

A guide to managing and restoring wetlands in Western Australia

Introduction to the guide


Version 1



Australian Government



Department of
Environment and Conservation

Our environment, our future 

Introduction to the guide

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When specific reference is made to this topic, the recommended reference is: Department of Environment and Conservation (2012). 'Introduction to the guide', in *A guide to managing and restoring wetlands in Western Australia*, Prepared by J Lawn, Department of Environment and Conservation, Perth, Western Australia.

Disclaimer

While every effort has been made to ensure that the information contained in this publication is correct, the information is only provided as a guide to management and restoration activities. DEC does not guarantee, and accepts no liability whatsoever arising from, or connected to, the accuracy, reliability, currency or completeness of any material contained in this guide.

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PART 1: THIS GUIDE

Why was this guide produced?

Western Australia's unique and diverse wetlands are rich in ecological and cultural values and form an integral part of the natural environment of Western Australia.

A guide to managing and restoring wetlands in Western Australia (the guide) provides information about the nature of Western Australia's wetlands, and practical guidance on how to manage and restore them for nature conservation.

Through the guide and other initiatives, the Western Australian Department of Environment and Conservation (DEC) seeks to assist individuals, groups and organisations to manage the state's wetlands for nature conservation. It is a free online resource produced by the DEC.

What are the contents of this guide?

The guide consists of multiple topics within five chapters.

Introduction

Introduction to the guide

Chapter 1: Planning for wetland management

Wetland management planning

Funding, training and resources

Chapter 2: Understanding wetlands

Wetland hydrology

Conditions in wetland waters

Wetland ecology

Wetland vegetation and flora

Chapter 3: Managing wetlands

Managing hydrology

Wetland weeds

Water quality

Secondary salinity

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Managing wetland vegetation

Nuisance midges and mosquitoes

Introduced and nuisance animals

Livestock

Chapter 4: Monitoring wetlands

Monitoring wetlands

Chapter 5: Protecting wetlands

Roles and responsibilities

Legislation and policy

Who is this guide for?

This guide is intended to be of assistance to anyone who is, or who is intending to, manage or restore a wetland in WA. This includes landowners, land managers, and natural resource managers, individuals, community members and employees of the public and private sector. As much as possible, the information is written to be accessible to this broad target audience.

This guide is not designed specifically for students or environmental consultants. The guide does not prescribe the actions that should be taken in managing and restoring wetlands and therefore is not suitable to be required to be followed as a condition of approval of any form.



Pink Lake, Lorna Glen Station, north of Wiluna in WA's Murchison/Gascoyne region.
Photo – © J Dunlop.

Distribution details

This guide has been produced in PDF format. Each individual topic is available online free of charge as a PDF that can be downloaded. Please see the DEC website at www.dec.wa.gov.au/wetlandsguide.

Each topic has a 'version' stamp on the front page. DEC recognises that there will be the need to correct, update and improve the information in this guide over time, with Version 1 reflecting the information and resources available to publish this document in 2012.

Updates to the guide (such as new versions) will also be posted on the webpage. You can be notified of updates to the webpage via RSS (real simple syndication); see the webpage for more information.

DEC welcomes your feedback and suggestions on the guide. A publication feedback form is available from the webpage www.dec.wa.gov.au/wetlandsguide.

How was this guide produced?

The demand for this guide was formally recognised during the development of the *Wetlands Conservation Policy for Western Australia* in the 1990s. The (then) Water and Rivers Commission initiated this project in liaison with the (then) Department of Conservation and Land Management in the 2000s with the ongoing support of the Western Australian Wetlands Coordinating Committee, the state's peak wetland conservation policy coordinating body.

The Department of Environment and Conservation has continued this work. Topics of the guide have predominantly been prepared by the department's Wetlands Section with input from reviewers and contributors from a wide range of fields and sectors.

The information presented in this guide is the product of the research and endeavours of many individuals in Western Australia and other areas of the globe. The authors have sought to interpret and collate this into a guide that is relevant to Western Australia's wetlands, to promote their sound management and restoration.

The guide, where possible, contains information relevant to all of the state. While the first version of this guide is Perth and south-west centric, the authors have endeavoured to be inclusive of wetlands of the Kimberley, Pilbara, deserts, Goldfields, and South Coast. It is hoped that future versions of the guide will better address statewide issues over time. We appreciate feedback via the form available from www.dec.wa.gov.au/wetlandsguide.

The development of the guide has received funding from the Australian Government, the Government of Western Australia, the Department of Environment and Conservation and the Department for Planning.

Acknowledgments

The following people prepared topics of the guide (in alphabetical order):

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This guide is the result of the effort and contribution of many people, including those acknowledged below. The information presented in this guide is an attempt to capture the essence of the collective years of research and on-ground work carried out by many people in this state, in Australia and in wetlands in other parts of the globe. The importance of the work carried out by all the people involved in wetland conservation in WA and beyond, and their willingness to contribute and share their knowledge and experience for the preparation of this guide, is gratefully acknowledged.

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The authors have drawn inspiration from the volunteers and land owners who care tirelessly for WA's wetlands; wetland researchers, including those in DEC and Australia's universities; and other professionals with a love of wetlands, including but not limited to the late Shirley Balla, the late Luke Pen, and Professor Phil Jennings.



What wetland information is not covered in this guide?

Scientific methodologies and administrative policies of the state government are not covered in this guide. For example:

- wetland mapping, delineation, classification and evaluation methodologies
- wetland buffer identification methodology
- wetland impact assessment methodology

For more information on these, please see the DEC wetlands webpage: www.dec.wa.gov.au/wetlands.

What wetland types are covered in this guide?

The focus of the guide is natural 'standing', or non-flowing, wetlands that retain conservation value. DEC is the Western Australian government agency with the lead role in the protection and management of these wetlands. Examples of wetlands covered by this guide are shown on the following page.



Seasonally inundated wetlands, such as Lake Eda, near Broome.



Seasonally inundated wetlands, such as salt lakes near Jurien.



Seasonally waterlogged wetlands, such as Hay Park in Bunbury



Intermittently inundated wetlands, such as this one in the Great Western Woodlands



Permanently inundated wetlands, such as Lake Preston near Mandurah.



Permanently waterlogged wetlands, such as Saunders Spring, Mandora Marsh



Seasonally waterlogged slopes, such as this paluslope in the south-west corner of WA



Seasonally waterlogged highlands, such as this palusmont in the south-west corner of WA

What wetland types are not covered in this guide?

The guide does not cover the management and restoration of flowing waters, such as waterways, their floodplains, estuaries and peripheral estuarine wetlands. The management of these wetlands is very important but they often require different management strategies to non-flowing wetlands.

These wetland types are the responsibility of the Department of Water unless these areas are, or are proposed to be, DEC managed estate.

Accordingly this guide does not cover:

- near-shore marine areas – for example, beaches and mangroves
- those wetlands that flow in channels – that is rivers, creeks, wadis and troughs – collectively referred to as ‘waterways’
- estuaries or peripheral estuarine wetlands that are influenced by tidal flows
- artificial wetlands.

For more information on the management of waterways, refer to the Department of Water’s River Restoration Manual (Water and Rivers Commission 2000) available at www.water.wa.gov.au/Managing+water/Rivers+and+estuaries/Restoring/River+restoration+manual/default.aspx

The focus of this guide is natural wetlands that retain conservation value. Artificial wetlands, including dams, can support wildlife. Readers with an interest in the management of artificial wetlands may find information in the guide to be of use. Other sources of information include:

- *Planting wetlands and dams: a practical guide to wetland design, construction and propagation* (Romanowski 1998).

Examples of wetlands not covered by this guide are shown below.

	
<p>Near-shore marine areas, such as Roebuck Bay</p>	<p>Waterways – all channel wetlands, including rivers, creeks, wadis, troughs – and their floodplains, such as the Ord River and floodplain</p>
	
<p>Estuaries and peripheral estuarine areas, such as the Hill River Estuary in the Midwest</p>	<p>Artificial wetlands, such as this lake in the southern suburbs of Perth.</p>

What principles underpin this guide?

The principles applied during the preparation of this guide include:

- The objective of this guide is to promote the conservation of natural values of WA's wetlands.
- Wetlands are assets to our society and their conservation is a priority. Raising awareness about the significant values of our wetlands is critical to wetland conservation.
- A high proportion of wetlands in WA are located on private land. Additionally many wetlands are located on publicly owned land for which the designated land manager is not a wetland specialist. Initiatives such as this guide are an important way of disseminating guidance to this broad spectrum of wetland managers.
- Although everyone values wetlands differently, they affect the lives of all Western Australians. Wetlands help shape neighbourhoods, towns, cities, farms, stations, properties and parks around the state and play an important role in our sense of place and cultural identity.
- We can't protect, manage and restore all wetlands. WA's wetlands may have competing land use pressures. They yield water, productive land, minerals, peat and other products that help maintain our lifestyles. We also cannot afford to manage and restore all of the remaining wetlands as our financial and human capital is limited and there are many competing demands on these. The conservation of natural biodiversity and geoheritage values should be a priority, and wetlands of high conservation significance should be prioritised over wetlands that are heavily degraded.
- On an on-going basis, decision-making authorities are making decisions about whether activities that will impact wetlands are acceptable; and what investment we will make in protecting, managing and restoring wetlands. The engagement of Western Australians in decisions about wetland conservation is important, as these decisions should reflect the informed position of our society broadly.
- The best nature conservation outcome is to maintain natural wetland processes and values. Since European settlement, there has been ongoing alteration of WA's wetlands to enhance certain features. These features are most commonly habitat for waterbirds, water storing capacity and duration of inundation. Islands, dredging, draining into and clearing have all been carried out to 'enhance' wetlands. Manipulating wetlands 'for wildlife' tends to result in degradation to the wetland or to the broader landscape, as outlined in many of the topics of the guide.
- Our community should be aware of the true cost of managing wetlands. Substantial financial and human capital is often required to protect and manage wetlands.
- Our community should be aware of the true cost of poorly-managed wetlands. Poorly managed wetlands can be a significant liability. Prioritising our investments also needs to be based on the cost of not managing wetlands and altering natural wetlands. These include, but are not limited to, the cost of acidified groundwater aquifers and infrastructure, the loss of water storage, the cost of mosquitoes and midges at nuisance population levels as well as the diseases that mosquitoes are vectors of, the cost of algal blooms, livestock poor health and deaths, and toxic air quality due to peat fires.
- Maintenance of existing wetland values is more cost effective than re-creation of those wetland values.





The Shoemaker crater, north east of Wiluna, is 30 kilometres in diameter. It contains wetlands which, when inundated, are a stunning array of colours. At around 1.7 billion years old, the crater is Australia's oldest known impact structure.

Lake Argyle is Australia's largest artificial lake and reservoir by volume, with a storage capacity of 10,760 million cubic metres. It is up to 2000 square kilometres when in flood. At up to 50 metres deep, it is the deepest wetland in WA, but is insignificant compared to Lake St Clair in Tasmania, which reaches depths of 174 metres.



Lake Mackay is one of the largest wetlands in Western Australia. Located in the Gibson Desert, it extends east into the Northern Territory.



Carnegie Lake is one of 75 places on Earth chosen by NASA to be on display in its book of striking satellite images, *Earth as Art* (2012). Lake Disappointment and Shoemaker Crater in WA were also chosen.

Although it is some distance from the ocean, Lake Macleod receives ocean water by subterranean vents, making the water chemistry of the lake unique.



Lake Hillier is one of Western Australia's wetlands that are located on islands. It is a striking wetland, coloured a deep pink due to the presence of algae. It is located on Middle Island on the Recherche Archipelago.

Even the Nullarbor supports wetlands. Tiny limestone rockholes, such as these, are one type of Nullarbor wetland. The much larger 'donga' wetlands also form on limestone in the region.



Bats are one of the more elusive wetland fauna. They are common in wetlands of the Pilbara and Kimberley.



The Kimberley is home to the greatest diversity of frogs in WA, and is considered to be a centre of frog endemism in Australia. It boasts over forty species, out of a total of 216 in Australia.



The rakali is a rarely seen mammal and top-order predator inhabiting permanently inundated wetlands in good condition along the WA coastline.



Birds breed in large numbers when intermittently inundated wetlands in the interior flood.



Incredible living rocks are formed by microbial communities of bacteria and algae. These types of communities are the earliest life forms, known to have existed 3.5 million years ago—outliving dinosaurs. They are now uncommon world-wide but WA has many of the remaining populations.



The prehistoric-looking shield shrimp found in claypans have not changed physically in almost 300 million years.



Most of the fish and crayfish of the south west are endemic to the region. The south west is home to remarkable burrowing species fish and crayfish.



Perth is home to the most endangered tortoise in the world.



PART 2: MANAGING AND RESTORING WETLANDS IN WESTERN AUSTRALIA

What are the safety considerations when managing and restoring wetlands?

