A framework for assigning conservation values to Avon Natural Resource Management region wetlands

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Prepared for the Avon Catchment Council

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1. Introduction

This framework, funded by the Avon Catchment Council (ACC), provides a consistent, practical procedure for classifying and evaluating the conservation value of wetlands within the Avon Natural Resource Management (NRM) region. This framework has been developed so that high conservation value wetlands can be identified and managed appropriately, and low conservation value wetlands can be considered for purposes other than conservation (e.g. incorporation into drainage schemes). The Avon NRM region is a threatened landscape and prioritisation of areas for management is vital for the protection of wetlands in the region.

Wetland evaluations can be undertaken at different scales. A level one assessment is a broad-scale assessment of wetlands in a large area using techniques and resources such as remote sensing, GIS products, predictive biological models and aerial photography. A level one assessment is currently being undertaken by the Department of Environment and Conservation (DEC) for all basin wetlands in the Avon NRM region. A level two assessment is a fine-scale assessment of individual wetlands using field survey techniques such as invertebrate, waterbird and vegetation species richness assessments (e.g. Cale *et al.*, 2004). This framework outlines a method for conducting a level two assessment.

This document is yet to be endorsed by the State Wetlands Coordinating Committee. This endorsement will ensure it is compatible with the broad methods recommended for all Western Australian wetland classification and evaluation frameworks (Department of Environment and Conservation, 2006), and that data collected following this framework can be fed into a state-wide database. This framework outlines an evaluation methodology that has been tailored to the current threats facing wetlands in the Avon NRM region, thus it may differ to wetland evaluation methodologies produced for other parts of Western Australia.

1.1 Framework objectives

The objective of this framework is to outline a transparent and accountable method of assigning conservation values (high, intermediate and low) to wetlands within the Avon NRM region. Wetlands will be evaluated using measures of naturalness, diversity, human significance, rarity, representativeness and ecological function.

1.2 Definition of terms

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

1.2.1 ‘Wetland’

This framework will follow the definition of a wetland outlined in the Wetlands Conservation Policy for Western Australia (Government of Western Australia, 1997), which generally follows 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)

However, the Wetlands Conservation Policy for Western Australia excludes tidal (e.g. salt marsh, coral reef) and channel (e.g. river) wetlands.

1.2.2 ‘Wetland classification’

‘A procedure in which individual items (i.e. wetlands as defined in section 1.2.1) are placed into groups based on quantitative information on one or more characteristics inherent in the items (referred to as traits, variables, characters, etc).’ This framework outlines two wetland classification systems based on geomorphological and biological characteristics.

1.2.3 ‘Conservation value’

‘The value of ecosystem structures and functions, expressed in terms of their naturalness, diversity, human significance, rarity, representativeness and ecological function.’

1.2.4 'Wetland evaluation'

'The process of assessing and documenting a wetland's values by considering information about its attributes and functions obtained during the data collection phase.' (Department of Environment and Conservation, 2006)

1.3 Framework limitations

This framework addresses the evaluation of permanent to intermittently inundated wetlands that occur in basin landforms (sensu Semeniuk and Semeniuk, 1995; see Table 1).

Intermittent wetlands occurring on granite outcrops are acknowedged to be of high conservation value but are not included in this framework. These wetlands are unique systems, which have different structure and ecological character to basin wetlands, and need to be addressed by a separate process as they are not influenced by the anthropogenic disturbances that affect their basin counterparts.

This framework does not address the evaluation of waterlogged systems (e.g. damplands, troughs, palusplains, paluslopes etc.), or any channel or flat landform wetlands (e.g. rivers, creeks etc.).

2. Background to the Avon NRM Region

The Avon NRM region (Figure 1) 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 purpose (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 have been mapped in this area by DEC, of which only a few hundred have varying amounts of on-ground data.

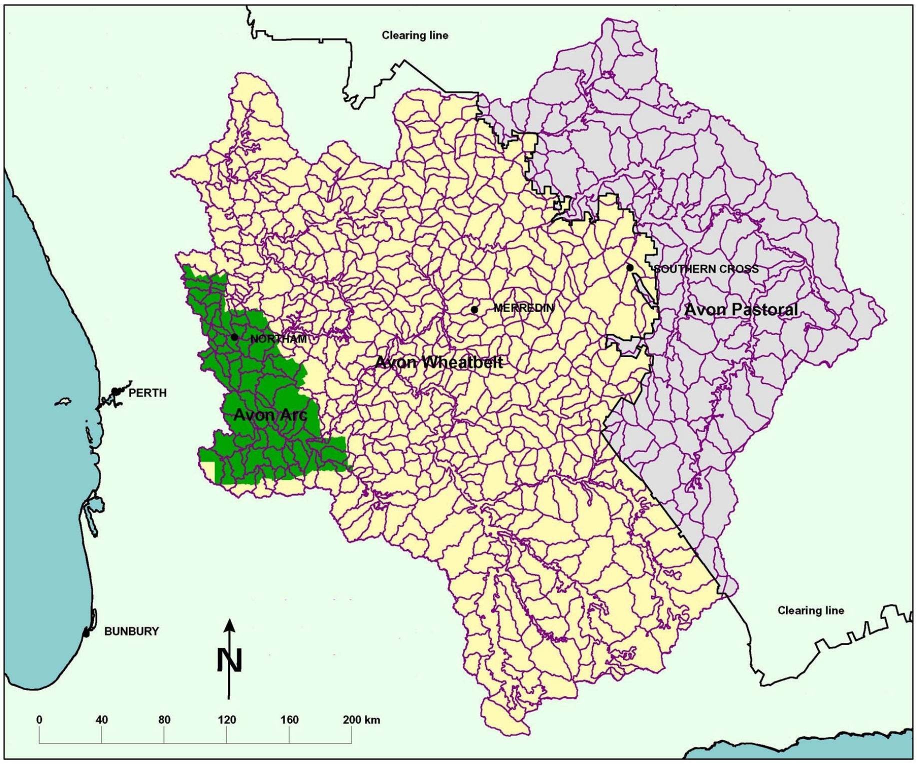


Figure 1 - Location and extent of the Avon NRM region

2.1 Climate

The climate of the Avon NRM region is described 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 semi-arid area of Australia, described as temperate to grassland by the Koeppen classification system. 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 fifty percent of this annual rainfall falls in the winter months, declining to only 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).

The Avon NRM region has extensive areas of shallow saline groundwater, which has been slowly rising in recent years. 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). Mobilization 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, known as dryland salinisation, has had a devastating effect on wetlands within the Avon NRM region (Williams, 1999; Clarke *et al*., 2002) and is predicted to worsen in the future (Short and McConnell, 2001; George and Coleman, 2002). It has been estimated that the cost of dryland salinity to farmers is between $60 million (SSS, 1996) and $1 billion a year (SCLC, 1991; George *et al*., 1997).

2.3 Previous wetland 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 DEC from 1997 to 2001 involved intensive studies at about 100 wetlands, 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 State Salinity Strategy also established a wetland monitoring program, which includes ten wetlands within the Avon NRM region. At these wetlands, terrestrial and aquatic 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.

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 quantitative information on one or more characteristics inherent in wetlands (for example social, hydrological, biological, chemical and/or physical properties). There are two classification systems presented in this document: (a) a geomorphic classification of wetlands into types and (b) a biological classification of wetlands into groups.

3.1 Geomorphic classification system

Semeniuk and Semeniuk, 1995 described a geomorphic classification system based on water permanency and landform that has been adopted as the primary wetland classification system in Western Australia. This Avon NRM framework will only address basin landform wetlands that are permanently to intermittently inundated (those highlighted in Table 1).

Table 1 – Geomorphic wetland types derived from a combination of landform and water permanency attributes (adapted from Semeniuk and Semeniuk, 1995).

Inundation frequency	Landform: Basin	Channel	Flat	Slope	Highland
Permanent	lake	river			
Seasonal	sumpland	creek	floodplain		
Intermittent	playa	wadi	barlkarra		
Seasonal waterlogging	dampland	trough	palusplain	paluslope	palusmont

3.2 Biological classification system

From previous biological studies conducted in the Wheatbelt, five broad wetland 'groups' are known to support distinct water chemistry, flora and/or fauna attributes (Lyons *et al.*, 2004; Pinder *et al.*, 2004). In this framework, wetlands are placed into these groups so that their qualities can be compared to near natural representatives of the same wetland group. Granite outcrop wetlands are included in the five broad groups of wetlands, but will not be discussed further in this framework.

