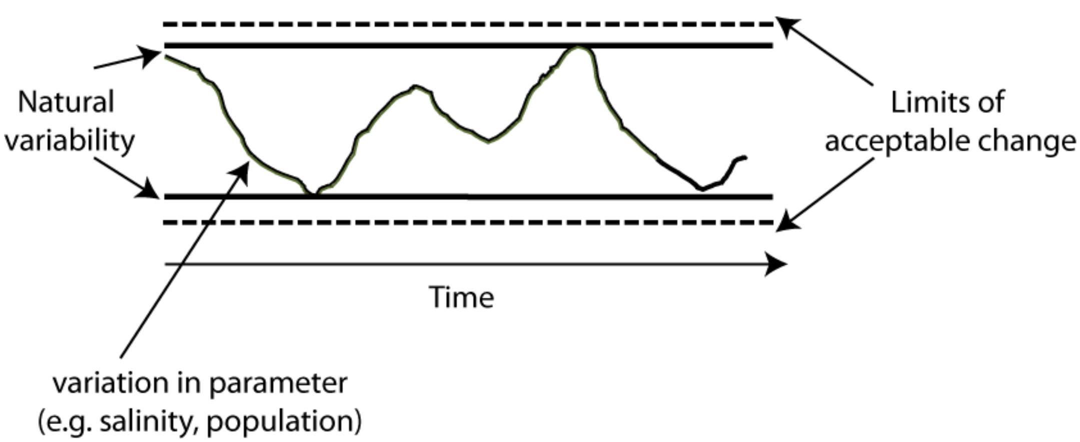

Figure 34. Natural variability and the limits of acceptable change (from Phillips, 2006).

Hale & Butcher (2007) explain that it is insufficient to set limits of acceptable change outside the extreme values of natural variability (i.e. based on maximum and minimum values), as these values alone fail to detect the full possible variability of any parameter (Figure 35). However, it is impossible to determine all the potential parameter variations outside of natural variability as this would involve knowing all the changes to parameters as a result of anthropogenic influences. In these instances the precautionary principle must be applied. There are multiple definitions of the precautionary principle although in essence a precautionary approach should be adopted where there is a lack of full scientific knowledge and there is a potential threat of serious or irreversible negative effects on environmental, human, animal and plant health.

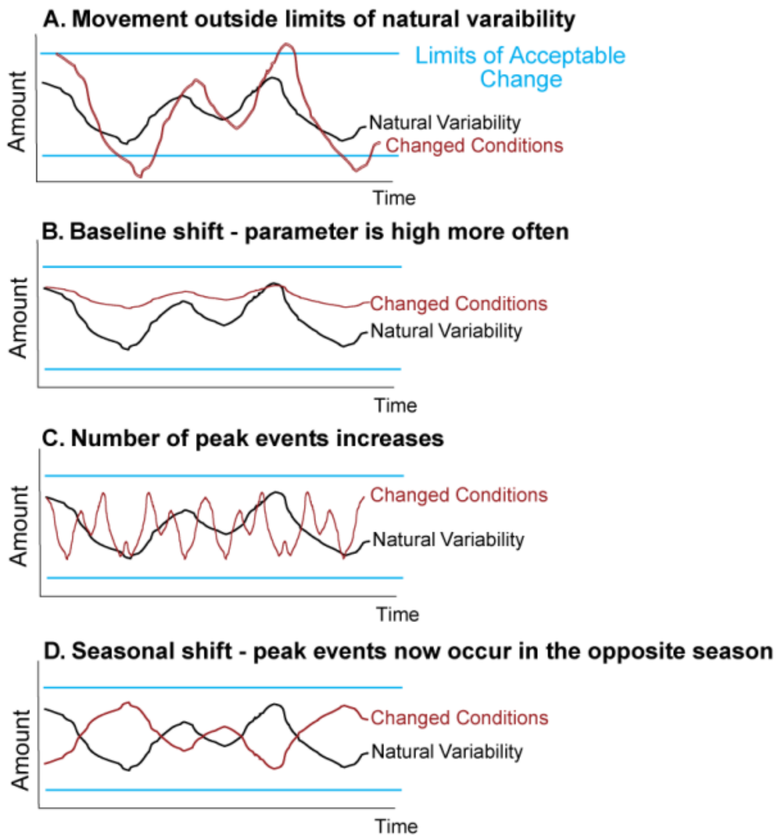

Figure 35. Illustration on setting limits of acceptable change based on maximum and minimum values outside of natural variability. A) This will only capture a change in maximum and minimum values; (B - D) Situations that involve shifts in baseline values; an increase in the number of peak events or a seasonal shift will not be captured (from Hale & Butcher, 2007).

Ideally, quantitative information should be used to determine limits of acceptable change (Davis & Brock, 2008), however, this information is often not available. Qualitative information can be used, however, careful use of language or clearly defined definitions must be provided as they could be open to interpretation.

The LAC for the Lake Gore Ramsar Site have been based on the requirements for the maintenance of the critical ecosystem components, processes, benefits and services that define the ecological character of the site. For example, the LAC for water physico-chemical parameters (e.g. pH and salinity) have been based on the requirements of the other critical ecosystem components and processes, such as waterbirds. This in turn aids in the continuation of critical ecosystem benefits and services such as recreational bird watching. The LAC have also been based on information that has previously been recorded at the site such as water physico-chemical parameters and waterbird species richness and abundance.

As discussed in Section 5.0, the Lake Gore Ramsar Site was already on a downward trajectory in terms of ecological character at the time of listing, due to a changing hydrological regime. It is acknowledged that LAC should be set for the ecological character of the site at the time of listing, however, LAC based on the historical hydrological regime of Lake Gore are likely to have already been exceeded. In consideration of this, two sets of LAC have been included in this ECD. The first LAC is set under the assumption that waterbirds are the biological indicator for Lake Gore and indirectly represent a historical hydrological regime through identification of optimum waterbird habitats. The second LAC is based on accepting a new hydrological regime and it is envisaged they will be used to detect any further changes in the ecological character of the site. However, it is unlikely that the Lake Gore Ramsar Site has reached a hydrological or ecological equilibrium and further changes to ecological character may occur. It is therefore difficult to set some of the hydrological based LAC as the system is yet to reach an alternative stable state.

