Technical review Coorong and Lakes Alexandrina and Albert 2006 Ecological Character Description

November 2011

Water's Edge Consulting
Environmental Management and Aquatic Sciences

Technical review of The Coorong, Lakes Alexandrina and Albert Ecological Character Description – Phillips and Muller (2006).

Final report November 2011

Report prepared for South Australian Department of Environment and Natural Resources by Dr Rhonda Butcher, Water's Edge Consulting.

Citation: Butcher, R.J. 2011. Technical review of The Coorong, Lakes Alexandrina and Albert Ecological Character Description. Prepared for the Department of Environment and Natural Resources, South Australia.

Acknowledgements: This review was undertaken in association with, and input from, the following SA DENR staff: Jason Higham, Russell Seaman, Amy George, and Rebecca Lester.

Front cover photo credits:
Banded stilt © Ian Montgomery, Birdway.
Red-necked avocet © Ian Montgomery, Birdway.
Curlew sandpiper © Ian Montgomery, Birdway.

Table of Content

1. Executive Summary

Phillips and Muller (2006) describes the ecological character of The Coorong, Lakes Alexandrina and Albert Ramsar site, however it was developed prior to the establishment of the national framework (DEWHA 2008) for developing Ecological Character Descriptions and therefore does not meet current requirements. This report presents the findings of a technical review of Phillips and Muller 2006) which identified the following:

- Phillips and Muller (2006) does not meet the current requirements under the national framework for preparing Ecological Character Descriptions (ECD). Several key sections are not at an acceptable level and require updating. These include:
    - criterion justification,
    - establishing the critical components, processes and services (CPS), and
    - the Limits of Acceptable Change (LAC).
- Coverage of ecosystem services in Phillips and Muller (2006) is inadequate and is a key area which needs attention.
- Phillips and Muller (2006) LAC are inadequate and predominantly not measurable or are written as management triggers. LAC were not presented for key biota and this is a major area in which further work is required.
- Some of the management triggers in Phillips and Muller (2006) may be able to be used in the development of a Ramsar Management Plan and monitoring program for maintaining the ecological character of the site. DENR should review these with the view of developing a nested set of management triggers and LAC and incorporate both into an appropriate monitoring program.
- The emphasis on management actions and issues presented in Phillips and Muller (2006) needs to be removed. ECD are not intended to be management plans. A large amount of the material presented in Phillips and Muller (2006) belongs in a management plan for the site.
- A complete restructure and rewriting of the ECD to reflect the steps in the national framework is required.
- A substantial amount of additional data have been collected for this site since 2006. The updated ECD should capture this material, in particular the conceptual modeling undertaken by Souter (2009a and b), and the relative findings/recommendations from the Murray Futures, Lower Lakes and Coorong Recovery program (Lester et al. 2011).

2. Scope

The Department of Environment and Natural Resources (DENR) South Australia intends to update the first Ecological Character Description (ECD) of the Coorong and Lakes Alexandrina and Albert Ramsar site (Phillips and Muller 2006) to align with current Australian Government requirements for ECD under the national framework for preparing ECD (DEWH 2008). In order to undertake the update guidance on where Phillips and Muller (2006) a compliance and technical review was sought. This review was supplied by Dr Rhonda Butcher, Water's Edge Consulting 7th October 2011.

This report contains three sections:

1. A technical and compliance review of the Coorong, Lakes Alexandrina and Albert ECD (Phillips and Muller 2006) against the national framework for preparing an ECD.

2. A review of LAC presented in Phillips and Muller (2006) with discussion on current guidance for preparing LAC. This includes discussion on the distinction between management triggers, interim LAC and LAC.
3. A review of existing conceptual models and their relevance for inclusion in an updated ECD.

An updated ECD will increase confidence with regards to reporting on status of ecological character for this site.

3. Technical and compliance review

This review has been undertaken based on advice received from SEWPaC (unpublished) regarding development of Limits of Acceptable Change (LAC), DEWHA (2008) National framework for preparing ECD, and guidance in the Ramsar Strategic Framework and guidelines (see http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-31-105^20823_4000_0__#V)

Phillips and Muller (2006) is a substantial piece of work, but is overly long and contains a large amount of material that is not relevant to an ecological character description under current guidelines. Significant departures from the national framework for preparing an ECD are evident. A notable feature of the ECD is the emphasis on management issues; these are not typically captured in ECD prepared inline with the national guidelines. ECD are not management plans.