3.2.1 Naturally saline basins (Figure 2)

Naturally saline basins are mostly moderately to highly saline playas, but do include some mildly saline swamps. These wetlands, especially the playas, support distinctive communities of endemic aquatic invertebrates and plants (generally restricted to the supra-litoral fringes, especially the lunettes). These wetlands can become degraded through the process of dryland salinisation (bottom photo in Figure 2) 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 ppK (can be greater than 300 ppK when the wetland is drying out)
- Generally alkaline water, though some are naturally acidic
- Generally clear water
- Seasonal to intermittent inundation

- Lunettes and associated crescentic embayments present on the downwind side of the basin
- Diverse and highly endemic vegetation communities on wetland fringes
- Salt-tolerant emergent (e.g. Shrubby Samphire *(Halosarcia halocnemoides),* Beaded Samphire *(Sarcocornia quinqueflora))* vegetation usually limited to the periphery of the wetland or absent
- Submerged vegetation such as *Ruppia polycarpa, Ruppia megacarpa,* Slender Water Mat *(Lepilaena preissii)*) often present

Features of degraded naturally saline wetlands are:

- Evidence of death of the surrounding terrestrial vegetation due to an increase in water level
- Sometimes acidic
- Unnaturally long inundation period

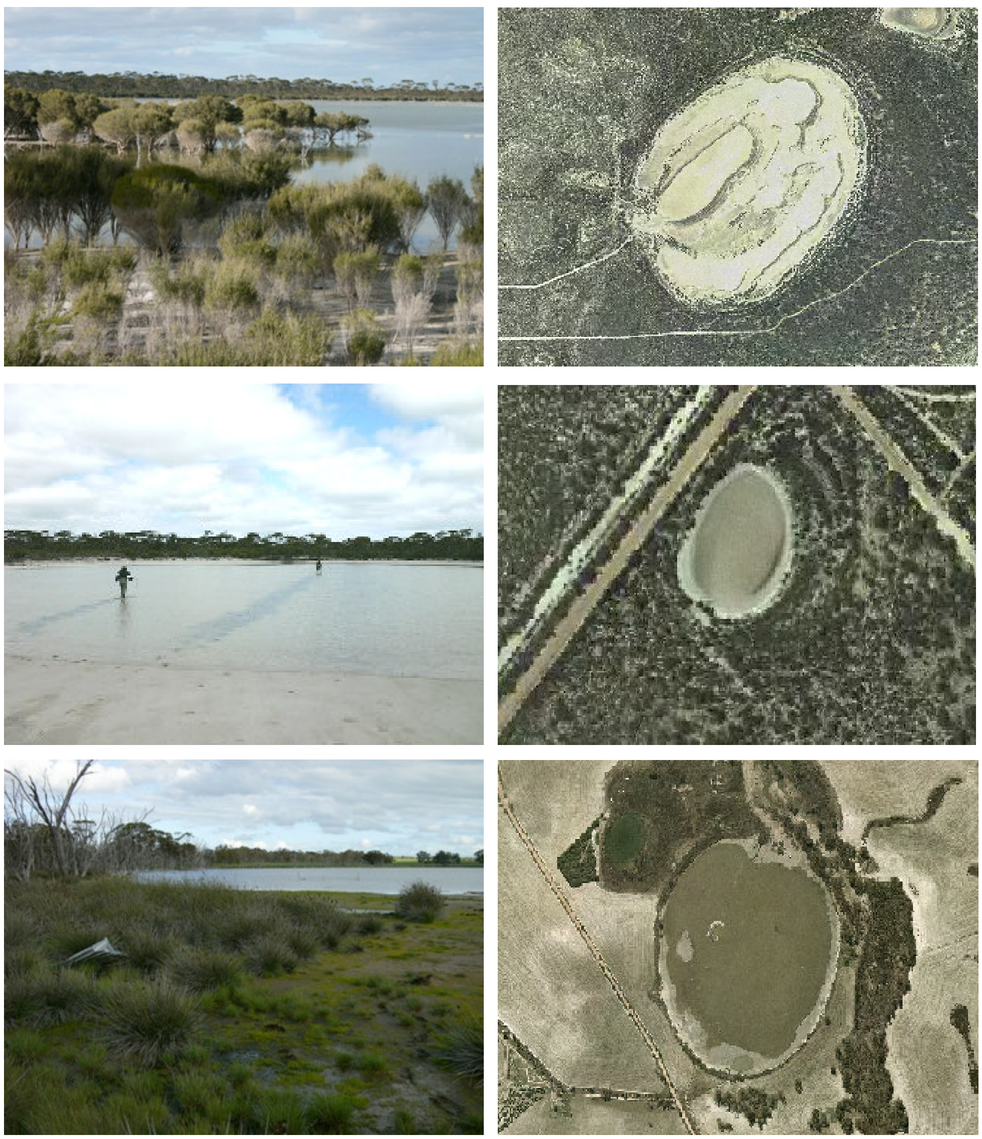


Figure 2 – Top and middle - a naturally saline basin in good condition pictured from the ground (left) and aerial photography (right). Bottom – a degraded naturally saline basin, pictured from the ground (left) and from aerial photography (right)

3.2.2 Freshwater basins

Freshwater basins (e.g. lakes, swamps - Figure 3) support a diverse range of flora and fauna, particularly providing critical habitat during the breeding cycle of many waterbird species. During the SAP biological survey of Wheatbelt wetlands it was recorded that freshwater wetlands support around 80% of the total invertebrate species richness found in all wetlands surveyed in the Wheatbelt (Pinder *et al.*, 2004).

Since European settlement, many freshwater wetlands in the Wheatbelt have been impacted by dryland salinisation. This process has affected the hydrology, water chemistry (especially salinity and pH) and the associated aquatic and terrestrial flora (e.g. George *et al.*, 1995; Lyons *et al.*, 2007) and fauna (Williams, 1999; Clarke *et al.*, 2002) of these wetlands. The freshwater wetlands that have been affected by this process are referred to as being ‘secondarily salinised’ (pictured on the bottom in Figure 3). Features of freshwater basins are:

- Salinity naturally less than 3 ppK when wetland near capacity
- Varied depths
- Generally seasonal, but sometimes intermittent inundation
- Emergent vegetation such as Yate (*Eucalyptus occidentalis*) and *Melaleuca spp.* may be present as a mosaic throughout the basin in shallow wetlands, while sedges and rushes (e.g Bulrush (*Typha orientalis)*, Pale rush (*Juncus pallidus))* usually dominate the periphery of deep, open water wetlands (Lyons *et al.*, 2004)
- Submerged vegetation such as *Isoetes australis* and *caroli* often present

Features of secondarily saline wetlands are:

- Salinity greater than 3ppK when wetland near capacity
- Evidence of death of the emergent and surrounding vegetation
- Sometimes acidic
- Unnaturally long inundation period

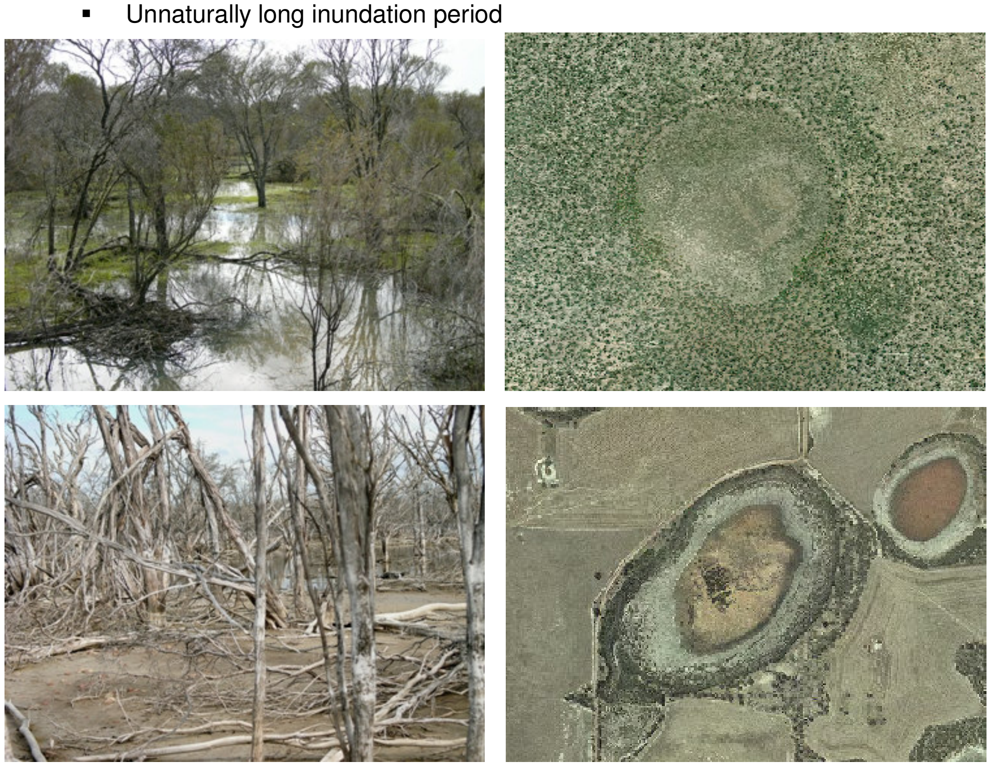


Figure 3 - Top - a freshwater basin in good condition, pictured on the ground (left) and from aerial photography (right). Bottom – a secondarily salinised basin, pictured from the ground (left) and from aerial photography (right)

3.2.3 Artificial reservoir basins (Figure 4)

As the name suggests, these wetlands are man-made structures used for storing water supplies for stock or human consumption. These wetlands should be evaluated as freshwater basins and can have a high conservation value as they often provide a refuge for freshwater species. Artificial waterbodies located on granite outcrops are considered to be reservoirs.