Where a lack of knowledge exists, the precautionary principle has been applied in setting the LAC for the Lake Gore Ramsar Site. Where little comprehensive knowledge is available these have also been outlined as knowledge gaps in Section 7.0. Table 10 details the LAC for the Lake Gore Ramsar Site and it is recommended that they are considered in management planning and monitoring for the site.

In the management and monitoring of the site LAC are ideally combined with management triggers values. Management trigger values are a precautionary alert purposely set below LAC so that an adaptive management response can occur prior to the LAC being reached. This ultimately aids in ensuring that a change in ecological character does not occur. It is not the purpose of an ECD to include management actions therefore management trigger values will be provided separately to land managers as an Annex to this report.

Additional LAC explanatory notes

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

Exceeding or not meeting LAC 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 LAC 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 LAC 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 LAC 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.

LAC 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 10. Limits of acceptable change for the Lake Gore Ramsar Site, Esperance, Western Australia. Neither set of LAC necessarily represent the natural variability of Lake Gore at the time of its listing as a Ramsar wetland

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
Abiotic components			
HYDROLOGY **Catchment surface water inputs into Lake Gore**	Catchment surface water inputs are yet to be quantified. However, an altered hydrological regime in the catchments surrounding the Ramsar site is recognised with increases in surface water runoff occurring (Comer et al., 2001; Komarzynski, 2001).	Baseline must be identified before limits can be set.	Catchment has not reached a hydrological equilibrium; therefore LAC can not be set. Interim limits - no further increase in surface water inputs into Lake Gore (subject to data collection).
HYDROLOGY **Groundwater inputs into Lake Gore**	Fresh and saline water inputs from surrounding aquifers into Lake Gore are likely to occur. Although groundwater data exists, the relationship between groundwater and the Ramsar site are not fully understood. Groundwater trends illustrate the altered hydrological regime in the catchments surrounding the Ramsar site. Many of the aquifers, including those thought to influence Lake Gore, are close to full capacity (John Simons, Regional Hydrologist DAFWA, pers. comm., 2008).	Baseline must be identified before limits can be set.	Catchment has not reached a hydrological equilibrium; therefore LAC can not be set. Interim limits - no further increase in groundwater inputs into Lake Gore (subject to data collection).
HYDROLOGY **Lake Gore hydrological regime**	Prior to listing, Lake Gore had a history of dry periods. Since listing, Lake Gore has remained inundated. Although no significant increases in water depth have occurred, an increase in the extent and duration of inundation has resulted in a reduction in the available shore zone (Massenbauer, 2008b; Robertson & Massenbauer, 2005). This has reduced wading waterbird habitat and has inundated vegetation (Massenbauer, 2008b; Massenbauer & Palmquist, 2006; Robertson &	Seasonal drying i.e. during autumn/ summer period in 1 out of every 5 years. At all other times the depth of Lake Gore should not exceed 16.6 m AHD; and/or the exposed shore zone should not fall below 45 ha.	Lake Gore has not reached a hydrological equilibrium, LAC can not be set. Interim limit - no further increases in water depth i.e. water depth must be below 17.03 m AHD.

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
	Massenbauer, 2005). The current depth range for Lake Gore is 16.2 m AHD to 17.03 m AHD with the optimum depth range for waterbird species richness and abundance being 15.8 m AHD (200 ha exposed shore zone) to 16.6 m AHD (45 ha exposed shore zone) (Massenbauer, 2008b; Robertson & Massenbauer, 2005).		
WATER QUALITY **Salinity of Lake Gore**	September and November salinity concentrations have been recorded between 6.5 ppt and 250 ppt (data from: Lane, 2008; Lane et al., 2004). Mean salinity concentrations for September and November were 44.2 ppt and 53.5 ppt respectively. The waterbirds recorded at Lake Gore have been recorded at average salinities between 1.7 ppt and 191 ppt (minimum <3 and maximum 344; see: Appendix B). Baseline information is not sufficient to derive seasonal trends. Salinity loads are also unknown.	Spring salinity concentration must not be greater than 100 ppt for more than 2 consecutive years.	Spring salinity concentration must not be greater than 100 ppt for more than 2 consecutive years.
WATER QUALITY **pH of Lake Gore**	The pH of Lake Gore for September and November has been between 6.8 and 9.8. (data from: Department of Environment and Conservation, 2008b; Lane, 2008). Waterbirds observed at Lake Gore have been recorded at average pH values between 6.3 and 8.7 (minimum 1.9 and maximum 11.5 see: Appendix	The minimum pH value must not fall below 6.5 and the maximum pH value must not be greater than 11.	The minimum pH value must not fall below 6.5 and the maximum pH value must not be greater than 11.

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
	B).		
WATER QUALITY **Nutrient status of Lake Gore**	September and November TP has ranged between 0.01mg/L and 0.37 mg/L. September and November TN has ranged between 2.1 mg/L and 4.9 mg/L. September and November SRP has ranged between 0.005 mg/L and 0.06 mg/L. September and November TSN has ranged between 0.95mg/L and 4.2 mg/L. (data from: Lane, 2008). Baseline information is not sufficient to derive seasonal trends. It is also not conclusive if these concentrations represent natural variabilty and/or pose a threat to the ecological character of the site. Using them as a baseline may reflect adverse environmental conditions. Nutrient loads are also unknown.	Insufficient data at this time.	Insufficient data at this time.
WATER QUALITY **Chlorophyll *a* status at Lake Gore**	One reading of chlorophyll *a* concentrations 0.81 mg/L taken in 1998 (Pinder et al., 2004). Baseline information is insufficient at this stage as to what concentrations of chlorophyll *a* represent natural baseline conditions at Lake Gore.	Insufficient data at this time.	Insufficient data at this time.
WATER QUALITY **Metal status at Lake**	The metal status of Lake Gore is unknown although elevated levels of metals have been recorded in the	Baseline must be identified before limits can be set.	Baseline must be identified before limits can be set.