Key areas needing attention are the criterion justification, establishing the critical components, processes and services (CPS) and the LAC. A summary of the technical review as per SEWPaC checklist is provided below and should be read in conjunction with comments made in the ECD. A complete restructure of the ECD to reflect the steps in the national framework is required. A suggested TOC is presented in Appendix A as a guide.

3.1 SEWPaC Checklist

In line with recent advice from SEWPaC, this review identifies areas that require action to meet the requirements of SEWPaC and the Ramsar Convention. These are contained in the checklist table below.

☑ indicates acceptable level of detail (may require some minor editing); ☑☒ indicates additional information or clarification required, significant editing required; ☒ complete section missing or requiring complete rewrite.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
☒	Executive summary of the ecological character of the site.	As it currently stands there is insufficient information regarding the specifics of the ecological character of the site and the Executive Summary format is not appropriate in terms of meeting the national framework. Here and throughout the rest of the document there is a strong emphasis is on obligations associated with managing a Ramsar site – this does not belong in an ECD, but rather a management plan. The Exec summary currently focuses on threats and operational concerns – this does not belong in the ECD except in the broadest terms.	To be updated in new draft. Needs to be a plain English summary of the main sections of the ECD. Avoid using a series of tables where possible as this is often considered insufficient. Restate/summarise location, time of listing, site description, criteria met, critical CPS, threats, LAC, changes since listing, any criteria no longer met, knowledge gaps and briefly discuss monitoring. Make it clear this is the second ECD prepared but the first using the national framework.
☑	Acknowledgements.	This should include a description or list of the people and organisations involved in developing or contributing to the ecological character description, including any funding bodies. Much of the information in the front of the document can be consolidated in the new draft – see notes in	To be updated in new draft.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
		ECD for specific comments.	
☑	Table of Contents.	None required.	To be updated in new draft.
☑	List of abbreviations.	None required.	To be updated in new draft.
☑☒	Site Details.	Existing information is not adequate – needs updating. In particular the site map (Fig 3 Phillips and Muller 2006) needs to show all key locations including North and South Lagoons, Finniss River and Currency Creek etc.	To be updated in new draft. Need to add standard table as per DEWHA (2008).
☑☒	Statement of purpose.	This should be brief and to the point – see recent ECD as examples – e.g. The Dales, Hosnie Springs, and Kakadu – as they become available on http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl .	To be updated in new draft.
☒	Relevant legislation.	Not in Phillips and Muller (2006).	The ECD is not a management document, and as such this information presented in this section can be brief – need to mention international (Ramsar, JAMBA, CAMBA etc) national (EPBC Act, Water Act etc) and state legislation which is relevant to the site. Provide a short paragraph for each relevant piece of legislation.
☑☒	Description of the site location.	Material in Phillips and Muller should be expanded – see DEWHA 2008 and published ECD at http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl for guidance/example.	To be updated in new draft. Need to put in context of bioregion – e.g. MDB.
☑☒	Maps, images and photographs of the site (including a map of the Ramsar site, clearly showing its	See individual comments in text. Most maps should be reusable in new draft.	To be updated in new draft.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
	location and the boundaries of the site), Maps should include border, orientation, legend, title and scale. Wetland boundaries should be drawn onto maps and satellite photographs.	If reused, Figure 6 Phillips and Muller (2006) needs fixing – several of the water source/inflows text boxes are pointing to the wrong locations. Figure 17 – OBP predicted habitats. Get actual count data and overlay – include assessment of areas within the boundary of the site only. Modify legend to make clear that the orange colour is predicted habitat – *not* OBP sightings. Figure 18 is not that informative, suggest delete or replace with map with localities of frogs within the site. Figures 14,15, 17-19, 24, 31 all need Ramsar boundary added. Figure 28 Legend is not legible, needs to be updated if used in updated ECD.	
☑☒	Description of the land tenure.	Not captured adequately.	To be updated in new draft. Should be brief, only a few paragraphs are required.
☒	The relevant listing criteria (e.g. Ramsar or DIWA).	The information regarding which criteria are met and the justification for each is spread throughout the document and is not adequate in some cases. For example 'regularly supports' has not been clearly illustrated for criterion 5.The RIS (Appendix C) provides more detail – this should be expanded on and moved up front of the document.	This should be a stand alone section at the front of the document – see proposed TOC. It needs to include actual data/graphs illustrating how each criterion is met. Criterion 2 should only be wetland dependent spp., criterion 5 and 6 should have actual data presented rather than just a list of species. Need to illustrate 'regularly supports' part of criterion is met. Criterion 1 and 3 need to