Features of artificial reservoir basins are:

- Salinity of the water mostly less than 3 ppK when full, unless salinised
- Dams used for stock watering or fire-fighting are often turbid but drinking water reservoirs are usually clear
- Shallow to deep
- Reduced diversity of flora and fauna compared to natural wetlands
- Emergent vegetation such as Annual Beardgrass *(Polypogon monspeliensis)* often present


Figure 4 - A freshwater artificial reservoir basin pictured from the ground (left) and aerial photography (right)

3.2.4 Freshwater claypan basins (Figure 5)

Freshwater claypans support a unique assemblage of aquatic invertebrates (e.g. clam shrimps and fairy shrimps (Pinder *et al*., 2004)) and wetland associated vegetation (Lyons *et al*., 2004). Claypans have very low salinities as the clay sediments act to isolate the waterbody from the water table so that the water is derived solely from rainfall. They are difficult to identify from aerial photography as seen in Figure 5. Features of freshwater claypan basins are:

- Salinity generally less than 1 ppK
- Alkaline water
- Generally turbid, shallow water
- Intermittent to seasonal inundation
- Clay sediments
- Emergent vegetation such as *Tecticornia verrucosa* may be present

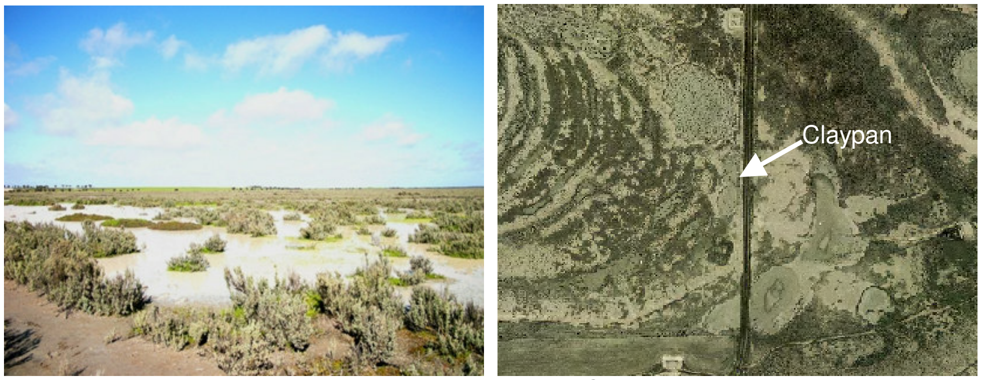


Figure 5 - Typical freshwater claypan south of Lake Grace. Pictured from the ground (left) and from aerial photography (right)

4. Evaluation of Avon NRM region wetlands

The aim of this wetland evaluation framework is to allow wetlands to be assigned to one of three conservation value categories: high, intermediate or low. This enables the high conservation value wetlands to be identified and targeted for future protection and/or restoration and low conservation value wetlands to be considered for purposes other than conservation (e.g. receiving drainage water).

Many existing classification and evaluation methodologies were reviewed prior to developing this framework. None were found to be suitable for adoption in the Avon NRM region without some modification. In many cases, pre-existing frameworks were not applicable to the wetland types found, and threats evident, in the Avon NRM region. The most relevant and useful evaluation schemes were Dunn, 2000, Bennett *et al*., 2002 and Kingsford *et al*., 2005. They were adapted for use on Avon NRM region wetlands despite being focused on riverine systems, to derive a list of six evaluation criteria:

1. Naturalness (Section 4.2)
2. Diversity (Section 4.3)
3. Human significance (Section 4.4)
4. Rarity (Section 4.5)
5. Representativeness (Section 4.6)
6. Ecological function (Section 4.7)

The steps involved in evaluating a wetland are:

1. Determine the wetland type (geomorphic classification) and group (biological classification) of the wetland
2. Assess the wetland for its 'naturalness' value
3. Assess the wetland for its 'diversity' value
4. Combine the naturalness and diversity scores into an average score
5. Assess the wetland for its 'human significance', 'rarity', 'representativeness' and 'ecological function' value
6. Combine the information collected into a final conservation value

A wetland evaluation fieldsheet (full version - Appendix B) is used to calculate a score for each evaluation criteria. A score between 1 and 3 is recorded on the fieldsheet for each indice, which are then averaged first into an indicator score and then into a final score for the naturalness and diversity criteria. A score of 1 indicates a low conservation value for that particular index, and a score of 3 indicates a high conservation value for that particular index.

4.1 Reference ranges

Reference ranges ensure a site is measured against a quantitative and transparent benchmark appropriate for the wetland group. This ensures that an accurate indication of a wetland's 'naturalness' and 'diversity' value is achieved.

The reference ranges for indicators such as water chemistry naturalness, and fauna and flora diversity have been calculated for each wetland group from existing survey data collected during the SAP survey of Wheatbelt wetlands. Wetlands that are in the Wheatbelt, but outside of the Avon NRM region boundary, have been included in these calculations to increase the quantity of data used. These reference ranges should be reviewed when additional data becomes available.

Reference ranges for pH and total soluble nitrogen indices within the naturalness water chemistry indicator were derived by taking the 25th and 75th percentile of measurements recorded at natural/near natural wetlands in each wetland group. The reference ranges given for the salinity index were derived from well acknowledged limits of freshwater species to salinity.

Reference ranges for indices within the flora and fauna diversity indicators were calculated by dividing the species/family richness data into wetland groups 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 reference ranges given for the habitat diversity indicator were derived from expert opinion of the habitats generally found at near natural representatives of each wetland group.

Data contributing to the calculation of reference ranges was collected using protocols outlined in Appendix C. Data used for wetland evaluation must be collected using these procedures. Invertebrate identifications should be completed following the guidelines in Appendix 3 of Pinder *et al.*, 2004 and Section 4.3.3 of this document. Wetlands should only be sampled in spring when the water level is at adequate capacity.

The definitions and relevant indicators for the six criteria are outlined below, as well as the relevant section of the fieldsheet.

4.2 Naturalness

Definition: A measure of how much a wetland has been protected from, or subjected to disturbance. 'Naturalness' reflects the condition of the wetland in comparison to a near-natural wetland.

4.2.1 Percentage of degrading land uses within 1 km of the wetland boundary. This indicator is calculated by dividing the area within 1 km of the wetland boundary into land use categories, then summing the land uses that have a negative affect on the wetland. Examples of degrading land uses are: agriculture (cropping, grazing), forestry, and developments for urban or industrial purposes. The total percentage of degrading land use is compared to the ranges associated with each score to give the final score.

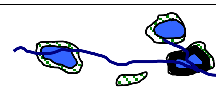
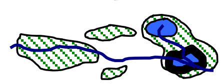
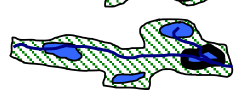
Degrading land use	**% Within 1 km of wetland**	**Final Score**
Cropping		1 = >50% 2 = 20 – 50% 3 =0 – 20%
Grazing		
Forestry		
Other		
Final land use score		

4.2.2 Percentage of the wetland affected by degrading structures. This indicator is calculated by estimating the percentage of the wetland that is likely to be affected by the presence of any structures. Structures such as drains generally affect the entire wetland, but this can be dependant on the size and discharge volume of the drain. The total percentage of wetland affected is compared to the ranges associated with each score to give the final score.

Structures present	**% Wetland affected**	**Final Score**
Drains		1 = ≥30% 2 = 1 – 30% 3 = 0%
Roads		
Dams		
Other		
Final structures score		

4.2.3 Modification to buffer vegetation. This indicator includes four indices, which are averaged to give a final score:

- *Percentage of buffer vegetation remaining within 50m of wetland boundary*. Buffer vegetation refers to remnant or natural vegetation that would have originally surrounded the wetland. The percentage of buffer vegetation remaining is compared to the ranges associated with each score to give the final score.
- *Buffer vegetation condition within 50m of the wetland boundary.* This index is calculated from the amount of tree death present at a wetland. The final score is calculated by placing the wetland into one of the categories associated with the three scores.
- *Connectivity of vegetation with other wetlands*. This index is calculated by comparing the connecting vegetation patterns of the wetland of interest with the picture shown in the relevant section of the fieldsheet below. The wetland of interest is blue, surrounded by a black bold outline, and the connecting vegetation is green. If the wetland is isolated from other wetlands then no score is given for this index.
- *Presence of weeds*. This index is calculated by surveying the quantity of weeds present within 50m of the wetland boundary, and comparing it to the categories associated with the three scores.