All natural areas have a range of natural hazards; the following are those most relevant to WA's wetlands which should be taken into account when visiting or working in wetlands:

- animals: ticks, crocodiles, snakes and wild pigs in particular
- cyanobacteria: avoid all contact with water containing toxic cyanobacteria
- use of chemicals: pesticides should only be handled by people with training
- animal control: firearms, traps, electroshocking all pose risks
- machinery: chainsaws, boats etcetera all pose risks
- electricity: electricity poses a particular risk in proximity to water
- fire: in all wetlands, but particularly peat wetlands, where volatile organic compounds and particulates can be inhaled, and where burning of sediments underground can continue long after the above-ground fire has passed
- drowning
- getting bogged
- dehydration
- water: avoid contacting or ingesting polluted water or water with low pH, or high levels of heavy metals or bacteria

What are the legal considerations when managing and restoring wetlands?

Before embarking on management and restoration investigations and activities, it is critical to ensure that any proposed actions are legal and safe. Key considerations are outlined below.

Authority to enter land and carry out actions

Where you are not the landowner, you must have approval (preferably written) from the landowner or vested land manager prior to entering onto the land containing the wetland and carrying out activities on the land.

Your local government (that is, shire, town or city council) can provide you with the ownership and vesting details of public lands. For information about privately owned land, see Landgate www.landgate.wa.gov.au.

Environmental harm

You must ensure that the actions you take do not cause environmental harm or break other laws. Actions with the potential to cause environmental harm include:

- Earthworks
This includes digging wetlands deeper and creating islands in wetlands
- Changes to the wetland's water
This includes draining into, or out of wetlands; altering structures for the conveyance of water, including pipes, weirs and floodgates
- Addition of chemicals
This includes liming agents, salts, chlorines, and pesticides which may harm wetland values, or when done in a manner that is not consistent with their approved use and application rates
- Clearing of native vegetation
This includes burning of vegetation
- Introduction of non-native plants and animals

The relevant topics of this guide provide guidance and further resources to aid you in determining whether your actions may cause environmental harm and what permits or other authorisations you may need to carry out an activity. If you are ever in doubt, seek guidance before initiating an activity. Good intentions can't mitigate the impacts of environmental harm!

Regulations that apply to the clearing of planted native vegetation

When planning to plant native vegetation in wetlands, it is important to be aware of the legal ramifications of doing so.

Under section 51A of the *Environmental Protection Act 1986*, "native vegetation" does not include vegetation that is intentionally sown, planted or propagated unless:

- the vegetation was sown, planted or propagated as required under the *Environmental Protection Act 1986* or another written law; or
- it is declared to be native vegetation under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

Vegetation that is required to be sown, planted or propagated under a written law will often be as a result of conditions of an authorisation or lease.

Regulation 4 prescribes the kinds of intentionally planted indigenous vegetation that are "native vegetation" and which therefore require a clearing permit or exemption to clear and includes:

- (a) Planting that was funded (wholly or partly):
 - (i) by a person who was not the owner of the land; and
 - (ii) for the purpose of biodiversity conservation or land conservation.

OR

- (b) Intentionally planted vegetation that has one of the following:
 - (i) a conservation covenant or agreement to reserve under section 30B of the *Soil and Land Conservation Act 1945*;
 - (ii) a covenant to conserve under section 21A of the *National Trust of Australia (WA)*

Act 1964;

(iii) a restrictive covenant to conserve under section 129B of the *Transfer of Land Act 1983*;

(iv) some other form of binding undertaking to establish and maintain, or maintain, the vegetation.

For the purposes of Regulation 4, biodiversity conservation includes conservation of species diversity, genetic diversity or ecosystem diversity and land conservation includes management of salinity, erosion, soil acidity or waterlogging. Planting includes to sow and to propagate.

Authorisations for activities

Table 1 outlines the authorisations you may require prior to carrying out wetland management and restoration activities.

Table 1. Activities that may require authorisation – a summary

Activity	Authorisation	Legislation	Topic of this guide with more information
Native fauna surveys (including macroinvertebrates)	Licence Permit (freshwater species including fish and crayfish)	<i>Wildlife Conservation Act 1950</i> <i>Fish Resources Management Act 1994</i> , Fish Resources Management Regulations 1995	Introduced and nuisance animals
Use of traps for land-based non-native species	Permit; plus individual local government authorities may also have requirements	<i>Agriculture and Related Resources Protection Act 1976</i> Agriculture and Related Resources Protection (Traps) Regulations 1982	Introduced and nuisance animals
Removal of introduced freshwater species of fish and crustaceans from wetlands	An exemption, approval, authority or licence	<i>Fish Resources Management Act 1994</i> , Fish Resources Management Regulations 1995	Introduced and nuisance animals
Relocation, introduction or reintroduction of freshwater species of fish and crayfish	An exemption, written authority or licence	<i>Fish Resources Management Act 1994</i> Fish Resources Management Regulations 1995 <i>Wildlife Conservation Act 1950</i>	Introduced and nuisance animals
Use of bird traps	Licence	<i>Wildlife Conservation Act 1950</i> Wildlife Conservation Regulations 1970	Introduced and nuisance animals
Use of firearm	Licence	<i>Firearms Act 1973</i>	Introduced and nuisance animals
Culling of native species for conservation purposes (e.g. kangaroos, Australian white ibis).	A licence may be required	<i>Wildlife Conservation Act 1950</i> Wildlife Conservation Regulations 1970	Introduced and nuisance animals
Use of pesticides including baits and 1080	NA	<i>Health Act 1911</i> ; Health (Pesticides) Regulations 1956	Introduced and nuisance animals

Activity	Authorisation	Legislation	Topic of this guide with more information
Shockwaves	Permit	<i>Explosives and Dangerous Goods Act 1961;</i> <i>Western Australian Explosives Regulations 1963</i>	Introduced and nuisance animals
'Take' flora	Licence	<i>Wildlife Conservation Act 1950</i>	Legislation and policy
Clearing of native vegetation	Permit	Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Legislation and policy
Use of herbicides	NA	<i>Health Act 1911;</i> Health (Pesticides) Regulations 1956	Wetland weeds
Herbicides other than as specified by the label	Permit	<i>Agricultural and Veterinary Chemicals Act 1994</i>	Wetland weeds
Burning of native vegetation	Permit	Environmental Protection (Clearing of Native Vegetation) Regulations 2004; <i>Bush Fires Act 1954</i>	Legislation and policy, Wetland weeds
Earthworks in/ near wetlands	Development approval	<i>Planning and Development Act 2005</i>	Legislation and policy
Construction of drains for saline water	Authorisation	<i>Soil and Land Conservation Act 1945</i>	Legislation and policy
Use of surface water	Licence	<i>Rights in Water and Irrigation Act 1914</i>	Legislation and policy
Abstract groundwater	Licence	<i>Rights in Water and Irrigation Act 1914</i>	Legislation and policy
Affect an Aboriginal site	Authorisation	<i>Aboriginal Heritage Act 1972</i>	Legislation and policy

PART 3: THE WETLANDS OF WESTERN AUSTRALIA

How are wetlands defined?

Globally, there are many definitions for the term 'wetland'. These definitions differ in scope, geographic origin and purpose. Some have been developed for the purpose of inventory, some for specific legal application and some to describe habitats of groups of plants or animals.

The Western Australian government uses a number of definitions of the term 'wetland' for various purposes (see text box below). All are inclusive of a broad spectrum of *wet land*. Land where the presence of water gives rise to distinguishable features that can be recognised as being distinct from the surrounding dry land, are identified as 'wetland'. As well as being identified by the presence of water, diagnostic features include the presence of wetland soils (also known as hydric soils) and wetland vegetation.

Areas of permanently inundated land are the best-conserved wetland types in WA. This can be attributed to their being more similar to wetlands of the northern hemisphere and therefore familiar to European settlers. They have been valued for holding and providing water and being habitat for waterbirds. They have also been afforded more protection because they are relatively difficult to use for agricultural purposes or convert to dryland.

Seasonally inundated land is a familiar feature of WA's landscapes, and these tend to be relatively well recognised as 'wetlands'. They are often referred to as 'seasonal wetlands' or 'ephemeral wetlands'. These terms are not used in this guide, because these ecosystems are wetlands all year round, with wet and dry phases, and should be managed as such. Most of the distinguishable features that make them recognisable as distinct ecosystems from surrounding drylands are present or leave diagnostic identifiers during the dry phase.

Intermittently inundated land is often wet or dry for long periods. The vernacular 'salt lake' is one type of wetland readily recognised by many West Australians living in, or familiar with, regional areas of WA, especially north of Perth. These have often been protected by virtue of the fact that they are not suitable for use for agricultural purposes.

Seasonally waterlogged land is least recognised as wetland amongst the general community, despite being a predominant wetland type in the south-west of the state, and where intact, being of high conservation value. Basins, flats, slopes and highlands may all support seasonal waterlogging. These areas are generally very productive agricultural land and there has been widespread clearing and alteration of these wetland types. Permanently waterlogged wetlands, such as mound springs, are generally well-recognised but also used as a water source on rural properties and stations.

Definitions of 'wetland'

The Australian government is a signatory to the Convention on Wetlands of International Importance (the Ramsar Convention), which defines wetlands as "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 depth of which at low tide does not exceed six metres". The Western Australian Government applies this definition during the course of business that relates to its obligations as a signatory to the Convention, for example, when nominating Ramsar sites.

Schedule 5 of the *Environmental Protection Act 1986* defines wetlands as "an area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring, dampland, tidal flat or estuary. The Western Australian Government uses this narrower definition in the course of most business.

The wetland types covered in this guide are wetlands in basins, flats, slopes and highlands that do not have a tidal influence. This includes lakes, sumplands, damplands, palusplains, palusmonts, paluslopes, barkarras, playas and self-emergent wetlands such as mound springs. Descriptions of each of these wetlands are provided below, under the heading 'Wetland classification'.

What do we know about WA's wetlands?

Compared to other states in Australia, the inventory (cataloguing) of WA's wetland is relatively incomplete. This is a reflection of the size of the state and the number and extent of wetlands in WA. DEC coordinates and maintains the wetland inventory of WA, including spatial (mapping) and biological (surveying) inventory. The ultimate objective of wetland inventory is to document wetland information to allow for informed decisions about the use, management and preservation of wetlands.

Wetland mapping

Wetland mapping, as a general term, may encompass one or more of the following:

- the identification of wetlands in the landscape
- the delineation of wetland boundaries
- the identification of characteristics and the grouping of wetlands according to these characteristics (classification)
- the identification of values (evaluation).

Wetland mapping, where available, is used in the processes of land use planning, conservation planning, water planning, controlled burn planning, as well as wetland inventory.

Decision-making authorities use wetland mapping to help prioritise the protection of high value wetlands when making decisions about land, water, fires and investment in wetland protection. However, other characteristics identified through wetland mapping are also very important, for example, controlled burn planning is informed by the location of all peat wetlands, whether or not they are of conservation value, because they need to be carefully managed in relation to fire.

The Environmental Protection Authority and the Western Australian Planning Commission are two of the key decision making authorities in WA in respect of proposals that affect wetlands. These authorities have established a framework for the use of wetland mapping to help guide decisions about land use planning. Land use planning refers to the process by which the government establishes the suitable uses of land, from a regional scale down to the scale of individual properties. The Environmental Protection Authority (EPA) states that, for the purposes of the environmental impact assessment process, the wetlands listed in B.4.2.2 of the *Environmental guidance for planning and development* (EPA 2008) are of high conservation significance and require a high level of protection. The EPA also notes that comprehensive surveys have not been carried out for all regions of the state, and further investigations are required when activities are proposed.

In preparing wetland mapping and considering mapping by third parties, DEC applies a draft framework for wetland mapping, entitled *Framework for mapping, classification and evaluation of wetlands in Western Australia*. The purpose of this framework is to produce coordination and consistency across the state in the approach to wetland mapping, classification and evaluation; certainty that data is collected using valid methodologies; avoidance of repetition in project planning; achievable aims in terms of scope and detail; a mechanism for ensuring that data is made publicly available; and a mechanism to endorse the results at a state level. The WA Wetlands Coordinating Committee oversees the wetland mapping work produced, with the technical input of one of its working groups, the Wetland Status Working Group. Both the Committee and its working group are chaired by DEC. These groups review wetland mapping methodologies and products, and following endorsement by the Wetlands Coordinating Committee, these products can be used as a basis to guide decision-making and made publicly available.

- For more information on the Wetlands Coordinating Committee, see the topic 'Roles and responsibilities' in Chapter 5 and the webpage www.dec.wa.gov.au/wetlandscoordinatingcommittee.

Wetland identification

A range of identification tools can be used to identify wetlands at the sub-regional to regional scale. Technological advances, particularly in relation to aerial photography and satellite imagery, provide opportunities to refine and increase the efficiency of wetland identification processes.

Desk top information that is typically used includes aerial and satellite imagery, topographical maps, soil maps and where available, vegetation maps.

The wetland types that are often most difficult to identify from desk top data are seasonally waterlogged wetlands, particularly those with a flat host landform. This highlights the importance of field reconnaissance, verification and random sampling to account for the limitations of desk top identification methods.