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
			be set in the context of the bioregion. See section 3.2 this report for more detail.
☑☒	A list and map of the wetland types within the wetland.	This is well covered in section 4 of Phillips and Muller (2006); however it is overly long and contains material best used elsewhere. There is considerable discussion of pre settlement or natural conditions – this should be removed from this section and presented in the section dealing with change since listing (where relevant). The description of wetland types is meant to represent the time of listing – not a dialogue on what has changed since pre-settlement. Much of the material on key biota could be moved to the sections describing components, processes and services.	Reduce this section considerably – the traffic light assessment should be removed. This should be a brief description of the six sub systems at the time of listing with a brief paragraph or two describing each of the wetland types. Reference to LAC should be removed.
☒	A summary of the critical components, processes and benefits/services of the wetland.	Not present. This is a major area which needs attention – the identification of critical CPS. Section 3 in Phillips and Muller (2006) is supposed to present an overview, however the detail specific to the site is lacking for most of the section and provides only very general statements which are more ecological theory than a description of the character of the site.	Undertake workshop to identify critical CPS using guidance as per DEWHA – this should be done prior to commencing writing – will speed things up. A draft list for discussion is presented in this report – see section 2.3. In the section/s on critical CPS a summary table should be included which lists key features for each critical CPS The overview section needs considerable rework – it should set the scene and provide context. Include a brief statement re criteria met, location - catchment context, site map, summary statement re range of wetland types. Include a summary of biota - number of

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
			spp across all groups - include terrestrial biota as relevant.
☒	A conceptual model for the site.	A simple model is presented in Figure 7 Section 3 (Phillips and Muller 2006); however this needs to be updated to reflect the terminology of DEWHA (2008).	Suggest keep a modified version of Figures 7 (Phillips and Muller 2006) but add critical services as a minimum. May also want to add linkages to Ramsar criteria met. This conceptual model is meant to be simple, and in itself meets the requirements of the national framework, however several additional models should be added to illustrate the ecological character of the site. These could include: Sub-system character models: 1. Freshwater lakes – main drivers and critical CPS associated with each of the lakes. 2. Freshwater wetlands/tributaries – importance of habitat for fish and endangered species. 3. Coorong and Murray Mouth – flushing of the Coorong and influence on critical CPS 4. Overarching – connection of lakes and Coorong – influence of barrages, opening of Murray mouth or, critical CPS models

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
			1. Hydrology – illustrate how this critical component/process works 2. Fish 3. Waterbirds 4. Plants 5. Salinity See section 4 for additional comments re existing models developed by Souter (2009). The range of models included in updated ECD will ultimately depend on the list of critical CPS.
☑ ☒	A quantitative description of the critical components, processes, benefits/services of the site and the relationships between them. Including the reasons why they were chosen.	Descriptions are provided of Ramsar significant ecological communities and species (section 5) and primary determinants (section 6). Language needs to be aligned with that of the framework. Much of the information presented in section 5 could be used to detail critical services (see text for comments). There is a fair amount of repetition in the ECD and the material presented in section 5 and 6 could be reduced considerably. Also there are a substantial number of tables, some of which can be put into appendices. Not sure why section 6 suddenly has dot points instead of paragraphs. There is too much emphasis on comparisons between pre settlement or natural conditions to current. Considerable detail on management issues is a strong theme throughout the ECD and in particular in section 6. Material on management issues should not be included in an ECD other than in setting the context of the site and in detailing changes since listing. The ECD describes the site at the time of listing.	The material in Phillips and Muller (2006) should be reworked to reflect the approach of essential elements and critical CPS. A suggested list of each of these is provided in section 2.3 of this review. In addition a suggested Table of Contents is provided to help structure the new ECD.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
☒	Limits of acceptable change for the key components, processes, benefits/services of the site.	This section needs updating to match current guidance on setting of LAC. Phillips and Muller (2006) LAC are in general not measurable, are written as management targets and lacking for key biota. LAC are provided for six primary determinants, 23 wetland types and 13 Ramsar significant biological components. There are a number of management triggers called LAC and interim LAC are also used. No LAC are presented for services.	Update to match list of critical CPS. See section 3 of this report for further guidance and comments on each LAC provided in Phillips and Muller (2006).
☒	The likely threats to the ecological character of the site, the likely timing and impacts or potential effects of the threat on the ecological character.	There is substantial material on threats to the site presented in Phillips and Muller (2006), much more than in most ECD prepared around this time. According to DEWHA (2008) the section on threats is not to be overly detailed/long. The basics are required – what threats are occurring or likely, their impacts on critical CPS and the likely timing. A summary table should be included and if necessary a stressor model showing broad impacts to critical CPS.	Review conceptual models developed in Rolling Review for inclusion in the threat section of the updated ECD. Make sure summary table is included – this is a key output for this part of the framework. See other ECD as an example at http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl .
☒	Summary of the knowledge gaps.	This is lacking in Phillips and Muller (2006). Throughout the ECD reference is made to numerous knowledge gaps however these are not systematically captured.	Add a section which summarises knowledge gaps, recommended actions and priorities. See other ECD for an example of how to format this section of the ECD http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl .
☒	Identify any changes in ecological character e.g. any changes in components, processes, and/or benefits/services of the site. If possible state whether these changes were adverse and human induced and whether they	A stand alone section is not presented in Phillips and Muller (2006) however throughout much of the ECD, notably sections 5 and 6, there is significant information documenting change since listing.	Extract and summarise changes in ecological character since listing. Section of the ECD should firstly cover off on any site changes since listing (land tenure etc) and then document any changes in each of the critical CPS. As a minimum this would include description