Index	**Scoring method**	**Score**
% Buffer veg remaining within 50m of wetland	1 = 0 - 25, 2 = 26 - 75% 3 = 76 - 100%	____
Buffer vegetation condition	1 = Significant tree death 2 = Some tree death 3 = No tree death	____
Connectivity of vegetation with other wetlands *(wetland highlighted in diagram is the wetland in question, if wetland isolated, no score is given)*	1 = Low  2 = Medium  3 = High 	____
Presence of weeds	1 = Heavy weed infestation, some dominant 2 = Some weeds present but none dominating vegetation communities 3 = Weeds absent or very scarce	____
Final Score for vegetation	**= Sum scores ÷ 4**	

4.2.4 Modification to water chemistry. This indicator is calculated by comparing measurements recorded at a wetland with reference ranges for that wetland group. All water chemistry measurements should be taken as outlined in Appendix C.

If a naturally saline wetland is known to be naturally acidic, then no score is given for the pH index. Generally, if the water is acidic (pH<7) and the surrounding vegetation is in near natural condition, then the wetland is naturally acidic.

Index	Reading	Reference ranges for each wetland group	Scoring method	Score
pH: *(do not score naturally acidic basins)*	__ . __ __	Naturally saline basin 7.8 – 8.9 Freshwater basin 6.9 – 8.1 Freshwater claypan 8.6 – 8.9	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Salinity:	_ _ _ _ _ _ ppK	Naturally saline basin N/A Freshwater basin 0 – 3.0 Freshwater claypan 0 – 1.0	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Total Soluble N	________µg/L	Naturally saline basin < 1200 Freshwater basin < 2075 Freshwater claypan < 2325	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Final score for modification to water chemistry			**= Sum scores ÷ 3**	

4.2.5 Modification to hydrology. This indicator is evaluated by determining whether the hydrology of the wetland has changed from natural. This can be inferred from features such as:

- significant tree death in or around the wetland
- change in the waterline
- change in water permanency

If the hydrology has altered from its natural state then a score of 1 is recorded. If the wetland retains a natural hydrology then a score of 3 is recorded.

The relevant scores for land use, structures, vegetation, water chemistry and hydrology are combined into a final 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 inidicating a highly modified wetland and 3 indicating a near natural wetland.

Indicator	Score	Final Criteria Score
Degrading land use		= Sum of scores ÷ no. of scores ___ . ___
Degrading structures		
Vegetation		
Water chemistry		
Hydrology		

4.3 Diversity

Definition: A measure of the level of diversity of features, communities or species at a wetland.

4.3.1 Level of wetland structural diversity. This indicator is calculated by counting the number of habitats present at the wetland, and comparing this total against the reference ranges to derive a final score.

A habitat can only be counted as being present if the area it occupies is at least 10% of the total possible area. This ensures that the habitat is performing an ecological function for biota.

<table>
<tr><th>Possible wetland habitats</th><th>Present (1) / absent (0)</th><th>Structural diversity reference range for each wetland group</th><th>Score</th></tr>
<tr><td>Submerged vegetation</td><td></td><td rowspan="10">
<table>
<tr><td>Wetland group</td><td>Score = 3</td><td>Score = 2</td><td>Score = 1</td></tr>
<tr><td>Naturally saline basin</td><td>>4</td><td>N/A</td><td>0 – 4</td></tr>
<tr><td>Freshwater basin</td><td>>5</td><td>3 – 5</td><td>0 – 2</td></tr>
<tr><td>Freshwater claypan</td><td>>1</td><td>N/A</td><td>0 – 1</td></tr>
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</td><td rowspan="10">———</td></tr>
<tr><td>Emergent shrubs</td><td></td></tr>
<tr><td>Emergent reeds</td><td></td></tr>
<tr><td>Surrounding terrestrial veg.</td><td></td></tr>
<tr><td>Large woody debris</td><td></td></tr>
<tr><td>Leaf litter</td><td></td></tr>
<tr><td>Deep water zones (≥1.5m)</td><td></td></tr>
<tr><td>Shallow wading zones</td><td></td></tr>
<tr><td>Island</td><td></td></tr>
<tr><td>Total</td><td></td></tr>
</table>

4.3.2 Level of native floral diversity. This indicator includes measures of native submerged, emergent and terrestrial (but restricted to wetlands) vegetation species richness. These indice scores are calculated 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 diversity.

<table>
<tr><th>Vegetation type</th><th>No. Sp found</th><th>Species richness reference range for each wetland group</th><th>Score</th></tr>
<tr><td>Submerged</td><td>———</td><td>
<table>
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<tr><td>Freshwater basin</td><td>>2</td><td>N/A</td><td>0 - 2</td></tr>
<tr><td>Freshwater claypan</td><td>>0</td><td>N/A</td><td>0</td></tr>
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</td><td>———</td></tr>
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<tr><td>Naturally saline basin</td><td>>2</td><td>1 - 2</td><td>0</td></tr>
<tr><td>Freshwater basin</td><td>>5</td><td>1 - 5</td><td>0</td></tr>
<tr><td>Freshwater claypan</td><td>>1</td><td>1</td><td>0</td></tr>
</table>
</td><td>———</td></tr>
<tr><td>Terrestrial, but restricted to wetland periphery</td><td>———</td><td>
<table>
<tr><td>Wetland group</td><td>Score = 3</td><td>Score = 2</td><td>Score = 1</td></tr>
<tr><td>Naturally saline basin</td><td>>27</td><td>12 - 27</td><td><12</td></tr>
<tr><td>Freshwater basin</td><td>>12</td><td>4 - 12</td><td><4</td></tr>
<tr><td>Freshwater claypan</td><td>>9</td><td>7 - 9</td><td><7</td></tr>
</table>
</td><td>———</td></tr>
<tr><td colspan="3">Final score for native flora diversity =sum scores ÷ 3</td><td></td></tr>
</table>

4.3.3 Level of native faunal diversity. This indicator includes measures of native invertebrate species/family richness and native waterbird species richness. These indice scores are calculated by comparing the observed species/family richness for each fauna type against the relevant reference range. The two indice scores are then averaged to give the final score for native fauna diversity.

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

- The first table of species level reference ranges include all micro and macro-invertebrate groups to species level, with the exceptions specified in Appendix 3 of Pinder *et al.*, 2004 (also not including any groups that are terrestrial e.g. Staphylinidae, Curculionidae, Carabidae).
- The second table of family level reference ranges include all micro and macro-invertebrate groups to family level, with the exceptions specified in Appendix 3 of Pinder *et al.*, 2004 (also not including any groups that are terrestrial e.g. Staphylinidae, Curculionidae, Carabidae.
- The third table of family level reference ranges include only macroinvertebrate groups to family level (excludes the groups Cladocera, Copepoda, Ostracoda, Rotifera and Protozoa), with the exceptions specified in Appendix 3 of Pinder *et al.*, 2004.

Fauna category	No. Sp found	Species and family richness reference range for each wetland group				Score
Invertebrates *(For further information on the invertebrate identification process see section 4.3.3 of this framework)*	______	**Species**	Score = 3	Score = 2	Score = 1	______
		Naturally saline basin	>15	6 – 15	0 – 5	
		Freshwater basin	>48	25 – 48	0 – 24	
		Freshwater claypan	>33	27 – 33	0 – 26	
		All families	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>15	7 – 15	0 – 6	
		Freshwater basin	>33	19 - 33	0 – 18	
		Freshwater claypan	>23	19 – 23	0 – 18	
		Macroinvertebrate fam.	Score = 3	Score = 2	Score = 1	
		Naturally saline basin	>10	5 – 10	0 – 4	
		Freshwater basin	>21	14 – 21	0 – 13	
		Freshwater claypan	>20	14 – 20	0 – 13	
Waterbirds	______	Wetland group	Score = 3	Score = 2	Score = 1	______
		Naturally saline basin	>6	N/A	0 - 6	
		Freshwater basin	>9	3 - 9	0 - 2	
		Freshwater claypan	>2	N/A	0 - 2	
Final score for native fauna diversity		**=sum scores ÷2**				

The relevant scores for structural, 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.

Indicator	Score	Final Criteria Score
Structural diversity		= Sum scores ÷ number of scores ___ . ___
Floral diversity		
Faunal diversity		

4.4 Human significance

Definition: Significance placed on wetlands by society; based on its biological, geographical, recreational, water supply, historical or cultural value

4.4.1 If a wetland is identified under any of the following directories or legislation it automatically becomes a high conservation value wetland:

- Ramsar wetland (UNESCO, 1971; Ward and Voelz, 1994)
- Directory of Important Wetlands (Environment Australia, 2001)
- Environmental Protection (South West Agricultural Zone Wetlands) Policy, 1998
- Rights In Water and Irrigation Act, 1914
- Country Areas Water Supply Act, 1947
- Waterways Conservation Act, 1976
- Avon Natural Resource Management Plan: Water Resource Supporting Document- local water assets (Avon Catchment Council, 2004)
- Regional water assets identified during the Salinity Investment Framework project (Department of Environment, 2003; Avon Catchment Council, 2004)

The Salinity Investment Framework identified biodiversity, water resource, economic and social assets within the Avon NRM region. The purpose of this framework was to determine NRM spending priorities to help manage salinity, so that assets of high public value at high threat from salinity are managed effectively. The biodiversity and water resource assets identified in this process have not been included in this list as they are covered by the sources listed above.

