Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region:

Stage Three Assessment Method

Susan Jones, Adrian Pinder, Lien Sim and Stuart Halse

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May 2009

Prepared by
Science Division
Department of Environment and Conservation

Executive summary: *Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region: Stage Three Assessment Method.*

Introduction
This publication describes a wetland evaluation and classification methodology for use at the individual wetland scale in the Avon Natural Resource Management (NRM) region. A trial of this method at two example wetlands in each biological wetland type is presented in section 6.

Table 1 - Form of wetland inventory

Form of wetland inventory	Methodology	Application
Identification		
Delineation		
Classification	√	
Evaluation	√	

Publication details
This methodology has been developed by the Science Division, Department of Environment and Conservation (DEC), Western Australia. The report was written by Susan Jones, Adrian Pinder, Lien Sim and Stuart Halse (DEC).

The authors of this document would like to acknowledge the following people for their important contributions:
- Members of the Wetland Status Working Group and Wetlands Coordinating Committee
- John Lizamore, Danielle Halliday, Cara Francis, Margaret Collins, Anna Leung, Kirsty Quinlan and David Cale from the Woodvale Wetlands Group within the DEC Science Division
- Glen Daniel and Stephen Kern from the Wetlands Section of the DEC Nature Conservation Division
- Ken Wallace from the DEC Nature Conservation Division, Kensington
- The Avon Catchment Council
- Mike Lyons from the DEC Science Division

Copies of this document can be viewed or downloaded from the Department of Environment and Conservation's website at www.dec.wa.gov.au, or alternatively by following the Baselining link on the Avon Natural Diversity Alliance website at www.avonnaturaldiversity.org.

For further information please contact the Science Division of the Department of Environment and Conservation:
Address: Wildlife Place, Woodvale 6946
Postal: PO Box 51, Wanneroo, WA 6946
Telephone: (08) 9405 5183
Website: www.dec.wa.gov.au or www.avonnaturaldiversity.org

Funding
This methodology was funded by the Avon Catchment Council's Avon Natural Diversity Alliance Program.

Study area
The area in which the methodology can be applied is the Avon NRM region as shown in Figure 1.

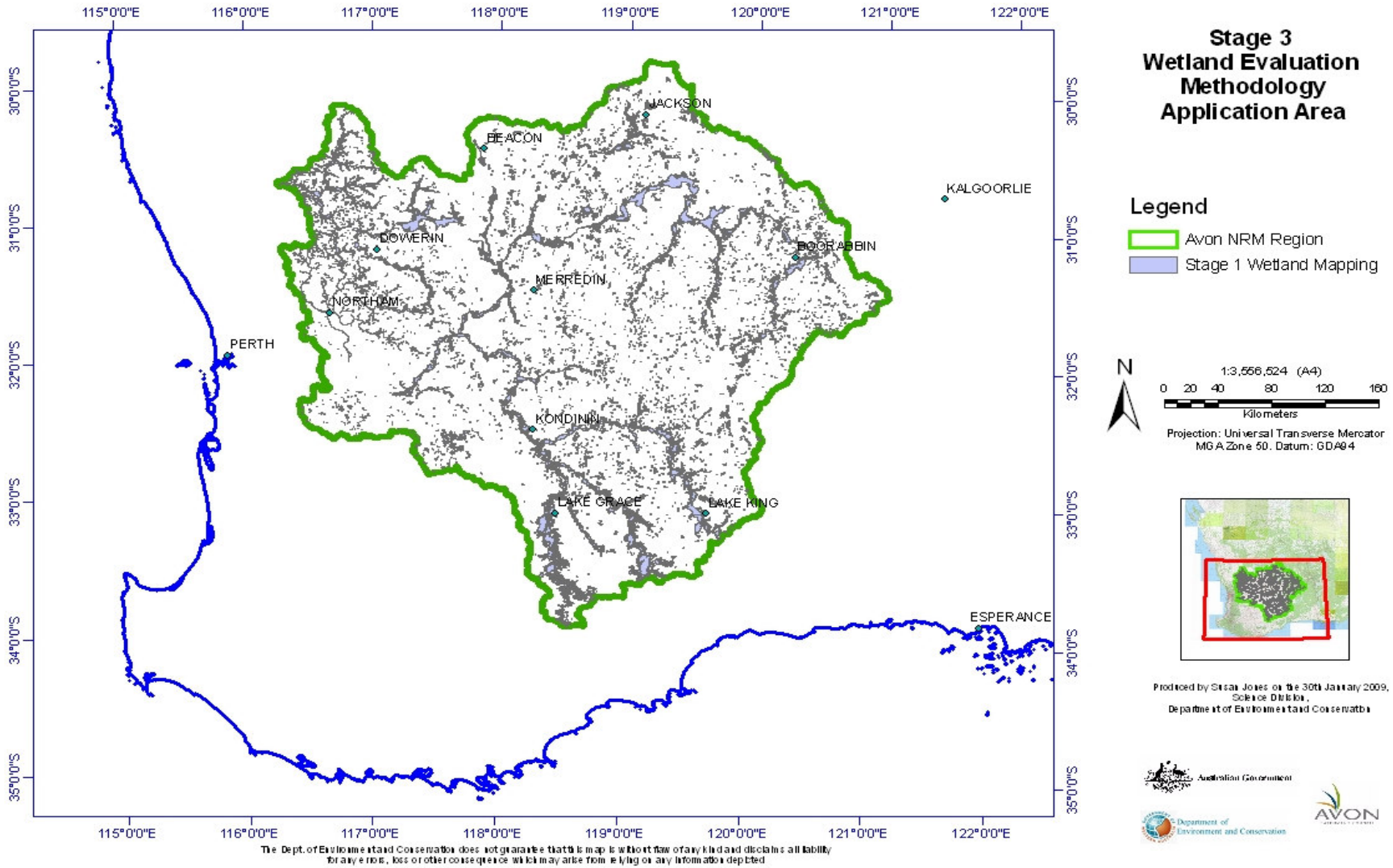

Figure 1 - Map showing the area to which the Avon Stage 3 methodology can be applied

Wetland mapping stage

The Western Australian Wetlands Coordinating Committee, with the advice of its Wetland Status Working Group, considers that the methodology fulfils the requirements of a Stage 3 evaluation methodology. Table 2 outlines the key aspects of a Stage 3 evaluation methodology.

Table 2- Primary stages of wetland mapping identified in Department of Environment and Conservation (2007).

Stage	Purpose/ objective	Scale	Approach	Mapping	Mapped classification	Evaluation	Outcome
1	Broad wetland distribution	Regional	Reconnaissance Desktop 'Drive by'	Satellite imagery, aerial photographs, topography Map 'centroid' or approximate boundary 1:250,000 to 1: 100,000 scale	Wetland vs. dryland	Existing data only No further evaluations	Quantify wetland resource
2	Asset evaluation, priority setting	Group of wetlands	Field sampling of sub-set and extrapolation of information	Aerial photograph. Precise or approximate boundaries 1:50,000 to 1:10,000 scale	Geomorphic wetland type	Preliminary indication of conservation value	Preliminary evaluation and prioritisation for future detailed assessment
3	Protection, management, environmental impact assessment	Individual	Individual wetland assessment in field	Aerial photographs (stereoscopic analysis). Precise boundaries 1:25,000 to 1:5,000 scale	Geomorphic wetland type	Detailed assessment of conservation value	Identification of values of individual wetlands as basis for protection, management and/or nomination.

Relevant wetland types

The evaluation methodology is applicable to the wetland types highlighted in Table 3:

Table 3 - The wetland types to which the methodology can be applied (shaded), from the geomorphic wetland types identified by Semeniuk and Semeniuk (1995).

Hydroperiod	Landform				
	Basin	Channel	Flat	Slope	Highland
Permanent inundation	Lake	River	-	-	-
Seasonal inundation	Sumpland	Creek	Floodplain	-	-
Intermittent inundation	Playa	Wadi	Barlkarra	-	-
Seasonal waterlogging	Dampland	Trough	Palusplain	Paluslope	Palusmont

Basin wetland types that are permanently, seasonally or intermittently inundated are the focus of this methodology due to the pressing need to understand their values, in order to inform natural resource management decision making, and in particular, the assessment of deep drainage proposals.

Evaluation summary
This document aims to provide a methodology for assigning inundated basin wetlands in the Avon NRM region to one of three wetland management categories. To achieve this, the following criteria are assessed:

- Rarity
- Naturalness
- Diversity
- Significance

Associated datasets
DEC has not applied this wetland evaluation and classification methodology to all of the wetlands in the study area. A trial of the method was conducted in spring 2008 at 28 wetlands located in the Avon. The wetlands that this method was trialled at were of different biological wetland types (e.g. turbid claypans, freshwater basins, and naturally saline basins) along a gradient of condition. The results of this trial will be available on WetlandBase.

Endorsement
Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region: Stage Three Assessment Method has been endorsed by the:

Department of Environment and Conservation
Wetland Status Working Group
Wetlands Coordinating Committee

Recommended reference
The recommended reference for this publication is:

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1. Introduction

This methodology, funded by the Avon Catchment Council (ACC), provides a consistent, practical procedure for classifying and evaluating the conservation significance of permanently, seasonally and intermittently inundated basin wetlands within the Avon Natural Resource Management (NRM) region. The wetland classification and evaluation procedure outlined in this document is intended to be undertaken by professionals in the field of wetland ecology. This may include staff from all levels of government, natural resource management groups and environmental consultants.

For the purposes of this methodology, the conservation significance of a wetland reflects its attributes and functions, which may include scientific, educational, amenity, spiritual, philosophical, recreational, consumptive use and ecosystem service values.

The classification and evaluation of wetlands provides information that contributes to an inventory of wetland assets in the region. This enables strategic catchment planning, so that wetlands of high conservation significance are maintained or improved, while those of low significance, with further assessment, may be considered for purposes other than conservation (e.g. incorporation into drainage schemes). The Avon NRM region is a threatened landscape (Avon Catchment Council, 2005) and prioritisation of areas for management is vital for the protection of wetlands in the region.

Wetland evaluations can be undertaken at different scales, as outlined in *A framework for mapping, classification and evaluation of wetlands in Western Australia* ('the framework', Department of Environment and Conservation, 2007). A stage 1 or 2 assessment is a regional-scale assessment of wetlands in a large area, using techniques and resources such as remote sensing, geographic information system (GIS) datasets and aerial photography. A stage 3 assessment is a fine-scale assessment of individual wetlands with accurately defined boundaries, using field survey techniques such as invertebrate, waterbird and vegetation species richness assessments (e.g. Cale*, et al.*, 2004). A stage 1 wetland evaluation methodology has been produced for the Avon NRM region by the Department of Environment and Conservation (DEC) (Jones*, et al.*, 2008), and endorsed by the State Wetlands Coordinating Committee (WCC).

This methodology outlines a procedure for conducting a stage 3 evaluation of intermittently to permanently inundated basin wetlands in the Avon NRM region. The framework recognises that approaches may differ between regions of the State as wetland values need to be interpreted within a regional context and may also vary due to the availability of information on wetland attributes. This level of assessment, according to the framework (Department of Environment and Conservation, 2007), is intended to identify values of individual wetlands as a basis for protection, management and/or nomination for protection under legislation.

DEC has received endorsement of this methodology by the State Wetlands Coordinating Committee. This endorsement ensures it is broadly consistent with the approaches undertaken in other areas of Western Australia, and that data collected in applying this methodology can be made publicly available through a State-wide database (e.g. WetlandBase).

1.1 Methodology objectives

There are two objectives of this document:

- To outline a method for classifying wetlands into groups based on a geomorphic and biological classification system. This classification provides information that contributes to an inventory of wetland groups in the region, as well as determining the reference ranges that a site is compared against.

- To outline a transparent and accountable method of evaluating the conservation significance of inundated basin wetlands within the Avon NRM region. This method will assign wetlands to one of three wetland management categories (Conservation, Resource Enhancement and Multiple Use), in accordance with the *Environmental Guidance for Planning and Development* (Environmental Protection Authority, 2008).

1.2 Definition of terms

For the purposes of this document, the following definitions apply:

'Wetland'

The Wetlands Conservation Policy for Western Australia (Government of Western Australia, 1997) uses the Ramsar definition of wetlands:

'Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.' (UNESCO, 1971)

This methodology applies to a sub-set of wetlands, which have a basin landform and are intermittently, seasonally or permanently inundated, as outlined in section 3.1 of this document.

'Wetland classification'

'A procedure in which wetlands (as defined above) are placed into groups based on quantitative and qualitative information on one or more characteristics inherent in wetlands (referred to as traits, variables, characters, etc).'

This methodology applies two wetland classification systems based on geomorphological and biological characteristics.

'Conservation significance'

'The importance of a wetland retaining or improving its current state, assessed on a combination of its attributes, functions and values.'

'Wetland evaluation'

'The process of assessing and documenting a wetland's values by considering information about it (Department of Environment and Conservation, 2007).'

1.3 Methodology limitations

This methodology is limited to permanently to intermittently inundated basin wetlands. Flat, slope and highland wetlands were excluded from this methodology as they were not part of the original scope of the project. Pools located on granite outcrops are known to be of high conservation significance in terms of the diverse and endemic flora and fauna species they support (Bayly, 1997; Main, 1997; Withers and Edward, 1997; Pinder*, et al.*, 2000; Bayly, 2002). However, these wetlands were not included as they are too hydrologically and physically dissimilar to other basin wetlands to be assessed by the same methodology. Also, the main anthropogenic pressures affecting granite outcrops are significantly different to those affecting most other basin wetlands in the Avon NRM region, which are predominantly dryland salinisation and acidification (see section 2.3.1). Waterlogged systems (e.g. damplands, palusplains, paluslopes etc.) were excluded from this methodology as they were not included in the original scope of the project.

1.4 Intended users

One of the intended applications of this methodology is to assess the conservation significance of wetlands in response to development applications that will impact them. In the Avon NRM region, the development activity most likely to affect wetlands is the drainage of groundwater away from agricultural growing areas into receiving basins. All landholders planning to drain are required to lodge a Notice of Intent to Drain (NOID) proposal prior to commencing work. This NOID proposal provides DEC staff with the opportunity to provide feedback to the Commissioner of Soil and Land Conservation (who administers the process) concerning the environmental risk associated with the drain. The Commissioner can then reject the NOID proposal based on the information he or she is given by DEC. A rapid assessment procedure for DEC staff to assess NOID proposals is currently being trialed (Lizamore*, et al.*, 2008). Where a high environmental risk is anticipated, a more detailed wetland assessment must be undertaken. This document is the detailed assessment method for basin wetlands recommended by the NOID rapid assessment procedure (Lizamore*, et al.*, 2008).

This methodology is intended to be used by professionals in the wetland ecology field. Considerable experience and skills are needed to complete the site visit component of the assessment (see section 5.3). It is recommended that wetland specialists undertake any evaluations required. In particular, personnel will require skills in the identification of vegetation, invertebrates and waterbirds to species level (there is an option to take invertebrates to family level) as well as the equipment required to complete these tasks (e.g. invertebrate sampling nets, stereo and compound microscopes). Personnel should also have a thorough understanding of wetland hydrology, geology and threats impacting wetlands in the Avon NRM region.

2. Background to the Avon NRM Region

The Avon NRM region (Figure 2) is one of six NRM regions within Western Australia. It has an area almost twice the size of Tasmania (11.8 million hectares (Avon Catchment Council, 2005)), extending east from the Perth Hills to include the Avon-Mortlock, Yilgarn and Lockhart river systems. Around 63% of the land in the Avon NRM region has been released for agricultural purposes (and mostly cleared), 8% has been set aside for conservation and 29% is either vacant crown land or pastoral lease with some mineral extraction (Avon Catchment Council, 2005). Around 12,000 basin wetlands and 6,000 granite outcrops have been mapped in this area by DEC (Lizamore J.M. for the Department of Environment and Conservation, 2008), and on-ground data is available for only a few hundred of these wetlands.

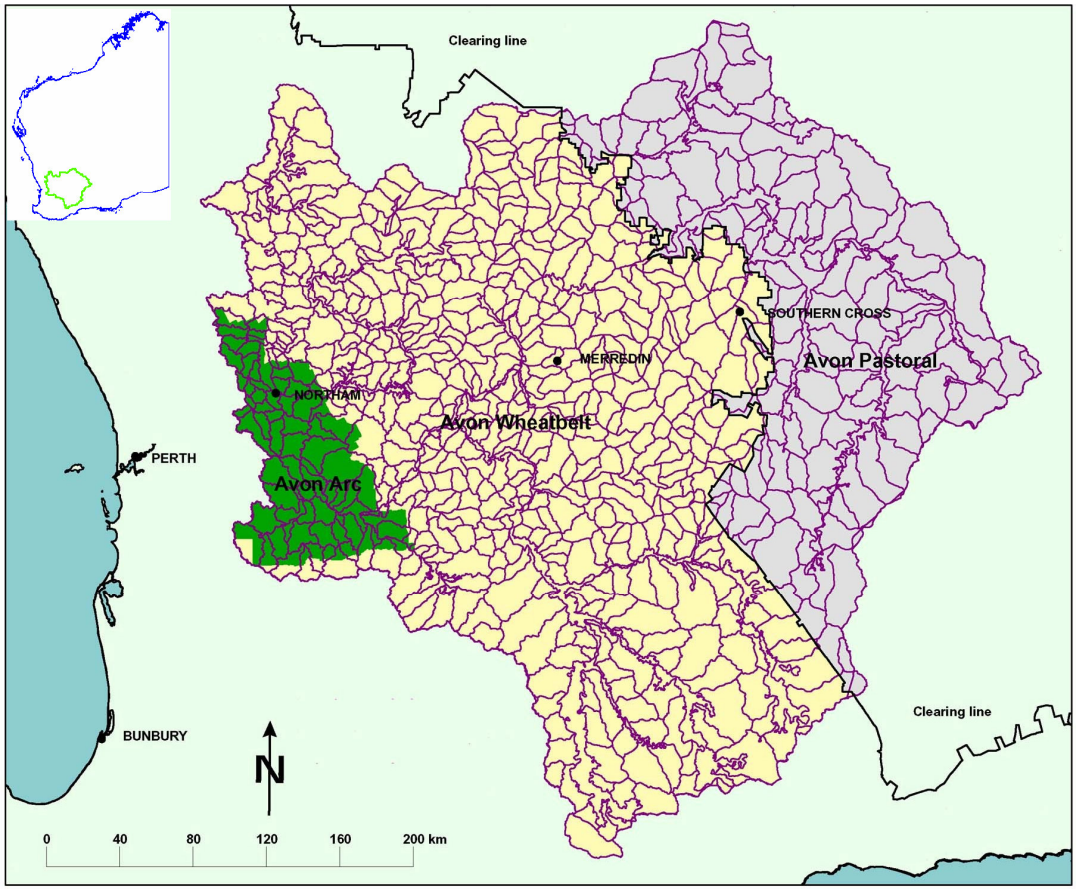


Figure 2 - Location and extent of the Avon NRM region

2.1 Climate

The climate of the Avon NRM region is characterised by hot, dry summers and cold winters. The average minimum temperature for the region is 6ºC in winter and 18 - 21ºC in summer. The average maximum temperature for the region is 15 - 21ºC in winter and 33 - 36ºC in summer.

The Avon NRM region mostly falls within a temperate to semi-arid area of Australia, as described by the Köppen classification system (McKnight and Darrel, 2000). The average annual rainfall declines from 500 – 600mm along the western boundary, to 300mm east of the line drawn between Bonnie Rock, Trayning and Southern Cross. Thirty to 50% of this annual rainfall falls in the winter months, declining to 10 – 20% in the summer months.

2.2 Geomorphology and hydrology

The Avon NRM region is underlain by ancient landforms of low fertility derived from crystalline rocks such as granite and gneiss, which are estimated to be 2 - 3 billion years old. More than 2 million years ago (Cretaceous period) the western section of the region was uplifted to form the Darling Scarp, and an area referred to as the Zone of Rejuvenated Drainage. Waterways in this zone flow annually to the Avon River and thence to the Swan-Canning Estuary. To the east of this zone, separated by the Meckering Line, lies the Zone of Ancient Drainage. Waterways in this zone form a sparse, open drainage network that roughly approximates the paths of an ancient in-filled river system. This network has local internal drainages, except in years of extremely high rainfall when flow extends for greater distances and occasionally feeds into the lower Avon (Mulcahy, 1967).

2.3 Wetlands and the Avon NRM region

2.3.1 Threats to wetlands in the Avon

The Avon NRM region has extensive areas of shallow, saline groundwater, which have been slowly rising since clearing. The rise in saline groundwater has been attributed to increased groundwater recharge and surface flow caused by the replacement of deep-rooted native vegetation with shallow-rooted annual agricultural crops (Teakle and Burville, 1938; Hobbs*, et al.*, 1993; George*, et al.*, 1997). Mobilisation of marine aerosol salts stored in the soil profile, due to groundwater rise (Hingston and Gailitis, 1976), has resulted in a salinised landscape. This process is known as dryland salinisation.

Dryland salinisation encompasses two threats:

- An increase in the salinity of groundwater, and therefore the water in groundwater-dependant wetlands. This has had a devastating effect on wetland vegetation and aquatic fauna (e.g. Williams, 1999; Clarke*, et al.*, 2002).
- A change in the hydrological regimes of wetlands, so that previously seasonally waterlogged areas now have periods of prolonged inundation. It has been reported that this is a contributing factor to vegetation change in affected areas (e.g. McFarlane and Williamson, 2002).

Estimates of the cost of dryland salinity to farmers has ranged from $60 million (State Salinity Strategy, 1996) to $1 billion a year (Select Committee Land Conservation, 1991; George*, et al.*, 1997), and is predicted to worsen in the future (Short and McConnell, 2001; George and Coleman, 2002).

Wetlands in the Avon NRM region continue to be threatened by dryland salinisation, however, there are also other threats evident in the region, such as:

- Drainage discharge
- Grazing of native vegetation by livestock
- Clearing of vegetation adjacent and within the wetland (not as prevalent anymore)
- The community perception of natural salt lakes as ‘dead’ systems without value
- Mining
- Invasion by exotic plants and animals (mainly rabbits, cats, foxes)
- Inappropriate rubbish disposal
- Surface water or groundwater contamination from the use of fertilisers and pesticides
- Surface water abstraction in freshwater wetlands
- Inappropriate recreational activities
- Climate change, although a drier climate could slow the rise of saline groundwater

2.3.2 Previous wetland field studies conducted in the region

Numerous surveys of various scales and intensities have been conducted at wetlands in the Avon NRM region. The Salinity Action Plan (SAP) Wheatbelt biological survey conducted by the former Department for Conservation and Land Management (now DEC) from 1997 to 2001 involved intensive studies at about 100 wetlands in the Avon, and is the largest survey that has been conducted in the region (Halse*, et al.*, 2004; Lyons*, et al.*, 2004; Pinder*, et al.*, 2004). The next largest survey was funded by the Avon Catchment Council, and involved the collection of water chemistry, invertebrate, waterbird and some vegetation data at 92 wetlands during the period from 2006 to 2008. The State Salinity Strategy also established a wetland monitoring program, which includes ten wetlands in the Avon NRM region. At these wetlands, biodiversity and water quality data is collected biennially (Cale*, et al.*, 2004). A summary of the various projects and the data collected is shown in Appendix A.

2.3.3 Wetland delineation

DEC's *Wetlands of the Wheatbelt and other prioritized areas* dataset (Lizamore J.M. for the Department of Environment and Conservation, 2008) is a stage 1 mapping dataset that was endorsed by the State WCC in November 2008. This dataset includes information on the landform, location and boundary of wetlands within the Avon NRM region that are greater than one hectare. The wetlands in the Avon NRM region have been mapped at a scale of 1:10,000, such that the boundaries are accurate at a scale of 1:100,000.

It is only valid to apply this stage 3 evaluation methodology to a wetland once the precise wetland boundary has been delineated. See Table 1 and the framework (Department of Environment and Conservation, 2007) for details of stage 3 mapping requirements. The approximate wetland boundaries identified in the stage 1 mapping dataset can provide a basis upon which to refine boundaries for stage 3 mapping work.