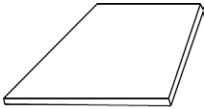
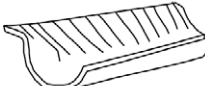
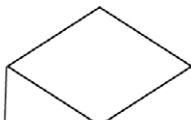

In the field, hydric soils and wetland vegetation are important features to identify for diagnostic purposes.

- DEC is preparing information on WA's hydric soils and wetland vegetation to aid wetland identification and delineation work. Once ready, it will be available from www.dec.wa.gov.au/wetlands

Wetland classification

Wetland classification is the identification of characteristics, and the grouping of wetlands according to these characteristics. Different classification systems may be applied, depending upon the purpose. The geomorphic wetland classification system described by Semeniuk and Semeniuk (1995) has been adapted as the primary classification system for wetland mapping in WA. Using the system, wetlands are assigned to one wetland ‘type’. A complementary classification system, the Australian National Aquatic Ecosystems framework, is also being used to classify wetlands in addition to the geomorphic classification system. The geomorphic classification system has been applied to wetlands in many areas of the state. It is based on the shape of the host landform and the hydroperiod. Table 2 shows the types of wetlands identified via this system. Wetland classification is primarily conducted using desk top information such as aerial and satellite imagery and topographical maps. Field reconnaissance, verification and random sampling are also important processes in wetland classification.

Table 2. Wetland types according to the global geomorphic classification system, adapted from Semeniuk and Semeniuk (1995) and Semeniuk and Semeniuk (2011).

Water periodicity	Landform				
	Basin	Flat	Channel	Slope	Highland
					
Permanently inundated	Lake	-	River	-	-
Seasonally inundated	Sumpland	Floodplain	Creek	-	-
Intermittently inundated	Playa	Barlkarra	Wadi	-	-
Seasonally waterlogged	Dampland	Palusplain	Trough	Paluslope	Palusmont

Wetland evaluation

Evaluation is the process of assessing and documenting a wetland’s values by considering information about its attributes and functions.

Considerations include:

- flora
- fauna
- linkages
- water quality
- wetland processes (e.g. hydrological and sedimentological processes)
- geomorphology
- scientific and educational
- cultural

These can be considered in relation to:

- naturalness
- representativeness
- scarcity

It is important to note that a wetland evaluation is not the same process as a wetland condition assessment. The evaluation of naturalness encompasses wetland condition, but it is not the only consideration when determining a wetland's values.

Wetland values need to be interpreted in a regional context and for this reason, evaluation of a region or sub-region should be conducted using a suitably designed method endorsed by the Wetlands Coordinating Committee.

Detailed evaluations enable DEC to assign wetlands to a 'management category'. Decision-making authorities use these management categories to inform their determinations.

Status of wetland mapping in WA

With significant areas of the state yet to be mapped (Figure 3), DEC continues to work upon extending, improving and updating knowledge of wetland extent, distribution and condition in priority areas of WA as resources allow. New mapping projects are often developed in partnership with organisations such as regional and sub-regional NRM organisations and other government departments. Table 3 and Table 4 outline the available mapping datasets and datasets in preparation. Table 5 outlines regional and sub-regional wetland mapping projects not digitised.

Available wetland mapping in WA

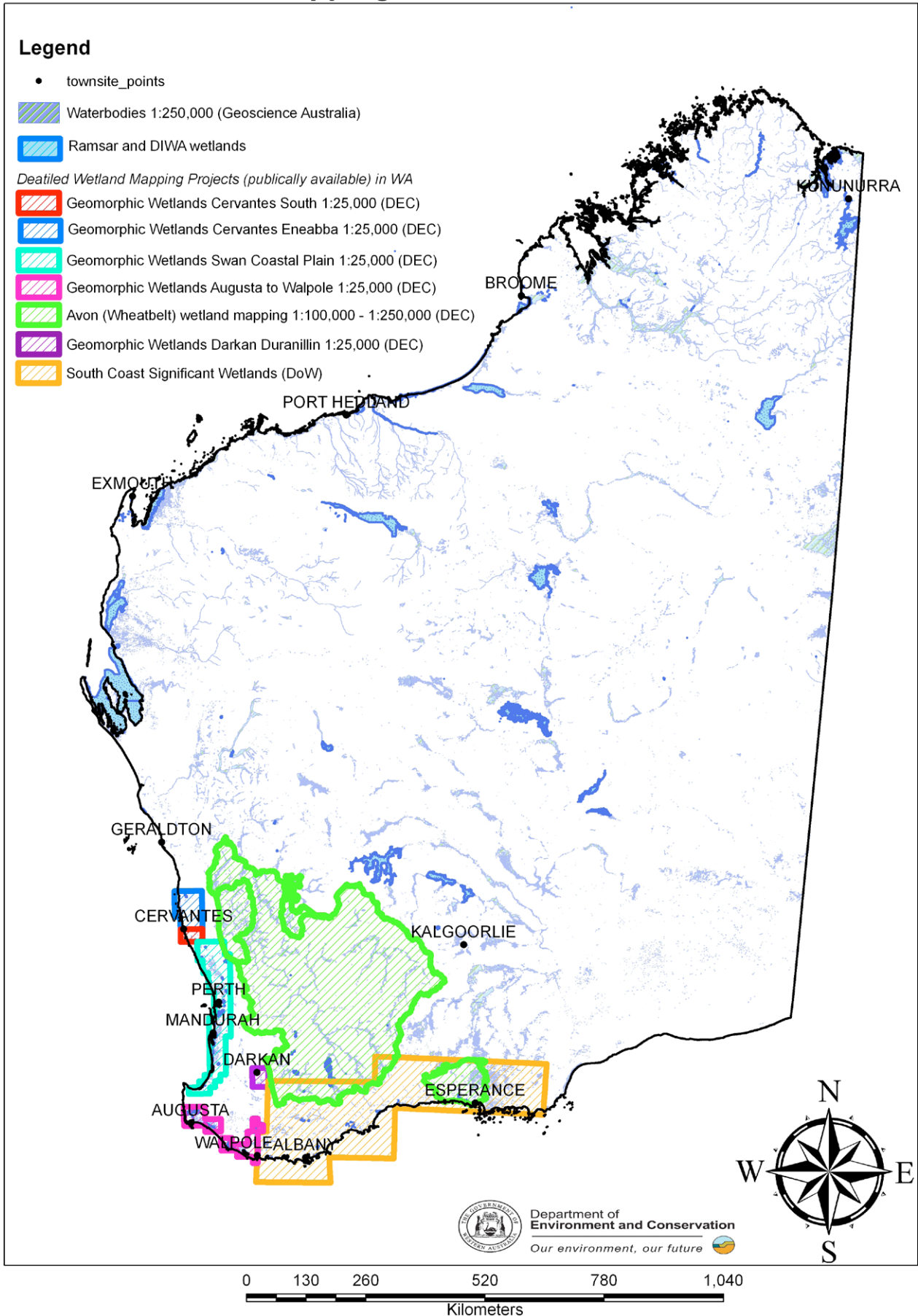


Figure 3. A summary of wetland mapping that is publicly available. See www.dec.wa.gov.au/management-and-protection/wetlands/wetlands-mapping.html for more details.

Table 3. Publicly available datasets of sub-regional spatial wetland mapping as at 2012

Map/project name	DEC region	Scale	Dataset information
Cervantes South	Mid West	1:25,000	Boundaries, wetland types.
Cervantes Eneabba	Mid West	1:50,000	Boundaries, wetland types.
Cervantes Coolimba Coastal	Mid West	1:25,000	Boundaries, wetland types, management categories, consanguineous suites.
Wheatbelt/Avon south (Esperance)	South Coast	1:100,000	Locations, landforms. Evaluation methodology to determine conservation significance is available for application.
South Coast Significant wetlands	South Coast	Based on existing data	'Significance' based on existing data sources
Augusta to Walpole	South West and Warren	1:25,000	Boundaries, wetland types.
Darkan-Duranillin	South West and Wheatbelt	1:25,000	Boundaries, wetland types.
Swan Coastal Plain	Swan	1:25,000	Boundaries, wetland types, management categories, consanguineous suites.
Wheatbelt/Avon (central, east, west)	Wheatbelt & Swan	1:100,000 – 1:250,000	Locations, landforms. Evaluation methodology to determine conservation significance is available for application.

Table 4. Digitised datasets in preparation or endorsement phases as at 2012

Map/Project name	DEC region
Albany urban area, Esperance groundwater area, Hopetoun.	South Coast
Areas of the south-west (Leeuwin Naturaliste Ridge, Donnybrook-Nannup, Margaret River east)	South West
Blackwood Plateau & eastern Scott Coastal Plain	South West and Warren

Table 5. Other wetland mapping projects (not digitised)

Report title	DEC region
Ecological Assessment and Evaluation of Wetlands in the System 5 Region (V & C Semeniuk Research Group 1994). Report to the Australian Heritage Commission.	MidWest
A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton-Walpole Region (Pen, L. 1997). WRC Report # WRAP 7.	South West, Warren
Preliminary Delineation of Consanguineous Wetland Suites Between Walpole and Fitzgerald Inlet, Southern Western Australia (V & C Semeniuk Research Group 1998). Unpublished report for the Water and Rivers Commission.	Warren and South Coast
Preliminary Delineation of Consanguineous Wetland Suites in the Pallinup-North Stirling Region, South Western Australia (V & C Semeniuk Research Group 1999). Unpublished report for the Water and Rivers Commission.	South Coast
Wetlands of the northwestern Great Sandy Desert in the LaGrange hydrological sub-basin (V & C Semeniuk Research Group 2000). Unpublished report for the Water and Rivers Commission.	Kimberley
Wetlands of the Pilbara Region: description, consanguineous suites, significance (V & C Semeniuk Research Group 2000). Unpublished report for the Water and Rivers Commission.	Pilbara
A Preliminary Evaluation of Wetlands in the Esperance Water Resource Region (Ecologia Environmental Consultants 2000). Unpublished report for the Water and Rivers Commission.	South Coast

The importance of wetland mapping – the Swan Coastal Plain example

The most detailed mapping has been produced for Perth and surrounds, encompassing the coastal plain from Wedge Island to Dunsborough, which is part of the Swan Coastal Plain. The mapping was originally produced by Hill, Semeniuk, Semeniuk and Del Marco (1996), with subsequent digital updates by the custodial agency (Water and Rivers Commission, Department of Environment and now Department of Environment and Conservation). The digital map of wetlands for this area is entitled *Geomorphic Wetlands Swan Coastal Plain* dataset. DEC is custodian of this dataset. It is publicly available online for both viewing and downloading (see below). It shows the location of wetlands, their boundary and data describing each wetland's attributes. This includes a unique feature identifier (UFI) assigned to each wetland. It also identifies the wetland type assigned to each wetland as a result of the application of the geomorphic classification system, described previously. In addition it identifies the wetland management category that is assigned to each wetland as a result of a wetland evaluation process, also described previously.

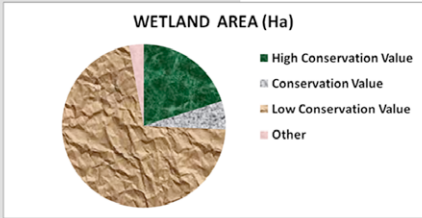
The *Geomorphic Wetlands Swan Coastal Plain* dataset is used by local governments, the Western Australian Planning Commission, the Environmental Protection Authority, the Department of Environment and Conservation and the Department of Water to help guide decisions that may affect these wetlands.

The wetlands of the Swan Coastal Plain are subject to change over time because Perth's dense population drives intensive land and water use and modifications to the natural environment. For this reason, the *Geomorphic Wetlands Swan Coastal Plain* dataset is not static. It is maintained as a live dataset with several updates per year. If the values of a wetland have changed over time, there is a process by which an individual or party may provide sufficient information to enable DEC to review the values of the wetland, and make changes as warranted to the dataset. This can apply where the values of the wetland have declined, or if wetland management and restoration activities have resulted in an increase in wetland values, or where it is believed that the evaluation is incorrect.

- For more information on this process, see the *Protocol for proposing modifications to the Geomorphic Wetlands Swan Coastal Plain dataset* (DEC 2007), available from www.dec.wa.gov.au/management-and-protection/wetlands/wetlands-mapping/geomorphic-wetlands-swan-coastal-plain-dataset.html

case study

The Swan Coastal Plain is the area between Jurien and Dunsborough. More than 25 per cent of this land area is wetland. However, most of it has been heavily degraded.



Twenty-nine sites are identified as nationally significant in the Swan Coastal Plain IBRA region (some sites contain more than one wetland).

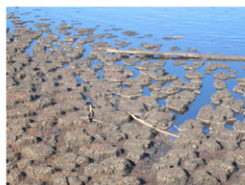
Permanently inundated basins (lakes) are naturally very scarce (3.9 percent by area of the total area of wetland). They are shown in pink on this map. They are well-conserved compared to other wetland types, with 87 per cent retaining values of high conservation significance. Most occur on the western Swan Coastal Plain.