4.4.2 If the wetland is either partly or totally within any of the following areas, it automatically becomes a high conservation value wetland:

- Public Drinking Water Supply Area (PDWSA; Department of Water, 2007). 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
- Public Drinking Water Protection Zone
- Natural Diversity Recovery Catchment (Walshe *et al.*, 2004)
- Registered Aboriginal Site managed by the Department of Indigenous Affairs
- Heritage listings controlled by the Commonwealth (Register of the national Estate (Australian Heritage Commission, 1990), The National Heritage List, The Commonwealth Heritage List)
- State Register of Heritage Places (Heritage Council of Western Australia, 2001)
- Municipal inventories

This criteria is included in the final decision making framework outlined in Section 4.8.

4.5 Rarity

Definition: A measure of the presence of rare habitats, species, communities and features within each wetland

A wetland that performs any of the following functions automatically becomes a high conservation value wetland:

4.5.1 Supports rare, threatened or significant fauna. A list of rare and threatened waterbirds identified under state and national legislation are listed in Appendix E. None of the invertebrates identified on the rare and threatened fauna document have been recorded in the Wheatbelt.

4.5.2 Supports rare, threatened or prioritised flora. A list of rare, threatened and prioritised flora that were recorded at wetlands in the SAP Wheatbelt biological survey are listed in Appendix G.

4.5.3 Supports a Threatened Ecological Community (TEC). A list of TEC's assigned to the Avon-Wheatbelt are listed in Appendix F**.**

4.5.4 Has a rare or threatened water chemistry or hydrology (e.g. a freshwater lake)

This criteria is included in the final decision making framework outlined in Section 4.8.

4.6 Representativeness

Definition: A typical example of the wetland type or group

If a wetland is the only representative of a geomorphic type and a wetland group combination in the region under consideration, it automatically becomes a high conservation value wetland. Artificial reservoirs are lumped with freshwater lakes as in the evaluation process. Table 2 below shows the possible combinations of geomorphic types and wetland groups that are included in the boundaries of this framework.

This criteria is included in the final decision making framework outlined in Section 4.8.

Table 2 - Possible combinations of geomorphic wetland types and wetland groups included in this framework

		Basin landform geomorphic wetland types		
		Lake	Sumpland	Playa
Biological wetland groups	Naturally saline basins	Naturally saline lake	Naturally saline sumpland	Naturally saline playa
	Freshwater basins	Freshwater lake	Freshwater sumpland	Freshwater playa
	Freshwater claypan basins	Freshwater claypan lake	Freshwater claypan sumpland	Freshwater claypan playa

4.7 Ecological function

Definition: A measure of whether a wetland provides an important ecological function within the landscape

4.7.1 Wetlands that are either headwater or throughflow basins can not be low conservation value wetlands as they influence the hydrology and water quality of wetlands downstream.

4.7.2 Wetlands that support waterbirds listed under international waterbird agreements (e.g. JAMBA, CAMBA, ROKAMBA, Wildlife Conservation Plan for Migratory Shorebirds, Important Bird Areas in Australia) automatically become a high conservation value wetland – see Appendix E

This criteria is included in the final decision making framework outlined in Section 4.8.

4.8 Combining the scores into a final conservation value for each wetland

Once a wetland has been assessed on its naturalness, diversity, rarity, human significance, representativeness and ecological function, a final decision needs to be made on the conservation value of the wetland.

In some systems, e.g. under the Ramsar Convention, a wetland is designated as high value even if it meets only one in the list of key criteria. However, because the Avon NRM region assessment is focused on a range of value levels, the system used here needs to have greater discrimination. The following key provides a decision-making tool to allocate a wetland to one of the three categories of conservation value:

Q.	Does OR is the wetland . .	Key	Details / comments
1	listed as a Ramsar or Directory of Important Wetlands wetland?	Yes: High conservation value No: go to *2*	
2	listed under any of the documents or is within any of the areas identified in Section 4.4?	Yes: High conservation value No: go to *3*	
3	support rare, threatened or significant fauna (including waterbirds protected under international agreements – see Appendix E)	Yes: High conservation value No: go to *4*	
4	support rare, threatened or prioritised flora – see Appendix G	Yes: High conservation value No: go to *5*	
5	support rare, threatened or significant ecological communities – see **Appendix F**	Yes: High conservation value No: go to *6*	
6	have a rare or threatened water chemistry or hydrology (e.g freshwater wetlands)	Yes: High conservation value No: go to *7*	
7	the only representative of its geomorphic type and wetland group combination within an area?	Yes: High conservation value No: go to *8*	
8	have a combined naturalness and diversity score >2.3?	Yes: High conservation value No: go to 9	
9	have a combined naturalness and diversity score ≥1.7?	Yes: go to *9* No: go to *10*	
10	a headwater or throughflow basin (i.e. has an influence on wetlands downstream)?	Yes: Intermediate conservation value No: Low conservation value	

5. Final comments and recommendations

- This framework outlines a method for assigning conservation values to wetlands within the Avon NRM region but is also applicable to wetlands in the wider Wheatbelt area.
- As this version of the evaluation methodology has not been field-tested, it is recommended that some practical assesements of the frameworks utility (ease of use) and performance are undertaken.
- Wetlands are dynamic systems that respond to local climatic and anthropogenic influences. In general, greatest wetland biodiversity is seen 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 C) and then stored in a centrally managed database such as WetlandBase. This will ensure an accurate and up-to-date information system that will contribute to efficient management and conservation of Avon NRM region wetlands.

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

Study / Paper name	Organisation / Authors	# Wetlands in Avon NRM	Data collected				
			Inverte-brate	Water Quality	Water-bird	Depth	Flora
Wheatbelt biological survey, 1997 - 2001	DEC.	~100	✓	✓	✓	✓	✓
Wheatbelt monitoring program, 1997 - current	DEC	10	✓	✓	✓	✓	✓
Assessment of conservation status of wetlands in the Trayning area in relation to disposal of deep drainage water	Bennelongia Pty Ltd, 2007	7	✓	✓	✓		✓
Oral histories documenting changes in Wheatbelt wetlands	Sanders, 1991	Many					
Lake McDermott BioBlitz	Davis, 2005	1			✓		✓
Kununoppin BioBlitz	Davis, 2005	1			✓		✓
Moningarin BioBlitz	Davis, 2005	1			✓		✓
Waterbirds in nature reserves of south-western Australia 1981-1985	Jaensch *et al*., 1988	71		✓	✓	✓	✓
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			✓		
Vegetation of depth-gauged wetlands in nature reserves of the south-west Western Australia	Halse *et al*., 1993	~22				✓	✓
Wheatbelt Geochemical Risk Assessment and Management Project	Dept of Water	53		✓			
A biological survey of the agricultural zone: vegetation and vascular flora of Drummond Nature Reserve	Keighery *et al*., 2002	2					✓
Wetland characteristics and waterbird use of wetlands in south-western Australia	Halse *et al*., 1993	~22		✓	✓	✓	✓
The aquatic macrophyte flora of saline wetlands in Western Australia in relation to salinity and permanence	Brock and Lane, 1983	~18		✓		✓	✓
Depths and salinities of wetlands in south-western Australia: 1977-2000	Lane *et al*., 2004	~36		✓		✓	

Appendix B - Wetland evaluation field sheet

Wetland evaluation field sheet

Department of Environment and Conservation

Wetland details

Site Code: ……………………………………… Date: __ __ / __ __ / 20 __ __
Site Name: ……………………………………… Time (24 hr): __ __:__ __
Personnel: ________ & ________ Weather: Fine / Overcast / Rain

Site information

Latitude:	- __ __ . __ __ __ __
Longitude:	__ __ __ . __ __ __ __
Datum:	__ __ __ __ __
Approx. water level:	__ __ __%.
Estimated wetland size:	_______Ha

Max. depth of wetland:	_______cm
Max depth measured at *(e.g. gauge)*:	………………
Photo No. – Site:	_______
Land tenure *(please circle)*:	Public Private
Contact Name:	
Contact Phone:	

1. Assign wetland to a geomorphic wetland type *(greyed out wetlands are not suitable for this method)*

Inundation	Landform			
	Basin	*Flat*	*Slope*	*Highland*
Permanent	lake	-	-	-
Seasonal	sumpland	floodplain	-	-
Intermittent	playa	barlkarra	-	-
Seasonal waterlogging	dampland	palusplain	paluslope	palusmont