As with wetland evaluation, specialised field, laboratory and desktop investigation skills are required to accurately undertake wetland identification and delineation. For more information on the process of identifying wetlands and delineating their boundaries, refer to Chapter B4 of EPA (2008) and in particular, Attachment B4-3; and <www.dec.wa.gov.au> for the latest information on relevant methods.

3. Classification of wetlands in the Avon NRM region

Classification of wetlands is a procedure in which individual wetlands are placed into groups based on qualitative and quantitative information on one or more characteristics inherent in them. The aim of classification is to produce an inventory of wetland groups present in the region, as well as determining the reference ranges a site is compared against. There are two classification systems presented in this document: a geomorphic classification and a biological classification, and these are combined into 12 wetland groups.

3.1 Geomorphic classification system

Semeniuk (1987), and Semeniuk and Semeniuk (1995) described a geomorphic classification system for inland wetlands based on hydroperiod and landform characteristics designed for use in wetland mapping and delineation. The geomorphic classification system has been adopted as the primary wetland classification system in Western Australia by DEC and the State WCC (Department of Environment and Conservation, 2007). This system has been used extensively in other wetland evaluation methodologies in Western Australia, such as the updated Swan Coastal Plain methodology (Department of Environment and Conservation, 2009).

3.1.1 Landform

The different landforms of a wetland are shown graphically in Figure 3 below.

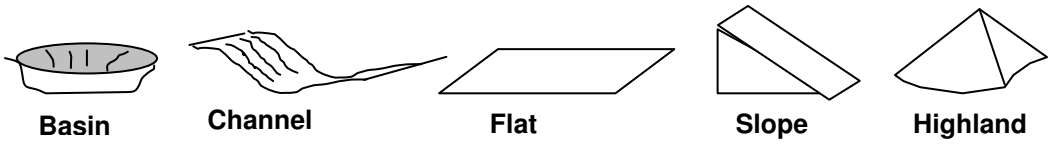


Figure 3 - Examples of different wetland landforms adapted from Semeniuk and Semeniuk (1995).

This methodology only addresses basin landform wetlands that are permanently to intermittently inundated (those highlighted in Table 3).

3.2 Avon biological classification system

This methodology has incorporated an extra level of classification by incorporating a biological classification system, which uses information on the water quality, flora and fauna present at the wetland.

From previous studies conducted in the Wheatbelt, four broad basin types have been recognised on the basis of distinct water chemistry, flora and/or fauna attributes (Lyons*, et al.*, 2004; Pinder*, et al.*, 2004). In this methodology, each wetland is placed into one of these groups so that their qualities can be compared to the appropriate reference ranges (i.e. near-natural, or the most species rich representatives of the same wetland group).

3.2.1 Naturally saline basins

Naturally saline basins (Figure 4) are mostly moderately to highly saline playas, but do include some mildly saline wetlands. These wetlands, especially the playas, support distinct communities of endemic aquatic invertebrates and plants (generally restricted to the supra-littoral fringes, especially the lunettes). These wetlands can become degraded through the process of dryland salinisation (bottom photo in Figure 4) and those that are affected by this are referred to as 'degraded naturally saline basins'.

Features of naturally saline basins are:

- Salinity greater than 10 ppt (can be greater than 300 ppt when the wetland is drying out).
- Generally alkaline water, though some are naturally acidic.
- Generally clear water, although can become turbid in windy conditions or when the wetland becomes very shallow.
- Intermittent to seasonal inundation (i.e. playas and sumplands).
- Lunettes and associated crescentic embayments present on the downwind side of the basin.
- Diverse and highly endemic vegetation communities on wetland fringes.
- Generally a lack of woody vegetation across the bed.
- Vegetation patterning on the margins of these systems is complex and driven by edaphic factors such as soil texture, salinity, pH and gypsum content - coupled with minor changes in elevation. Chenopod communities dominate lower elevations (typically *Tecticornia* spp. - formerly *Halosarcia*) and give way to *Melaleuca* and *Acacia* dominated shrublands upslope. These communities also include a rich herbaceous flora.
- During the wet phase, naturally saline basins may contain the widespread salt tolerant aquatic species: *Ruppia polycarpa, R. megacarpa* and *Lepilaena preissii*.

Features of degraded naturally saline wetlands are:

- Evidence of death of the fringing vegetation due to an increase in water level.
- More acidic (e.g. pH 2 - 4) than most naturally saline wetlands. However, it is possible to have a naturally acidic saline basin. Refer to section 5.3.
- Unnaturally long inundation period compared to naturally saline basins – may be permanently inundated.

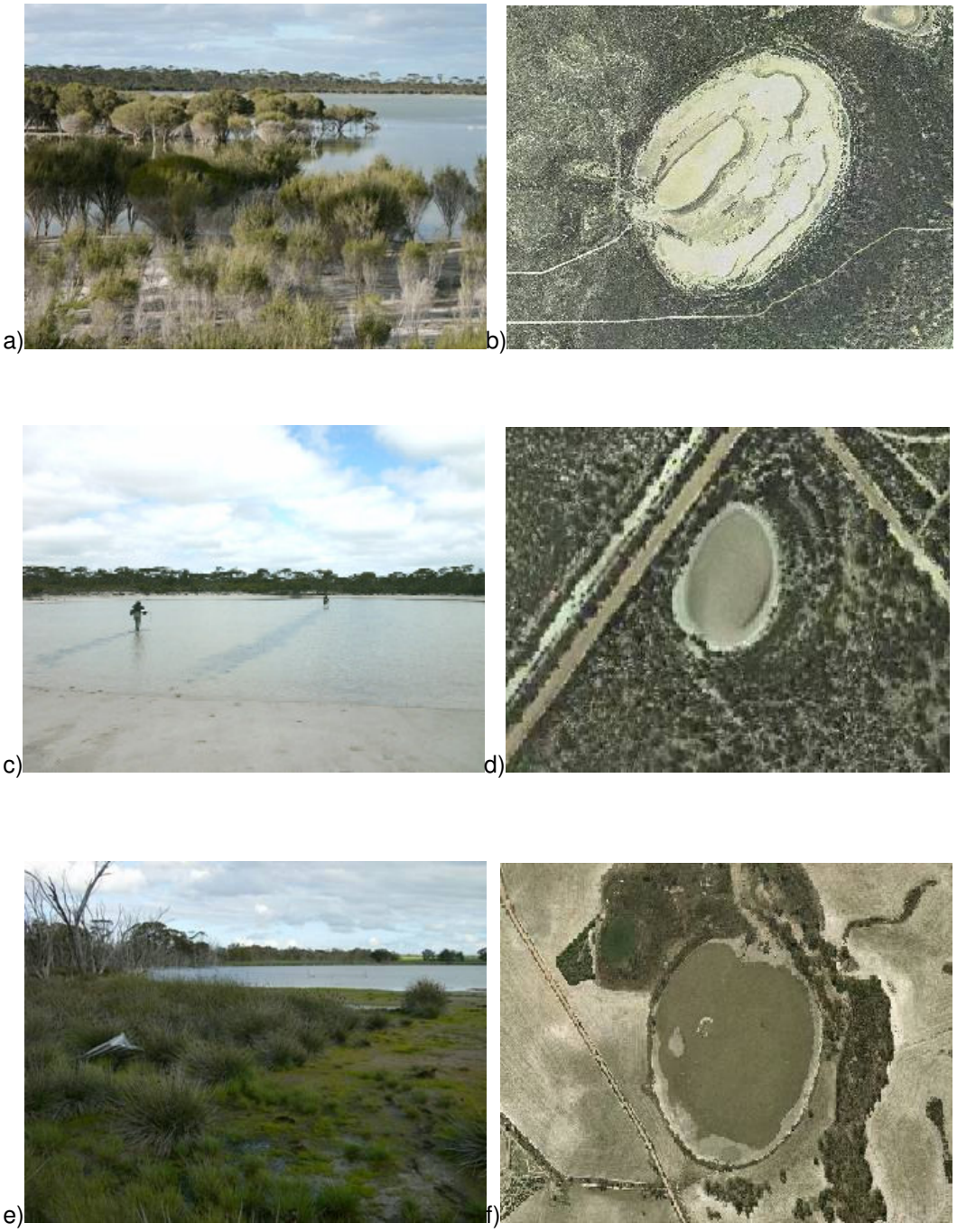


Figure 4 – a, b (lake in Lake Magenta Nature Reserve) and c, d (playa in Lake Cairlocup Nature Reserve) - naturally saline basins in good condition pictured from the ground (left) and aerial photography (right). e, f (lake east of Bejoording) – a degraded naturally saline basin, pictured from the ground (left) and from aerial photography (right).

3.2.2 Freshwater basins

Freshwater basins (Figure 5) support a diverse range of flora and fauna, particularly providing critical habitat during the breeding cycle of many waterbird species. Analysis of the SAP biological survey data for Wheatbelt wetlands indicates that freshwater wetlands support around 80% of the total invertebrate species richness found in all wetlands surveyed in the Wheatbelt (Pinder*, et al.*, 2004).

Dryland salinisation has affected the hydrology, water chemistry (especially salinity and pH) and the associated aquatic and terrestrial flora (e.g. George and McFarlane, 1995; Cramer and Hobbs, 2005; Lyons*, et al.*, 2007) and fauna (e.g. Williams, 1999; Clarke*, et al.*, 2002; Halse*, et al.*, 2003) of many freshwater wetlands in the Wheatbelt. These wetlands are referred to as being 'secondarily salinised' (pictured on the bottom in Figure 5).

Features of freshwater basins are:

- Salinity naturally less than 3 ppt when wetland near capacity.
- Varied depths.
- Generally seasonal (sumplands), but sometimes intermittent inundation (playas).
- In shallow freshwater wetlands, emergent vegetation such as Yate (*Eucalyptus occidentalis*), *Melaleuca strobophylla* and *Casuarina obesa* may occur in various combinations across the bed. In the northern Wheatbelt, *Eucalyptus occidentalis* is replaced by *Eucalyptus camaldulensis var. obtusa*. The periphery of these wetlands contains a suite of annuals including *Agrostis avenacea, Elatine gratioloides* and *Centipeda* spp. These latter species may occur across the bed as the wetland dries *(M. Lyons, DEC, pers. comm. April 2008).*
- In higher rainfall areas, deeper freshwater basins are increasingly dominated by sedges including *Baumea articulata* and *B. arthrophylla (M. Lyons, DEC, pers. comm. April 2008).*

Features of secondarily saline wetlands are:

- Salinity greater than 3 ppt when wetland near capacity.
- Evidence of death of the emergent and surrounding vegetation.
- Sometimes more acidic (pH 2 – 4) than most natural wetlands (e.g. pH 6 - 8).
- Unnaturally long inundation period compared to natural freshwater basins – may be permanently inundated.

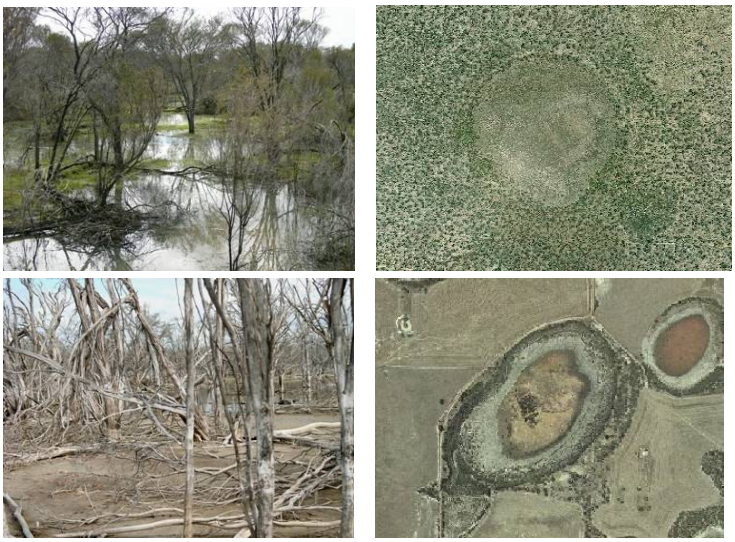


Figure 5 – Top (Dobaderry Swamp) - a freshwater basin in good condition, pictured on the ground (left) and from aerial photography (right). Bottom (Lake at Ongerup) – a secondarily salinised basin, pictured from the ground (left) and from aerial photography (right).

3.2.3 Artificial reservoirs

As the name suggests, artificial reservoirs (Figure 6) are man-made structures used to store water supplies for stock or human consumption. In the assessment process, these wetlands are evaluated as freshwater basins, and can have high conservation significance as they often provide a refuge for freshwater fauna. Artificial waterbodies located on granite outcrops are considered to be reservoirs.

Features of artificial reservoirs are:

- Man-made structures.
- Salinity of the water mostly less than 3 ppt when full, unless the reservoir has become secondarily salinised.
- Dams used for stock watering or fire-fighting are often turbid and those used for drinking water are usually clear.
- Varied depths.
- Reduced diversity of flora and fauna compared to natural wetlands.
- The vegetation at the periphery of these wetlands is variable depending on the area, but often includes *Typha* and *Juncus* species, and a suite of introduced taxa, including *Polypogon monspeliensis, Symphyotrichum subulatum* and *Rumex crispus (M. Lyons, DEC, pers. comm. April 2008).*

Figure 6 - A freshwater artificial reservoir basin (Kondinin Golf Club Dam) pictured from the ground (left) and aerial photography (right)

3.2.4 Turbid claypans

Turbid claypans (Figure 7) support a unique assemblage of aquatic invertebrates [e.g. clam shrimps and fairy shrimps (Pinder, *et al.*, 2004)] and wetland vegetation (Lyons, *et al.*, 2004; Gibson, *et al.*, 2005). These basins are separated from freshwater basins due to their high turbidity, clay sediments and unique flora and fauna. In the south-west, 36 plant taxa, occurring in 6 floristic communities, are identified as claypan specialists (Gibson, *et al.*, 2005). Claypans have very low salinities as the clay sediments isolate surface water from the water table so that the water is derived solely from surface runoff and direct filling from rainfall (i.e. are perched). These wetlands are quite uncommon and they are difficult to identify from aerial photography (as seen in Figure 7).

Features of turbid claypans are:

- Salinity generally less than 1 ppt.
- Alkaline water.
- Generally turbid, shallow water.
- Intermittent to seasonal inundation (playas and sumplands).
- Clay sediments.
- Isolated from saline surface flows.
- Vegetation composition of turbid claypans is variable depending on wetland depth, hydroperiod and turbidity. Vegetation species richness, and the occurrence of sedges and rushes, tends to increase with rainfall (Gibson, *et al.*, 2005).
- The species of vegetation often includes *Tecticornia verrucosa* or *Muehlenbeckia florulenta* in lower rainfall areas. More typically these wetlands are herb dominated at their margin and across the bed in the drying phase. Scattered trees such as *Casuarina obesa* and *Melaleuca* spp. may also be present. In the western areas of the Avon, taxa include *Chorizandra enodis, Amphibromus nervosus and Eleocharis keigheryi (M. Lyons, DEC, pers. comm. April 2008).*

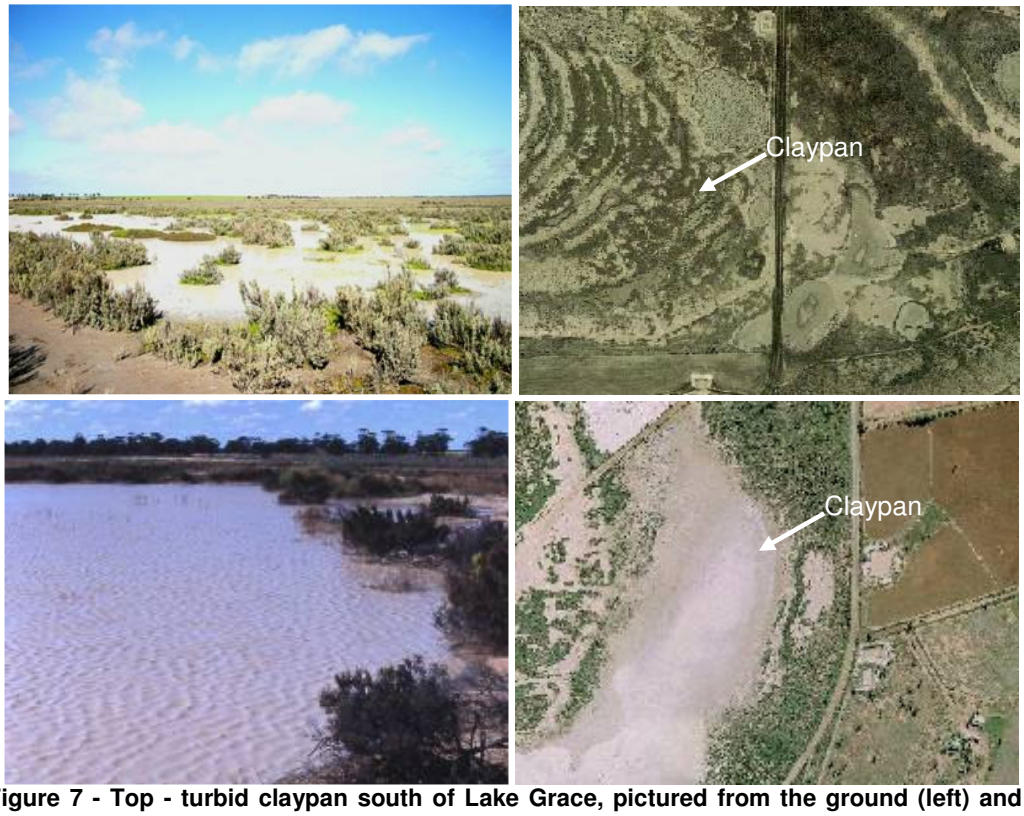


Figure 7 - Top - turbid claypan south of Lake Grace, pictured from the ground (left) and from aerial photography (right). Bottom - (Koorda Claypan), pictured from the ground (left) and from aerial photography (right)

Twelve wetland groups are created by the combination of the geomorphic and biological classification systems. These wetland groups are used in scoring the representativeness criteria (see section 5.3.1 and 5.3.4). These are:

- Naturally saline lake
- Naturally saline sumpland
- Naturally saline playa
- Freshwater lake
- Freshwater sumpland
- Freshwater playa
- Artificial freshwater lake
- Artificial freshwater sumpland
- Artificial freshwater playa
- Turbid claypan lake
- Turbid claypan sumpland
- Turbid claypan playa

Some of these wetland groups are unlikely to occur in the Wheatbelt, for example turbid claypan lakes.

4. Introduction to the evaluation of Avon NRM region wetlands

The aim of this stage three wetland evaluation methodology is to present a transparent and accountable method of evaluating the conservation significance of inundated basin wetlands within the Avon NRM region. This enables Conservation category wetlands to be identified and prioritised for future protection and/or restoration, and Multiple Use category wetlands to be assessed for purposes other than conservation (e.g. receiving drainage water). Table 4 below outlines the description and objectives of each management category (Environmental Protection Authority, 2008 adapted from Hill*, et al.*, 1996a).

Table 4 - Wetland management categories and associated description and management objectives (Environmental Protection Authority, 2008 adapted from Hill*, et al.*, 1996a)

Management category	General description	Management objectives
Conservation	Wetlands which support a high level of attributes and functions	Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including: • reservation in national parks, Crown reserves and State owned land, • protection under Environmental Protection Policies, and • wetland covenanting by landowners.
Resource enhancement	Wetlands which may have been partially modified but still support substantial ecological attributes and functions	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
Multiple use	Wetlands with few remaining important attributes and functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through Landcare.

The conservation significance of a wetland is determined by assessing its values based on various attributes and functions. The attributes and functions listed below have mainly been taken from *Environmental Guidance for Planning and Development* (Environmental Protection Authority, 2008), with some components from Kotze *et al.* (2005).

Attributes

Wetland attributes are a characteristic, or a combination of characteristics, including:

- **diversity** of flora, fauna or habitats
- **social** qualities such as landscape and aesthetics
- **rare** qualities that support the collection of scientific information or survival of a species (e.g. demonstrates evolutionary processes, presence of rare flora or fauna)

Functions

Wetland functions are the physical, biological or chemical processes occurring in a wetland, including:

- maintaining the local and regional ground and surface water regimes (hydrological balance) through regulating water quality and quantity
- sediment trapping, nutrient/pollutant/pathogen stripping
- flood attenuation
- mitigating climate change by absorbing carbon
- maintaining hydrological and terrestrial connectivity with other natural areas, providing migration corridors for aquatic and terrestrial species

Values

A wetland value is a beneficial use of the environment (including social and economic values that derive from the environment); or an ecosystem health condition. An ecosystem health condition means a condition of the ecosystem which is relevant to the maintenance of ecological structure, ecological function or ecological process and which requires protection from the effects of emissions or of environmental harm; or identified and declared to be protected under an approved policy (Environmental Protection Authority, 2008). Wetland 'values' encompass the attributes and functions of a wetland. These can be divided into values that benefit the ecosystem or human uses.

- **Ecosystem values** - support high biological diversity and productivity, provide habitat for rare/threatened species, or provide hydrological or terrestrial vegetation connectivity with other ecosystems.
- **Human values** – recreational, spiritual, amenity, tourism, consumptive use, scientific or ecosystem service values beneficial to humans (e.g. flood attenuation).

This methodology aims to assess wetlands so that the assigned wetland management category reflects the values of the wetland. To encompass the possible values, the following criteria have been used: rarity, naturalness, diversity, and significance. Table 5 provides a summary of the indicators that will be assessed under each of these criteria.

Table 5 - Summary of evaluation criteria and their associated indices

Criteria	Indicator	Index	Scoring
Rarity	Flora	Declared Rare & Priority flora	Automatic assignment to Conservation category by meeting either single or multiple criteria.
	Fauna	Threatened, Specially Protected & Priority fauna	
	Communities	Threatened & Priority Ecological Communities	
	Other	E.g. geology, hydrology, water chemistry	
Naturalness	Modification to water chemistry	pH	Each index is given a score between 1 and 3. This is averaged into an indicator score. Then the scores for each indicator are averaged into a naturalness score. 1 = no significant naturalness value 3 = significant naturalness value
		Salinity	
		Total N	
	Modification to vegetation	Regenerative capacity	
		Weed invasion	
		Structure	
		State	
	Other disturbances	Other disturbances	
Diversity	Habitat	Habitat	Each index is given a score between 1 and 3. This is averaged into an indicator score. Then the scores for each indicator are averaged into a diversity score. 1 = no significant diversity value 3 = significant diversity value
	Flora	Submerged	
		Emergent	
		Fringing	
	Fauna	Invertebrates	
		Waterbirds	
		Other	
Significance	Human	Consumptive use value	Wetlands that have any of these values cannot be assigned a "Multiple Use" management category.
		Recreational value	
		Philosophical / Spiritual value	
		Ecosystem service value	
		Scientific / Educational value	
	Ecological	Representativeness value	
		Vegetation connectivity value	

4.1 Evaluation process

A wetland is assigned to one of three conservation significance categories using the steps outlined below. A full description of the evaluation methodology is given in section 5.

1. Classify the wetland into a group by combining the geomorphic and biological classifications. See section 3 for further details.
2. Conduct a preliminary investigation to determine if the wetland is automatically a Conservation category wetland. See section 5 for further details.
3. If the wetland is not automatically a Conservation category wetland then a site visit must be completed. The wetland is assessed using the scoring system outlined in section 5.3.

4.2 Information sources

There are various sources of information that can be reviewed in the initial phases of the assessment. Published reports and scientific papers, previously collected field data as well as information acquired from the general public are all extremely useful sources and may reduce the data collection required. A summary of the information sources that may be useful for assessing wetlands in the Wheatbelt is provided in Appendix B.

If the wetland is not automatically assigned to the Conservation category, information is then gathered on water chemistry, invertebrate richness, waterbird richness, and the richness and condition of the vegetation. The field sheet, evaluation sheet and sampling protocol to conduct a stage 3 wetland evaluation are outlined in Appendix C, Appendix D and Appendix E respectively. Considerable technical expertise and time is involved in carrying out this protocol, and it is assumed that the personnel involved will have the necessary skills.