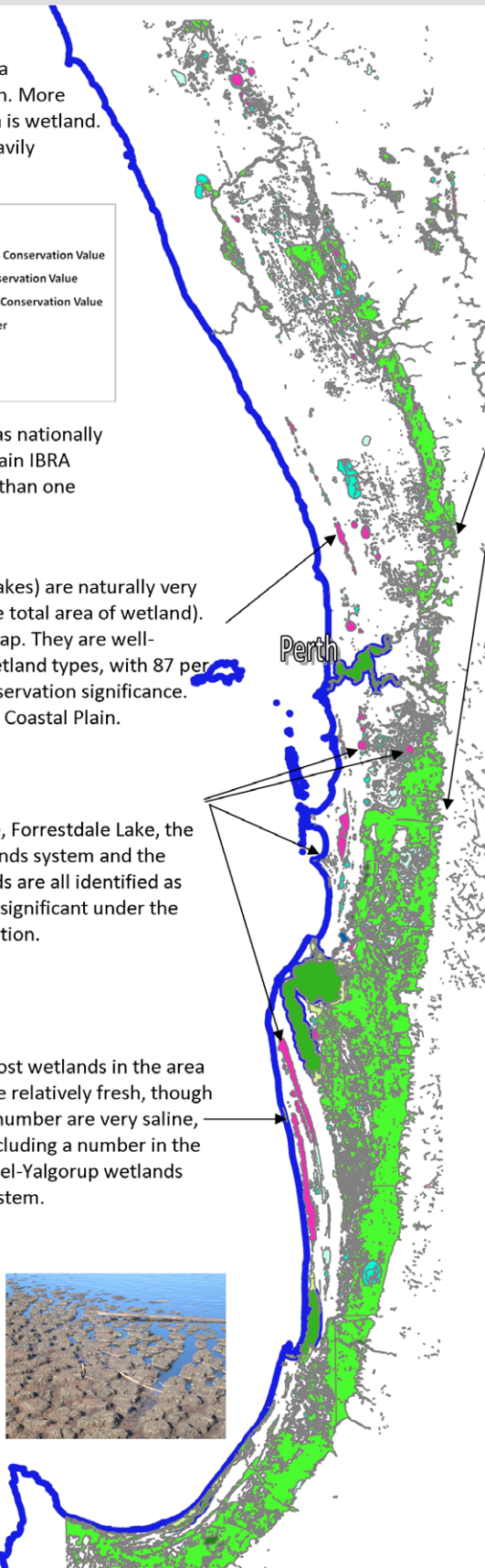
Thomsons Lake, Forrestdale Lake, the Yalgorup wetlands system and the Becher wetlands are all identified as internationally significant under the Ramsar convention.



Most wetlands in the area are relatively fresh, though a number are very saline, including a number in the Peel-Yalgorup wetlands system.



A range of organic and mineral components form wetland sediments on the Swan Coastal Plain. These include diatomaceous earth, peat, calcilutite and other matter of organic origin.



Many of the wetlands north of the Swan River are sustained by their connection with the Gnangara Mound groundwater system. Their fate is intimately tied to that of the mound and our use of the water in the mound.

All of the area mapped in light green is seasonally waterlogged flats, or palusplains. They occur on the eastern side of the coastal plain. Palusplains are the most extensive in terms of area, accounting for 66 per cent of wetland area between Wedge Island and Dunsborough.



Palusplains have sustained the most extensive degradation in terms of area: more than 94 per cent of the area of palusplain is heavily degraded such that it no longer retains conservation value.



Biological and physico-chemical inventory

Biological and physico-chemical wetland inventory in WA is primarily conducted ad-hoc and much of the data is in report form rather than being collated into databases. While many of these reports are unpublished, many published reports can be found in DEC's library catalogue: <http://science.dec.wa.gov.au/conslib.php>.

WetlandBase (<http://spatial.agric.wa.gov.au/wetlands>) is a publicly available database that provides data on WA wetlands. Point data from surveys and sampling is available, and includes data on water chemistry, waterbirds, aquatic invertebrates and vegetation. Note that DEC is preparing an alternative to *WetlandBase*, scheduled for release in 2013, that will continue to make this data publicly available.

WetlandBase stores data from many of the significant wetland inventory projects conducted over the last twenty years:

- Resource condition monitoring: surveys of forty-five significant wetlands across WA by DEC in 2008. See www.dec.wa.gov.au/management-and-protection/wetlands/wetlands-data/wetland-condition-monitoring.html
- South West wetlands monitoring: surveys at twenty-five wetlands between Mandurah and Augusta between 2006 and 2008, conducted by DEC. See www.dec.wa.gov.au/management-and-protection/wetlands/wetlands-data/south-west-wetlands-monitoring.html
- 40 Wetlands Study, Murdoch University
- Jandakot Mound Monitoring Program, Murdoch University
- Gnangara Mound Monitoring Program, Edith Cowan University
- Aquatic Projects Database (Salinity Action Plan Survey), DEC
- Annual Waterfowl Counts in South West WA, DEC
- Waterbirds in Nature Reserves of South West WA, DEC
- South Coast Regional Wetland Monitoring Program, Department of Water

Other notable surveys with a wetland component include:

- Pilbara Region Biological Survey 2002–2012, in which over 1000 collections were made in aquatic areas. See www.dec.wa.gov.au/our-environment/science-and-research/biological-surveys/pilbara-biological-survey.html

Other databases with available data include:

- *NatureMap* www.naturemap.dec.wa.gov.au

NatureMap is a collaborative website of DEC and the Western Australian Museum. It presents the most comprehensive and authoritative source of information on the distribution of WA's plants and animals. It is an interactive tool designed to provide users with comprehensive and up-to-date information on plants, animals, fungi and other groups of biodiversity. It can be used to produce maps, lists and reports of WA's plant and animal diversity.

- *Freshwater fish distribution in Western Australia* database <http://freshwater.fish.wa.gov.au>

This spatial dataset by the Department of Fisheries enables users to search all available information on the distribution of native and introduced freshwater fish and crustaceans in WA.

What are the cultural values of Western Australian wetlands?

Wetlands form a part of our cultural identity and history. Wetlands directly affect the lives of millions of Western Australians, helping to shape neighbourhoods, towns, cities, farms, stations, properties and parks around the state. They form part of our sense of place.

Cultural values of wetlands include:

- spiritual values
- recreation values
- commercial values
- resource values
- scientific values

Much has been written about these values, so they won't be covered here in any detail. The case study and profiles on the following pages provide examples of the scope and diversity of cultural values.



Photo – Wetlands Section/DEC.

Aboriginal values of WA wetlands - by Melissa Bastow, DEC

Humans have valued and utilised wetlands in Western Australia for at least 40,000 years and many of these traditional practices are still continuing today (Balla, 1994). Prior to European settlement, Aboriginal people gathered in large groups around wetlands to take advantage of the rich diversity of game, vegetables and building materials in substantial supply. Resources and materials commonly consumed or collected by early Aboriginal people include water, fish, waterfowl, large mammals, frogs, reptiles, roots, yams, nuts, fruit, fungi, fibre, paperbark and wood. Anthropological and archaeological evidence has demonstrated that resource usage from Aboriginal populations was the densest around wetlands and rivers (McGuire, 1996).

Historically, wetlands were utilised as congregation points, camping sites, pathways and direct access tracks for the migration of inland people (O'Connor et al, 1989 & 1995). Wetlands were also used as access tracks to locate ceremonial places, for example, as occurred at Yanchep, Loch McNess, which was used as a track and camping ground.

Many wetlands in Western Australia contain significant evidence of evolutionary and archaeological past including fossils and Aboriginal remains. All fresh water sources, in particular wetlands and inland rivers, were important to Aboriginal people, and there is a higher likelihood of finding artefacts around freshwater sources (Goode).

A number of different archaeological site types and artefacts are discovered near wetlands, however, the most common is surface artefact scatters, which are sites containing three or more artefacts together in association (O'Connor et al. 1989 and 1995). Some of the other common artefacts discovered near wetlands include marked trees, quarries, middens, seed grindings, habitation structures, engravings, stone arrangements, structures and factory sites, paintings and quarries.

Aboriginal people viewed wetlands as an intricate part of their heritage, culture and way of life and conducted many ceremonial and burial events in their proximity. Wetlands hold values which are significant in the customs, folklore, traditional lifestyle and spiritual beliefs of Aboriginal groups. Of special spiritual and cultural values to the Aboriginal people in the south-west of Western Australia is the Waugal (WRC 2002).

The Waugal is an ubiquitous, dreaming ancestor referred to in the majority of past Aboriginal mythological stories. The Waugal (also known as Wagal, Wagyl, Uocol, Beermarra, Warlu and Wompi) is the serpent spirit of the water who, according to local Aboriginal tradition, created the rivers, wetlands, valleys and other landscape features wherever it travelled (Goode). It has been noted (Bates 1985) that places where the Waugal camped during its travels formed wetlands and deep river pools which have become sacred and significant sites to Aboriginal people. Today, the Waugal is documented to be sleeping in a variety of locations including the deep river pools (Mundrooroo) and at the foot of Kings Park (Green 1979).

References to the Waugal are widespread throughout Australia, however, records are most abundant from the Nyungar people who live in the southwest of Western Australia. Most of the major rivers, creeks, pools, swamps and lakes which drain the Darling Escarpment on the Swan Coastal Plain, are believed to be associated with the Waugal (O'Connor et al, 1989 and 1995).

Early mythological records of the Waugal focus on its creative and spiritual punitive force and the connection between the land and people. Contemporary Nyungar people discuss the destructive and healing powers of the Waugal and its bringing of clean water. Modern anthropologists document that the Waugal is not just a spirit living in the watercourses, but a being which dies when a water source dries up.

In contemporary times, Aboriginal people continue to value and use wetlands for traditional as well as for modern uses including recreation and ecotourism (McGuire, 1996). DEC recognises that Aboriginal people are the traditional custodians of the lands and waters it manages, and supports Aboriginal people connecting with country. The ability to carry out cultural activities on country is an important part of Aboriginal culture and connection to the land. Recent changes to the Conservation and Land Management Act 1984 have extended the opportunities for Aboriginal people to access DEC-managed lands and waters for customary activities. For more information, see www.dec.wa.gov.au/aca. Aboriginal groups are also active in the management, protection and conservation of wetlands.

A raft of algal production projects are underway in the Pilbara and the Wheatbelt to make commercial use of algal products. In the Midwest, Hutt Lagoon is the world's largest microalgae production plant—a 250 hectare series of artificial ponds used to farm *Dunaliella salina*. This microalgae gives the lagoon its colouring and is used to produce beta-carotene, a source of vitamin A used in vitamin supplements, and a food colouring agent used in products such as margarine, noodles and soft drinks.



Bentonite is mined from 'bentonite wetlands' in Watheroo and other locations. This clay has a number of applications.

Many wetlands in the interior are used as discharge sites for mine waters.

Gypsum is mined from wetlands including some in the Jurien area. Gypsum has a number of uses.

Diatomaceous earth has been mined from a number of wetlands, including Lake Gnangara.



Salt has been mined from wetlands since settlement. In Lake Lefroy it has been harvested since 1945. It was initially shovelled by hand into hessian bags and packed into horse-drawn carts. Later on, trucks were used, but sometimes sank into the sediment under their heavy loads. This operation was later moved to Lake Deborah in the early 1970s.



Peat has been mined from many wetlands in Perth and the south-west.



Silica sand mining in the south-west often occurs in areas containing waterlogged wetlands.

Recreational fishing is a popular pastime at Lake Kununurra. Baby barramundi are being released in the lake to ensure a sustainable fishing program.



An annual freshwater swim event at Lake Argyle that aims to promote a healthy lifestyle through swimming while encouraging visitors to the East Kimberly.



The Herdsman Lake Wildlife Centre, in the centre of the Perth metro area, is involved in environmental education programs for schools and the general community.



Lake Ballard has been transformed into a spectacular outdoor art gallery. World renowned artist Antony Gormley has created 51 unique sculptures that represent the residents of the local town, Menzies.



Lake Walyungup is a shallow saline lake that provides great conditions for seasonal land yacht sailing and model aircraft flying.

Lake Towerrinning is a large freshwater lake with sandy beaches. It's a popular holiday destination for camping, swimming and waterskiing.



The Kewari Wetland Trail is an interpretive trail designed to highlight the importance of the internationally significant Lake Warden Wetland System at Esperance.

PART 4: GLOSSARY

This glossary is a compilation of glossary terms from each topic of this guide.