2. Assign the wetland to a wetland group *(Artificial wetlands are assessed with freshwater wetlands)*

Wetland group	Features of each wetland group
Naturally saline basin	▪ Salinity greater than 10 ppK (can be over 300 ppK when the wetland is drying out) ▪ Generally alkaline water, though some are naturally acidic ▪ Generally clear water ▪ Seasonal to intermittent inundation ▪ Lunettes and associated crescentic embayments on the downwind side of the basin ▪ Diverse and highly endemic vegetation communities on wetland fringes ▪ Salt-tolerant emergent (e.g. Shrubby Samphire *(Halosarcia halocnemoides),* Beaded Samphire *(Sarcocornia quinqueflora))* vegetation usually limited to the periphery of the wetland or absent ▪ Submerged vegetation such as *Ruppia polycarpa, Ruppia megacarpa,* Slender Water Mat *(Lepilaena preissii))* often present **Features of degraded naturally saline wetlands are:** ▪ Evidence of death of the surrounding terrestrial vegetation due to an increase in water level ▪ Sometimes acidic ▪ Unnaturally long inundation period
Freshwater basin	▪ Salinity naturally less than 3 ppK when wetland near capacity ▪ Varied depths ▪ Generally seasonal, but sometimes intermittent inundation ▪ Emergent vegetation such as Yate (*Eucalyptus occidentalis*) and *Melaleuca spp.* may be present as a mosaic throughout the basin in shallow wetlands, while sedges and rushes (e.g Bulrush (*Typha orientalis)*, Pale rush (*Juncus pallidus))* usually dominate the periphery of deep, open water wetlands (Lyons *et al.*, 2004) ▪ Submerged vegetation such as *Isoetes australis* and *caroli* often present **Features of secondarily saline wetlands are:** ▪ Salinity greater than 3ppK when wetland near capacity ▪ Evidence of death of the emergent and surrounding vegetation ▪ Sometimes acidic ▪ Unnaturally long inundation period
Freshwater claypan	▪ Salinity less than 2 ppK ▪ Alkaline water ▪ Generally turbid, shallow water ▪ Intermittent to seasonal inundation ▪ Clay sediments ▪ Emergent vegetation such as *Tecticornia verrucosa* may be present

Wetland Group = ___________________________________

Wetland evaluation field sheet

Department of Environment and Conservation

Naturalness

3. Assess disturbance of / from:

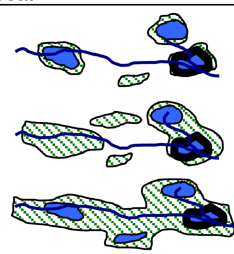
(a) Land use

Degrading land use	% Within 1 km of wetland	Final Score
Cropping		1 = >50% 2 = 20 – 50% 3 =0 – 20%
Grazing		
Forestry		
Other		
Final land use score		

(b) Structures

Structures present	% Wetland affected	Final Score
Drains		1 = ≥30% 2 = 1 – 30% 3 = 0%
Roads		
Dams		
Other		
Final structures score		

(c) Vegetation

Index	Scoring method	Score
% Buffer veg remaining within 50m of wetland	1 = 0 - 25, 2 = 26 - 75% 3 = 76 - 100%	____
Buffer vegetation condition	1 = Significant tree death 2 = Some tree death 3 = No tree death	____
Connectivity of vegetation with other wetlands *(wetland highlighted in diagram is the wetland in question, if wetland isolated, no score is given)*	1 = Low 2 = Medium 3 = High 	____
Presence of weeds	1 = Heavy weed infestation, some dominant 2 = Some weeds present but none dominating vegetation communities 3 = Weeds absent or very scarce	____
Final Score for vegetation	**= Sum scores ÷ 4**	

(d) Water chemistry

Index	Reading	Reference ranges for each wetland group	Scoring method	Score
pH: *(do not score naturally acidic basins)*	__ . __ __	Naturally saline basin 7.8 – 8.9 Freshwater basin 6.9 – 8.1 Freshwater claypan 8.6 – 8.9	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Salinity:	_ _ _ _ _ _ ppK	Naturally saline basin N/A Freshwater basin 0 – 3.0 Freshwater claypan 0 – 1.0	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Total Soluble N	________µg/L	Naturally saline basin < 1200 Freshwater basin < 2075 Freshwater claypan < 2325	3 = inside ref range 2 = <10% outside ref range 1 = >10% outside ref range	____
Final score for modification to water chemistry			**= Sum scores ÷ 3**	

(e) Hydrology – Is their evidence that the wetlands hydrological regime has altered from its natural state? ________

Final Score for modification to hydrology *(No – Score = 3, Yes – Score = 1)*

Final naturalness score

Indicator	Score	Final Criteria Score
Degrading land use		= Sum of scores ÷ no. of scores ___ . ___
Degrading structures		
Vegetation		
Water chemistry		
Hydrology		

Wetland evaluation field sheet

Department of Environment and Conservation

Diversity

4. Assess level of diversity

(a) Structural

Possible wetland habitats	Present (1) / absent (0)	Structural diversity reference range for each wetland group	Score
Submerged vegetation			____
Emergent shrubs			
Emergent reeds			
Surrounding terrestrial veg.			
Large woody debris			
Leaf litter			
Deep water zones (≥1.5m)			
Shallow wading zones			
Island			
Total			

Wetland group	Score = 3	Score = 2	Score = 1
Naturally saline basin	>4	N/A	0 – 4
Freshwater basin	>5	3 – 5	0 – 2
Freshwater claypan	>1	N/A	0 – 1

(b) Floral *(Ensure samples are collected as outlined in* Appendix C*)*

Vegetation type	No. Sp found	Species richness reference range for each wetland group	Score
Submerged	______	see below	____
Emergent	______	see below	____
Terrestrial, but restricted to wetland periphery	______	see below	____
Final score for native flora diversity		**=sum scores ÷ 3**	

Submerged:

Wetland group	Score = 3	Score = 2	Score = 1
Naturally saline basin	>1	N/A	0 - 1
Freshwater basin	>2	N/A	0 - 2
Freshwater claypan	>0	N/A	0

Emergent:

Wetland group	Score = 3	Score = 2	Score = 1
Naturally saline basin	>2	1 - 2	0
Freshwater basin	>5	1 - 5	0
Freshwater claypan	>1	1	0

Terrestrial, but restricted to wetland periphery:

Wetland group	Score = 3	Score = 2	Score = 1
Naturally saline basin	>27	12 - 27	<12
Freshwater basin	>12	4 - 12	<4
Freshwater claypan	>9	7 - 9	<7

(c) Fauna *(Ensure samples are collected as outlined in* Appendix C*)*

Fauna category	No. Sp found	Species and family richness reference range for each wetland group	Score
Invertebrates *(For further information on the invertebrate identification process see section 4.3.3 of this framework)*	______	see below	____
Waterbirds	______	see below	____
Final score for native fauna diversity		**=sum scores ÷2**	

Invertebrates:

Species	Score = 3	Score = 2	Score = 1
Naturally saline basin	>15	6 – 15	0 – 5
Freshwater basin	>48	25 – 48	0 – 24
Freshwater claypan	>33	27 – 33	0 – 26

All families	Score = 3	Score = 2	Score = 1
Naturally saline basin	>15	7 – 15	0 – 6
Freshwater basin	>33	19 - 33	0 – 18
Freshwater claypan	>23	19 – 23	0 – 18

Macroinvertebrate fam.	Score = 3	Score = 2	Score = 1
Naturally saline basin	>10	5 – 10	0 – 4
Freshwater basin	>21	14 – 21	0 – 13
Freshwater claypan	>20	14 – 20	0 – 13

Waterbirds:

Wetland group	Score = 3	Score = 2	Score = 1
Naturally saline basin	>6	N/A	0 - 6
Freshwater basin	>9	3 - 9	0 - 2
Freshwater claypan	>2	N/A	0 - 2

Final wetland diversity score

Indicator	Score	Final Criteria Score
Structural diversity		= Sum scores ÷ number of scores
Floral diversity		___ . ___
Faunal diversity		

Wetland evaluation fieldsheet

Wetland conservation value

Department of Environment and Conservation

5. Calculate combined naturalness and diversity score

= average naturalness score + average diversity score ÷ 2

= ___________

6. Calculate final conservation value

Q.	Does OR is the wetland . .	Key	Details / comments
1	listed as a Ramsar or Directory of Important Wetlands wetland?	Yes: High conservation value No: go to *2*	
2	listed under any of the documents or is within any of the areas identified in Section 4.4?	Yes: High conservation value No: go to *3*	
3	support rare, threatened or significant fauna (including waterbirds protected under international agreements – see Appendix E**)**	Yes: High conservation value No: go to *4*	
4	support rare, threatened or prioritised flora – see Appendix G	Yes: High conservation value No: go to *5*	
5	support rare, threatened or significant ecological communities – see Appendix F	Yes: High conservation value No: go to *6*	
6	have a rare or threatened water chemistry or hydrology (e.g freshwater wetlands)	Yes: High conservation value No: go to *7*	
7	the only representative of its geomorphic type and wetland group combination within an area?	Yes: High conservation value No: go to *8*	
8	have a combined naturalness and diversity score >2.3?	Yes: High conservation value No: go to 9	
9	have a combined naturalness and diversity score ≥1.7?	Yes: go to *9* No: go to *10*	
10	a headwater or throughflow basin (i.e. has an influence on wetlands downstream)?	Yes: Intermediate conservation value No: Low conservation value	

Final conservation value assigned to wetland (please circle)

High **Intermediate** **Low**

Appendix C - Wetland survey protocol

Scope

This procedure describes the collection of water chemistry, invertebrate and waterbird data at basin wetland types that are intermittently to permanently inundated.