4.2.1 Reference ranges

For the naturalness and diversity criteria, a number of indicators are evaluated. Some of these, such as the water chemistry and the diversity indicators, need to be evaluated against near natural or most species rich representatives of their biological wetland type, as values can differ significantly between types. To achieve this, reference ranges have been calculated for the water chemistry, habitat diversity, flora richness and fauna richness indicators. These reference ranges are used to ensure a site is measured against a quantitative and transparent benchmark appropriate for the type of wetland.

The reference ranges have been calculated for each biological wetland type using existing survey data collected during the SAP survey of Wheatbelt wetlands (DEC) and the Avon Baselining Project (DEC). With the exception of claypans, the reference ranges have been calculated using only data collected within the Avon NRM region boundary. Turbid claypans are an unusual wetland type, therefore data available for the calculation of reference ranges was minimal. This is evident in the relatively narrow reference ranges given for turbid claypans and it is recommended that these ranges are reviewed when additional data becomes available.

Reference ranges for indices within the 'modification to water chemistry' indicator (naturalness criterion) were derived by taking the 25^{th} and 75^{th} percentile of measurements recorded at selected wetlands of the same biological wetland type. The selected wetlands were deemed by expert opinion to be the least disturbed representatives of the wetlands for which data was available. The salinity index is not assessed for naturally saline basins as the salinity in these wetlands can vary greatly depending on the water level.

The reference ranges given for the habitat diversity indicator were derived from the opinions of wetland ecologists experienced in the region. Knowledge of near natural, and highly degraded representatives of each wetland type was used to determine the ranges of the highest (3) and lowest (1) score, respectively.

Reference ranges for indices within the flora and fauna richness indicators were calculated by dividing the species/family richness data into biological wetland types, and then sorting it from highest to lowest richness within each group. The data was then divided into three bands:

- top 25% of richness values (score = 3)
- middle 50% of richness values (score = 2)
- bottom 25% of richness values (score = 1)

The collection of invertebrate species richness data can prove difficult depending on the resources available to the project. To accommodate this, three invertebrate richness reference ranges are provided for different levels of taxonomic resolution. These are outlined in section 5.3 of this document.

As the reference ranges are calculated using existing data held by the Department of Environment and Conservation, all data must be collected following the sampling protocol outlined in Appendix E. This ensures that the data collected is comparable to the reference ranges provided, and an accurate assessment is made. In particular, site visits must be conducted in spring when the wetland has the highest water level following winter rainfall (i.e. greater than around 50% capacity), but not during flood conditions. This period is when the wetland has the most favourable water chemistry, and hence the greatest diversity of aquatic invertebrates, submerged vegetation and fringing annual vegetation.

5. Evaluation methodology

The steps involved in the assessment of the conservation significance of inundated basin wetlands in the Avon NRM region are outlined below.

5.1 Classify the wetland into a wetland group

Initially, classify the wetland into a geomorphic and a biological wetland type. The biological classification determines the reference ranges that various attributes of the wetland will be compared to. Secondly, classify the wetland into one of the 12 groups by combining the geomorphic and biological classifications (see section 3).

5.2 Desktop evaluation

The initial component of the evaluation is desktop-based. This is to make the process more efficient by preventing the collection of unnecessary data. If the wetland is currently recognised as internationally or nationally significant for its natural values it is automatically assigned as Conservation management category. However, if the wetland does not retain the values for which it was registered for, it is subject to a detailed site visit (section 5.3). Further information on sources of this information is available in Appendix B. Lists or registers include:

1. Ramsar Convention on wetlands (UNESCO, 1971; Ward and Voelz, 1994)
2. State Government endorsed candidate sites for the Ramsar Convention on Wetlands
3. Directory of Important Wetlands (Environment Australia, 2001)
4. *Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998*
5. World Heritage List (World Heritage Convention). There are currently no World Heritage sites that include wetlands in the Avon NRM region.
6. Heritage listings controlled by the Commonwealth [Register of the National Estate (Australian Heritage Commission, 1990), The National Heritage List, The Commonwealth Heritage List]. Currently, there are no basin wetlands within the Avon NRM region that are listed on The National Heritage List or The Commonwealth Heritage List. However, there are many natural areas within the Avon NRM region that are listed on the Register of the National Estate, which have basin wetlands within them.

5.3 Site visit

The third component of the assessment is a site visit, which involves the collection of detailed data on water chemistry, hydrology, fauna, flora and other ecological processes occurring at the wetland. All of this data may not be required if the wetland meets the criteria for an automatic assignment to Conservation category.

5.3.1 Step 1 - Identify values for automatic assignment to Conservation category

There are two tiers of the automatic assignment – via meeting either a single or multiple criteria. Additional sources of information on wetlands in the Avon NRM region are provided in Appendix B.

If the attributes of a wetland meet only one of the following criteria, it is automatically assigned to Conservation category:

1. Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6).

2. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government (e.g. Environmental Protection Authority and Department of Conservation and Environment, 1983).

3. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and supports an identified occurrence of Threatened Ecological Community (TEC). TEC's that occur in the Avon-Wheatbelt are listed in Appendix G.

4. The wetland supports a breeding, roosting, or refuge site, or a critical feeding site for populations of fauna listed by the Australian Government (e.g. *Environment Protection and Biodiversity Conservation Act 1999*, JAMBA, CAMBA, ROKAMBA) or the State Government (e.g. Threatened or Specially Protected Fauna listed under the *Wildlife Conservation Act 1950).* A list of rare and threatened waterbirds protected under State and National legislation are listed in Appendix F. None of the invertebrates identified by the Western Australian government as Threatened or Specially Protected have been recorded in the Wheatbelt.

If the attributes of a wetland meet two or more of the following criteria then it is automatically assigned to Conservation category.

1. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and is the best known representative of the wetland group in the catchment (see section 5.3.5). This excludes artificial reservoirs.

   The catchments used to assess representativeness are those identified in the *Hydrographic Catchments – Catchments* dataset produced by the Department of Water (see Appendix B). There are seven catchments within the Avon NRM region boundary: Swan-Avon Mortlock, Swan-Avon Main Avon, Swan-Avon Salt River, Swan-Avon Yilgarn, Swan-Avon Lockhart, Culham Inlet Phillips West Steere and Magenta Internal.

2. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species. A list of Rare, Threatened and Prioritised flora that were recorded at wetlands during the SAP Wheatbelt biological survey are listed in Appendix I.

3. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and supports an identified occurrence of a Priority 1 or 2 Ecological Community (PEC). PEC's that occur in the Avon-Wheatbelt are listed in Appendix H.

4. Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale (Government of Western Australia, 2000, see Table 6) and supports internationally, nationally or State-wide significant scientific values, including geoheritage and geoconservation. A thorough overview of the status of geoheritage and geoconservation in Australia is given by Brocx and Semeniuk (2007). An example of a nationally significant geoconservation site in the Avon region is Wave Rock. As yet there is no formal method of identifying a site with geoheritage, or geoconservation value and this must be a matter of expert opinion at the time of assessment.

5. The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other attribute considered rare by expert opinion (e.g. freshwater (salinity < 3 ppt) is a rare water chemistry in the Avon NRM region). This only includes basins that have natural water chemistry (i.e. artificial reservoirs are excluded).

6. The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.

7. The wetland supports cultural values that are based on natural attributes or functions. For example, a registered Aboriginal site listed for natural features.

Table 6 - Vegetation condition scale used in *Bush Forever* (adapted from Keighery, 1994)

Category	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

5.3.2 Step 2 - Score Naturalness criterion

Naturalness is defined as the degree to which a wetland is unaltered by anthropogenic disturbance. Wetlands that are close to natural have a high ecological, scientific and educational value as they are representative of pre-European conditions. They also provide an amenity value, as humans tend to be attracted to aesthetically pleasing sites for relaxation and leisure activities (e.g. bird-watching).

There are three indicators that are scored here: modification to water chemistry, modification to vegetation and other disturbances. Each indicator may have multiple indices, which are averaged to produce a single score for each indicator. Scores range from 1 to 3, with 1 being the least natural and 3 being the most natural.

1. Modification to water chemistry

This indicator is assessed by comparing measurements recorded at a wetland against reference ranges for that wetland group (see Table 7). Reference ranges were derived from values obtained at wetlands deemed by expert opinion to be the least disturbed of the wetlands for which data was available for their wetland group. All water chemistry measurements should be taken as outlined in Appendix E.

There are two important exceptions to note regarding the pH index. Firstly, pH changes over the diurnal cycle and is likely to be higher later in the day due to the effects of the process of photosynthesis removing carbon dioxide from the water. Secondly, some wetlands can be naturally acidic, with pH < 5. Naturally acidic wetlands usually have outcrops of granite, sandstone or possibly laterite immediately adjacent to the wetland, from which water seeps. The water seep will be brown or yellow (due to iron oxides deposited by bacterial action). If a wetland with acidic water is in sandy, clayey or granite derived soils or limestone then the acidity is not likely to be natural *(B. Timms, University of Newcastle, pers.comm. October 2006 based on observations from the Esperance/Norseman area*). Naturally acidic wetlands should not record a score for the pH index, as it is difficult to determine what the natural acidity of the wetland would be.

A reference range has not been provided for naturally saline basins because of the great range of salinities that can be recorded in this type of wetland. Salinities change greatly over time depending on the extent of inundation, which makes it difficult to determine whether recorded salinity is natural for that wetland, or whether it has been altered as a result of salinisation.

The total soluble nitrogen reference ranges given for claypans are significantly higher than those given for freshwater or naturally saline basins. As claypans are highly turbid, filtering of the water sample in the field is impossible. Water samples from claypans should be centrifuged at the laboratory to eliminate most of the suspended clay particles, as nutrients adhere to these clay particles resulting in elevated nitrogen readings (Scheffer, 1998).

Table 7 - Scoring guidelines for the modification to water chemistry indicator

Index	Reading	Reference ranges for each wetland group		Scoring method	Score
pH: *(do not score naturally acidic basins)*	__ . __ __	Naturally saline basin Freshwater basin Turbid claypan	7.8 – 8.7 6.8 – 8.1 8.6 – 8.9	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	____
Salinity: *(do not score naturally saline basins)*	_ _ _ _ _ _ ppt	Naturally saline basin Freshwater basin Turbid claypan	N/A 0 – 1.1 0 – 0.6	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	____
Total Soluble N	_____µg/L	Naturally saline basin Freshwater basin Turbid claypan	< 1100 < 1900 < 2325	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	____
Final score for modification to water chemistry				**= sum scores ÷ # indices**	

2. Modification to vegetation

Ideally, modification to vegetation would be judged by comparison to some pre-European state. However, in many circumstances it is very difficult to determine the original wetland vegetation community.

As a surrogate, this scoring system is based on the condition of the current vegetation (see Table 8). The condition of vegetation can reflect some of the past, as well as current disturbances that may be affecting wetland vegetation, such as dryland salinisation, weed invasion, feral animals, grazing and side effects of the surrounding agriculture (e.g. pesticides and fertilisers). This indicator is scored using four indices - regenerative capacity, weed invasion, structure and state.

The vegetation condition information must be collected following the procedure outlined in Appendix E and using the field sheet in Appendix C. The decision-making process for converting the raw data into a score for each index is shown below. This table must be filled out for each quadrat sampled at a wetland, except for aquatic quadrats. The index scores are then averaged for the site. Some of the index descriptions have come from Thackway and Lesslie (2005).

Table 8 - Scoring guidelines for the modification to vegetation indicator. This table must be completed for each vegetation quadrat surveyed (excluding aquatic quadrats)

	Score = 3 Natural	Score = 2 Impacted	Score = 1 Degraded - Replaced	Index score
Regenerative Capacity *	Regenerative capacity intact. All species expected to show regeneration are doing so. Alternatively for naturally bare areas, the natural regenerative capacity is unmodified, ephemeral and lower plants only.	Natural regenerative capacity somewhat reduced, but endures under current and past land management practices.	Natural regenerative potential of native vegetation has been suppressed by ongoing disturbances. Rehabilitation and restoration possible through removal of threats.	_____
Weed invasion	Weeds are absent or comprised of non-aggressive species.	The presence of some very aggressive weeds at high density.	Weeds and/or crop species comprise the majority of species present with some isolated native trees or shrubs.	_____
Structure	Structural integrity of native vegetation is very high. All expected strata, growth forms and age classes are present. Alternatively, for naturally bare areas there is nil/minimal vegetation structure.	Structure is altered but persists i.e. some elements of a stratum are missing.	Structure of native vegetation is significantly altered i.e. one or more strata are missing entirely or highly degraded.	_____
State	On average, 0 – 5% of the native vegetation present in the upper and middle strata of the community are showing signs of stress.	On average, 5 – 10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	On average, >10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	_____
Final Indicator Score ***(= sum scores ÷ # indices)***				_____

* - Regeneration is assessed by the presence of seedlings

3. *Other disturbances*

This indicator is included to encompass any disturbances to the wetland that are not reflected in the scoring of the first two indicators. It is assumed that the assessor has an adequate knowledge of wetland systems and their interaction with the surrounding environment. It is acknowledged by the authors that the scoring of this indicator is very subjective, however, every wetland is different and it is impossible to come up with a one size fits all qualitative scoring system.

Minor disturbances may include, but are not limited to: presence of buildings, minor recreational activity (e.g. bird watching, bush walking) or dumping of rubbish (depending on proximity to wetland and rubbish contents).

Moderate or major disturbances may include, but are not limited to: significant recreational activity (such as excessive boat use), dumping of toxic waste and the presence of structures such as dams, roads or drains. Disturbances should be rated according to the severity of the effect on the fauna, flora, hydrology or other processes occurring in the wetland.

Note that a disturbance may be minor at one wetland but moderate or major at another wetland. For example, a road may cut along the edge of one wetland, but may run right through the middle of another, so that the disturbance is the same, which is a road, but the impact is different. The assessor must use their expert opinion to make an adjustment to the score based on the criteria in Table 9 below.

Table 9 - Scoring guidelines for the other disturbances indicator

Criteria	Adjustment to score
No disturbances at the wetland that may potentially affect the fauna, flora or hydrology of the wetland. For example, the presence of a building is not natural but does not affect the wetland system.	0
A few minor or one moderate disturbance/s present at the wetland. These may affect the fauna, flora or hydrology of the wetland but not so much as to change the fauna or flora community composition. For example, a road cutting through the edge of a wetland may disturb the vegetation present at the affected site but will not change the vegetation communities present at the wetland.	-0.17
One or more major disturbances impacting the wetland. These significantly affect the fauna, flora or hydrology of the wetland in a way that changes the community composition. For example, a deep drain discharging hypersaline, acidic water into a wetland is likely to change the composition of aquatic fauna and flora.	-0.33

4. *Final naturalness score*

The final naturalness score is calculated using the formula below. Note that the score is truncated at 1, so a wetland cannot score below 1.

Naturalness score = (Modification to water chemistry score + Modification to vegetation score) – adjustment for 'Other disturbances'

5.3.3 Step 3 - Score Diversity criterion

For the purposes of this methodology, diversity is defined as the number of habitats or species at a wetland. Wetlands with a high diversity of habitats or species have a scientific and educational value, as they provide unique species associations and combinations.

There are three indicators that are scored here, which are habitat diversity, flora richness and fauna richness. Each indicator may have multiple indices, which are averaged to produce a single score for each indicator. Scores range from 1 to 3, with 1 indicating the least diversity and 3 indicating the most diversity.

1. Habitat diversity

This indicator is calculated by summing the number of habitats present at the wetland, and comparing this total against the reference ranges for that wetland group (see Table 10).

The habitats listed have been identified as being important for different groups of biota. Habitat features such as shallow wading zones, deep water zones and emergent vegetation have been identified as being critical for wetland use by waterbirds (Halse*, et al.*, 1993b), and other habitats such as islands and surrounding vegetation are also thought to be important. Habitat features such as submerged and emergent vegetation have been found to support different invertebrate assemblages, and therefore provide different functions in the ecosystem (Storey and Lynas, 2007). The habitat of emergent shrubs or trees should only be counted as being present if comprised of wetland species (e.g. Yate) and the habitat has not been created by a sudden change in wetland extent.

Table 10 - Scoring guidelines for habitat diversity indicator

Possible wetland habitats	**Present (1) / absent (0)**	**Structural diversity reference ranges for each wetland group**				**Score**
Submerged vegetation						
Emergent shrubs / trees						
Emergent reeds / sedges						
Surrounding terrestrial veg.		Wetland group	Score = 3	Score = 2	Score = 1	
Large woody debris		Naturally saline basin	>5	4 or 5	0 – 3	
Leaf litter		Freshwater basin	>6	4 – 6	0 – 3	———
Deep water zones (≥1.5m)		Turbid claypan	>3	2 or 3	0 or 1	
Shallow wading zones						
Island						
Total						

2. Flora richness

This indicator includes measures of indigenous submerged, emergent and fringing wetland vegetation species richness (see Table 11). These indices are assessed by comparing the observed species richness for each vegetation type against the relevant reference range. The three scores are then averaged to give a final score for native flora richness.

A list of vegetation species associated with each of these categories can be found in Appendix I. This list has been taken from Appendix 3 of Lyons *et al.* (2004, wetland flora component of the SAP Wheatbelt Biological Survey), except that species classified as terrestrial (or habitat 4) by Lyons *et al.* (2004) have been excluded. Habitats 1, 2 and 3 identified by Lyons *et al.* (2004) are equal to submerged, emergent and fringing categories, respectively. Fringing vegetation refers to wetland vegetation that is not emergent or submerged. Note that when the water level is low, emergent species may appear to be fringing species, or during floods, fringing species may appear to be emergent species.

Submerged vegetation is either not scored if it is absent, or receives a score of 2 or 3 if it is present (depending on wetland type). This is because its presence is highly variable over the growing season and a wetland should not be downgraded for its absence.

Table 11 - Scoring guidelines for the flora richness indicator

Vegetation type	No. Sp found	Species richness reference range for each wetland group				Score
Submerged	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>0	No score	No score	
		Freshwater basin	>1	1	No score	
		Turbid claypan	>0	No score	No score	
Emergent	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>1	1	0	
		Freshwater basin	>3	1 - 3	0	
		Turbid claypan	>0	No score	0	
Fringing	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>16	10 - 16	<10	
		Freshwater basin	>6	2 - 6	<2	
		Turbid claypan	>8	7 - 8	<7	
Final score for native flora richness				**=sum scores ÷ # indices**		

3. Fauna richness

This indicator includes measures of micro and macro invertebrate species/family richness, waterbird species richness and any other fauna that may have been observed during the site visit (must be native and reliant on the wetland – e.g. native fish, frogs, turtles) (see Table 12).

The invertebrate and waterbird indices are assessed by comparing the observed species/family richness for each fauna type against the relevant reference range. Turbid claypans are not scored for waterbird richness, as to date there has only been one record of a bird present at a claypan (DEC, unpublished data).

Three reference ranges for invertebrates have been provided for various levels of taxonomic resolution:

- The first table of reference ranges includes all fully aquatic micro and macro-invertebrate groups at species level.
- The second table of reference ranges includes all fully aquatic micro and macro-invertebrate groups at family level.
- The third table of reference ranges includes only fully aquatic macro-invertebrate groups at species level (excludes the groups Acarina, Cladocera, Copepoda, Conchostraca, Ostracoda, Rotifera, Tardigrada and Protozoa).

If there are additional native fauna groups observed (they must be reliant on the wetland), then a score of 3 is recorded in the third row of the table following. If no additional fauna groups are observed this row is left blank.

The index scores are then averaged to give the final score for fauna richness. All data should be collected following the protocols outlined in Appendix E and using the field sheet available in Appendix C.

Table 12 - Scoring guidelines for the fauna richness indicator

Fauna category	No. Sp found	Species and family richness reference range for each wetland group				Score
Invertebrates	_____	**All species**	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>14	6 - 14	<6	
		Freshwater basin	>54	27 – 54	<27	
		Turbid claypan	>29	23 – 29	<23	
		All families	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>10	4 - 10	<4	
		Freshwater basin	>28	17 - 28	<17	
		Turbid claypan	>16	13 - 16	<13	
		Macroinvert species	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>8	3 - 8	<3	
		Freshwater basin	>35	18 - 35	<18	
		Turbid claypan	>7	3 - 7	<3	
Waterbirds (*claypans are not scored for waterbird richness)*	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>4	1 - 4	0	
		Freshwater basin	>9	3 - 9	<3	
Other native wetland fauna observed *(E.g. turtles, fish, frogs)*	Other fauna observed (*If present then a score of 3 is recorded)* _____ _____					_____
Final score for fauna richness				**=sum scores ÷ # indices**		

4. Final diversity score

The relevant scores for habitat, flora and fauna diversity are combined into a final diversity criteria score. This is achieved by first summing all of the available scores, and then dividing by the number of scores. This will result in a score between 1 and 3, with 1 indicating a low overall diversity and 3 indicating a high overall diversity.

Diversity score =	**(Habitat diversity score + flora richness score + fauna richness score) ÷ 3**

5.3.4 Step 4 – Preliminary assignment to wetland management category

The naturalness and diversity scores are combined to place the wetland into a preliminary wetland management category using the figure below.

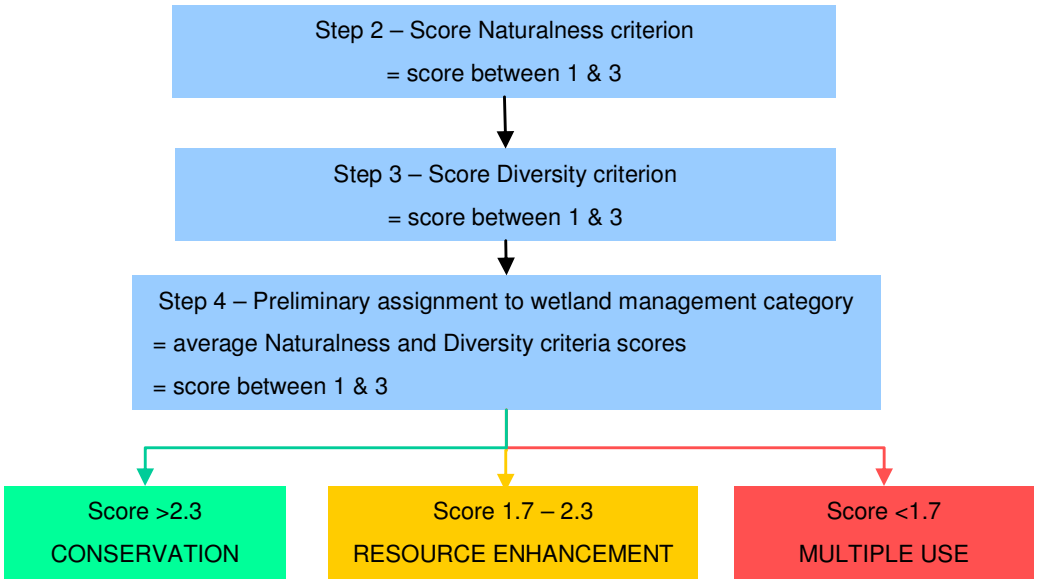


Figure 8 - Diagram summarising the scoring for preliminary assignment to wetland management category

5.3.5 Step 5 – Incorporate significance values

This step is only required for those wetlands that have been determined to be in the 'Multiple Use' wetland management category in step 4. If a wetland has any of the following values then it **cannot** be assigned to the 'Multiple Use' wetland management category, and should be upgraded to the Resource Enhancement category. Wetlands with any of the following values require some protection against further degradation as they either have a human or ecosystem significance.

1. Consumptive use value

Wetlands with consumptive use value should be protected against further degradation to identify and secure water sources for the future. Wetlands with consumptive use value can include wetlands that are identified under formal legislation, or those that are not formally recognised as water supply areas.

Wetlands with formal recognition are identified as Public Drinking Water Supply Areas (PDWSA; Department of Water, 2007) and Protection Zones, and are covered under the Country Areas Water Supply Act, 1947. The PDWSA's in the Avon NRM region are:

- Bolgart Water Reserve
- Brookton-Happy Valley Water Reserve
- Brookton Water Supply Catchment Area
- Bull Road Wellfield
- Yerecoin Water Reserve

Wetlands without formal recognition may be used for a variety of purposes - irrigation, stock watering, fire-fighting or human consumption. Such wetlands are usually apparent at the time of assessment as they generally have water pumping equipment nearby or obvious signs of livestock access.