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
Gore	Dalyup catchment (see: Lillicrap & Simons, 2009). Baseline information is insufficient at this stage.		
PHYSICAL PROCESSES **Sedimentation at Lake Gore**	Pre-clearing sedimentation rates in Lake Gore were 8mm /100 years. Post clearing are 400mm / 50 years (Street & Abbott, 2005). Lake Gore has annually received 11,508 t yr^{-1} of sediment with a specific yield of 37.5 km^2 yr^{-1} (Callow, 2007). Information on spatial variability of sedimentation of Lake Gore is unknown. Sedimentation and its actual affects on altering the bathymetry and aspects of hydrological regime of Lake Gore are also limited.	Baseline must be identified before limits can be set.	Sediment rates are the result of catchment clearing and the subsequent hydrological regime. LAC can not be set until a hydrological equilibrium is reached. Interim limit - of no further increase in sedimentation rates.
Biotic components			
BIOTA **Waterbird diversity and abundance**	The site has supported > 1% of the South-west Australian population of the Australian Shelduck and Chestnut Teal. The site has supported > 1% of the Western Australian Population of Hooded Plover. The site has supported > 1% of the Australian population of the Banded Stilt. Regularly supports thousands of moulting Shelducks. A total of 53 species of waterbirds have been recorded at the site, 25	The Ramsar Site supports: • > 1% of the South-west Australian population of Australian Shelduck in at least 4 out of 5 years • > 1% of the South-west Australian population of Chestnut Teal in at least 2 out of 5 years • > 1% of the Western Australian population of the Hooded Plover in at least 2 out of 5 years • > 1% of the Australian population of the Banded Stilt in at least 1 out of 5 years • > 0.5% of the South-west	It is anticipated that the waterbird species composition, richness and abundance experienced historically will continue only if appropriate aquatic habitats are provided by the hydrological regime. As hydrological equilibrium has not been reached LAC can not be set, however the following will serve as interim limits as they will still indicate a change in ecological character. The Ramsar Site supports: • > 1% of the South-west Australian population of Australian Shelduck in at least 4 out of 5 years

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
	species listed under the EPBC Act : 24 "Marine" ,14 "Migratory" species listed under international migratory agreements (CAMBA, JAMBA, ROKAMBA and CMS) Waterbird use of the Lake Gore Ramsar Site is highly variable. At the regional scale it is strongly influenced by changes in wetland availability in the South-west of Australia. At the local scale it is influenced by changes in water levels in the lakes as this determines habitat availability.	Australian population of the Australian Shelduck, during the moulting period, in at least 4 out of 5 years These LAC are set under the assumption that environmental conditions external to the site remain stable and regular waterbird surveys are conducted.	• > 1% of the South-west Australian population of Chestnut Teal in at least 2 out of 5 years • > 1% of the Western Australian population of the Hooded Plover in at least 2 out of 5 years • > 1% of the Australian population of the Banded Stilt in at least 1 out of 5 years • > 0.5% of the South-west Australian population of the Australian Shelduck, during the moulting period, in at least 4 out of 5 years
BIOTA **Fish**	The Western Trout Minnow, Blue Spotted Gobi and Black Bream have been recorded in the past at Lake Gore (Lenanton, 1974). Hardy Head and the Swan River Gobi have also been recorded in the Dalyup River prior to its termination at Lake Gore (Cook & Janicke, 2008). There is no current information to the actual existence or continued existence of any of these fish species at Lake Gore.	Baseline must be identified before limits can be set.	Baseline must be identified before limits can be set.
BIOTA **Aquatic invertebrates**	A total of 28 species of aquatic invertebrates have been recorded for Lake Gore (see: Brock & Shiel, 1983; Department of Environment and Conservation, 2008e; Pinder et al., 2004; Singor, 1999). *Coxiella* sp., thought to be *Coxiella*	Insufficient information available at this time, although no changes in the presence of *Coxiella* sp. should occur.	Insufficient information available at this time, although no changes in the presence of *Coxiella* sp. should occur.

Ecological components and processes	Baseline condition/ ecological requirements	1. Limits of acceptable change (for optimum waterbird habitat)	2. Limits of acceptable change (new hydrological regime)
	exposita, is present on the shores of Lake Gore and is an important food source for waterbirds, particularly the Hooded Plover (Singor, 1999; Weston & Elgar, 2000). The invertebrate species composition has been highly variable at Lake Gore with a total of three surveys yielding different results. Variability in species composition and abundance as it pertains to water quality i.e. salinity, is also unknown. As the aquatic invertebrate species found at the site are halotolerant or halophytes, species richness and abundance may change depending on fluctuations in seasonal salinity.		
BIOTA **Vegetation**	Approximately 53% of the riparian vegetation of Lake Gore catchment is either dead or declining due to an altered hydrological regime (Massenbauer & Palmquist, 2006).	Baseline must be identified before limits can be set.	Hydrological equilibrium has not been reached and further death in the riparian vegetation may occur, therefore LAC can not be set. As a precautionary interim limit - no further decline in the riparian vegetation (i.e. > 53%) of the Lake Gore catchment.

7.0 KNOWLEDGE GAPS

There are numerous knowledge gaps identified for the Lake Gore Ramsar Site (Table 11). To fully describe and set limits of acceptable change for the critical ecological components and processes, these knowledge gaps should be addressed. Initially, surveillance of some of the identified knowledge gaps will have to take place. Once the critical ecological components and processes are better understood, management triggers and limits of acceptable change can be "tightened" for some parameters and assigned for others. These predetermined levels can then be used in monitoring of the wetland.