Accuracy: closeness to the 'true' value of the parameter being measured

Acid sulfate soils: (also known as acid sulphate soils) all soils in which sulfuric acid is produced, may be produced or has been produced in quantities that can affect the soil properties

Actual/active acid sulfate soils: (also known as actual acid sulphate soils) soils in which the sulfidic minerals have oxidised and the pH has fallen to very low levels

Acute toxicity: sublethal or lethal impacts resulting from a single or multiple exposures to an agent in a short time (usually less than 24 hours)

Adaptive management: an approach that involves learning from management actions, and using that learning to improve the next stage of management

Adventitious roots: roots that arise from mature plant tissue such as stems or trunks and which take up oxygen and nutrients in inundated conditions

Aeration: the addition of oxygen to the water column of a wetland

Aerenchyma: interconnected air-filled spaces within plant tissue that transport air from plant parts above the water or saturated soils to the roots

Aerobic: an oxygenated environment (organisms living or occurring only in the presence of oxygen are aerobes)

Aestivating: being in a state of dormancy that occurs in some animals to survive a period when conditions are hot and dry

Algae: a general term referring to the mostly photosynthetic, unicellular or simply constructed, non-vascular, plant-like organisms that are usually aquatic and reproduce without antheridia and oogonia that are jacketed by sterile cells derived from the reproductive cell primordium; includes a number of divisions, many of which are only remotely related to one another

Algal bloom: the rapid, excessive growth of algae, generally caused by high nutrient levels and favourable conditions

Alkalinity: a solution's capacity to neutralise an acid

Allochthonous: derived from outside a system, such as the leaves of terrestrial plants that are carried into a wetland

Alluvial soil: soil deposited by flowing water on floodplains, in river beds, and in estuaries

Amphibians: the class of animals to which frogs, toads and salamanders belong. They live on land but develop by a larval phase (tadpoles) in water

Anaerobic: without air (organisms that live in these conditions are anaerobes)

Anaerobic respiration: respiration without oxygen (O₂). Respiration is the process by which organisms convert the energy stored in molecules into a useable form. In most organisms, respiration requires oxygen, which is why breathing by animals is referred to as respiration. However, some bacteria are capable of anaerobic respiration, in which other inorganic molecules (such as sulfur, metal ions, methane or hydrogen) are used instead of oxygen.

Anoxic: deficiency or absence of oxygen

Annual: a plant that completes its life cycle within a single growing season (from germination to flowering, seed production and death of vegetative parts)

Aquaculture: the keeping, breeding, hatching, or culturing of fish

Aquatic invertebrates: those animals without a backbone (such as insects, worms, snails, molluscs, water mites and larger crustacean such as shrimps and crayfish) that live in or on water for at least one phase in their lifecycle

Aquatic plant: a plant that grows for some period of time in inundated conditions and depends on inundation to grow and, where applicable, flower

Aquiclude: an impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater to or from an adjacent aquifer

Aquifer: a geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water

Aquitard: a low permeability body of rock or stratum of sediment that retards but does not prevent the flow of groundwater to or from an adjacent aquifer

Artesian groundwater: groundwater confined under pressure

Australian Height Datum: is a fixed survey point from which the elevation of any point in Australia may be measured

Authorisation: a licence, permit, approval or exemption granted, issued or given under the Part V environmental regulations

Bassendean Sands: (also known as the Bassendean Dunes) a landform on the Swan Coastal Plain, comprised of heavily leached aeolian sands, located between the Spearwood Dunes to the west and the Pinjarra Plain to the east

Benefit: the economic, social and cultural benefits that people received from an ecosystem. These benefits often rely on the components and processes which make up a wetland. This term is often used in conjunction with the term 'services'. See also 'services'.

Benthic: the lowermost region of a wetland water column; the organisms inhabiting it are known as benthos

Benthic microbial communities: bottom-dwelling communities of microbes (living on the wetland sediments)

Benthos: organisms living in or on the wetland substrate

Bentonite: a type of clay (aluminium phyllosilicate)

Bioavailable: in a chemical form that can be used by organisms

Biodiversity: encompasses the whole variety of life forms—the different plants, animals, fungi and microorganisms—the genes they contain, and the ecosystems they form. A contraction of 'biological diversity'

Biogeochemical: the chemical, physical, geological and biological processes and reactions that govern the composition of the natural environment, and in particular, the cycles in which material is transferred between living systems and the environment

Biogenic: produced by organisms

Biological control: the control of an introduced plant or animal by the introduction of a natural predator or pathogen, usually bacteria, viruses or insects, or by biological products such as hormones

Biological oxygen demand: a measure of the oxygen in the water column or sediment pore waters that is being used by organisms

Biofilm: bacteria, microalgae, fungi and unicellular microorganisms enmeshed in a hydrated mucopolysaccharide secretion that sequesters ions and isolates microorganisms from the water column. May be present on living and non-living surfaces and substrates.

Biomass: the total mass of biological material (living or dead), usually expressed as live or dry weight per unit area or volume

Bioregion: a territory defined by a combination of biological, social and geographic criteria rather than by geopolitical considerations; generally, a system of related, interconnected ecosystems

Bioremediation: the use of microorganisms to break down environmental pollutants

Birrida: a local Aboriginal name for a seasonally inundated gypsum saltpan wetland in sand dunes in the Shark Bay area. Some have a distinctive central raised platform and moat feature.

Blank: a solution (usually deionised water) that has a value of zero for the parameter being assessed. Used to calibrate meters.

Broadleaf: plants that possess relatively broad flat leaves rather than needle-like leaves

Blue-green algae: an older term for cyanobacteria

Bore: a narrow, normally vertical hole drilled into a geological formation, usually fitted with a PVC casing with slots to allow interaction with the aquifer, to monitor or withdraw groundwater from an aquifer

Botulism: a paralytic disease caused by ingestion or exposure to a toxin produced by the bacteria *Clostridium botulinum*

Box-subsampler: a watertight box that is divided into a number of cells. A box-subsampler is used when sorting aquatic invertebrates to eliminate observer bias. Dividing the sample into a number of cells which are sorted individually, and in their entirety, reduces the likelihood of preferential selection of larger or more conspicuous taxa.

Brackish: subsaline or hyposaline waters, used in reference to estuarine waters, and often in reference to inland waters

Bradley method: working from the most intact parts of a bushland area out towards more degraded areas, to allow natural regeneration to occur, for example, when weeding

Browse: to feed on leaves, twigs or bark from non-herbaceous (woody) plants, such as trees and shrubs

Buffering capacity: a solution's capacity to resist large or sudden changes in pH

Canopy cover: the proportion of ground surface covered by the leaves and branches of plants when projected vertically downwards

Catchment: an area of land which is bounded by natural features such as hills or mountains from which all surface runoff water flows downslope to a particular low point or 'sink' (a place in the landscape where water collects)

Causation: showing a relationship exists between two variables such that a change in one (the cause) causes a change in the other (the effect). To be sure of the relationship between cause and effect, it is also necessary to show that the effect will not occur if the cause does not.

Charophytes: green algae of the Characeae family; complex algae that superficially look like submerged flowering plants

Chemosynthesis: the process by which organisms such as certain bacteria and fungi produce carbohydrates and other compounds from simple compounds such as carbon dioxide, using the oxidation of chemical nutrients as a source of energy rather than sunlight

Chlorophyll a: a light-capturing pigment found in plant and algal cells. Measurement of chlorophyll a is used as a surrogate for cell counts of algae.

Chroma: the purity of a colour, or its freedom from white or grey

Chronic toxicity: sublethal or lethal impacts resulting from a single or multiple exposures to an agent over a longer time period (months or years)

Clearing: any act that kills, removes or substantially damages native vegetation in an area. This includes severing or ringbarking of trunks or stems, draining or flooding of land, burning of vegetation and grazing of stock or any other act or activity that causes damage to some or all of the native vegetation in an area.

Colony (algal): a closely associated cluster of cells, joined together or enclosed within a common sheath or mucilage. A colony may incorporate thousands of cells.

Colour: the concentration of dissolved organic materials and dissolved metals in water

Coloured wetlands: wetlands with dissolved organic materials and dissolved metals; on the Swan Coastal Plain, nominally those wetlands with more than 52 g₄₄₀/m (gilvin)

Community: a general term applied to any grouping of populations of different organisms found living together in a particular environment

Community composition: the plant taxa that occur in a given community

Community structure: the three-dimensional distribution (height and width of foliage) and abundance of plant taxa and growth forms within a community

Confined aquifer: an aquifer deep under the ground that is overlain and underlain by relatively impermeable materials, such as rock or clay, that limit groundwater movement into and out of the aquifer

Consanguineous suite: area/s defining a group of wetland with common or interrelated features

Consumer: an organism that feeds on other organisms, either dead or alive

Contributing offsets: complementary activities which, together with direct offsets, meet the offset principles. These include education, research, removal of threats, and or contribution to an approved credit trading scheme or trust fund.

Control: a subject that is identical to the experimental subject in every way, except that the experimental subject receives the treatment and the control does not. This means that if a change is observed in the experimental subject after the treatment, but not observed in the control, that change could only have occurred due to the treatment.

Corms, bulbs, tubers: specialised underground fleshy storage organs that allow plants to flourish in nutrient deficient soils or to die back and enter a state of dormancy when conditions are extreme, such as during fire or drought

Cosmopolitan: can be found almost anywhere in the world

Critical environmental assets: the most important environmental assets in the state that should be protected and conserved

Critical threshold: a limit of disturbance of vegetation condition beyond which natural wetland processes are unlikely to restore full ecological function

Crown cover: the vertical projection of the outer extent of the crown of a plant. A line around the outer edge defines the limits of an individual canopy, and all the area within is treated as 'canopy' irrespective of gaps and overlaps.

Crustaceans: a class of animals that have a hard exoskeleton (shell) and usually live in the water, for example, crabs, lobsters, yabbies and microcrustaceans

Cyanobacteria: a large and varied group of bacteria which are able to photosynthesise

Cyanobacterial bloom: the rapid, excessive growth of cyanobacteria, generally caused by high nutrient levels and favourable conditions

Data confidence: the degree of certainty with which it is possible to state that a change has (or has not) occurred in a system and what the cause of the change is

Data quality: the degree to which the data set truthfully represents conditions at the monitoring site. High quality data are achieved by eliminating errors from the dataset.

Data visualisation: the technique of summarising a dataset graphically

Datum: an established point on the globe that is used as the reference from which other locations are calculated. Australia uses the Geographic Datum of Australia 1994 (GDA94).

Deciduous: a plant that sheds its leaves annually

Decision making authority: a public authority empowered to make a decision in respect of a proposal. Often abbreviated to DMA.

Decomposer: organisms, mainly bacteria and fungi, which break down complex organic molecules from detritus, liberating nutrients and assimilating carbon

Decomposition: the chemical breakdown of organic material mediated by bacteria and fungi, while 'degradation' refers to its physical breakdown. Also known as mineralisation

Desmid: a member of the Desmidiaceae (Zygnemophyceae) within the Division Chlorophyta (green algae)

Derived proposal: a proposal referred to the Environmental Protection Authority under section 38 of the *Environmental Protection Act 1986* that is declared by the EPA to have been identified in a strategic proposal that has been assessed and granted approval under Part IV of the EP Act

Detritivore: an animal that feeds on detritus

Detritus: organic material originating from living, or once living sources including plants, animals, fungi, algae and bacteria. This includes dead organisms, dead parts of organisms (e.g. leaves), exuded and excreted substances and products of feeding

Diatom: a microscopic, single-celled alga with cell walls made of hard silica, freely

moving in the open water and forming fossil deposits

Diatomite, diatomaceous earth: siliceous deposits made up of the sedimentary build up of diatom shells (frustules)

Dicotyledons (dicots): flowering plants that typically have seedlings with two cotyledons (seed leaves), a tap root system, and they can form wood and have network leaf venation. Dicots include a range of herbs, shrubs and trees.

Direct offsets: activities which counterbalance the environmental impact of a proposal and are in addition to normal environmental management requirements. This includes restoration (offsite), rehabilitation (offsite), re-establishment, sequestration and acquisition of other land/s under threat for inclusion into conservation estate.

Discharge wetland: a wetland into which groundwater discharges

Disturbance opportunists: responding positively and rapidly to habitat disturbance

Diversity: a measure of the number of species of a particular type and their abundance in a community, area or ecosystem. It can refer to a particular group of organisms, such as native plant diversity or frog diversity.

Dongas: playas (intermittently inundated basins) in the Nullarbor, usually 2–3 metres deep and up to 800 metres in diameter, supporting trees. They hold water for a short time after rain due to their hard clay surface.