2. Recreational value

Wetlands with recreational value are important to protect against further degradation as they are significant to the community. Currently, the only wetlands that are recognised for their recreational value are those identified in the Avon Natural Resource Management Plan: Water Resource Supporting Document (Avon Catchment Council, 2004, Appendix I). Landowners may also be able to provide information on the recreational uses of the wetland being assessed.

3. Philosophical/spiritual value

Wetlands with a high philosophical or spiritual value are vital to a community's 'sense of place', and thus should be conserved. The following documents and registers provide listings of the wetlands in the Avon NRM region that are currently considered to have high philosophical or spiritual value. This is not an exhaustive list, as the philosophical or spiritual value of many wetlands has not been realised. Future projects are likely to add to this list:

- Avon Natural Resource Management Plan: Water Resource Supporting Document - local and regional water assets (Avon Catchment Council, 2004). These are listed in Appendix I.
- Municipal inventories

4. Ecosystem service value

Wetlands are at the receiving end of runoff after heavy rainfall events. This runoff, which is generally created from degrading land uses, such as hard surfaces and agriculture, can be full of nutrients, sediments and trace metals. Along with providing a depository for large amounts of water, wetlands can also work as the kidneys of the system, filtering out the toxins, nutrients and sediments, resulting in a cleaner outflow into downstream systems. The following ecosystem services are most commonly performed by wetlands.

- Flood attenuation. As a guideline, if the area of the wetland is 6% or greater of the catchment area, storm flows spread across the area at least once every five years and the wetland is not permanently inundated, then the wetland performs this ecosystem service. These guidelines are a simplified version of the assessment presented in Kotze *et al.* (2005) and are taken from the cutoffs for a Moderate-High to High score. Note that certain requirements listed by Kotze *et al.* (2005) have been deleted as they are not applicable to basin wetlands in the Avon NRM region (e.g. sinuosity of the stream channel).

- Nutrient/pesticide/pathogen stripping. The following guidelines have come from Kotze *et al.* (2005) and are taken from the cutoffs for a Moderate-High to High score. A good knowledge of the wetland hydrology and underlying geology is required to assess this ecosystem service. Geological information may be obtained from the Atlas of Australian Soils for Western Australia (see Appendix B).

  Wetlands that have an area greater than 30% that is seasonally or permanently inundated, are predominantly well covered with permanent vegetation and a relative contribution of sub-surface water inputs to surface water inputs greater than 36%, are likely to perform this function.

  In determining the contribution of sub-surface water inputs to a wetland consider the following features:
  - The size of the wetland relative to its catchment, the greater the relative size of the wetland, the greater the likely contribution of sub-surface water.
  - Whether the wetland has overlying geology characterised by a ground-surface water linkages, such as sandstone or dolomite.

5. Scientific/educational value

These wetlands are important to conserve so that their purpose for education is maintained. Wetlands with a scientific or educational value may be those used for:

- Biological / hydrological monitoring
- Ongoing research
- Part of a catchment management program, subject to consultation with managers about its significance in this respect
- Trial engineering works
- Wetland education by schools, universities or community groups

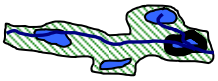
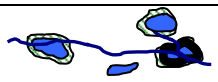
6. Vegetation connectivity value

Wetlands that have good vegetation connections with other natural areas are providing habitat corridors for wetland-dependant species to move from the wetland to other wetlands or natural areas.

This index is assessed by comparing the connecting vegetation patterns of the wetland of interest with other wetlands or natural areas. This can be assessed by comparing the figures in Table 13 with a combination of on-ground observations and aerial photography. In the figure, the wetland

of interest is blue, surrounded by a bold black outline, and the connecting vegetation is green. A wetland with a "High" connectivity, as described below, is determined to be performing this ecosystem service.

Table 13 - Description of categories of vegetation connectivity

Category	Description	Graphical description
High	Vegetation surrounding the wetland is completely connected with more than one other wetland and/or natural area.	
Intermediate	Buffer vegetation is completely connected with one other wetland or natural area, however is mostly fragmented.	
Low	Buffer vegetation is not connected with other hydrologically connected wetlands or natural areas.	

7. Representativeness value

Protecting a selection of representatives from each wetland group, within each catchment provides a good foundation for the conservation of a wide selection of species, communities and geomorphologies. For a wetland to have representativeness value, it must be the wetland with the best known condition (in terms of naturalness and diversity) within that wetland group, within that catchment.

Unless all wetlands in the catchment have been sampled, it is difficult to know whether the wetland of interest is the best representative of a wetland group. However, previously collected data from other wetlands in the same wetland group and catchment can be used to aid in this decision as they provide context to the values supported by the wetland being assessed.

5.4 Finalise wetland management category

Once steps 1 to 5 of the site visit are completed the wetland can be assigned to a wetland management category. The complete evaluation process covered in sections 5.1 to 5.3 is summarised in Figure 9 below.

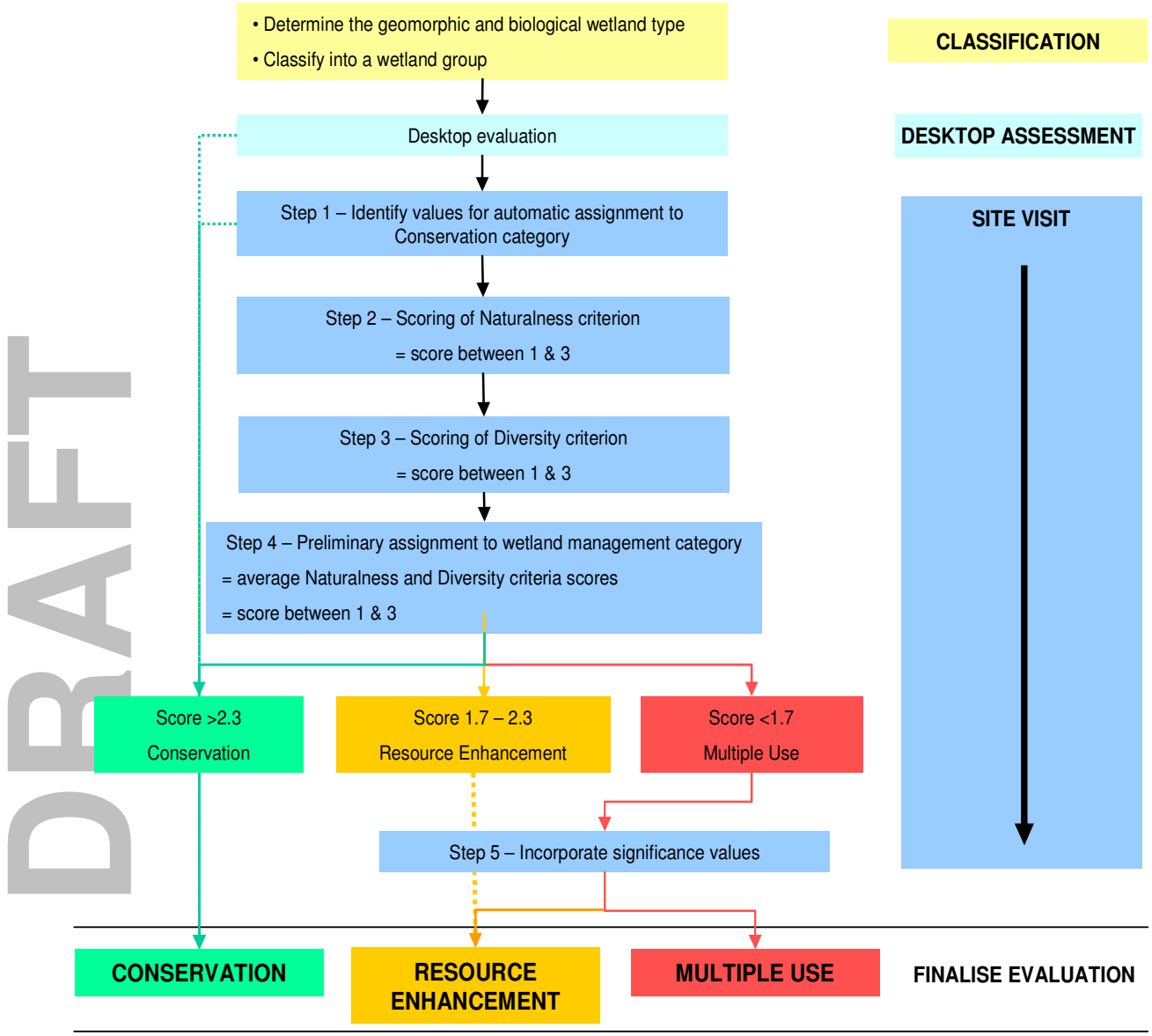


Figure 9 - Summary of the stage 3 basin wetland evaluation process for the Avon NRM region.

6. Application of the methodology – six case studies from the Avon NRM region

To trial the application of this methodology, DEC conducted site assessments of twenty-eight wetlands across the Avon NRM region. The information collected during this trial will be made available on WetlandBase. This trial was aimed at ensuring the assessment system provided results comparable to expert opinion, and testing the usability of the field sheets and duration of time taken to complete the assessment. The results of this trial were fed back into the methodology to refine and improve the process. This refinement has brought about the methodology and information presented in this document.

A map showing the locations of sites at which this methodology was tested is shown in Figure 10 below. Wetlands of different conditions in each of the biological classifications (freshwater basins/reservoirs, turbid claypans and naturally saline basins) were visited during the field trial. The sites visited were restricted to areas of the Avon that had had average rainfall in winter 2008, and therefore where basins contained adequate water levels.

The sections below present six case study wetlands where this methodology was applied. There are two examples each of naturally saline basins, freshwater basins and turbid claypans. Each of the two example wetlands are in contrasting condition.

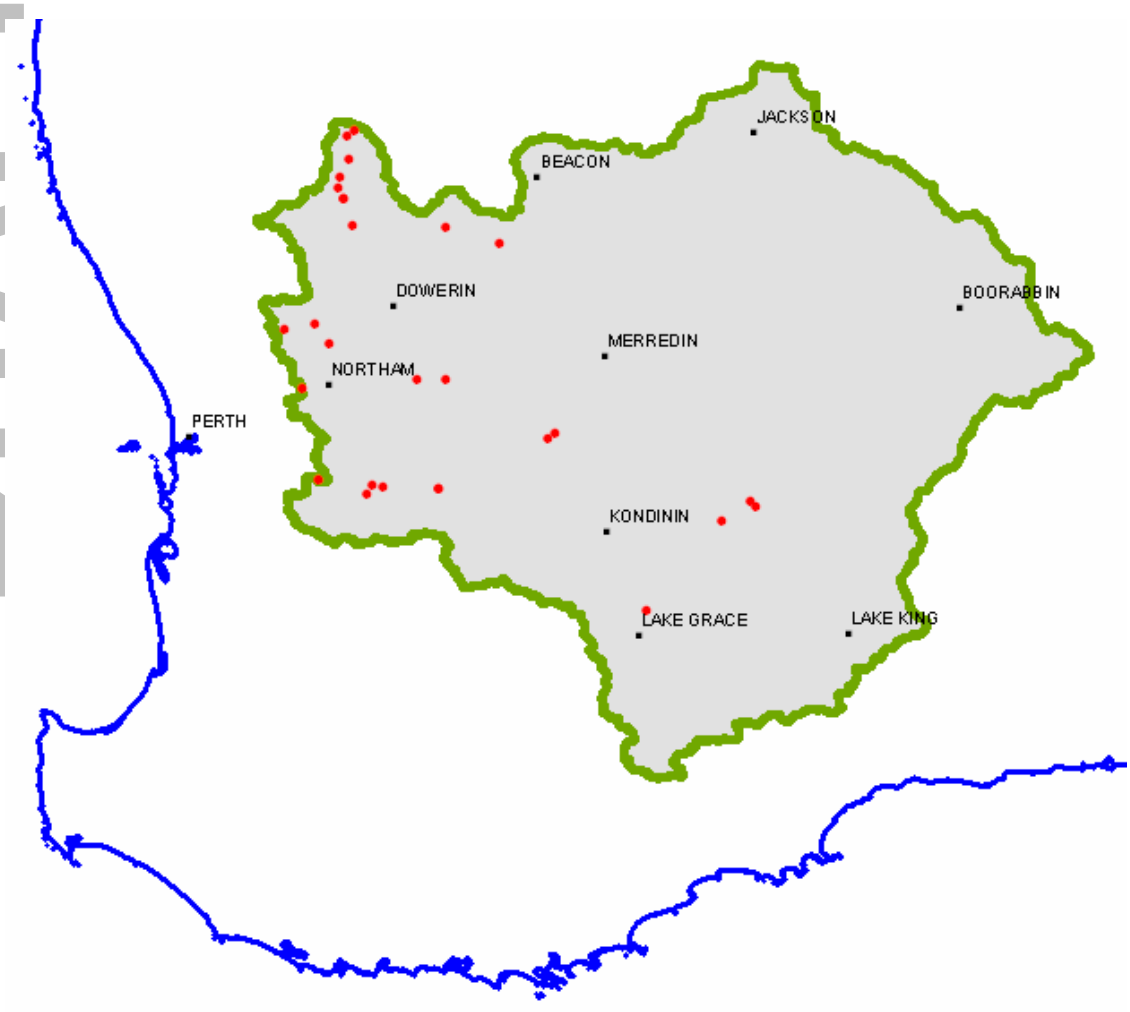


Figure 10 - Map showing the locations of wetlands at which this methodology was trialed within the Avon NRM region.

6.1 Time estimates

Time estimates for the completion of a full site assessment are given below. The time taken to complete a site assessment will vary greatly depending on the salinity, condition and size of the wetland. The guidelines provided below are an average for a small wetland (1 - 20 hectares), using two staff who are experienced in the collection and identification of wetland flora and fauna to species level. A full day refers to an 8 – 9 hour period.

- A full day for the collection of invertebrate, water chemistry, waterbird and vegetation data, including plant pressing. Additional time is required to re-score vegetation quadrats. The results of water chemistry samples take around 2 weeks to return from the laboratory.
- Around 2 - 3 days to sort and identify invertebrates to species level from a saline site, and around 2 - 5 days to sort and identify invertebrates to species level from a freshwater site, depending on identification experience and invertebrate diversity of wetland.
- Around 5 days to identify vegetation to species level.

From the time estimates given above, a full site assessment should take around 2 weeks for two people. A large portion of this time (1 – 1.5 weeks) is used to identify invertebrates to species level. If invertebrates were only identified to family level, the time taken to sort and identify invertebrates would be significantly reduced. However, it is recommended that species level invertebrate identifications are undertaken. This ensures complete information is available for the site, in addition to identifying any possible invertebrate species that may be listed as Threatened or Specially Protected in the future.

6.2 Naturally saline basins

Site Name: Lake Mokami at Erikin South Road
Site Code: ABP126
Latitude: -31.96197
Longitude: 117.93203
Date Assessed: 1/10/2008
Personnel: SMJ, MTC, DLH, CJF
Geomorphic wetland type: Playa
Biological classification: Naturally saline basin

Site summary

This is a good condition naturally saline basin located within a nature reserve. Some tree death on the northern side of the lake suggests waterlogging problems. Vegetation and invertebrate diversity were high.

Site Photos

Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**No**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	×
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**No**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	Possibly
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	×
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	×
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×
	Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed*)?	**No**

Site Evaluation

1 Naturalness

	a Modification to Water Chemistry	Reading	Comments	Index Score	Indicator Score
	pH	6.46	-	2	
	Salinity (g/L)	37	-	N/A	
	Total Soluble N (µg/L)	550	-	3	
	Final Score for modification to water chemistry				*2.50*
	b Modification to vegetation				
	Regenerative capacity	- Moderate amount of regeneration of native vegetation species occurring.		2.3	
	Weed invasion	- Weed species present but not significant.		3.0	
	Structure	- All expected structural layers present, with some death.		2.7	
	State	- Some *Tecticornia* species showing signs of stress.		2.0	
	Final Score for modification to vegetation				*2.50*
	c Other disturbances				
	Adjustment to score		-		*0.00*

Final naturalness score = average (water chemistry, vegetation) – other disturbances ***2.50***

2 Diversity

	a Habitat diversity	# Habitats	Comments	Index Score	Indicator Score
	Final score for habitat diversity	5	-		*2.00*
	b Flora richness	# Species			
	No. submerged species	1	-	3	
	No. emergent species	1	-	2	
	No. fringing species	11	-	2	
	Final flora richness score				*2.33*
	c Fauna richness	# Species			
	Invertebrates	25	-	3	
	Waterbirds	3	- Australian Shelduck, Grey Teal, Silver Gull.	2	
	Other native wetland fauna observed		- No other fauna observed.	N/A	
	Final fauna richness score				*2.5*

Final diversity score = average (habitat diversity, flora richness, fauna richness) ***2.28***

3 Significance

• Does the wetland have a consumptive use value?	-	×
• Does the wetland have a recreational value?	-	×
• Does the wetland have a spiritual/philosophical value?	-	×
• Does the wetland perform an ecosystem service?	- Quite a large wetland with dense stands of submerged vegetation – could perform a nutrient stripping or flood attenuation function.	Possibly
• Does the wetland have a scientific/educational value?	-	×
• Does the wetland have a vegetation connectivity value?	- Good vegetation connections to nearby flat areas.	✓
• Does the wetland have a representativeness value?	- This is very hard to assess, as this wetland is in quite good condition but there are many naturally saline playas that could be in good condition but have not been assessed in the Swan-Avon Lockhart catchment.	Possibly

Final Evaluation

Average diversity and naturalness score	**2.39**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**Conservation**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**No**
Final wetland management category	**Conservation**

Site Name: Saline Lake at Cunderdin
Site Code: ABP128
Latitude: Private property
Longitude: Private property
Date Assessed: 14/10/08
Personnel: SMJ, MTC, DLH, CJF
Geomorphic wetland type: Playa
Biological classification: Naturally saline basin

Site summary

This wetland is severely degraded. Few native vegetation species remain and there was low invertebrate and waterbird diversity. Water quality was also poor.

Site Photos



Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**No**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	×
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**No**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	×
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	×
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community. Priority species recorded but not more than 50% of vegetation in "Good" or better condition.	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	×
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed)*? No

Site Evaluation

1 Naturalness

	Modification to Water Chemistry	Reading	Comments	Index Score	Indicator Score
	pH	3.36	-	1	
	Salinity (g/L)	120	-	N/A	
	Total Soluble N (µg/L)	2000	- Likely due to surrounding agricultural land, a lot of sheep manure on wetland edge.	2	
	Final Score for modification to water chemistry				*1.50*
b	Modification to vegetation				
	Regenerative capacity	- Little recruitment of native vegetation species occurring.		1	
	Weed invasion	- Aggressive weed species dominating.		1	
	Structure	- Upper shrub layer still present in very small areas, vegetation heavily cleared.		2	
	State	- Plants showing moderate signs of stress.		2	
	Final Score for modification to vegetation				*1.50*
c	Other disturbances				
	Adjustment to score	- No other physical disturbances at the wetland.			*0.00*
	Final naturalness score = average (water chemistry, vegetation) – other disturbances				***1.50***

2 Diversity

	Habitat diversity	# Habitats	Comments	Index Score	Indicator Score
	Final score for habitat diversity	4	-		*2.00*
b	Flora richness	# Species			
	No. submerged species	0	-	N/A	
	No. emergent species	1	-	2	
	No. fringing species	8	-	1	
	Final flora richness score				*1.50*
c	Fauna richness	# Species			
	Invertebrates	4	-	1	
	Waterbirds	0	-	1	
	Other native wetland fauna observed		-No other fauna observed		
	Final fauna richness score				*1.00*
	Final diversity score = average (habitat diversity, flora richness, fauna richness)				***1.50***

3 Significance

•	Does the wetland have a consumptive use value?	-	×
•	Does the wetland have a recreational value?	-	×
•	Does the wetland have a spiritual/philosophical value?	-	×
•	Does the wetland perform an ecosystem service?	-	×
•	Does the wetland have a scientific/educational value?	-	×
•	Does the wetland have a vegetation connectivity value?	- No vegetation connectivity with other wetlands or natural areas.	×
•	Does the wetland have a representativeness value?	- Definitely not the best condition representative of naturally saline playa in the Swan-Avon Mortlock catchment.	×

Final Evaluation

Average diversity and naturalness score	**1.50**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**Multiple Use**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**No**
Final wetland management category	**Multiple Use**

6.3 Freshwater basins

Site Name: ABP032
Site Code: Drummond Lake #1 @ Old Plains Road
Latitude: -31.3269
Longitude: 116.4025
Date Assessed: 11/09/2007
Personnel: SMJ, MTC, DLH, CJF
Geomorphic wetland type: Sumpland
Biological classification: Freshwater basin

Site summary

This wetland is in near pristine condition and has particular value in the diversity of vegetation and invertebrate species that it supports. There is a Threatened Ecological Community as well as Declared Rare and Priority flora species occurring at this wetland

Site Photos



Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**Yes**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	✓
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	✓
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**Yes**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	✓
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	✓
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	×
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed)*? Yes

Site Evaluation

1 Naturalness

		Reading	Comments	Index Score	Indicator Score
a	Modification to Water Chemistry				
	pH	5.4	- pH is a little acidic for a freshwater wetland.	2	
	Salinity (g/L)	0.099	-	3	
	Total Soluble N (µg/L)	1000	-	3	
	Final Score for modification to water chemistry				*2.67*
b	Modification to vegetation				
	Regenerative capacity	- Species expected to be recruiting were doing so.		3	
	Weed invasion	- Few weed species present but not significant.		3	
	Structure	- All structural elements expected were present.		3	
	State	- No signs of stress in the vegetation.		3	
	Final Score for modification to vegetation				*3.00*
c	Other disturbances				
	Adjustment to score	- No other physical disturbances at the wetland.			*0.00*

Final naturalness score = average (water chemistry, vegetation) – other disturbances ***2.84***

2 Diversity

		# Habitats	Comments	Index Score	Indicator Score
a	Habitat diversity				
	Final score for habitat diversity	5	-		*2.00*
b	Flora richness	# Species			
	No. submerged species	8	-	3	
	No. emergent species	7	-	3	
	No. fringing species	4	-	2	
	Final flora richness score				*2.67*
c	Fauna richness	# Species			
	Invertebrates	45	-	2	
	Waterbirds	0	-	1	
	Other native wetland fauna observed	1	-Tadpoles observed.	3	
	Final fauna richness score				*2.00*

Final diversity score = average (habitat diversity, flora richness, fauna richness) ***2.22***

3 Significance

•	Does the wetland have a consumptive use value?	- Although this site is freshwater, it is not currently in a PDWSA or used for consumption. ×
•	Does the wetland have a recreational value?	- ×
•	Does the wetland have a spiritual/philosophical value?	- ×
•	Does the wetland perform an ecosystem service?	- ×
•	Does the wetland have a scientific/educational value?	- Yes, this is a site that has been the subject of quite a few studies. ✓
•	Does the wetland have a vegetation connectivity value?	- This wetland has good vegetation connections with another freshwater wetland in the same reserve. ✓
•	Does the wetland have a representativeness value?	- This wetland is in very good condition and although not all wetlands in this catchment have been sampled, it is likely to be one of the best condition representatives. ✓

Final Evaluation

Average diversity and naturalness score	**2.53**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**N/A**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**No**
Final wetland management category	**Conservation**

Site Name: Secondarily saline lake at Nugadong East Rd

Site Code: ABP110

Latitude: Private property

Longitude: Private property

Date Assessed: 15/09/2008

Personnel: SMJ, MTC, DLH, CJF

Geomorphic wetland type: Playa
Biological classification: Freshwater basin

Site summary

This site is very degraded. The only native vegetation surrounding the wetland is a thin strip of Samphire. This wetland has also been severely affected by secondary salinisation, as it was confirmed by landowner that it was originally freshwater. The only sign of life were some nesting Red-Necked Avocets.