Ideally, it would be beneficial to investigate all of the knowledge gaps for this site, however, resources are often limited and therefore the knowledge gaps that are important for describing the ecological character should be prioritised. The highest priority knowledge gap for the Lake Gore Ramsar Site is hydrology, as it impacts many other critical ecosystem components, processes, benefits and services.

Table 11. Summary of knowledge gaps and recommended actions for the Lake Gore Ramsar Site, Esperance, Western Australia.

Overarching component/process/ benefit/ service	Specific component / process	Identified knowledge gaps	Recommended action
Hydrology	Surface and groundwater interaction	Surface and groundwater interactions not fully described or quantified.	Quantify and describe surface and groundwater interactions to obtain a detailed water balance for the site. Monitor groundwater levels and surface water flows/ volumes i.e. Dalyup River.
	Lake Gore water depth	Limited long term records on the seasonal flux in water levels.	Continue dedicated monthly surveillance/ monitoring of water levels at Lake Gore.
	Extent and timing of inundation Seasonal hydrological regime	The optimum extent of inundation for waterbird abundance and richness is known for Lake Gore (see: Massenbauer, 2008b; Robertson & Massenbauer, 2005). However, the optimum seasonal hydrological regime is unknown.	Remote sensing and quantification of wetland extent. Measurements to coincide with depth gauge information. Comprehensive research on the ecological water requirements for optimum biodiversity at the site. Continue with depth and volume calculations to ascertain optimum seasonal hydrological regime for biodiversity (see: Massenbauer, 2008b; Robertson & Massenbauer, 2005)
Water quality	Water physico-chemical properties Lake Gore	Analysis of Lake Gore's physico-chemical properties has been limited to salinity, TN, TP, FRP and TSN concentrations and pH	Water surveillance/monitoring on a complete physico-chemical suite of parameters which must include metals, salinity and nutrient loads, as well as concentrations.
	Water physico-chemical properties Catchment inputs	Water quality and the rate of surface drainage input into Lake Gore. Specific gaps on the acidity, salinity and the metals in the water entering Lake Gore.	Establish gauging stations on drainages and a water quality monitoring programme. This is specifically to monitor the identified threat of acidity.
	Fresh/brackish water inputs to Lake Gore	Presence of fresh/brackish water seeps.	Remote sensing (thermal infrared) to identify groundwater discharge zones. Shallow groundwater investigations around Lake Gore.
Physical processes	Sedimentation	Preliminary assessment of the rates of sedimentation has been spatially limited. Sedimentation and its affects on bathymetry	Investigate and monitor spatial sedimentation rates at Lake Gore. Monitor sediment loads from the Dalyup River

Overarching component/process/ benefit/ service	Specific component / process	Identified knowledge gaps	Recommended action
		are also limited. Along with temporal changes. Knowledge on the sediment loads entering Lake Gore is limited.	and correlate with Dalyup River flows.
Wetland soil quality	Geochemical cycling between sediments and water column	Mineralogy and geochemistry of lake sediments and fringing soils.	Undertake sediment and soil sampling programme in Lake Gore.
	Geochemical cycling between sediments and water column	Temporal variation of sediment quality in Lake Gore.	Establish sediment and soil quality monitoring programme.
	Acid sulfate soils	Absolute presence of potential acid sulfate soils unknown.	Investigate and map the presence of potential acid sulfate soils in catchments.
Biota	Waterbirds	No uniform methodology in bird surveys.	Implement an appropriate bird survey method for recording maximum abundance and species richness.
	Waterbirds	No temporally consistent bird surveys.	Implement an appropriate waterbird survey regime. This will ensure that the wetland is surveyed with uniform frequency at appropriate times of the year, recording the maximum abundance and species richness.
	Fish	No recent fish surveys.	Fish surveillance/monitoring taking into account different seasons and changes in salinity
	Aquatic invertebrates	Seasonal changes in invertebrate species richness or abundance not known. No changes in invertebrate species richness or abundance recorded as they pertain to water quality i.e. salinity.	Aquatic invertebrate surveillance/monitoring taking into account different seasons and changes in salinity.
	Vegetation	Current condition and extent of riparian vegetation last recorded in 2006.	Continue work of (Massenbauer & Palmquist, 2006) to monitor vegetation condition at the Ramsar site.
	Non-native and alien species *Phytophthora* Dieback	No *Phytophthora* Dieback mapping	Map vegetation affected by *Phytophthora cinnamomi.* Requires updating to ascertain rate of spread.

Overarching component/process/ benefit/ service	Specific component / process	Identified knowledge gaps	Recommended action
	Non-native and alien species Weeds	No weed mapping	Map weeds at the Lake Gore Ramsar Site. Requires updating to ascertain rate of spread.
Regulating Service	Pollution control and detoxification	Monetary benefits of the Lake Gore Ramsar Site in providing this regulating service	Investigation and quantification of the economic value of the site as an ecosystem.
Cultural Service	Recreation	Quantified impacts of recreation	Comprehensive investigation

8.0 MONITORING REQUIREMENTS

The aim of this section is not to develop a monitoring programme, rather to highlight what aspects of the ecological character or which threats to the ecological character require observation. This section is not exhaustive and further studies into the site may identify additional monitoring requirements.

It is important that actual "monitoring" occurs so that the collection of data is driven and comparable with pre-determined objectives or standards. *"It appears that Australian agencies have been actively undertaking surveillance and not monitoring"* (Finlayson & Mitchell, 1999). The differentiation between these two important processes (monitoring and surveillance) must be understood by land managers so that appropriate adaptive management outcomes are the result for the Lake Gore Ramsar Site and other managed areas.