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 an adequately experienced staff member

Stores, equipment & preparation

The following section outlines the equipment necessary in collecting water chemistry, invertebrate and waterbird data at **one typical site,** therefore the inventory list must 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)

6.1 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, 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)

6.2 Invertebrate sampling equipment

- 250 µm net for benthic invertebrate sample (30cm long) (2)
- 50 µm net for plankton sample (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 (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)

6.3 Water bird sampling equipment

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

6.4 Miscellaneous

- Stationary – markers, pens, pencils, leads, erasers
- Waterproof fieldsheet (1)
- Clipboard (1)
- Folder for storing fieldsheets (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

6.5 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 site will be located. Select an area of the wetland that is easy to access, and most importantly representative of the entire wetland in terms of habitat availability, depth, anthropogenic influences etc.

- Fill in site details and general observations on the first page of the datasheet
  - Take a GPS reading on the bank of the wetland and record latitudes and longitudes in **decimal degrees**
  - 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
  - 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
  - Estimate the percentage of submerged and emergent macrophyte across the wetland and record on the datasheet
- Assign wetland to a geomorphic wetland type using inundation and landform characteristics. This sampling procedure is not suitable for wetlands that are waterlogged or located on flat or slope landforms
- Assign the wetland to a wetland group: naturally saline lake, freshwater lake (includes artificial reservoirs), freshwater claypan or granite outcrop. 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 (note that degraded freshwater lakes are usually saline to hypersaline)
- Take digital photos that represent the site (e.g. one facing the wetland and one facing away from the wetland) and record the photo numbers on the fieldsheet
- Assess the disturbance to the wetland by completing the following components:
  - Percent of degrading land uses within 1 km of wetland. Aerial photography can be used to estimate this
  - Percent of wetland affected by degrading structures (for example a structure such as a drain affects the entire wetland)
  - Vegetation - percent buffer remaining, vegetation condition, vegetation connectivity with other wetlands and impacts from weeds

6.6 Collect *in situ* water quality measurements

Prior to collecting *in situ* water quality measurements, the **calibration of the pH 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 a representative site is found, place the pH and conductivity/salinity probes in undisturbed 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 2 of the fieldsheet. Ensure that the units recorded match the units specified on the datasheet.

Note: To convert from mS/cm to μS/cm multiply by 1,000 (e.g. 1mS/cm = 1,000 μS/cm). To convert from ppK to ppM multiply by 1,000 (e.g. 1 ppK = 1,000 ppM)

6.7 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

6.7.1 Unfiltered general chemistry sample (500mL – Cl, pH, EC, Alkalinity, HCO_3, CO_3, SO_4, colour, turbidity, TDS)

- 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 downstream (if there is any flow) 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
- 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 write over the scratching with permanent marker
- There is no preservation method required for this sample

6.7.2 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
- 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 two steps
- 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
- 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 claypans filtering is impossible so collect an unfiltered 125mL water sample and make a note on the fieldsheet.

6.8 Collect invertebrate sample

6.8.1 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 in the assessment the different wadable depths available, there is 50 metres of sample to be collected (for example 10m bare sediment (5m shallow, 5m deep), 20m macrophyte (all shallow), 10m leaf litter (2m shallow, 8m deep), 10m sedges (all shallow))
- 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
  - Vigourously 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.

- 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)
- Record on the datasheet that this sample has been taken as well as the percentage of different habitats sampled
- 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

6.8.2 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 <u>50 metres of sample to be collected</u> (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. <u>Never</u> touch the sediment with the net
    - Macrophytes – <u>Very gently</u> 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 <u>rare occasion</u> 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
- Record on the datasheet that this sample has been collected as well as the different percentage of habitats sampled
- Estimate the maximum sample depth and record in the appropriate place on the datasheet
- Estimate the percentage of different substrate types encountered during the invertebrate sampling and record in the appropriate place on the datasheet
- Place 50 µm mesh net in a sealed container of dilute Decon. At the end of the day wash the net under the tap and leave to dry

    <u>Note:</u> Always wash hands thoroughly after using formalin fixative as it is a known carcinogen

6.9 Collect waterbird data

Depending on the size of the wetland, waterbird data is collected in different ways

- Use estimates of wetland size and maximum depth of wetland to determine method of assessment

6.9.1 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)

6.9.2 Large, shallow wetlands

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

6.9.3 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, or large, shallow wetlands that cannot be traversed on foot

- Identify birds using binoculars or spotting scope and the waterbird field guide
  - Listen for clamorous reed warblers in dense reeds
- Record abundance counts of all species present on datasheet
  - 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

6.10 Structural diversity

- After all samples have been collected, record the number of habitats identified in the wetland on page 3 of the fieldsheet.

6.11 Floral diversity

- The floral survey should be conducted by botanists experienced in identifying both aquatic and terrestrial wetland-related vegetation to species level
- Identify the species of **native** flora observed at the wetland in each of the habitat types and record on page three of the fieldsheet:
  - Submerged
  - Emergent
  - Terrestrial vegetation restricted to wetland landforms

Interferences

6.11.1 *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)

6.11.2 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

6.11.3 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

6.11.4 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

6.11.5 Floral diversity

The interferences associated with the collection of floral data are:

- Incorrect identification of vegetation
- Underestimation of diversity due to missed sightings

Appendix D - 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

Wetland or area	Regional water assets identified during the Salinity Investment Framework project	ACC - local water assets		
		Highly valued	Iconic	Threatened
Beaton Lake				✓
Carratti Lake				✓
Corrigin Water Reserve		✓		
Cowcowing Lakes		✓	✓	
Dragon Rocks Nature Reserve	✓			
Gnamma Holes near Trayning	✓			
Hamilton Dam	✓			
Harvey Lake				✓
Hunts Well at Tammin		✓		
Job Lake				✓
Kokerbin Rock		✓		
Bandee Lakes	✓			
Lake Borona				✓
Lake Bryde Wetlands Complex	✓		✓	
Lake Camm			✓	
Lake Campion	✓			
Lake Grace System (many lakes incl. Lake Grace North, Lake Grace South, Lake Altham, Cemetery Lake, Chinocup Lake)	✓(significant indigenous heritage)		✓	
Lake Gulson			✓	
Lake King	✓			
Lake Kondinin			✓	
Lake Kurrenkutten			✓	
Lake Mcdermott System				✓
Lake Mears	✓			
Lake Royston			✓	
Lake Wallambin				✓
Mt Roe Dam	✓	✓		
Myarin Rock		✓		
Narembeen Ski Lake				✓
Paperbark Swamp				✓
Perched freshwater wetlands around Dowerin	✓			
Pink Lake			✓	
Scotsman Lake		✓		
Sewell Rock			✓	
Wadderin Dam/WR	✓	✓	✓	
Wagerlin Rock			✓	
Water Corporation tanks in Mount Marshall	✓			
Water resources on freshwater seeps	✓			
Wave Rock	✓			
Yealering Lake System (Brown lake, White Water Lake, Nonalling Lake, Yealering Lake)	✓	✓		
Yenyenning Lakes	✓		✓	
Yorkrakine Rock Pools	✓	✓		

Appendix E - Bird species protected under national and international agreements and legislation, that have been recorded in inland South-Western Australia

Common name	Scientific name	JAMBA	CAMBA	ROKAMBA	WCP for migratory shorebirds	IBA	Australian Status	WA gov. threatened species	CMS -Threatened with Extinction
Australasian Bittern (30)*	*Botaurus poiciloptilus*					✓		✓	
Australasian Darter (1,000)	*Anhinga melanogaster*					✓			
Australasian Grebe (5,000)*	*Tachybaptus novaehollandiae*					✓			
Australasian Shoveler (1,500)*	*Anas rhynchotis*					✓			
Australian Pelican (10,000)*	*Pelecanus conspicillatus*					✓			
Australian Shelduck (5,000)*	*Tadorna tadornoides*					✓			
Australian White Ibis (10,000)*	*Threskiornis molucca*					✓			
Australian Wood Duck (10,000)*	*Chenonetta jubata*					✓			
Banded Lapwing (5,000)*	*Vanellus tricolor*					✓			
Banded Stilt (2,100)*	*Cladorhynchus leucocephalus*					✓			
Bar-tailed Godwit (12,000)	*Limosa lapponica*	✓	✓	✓	✓	✓			
Black Swan (10,000)*	*Cygnus atratus*					✓			
Black-fronted Dotterel (170)*	*Charadrius (Elseyornis) melanops*					✓			
Black-tailed Godwit (7,500)	*Limosa limosa*	✓	✓	✓	✓	✓			
Black-tailed Native Hen (5,000)*	*Gallinula ventralis*					✓			
Black-winged Stilt (3,000)*	*Himantopus kimantopus*					✓			
Blue-billed Duck (150)*	*Oxyura australis*					✓			
Caspian Tern (3,000)	*Hydropogne tschegrava (Hydroprogne caspia)*		✓			✓			
Cattle Egret (60,000)	*Bubulcus ibis (Ardeola ibis)*	✓	✓			✓			
Chestnut Teal (1,000)*	*Anas castanea*					✓			
Common Sandpiper (40,000)*	*Tringa hypoleucos (Actitis hypoleucos)*	✓	✓	✓	✓	✓			
Crested Tern	*Sterna bergii*	✓							✓
Curlew Sandpiper (18,000)*	*Calidris ferruginea*	✓	✓	✓	✓	✓			
Dirk Hartog Island Rufous Fieldwren	*Calamanthus campestris hartogi*							✓	
Dorre Island Rufous Fieldwren	*Calamanthus campestris dorrie*							✓	
Eurasian Coot (100,000)*	*Fulica atra*					✓			
Freckled Duck (250)*	*Stictonetta naevosa*					✓			