Dormancy: a state of temporary inactivity when plants are alive but not growing

Dynamic environment: a process or system which is characterised by constant change or activity

Dystrophic: wetlands that suppress increased algal and plant growth even at high nutrient levels due to light inhibition

Ecological community: naturally occurring biological assemblages that occur in a particular type of habitat

Ecological character: the sum of a wetland's biotic and abiotic components, functions, drivers and processes, as well as the threatening processes occurring in the wetland, catchment and region

Ecological linkage: a network of native vegetation that maintains some ecological functions of natural areas and counters the effects of habitat fragmentation; a series of (both contiguous and non-contiguous) patches of native vegetation which, by virtue of their proximity to each other, act as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape

Ecological water requirements (EWRs): the water regime needed to maintain the ecological values of a water dependent ecosystem at a low level of risk

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)

Ecosystem: a community of interdependent organisms together with their non-living environment

Ecosystem processes: the complex interactions (events, reactions or operations) among biotic (living) and abiotic (non-living) elements of ecosystems that lead to a definite result

Ecosystem services: benefits that people receive or obtain from an ecosystem, including

provisioning services (such as food, fuel and fresh water), regulating services (such as ecosystem processes such as climate regulation, water regulation and natural hazard regulation), cultural services (such as spiritual enrichment, recreation, education and aesthetics) and supporting services (such as the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota)

Ecotype: a genetically distinct geographic variety, population or race within a species which is adapted to specific environmental conditions. Typically ecotypes exhibit differences in morphology or physiology stemming from this adaptation, but are still capable of breeding with adjacent ecotypes without loss of fertility or vigour

Electrical conductivity (EC): the ability of a solution to conduct an electric current, and is measured as 'specific conductance'; the rate of flow of ions between two electrodes at a fixed distance apart, measured at a known temperature

Electrofishing: a technique in which an electric current is applied to the water in order to temporarily stun fish

Emergent: plants that are rooted below the water surface, but with their shoots and/or leaves above the water

Enacted: to make into law

Endemic: naturally occurring only in a restricted geographic area

Endorsed management plan: a management plan that has been approved and/or modified by the Minister for Environment as he/she thinks fit

Environmental impact assessment: an orderly and systematic process for evaluating a scheme or proposal, including its alternatives where relevant, and its effects on the environment, including the mitigation and management of those effects

Environmental offset: an offsite action or actions to address significant residual environmental impacts of a development or activity

Environmental protection policies: whole of government policies which have been agreed to by Parliament and have the force of law as if part of the Act

Environmental water provisions (EWPs): the water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts. They may meet in part or in full the ecological water requirements.

Environmental weeds: plants that become established in natural ecosystems, altering natural processes and leading to the decline of the communities they invade

Ephemeral (plant): marked by short life cycles, usually a single season

Epiphyte: organisms such as bacteria, algae and plants that grow attached to plants

Erosion: the gradual wearing away and movement of land surface materials (especially rocks, sediments, and soils) by the action of water, wind, or a glacier

Euphotic zone: (also known as the 'photic zone' and 'photozone') the section of a water mass penetrated by light of sufficient intensity and of suitable wavelength to promote photosynthesis by aquatic plants

Eutrophication: the nutrient enrichment of a water body, which can trigger prolific growth of plant material (phytoplankton, macrophytes or both). May occur naturally over geologic time or may be human-induced.

Evaporation: the change of liquid water into water vapour in the atmosphere

Evapotranspiration: a collective term for the transfer of water, as water vapour, to the atmosphere from both vegetated and un-vegetated land surfaces

Facultative wetland plants: plants that can occur in both wetlands and dryland in a given setting

Feral animals: introduced animals that have escaped, or have been released, from domestication and returned, partly or wholly, to their wild state

Ferns, fern allies: plants with stems, leaves and roots like other vascular plants, but which reproduce via spores instead of seeds or flowers

Filament: cells in a linear series, usually abutting one another, creating threads or strands

Filamentous: a very fine thread-like structure

Fire-responsive: plants which have seed pods that open, seeds that germinate, or epicormic buds or lignotubers that resprout in response to a fire event. Some of these responses are triggered by the chemicals produced in smoke during the fire event.

First flush: the first rainfall for a period of time, resulting in stormwater dislodging and entraining relatively high loads of sediments, particulates and pollutants that have built up in the intervening period between rainfall events, and typically carrying a higher pollutant load than subsequent events

Flocculation: the joining of particles (small objects) into loose masses (floc) in water

Flocculent: loosely massed

Flora: plant species, subspecies and varieties in a given area

Flow-through wetland: a wetland which receives groundwater inputs in some parts of its area and discharges water to the groundwater in other areas

Flyway: a geographic region that supports a group of populations of migratory waterbirds throughout their annual cycle. Up to nine flyways are recognised worldwide

Food chain: a diagram of who eats whom in a simple linear order, representing the flow of energy or nutrients in ecosystems. Two basic food chains are the grazing and detrital food chains.

Food web: a diagram that represents the feeding relationships of organisms within an ecosystem. It consists of a series of interconnecting food chains.

Functioning ecosystem: a community of interdependent organisms together with their non-living environment. A functioning ecosystem is one which has a full suite of these normal resources and functions successfully, interacting within an ecosystem all of the time to maintain a stable sustainable system over time.

Generalist: a species that can live in many different habitats and can feed on a variety of different organisms

Geomorphology: landscape features and shape, at various spatial scales

Geology: the composition, structure and features of the Earth, at the surface and below the ground

Gilvin: a measure of the absorbance of light by humic substances at a wavelength of 440 nm (after filtration through a 0.2 µm filter), expressed in units of g_{440}/m (absorbance at 440 nanometres per metre)

Gnamma: a hole (commonly granite) that collects rainwater, forming a wetland. This word is of Nyungar origin

Goal: a specific statement detailing the desired state of a wetland component or process

Grass: tufted or spreading plant from the family Poaceae. The leaf sheath is always split, a ligule is present, the leaf is usually flat, a stem cross-section circular and all internodes evenly spaced. Some grasses are called reeds (the *Phragmites* and *Arundo* genera).

Grazing: feeding on grasses and other low-growing herbaceous vegetation

Government Gazette: a government publication issued by the State Government which includes details of statutory matters, available from the State Law Publishers

Groundcover: the percentage of ground covered by plant materials (alive or dead) and leaf litter

Groundwater: water occurring beneath the ground surface in spaces between soil grains and pebbles and in fractures or crevices in rocks

Groundwater capture zone: the area within which any recharge (infiltrating water) eventually flows into the wetland

Groundwater dependent ecosystems: those parts of the environment, the species composition and natural ecological processes of which are dependent on the permanent or temporary presence or influence of groundwater

Groundwater model: a simplified representation of a groundwater system

Groundwater mound: convex regional mounding of the water table in an unconfined aquifer. The top of the mound is where the water table is highest above sea level. Water flows down gradient of this point.

Groundwater table: the upper surface of the groundwater in an unconfined aquifer (top of the saturated zone). In technical terms, the surface where the water pressure head is equal to the atmospheric pressure.

Guild: a group of species that exploit similar resources in a similar fashion

Gymnosperms: plants with unprotected seeds, often in cones, including the conifers and cycads

Gypsum: dihydrous calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

Habitat: an area or environment where conditions are suitable for the survival of an organism, taxon or community

Habitat type: 'habitat' is a species specific term, with every taxon having its own environmental requirements. 'Habitat type' is used here to refer to areas where environmental conditions are appreciably different from their surroundings. These differences increase the likelihood that the area may support a distinctive flora or fauna assemblage.

Halophile: a species that shows a preference for saline habitat such as salt lakes

Headwater wetland: a wetland at the top of the wetland chain where water originates

Heartwood: the central, woody core of a tree, no longer serving for the conduction of water and dissolved minerals. Heartwood is usually denser and darker in colour than the outer sapwood.

Herbs: plants with non-woody stems that are not grasses or sedges. Generally under half a metre tall. Most monocots are herbs.

Herbivores: animals that chiefly eat plants

Hybrids: the results of interbreeding between two animals or plants of different species

Hydraulic conductivity: a property of plant material, soil or rock that describes the ease with which water can move through pore spaces or fractures. It depends on the permeability of the material and on the degree of saturation.

Hydroecology: the study of the water regimes required to maintain and enhance conservation values of ecosystems

Hydrogeology: the distribution and movement of groundwater

Hydrology: the properties of the Earth's water, particularly the distribution and movement of water between the land surface, groundwater and atmosphere

Hydroperiod: the periodicity (permanent, seasonal, intermittent) of waterlogging or inundation of a wetland

Hue: the property of colours by which they can be perceived as ranging from red through yellow, green, and blue, as determined by the dominant wavelength of the light

Humic: substances formed from the decomposition products of polyphenols such as tannins, which are complex organic compounds derived from plant materials

Humus: the organic constituent of soil, usually formed by the decomposition of plants by soil bacteria

Hypothesis: a concept that is not yet verified but that, if true, would explain certain facts or phenomena

Impermeable: does not allow water to move through it

Indicators: the specific components and processes of a wetland that are measured in a monitoring program in order to assess changes in the conditions at a site

Indigenous: a species that occurs at a place within its historically known natural range and that forms part of the natural biodiversity of a place

Infiltration: the downward movement of water into the soil profile via spaces between soil particles (called pores) and cracks and fractures in the ground

Inorganic: compounds that are not organic (broadly, compounds that do not contain carbon)

Introduced animals: species of animals that have been intentionally or unintentionally brought into a region where they did not historically occur, usually facilitated by humans

Interception: occurs when rainfall that falls over an area is captured on the surface of vegetation (foliage, stems, branches, trunks or leaf litter). This water may evaporate to the atmosphere or falling to the ground (throughfall).

Interflow: shallow lateral subsurface flow of water, which moves nearly parallel to the soil surface, usually in response to a layer of soil that impedes percolation

Intermittent: present for variable periods with no seasonal periodicity

Interquartile range: the distance between the 25th and 75th percentile

Inorganic carbon: (in a wetland) various forms of carbon in solution from non-organic sources including dissolved carbon dioxide (CO₂), bicarbonate (HCO₃⁻), carbonate (CO₃²⁻) and carbonic acid (H₂CO₃).

Inundation: where water lies above the soil surface (also called surface ponding)

Invertebrate: animal without a backbone

Ion: an atom with an electrical charge. Used to refer to dissolved salts such as sodium (Na⁺) or chloride (Cl⁻) in solution.

Ionic composition: the particular ions making up a solution, usually expressed in terms of the relevant dominances of the major (most abundant) positively charged and negatively charged ions in a solution

Juvenile: young or immature

Landform: a natural feature of a landscape such as a valley, mountain, basin or plain

Land capability: the ability of land to be used for a particular purpose or managed in a particular way without becoming degraded

Larvae: juvenile insects (the singular being 'larva')

Leaf litter: dead plant matter including leaves, flowers, nuts, sticks and bark which accumulates on the ground

Lentic: standing water

Lethal effect: where exposure to an agent such as a toxin results in death

Lichen: a composite organism consisting of a fungus and a cyanobacterium living in symbiotic association

Life form: the shape or appearance of a plant that mostly reflects inherited or genetic influences

Lignin: a material (a complex organic polymer) deposited in the cell walls of many plants, making them rigid and woody

Lignotuber: a large woody swelling of the plant stem that occurs at and below the soil surface. Regrowth from lignotubers can occur following fire, drought and grazing.

Limiting nutrient: the nutrient in an ecosystem which limits further growth because it is available at proportionately lower levels with respect to other nutrients needed for primary producers to increase their abundance

Livestock: introduced domestic ungulate (or hoofed) animals

Local planning scheme: a set of provisions that identifies the way land in a scheme area is to be used and developed. It may comprise a scheme map(s), a scheme text and an explanatory report.

Local provenance: local origin

Low-stress livestock handling: a method of herding livestock with prompts rather than force

Luxury uptake: the process by which some organisms take up more nutrients than they need for current growth, instead storing them for future growth

Macroalgae: algae large enough to be seen with the unaided eye

Macroinvertebrate: an invertebrate that, when fully grown, is large enough to see with the naked eye (larger than 0.25 millimetres)

Macropores: spaces in the soil (usually less than 2 millimetres diameter) that include channels created by cracking, old plant roots and soil fauna (such as earthworms). Macropores indicate good soil structure.

Mallees: plants with many trunks (usually 2–5) arising from a lignotuber. The canopy is usually well above the base of the plant. In Western Australia, most are from the genus *Eucalyptus*.

Management planning: the process of setting management goals for a site and then developing, implementing and reviewing management strategies to meet these goals

Management strategy: a set of actions that will be undertaken in order to achieve goals relating to a wetland component or process

Mangrove: any of various tropical or semi-temperate trees or shrubs of the genera *Rhizophora*, *Bruguiera* and *Avicennia* growing in intertidal shore mud with many tangled roots above the ground

Marl: fine-grained calcareous material (usually from dead charophyte algae that are able to biogenically precipitate calcium carbonate)

Mean: Representative of the values being summarised due to being intermediate between the extremes of the dataset

Median: The value for which one-half (50%) of the observations (when ranked) will lie above that value and one-half will lie below that value

Mesa: an isolated flat-topped hill with steep sides

Metabolic functions: the processes occurring within a living organism that are necessary to maintain life

Metabolism: the chemical reactions that occur in living things that are necessary to maintain life, including the digestion of food

Methanogenesis: the production of methane by microbes

Metropolitan Regional Scheme (MRS): the region planning scheme for the Perth region

Microalgae: microscopic algae

Microbe: an organism that can be seen only with the help of a microscope for example, bacteria, some algae (also referred to as microorganisms)

Microinvertebrate: an invertebrate that is too small to see with the naked eye (smaller than 0.25 millimetres)

Midges: biting and non-biting species of a number of families within the true flies (Diptera) including the Chironomidae and Ceratopogonidae

Migratory species: those animals that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations

Mode: The most commonly occurring value in a dataset

Monitoring: the systematic collection of data, over time, in order to test a hypothesis

Monocotyledons (monocots): flowering plants that typically have seedlings with

one cotyledon (seed-leaf) and a fibrous root system. They do not form wood and have strappy leaves with parallel veins. Some herbs and all grasses and sedges are monocots.