The difference between survey, surveillance and monitoring is outlined by Hellawell (1991):

*"**Survey** is an exercise in which a set of qualitative observations are made but without any preconception of what the findings ought to be.*
***Surveillance** is a time series of surveys to ascertain the extent of variability and/or range of values for particular parameters.*
***Monitoring** is based on surveillance and is the systematic collection of data or information over time in order to ascertain the extent of compliance with a predetermined standard or position".*

A comprehensive monitoring programme for the Lake Gore Ramsar Site is recommended in order to help detect changes in the critical ecosystem components, processes, benefits and services, prior to irrevocable changes in the ecological character of the site. Table 12 details the monitoring requirements of the Lake Gore Ramsar Site. The monitoring requirements have been given a relative priority ranking, so that funding for monitoring can be distributed accordingly. However, it is preferable that as many of the components and processes identified for monitoring are recorded simultaneously. This allows for a greater understanding of trends and any relationships between components and processes.

Table 12. Monitoring requirements for the Lake Gore Ramsar Site, Esperance, Western Australia.

Overarching Component/ process	Specific component/ process	Requirement & Objective	Indicator	Frequency	Priority
Hydrology	Surface and groundwater interaction	Monitor to establish baseline and to detect change against predetermined standards/levels. Gauging stations required on the Dalyup River.	• Depth to groundwater • Flows (m^3/s) of Dalyup River	Monthly	High
	Lake Gore water depth	Monitor to obtain greater understanding of seasonal variation and to detect change against predetermined standards/levels.	• Water depth at depth gauge	Monthly	High
	Extent and duration of inundation Seasonal hydrological regime	Monitor to obtain greater knowledge of the relationship between water depth and extent of inundation and to detect change against predetermined standards/levels.	• Remote sensing	Seasonally with water depth data until relationship between water depth and extent of inundation is understood.	High
Water quality	Water physico-chemical properties Lake Gore	Monitor to establish baseline information and to detect change against predetermined standards/levels. This is depending on the parameter; some baseline information is already available.	• pH • Salinity loads and concentration • Nutrient loads and concentration: TN, TP, FRP and TSN • Dissolved oxygen • Chlorophyll *a* (biomass of phytoplankton) • Algae (phytoplankton cell count), Macro algae • Metals including heavy metals	Monthly to bi-annually depending on the parameter.	Medium
	Water physico-chemical properties Catchment inputs	Monitor to establish baseline information and to detect change against predetermined standards/levels.	• pH • Salinity loads and concentration • Nutrient loads and concentration: TN, TP,	Monthly to bi-annually depending on the parameter.	Medium

Overarching Component/ process	Specific component/ process	Requirement & Objective	Indicator	Frequency	Priority
		This is depending on the parameter some baseline information is already available. Gauging stations required on Dalyup River.	FRP and TSN • Metals including heavy metals		
Physical processes	Sedimentation	Monitor to detect change in the sediment levels and rates in Lake Gore against predetermined standards/levels.	• Rates per year	Annually	Medium
Wetland soil quality	Geochemical cycling between sediments and water column	Monitor to establish baseline information and to detect change against predetermined standards/levels.	• A range of physico-chemical parameters to be determined	Every 5 years	Medium
Biota	Waterbirds	Monitor to detect change against predetermined standards/levels.	• Richness and abundance • Breeding observations: number of breeding pairs, number of nests	This needs to be determined as outlined in Section 7.0 knowledge gaps Table 11. At least on a seasonal basis.	High
	Fish	Monitor to establish baseline information and to detect change against predetermined standards/levels.	• Richness and abundance	Seasonally	Medium
	Aquatic invertebrates	Monitor to detect change against predetermined standards/levels.	• Richness and abundance of families	Seasonally	Medium
	Vegetation	Monitor to detect change against predetermined standards/levels.	• Mapping of vegetation communities, condition and recruitment	Every 3 years	High
	Non-native and alien species *Phytophthora*	Monitor to establish baseline information and to detect change against predetermined standards/levels.	• Mapping of *Phytophthora* Dieback	Every 3 years	Low/Medium

Overarching Component/ process	Specific component/ process	Requirement & Objective	Indicator	Frequency	Priority
	Dieback				
	Non-native and alien species Weeds	Monitor to establish baseline information and to detect change against predetermined standards/levels.	• Weed mapping	Every 3 years	Low/Medium

9.0 COMMUNICATION, EDUCATION AND PUBLIC AWARENESS

This section identifies important communication, education and public awareness messages for the Lake Gore Ramsar Site. Under the Ramsar Convention a programme of Communication, Education and Public Awareness 2009 - 2015 was established. The programme is aimed to raise public awareness into the values and functions of wetlands. These are achieved through coordinated international and national public awareness campaigns.

Current CEPA for the Lake Gore Ramsar Site includes:

- Birds Australia has produced a Hooded Plover Management Plan that includes the Esperance region. The plan itself details specific threats to wetlands and Hooded Plovers. It also includes specific strategies for the Esperance region for management and conservation; and
- Department of Agriculture and Food WA have a range of advisory services which provide education about a range of catchment management issues including salinity and weed/pest management. Their services also include surface and ground water management and an essential component of this is advice is managing stock access to water ways. They are also able to aid in cost benefit analysis for fertiliser application rates to prevent over application.

The following CEPA activities are suggested for Lake Gore and are based on the information derived during the preparation of this ECD:

- The State Government funded Ribbons of Blue programme aims to increase awareness and understanding about local water quality through engaging school groups in sampling waterbodies throughout the state. Esperance Senior High School was involved in the Ribbons of Blue programme and students sampled Lake Gore’s water quality for a number of years but this is no longer occurring. This important conservation and education tool could be reintroduced in the region;

- Responsible Four Wheel driving - educating drivers on how to minimise impact to flora and fauna;
- Interpretive signage at the site, consistent with the Ramsar guidelines for signs, to highlight the international significance of the site;
- Effect of disturbance on waterbirds - community education to identify waterbird habitat and minimise disturbance;
- Importance of wetlands - with particular emphasis on Lake Gore and the waterbird species that visit;
- Surface water engineering options for Lake Gore have been discussed to reduce the volume of water in Lake Gore (see: Maunsell/Aecom, 2006) - public awareness of the potential project; and
- Provisioning Service (Human Health) - the recognition that the Lake Gore Ramsar Site contributes to human health.