Common name	Scientific name	JAMBA	CAMBA	ROKAMBA	WCP for migratory shorebirds	IBA	Australian Status	WA gov. threatened species	CMS -Threatened with Extinction
Glossy Ibis (25,000)*	*Plegadis falcinellus*		✓			✓			✓
Great Cormorant (17,000)*	*Phalacrocorax carbo*					✓			
Great Crested Grebe (12,000)*	*Podiceps cristatus*					✓			
Great Egret (White Egret) (20,000)*	*Egretta alba*	✓	✓			✓			
Greenshank (Common Greenshank) (14,000)*	*Tringa nebularia*	✓	✓	✓	✓	✓			
Grey (Black-bellied) Plover (7,000)*	*Pluvialis squatarola*	✓	✓	✓	✓	✓			
Grey Teal (20,000)*	*Anas gracilis*					✓			
Gull-billed Tern (3,400)*	*Sterna nilotica*					✓			
Hardhead (10,000)*	*Aythya australis*					✓			
Hoary-headed Grebe (5,000)*	*Poliocephalus poliocephalus*					✓			
Hooded Plover (105)*	*Thinornis rubricollis*					✓			
Inland Dotterel (140)	*Peltohyas (Charadrius) australis*					✓			
Intermediate Egret (10,000)	*Ardea intermedia*					✓			
Latham's Snipe (Japanese Snipe) (370)	*Gallinago hardwickii (Capella hardwickii)*	✓	✓	✓	✓	✓			
Little Bittern (4,000)	*Ixobrychus minutus*					✓			
Little Black Cormorant (10,000)*	*Phalacrocorax sulcirostris*					✓			
Little Curlew (Little Whimbrel) (1,800)*	*Numenius minutus (Numenius borealis)*	✓	✓	✓	✓	✓			
Little Egret (20,000)	*Ardea (Egretta) garzetta*					✓			
Little Pied Cormorant (5,000)*	*Phalacrocorax melanolucos*					✓			
Little Ringed Plover	*Charadrius dubius*		✓	✓					
Little Stint	*Calidris minuta*			✓					
Long-toed Stint (250)	*Calidris minutilla (including Calidris subminuta)*	✓	✓	✓	✓	✓			
Magpie Goose (60,000)	*Anseranas semipalmata*					✓			
Marsh Sandpiper (12,000)	*Tringa stagnatilis*	✓	✓	✓	✓	✓			
Musk Duck (500)*	*Biziura lobata*					✓			
Nankeen Night Heron (10,000)*	*Nycticorax caledonicus*					✓			
Night Parrot	*Pezoporus occidentalis*					✓	Endangered	✓	
Oriental Plover (700)	*Charadrius veredus*			✓	✓	✓			
Oriental Pratincole (29,000)	*Glareola maldivarum*		✓	✓	✓	✓			
Pacific Black Duck (6,000)*	*Anas superciliosa*					✓			
Painted Snipe (5,000)	*Rostratula benghalensis*		✓			✓	Vulnerable	✓	
Pectoral Sandpiper	*Calidris melanotos*	✓		✓	✓				

Common name	Scientific name	JAMBA	CAMBA	ROKAMBA	WCP for migratory shorebirds	IBA	Australian Status	WA gov. threatened species	CMS -Threatened with Extinction
Pied Cormorant (5,000)*	*Phalacrocorax varius*					✓			
Pink-eared Duck (10,000)*	*Malacorhynchus membranaceus*					✓			
Pintail Snipe (Pin-tailed Snipe)	*Gallinago stenura (Capella stenura)*		✓	✓	✓				
Plumed Whistling-Duck (10,000)	*Dendrocygna eytoni*					✓			
Red-capped Plover (950)*	*Charadrius ruficapillus*					✓			
Red-kneed Dotterel (5,000)*	*Erythrogonys cinctus*					✓			
Red-necked (Northern) Phalarope (Red-necked Phalarope)*	*Phalaropus lobatus*	✓	✓	✓	✓				
Red-necked Avocet (1,100)*	*Recurvirostra novaehollandiae*					✓			
Red-necked Stint (3,200)*	*Calidris ruficollis*	✓	✓	✓	✓	✓			
Royal Spoonbill (1,000)	*Platalea regia*					✓			
Sharp-tailed Sandpiper (1,600)*	*Calidris acuminata*	✓	✓	✓	✓	✓			
Silver Gull (20,000)*	*Larus novaehollandiae*					✓			
Straw-necked Ibis (10,000)*	*Threskiornis spinicollis*					✓			
Wandering Whistling-Duck (20,000)	*Dendrocygna arcuata*					✓			
Whiskered Tern (10,000)*	*Chlidonias hybridus*					✓			
White-faced Heron (5,000)*	*Ardea novaehollandiae*					✓			
White-necked Heron (500)*	*Ardea pacifica*					✓			
White-winged Black Tern (30,000)	*Chlidonias leucopterus (Sterna leucoptera)*	✓	✓	✓		✓			
White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren	*Malurus leucopterus leucopterus*						Vulnerable	✓	
Wood Sandpiper (33,000)*	*Tringa glareola*	✓	✓	✓	✓	✓			
Yellow-billed Spoonbill (1,000)*	*Platalea flavipes*					✓			

Numbers in brackets indicate the 1% threshold of global populations. If numbers exceeed this at a site, it becomes an Important Bird Area

JAMBA = Japan-Australia Migratory Bird Agreement

CAMBA = China-Australia Migratory Bird Agreement

ROKAMBA = Republic of Korea-Australia Migratory Bird Agreement

WCP = Wildlife Conservation Plan

IBA - Important Bird Areas

CMS – Conservation of Migratory Species

** - previously recorded at wetlands in the Avon*

Appendix F - Threatened Ecological Communities listed in the Avon-Wheatbelt area

Source: Western Australia Threatened Species and Communities website

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 Edangered; EN – Endangered; VN – Vulnerable; PD – Presumed Destroyed

Appendix G - Rare, threatened or prioritised flora that were recorded at Wheatbelt wetlands during the SAP biological survey

Scientific name	Conservation Code
Angianthus drummondii	3
Angianthus micropodioides	3
Astartea sp.Esperance(A.Fairall 2431)	1
Austrostipa geoffreyi	1
Blennospora phlegmatocarpa	3
Brachyscome halophila	3
Calandrinia porifera	3
Chamaescilla gibsonii	3
Dampiera orchardii	2
Drosera salina	2
Epitriche demissus	2
Eryngium pinnatifidum	3
Fitzwillia axilliflora	2
Frankenia bracteata	1
Frankenia conferta	R
Frankenia drummondii	3
Frankenia glomerata	3
Gastrolobium propinquum	1
Gnephosis setifera	1
Goodenia sp.Lake King(M.Gustafsson et K.Bremer 132)	2
Haegiela tatei	2
Hopkinsia adscendens	3
Hopkinsia anoectocolea	3
Hydrocotyle coorowensis	2
Hydrocotyle hexaptera	1
Hydrocotyle muriculata	1
Hydrocotyle vigintimilia	1
Hypoxis salina	1
Isoetes brevicula	3
Isolepis australiensis	2
Lepidium genistoides	2
Melaleuca incana	3
Microseris scapigera	3
Millotia steetziana	2
Mimulus repens	3
Muehlenbeckia horrida	R
Myriocephalus appendiculatus	3
Pimelea halophila	2
Podotheca pritzelii	2
Ptilotus fasciculatus	R
Rhodanthe pyrethrum	3
Roycea pycnophylloides	R
Sarcocornia globosa	3
Schoenus natans	4
Tribonanthes minor	3
Triglochin protuberans	3
Triglochin stowardii	3
Velleia exigua	2
Villarsia submersa	4
Wurmbea murchisoniana	4

R = declared rare flora
1 = taxathat are known from one or few (generally<5) populations that are under threat
2 = taxa that are known from one or few (generally <5) – some not believed to be under immed. threat
3 = taxa that are known from several populations – some not believed to be under immed. Threat
4 = taxa that are considered to be adequately surveyed – not currently threatened, still require monitoring