Monotypic: a genus with only one species

Motile: capable of motion

Mound spring: an upwelling of groundwater emerging from a surface organic mound

Mycorrhiza: a close physical association between a fungus and the roots of a plant, from which both fungus and plant appear to benefit

Native vegetation: native aquatic or terrestrial vegetation, and includes dead vegetation unless that dead vegetation is of a class declared by regulation to be excluded from this definition but does not include vegetation in a plantation or which was intentionally sown, planted or propagated unless that vegetation was sown, planted or propagated as required under law

Naturalised: plants that spread and persist outside of their normal range of distribution

Niche: the role of an organism in a community, in terms of its presence, activity, habitat and the resources it uses

Nocturnal: primarily active during the night

Non-residual herbicides: (or knockdowns) refer to herbicides that kill existing weeds but have no effect on germinating seeds

Non-selective herbicide: (or broad spectrum) refers to herbicides that kill a wide range of plants

Non-synthetic: of natural origin; not derived artificially by chemical reaction, and free from chemical treatments or additives. Other terms commonly used to describe non-synthetic herbicides include natural or organic herbicides.

Non-woody weeds: refer to weeds with a non-woody green stem

NTU: nephelometric turbidity unit is a measure of the clarity of water. Turbidity in excess of 5 NTUs is just noticeable to most people.

Nuisance fauna: a population of native fauna occurring in densities such that it causes harm to the environment or to humans

Nutrient cycling (wetlands): the transformation of nutrients between different chemical forms, and their transport into and out of wetlands

Nymph: a juvenile insect that closely resembles the adult, but has poorly developed wings

Objective: a statement detailing a short to medium-term result of a strategy, which may relate to an output or outcome as it relates to the state of a threat

Obligate wetland plants: plants that are generally restricted to wetlands under natural conditions in a given setting

Observation bore: a non-pumping well with a long slotted section that crosses the water-table

Omnivorous: feeding on both plants and animals

Organic: compounds containing carbon and chiefly or ultimately of biological origin

Organic carbon: carbon existing in or derived from living organisms including all living

and dead plant, animal and microbial material

Organism: any living thing

Osmoconformers: species who are not able to regulate the concentration of their internal fluids, so their internal concentrations reflect that of the solution they are immersed in

Osmoregulators: species that are able to regulate the concentration of their internal fluids in relation to the environment

Outcome: a measurable consequence of the project's activities

Outputs: activities undertaken, or products produced, by a particular project

Oxidation: the removal of electrons from a donor substance

Palatable: pleasant-tasting

Palaeochannel: a channel formed by a palaeoriver (ancient river), infilled with deposited sediments and buried over time, often forming modern-day groundwater aquifers

Paluslope: a seasonally waterlogged slope wetland

Pan-tropical: distributed throughout the tropical regions of the earth

Particulate: in the form of particles (small objects)

Peat: partially decayed organic matter, mainly of plant origin

Percentile: The value below which a given percentage of the data values lie. The pth percentile is the value in the dataset which p% of values is less than. The 25th, 50th and 75th percentile are called quartiles. The 50th percentile is the median.

Perched: not connected to groundwater

Perched aquifer: a local aquifer close to the land surface that receives direct recharge from rainfall, but is above and disconnected from the regional unconfined aquifer

Percolation: flow of water down through soil, sediments or rocks without these being completely saturated

Perennial: a plant that normally completes its lifecycle in two or more growing seasons (from germination to flowering, seed production and death of vegetative parts)

Periphyton: organisms such as bacteria, fungi, algae and invertebrates that are attached to underwater surfaces including sediment, rocks, logs and plants

Pesticide: any chemical or biological agent intended to kill plant or animal pests

pH: a soil or water quality measure of the concentration of hydrogen ions in a solution, which indicates whether the water is acidic, neutral or alkaline; dissolved hydrogen ions being responsible for giving a solution the properties of an acid

Photodegradation: chemical breakdown caused by UV light

Photosynthesis: the process in which plants and some other organisms such as certain bacteria and algae capture energy from the sun and turn it into chemical energy in the form of carbohydrates. The process uses up carbon dioxide and water and produces oxygen.

Physiochemical environment: the physical and chemical environment

Phytoplankton: aquatic organisms that photosynthesise and which float or are suspended in water, drifting with water movements and generally having minimal ability to control their location, such as algae

Piezometer: a non-pumping well, with a short length (often 2 metres) of slotted section at the base often below the water table, which is used to measure the potentiometric surface

Plankton: aquatic organisms floating or suspended in the water that drift with water movements, generally having minimal ability to control their location, such as phytoplankton (photosynthetic plankton including algae and cyanobacteria) and zooplankton (animals)

Plant community: a discernable grouping of plant populations within a shared habitat. A community develops due to a unique combination of geologic, topographic and climatic factors and will be recognisable where those factors co-occur.

Playa: a wetland with a basin landform that is intermittently inundated

Population: in statistics, the term population refers to the entire aggregation of components that are the subject of a study. This may be all the individuals in a biological population, but it may equally relate to a non-biological entity such as quadrats.

Potential acid sulfate soils: (also known as potential acid sulphate soils) soils that can contain significant sulfidic material, which on oxidation can cause the pH of the soil to fall to very low levels

Precipitate: cause a substance to be deposited in solid form from a solution

Precision: minimal variability between measurements

Pre-emergent herbicides: refers to herbicides that kill germinating seedlings when applied to the soil before germination

Primary producer: a photosynthesising organism. Primary producers, through photosynthesis, harness the sun's energy and store it in carbohydrates built from carbon dioxide

Primary production: the production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis, with chemosynthesis being much less important

Propagate: grow plant specimens from parent material

Propagule: a unit or a piece of an organism that facilitates the organisms' reproduction. Plant propagules primarily include seeds, spores and plant parts capable of growing into new plants. Invertebrate propagules are usually eggs or, in the case of sponges, gemmules. Protist propagules are usually cysts. Bacteria and algae propagules are usually spores.

Property management plan: Also called a whole farm plan; a working plan for the design and management of a property based on its natural resources, the activities undertaken (such as horse breeding or beef production), the manager's goals and financial considerations

Proponent: the person who is responsible for the proposal, or the public authority on which the responsibility for the proposal is imposed under a written law

Provenance: the place of origin

Pugging: depressions, hoof prints or 'pug' marks made in wet soil by trampling animals

Pyritic sediments: sediments containing iron pyrite

Pyrite: FeS_2 , an iron sulfide mineral that is a common component of sulfidic material

Qualitative data: descriptive data; they are collected using techniques such as estimation, categorisation, statements of type or condition, diagrams photographs and maps

Quality assurance: the process of documenting data quality and data confidence by describing how the dataset was collected, analysed and stored

Quality control: the process of detecting errors and determining their magnitude

Quantitative data: data that are measured or counted in some way, for example, the number of plants in a plot or the pH of a water sample

Rainfall: a product of the condensation of atmospheric water vapour that is deposited on the Earth's surface

Ramsar Convention: an international treaty that focuses on the conservation of internationally important wetlands, signed in Ramsar, Iran in 1971 (the Convention on Wetland of International Importance Especially as Waterfowl Habitat)

Range: The difference between the maximum and minimum value in a dataset

Range ends: Populations at the margins of the area to which a species is native

Recharge: the physical process where water naturally percolates or sinks into a groundwater basin

Recharge area: the land surface area over which recharge occurs to a particular groundwater aquifer

Recharge wetland: a term used by geologists to describe wetlands from which water flows out of into the groundwater, 'recharging' it

Recruitment: addition of new individuals to a population (usually through reproduction)

Red list criteria: developed by the International Union for the Conservation of Nature (IUCN) to allocate species of flora and fauna into threat categories of critically endangered, endangered and vulnerable, based on their likelihood of becoming extinct

Redox: the removal ('oxidation') or addition ('reduction') of electrons

Redox potential: the potential of chemical substances to undergo two (coupled) types of chemical change: the removal ('oxidation') or addition ('reduction') of electrons

Reduction: the addition of electrons to an acceptor substances

Reference range: a quantitative and transparent benchmark appropriate for the type of wetland

Reference wetland: a wetland used to provide a model for planning a management project

Refugia: restricted environments that have been isolated for extended periods of time, or are the last remnants of such areas

Region planning scheme (region scheme): a planning scheme prepared for matters of state or regional importance to enable effective planning and coordination of land use and development. Also known as a region scheme.

Regional open space: land defined under a region scheme, regional structure plan

or sub-regional structure plant as a parks and recreation reserve or regional open space reserve, to accommodate active and passive recreation such as major playing fields and/or regional conservation and environmental features

Regulation: a law made under the authority of an Act of Parliament

Rehabilitation: the re-establishment of ecological attributes in a damaged ecological community although the community will remain modified

Reintroduction: the deliberate release of a species in an area which is part of its natural historical range but in which it no longer occurs

Replication: repeating an experiment several times and collating all the results. It allows the error margin of the measurements and natural variations in the subjects to be discounted from consideration.

Representativeness: how well a series of measurements reflect the full range of values in the system being measured

Reserved: set aside for public purposes

Residual herbicides: refer to herbicides that remain active in the soil for some time and may kill germinating seeds and susceptible plants

Resilience: capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks

Respiration: the process in which oxygen is taken up by a plant, animal or microbe, and carbon dioxide is released

Restoration: returning an ecological community to its pre-disturbance or natural state in terms of abiotic conditions, community structure and species composition

Revegetation: return vegetation (indigenous or otherwise) to an area

Rhizome: a horizontal, underground stem which bears roots and leaves and can usually persist, even if above-ground parts die back

Rhizosphere: the area of soil immediately surrounding plant roots, which is altered by their growth, respiration, exchange of nutrients etc

Ringbark: to completely removing a strip of bark around the trunk or main stem of a tree or shrub, causing its death

Riparian: habitats adjacent to waterways and estuaries

Rotational grazing: a type of controlled grazing system. Paddocks are usually subdivided into smaller pastures and grazed at higher intensities for shorter periods (to achieve more even grazing), then spelled (or rested).

Rush: see the definition of 'sedge'

Salinisation: the process of accumulation of salts in soils, waters or sediments

Salinity: a measure of the concentration of ions in waters, soils or sediments. This measurement is used to describe the differences by waters that are considered 'fresh' (with very low concentration of ions) and those that are considered 'saline' (with high concentrations of ions)

Salts: ionic compounds comprised of cations (positively charged ions, such as sodium, Na⁺) and anions (negative ions, such as chloride, Cl⁻)

Salt scald: a bare area of ground caused by secondary salinisation, in which vegetation has died and solid salt is visible

Samphire: the common name for a group of succulent sub-shrubs and shrubs including *Tecticornia*, *Halosarcia*, *Sarcocornia*, *Sclerostegia*, *Tegicornia* and *Pachycornia*, belonging to the family Chenopodiaceae

Sampling: the process of selecting a set of individuals that will be analysed to yield some information about the entire population from which they were drawn

Sampling point: the precise place at which a sample is taken

Saprotroph: an organism that absorbs soluble organic nutrients from inanimate objects (e.g. from dead plant or animal matter, from dung etc)

Sapwood tissue: specialised plant tissue that transports water and minerals upwards from the roots to the stem, via capillary action

Saturated: the state in which all available spaces are filled with water

Savanna: a grassy woodland, grassland with small or widely spaced trees so that the canopy is always open allowing a continuous layer of grasses underneath

Scalping: involves slicing off the top layer of soil which contains weeds and weed seeds, leaving the surface bare in preparation for revegetation

Scheme: a redevelopment scheme, a region planning scheme, a local planning scheme or a State planning policy to which section 32 of the *Planning and Development Act 2005* applies, or an amendment to any of these

Scum: froth or floating matter on the water surface

Seasonal: present during a given period of the year, recurring yearly

Secondary salinisation: a human-induced process in which the salt load of soils, waters or sediments increases at a faster rate than naturally occurs

Sediment: in general terms, the accumulated layer of mineral and dead organic matter forming the earth surface of a wetland. Used interchangeably in this guide with the terms 'wetland soil' and 'hydric soil', although all three of these terms have more specific meaning in wetland pedology

Sedimentation: the process by which soil particles (sand, clay, silt, pebbles and organic materials) suspended in water are deposited or settle to the bottom of a water column

Sedge: tufted or spreading plant from the families Cyperaceae, Centrolepidaceae, Hydatellaceae, Juncaginaceae Restionaceae, Juncaceae, Typhaceae and Xyridaceae. In these plants the leaf sheath generally not split, there is usually no ligule, the leaf is not always flat and there is an extended internode below inflorescence. Some sedges are also known as rushes.