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APPENDICES

APPENDIX A: METHODS

The Lake Gore Ramsar Site ECD was prepared by undertaking:

1. Desktop study

The Lake Gore Ramsar Site ECD was prepared, based on a desktop study of the site using existing information. A literature review was undertaken by the author to compile information pertaining to the Lake Gore Ramsar Site. Raw data was also compiled and some statistical analysis was performed.

2. Site visit

A site visit with a representative of the DEC Esperance District Office was conducted for familiarisation with the ecosystem components, processes, benefits and services of the site.

3. Consultation

Consultation and liaison with a wide range of stakeholders including various state government Department representatives, wetland and waterbird experts and other external stakeholders such as community members. The technical advisory group (TAG) met in Esperance and a public forum was also conducted. The TAG was formed specifically to provide technical advice on the ecosystem components, processes, benefits and services of the site.

4. Draft Documents

The ECD was developed in accordance with the requirements detailed in the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands: Module 2 of the National Guidelines for Ramsar Wetlands - Implementing the Ramsar Convention in Australia*. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra (see: DEWHA, 2008).

A draft ECD for the Lake Gore Ramsar Site was prepared and the Ramsar Information Sheet (RIS) was updated, based on the 12 step process described in the national framework and guidance (Table A1). Please note the ECD has not necessarily been presented in this order.

Table A1. Twelve key steps in the preparation of the draft ECD and RIS for the Lake Gore Ramsar Site, Esperance, Western Australia (after DEWHA, 2008).

Step	Outline of tasks performed
1. Introduction to the description	A summary of the site and a statement to the purpose of describing ecological character and the objectives of the ECD was provided. This included legislation that is relevant to the site.
2. Describe the site	A more detailed description of the Lake Gore Ramsar Site including location, climate, maps, tenure and wetland types was provided. This step also involved detailing the Ramsar Criteria applicable to the site.
3. Identify and describe the critical components and services	All possible components, processes, benefits and services of the Lake Gore Ramsar Site were identified. The critical ecosystem components, processes, benefits and services of the Lake Gore Ramsar Site were then identified and described.
4. Develop a conceptual model for the wetland	A series of control and stressor models were developed for the ECD. These were developed by the author using particular information in relation to the site and inferred ecological knowledge. Control models were included to depict the interaction of the critical ecosystem, components, benefits and services of the site. Stressor models were used to depict the effect of threatening processes on critical ecosystem, components, processes, benefits and services of the site.
5. Set limits of acceptable change	Limits of Acceptable Change were set for the critical ecosystem components and processes where possible.
6. Identify threats of the site	The actual or likely threats to the Lake Gore Ramsar Site were identified and the affect on the critical ecosystem components, processes, benefits and services were identified. This was performed using information derived from steps 3-5 and other contextual information.
7. Describe the changes to ecological character	The interaction between the critical ecosystem components, processes, benefits, services and threats were described. Changes in the ecological character of the Lake Gore Ramsar Site were described and quantified where possible.
8. Summarise the knowledge gaps	Knowledge gaps regarding the Lake Gore Ramsar Site were highlighted along with recommended actions. Knowledge gaps were identified using information derived from steps 3-7.
9. Identify site monitoring needs	The monitoring requirements for the Lake Gore Ramsar Site were described based on maintaining the ecological character of the site. Monitoring requirements were identified using information derived from steps 3-8.
10. Identify communication and education messages	Important communication, education and public awareness messages applicable to the Lake Gore Ramsar Site were described. They were identified during the preparation of the ECD.
11. Compile the description of the ecological character	The information was compiled and a draft ecological character description of the site was prepared.
12. Prepare or update the RIS	The RIS was updated using the information derived from the preparation of the draft ECD.

5. Final Documents

Two draft versions of the ECD and RIS were prepared and submitted to the TAG and the Department of Environment, Water, Heritage and the Arts (DEWHA) for review. The final ECD and RIS documents were prepared after incorporating the comments from the TAG and DEWHA.

APPENDIX B: WATERBIRDS

Table B1. Waterbirds recorded for Lake Gore, Esperance Western Australia 1981 - 2008 and feeding guilds. Note: X: Denotes species present; Guild 1 - Shore: Majority of feeding is on dry land; Guild 2 - Wading birds and shallow feeders: Feeding in water that is ≤ 0.5m. Birds within this group may also feed within wet mud and guild 1; Guild 3 - Deep feeders: Requiring a water depth that is ≥ 1m but can also occupy guilds 1 and 2; Guild 4 - Aerial feeders: Birds of prey (guild information adapted from Cowcher, 2005; Jaensch, 2002).

Key:
EPBC Act Status: “Migratory” B - CMS species, C - CAMBA species, J - JAMBA species, R - ROKAMBA species
“Marine” - M

IUCN Red List Status: “Near Threatened” - RNT
“Vulnerable” - RV

Scientific name	Common name	Guild 1.	Guild 2.	Guild 3.	Guild 4.
ACCIPITRIDAE					
Circus aeriginosus	Marsh Harrier **M**				X
ANATIDAE					
Oxyura australis	Blue-billed Duck			X	
Biziura lobata	Musk Duck			X	
Stictonetta naevosa	Freckled Duck			X	
Cygnus atratus	Black Swan			X	
Tadorna tadornoides	Australian Shelduck		X		
Chenonetta jubata	Australian Wood Duck		X		
Anas superciliosa	Pacific Black Duck		X		
Anas rhynchotis	Australasian Shoveler			X	
Anas gibberifrons	Grey Teal		X		
Anas castanea	Chestnut Teal		X		
Melacorhynchus membranaceus	Pink-eared Duck		X		
Aythya australis	Hardhead			X	
ANHINGIDAE					
Anhinga melanogaster	Darter **RNT**			X	