Site Photos



Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**No**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	×
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**No**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	×
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	×
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	×
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed)*? No

Site Evaluation

1 Naturalness

	Modification to Water Chemistry	Reading	Comments	Index Score	Indicator Score
	pH	6.44	-	2	
	Salinity (g/L)	98	- Highly saline even for a secondarily saline wetland.	1	
	Total Soluble N (µg/L)	4000	- Likely that high nitrogen levels are from surrounding cropping areas.	1	
	Final Score for modification to water chemistry				*1.33*

	Modification to vegetation		
	Regenerative capacity	- Most recruitment observed was of weed species.	1
	Weed invasion	- Aggressive weeds present at higher elevations.	1.5
	Structure	- Upper shrub layer completely removed/replaced.	1
	State	- *Enchylaena* and *Tecticornia* species very stressed.	1
	Final Score for modification to vegetation		*1.13*

	Other disturbances		
	Adjustment to score	- There is a road running through what would have been the middle of the wetland.	*-0.17*

Final naturalness score = average (water chemistry, vegetation) – other disturbances ***1.06***

2 Diversity

	Habitat diversity	# Habitats	Comments	Index Score	Indicator Score
	Final score for habitat diversity	3	-		*1.00*

	Flora richness	# Species		
	No. submerged species	0	- Highly anoxic sediment	1
	No. emergent species	0	-	1
	No. fringing species	4	-	2
	Final flora richness score			*1.33*

	Fauna richness	# Species		
	Invertebrates	6	-	1
	Waterbirds	1	- 2 pairs of nesting Red-necked Avocets.	1
	Other native wetland fauna observed		- No other fauna observed.	N/A
	Final fauna richness score			*1.00*

Final diversity score = average (habitat diversity, flora richness, fauna richness) ***1.11***

3 Significance

•	Does the wetland have a consumptive use value?	-	×
•	Does the wetland have a recreational value?	-	×
•	Does the wetland have a spiritual/philosophical value?	-	×
•	Does the wetland perform an ecosystem service?	-	×
•	Does the wetland have a scientific/educational value?	-	×
•	Does the wetland have a vegetation connectivity value?	- There is no vegetation connecting this wetland with any other wetland or natural area.	×
•	Does the wetland have a representativeness value?	-	×

Final Evaluation

Average diversity and naturalness score	**1.09**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**Multiple Use**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**No**
Final wetland management category	**Multiple Use**

6.4 Turbid claypans

Site Name: Claypan at King Rocks Rd
Site Code: ABP130
Latitude: -32.32719
Longitude: 119.10227
Date Assessed: 14/10/08
Personnel: SMJ, MTC, DLH, CJF
Geomorphic wetland type: Playa
Biological classification: Turbid claypan

Site summary

This turbid claypan wetland has highly diverse communities of vegetation. It also supports significant numbers of Bullfrog tadpoles and has extensive vegetation connections with other nearby wetlands.

Site Photos



Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**Yes**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	✓
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	×
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**Yes**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	✓
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	✓
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	✓
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed*)? **Yes**

Site Evaluation

1 Naturalness

	Modification to Water Chemistry	Reading	Comments	Index Score	Indicator Score
	pH	8.2	-	2	
	Salinity (g/L)	0.19	-	3	
	Total Soluble N (µg/L)	1000	-	3	
	Final Score for modification to water chemistry				*2.70*
b	Modification to vegetation				
	Regenerative capacity	- Regeneration of the upper and middle shrub layers occurring.		2.7	
	Weed invasion	- Few weed species present but not significant.		3.0	
	Structure	- All expected structural layers present.		3.0	
	State	- Some *Melaleuca* and *Tecticornia* showing moderate signs of stress.		2.0	
	Final Score for modification to vegetation				*2.68*
c	Other disturbances				
	Adjustment to score	- There is a road running through what would have been the edge of the wetland.			*-0.17*
	Final naturalness score = average (water chemistry, vegetation) – other disturbances				***2.52***

2 Diversity

	Habitat diversity	# Habitats	Comments	Index Score	Indicator Score
	Final score for habitat diversity	7	- Many habitats present compared to a typical claypan.		*3.00*
b	Flora richness	# Species			
	No. submerged species	2	- This is unusual since the water was quite turbid.	3	
	No. emergent species	1	-	3	
	No. fringing species	10	-	3	
	Final flora richness score				*3.00*
c	Fauna richness	# Species			
	Invertebrates	34	-	3	
	Waterbirds	0	-		
	Other native wetland fauna observed	1	- Large numbers of Bullfrog tadpoles.	3	
	Final fauna richness score				*3.00*
	Final diversity score = average (habitat diversity, flora richness, fauna richness)				***3.00***

3 Significance

•	Does the wetland have a consumptive use value?	- This is a freshwater wetland but is not currently used as a water supply to our knowledge. ×
•	Does the wetland have a recreational value?	- ×
•	Does the wetland have a spiritual/philosophical value?	- ×
•	Does the wetland perform an ecosystem service?	- ×
•	Does the wetland have a scientific/educational value?	- ×
•	Does the wetland have a vegetation connectivity value?	- Yes, this wetland has good vegetation connections with the large saline wetland on the southern side. ✓
•	Does the wetland have a representativeness value?	- Yes, to our knowledge, this is the best condition turbid claypan wetland in this catchment. ✓

Final Evaluation

Average diversity and naturalness score	**2.76**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**N/A**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**N/A**
Final wetland management category	**Conservation**

Site Name: Claypan at Ballidu
Site Code: ABP114
Latitude: Private property
Longitude: Private property
Date Assessed: 17/09/2008
Personnel: SMJ, MTC, DLH, CJF
Geomorphic wetland type: Playa
Biological classification: Turbid claypan

Site summary

This site was dug out by the property owners many years ago for a drinking water source. It has since gone brackish and has changed significantly from natural.

Site Photos



Automatic Conservation category criteria evaluation

1	*Is the wetland identified under any of the following agreements?*	**No**
	• Ramsar Convention on wetlands	×
	• State Government endorsed candidate sites for the Ramsar Convention on Wetlands	×
	• Directory of Important Wetlands	×
	• Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998	×
	• World/National Heritage listings	×
2	*Does the wetland meet **one** of the following criteria?*	**No**
	• Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.	×
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.	×
	• The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian or State Government.	×
3	*Does the wetland meet **two** of the following criteria?*	**No**
	• Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:	
	▪ is the best known representative of the wetland group in the catchment	×
	▪ supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species	×
	▪ supports an identified occurrence of a Priority 1 or 2 Ecological Community	×
	▪ supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation	×
	• The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.	×
	• The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.	×
	• The wetland supports cultural values that are based on natural attributes or functions.	×

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed)*? No

Site Evaluation

1 Naturalness

	Modification to Water Chemistry	Reading	Comments	Index Score	Indicator Score
	pH	9.05	-	2	
	Salinity (g/L)	5.3	-	1	
	Total Soluble N (µg/L)	1600	-	3	
	Final Score for modification to water chemistry				*2.00*

	Modification to vegetation			
	Regenerative capacity	- Regeneration of *Tecticornia* occurring in upper slope.	2.0	
	Weed invasion	- Some weed species present but not significant.	2.5	
	Structure	- Structural layers are as expected for a claypan.	3.0	
	State	- Significant area of *Tecticornia* showing signs of stress.	1.5	
	Final Score for modification to vegetation			*2.25*

	Other disturbances		
	Adjustment to score	- Landholder historically excavated claypan for water resource.	*-0.33*

Final naturalness score = average (water chemistry, vegetation) – other disturbances ***1.80***

2 Diversity

	Habitat diversity	# Habitats	Comments	Index Score	Indicator Score
	Final score for habitat diversity	3	-		*2.00*

	Flora richness	# Species		
	No. submerged species	1	-	3
	No. emergent species	0	-	1
	No. fringing species	5	-	1
	Final flora richness score			*1.67*

	Fauna richness	# Species			
	Invertebrates	28	-	2	
	Waterbirds	0	-	N/A	
	Other native wetland fauna observed	1	- Significant numbers of tadpoles observed, although appeared to be struggling due to increasing salinity as basin dries.	3	
	Final fauna richness score				*2.50*

Final diversity score = average (habitat diversity, flora richness, fauna richness) ***2.06***

3 Significance

•	Does the wetland have a consumptive use value?	- Wetland was historically used as a human water supply, however this ceased once it became brackish. ×
•	Does the wetland have a recreational value?	- ×
•	Does the wetland have a spiritual/philosophical value?	- ×
•	Does the wetland perform an ecosystem service?	- ×
•	Does the wetland have a scientific/educational value?	- ×
•	Does the wetland have a vegetation connectivity value?	- No vegetation connections to other wetlands. ×
•	Does the wetland have a representativeness value?	- ×

Final Evaluation

Average diversity and naturalness score	**1.93**
Initial wetland management category *(average naturalness and diversity >2.3 = Conservation, 1.67-2.3 = Resource Enhancement, <1.67 = Multiple Use)*	**Resource Enhancement**
If the wetland is in the Multiple Use category and has an ecosystem or human significance, then it is upgraded to Resource Enhancement category. Is this applicable?	**No**
Final wetland management category	**Resource Enhancement**

7. Final comments and recommendations

- This document outlines a methodology for assigning wetland management categories to intermittently to permanently inundated basin wetlands within the Avon NRM region but is also applicable to these wetland types in the wider Wheatbelt area.
- This methodology should be undertaken by professionals who are experienced in the field of wetland ecology.
- Wetlands are dynamic systems that respond to local climatic and anthropogenic influences. In general, greatest wetland biodiversity in this study area is evident in spring following winter rainfall and this is likely to be the optimal time for undertaking an evaluation. However, an evaluation undertaken at one point in time may not reveal the full conservation values represented at the wetland. Furthermore, an evaluation reflects values present at a point in time and may be out of date if not contemporaneous with the application of those evaluations.
- It is vital that the evaluation data is captured as outlined in the wetland survey protocol (Appendix E) and then stored in a centrally managed database such as WetlandBase (see Appendix B for details). This will ensure an accurate and up-to-date information system that will contribute to the efficient management and conservation of Avon NRM region wetlands.
- Once additional data becomes available, reference ranges should be recalculated to ensure that they are as representative as possible. This is particularly important for turbid claypans due to the limited information that was available at the time of writing.
- Future work should be focused on extending this methodology to include wetlands with other landforms (flat, slope highland) and waterlogged wetlands.

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Appendix A - Previous studies conducted on wetlands in the Avon NRM region

Study / Paper name	Organisation / Reference	# sites in Avon NRM	Data collected				
			Inverte-brate	Water Quality	Water-bird	Depth	Flora
A biological survey of the agricultural zone: vegetation and vascular flora of Drummond Nature Reserve	Keighery, *et al.*, 2002	2					✓
Annual waterfowl counts in South-Western Australia: 1988 – 1992	Halse, *et al.*, 1990; Halse, *et al.*, 1992; Halse, *et al.*, 1994; Halse, *et al.*, 1995	107			✓		
Assessment of conservation status of wetlands in the Trayning area in relation to disposal of deep drainage water	Bennelongia Pty Ltd, 2007	7	✓	✓	✓		✓
Avon Catchment acidic groundwater - geochemical risk assessment	Multi-agency project (Shand and Degens, 2008)	78 lakes, 19 drains	✓				
Baselining the diversity of the Avon NRM region – wetlands component	DEC (unpublished)	92	✓	✓	✓		28
Depths and salinities of wetlands in south-western Australia: 1977-2000	Lane, *et al.*, 2004	~36		✓		✓	
Diatoms as ecological indicators in lakes and streams of varying salinity from the Wheatbelt region of Western Australia	Taukulis and John, 2006	~27 (incl. river sites)	✓	✓			
Distribution and environmental tolerances of aquatic macroinvertebrate families in the agricultural zone of southwestern Australia	Kay, *et al.*, 2001	~26 river/ streams	✓	✓			✓
Downstream ecological impacts of engineering interventions on natural streams and rivers in the Wheatbelt of Western Australia: Narembeen Draft Final Report	Cook, *et al.*, 2007	12 (incl. 4 drain sites)	✓	✓			✓
Evaluating the conservation significance of basin and granite outcrop wetlands within the Avon Natural Resource Management region: Stage One Assessment Method	Jones, *et al.*, 2008	10000's		✓			✓
Kununoppin BioBlitz	Davis, 2005a	1			✓		✓
Lake McDermott BioBlitz	Davis, 2005b	1			✓		✓
Moningarin BioBlitz	Davis, 2005c	1			✓		✓
On the chemistry and biota of some saline lakes in Western Australia	Geddes, *et al.*, 1981	~38	✓	✓		✓	✓
Oral histories documenting changes in Wheatbelt wetlands	Sanders, 1991	Many			✓		✓
Salinity Action Plan Wheatbelt biological survey (1997 – 2001)	DEC (Blinn, *et al.*, 2004; Lyons, *et al.*, 2004; Pinder, *et al.*, 2004)	~100	✓	✓	✓	✓	✓

Study / Paper name	**Organisation / Reference**	**# sites in Avon NRM**	**Data collected**				
			Inverte-brate	**Water Quality**	**Water-bird**	**Depth**	**Flora**
Salinity Action Plan Wheatbelt wetland monitoring program (1997 – current)	DEC (Halse*, et al.*, 1993a; Cale*, et al.*, 2004; Lyons*, et al.*, 2007)	10	✓	✓	✓	✓	✓
The aquatic macrophyte flora of saline wetlands in Western Australia in relation to salinity and permanence	Brock and Lane, 1983	~18		✓		✓	✓
The composition of aquatic communities in saline wetlands of Western Australia	Brock and Shiel, 1983	~7	✓	✓		✓	✓
Transitions between ecological regimes in salinising wetlands	Sim, 2005	3	✓	✓	✓		✓
Vegetation of depth-gauged wetlands in nature reserves of the south-west Western Australia	Halse*, et al.*, 1993a	~22				✓	✓
Waterbirds in nature reserves of south-western Australia 1981-1985	Jaensch*, et al.*, 1988; Halse and Jaensch, 1989; Goodsell, 1990; Halse*, et al.*, 1993b	71		✓	✓	✓	✓
Wetland characteristics and waterbird use of wetlands in south-western Australia	Halse*, et al.*, 1993b	~22		✓	✓	✓	✓

Appendix B - Wetland information sources

Wetland mapping

- Stage 1 wetland mapping (Department of Environment and Conservation, 2007) will be available for the entire Avon NRM region through DEC's NatureMap <http://naturemap.dec.wa.gov.au>. This mapping is based on the endorsed methodology by Lizamore (2008), which is also available on this website.

On-ground data and technical reports

- Studies listed in Appendix A.
- WetlandBase – The Western Australian Wetlands Database, maintained by DEC, contains both wetland mapping and on-ground data for specific sites across Western Australia. This includes on-ground water quality, waterbird, aquatic invertebrates and records of Declared Rare, Threatened or Priority fauna, flora and ecological communities. This is periodically being updated with additional data and is a very useful source of information. This database is accessed through the DEC website <www.dec.wa.gov.au> Management and Protection > Wetlands > Wetlands Data > WetlandBase.
- The Department of Water's (DoW) Geographic Data Atlas contains a significant amount of surface water quality data. This is accessed through the DoW website <http://portal.water.wa.gov.au> Maps, data and atlases > Geographic Data Atlas.
- Publications from the various water projects run by the Avon Catchment Council, are available through the Avon Catchment Council's (ACC) website <www.avonnrm.org.au> Projects 2008-2009 > Water.
- Reports from the Avon Baselining Project are available from the Avon Natural Diversity Program website <www.avonnaturaldiversity.org> ND001 Baselining > Wetlands.

International, national and regional significance

- *Ramsar Convention on wetlands* (UNESCO, 1971, www.ramsar.org) or the Department of Environment, Water, Heritage and the Arts (DEWHA) website <www.environment.gov.au> Databases and maps > Australian Wetlands Database.
- *Directory of Important Wetlands in Australia* (Environment Australia, 2001, <http://www.environment.gov.au/water/publications/environmental/wetlands/directory.html>)
- *Environmental Protection (South West Agricultural Zone Wetlands) Policy* 1998 can be found on the WA Environmental Protection Authority website <www.epa.gov.au> Environmental Protection Policies (EPP) > South West Agricultural Zone Wetlands.
- *Heritage listings controlled by the Commonwealth.* This includes the Register of the National Estate (Australian Heritage Commission, 1990), The National Heritage List and The Commonwealth Heritage List. These can be found on the DEWHA website <www.environment.gov.au> Heritage > About Heritage. Currently, there are no basin wetlands within the Avon NRM region that are listed on The National Heritage List or The Commonwealth Heritage List. However, there are many natural areas within the Avon NRM region with basins within them, which are listed on the Register of the National Estate.
- *Avon Natural Resource Management Plan: Water Resource Supporting Document* can be found on the ACC's website <www.avonnrm.org.au> NRM Information > Avon NRM Strategy Supporting Documents. Local and regional water assets identified in this document are listed in Appendix I.
- The following *International agreements for waterbirds and conservation plans* can be found on the DEHWA website <www.environment.gov.au> Biodiversity > Migratory Species > Migratory Waterbirds*:*
    - Agreement between the government of Australia and the government of Japan for the protection of migratory birds in danger of extinction and their environment (JAMBA).

  - Agreement between the government of Australia and the government of the People's Republic of China for the protection of migratory birds in danger of extinction and their environment (CAMBA).
  - Agreement between the government of Australia and the government of the Republic of Korea on the protection of migratory birds (ROKAMBA).
- Information on Aboriginal cultural values can be obtained from the Department of Indigenous Affairs (DIA) *Aboriginal Heritage Inquiry System.* This is available on the DIA website <www.dia.wa.gov.au> Aboriginal Site Search.
- A municipal inventory is a list of local cultural heritage significance in the local government. Local governments are required under Section 45 of the *Heritage of Western Australia Act, 1990* to prepare such lists and may be obtained from the relevant local government authority.
- Information and lists of *Declared Rare, Priority and other significant flora and Threatened and Priority Ecological Communities* in the Wheatbelt region are available on DEC's website <www.dec.wa.gov.au> Management and protection > Plants.
- Information on *Threatened or Specially Protected and Priority fauna* in Western Australia is available on DEC's website <www.dec.wa.gov.au> Management and protection > Animals.
- DEC can also be contacted directly for information on flora or fauna for a specific site (08) 9334 0333.

Geological Information

- Soils data from the Atlas of Australian Soils for Western Australia is available from the Department of Agriculture and Food's (DAFWA) website <www.agric.wa.gov.au> Maps and Data > SLIP NRM Info > Go to Maps.
- Information on geology, geoheritage and topography (GeoVIEW.WA) is available from the Department of Industry and Resources website <www.doir.wa.gov.au> Department of Mines and Petroleum > Geological Survey of WA > Geoscience Products > Data and Software Centre.
- There is currently no system for formal recognition of geoheritage. The Geological Society of Australia (GSA) has identified approximately 150 significant geological sites in WA. More information can be found on the GSA website <www.gsa.org.au> Heritage.
- Geoheritage and Geoconservation reference article on the history, definition, scope and scale of geoheritage and geoconservation in Australia, with particular focus on Western Australia - Brocx and Semeniuk, 2007.

Other Resources

- Aerial photography can be purchased from Landgate <www.landgate.wa.gov.au> Products & Services > Imagery > Aerial Photography.
- Appendices in this document provide comprehensive lists of fauna, flora and communities which are currently protected under legislation.
- *Environmental Guidance for Planning and Development, Guidance Statement No. 33* (EPA, 2008). Available from the EPA website <www.epa.wa.gov.au> Guidance Statements > Environmental Guidance for Planning and Development.
- Catchments identified in the *Hydrographic Catchments – Catchments* dataset can be assessed through the Department of Water's website <www.water.gov.au> Tools > Maps and Atlases > Geographic Data Atlas > Inland Waters tab

Appendix C – Site visit field sheet

Avon Stage 3 site data – General and aquatic

Department of Environment and Conservation

*SITECODE:*_____

Site name: ……..

Dates surveyed and weather: ……

Personnel: _____ & _____ & _____

Geomorphic wetland type: ……..

Biological wetland type: ……..

Wetland group: ……..

Site information

Latitude:	- __ __ . __ __ __ __	Max. depth of wetland:	……cm
Longitude:	__ __ __ . __ __ __ __	Max. depth measured at *(e.g. gauge)*:	……
Datum:	__ __ __ __ __	Contact Name:	……
Photo No. – Site:	……	Contact Phone:	……
Estimated wetland size:	……..Ha	Land tenure *(please circle)*:	Public Private
Approx. water level:	__ __ __% Waterlogged soil / Filling / Drying		

Site sketch *(include access details, land use, vegetation zones, sample/photo points, north arrow, major habitats, include a cross section showing topography of wetland and surrounding dunes)*

Samples for analysis		***In-situ* measurements**
500mL unfiltered sample – no preservation:	□	pH: __ . __ __
125 mL filtered nutrients sample – frozen:	□	Salinity: __ __ __ __ __ __ ppt
Benthic invertebrate sample using 250 micron mesh net (1-2 2L	□	
Plankton invertebrate sample using 50 micron mesh net (1 vial/sample)	□	
Max. depth of invert. sample: _____cm		

Avon Stage 3 site data - Waterbirds

*SITECODE:*_____

Department of Environment and Conservation

No waterbirds observed ☐

Waterbird name	Abundance Counts (tally)												Brood Counts		
	5	10	15	20	25	30	35	40	45	50	Estimate lge no's	Total	5	10	Total

DRAFT

Sketches of unidentified birds

Sketches of unidentified birds

Notes on any unidentifiable birds

_____

_____

_____

_____

_____

_____

Avon Stage 3 site data - Vegetation

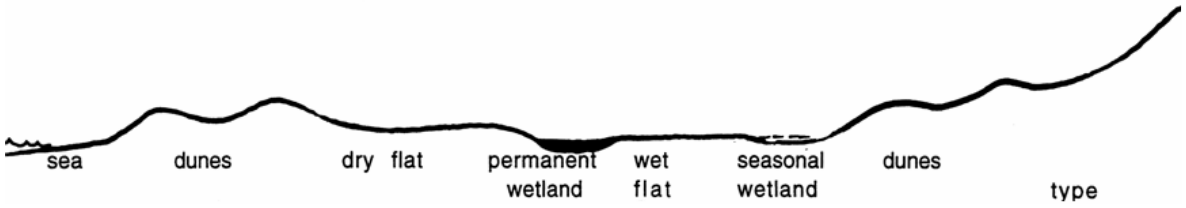
*SITECODE:*_____

Department of Environment and Conservation

Site sketch (*Please draw a sketch of wetland including the location of quadrats sampled and their unique identifier)*

↑ N

Topographic position of quadrats *(Circle and label position of quadrats on cross section)*
Wheatbelt wetlands



Vegetation condition of wetland as a whole *(Please estimate the percentage of wetland vegetation that is in each category).* The following is the scale used in *Bush Forever* (Government of Western Australia, 2000)

Category	Percent cover	Description
Pristine		Pristine or nearly so, no obvious signs of disturbance.
Excellent		Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good		Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Good		Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded		Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded		The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Avon Stage 3 site data - Vegetation

Department of Environment and Conservation

SITECODE:______________________

Vegetation species presence

Insert plants name/working name (column 1), unique identifier (column 2), and tick column 3 when ID has been checked
Unique identifier is the quadrat ID and specimen number. Quadrat ID = Site Code + Quadrat number e.g. ABP001_12

Aquatic quadrat sampled ☐ **Photo numbers**____

Name	Unique ID	ID complete
Trees		
Shrubs		

Name	Unique ID	ID complete
Shrubs (cont.)		
Grasses		

Avon Stage 3 site data - Vegetation

Department of Environment and Conservation

SITECODE:______________________

Vegetation species presence (cont.)

Name	Unique ID	ID complete
Herbs		

Name	Unique ID	ID complete
Sedges		
Additional		

Avon Stage 3 site data - Vegetation

Department of Environment and Conservation

*SITECODE:*_____

Individual Quadrat data *(will need a copy of this page for each quadrat – do not need to fill out for aquatic quadrats)*

Quadrat ID (e.g. A, B, C): ……..