Sediment pore water: water present in the spaces between wetland sediment grains at or just below the sediment surface. Also called interstitial waters.

Seed dispersal mechanisms: the means by which plants distribute their seeds, for example via wind, water, birds and insects, etc

Selective herbicide: refers to herbicides that have been developed to kill a particular type of plant (e.g. grasses)

Semi-confined aquifer: an aquifer deep under the ground with leaky aquitards

Senescence: the natural aging and subsequent death of an organism

Sensitivity: the ability to distinguish between different values in the parameter being measured

Services: benefits that people receive or obtain from an ecosystem. This term is often used in conjunction with the term 'benefits'. See also 'benefits'.

Shallow aquifer: another term for unconfined aquifer

Shelterbelts: belts or rows of trees and shrubs planted to provide protection against prevailing winds

Shorebirds: those birds commonly found wading near the shores of wetlands, beaches, mudflats and lagoons in search of food. They include plovers, sandpipers, stone-curlews, snipes, pratincoles, oystercatchers, stilts and avocets.

Shrubs: plants with one or more woody stems and foliage all or part of the total height of the plant

Significant proposal: a proposal likely, if implemented, to have a significant effect on the environment.

Slightly disturbed: ecosystems that have undergone some changes but are not considered so degraded as to be highly disturbed. Aquatic biological diversity may have been affected to some degree but the natural communities are still largely intact and functioning. An increased level of change in physical, chemical and biological aspects of these ecosystems is to be expected.

Soil texture: the distribution of grain sizes of the mineral particles in a soil

Soluble: able to dissolve

Solubility: a measure of how soluble a substance is

Sorting (aquatic invertebrates): picking individual organisms from a sample to form a sub-sample

Spatial scale: the minimum size of an area about which data are collected

Spawn: eggs surrounded by jelly; generally applied to a group of eggs

Species: a group of organisms capable of interbreeding and producing fertile offspring, for example, humans (*Homo sapiens*)

Species richness: the total number of species (in a defined area)

Spelling: of a paddock or pasture, involves removing livestock grazing pressure for a period of time so that vegetation can regenerate

Spicule: minute, needle-like body made of silica or calcium salts found in some invertebrates

Spore: a reproductive structure that is adapted for dispersal and surviving for extended periods of time in unfavourable conditions

Stable stratification: stratification which persists for much longer than a day (often months)

Stakeholder: individuals, groups or institutions that have an interest in or will be affected by a project's activities.

Standard deviation: A measure of how closely the values in a dataset are clustered around the mean

Standard error: A measure of how close the sample mean is likely to be to the population mean

State Environmental Policies (SEPs): non-statutory policies which are developed by the EPA under provisions of Part II of the EP Act through public consultation and are adopted following Cabinet consideration and approval

Statute: a law enacted by the State or the Federal Parliament

Stocking rate: the number of livestock that can consistently be kept on an area of pasture all year round with minor additional feed and without causing environmental degradation

Stolons: stems that usually run horizontally along the soil surface

Stomata (plural of stomate): pores in leaves and stems used for gas exchange

Stonewort: a term applied to Chara species that precipitate and deposit calcium carbonate on their surfaces

Stormwater: water flowing over ground surfaces, in natural streams and drains as a direct result of rainfall over a catchment. It consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow

Strategic proposal: a future proposal that will be a significant proposal; or future proposals likely, if implemented in combination with each other, to have a significant effect on the environment

Strategies: in the context of management planning, a set of actions that will be undertaken in order to achieve goals relating to a wetland component or process

Stratify: separate the water column into distinct layers

Stratification: the division of the water column into distinct layers called the epilimnion (top), the metalimnion (middle) and the hypolimnion (bottom), due to differences in water density between these layers

Stratum: (plural strata) a visibly conspicuous layer of photosynthetic tissue within a plant community

Stromatolite: a type of microbial structure formed by microbial communities precipitating calcium carbonate (see also 'thrombolite')

Structure plan: a plan that provides a framework for the coordinated provision of land use, development, infrastructure and allocation of services at either the regional, district or local level. Not always a statutory requirement.

Study site: the wetland that is being monitored

Subdivision: the division of land into lots

Sublethal effect: where exposure to an agent such as a toxin is insufficient to cause death, but may result in other adverse impacts

Submerged: a plant that is entirely underneath the surface of the water

Substrate: a generic term denoting the material forming the floor of a wetland and its surrounds. It is used here because the term 'soil' is not inclusive of organic substrates.

Succession: progressive change in species composition and/or structure that occurs following disturbance of a site

Succulent: plants which have specialised fleshy, soft and juicy tissues designed for the conservation of water e.g. cacti

Sulfate reduction: the chemical process where sulfate is joined with hydrogen and gains electrons

Summary statistics: measures that express the central tendency and variability of a dataset; most commonly mean, median, mode, range, standard deviation, standard error and percentile

Superficial aquifer: another term for unconfined aquifer

Surfactant: a substance that helps water or other liquid to spread or penetrate. Also known as a wetting agent or penetrant.

Surficial aquifer: another term for unconfined aquifer

Surface run-off: water that flows down slope over the ground surface; also called overland flow

Surrogate measure: another component of the system that shows a correlated response to the management issue being evaluated

Survey location: the area of the wetland where a survey is completed

Swan Coastal Plain: a coastal plain in the south west of Western Australia, extending from Jurien south to Dunsborough, and the Indian Ocean east to the Gingin, Darling and Whicher Scarps

Symbiosis: a relationship in which dissimilar organisms live in close association, and which is mutually beneficial to both organisms

Tannins: complex organic compounds (polyphenols) occurring in various plants

Taxa: a taxonomic group (the singular being taxon). Depending on the context, this may be a species or their subdivisions (subspecies, varieties etc), genus or higher group.

Temporal: of or pertaining to time

Temporal variations: changes that occur over time

Terminal wetland: a wetland at the bottom of the wetland chain. It receives water from other systems but water generally does not exit it other than through evaporation or seepage into the ground (or occasional flooding overflow in large events).

Thermal water pollution: the excessive raising or lowering of water temperatures above or below normal seasonal ranges as a result of the discharge of hot or cold effluents

Thermocline: the narrow vertical layer within a body of water between the warmer and colder layers where a rapid temperature change occurs

Threat: any factor that is currently or may potentially negatively affect wetland components or processes. A threat can be currently active or present (such as weeds), or a potential threat (such as a proposal to expand a picnic area into native vegetation in good condition).

Threatened ecological community: naturally occurring biological assemblages that occur in a particular type of habitat that has been endorsed by the WA Minister for Environment as being subject to processes that threaten to destroy or significantly modify it across much of its range

Threatened flora: flora that has been assessed as being at risk of extinction or is rare or otherwise in need of special protection and gazetted as such by the Minister for Environment. These species are commonly referred to as declared rare flora.

Threatening process: processes that threaten the survival, abundance or evolutionary development of a native species or ecological community

Thresholds: points at which a marked effect or change occurs

Thrombolite: a type of microbial structure formed by microbial communities precipitating calcium carbonate (see also 'stromatolite')

Throughflow wetland: a wetland that lies between headwater wetlands and terminal wetlands (or the sea) in a wetland chain. It receives water from upgradient wetlands and supplies water to downgradient wetlands.

Total dissolved solids (TDS): a measure used to approximate the concentration of ions in wetland water (that is, total dissolved salts/salinity). It will usually over-estimate these as TDS includes dissolved organic compounds.

Total grazing pressure: describes the combined impact of all grazing animals – domestic, wild, native and feral – on the vegetation, soil and water resources of a particular area

Transparency: a measure of the degree to which light is able to penetrate the water column

Transpiration: the process in which water is absorbed by the root systems of plants, moves up through the plant, passes through pores (stomata) in the leaves and other plant parts, and then evaporates into the atmosphere as water vapour.

Treatment: subjection to some agent or action. In the case of a monitoring program, the treatment will be the management regime that is expected to cause some change in the condition of the site

Trees: plants with a single trunk and a canopy. The canopy is less than or equal to two thirds of the height of the trunk. No lignotuber is evident.

Trigger values: quantified limits that, if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response e.g. further investigation

Tolerance limits: the upper and lower limit to the range of particular environmental factors (e.g. light, temperature, salinity) within which an organism can survive. Organisms with a wide range of tolerance are usually distributed widely, while those with a narrow range have a more restricted distribution

Total nitrogen: the sum of all chemical forms of nitrogen

Total phosphorus: the sum of all chemical forms of phosphorus

Trophic: relating to nutrition, food or feeding

Trophic classification: the classification of an ecosystem on the basis of its productivity or nutrient enrichment

True colour: a measure of colour which includes the influence of humic substances and other dissolved substances such as iron, measured in true colour units (TCU)

Tubers: specialised fleshy storage organs of the stem that are present in some plant species, usually found underground

Tufa: a porous rock composed of calcium carbonate and formed round mineral springs

Tumulus mound spring: peat-formed mound spring

Turbid: the cloudy appearance of water due to suspended material

Turbidity: the extent to which light is scattered and reflected by particles suspended or dissolved in the water column

Turn out location: the site at which livestock are released into a fresh pasture

Unconfined aquifer: an aquifer close to the land surface which receives direct recharge from rainfall. Its upper surface is the water table. Also referred to as a superficial or surficial aquifer.

Understorey: the layer of vegetation beneath the main canopy

Unstable stratification: layers form in the wetland water column each day (usually in the afternoon) and mixing occurs over night

Vacuole: a storage compartment found within a cell

Value (soils): the property of a colour by which it is distinguished as bright or dark; also known as luminosity

Values: the internal principles that guide the behaviour of an individual or group and determine the importance that people place on the natural environment and how they view their place within it

Vascular plants: plants with defined tubular transport systems. Non-vascular plants include algae, liverworts and mosses.

Vegetation: combinations of plant species within a given area, and the nature and extent of each area

Vegetation structure: the three-dimensional distribution of plant material. It includes the horizontal spacing of plants and the vertical heights or layers

Vegetative: a stage or structure of a plant that is concerned with feeding, growth or asexual reproduction, rather than sexual reproduction

Vegetative reproduction: a type of asexual reproduction found in plants. Also called vegetative propagation or vegetative multiplication.

Vertebrate: animal with a backbone

Vision: the desired state or ultimate condition that a plan is working to achieve which is usually expressed in the form a statement

Water budget: the balance of all of the inflows and outflows of water

Water column: the water within an inundated wetland that is located above the surface of the wetland soils (as distinct from sediment pore waters of inundated and waterlogged wetlands)

Water cycle: Continual circulation of water between the land, the oceans and the atmosphere. Also called the hydrological cycle.

Waterlogged: saturation of the soil

Water quality: the quality of water relative to its natural, undisturbed state

Water regime: the specific pattern of when, where and to what extent water is present in a wetland. The components of water regime are the timing, frequency, duration, extent and depth and variability of water presence.

Water requirements: the water required by a species, in terms of when, where and how much water it needs, including timing, duration, frequency, extent, depth and variability of water presence

Water table: the upper surface of the groundwater in an unconfined aquifer (top of the saturated zone). In technical terms, the surface where the water pressure head is equal to the atmospheric pressure.

Waterbirds: birds that have specialised beaks and feet that allow them to swim, dive and feed in water. Examples include egrets, crakes, herons, ducks, swans and grebes.

Weed: a plant that requires some form of action to reduce its harmful effects on the economy, the environment, human health and amenity, and can include plants from other countries or other regions in Australia or Western Australia

Wetland: an area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, spring, dampland, tidal flat or estuary

Wetland buffer: an interface adjoining a wetland that is designated to assist in protecting the wetland's natural values from the threats posed by the surrounding land use(s)

Wetland conceptual model: a simplified diagram that expresses ideas about components and processes that are important to the ecosystem

Wetland components: the physical, chemical and biological parts of a wetland, from large-scale to very small scale e.g. habitat, species and genes and include the physical form of the wetland, wetland soils, physicochemical properties of the water and the wetland flora and fauna

Wetland flora: wetland plant species, subspecies and varieties in a given area

Wetland hydrology: the movement of water into and out of, and within a wetland

Wetland plants: plants that inhabit wetlands

Wetland processes: the dynamic physical, chemical and biological forces within a wetland, including interactions that occur between wetland organisms, within the physical/chemical environment, and the interactions of these

Wetland state: the ecological characteristics of a wetland as they exist at a particular time

Wetland typology: a process of classifying wetlands according to characteristics of their hydrological, morphological, chemical and biological factors

Wetland vegetation: combinations of wetland plants in a given area, and the nature and extent of each area

Wetting agent: a substance that helps water or other liquid to spread or penetrate (also known as a surfactant or penetrant)

Woody weeds: perennial weeds with woody stems including shrubs, trees and some vines

Zooplankton: tiny invertebrates and protozoans floating or suspended in the water that drift with water movements, generally having little or minimal ability to control their location