Scientific name	Common name	Guild 1.	Guild 2.	Guild 3.	Guild 4.
ARDEIDAE					
Ardea novaehollandiae	White-faced Heron		X		
Ardea pacifica	White-necked Heron		X		
Egretta alba	Great Egret **CJ;M**		X		
CHARADRIIDAE					
Erythrogonys cinctus	Red-kneed Dotterel		X		
Charadrius ruficapillus	Red-capped Plover **M**		X		
Charadrius leschenaultii	Large Sand Plover **BCJR**		X		
Thinornis rubricollis	Hooded Plover **M.RNT**		X		
Vanellus tricolor	Banded Lapwing		X		
Pluvialis dominica	Lesser Golden Plover **BC;M**		X		
Vanellus miles	Masked Lapwing		X		
LARIDAE					
Larus novaehollandiae	Silver Gull **M**	X			
Sterna nereis	Fairy Tern **M.RV**			X	
Chlidonias hybridus	Whiskered Tern **M**			X	
PELECANIDAE					
Pelecanus conspicillatus	Australian Pelican **M**			X	
PHALACROCORACIDAE					
Phalacrocorax melanoleucos	Little Pied Cormorant			X	
Phalacrocorax sulcirostris	Little Black Cormorant			X	
Phalacrocorax carbo	Great Cormorant			X	
PODICIPEDIDAE					
Tachybaptus novaehollandiae	Australasian Grebe			X	
Poliocephalus poliocephalus	Hoary-headed Grebe			X	
Podiceps cristatus	Great Crested Grebe			X	

Scientific name	Common name	Guild 1.	Guild 2.	Guild 3.	Guild 4.
RALLIDAE					
Gallinula ventralis	Black-tailed Native Hen	X			
Fulica atra	Eurasian Coot			X	
RECURVIROSTRIDAE					
Himantopus himantopus	Black-winged Stilt **M**		X		
Recurvirostra novaehollandiae	Red-necked Avocet **M**		X		
Cladorhynchus leucocephalus	Banded Stilt		X		
SCOLOPACIDAE			X		
Limosa limosa	Black-tailed Godwit **BCJR;M.RNT**		X		
Calidris alba	Sanderling **BCJR;M**		X		
Actitis hypoleucos	Common Sandpiper **BCJR;M**		X		
Arenaria interpres	Ruddy Turnstone **BCJR;M**		X		
Calidris tenuirostris	Great Knot **BCJR;M**		X		
Calidris canutus	Red Knot **BCJR;M**		X		
Calidris ruficollis	Red-necked Stint **BCJR;M**		X		
Calidris acuminata	Sharp-tailed Sandpiper **BCJR;M**		X		
Calidris ferruginea	Curlew Sandpiper **BCJR;M**		X		
Tringa nebularia	Common Greenshank **BCJR;M**		X		
STERNIDAE					
Hydroprogne caspia	Caspian Tern **CJ;M**			X	
THRESKIORNITHIDAE			X		
Threskiornis molucca	Australian White Ibis **M**		X		
Platalea flavipes	Yellow-billed Spoonbill		X		
Threskiornis spinicollis	Straw Necked Ibis **M**		X		

Table B2. Preferred waterbird water quality requirements (salinity and pH where available). Note: Figures in parenthesis are averages; * can cope with saline water if there is fresh water available; # not unusual for feeding at both acidic and non-acidic hypersaline waters (from Cowcher, 2005).

	Salinity (ppt)	pH
Ducks, Geese, Swans		
Australasian Shoveler	0.97-22.2 (9.25)	6.2-10 (8.4)
Australian Shelduck*#	0.35-57.0 (12.0)	4.8-9.8 (8.2)
Australian Wood Duck	0.14-9.5 (3.54)	7.0-9.6 (8.1)
Black Swan*	0.4-43.5 (9.65)	6.2-10.2 (8.2)
Blue-billed Duck	0.65-6.4 (1.72)	6.7-9.1 (8.6)
Chestnut Teal	≤ 3-25	>7
Freckled Duck	7.7-9.0 (8.3)	1.9-11.5 (6.34)
Grey Teal*#	0.12-37.65 (6.9)	6.2-10.1 (8.2)
Hardhead	0.4 - 4.9 (2.32)	6.4-9.0 (8.1)
Musk Duck	0.1 - 11.4 (2.74)	6.4-9.1 (8.3)
Pacific Black Duck*	0.2 - 14.6 (2.85)	6.7-10 (8.0)
Pink-eared Duck	0.14 - 17.0 (5.23)	6.7-10 (8.3)
Grebes		
Australasian Grebe	0.73 - 9.95 (4.04)	7.1-10.1 (8.1)
Great Crested Grebe	0.65 - 8.32 (3.47)	7.7-11.0 (8.7)
Hoary-headed Grebe	0.73 - 9.87 (4.57)	6.8-10.0 (8.4)
Pelicans, Cormorants, Darters		
Australian Pelican	<10	
Darter	1.67 - 7.3 (4.83)	7.0-10 (7.7)
Great Cormorant	0.96 - 4.7 (2.82)	7.3-8.1 (7.6)
Little Black Cormorant	0.87 - 17.2 (3.64)	6.2-9.0 (7.4)
Little Pied Cormorant	0.71 - 17.2 (5.77)	5.7-10.0 (7.9)
Herons, Ibis, Egrets, Spoonbills		
Australian White Ibis	≤ 3-<10	
Great Egret	1.5 - 10.2 (3.82)	7.0-8.1 (7.4)
White-faced Heron	0.14 - 25.8 (3.29)	6.0-9.1 (7.8)
White-necked Heron	≤ 3	
Yellow-billed Spoonbill	0.81 - 7.45 (2.42)	6.2-7.7 (7.2)
Straw Necked Ibis	0.81 - 2 (1.324)	6.2-7.0 (6.9)
Hawks, Eagles, Falcons		
Marsh Harrier		
Crakes, Rails, Water Hens, Coots		
Black-tailed Native Hen		>7
Eurasian Coot	0.17 - 32.1 (6.15)	6.2-10.2 (8.5)
Shorebirds		
Banded Lapwing		
Banded Stilt	10-25	>7
Black-tailed Godwit	≤ 3-<10	
Black-winged Stilt	0.127 - 21.52 (7.89)	6.8-10.1 (8.6)