Elevation *(1=basin, 2=beach, 3=dune)* ……..

Reason for quadrat location: ……

Photograph Numbers: ……

GPS point taken: ☐

Vegetation composition

Stratum # *(For example: U2 = the second layer of upperstorey)*	% Cover	**Dominant Species** *(list in order)*	**% Showing Stress**	**Recruitment?** *(if possible estimate number of seedlings observed)*
Stratum -____				
Growth form				
Height range (m)				
Stratum -____				
Growth form				
Height range (m)				
Stratum -____				
Growth form				
Height range (m)				

Vegetation condition within quadrat

Table partly from Thackway, R. and Lesslie, R. (2005). Vegetation Assets, States, and Transitions (VAST): accounting for vegetation condition in the Australian landscape. Technical Report. Bureau of Rural Sciences,Canberra.

Index	**Score = 3 Natural**	**Score = 2 Impacted**	**Score = 1 Degraded - Replaced**	**Score**
Regenerative Capacity	Regenerative capacity intact. All species expected to show regeneration are doing so. Alternatively for naturally bare areas, the natural regenerative capacity is unmodified, ephemeral and lower plants only.	Natural regenerative capacity somewhat reduced, but endures under current / past land management practices.	Natural regenerative potential of native vegetation has been suppressed by ongoing disturbances. Rehabilitation and restoration possible through removal of threats.	_____
Weed invasion	Weeds are absent or comprised of non-aggressive species.	The presence of some very aggressive weeds at high density.	Weeds and/or crop species comprise the majority of species present with some isolated native trees or shrubs.	_____
Structure	Structural integrity of native vegetation is very high. All expected strata, growth forms and age classes are present. Alternatively, for naturally bare areas there is nil/minimal vegetation structure.	Structure is altered but persists i.e. some elements of a stratum are missing.	Structure of native vegetation is significantly altered i.e. one or more strata are missing entirely or highly degraded.	_____
State	On average, 0 – 5% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	On average, 5 – 10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	On average, >10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	_____
Notes *(e.g. what vegetation has been replaced)*	…… ……			

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Avon Stage 3 site data – Other site information

Department of Environment and Conservation

*SITECODE:*_____

Rarity

1. Are the vegetation communities found at this wetland unusual? If so, explain._____

_____

2. Does the wetland have a rare or threatened natural water chemistry, hydrology, geomorphology, or any other attribute (e.g. sediments) considered rare by expert opinion? If so, explain. _____

_____

_____

3. Have any Declared Rare, Threatened, Priority or Specially Protected flora or fauna (including migratory birds protected under international agreements) been collected or observed at the wetland? If so list species, their numbers and status._____

_____

_____

Significance

1. Is the wetland formally or informally recognised as a water resource for stock or human consumption?_____

_____

2. Is the wetland recognised by the community as a recreational area?_____

3. Ecosystem service value:

Flood attenuation

- What is the estimated size of the wetland catchment:_____Hectares
- What is the estimated size of the wetland?_____Hectares
- What is the relative size of the wetland unit relative to the catchment?_____%
- How often does this area experience storm flows?_____

Nutrient/pesticide/pathogen stripping

- What is the percentage of permanent vegetation across the bed?_____%
- What is the area of the wetland that is permanent or seasonal? _____%
- Estimate the relative contribution of sub-surface water inputs compared to surface water inputs:_____%

4. Is the wetland used for scientific or educational purposes (e.g. monitoring site, research, catchment management, wetland education)?_____

_____

5. Vegetation connectivity

- Does the vegetation of the wetland connect to other natural areas and therefore provide habitat corridors for fauna? Use diagram below to assign to a category_____

Category	Description	Graphical description
High	Vegetation surrounding the wetland is completely connected with more than one other wetland and/or natural area.	
Intermediate	Buffer vegetation is completely connected with one other wetland or natural area, however is mostly fragmented.	
Low	Buffer vegetation is not connected with other hydrologically connected wetlands or natural areas.	

Avon Stage 3 site data – Other site information

Department of Environment and Conservation

*SITECODE:*_____

6. Is the wetland the best known condition representative (based on naturalness and diversity) of the wetland group in the catchment? _____
_____

Naturalness

1. Does the wetland appear to have undergone changes to its hydrology? Yes No
Comments:_____
_____

2. List the other disturbances present at the wetland and the severity of impact on the wetland biota (major or minor)._____
_____

Diversity

1. Habitat

Possible wetland habitats	Percent area	Present (1) / absent (0)
Submerged vegetation		
Emergent shrubs / trees		
Emergent reeds / sedges		
Surrounding terrestrial veg. (within 50m)		
Large woody debris		
Leaf litter		
Deep water zones (≥1.5m)		
Shallow wading zones (<15cm)		
Island		
	Total	

2. Fauna
Were any other fauna groups observed at the wetland? List species names if possible_____
_____
_____

Other general site notes or reasons why the wetland should be automatically assigned to the "Conservation" or any other wetland management category?-
_____
_____
_____
_____
_____
_____

Appendix D - Avon stage 3 wetland evaluation proforma

Avon Stage 3 wetland evaluation

Department of Environment and Conservation

*SITECODE:*_____

Site information

Site name: ……

Personnel: …….. **Period surveyed**: ……

Latitude: …… **Longitude:** ……

Catchment: ……

Geomorphic wetland type: ……

Biological wetland type: ……

Wetland group: ……

Desktop evaluation

Is the wetland identified under any of the following agreements?

- Ramsar Convention on wetlands _____
- State Government endorsed candidate sites for the Ramsar Convention on Wetlands _____
- Directory of Important Wetlands _____
- Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998 _____
- World/National Heritage listings _____

Site visit

Step 1. Identify values for automatic assignment to Conservation category

*Does the wetland meet **one** of the following criteria (please circle)?If so it is automatically assigned to "Conservation" category* _____

- Equal to or greater than 90% of the wetland supports native vegetation in 'Good' or better condition using the *Bush Forever* scale.
- Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and is identified as significant for its natural values in regional or sub-regional studies endorsed by the State Government.
- Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and supports an identified occurrence of a Threatened Ecological Community.
- The wetland supports a breeding, roosting, or refuge site or a critical feeding site for populations of fauna listed by the Australian Government.

*Does the wetland meet **two** of the following criteria?* _____

- Greater than 50% of the wetland has native vegetation in 'Good' or better condition using the *Bush Forever* scale and:
  - is the best known representative of the wetland group in the catchment
  - supports an identified occurrence of a Declared Rare or Priority 1, 2, 3 or 4 flora species
  - supports an identified occurrence of a Priority 1 or 2 Ecological Community
  - supports internationally, nationally or State-wide significant values, including geoheritage and geoconservation
- The wetland supports regionally rare or threatened natural water chemistry, hydrology, geomorphology or any other rare attribute.
- The wetland supports a breeding, roosting, refuge or critical feeding site for populations of Priority 1 or 2 fauna listed by the State Government.
- The wetland supports cultural values that are based on natural attributes or functions.

Is the wetland automatically a Conservation category wetland (*If yes, no further evaluation needed*)? ☐

Avon Stage 3 wetland evaluation

Department of Environment and Conservation

*SITECODE:*_____

Step 2. Score Naturalness criterion

- *Modification to water chemistry*

Index	Reading	Reference ranges for each wetland group		Scoring method	Score
Field pH: *(do not score naturally acidic basins)*	__ . __ __	Naturally saline basin Freshwater basin Turbid claypan	7.8 – 8.7 6.8 – 8.1 8.6 – 8.9	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	_____
Lab salinity: *(do not score naturally saline basins)*	_ _ _ _ _ _ ppt	Naturally saline basin Freshwater basin Turbid claypan	N/A 0 – 1.1 0 – 0.6	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	_____
Total Soluble N	_____µg/L	Naturally saline basin Freshwater basin Turbid claypan	< 1100 < 1900 < 2325	3 = inside ref range 2 = <20% outside ref range 1 = >20% outside ref range	_____
Final score for modification to water chemistry				**= sum scores ÷ # indices**	

- *Modification to vegetation (this table is the average of all quadrats)*

Index	Score = 3 Natural	Score = 2 Impacted	Score = 1 Degraded - Replaced	Score
Regenerative Capacity	Regenerative capacity intact. All species expected to show regeneration are doing so. Alternatively for naturally bare areas, the natural regenerative capacity is unmodified, ephemeral and lower plants only.	Natural regenerative capacity somewhat reduced, but endures under current / past land management practices.	Natural regenerative potential of native vegetation has been suppressed by ongoing disturbances. Rehabilitation and restoration possible through removal of threats.	_____
Weed invasion	Weeds are absent or comprised of non-aggressive species.	The presence of some very aggressive weeds at high density.	Weeds and/or crop species comprise the majority of species present with some isolated native trees or shrubs.	_____
Composition	Compositional integrity of native vegetation is very high. All species expected at the site are present. Alternatively, for naturally bare areas there is nil / minimal vegetation composition.	Composition of native vegetation is altered. All major species are present, although proportions may have changed. Some minor species may be missing.	Significant species are missing from the site or native vegetation may have been entirely replaced with opportunist species. Loss of species affects structure of vegetation.	_____
State	On average, 0 – 5% of the native vegetation present in the upper and middle strata of the community are showing signs of stress.	On average, 5 – 10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	On average, >10% of the native vegetation present in the upper and middle strata of the community showing signs of stress.	_____
Final score for modification to vegetation			**= sum scores ÷ # indices**	

- *Other disturbances*

Criteria	Adjustment to score
No disturbances at the wetland that may potentially affect the fauna, flora or hydrology of the wetland. For example, the presence of a building is not natural but does not affect the wetland system.	0
A few minor or one moderate disturbance/s present at the wetland. These may affect the fauna, flora or hydrology of the wetland but not so much as to change the fauna or flora community composition. For example, a road cutting through the edge of a wetland may disturb the vegetation present at the affected site but will not change the vegetation communities present at the wetland.	-0.17
One or more major disturbances impacting the wetland. These significantly affect the fauna, flora or hydrology of the wetland in a way that changes the community composition. For example, a deep drain discharging hypersaline, acidic water into a wetland is likely to change the composition of aquatic fauna and flora.	-0.33

Final Naturalness Score
= average (modification to water chemistry, modification to vegetation) – Other disturbances **=**

Avon Stage 3 wetland evaluation

Department of Environment and Conservation

*SITECODE:*_____

Step 3. Score Diversity criterion

- *Habitat diversity*

		Structural diversity reference range for each wetland group				Score
No of habitats identified to be present at wetland.	_____	Wetland group	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>5	4 or 5	0 – 3	
		Freshwater basin	>6	4 – 6	0 – 3	
		Turbid claypan	>3	2 or 3	0 or 1	

- *Flora richness*

Vegetation type	No. Sp found	Species richness reference range for each wetland group				Score
Submerged	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>0	No score	No score	
		Freshwater basin	>1	1	No score	
		Turbid claypan	>0	No score	No score	
Emergent	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>1	1	0	
		Freshwater basin	>3	1 - 3	0	
		Turbid claypan	>0	No score	0	
Fringing	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>16	10 - 16	<10	
		Freshwater basin	>6	2 - 6	<2	
		Turbid claypan	>8	7 - 8	<7	
Final score for native flora richness				**=sum scores ÷ # indices**		

- *Fauna richness*

Fauna category	No. Sp found	Species and family richness reference range for each wetland group				Score
Invertebrates	_____	**All species**	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>14	6 - 14	<6	
		Freshwater basin	>54	27 – 54	<27	
		Turbid claypan	>29	23 – 29	<23	
		All families	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>10	4 - 10	<4	
		Freshwater basin	>28	17 - 28	<17	
		Turbid claypan	>16	13 - 16	<13	
		Macroinvert species	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>8	3 - 8	<3	
		Freshwater basin	>35	18 - 35	<18	
		Turbid claypan	>7	3 - 7	<3	
Waterbirds (*claypans are not scored for waterbird richness)*	_____	Wetland group	Score = 3	Score = 2	Score = 1	_____
		Naturally saline basin	>4	1-4	0	
		Freshwater basin	>9	3 - 9	<3	
Other native wetland fauna observed *(E.g. turtles, fish, frogs)*	Other fauna observed (*If present then a score of 3 is recorded)* _____					_____
Final score for fauna richness				**=sum scores ÷ # indices**		

Final Diversity Score
= average (habitat diversity, flora richness, fauna richness) **=**

Avon Stage 3 wetland evaluation

Department of Environment and Conservation

*SITECODE:*_____

Step 4. Preliminary assignment to wetland management category

1. *Has the wetland already been automatically assigned to Conservation category? If so, this is the final wetland management category and should be circled at the bottom of this page.*

2. *Average the naturalness and diversity scores = (naturalness score + diversity score) ÷ 2 =* _____

3. *Using the average naturalness and diversity score, place the wetland into one of the three management categories by circling the relevant box, below:*

Score > 2.3 Conservation	Score 1.7 – 2.3 Resource Enhancement	Score < 1.7 Multiple Use

4. *If the wetland has been assigned to the "Multiple Use" category, continue onto Step 5. If the wetland has been assigned to the "Conservation" or "Resource Enhancement" categories, this is the final wetland management category and should be circled at the bottom of this page.*

Step 5. Incorporate significance values

If the wetland has any of the following values than it cannot be assigned to the 'Multiple Use' wetland management category. Tick the values that are applicable below

Consumptive use value	
Recreational value	
Philosophical or spiritual value – these are wetlands that have been formally recognised by the community as important places. These can be listed in local or State government documents (e.g. Avon Natural Resource Management Plan: Water Resource Supporting Document, Municipal inventories)	
Ecosystem service value (mostly from Kotze *et al*, 2005) 1. Flood attenuation – Does the wetland: have an area 6% or greater of the catchment area *and* have storm flows that spread across the area at least once every five years, *and* not have permanent inundation? 2. Nutrient/pesticide/pathogen stripping – Does the wetland have: an area >30% that is seasonally or permanently inundated *and* a predominant coverage of permanent vegetation, *and* a relative input of sub-surface to surface water >36%?	_____ _____
Scientific/educational value – Is this wetland used for scientific or educational purposes?	
Connectivity value – Does the wetland have vegetation connections with other wetlands or natural areas that place it into the "High" category?	
Representativeness value – Is this wetland the best known representative of its wetland group in the catchment?	

The final wetland management category for this wetland is *(please circle)*:

Score >2.3 CONSERVATION	Score 1.7 – 2.3 RESOURCE ENHANCEMENT	Score <1.7 MULTIPLE USE

Appendix E - Wetland survey protocol

Scope

This section describes the protocol for the collection of water chemistry, invertebrate, waterbird and vegetation data at inundated basins in the Avon Natural Resource Management (NRM) region. This wetland survey protocol accompanies the following wetland evaluation methodology:

Jones, S. M., Pinder, A. M., Sim, L.L., Halse, S. A. (2009). Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region: Stage Three Assessment Method. Prepared for the Avon Catchment Council by the Department of Environment and Conservation, Perth.

Wetland surveys involving the collection of these data should only be conducted during peak water levels and not during flooded conditions. In the Wheatbelt, peak water levels generally occur in early spring following winter rainfall.

Training & Experience

Personnel performing wetland surveys must have:

- Previous experience in the methods described in this document and/or,
- Suitable training in the collection of the aforementioned data by adequately experienced individuals

Stores, equipment & preparation

The following section outlines the equipment required to collect the data for a stage 3 evaluation of a basin wetland in the Avon NRM region. The inventory list will need to be multiplied where necessary to cope with the collection of samples/data from additional sites or collection of data at particularly turbid wetlands (e.g. claypans require more syringe filters).

Water chemistry sampling equipment (quantity outlined in brackets includes spares)

- 50mL syringe (1)
- Acrodisk syringe filter (0.45µm Supor membrane 25mm diameter) (2)
- Salinity and pH meter including manual, charger, calibration solutions
- Distilled water (2L)
- Squirt bottle (1)
- 125 mL bottle for Total N, Total P filtered water samples (1)
- 500 mL bottle for general chemistry analyses (1)

Invertebrate sampling equipment

- 250 µm net for benthic invertebrate sample (30cm long) (2)
- 50 µm net for plankton sample. Pocket of net is open with an attachment for screwing vial on (2)
- Sampling pole for 50 and 250 µm nets (2)
- Vial for plankton sample net (1)
- 100% ethanol (2L)
- 2 L plastic pot with lids (2)

- Made-up buffered formalin fixative (just over 1Litre = 125mL formalin, 20mL propylene glycol, 20g Borax (sodium tetraborate), 880mL water)
- 120 mL polycarb vials for plankton sample (2)
- Detergent for washing nets (500mL bottle)
- Buckets (2)
- Waterproof invertebrate sample labels (4)
- Adhesive invertebrate sample labels for benthic and plankton sample (2)
- Disposable gloves (2 pairs)

Water bird sampling equipment

- Binoculars (2)
- Spotting scope (1)
- Tripod for spotting scope (2)
- Waterbird identification guide (2)

Vegetation sampling equipment

- 50m measuring tape
- Plant identification books
- Plant press
- Collecting bags
- Identification tags
- Trowel
- Secateurs

Miscellaneous

- Stationary – markers, pens, pencils, leads, erasers
- Waterproof field sheet (1)
- Clipboard (1)
- Folder for storing field sheets (1)
- Notebook (1)
- Map, road atlas (Map case) (1)
- Digital camera (incl. memory card, leads, charger) (1)
- GPS (incl. Spare batteries) (1)
- 2-way radios (2)
- Engel for freezing (1)
- Waders (2)

Procedure for wetland survey

Select water sampling site and record wetland details

On arrival at the site, do a quick survey of the wetland to determine where the sampling sites will be located.

- Fill in site details and general observations on the first page of the datasheet, in particular:
  - Assign the wetland a name and unique site code. This site code will be used to label all samples collected from the wetland.
  - Assign the wetland to a geomorphic wetland type by identifying the hydroperiod (landform will always be basin). It may be necessary to consult with local landholders or regional ecologists from DEC for historical observations.

- Assign the wetland to a biological wetland type: naturally saline, freshwater (artificial reservoirs are assessed as freshwater basins), or turbid claypans. The wetland may be a degraded form of the original type so take into account features such as surrounding vegetation composition and condition, wetland form and salinity. Detailed descriptions of each biological wetland type can be found in section 3.2 of the methodology.
- Assign the wetland to a final wetland group – see section 3.
- Take a GPS reading on the bank of the wetland and record latitude and longitude in decimal degrees.
- Take photos at four points around the wetland, including unusual features. Record the photo numbers on the field sheet.
- For small wetlands, estimate the wetland size by looking at it. For large wetlands, estimate the wetland size from topographic maps and record the value in hectares. Note that 100m x 100m = 1 hectare. Also possible to get the wetland size by using the 'track' function on a GPS and walking around what is believed to be the wetland boundary.
- Estimate the maximum depth of the wetland (use a gauge if available) and record this along with the place the measurement was taken at (e.g. gauge) on the datasheet.

- Do a sketch of the site including features such as vegetation zones, land use, sampling points for water quality and invertebrates, major habitats (islands, large woody debris) and a cross section indicating depth of wetland and height of surrounding dunes.

Collect *in situ* water quality measurements

Prior to collecting *in situ* water quality measurements, the calibration of the pH, conductivity and salinity meter must be checked according to the manual. Read the manual for instructions on the correct operation and maintenance of the meter prior to commencing observations.

- Turn on the meter.
- Enter the water, trying not to stir the sediment up into the water column.
- Once at an undisturbed site, place the pH and conductivity/salinity probes in the water to a depth of 10-20cm if possible, otherwise as deep as possible without stirring up the sediment.
- Wait for the readings to stabilise.
- Record pH and salinity measurements on page 1 of the field sheet. Ensure that the units recorded match the units specified on the datasheet.

Note: To convert from ppM to ppt divide by 1,000 (e.g. 1 ppt = 1,000 ppM).

Collect water quality samples

When collecting water quality samples it is vital not to cross contaminate samples within a wetland and between wetlands. Take particular note of the points below:

- Do not use sunscreen, chemicals or smoke cigarettes immediately prior to collecting water samples as these chemicals can contaminate the samples.
- Do not touch any part of the inside of the bottle or syringe with fingers or any other material.
- After collection of filtered nutrient samples, rinse the syringe thoroughly with distilled water at the site. This equipment should then be soaked in distilled water between sites and the distilled water used for soaking changed regularly.

Unfiltered general chemistry sample (500mL)

Some wetlands in the Wheatbelt have higher salinities than the range of most handheld meters. Therefore, to ensure consistent measurements are recorded, the salinity used in the 'modification to water chemistry' section of the wetland evaluation is a lab reading. Other

measurements may also be requested from the laboratory, depending on the focus of the project.

- Obtain a 500mL water sample bottle from the appropriate analysis centre. Complete the label on the bottle with a permanent marker before collecting the sample.
- Enter the wetland downwind of the sample collection site. Ensure the area chosen for collection of the water quality sample is representative of the wetland, and has not recently been disturbed by animals or humans walking through it. Avoid stirring up the water by charging in.
- Fill the 500mL sample bottle, cap and shake, then empty the contents of the bottle behind you.
- Repeat the above step twice so that the bottle has been rinsed three times.
- Take a few steps forward and refill the bottle by inserting the bottle into the water upside down to a depth of 10-20cm, and tipping it upright so that the bottle fills from 10-20cm down into the water column. If the wetland is less than 20cm deep this will not be possible so fill the bottle from as deep as possible without stirring up the sediment.
- Fill the bottle to capacity, so that there is as little air left in the bottle as possible.
- Scratch the site code and sample type on the sample bottle and trace with permanent marker.
- Although not essential, it is recommended that these samples are kept chilled.

Filtered Total N and Total P sample:

- Obtain a 125mL water sample bottle from the appropriate analysis centre. Complete the label on the bottle with a permanent marker before collecting the sample.
- Rinse the syringe in distilled water by filling and squirting.
- Collect a bucket of water from the wetland, again avoiding areas that have previously been disturbed.
- Draw 20 mL of collected wetland water, pull out the syringe to capacity, swish and squirt out.
- Repeat the above step twice.
- Draw 50 mL of wetland water into the syringe.
- Attach a disposable syringe filter to the syringe, being careful not to touch the outlets with your fingers, and squirt into the 125 mL filtered nutrients sample bottle.
- Cap the bottle, shake and discard.
- Remove the disposable syringe filter and repeat the above three steps twice so that the bottle has been rinsed with filtered water three times.
- Remove the disposable syringe filter and draw 50 mL of wetland water.
- Attach a disposable syringe filter and squirt into the 125 mL sample bottle.
- Repeat the above two steps until the bottle is close to capacity, remembering to leave a 2cm gap for liquid expansion during freezing.
- Scratch the site code and sample type on the sample bottle and trace with permanent marker.
- Immediately place the sample bottle in the freezer for preservation.
- Rinse the syringe with distilled water and discard the used syringe filters.

Note: If the sample water is too turbid or there is too much algae present then filtering becomes difficult. When sampling turbid claypans filtering is impossible, so collect an unfiltered 125mL water sample and make a note on the field sheet. Ask the laboratory that is analysing the sample to centrifuge it to eliminate most of the sediment before measuring soluble nitrogen.