	Salinity (ppt)	pH
Common Greenshank	<10	
Common Sandpiper	<10	>7
Curlew Sandpiper	≤ 3-25	
Great Knot	≤ 3-25	
Hooded Plover	≤ 3->35	
Large Sand Plover		
Lesser Golden Plover		
Masked Lapwing		
Red Knot	≤ 3-25	
Red-capped Plover	25	
Red-kneed Dotterel		
Red-necked Avocet	114.0 - 344.0 (191.67)	2.8-8.6 (5.0)
Red-necked Stint	≤ 3-25	
Ruddy Turnstone	<10-25	
Sanderling		
Sharp-tailed Sandpiper	≤ 3-<10	
Gulls and Terns		
Caspian Tern	<10-25	
Fairy Tern	<10-25	
Silver Gull	25	
Whiskered Tern	<10-25	

APPENDIX C: AQUATIC INVERTEBRATES

Table C1. Aquatic invertebrates recorded at the Lake Gore Ramsar Site (taxonomic placement and data from Brock & Shiel, 1983; Pinder et al., 2004; Singor, 1999; Weston & Elgar, 2000).

Class	Order	Family	Lowest Identification
Arachnida	Arcariformes		Oribatida
Branchiopoda	Cladocera	Daphniidae	*Daphniopsis pusilla*
Crustacea	Ostracoda		Unidentified x 4
Crustacea	Ostracoda	Cyprididae	*Australocypris insularis*
Crustacea	Ostracoda	Cyprididae	*Diacypris compacta*
Crustacea	Ostracoda	Cyprididae	*Platycypris baueri*
Crustacea	Copepoda	Canthcamptidae	*Canthocampus* sp.
Crustacea	Copepoda	Canthcamptidae	*Mesochra* sp.
Crustacea	Copepoda	Centropagidae	*Gladioferens* sp.
Crustacea	Copepoda	Cyclopidae	*Meridiecyclops bayly*
Crustacea	Copepoda	Cyclopidae	*Microcyclops*
Crustacea	Isopoda	Oniscidae	*Haloniscus searlei*
Gastropoda	Hypsogastropoda	Pomatiopsidae	*Coxiella* sp.
Insecta	Coleoptera	Dytiscidae	*Necterosoma penicillatus*
Insecta	Diptera	Centropagidae	*Culicoides* sp.
Insecta	Diptera	Chironomidae	*Dicrotendipes pseudoconjunctus*
Insecta	Diptera	Chironomidae	*Tanytarsus barbitarsus*
Insecta	Diptera	Ephydridae	*Ephydrid* sp. x 3
Insecta	Diptera	Muscidae	*Muscid* sp. x 2
Insecta	Diptera	Stratiomyidae	Stratiomyidae
Monogononta	Ploima	Brachionidae	*Brachionus plicatilis*
Polychaeta		Capitellidae	*Capitella* sp.

APPENDIX D: NATIVE VEGETATION

Table D1. Native vegetation recorded at the Lake Gore Ramsar Site, Esperance, Western Australia (data from Department of Environment and Conservation, 2008e; Halse et al., 1993; Massenbauer & Palmquist, 2006).

Acacia nigricans	*Leucopogon revolutus*
Acacia saligna	*Melaleuca brevifolia*
Adenanthos cuneatus	*Melaleuca cuticularis*
Allocasuarina huegeliana	*Melaleuca lanceolata*
Anarthria laevis	*Melaleuca pentagona*
Anarthria scabra	*Melaleuca striata*
Anigozanthos rufus	*Melaleuca thymoides*
Apium prostratum var. *prostratum*	*Mesomelaena stygia*
Arctotheca calendula	*Muehlenbeckia adpressa*
Banksia speciosa	*Myoprum* sp.
Baumea juncea	*Nuytsia floribunda*
Calothamnus gracilis	*Pomaderris myrtilloides*
Calothamnus quadrifidus	*Pultenaea obcordata*
Carpobrotus sp.	*Nuytsia floribunda*
Darwinia vestita	*Rhadinothamnus rudis*
Dianella brevicaulis	*Rhagodia baccata* subsp. *baccata*
Disphyma sp.	*Samolus repens*
Distichlis distichophylla	*Sarcocornia quinqueflora*
Dryandra longifolia subsp. calcicola	*Schoenus brevifolius*
Eucalyptus occidentalis	*Sporobolus virginicus*
Eucalyptus preissiana	*Spyridium globulosum*
Eucalyptus tetragona	*Suaeda australis*
Eucalyptus uncinata	*Templetonia retusa*
Ficinia nodosa	*Threlkeldia diffusa*
Frankenia sp.	*Thryptomene australis*
Gahnia ancistrophylla	*Verticordia sieberi Schauer* var. *sieberi*
Gahnia trifida	*Villarsia parnissifolia*
Grevillea oligantha	*Xanthorrhoea preissii*
Halosarcia sp.	
Hakea lissocarpha	
Hakea nitida	
Hakea trifurcata	
Heliotropium curassavicum	
Isolepis nodosa	
Isopogon formosus subsp. *formosus*	
Isopogon trilobus	
Juncus kraussii subsp. *australiensis*	
Juncus pallidus	
Lawrencia glomerata	
Lepidosperma species	