Collect invertebrate sample

Benthic sample (using 250µm mesh net):

- Attach a clean 250 µm mesh net to the pole.
- Rinse the net in wetland water.
- Do a quick, visual survey of the wetland and mentally note the major habitats available and their relative proportions. Logically, there will be more bare sediment than other microhabitats, however there is little diversity in this habitat so do not sample this habitat excessively (depending on other habitats available).
- Sample each of the major habitats in proportion to their existence in the wetland, including the different depths available (up to waist height), there is 50 metres of sample to be collected (for example 10m bare sediment (5m shallow, 5m deep), 20m macrophyte, 10m leaf litter (2m shallow, 8m deep), 10m sedges).
- For each metre of sample, three sweeps of the net are required:
  - Logs: use the nets to scrape up and down the length of the log
  - Leaf litter: stir the leaf litter up with feet so that the animals are dislodged and sweep the net through the water column
  - Sediment: use a shuffling motion with feet to disturb the sediment, wait a second and then sweep through the water column just above the sediment
  - Sedges – use the first sweep of the net to vigorously disturb the vegetation and then use the second and third sweeps to collect animals dislodged in the water column
  - Macrophyte – Sweep the net back and forth through the vegetation in a zig-zag motion
- Empty the contents of the net into a bucket once the net is full or getting heavy. This can be done multiple times during the one sampling occasion.
- If the sample contains excessive amounts of sediments, the volume of the sample can be reduced by elutriation. This should be done with care and only when necessary:
  - Place the sample in a bucket and fill ¾ with clean wetland water
  - Remove coarse leaf litter and sticks once they have been visually inspected for attached invertebrates
  - Vigorously stir the contents of the bucket
  - Pour the sample through the net minus the sediments settled in the bottom of the bucket
  - Repeat the above steps until the bulk of the sediment is removed from the sample
- Transfer net contents into 1 or 2, two-litre pots. Do not fill the pots more than two thirds. No more than 2 pots should be required.
- Fill pots with 100% ethanol, add lid and gently rotate to mix sample and ethanol.
- Place plastic label inside and an adhesive label on the outside of the pot that contains the sample type, site code, date collected, collector and if necessary the number of the pot (e.g. 1 of 2, 2 of 2).
- Place 250 *µ*m mesh net in a sealed container of dilute detergent. At the end of the day wash the net under the tap and leave to dry.

Plankton sample (using 50µm mesh net)

- Attach a clean 50µm mesh net to the pole, ensuring that the small vial is firmly screwed on.
- Rinse the net in wetland water.
- Identify the major habitats available to be sampled. In general, there will be only open water and macrophyte communities.
- Sample each of the major habitats, there is 50 metres of sample to be collected (for example 20m open water, 30m macrophyte). The aim here is to get a very clean sample with zooplankton and some attached rotifers:

  - Water column - Sweep through water column in 1 metre arcs from the surface to near the bed and back to the surface, lifting net out of water and draining at end of each sweep. Never touch the sediment with the net
  - Macrophytes – Very gently move the net through and between all of the different submerged macrophyte communities
- Once sample collection is complete, ensure the organisms are washed from the net down into the vial by rinsing with clean wetland water.
- Drain fluid out of the attached vial by tipping it against the net and flicking it back down into the vial. If the vial is too full (should be about 80% full), tip some water out through the net and rewash the sides of the net.
- Unscrew the net vial from the sample net and empty contents into a 120 mL polycarbonate vial.
- Wearing gloves, use formalin fixative to rinse out the net vial into the 120 mL vial. Top up the sample vial with fixative, which should make-up at least 50% of the volume.
- On the rare occasion that the sample is too large to fit into one vial, two vials can be used. Be cautious not to collect unnecessary material when sampling as these samples are very time consuming to sort.
- Complete the plastic sample label and place it inside the 120mL sample vial.
- Complete the external adhesive label [with site code, sample type, date collected, collector and vial number (e.g. 1 of 2, 2 of 2)] and stick to 120mL sample vial.
- Agitate sample to mix.
- Place 50 µm mesh net in a sealed container of dilute detergent. At the end of the day wash the net under the tap and leave to dry.

Note: Always wash hands thoroughly after using formalin fixative as it is a known carcinogen.

Collect waterbird data

Waterbirds are vagrant species that can be difficult to identify from a distance and are easily scared off. When you arrive at a site, you should take a not of what waterbirds are present before scaring them off. Identify birds using binoculars or spotting scope and the waterbird field guide. Depending on the size of the wetland, waterbird data is collected in different ways:

Small wetlands (circumference <5km – can walk around in <1 hour):

- Walk around the wetland, surveying all habitats (for example: emergent vegetation, inundated trees, shorelines, open water, riparian trees).

Large, shallow wetlands:

- Walk at least one kilometre along the shoreline, surveying all habitats (for example: emergent vegetation, inundated trees, shorelines, open water, fringing wetland trees).
- Use spotting scope for inaccessible areas, or large, shallow wetlands that cannot be traversed on foot.

Large, deep wetlands (>0.5m deep):

- With a boat, motor around the entire wetland using a combination of motoring slowly to approach shy and diving birds (such as grebes) and at speed to make ducks take to the air so that they are easier to count.
- Use spotting scope for inaccessible areas

When identifying waterbirds, keep the following in mind:

- Listen for clamorous reed warblers in dense reeds.
- Keep track of moving birds so that an individual is not counted more than once.
- If there are small numbers of birds, use the tally system.

- If there are large flocks of birds, do multiple counts from different perspectives and record the maximum count.
- Record brood counts (i.e. clutches of chicks/juveniles) of each species present.
- If a bird cannot be identified, record copious notes on general shape, colouring, calls, distinctive features as well as making detailed sketches on the datasheet.
- Record presence and abundance of all species on the second page of field sheet.

Collect vegetation data

The floral survey should be conducted by botanists experienced in identifying both aquatic and non-aquatic wetland-related vegetation to species level. Quadrats will need to be re-visited at the beginning to middle of summer to collect any previously unavailable seeds (e.g. *Tecticornia*) and additional annual species.

General site information (may need to be completed after sampling) – page 3

- Walk around the wetland (if feasible) and determine the location of sampling quadrats by identifying the major structural vegetation zones. Around large playas, quadrats should be placed to sample the vegetation of the different substrates associated with the evaporite and non-evaporite derived plant materials. Between 1 and 10 quadrats can be established, depending on the diversity of flora and size of the wetland. At a typical, small naturally saline wetland, at least 1 quadrat will be established on the beach and two on the dunes. If there is submerged vegetation present, then a quadrat should be established to encompass the dominant aquatic species.
- Complete a site sketch including location of quadrats in relation to the wetland and any other prominent vegetation-related features of the wetland.
- Circle and label the location of the quadrats on the cross-section of a typical Wheatbelt wetland.
- Based on expert opinion, estimate the percentage of wetland vegetation in each condition category for the whole wetland (table on page 3 of the datasheet).

Quadrat information

- Ideally, quadrats should be established and sampled at the beginning of spring and again at the end of the growing season, as this is when many of the aquatics flourish.
- Establish the quadrat (these are normally 10m x 10m, otherwise 5 x 20m if dealing with a narrow vegetation zone) by measuring the quadrat with a marking tape and banging in star pickets in each corner. Mark the centre of the quadrat with a GPS.
- Record the name of the quadrat, which consists of the site code and a quadrat letter (e.g. ARB001A). On the field sheet, provide a thorough description of the quadrat including the elevation code (1 = wetland basin, 2 = zone of typical inundation/wave action, 3 = elevated flat inundated in extreme events and 4 = terrestrial) and structural zone (e.g. lunette). Mark on the site sketch where samples were collected.
- Take photos from each corner of the quadrat, looking into it. Record the photo numbers beside the quadrat name on the field sheet.
- Within the quadrat area, identify the species of vegetation present. If identifications cannot be made at the site by an experienced botanist, collect samples of each species, ensuring to gather the best example seed heads, flowers and roots (if possible).
- Label each specimen with the Quadrat ID and description and place into a large plastic bag labelled with the Quadrat ID. Keep specimens from different quadrats separated.
- Write any species names or temporary descriptions on the field sheet. These names should correspond to the labels attached to each collected specimen. There should be a record for each vegetation species present in the quadrat.

- Complete the vegetation composition table on the last vegetation fieldsheet for every quadrat except aquatic ones. For each stratum (e.g. tree, upper shrub, lower shrub, herb), identify the percent cover, percent stressed and recruitment of dominant species. This information is used to complete the vegetation condition information at the bottom of the same page. Use the descriptions to score the regenerative capacity, weed invasion, structure and state of the vegetation in the quadrat. Also note any species that are likely to have been lost from the area due to threats.
- Repeat this process for each major structural vegetation zones identified in the wetland.

Other observations

The last two pages of the field sheet involve the collection of various other observations regarding the rarity, naturalness, diversity and significance values of the wetland. These have been discussed in the stage 3 wetland evaluation methodology and therefore will not be discussed in detail in this protocol.

Interferences

In situ water quality measurements

The interferences associated with the collection of this type of data are:

- Inaccurate meter calibration
- Incorrect recording of readings (including incorrect units)

Water quality samples

The interferences associated with the collection of water quality samples are:

- Contamination of the samples from:
  - Sunscreens or other chemicals on hands
  - Not rinsing equipment properly at or between sites
  - Touching syringe and water sample bottles with fingers or other chemicals
- Inaccurate results from the laboratory due to:
  - Incorrect labelling of samples
  - Incorrect preservation of samples
  - Laboratory error

Invertebrate samples

The interferences associated with the collection of invertebrate samples are:

- Cross contamination of samples between sites due to ineffective washing of nets
- Incorrect labelling of samples
- Incorrect preservation of samples
- Incorrect collection of samples
- Incorrect identification of invertebrates in the laboratory

Waterbird data

The interferences associated with the collection of waterbird data are:

- Incorrect identification of waterbirds
- Incorrect counts of waterbirds
- Recording the species or counts incorrectly
- Underestimation of species numbers due to missed sightings

Vegetation data

The interferences associated with the collection of floral data are:

- Incorrect identification of vegetation
- Incorrectly labeling specimens
- Underestimation of diversity due to missed sightings / collections of new species
- Under-sampling the site so that major structural zones are missed (i.e. not sampling enough quadrats)

Appendix F- Bird species listed by the Australian and State governments, which have been recorded in inland South-Western Australia

Common name	Scientific name	JAMBA	CAMBA	ROKAMBA	Australian Status	WA gov. threatened species
Australasian Bittern*	*Botaurus poiciloptilus*					✓
Bar-tailed Godwit	*Limosa lapponica*	✓	✓	✓		
Black-tailed Godwit	*Limosa limosa*	✓	✓	✓		
Caspian Tern	*Hydropogne tschegrava (Hydroprogne caspia)*		✓			
Cattle Egret	*Bubulcus ibis (Ardeola ibis)*	✓	✓			
Common Sandpiper*	*Tringa hypoleucos (Actitis hypoleucos)*	✓	✓	✓		
Crested Tern	*Sterna bergii*	✓				
Curlew Sandpiper*	*Calidris ferruginea*	✓	✓	✓		
Dirk Hartog Island Rufous Fieldwren	*Calamanthus campestris hartogi*					✓
Glossy Ibis*	*Plegadis falcinellus*		✓			
Great Egret (White Egret)*	*Egretta alba*	✓	✓			
Greenshank (Common Greenshank)*	*Tringa nebularia*	✓	✓	✓		
Grey (Black-bellied) Plover*	*Pluvialis squatarola*	✓	✓	✓		
Latham's Snipe (Japanese Snipe)	*Gallinago hardwickii (Capella hardwickii)*	✓	✓	✓		
Little Curlew (Little Whimbrel) *	*Numenius minutus (Numenius borealis)*	✓	✓	✓		
Little Ringed Plover	*Charadrius dubius*		✓	✓		
Little Stint	*Calidris minuta*			✓		
Long-toed Stint	*Calidris minutilla (including Calidris subminuta)*	✓	✓	✓		
Marsh Sandpiper	*Tringa stagnatilis*	✓	✓	✓		
Night Parrot	*Pezoporus occidentalis*				Endangered	✓
Oriental Plover	*Charadrius veredus*			✓		
Oriental Pratincole	*Glareola maldivarum*		✓	✓		
Painted Snipe	*Rostratula benghalensis*		✓		Vulnerable	✓
Pectoral Sandpiper	*Calidris melanotos*	✓		✓		
Pintail Snipe (Pin-tailed Snipe)	*Gallinago stenura (Capella stenura)*		✓	✓		
Red-necked (Northern) Phalarope (Red-necked Phalarope)*	*Phalaropus lobatus*	✓	✓	✓		
Red-necked Stint*	*Calidris ruficollis*	✓	✓	✓		
Sharp-tailed Sandpiper*	*Calidris acuminata*	✓	✓	✓		
White-winged Black Tern	*Chlidonias leucopterus (Sterna leucoptera)*	✓	✓	✓		
White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren	*Malurus leucopterus leucopterus*				Vulnerable	✓
Wood Sandpiper*	*Tringa glareola*	✓	✓	✓		

JAMBA = Japan-Australia Migratory Bird Agreement, CAMBA = China-Australia Migratory Bird Agreement, ROKAMBA = Republic of Korea-Australia Migratory Bird Agreement

** - previously recorded at wetlands in the Avon*

Appendix G - Threatened Ecological Communities listed for the Avon-Wheatbelt area of Western Australia

Source: <http://www.dec.wa.gov.au/management-and-protection/threatened-species/wa-s-threatened-ecological-communities.html>

Dated December 2006

No	Threatened Ecological Community	Category of threat and criteria met under WA criteria
1	Perched wetlands of the Wheatbelt region with extensive stands of living Swamp Sheoak (*Casuarina obesa*) and Paperbark (*Melaleuca strobophylla*) across the lake floor.	CR A) i); CR A) 11); CR C)
2	Perched fresh-water wetlands of the northern Wheatbelt dominated by extensive stands of living *Eucalyptus camaldulensis* (River Red Gum) across the lake floor.	PD B)
3	Unwooded freshwater wetlands of the southern Wheatbelt of Western Australia, dominated *by Muehlenbeckia horrida* subsp. *abdita* and *Tecticornia verrucosa* across the lake floor.	CR B) i), CR B) ii)
4	Herbaceous plant assemblages on Bentonite Lakes	EN B) iii)
5	Heath dominated by one or more of *Regelia megacephala, Kunzea praestans* and *Allocasuarina campestris* on ridges and slopes of the chert hills of the Coomberdale floristic region.	EN B) ii)
6	Plant assemblages of the Billeranga System (Beard 1976): *Melaleuca filifolia – Allocasuarina campestris* thicket on clay sands over laterite on slopes and ridges; open mallee over mixed scrub on yellow sand over gravel on western slopes; *Eucalyptus loxophleba* woodland over sandy clay loam or rocky clay on lower slopes and creeklines; and mixed scrub or scrub dominated by *Dodonaea inaequifolia* over red/brown loamy soils on the slopes and ridges	VN A), VN B)
7	Plant assemblages of the Koolanooka System (Beard 1976): *Allocasuarina campestris* scrub over red loam on hill slopes; Shrubs and emergent mallees on shallow loam red over massive ironstone on steep rocky slopes; *Eucalyptus ebbanoensis* subsp. *ebbanoensis* mallee and *Acacia* sp. scrub with scattered *Allocasuarina huegeliana* over red loam and ironstone on the upper slopes and summits; *Eucalyptus loxophleba* woodland over scrub on the footslopes; and mixed *Acacia* sp. scrub on granite	VN A), VN B)
8	Plant assemblages of the Moonagin System (Beard 1976): *Acacia* scrub on red soil on hills; *Acacia* scrub with scattered *Eucalyptus loxophleba* and *Eucalyptus oleosa* on red loam flats on the foothills.	VN A), VN B)
9	Clay flats assemblages of the Irwin River: Sedgelands and grasslands with patches of *Eucalyptus loxophleba* and scattered *E. camaldulensis* over *Acacia acuminata* and *A. rosellifera* shrubland on brown sand/loam over clay flats of the Irwin River.	PD A), PD B)
10	Plant assemblages of the Inering System (Beard 1976)	VN A)
11	Plant assemblages of the Broomehill System	PD A)
12	Assemblages of the organic mound springs of the Three Springs area	EN B) i), EN

CR – Critically Endangered; EN – Endangered; VN – Vulnerable; PD – Presumed Destroyed

Appendix H - Priority Ecological Communities (PEC) listed for the Wheatbelt region of Western Australia

Source: <http://www.dec.wa.gov.au/management-and-protection/threatened-species/wa-s-threatened-ecological-communities.html>

Dated August 2008

Priority Ecological Community	Other information	Status
Highclere Hills (Mayfield) vegetation complex (banded ironstone formation)	Threats: iron ore mining.	Priority 1
Red Morrel Woodland of the Wheatbelt	Tall open woodlands of *Eucalyptus longicornis* (red morrell) found in the Wheatbelt on lateritic, ironstone or granitic soil types. Sometimes found with *Eucalyptus salmonophloia* (Salmon Gum), or *E. loxophleba* (York Gum) woodlands and has very little understorey. It is also found directly above lake systems in the central and eastern Wheatbelt. The landscape unit in which it is found is valley floors, usually adjacent to saline areas.	Priority 1
Avon Pools	Deep pools and natural braided sections of fresh to brackish rivers of the Avon Botanical District.	Priority 1
Canegrass perched clay wetlands of the wheatbelt dominated by *Eragrostis australasica* and *Melaleuca strobophylla* across the lake floor		Priority 1
Mottlecah dominated heathland on deep white sands	Wheatbelt Mottlecah *(Eucalyptus macrocarpa* subsp. *macrocarpa)* dominated heathland on deep white sands. *Eucalyptus macrocarpa* over proteaceous sandplain community.	Priority 1
Natural organic saline seeps of the Avon Botanical District	The known occurrence of this community is characterised by vegetation in a series of bands from the upland to the saline seep. 1) Dunes and sandplain, 2) Saline seep and 3). Adjacent flats and flow lines.	Priority 1
Dense Melaleuca thickets with emergent mallee *Eucalyptus erythronema* var. *marginata* and *Eucalyptus transcontinentalis* of the Wheatbelt Region		Priority 1
Tamma-Dryandra-Eremaea shrubland	Tamma-Dryandra-Eremaea shrubland on cream sands of the Ulva Landform Unit. *Acacia lasiocalyx* and *Allocasuarina campestris* over *Eremaea pauciflora*, *Dryandra armata*, *Hakea aculeata* and *Dryandra erythrocephala* open heath over *Neurachne alopecuroidea* very open grassland over cream sands of the Ulva Landform Unit.	Priority 1
Banksia prionotes and *Xylomelum angustifolium* low woodlands on transported yellow sand	*Banksia prionotes* and *Xylomelum angustifolium* Low Woodlands on large yellow sands dunes (formed from sheets of transported sand in the valleys) on the Ulva Landform Unit. The community has a species rich understorey of *Grevillea eriostachya, Melaleuca leptospermoides, Verticordia roei, Calytrix leschenaultii, Dampiera* spp., *Baeckea preissiana* and *Borya constricta.*	Priority 1
Salt Flats Plant Assemblages of the Mortlock River (East Branch)	The habitat comprises braided channels (up to 2 km wide), flats, wash-lines and sandy rises (up to 2m high) stretching 39 km along the Mortlock River (East) from Meckering eastwards to 8 km west of Tammin. A mosaic of plant communities assorted by elevation occurs on the river flats. The area represents the most extensive braided saline drainage line in this part of the SW agricultural zone. The plant community comprises mixed shrubs (*Scholtzia capitata*, *Melaleuca* aff. *uncinata*) over species rich herbs on sandy rises, with *Melaleuca thyoides* on margins, dwarf scrub and species rich herbs on washlines and saline wetlands.	Priority 1
Brown mallet *Eucalyptus astringens* communities in the western Wheatbelt on alluvial flats (previously 'Beaufort River Flats')	Near York and on the Arthur River on grey clays the understorey is dominated by *Melaleuca viminea* over sedges (*Gahnia trifida*) and bunch grasses. At Kojunup and near Tambellup on brown clays sparse shrubs and succulent shrubs (*Disphyma crassifolium*) dominate the understorey.	Priority 1
Yate (*Eucalyptus occidentalis*) dominated alluvial claypans of the Jingalup Soil System		Priority 2
Gypsum Dunes (Lake Chinocup)	*Eucalyptus* aff. *incrassata* mallee over low scrub on gypsum dunes.	Priority 2

Priority Ecological Community	**Other information**	**Status**
Wheatbelt *Allocasuarina huegeliana* over *Pteridium esculentum* fernland community	Tall emergent *Eucalyptus salmonophloia* over *Allocasuarina huegeliana* tall closed forest over *Acacia acuminata* mid-high isolated trees over *Alyxia buxifolia* tall sparse shrubland over *Pteridium esculentum* very tall closed fernland over various sparse forbland. Occurs in a drainage line near the base of a granite inselberg.	Priority 2
Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs*	Claypans (predominantly basins) usually dominated by a shrubland of *Melaleuca lateritia* occurring both on the coastal plain and the adjacent plateau. These claypans are characterized by aquatic (*Hydrocotyle lemnoides* – Priority 4) and amphibious taxa (e.g. *Glossostigma diandrum*, *Villarsia capitata* and *Eleocharis keigheryi* - DRF).	Priority 2
Allocasuarina huegeliana and *Lepdiosperma tuberculatum* growing on the south-western side of granite outcrops adjacent to laterite on the eastern slopes of the Darling Scarp.		Priority 2
Parker Range vegetation complexes	*Hakea pendula* Tall Shrubland is of particular significance. *Eucalyptus sheathiana* with *E. transcontinentalis* and/or *E. eremophila* woodland on sandy soils at the base of ridges and low rises; *E. longicornis* with *E. corrugata* and *E. salubris* or *E. myriadena* woodland on broad flats; *E. salmonophloia* and *E. salubris* woodland on broad flats; *Allocasuarina acutivalvis* and *A. corniculata* on deeper sandy soils of lateritic ridges; *E. capillosa* subsp. *polyclada* and/or *E. loxophleba* over *Hakea pendens* thicket on skeletal soils on ridges (laterites, breakaways and massive gossanous caps); and *Callitris glaucophylla* low open woodland on massive greenstone ridges.	Priority 3(iii)
Plant assemblages of the Wongan Hills System	Mallee over *Petrophile shuttleworthiana/Allocasuarina campestris* thicket on shallow gravely soils over ironstone on summit and slopes; Shrub mallee on slopes of lateritic hills; Mallee over *Allocasuarina campestris* thicket on the slopes of the laterite plateaus; Mallee over Melaleuca thicket on red brown loam over gravel on slopes below the plateau; Mallee over *Melaleuca coronicarpa* heath on shallow red soil on scarp slopes; *A. campestris/Calothamnus asper* thicket over red-brown clay/ironstone/greenstone on scree slopes; and in lower areas: *Eucalyptus longicornis/ E. salubris* woodland, *E. salmonophloia* and *E. loxophleba* woodlands; *Acacia acuminata* low forest; *E. ebbanoensis* mallee over scrub; and open mallee of *E. drummondii.*	Priority 4(a)

Appendix I - Flora species that were identified as restricted to wetlands during the SAP survey of Wheatbelt wetlands (whole area) (Lyons *et al.,* 2004)

Species name	Status	Habitat	Species name	Status	Habitat
Actinostrobus pyramidalis		Fringing*	*Callitriche hamulata*		Aquatic
Agonis juniperina		Amphibious	*Callitriche stagnalis*		Aquatic
Agrostis avenacea		Fringing*	*Carex inversa*		Fringing*
Alternanthera nodiflora		Fringing*	*Casuarina obesa*		Amphibious
Amphibromus nervosus		Aquatic	*Centaurium erythraea*		Fringing*
Angianthus drummondii		Fringing*	*Centella asiatica*		Fringing*
Angianthus gypsophilus ms (P.S. Short 2360 & L. Haegi)		Fringing*	*Centipeda crateriformis* subsp. *compacta*		Fringing*
Angianthus micropodioides	P3	Fringing*	*Centipeda crateriformis* subsp. *crateriformis*		Fringing*
Angianthus preissianus		Fringing*	*Centrolepis alepyroides*		Fringing*
Angianthus prostratus		Fringing*	*Centrolepis humillima*		Fringing*
Angianthus pygmaeus		Fringing*	*Chaetanthus aristatus*		Fringing*
Apium annuum		Fringing*	*Chamaescilla gibsonii*	P3	Fringing*
Astartea aff. fascicularis		Fringing*	*Chenopodium glaucum*		Fringing*
Astartea sp. Eastern swamps (A.G. Gunness 2434)		Fringing*	*Chondropyxis halophila*		Fringing*
Astartea sp. Esperance (A. Fairall 2431)	P1	Fringing*	*Chordifex laxus*		Fringing*
Astartea sp. Rivers(K. Newbey 1740)		Fringing*	*Chorizandra cymbaria*		Amphibious
Atriplex codonocarpa		Fringing*	*Chorizandra enodis*		Amphibious
Atriplex holocarpa		Fringing*	*Cicendia filiformis*		Fringing*
Atriplex hymenotheca		Fringing*	*Cicendia quadrangularis*		Fringing*
Atriplex nana		Fringing*	*Cotula bipinnata*		Fringing*
Atriplex prostrata		Fringing*	*Cotula coronopifolia*		Fringing*
Atriplex semibaccata		Fringing*	*Cotula cotuloides*		Fringing*
Atriplex semilunaris		Fringing*	*Crassula alata*		Fringing*
Austrostipa geoffreyi	P1	Fringing*	*Crassula natans*		Aquatic
Austrostipa juncifolia		Fringing*	*Crenidium spinescens*		Fringing*
Austrostipa vickeryana		Fringing*	*Cyclosorus interruptus*		Fringing*
Baeckea pygmaea		Fringing*	*Cynodon dactylon*		Amphibious
Baeckea uncinella		Fringing*	*Cyperochloa hirsuta*		Fringing*
Banksia littoralis		Fringing*	*Cyperus congestus*		Fringing*
Banksia occidentalis		Amphibious	*Cyperus gymnocaulos*		Fringing*
Baumea arthrophylla		Amphibious	*Cytogonidium leptocarpoides*		Fringing*
Baumea articulata		Amphibious	*Damasonium minus*		Aquatic
Baumea juncea		Amphibious	*Darwinia halophila*		Fringing*
Baumea preissii subsp. *laxa*		Amphibious	*Deyeuxia quadriseta*		Fringing*
Baumea rubiginosa		Amphibious	*Dichopogon* aff. *preissii*		Fringing*
Baumea vaginalis		Amphibious	*Didymanthus roei*		Fringing*
Bergia perennis subsp. *exigua*		Fringing*	*Distichlis distichophylla*		Fringing*
Blennospora phlegmatocarpa	P2	Fringing*	*Dithyrostegia amplexicaulis*		Fringing*
Bolboschoenus caldwellii		Amphibious	*Diuris drummondii*	R	Fringing*
Boronia denticulata		Amphibious	*Drosera gigantea*		Fringing*
Boronia juncea		Amphibious	*Drosera salina*	P2	Fringing*
Boronia spathulata		Amphibious	*Drosera zigzagia*		Fringing*
Bossiaea halophila		Fringing*	*Elatine gratioloides*		Aquatic
Brachyscome aff. iberidifolia		Fringing*	*Elatine macrocalyx*		Aquatic
Brachyscome halophila	P3	Fringing*	*Eleocharis acuta*		Aquatic
Brachysema melanopetalum		Fringing*	*Eleocharis keigheryi*	R	Aquatic
Bromus arenarius		Fringing*	*Eleocharis pusilla*		Aquatic
Calandrinia sp. Hyden (R.J. Cranfield 11298)		Fringing*	*Epilobium billardiereanum*		Fringing*
Calandrinia sp. Needilup (K.R. Newbey 4892)		Fringing*	*Epilobium billardiereanum subsp. billardiereanum*		Fringing*
Callistemon phoeniceus		Amphibious	*Epilobium ciliatum*		Fringing*

Species name	Status	Habitat	Species name	Status	Habitat
Epilobium hirtigerum		Fringing*	*Gunniopsis glabra*		Fringing*
Epilobium tetragonum		Fringing*	*Gunniopsis intermedia*		Fringing*
Epitriche demissus	P2	Fringing*	*Gunniopsis quadrifida*		Fringing*
Eragrostis australasica		Amphibious	*Gunniopsis rodwayi*		Fringing*
Eryngium ferox ms	P3	Fringing*	*Gunniopsis rubra*	P3	Fringing*
Eryngium pinnatifidum ssp. minus ms		Fringing*	*Gunniopsis septifraga*		Fringing*
Eryngium pinnatifidum subsp *umbraphilus* ms (B.J.Keighery 2129)		Fringing*	*Haegiela tatei*	P2	Fringing*
Eryngium pinnatifidum subsp. *palustre* ms		Fringing*	*Hainardia cylindrica*		Amphibious
Eryngium sp. Lake Muir (E. Wittwer 2293)		Fringing*	*Heliophila* sp. Gunyidi (R.G. Rees 42)		Fringing*
Eucalyptus camaldulensis var. obtusa		Amphibious	*Heliotropium curassavicum*		Fringing*
Eucalyptus camaldulensis x rudis		Amphibious	*Hemarthria uncinata*		Amphibious
Eucalyptus occidentalis		Amphibious	*Hemichroa diandra*		Fringing*
Eucalyptus rudis		Amphibious	*Hemichroa pentandra*		Fringing*
Eucalyptus salicola		Fringing*	*Holcus setiger*		Fringing*
Eucalyptus sargentii		Fringing*	*Hopkinsia adscendens*	P3	Fringing*
Eucalyptus victrix		Fringing*	*Hopkinsia anoectocolea*	P3	Fringing*
Fitzwillia axilliflora	P2	Fringing*	*Hydrocotyle coorowensis*	P2	Fringing*
Frankenia aff. *cinerea* (Barnsley 1696)		Fringing*	*Hydrocotyle crassipes*		Fringing*
Frankenia aff. *laxiflora* (M.N. Lyons 2867)		Fringing*	*Hydrocotyle hexaptera*	P1	Fringing*
Frankenia bracteata	P1	Fringing*	*Hydrocotyle lemnoides*	P4	Aquatic
Frankenia cinerea		Fringing*	*Hydrocotyle medicaginoides*		Fringing*
Frankenia cinerea/punctata species complex		Fringing*	*Hydrocotyle muriculata*	P1	Fringing*
Frankenia conferta	R	Fringing*	*Hydrocotyle* sp. Truslove (M.A.Burgman 4419)	P1	Fringing*
Frankenia drummondii	P3	Fringing*	*Hydrocotyle vigintimilia*	P1	Fringing*
Frankenia glomerata	P1	Fringing*	*Hypericum japonicum*		Fringing*
Frankenia pauciflora "broad hispid" (M.N. Lyons 2868)		Fringing*	*Hypoxis salina* ms (R.Cugley 89)		Fringing*
Frankenia pulverulenta		Fringing*	*Isoetes australis*		Aquatic
Frankenia punctata		Fringing*	*Isoetes drummondii*		Aquatic
Frankenia setosa/glomerata species complex		Fringing*	*Isoetes muelleri*		Aquatic
Frankenia sp. southern gypsum (M.N. Lyons 2864)		Fringing*	*Isolepis aff. fluitans*		Aquatic
Frankenia tetrapetala		Fringing*	*Isolepis australiensis*	P2	Fringing*
Gahnia trifida		Fringing*	*Isolepis cernua*		Fringing*
Glossostigma diandrum		Amphibious	*Isolepis congrua*		Amphibious
Glossostigma drummondii		Amphibious	*Isolepis fluitans*		Aquatic
Glyceria drummondii	R	Fringing*	*Isolepis oldfieldiana*		Fringing*
Gnephosis acicularis		Fringing*	*Isolepis producta*		Aquatic
Gnephosis cassiniana	P1	Fringing*	*Isolepis setiformis*		Fringing*
Gnephosis macrocephala		Fringing*	*Isolepis stellata*		Fringing*
Gnephosis multiflora		Fringing*	*Isotoma pusilla*		Fringing*
Gnephosis setifera	P1	Fringing*	*Jacksonia arida*		Fringing*
Gnephosis trifida		Fringing*	*Juncus acutus*		Fringing*
Gnephosis uniflora		Fringing*	*Juncus aridicola*		Amphibious
Gomphrena sp. Nullewa Lake (M.N.Lyons 2914)		Fringing*	*Juncus bufonius*		Fringing*
Goodenia aff. sp. Scadden (C.D. Turley 41VM/1099)		Fringing*	*Juncus capitatus*		Fringing*
Goodenia micrantha		Fringing*	*Juncus flavidus*		Amphibious
Goodenia occidentalis		Fringing*	*Juncus kraussii* subsp. *australiensis*		Amphibious
Goodenia sp. Lake King (M.Gustafsson et K. Bremer 132)	P2	Fringing*	*Juncus pallidus*		Amphibious
Gratiola pubescens		Amphibious	*Juncus radula*		Amphibious

Species name	Status	Habitat	Species name	Status	Habitat
Juncus subsecundus		Amphibious	*Melaleuca viminea*		Fringing*
Kippistia suaedifolia		Fringing*	*Mesembryanthemum nodiflorum*		Fringing*
Lawrencia diffusa		Fringing*	*Micropterum papulosum*		Fringing*
Lawrencia glomerata		Fringing*	*Microtis orbicularis*		Amphibious
Lawrencia spicata		Fringing*	*Millotia steetziana*	P2	Fringing*
Lawrencia squamata		Fringing*	*Mimulus repens*	P3	Amphibious
Lechenaultia expansa		Fringing*	*Montia australasica*		Aquatic
Lemna disperma		Aquatic	*Muehlenbeckia* aff. *florulenta*		Amphibious
Lepidosperma longitudinale		Fringing*	*Muehlenbeckia florulenta*		Amphibious
Lepilaena aff. *cylindrocarpa*		Aquatic	*Muehlenbeckia horrida* subsp. *abdita*	R	Amphibious
Lepilaena australis		Aquatic	*Myosurus minimus* var. *australis*		Fringing*
Lepilaena cylindrocarpa		Aquatic	*Myriocephalus appendiculatus*	P3	Fringing*
Lepilaena preissii		Aquatic	*Myriocephalus gascoynensis*		Fringing*
Leptocarpus tenax		Amphibious	*Myriocephalus occidentalis*		Fringing*
Lepyrodia fortunata	P2	Amphibious	*Myriocephalus oldfieldii*		Fringing*
Lepyrodia glauca		Amphibious	*Myriocephalus pygmaeus*		Fringing*
Lepyrodia muirii		Amphibious	*Myriophyllum* aff. *tillaeoides*		Aquatic
Limosella australis		Amphibious	*Myriophyllum drummondii*		Aquatic
Lobelia alata		Fringing*	*Myriophyllum echinatum*	P3	Aquatic
Lomandra micrantha subsp. teretifolia "robust form" (A.S. George 14295)		Fringing*	*Myriophyllum limnophilum*		Aquatic
Lythrum hyssopifolia		Fringing*	*Najas marina*		Aquatic
Lythrum wilsonii		Fringing*	*Neosciadium glochidiatum*		Fringing*
Maireana amoena		Fringing*	*Olearia incondita*		Fringing*
Maireana atkinsiana		Fringing*	*Olearia trifurcata*		Fringing*
Marsilea angustifolia		Amphibious	*Ottelia ovalifolia*		Aquatic
Marsilea costulifera		Amphibious	*Oxylobium lineare*		Fringing*
Marsilea drummondii		Amphibious	*Parapholis incurva*		Fringing*
Marsilea mutica		Amphibious	*Paspalum distichum*		Amphibious
Meeboldina cana		Amphibious	*Paspalum vaginatum*		Fringing*
Meeboldina coangustata		Amphibious	*Patersonia* sp. Swamp form (N. Gibson & M. Lyons 544)		Fringing*
Meeboldina crebriculmis		Amphibious	*Peplidium* sp. C Evol.Fl.Fauna Arid Aust. (N.T. Burbidge & A. Kanis 8158)		Aquatic
Meeboldina kraussii		Amphibious	*Pericalymma ellipticum*		Amphibious
Meeboldina roycei		Amphibious	*Pericalymma ellipticum* var. *ellipticum*		Amphibious
Meeboldina scariosa		Amphibious	*Persicaria prostrata*		Amphibious
Meeboldina tephrina		Amphibious	*Phalaris minor*		Amphibious
Melaleuca aff. *stereophloia* (G.J. Keighery & N. Gibson 3844)		Fringing*	*Phalaris paradoxa*		Amphibious
Melaleuca atroviriis ms		Fringing*	*Pimelea halophila*	P2	Fringing*
Melaleuca basicephala	P4	Fringing*	*Podotheca pritzelii*	P2	Fringing*
Melaleuca brevifolia		Fringing*	*Podotheca uniseta*	P3	Fringing*
Melaleuca brophyi		Fringing*	*Polypogon monspeliensis*		Amphibious
Melaleuca cuticularis		Amphibious	*Potamogeton crispus*		Aquatic
Melaleuca densa		Amphibious	*Potamogeton drummondii*		Aquatic
Melaleuca halmaturorum		Amphibious	*Potamogeton ochreatus*		Aquatic
Melaleuca incana subsp. *incana*		Amphibious	*Potamogeton pectinatus*		Aquatic
Melaleuca incana subsp. *tenella*	P3	Amphibious	*Prasophyllum gracile*		Amphibious
Melaleuca lateritia		Amphibious	*Pseudognaphalium luteoalbum*		Fringing*
Melaleuca preissiana		Amphibious	*Ptilotus fasciculatus*	R	Fringing*
Melaleuca rhaphiophylla		Amphibious	*Ptilotus* sp. salt lake (M. Graham G 200.28)		Fringing*
Melaleuca stereophloia		Fringing*	*Puccinellia ciliata*		Fringing*
Melaleuca strobophylla		Amphibious	*Puccinellia stricta*		Fringing*
Melaleuca subalaris		Fringing*	*Ranunculus colonorum*		Fringing*
Melaleuca teretifolia		Fringing*	*Ranunculus pumilio*		Fringing*
Melaleuca thyoides		Fringing*	*Ranunculus sessiliflorus*		Fringing*

Species name	Status	Habitat	Species name	Status	Habitat
Regelia inops		Fringing*	*Stylidium inundatum*		Amphibious
Rhodanthe pyrethrum	P3	Amphibious	*Stylidium lepidum*	P3	Fringing*
Roycea divaricata		Fringing*	***Stylidium longitubum*	P3	Fringing*
Roycea pycnophylloides	R	Fringing*	*Stylidium roseonanum*		Fringing*
Roycea spinescens		Fringing*	*Suaeda australis*		Fringing*
Rumex crispus		Amphibious	*Symphyotrichum subulatum*		Fringing*
Ruppia maritima		Aquatic	*Tecticornia* aff. *doleformis*		Fringing*
Ruppia megacarpa		Aquatic	*Tecticornia* aff. *pergranulata*		Fringing*
Ruppia polycarpa		Aquatic	*Tecticornia* aff. *pergranulata*		Fringing*
Ruppia tuberosa		Aquatic	*Tecticornia* aff. *undulata*		Fringing*
Samolus caespitosus		Fringing*	***Tecticornia arborea*		Amphibious
Samolus junceus		Fringing*	*Tecticornia doleiformis*		Fringing*
Samolus repens var. *floribundus*		Fringing*	*Tecticornia entrichoma*	P4	Amphibious
Samolus repens var. *repens*		Fringing*	*Tecticornia fimbriata*		Fringing*
***Sarcocornia blackiana*		Fringing*	*Tecticornia halocnemoides*		Amphibious
Sarcocornia globosa	P3	Fringing*	*Tecticornia indica* subsp. *bidens*		Fringing*
***Sarcocornia quinqueflora*		Amphibious	*Tecticornia lepidosperma*		Fringing*
Scaevola collaris		Fringing*	*Tecticornia leptoclada* subsp. *inclusa*		Fringing*
***Scaevola pulvinaris*		Fringing*	*Tecticornia lylei*		Fringing*
***Schoenolaena juncea*		Amphibious	*Tecticornia peltata*		Fringing*
***Schoenus capillifolius*	P2	Aquatic	*Tecticornia pergranulata*		Fringing*
***Schoenus elegans*		Fringing*	*Tecticornia pergranulata x doleiformis*		Fringing*
Schoenus loliaceus	P2	Aquatic	*Tecticornia pruinosa*		Fringing*
Schoenus nanus "dwarf form" (G.J. Keighery & N. Gibson 6732)		Fringing*	*Tecticornia pterygosperma*		Fringing*
Schoenus natans	P4	Aquatic	*Tecticornia* sp. Central Wheatbelt (M.N. Lyons & S.D. Lyons 2760)		Fringing*
Schoenus plumosus		Fringing*	*Tecticornia* sp. Gunyidi (M.N. Lyons 2607)		Fringing*
***Schoenus* sp. Jindong (R.D. Royce 2485)	P1	Fringing*	*Tecticornia* sp. Lake Moore (M.N. Lyons 2603)		Fringing*
Schoenus tenellus		Fringing*	*Tecticornia syncarpa*		Fringing*
Scholtzia capitata		Fringing*	*Tecticornia undulata*		Fringing*
Sclerostegia aff. *disarticulata*		Fringing*	***Tecticornia verrucosa*		Amphibious
Sclerostegia arbuscula		Fringing*	*Tegicornia uniflora*	P4	Fringing*
Sclerostegia disarticulata		Fringing*	***Thysanotus* aff. *nudicaulis* (M.N.Lyons 2863)		Fringing*
Sclerostegia moniliformis		Fringing*	*Thysanotus nudicaulis*		Fringing*
Sebaea ovata		Fringing*	*Tribonanthes longipetala*		Amphibious
Sonchus hydrophilus		Fringing*	*Tribonanthes minuta* ms (M. N. Lyons 2929)		Fringing*
Sondottia connata		Fringing*	*Tribonanthes* sp. Lake Muir (G.J. Keighery & N. Gibson 2387)		Amphibious
Spergularia marina		Fringing*	*Tribonanthes uniflora*		Fringing*
Spergularia sp.1 Mollerin (P.G. Wilson 6078)		Fringing*	*Tribonanthes violacea*		Fringing*
Spergularia sp.3 Bullfinch (R.A. Saffrey 905)		Fringing*	*Trichanthodium exile*		Fringing*
Sporobolus virginicus		Fringing*	*Trichocline* sp. Treeton (B.J. Keighery & N. Gibson 564)		Fringing*
Stemodia florulenta		Fringing*	*Triglochin calcitrapa* "slender sessile" (M.N.Lyons 2821)		Fringing*
Stenopetalum salicola		Fringing*	*Triglochin calcitrapum* "fat sessile" (M.N.Lyons 2942)		Fringing*
Stylidium aff. *obtusatum* (M.N. Lyons 2819)		Fringing*	*Triglochin calcitrapum* "slender pedicellate" (A.G. Gunness et al. OAKP4/52)		Fringing*
Stylidium caespitosum		Fringing*	*Triglochin calcitrapum* subsp. *calcitrapum* ms (G.J.Keighery & N. Gibson 7087)		Fringing*
Stylidium guttatum		Fringing*	*Triglochin calcitrapum* subsp. *incurvum* ms (G.J.Keighery 2477)		Fringing*
Stylidium insensitivum		Fringing*	*Triglochin calcitrapum* subsp. recurvum ms (M.N.Lyons 2940)		Fringing*

Species name	Status	Habitat	Species name	Status	Habitat
Triglochin centrocarpa		Fringing*	*Utricularia violacea*		Aquatic
Triglochin elongatum ms (P.G. Wilson 8811)		Fringing*	*Utricularia volubilis*		Aquatic
Triglochin huegelii		Aquatic	*Velleia exigua*	P2	Fringing*
Triglochin linearis		Aquatic	*Vellereophyton dealbatum*		Fringing*
Triglochin lyonsii ms (M.N.Lyons 2855)		Fringing*	*Villarsia albiflora*		Aquatic
Triglochin minutissima		Fringing*	*Villarsia capitata*		Aquatic
Triglochin mucronata		Fringing*	*Villarsia parnassifolia*		Amphibious
Triglochin muelleri		Fringing*	*Villarsia submersa*	P4	Aquatic
Triglochin nana subsp. *salina* ms (M.N.Lyons 2833)		Fringing*	*Viminaria juncea*		Fringing*
Triglochin protuberans	P3	Fringing*	*Wilsonia backhousei*		Amphibious
Triglochin striata		Amphibious	*Wilsonia humilis*		Fringing*
Triglochin turriferum		Fringing*	*Wilsonia rotundifolia*		Fringing*
Trithuria bibracteata		Aquatic	*Wurmbea* aff. *dioica* “Salt Lake” (S.D. Hopper 4164)		Fringing*
Typha domingensis		Aquatic	*Wurmbea dioica*		Amphibious
Typha orientalis		Amphibious	*Wurmbea murchisoniana*	P4	Aquatic
Utricularia gibba		Aquatic	*Xyris lacera*		Amphibious
Utricularia inaequalis		Aquatic			

** These species are terrestrial, but restricted to the wetland landform (habitat 3 in Lyons et al. 2004)*
*** These species are introduced to the area*

R = Declared rare flora – Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such, following approval by the Minister for the Environment, after recommendation by the State's Endangered Flora Consultative Committee

P1 = Priority one flora - Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road reserves, urban areas, farmland, active mineral leases etc., or the plants are under threat from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora' but are in urgent need of further survey.

P2 = Priority two flora - Taxa which are currently known from one or a few (generally <5) populations, at least some of which are believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora' but are in urgent need of further survey.

P3 = Priority three flora - Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

P4 = Priority four flora - Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by identifiable factors. These taxa require monitoring every 5 - 10 years.

Appendix J- List of wetlands in the Avon NRM region that have been identified as regional or local water assets

Source: Department of Environment, 2003; Avon Catchment Council, 2004

Asset Name	National	State	Regional	Local			
				Most valued	Most threatened	Iconic	Recreation
Abbots Lake		✓					
All granite outcrops	✓	✓	✓	✓	✓	✓	
Ardath Lake		✓					
Askew Lake		✓			✓		
Baandee Lake		✓	✓				✓
Beaton Lake					✓		
Bolgart Lakes		✓					
Carratti Lake					✓		
Chinocup Lake		✓	✓			✓	
Chook Run Water Reserve		✓					
Corrigin Water Reserve				✓			
Cowcowing Lakes	✓	✓		✓		✓	
Dragon Rocks Nature Reserve			✓				
Drummonds Wetlands		✓					
Fresh water Lake - Mills		✓					
Freshwater Lake- Watts		✓					
Freshwater lakes		✓					
FW Lakes 2 (3 Lakes)		✓					
Gidgeganup springs		✓					
Hagboom Lake		✓					
Hamilton Dam			✓				
Harvey Lake					✓		
Jilakin Lake system		✓					
Job Lake		✓			✓		
Kondinin/Kurrenkutten Lake System		✓				✓	
Koojedda Wetland		✓					
Lake Baandee		✓	✓				✓
Lake Borona					✓		
Lake Bryde Wetlands complex		✓	✓			✓	✓
Lake Camm						✓	
Lake Campion			✓				
Lake Cemetery			✓				✓
Lake Cronin	✓	✓					
Lake Grace System	✓		✓				
Lake Gulson						✓	
Lake King			✓				✓
Lake Magic		✓					
Lake McDermott System		✓			✓		
Lake Mears			✓				✓
Lake Mollerin System		✓			✓		
Lake Moore				✓			
Lake Ninan		✓					
Lake Royston						✓	
Lake Wallambin System		✓			✓		

Asset Name	National	State	Regional	Local			
				Most valued	Most threatened	Iconic	Recreation
Metcalf Lake		✓					
Mt. Cramphorn Water Reserve		✓					
Mt. Roe Dam Water Reserve		✓	✓	✓			
Myarin Rock				✓			
Narembeen Ski Lake					✓		✓
Paperbark Swamp					✓		
Perched Freshwater Wetlands around Dowerin		✓	✓	✓			
Pink Lake						✓	
Pinkwerring Soak and Well		✓					
Rail dam (Wongan)		✓					
Red Swamp Brook		✓					
Sachses Lakes		✓					
Salt lake chain - south of Bullfinch Road for 1 kilometre and after		✓					
Scotsman Lake		✓		✓			
Shakelton Lakes		✓					
Telephone Exchange Lake		✓					
Wadderin Water Reserve		✓	✓	✓		✓	
Walyormouring Lake		✓					
Water Corporation tanks/Water reserves in Mount Marshall				✓			
Waterbidden Water Reserve		✓					
Wattening Lakes		✓					
Yealering Lake System (Brown lake, White Water Lake, Nonalling Lake, Yealering Lake)	✓		✓	✓			
Yenyening Lake System		✓	✓			✓	✓