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
	were beyond the bounds of normal seasonal variation or specified limits of acceptable change.		in change in hydrology, salinity, wetland vegetation, fish, and possibly several services such as physical habitat for breeding. This section must include a concluding statement regarding the status of ecological character and restate which listing criteria are met. Also included in this section should be an assessment against the LAC. This will help inform final statement re change in ecological character. See proposed TOC for subsection headings.
☒	The Ramsar criteria that the site met at time of listing and meets at present.	Not included. This forms part of the section detailing changes since listing.	Needs to be restated in the section dealing with change since listing – see proposed TOC.
☒	Recommendations for monitoring including frequency, type, and priorities.	The monitoring section contains a lot of information that is not required for an ECD. Most of the text presented in Phillips and Muller should be deleted.	A comprehensive monitoring program is beyond the scope of an ECD. What should be provided is an identification of monitoring needs required to both set baselines for critical CPS and to assess against LAC. It should be noted that the focus of the monitoring recommended in an ECD is an assessment against LAC and determination of changes in ecological character. This monitoring is not designed as an early warning system whereby trends in data are assessed to detect changes in components and processes prior to a change in ecological character of the site. The latter must be included in the management plan for the site.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
			The monitoring requirements can be summarised in table format with the following column headings: critical CPS, Purpose, Indicator, Location, Frequency, and Priority.
☒	Any communication, education and public awareness messages identified during preparation of the ecological character description.	Stand alone section not present.	Add to updated ECD – see other ECD as examples. Messages need to cover off on main values of the site.
☑	References and sources of information.	Assumed a reference check was undertaken – not reviewed.	Update as required.
☑☒	Glossary	A glossary is included in Phillips and Muller (2006) and needs to be cross referenced to that suggested in DEWHA (2008).	Update as required.
☒	Methods used to compile the description.	See comments in Sections 1-2 of Phillips and Muller (2006). Some material can be kept, however the method adopted for the update will reflect DEWHA (2008) requirements and as such some information in these sections will not be needed.	To be included in updated ECD.
☑ ☒	List of community assemblages for the site.	Much of the material presented in tables throughout Phillips and Muller (2006) should be removed to Appendices.	Update lists as needed.
☒	Short curriculum vitae for each author.	Not included in Phillips and Muller (2006).	To be included in updated ECD.
☒	Updated Ramsar Information Sheet.	Will need to be updated to latest RIS format. Criterion 2 only relates to wetland dependent spp. – don't include terrestrial plant species. Criterion 5 there is no evidence provided that the site meets the 'regularly support' part of the criterion – need an actual graph illustrating meets 'regularly support' i.e. 3 of 4	The update of the ECD will require that an updated RIS be prepared as well for submission to the Ramsar Convention.

☑ ☒	Requirement	Comment re Phillips and Muller (2006)	Recommended Action
		seasons for which there is data, not just a statement (this has been misapplied at a number of sites – hence the need to actually demonstrate it meets the criterion). A number of sub-criterion/decision rules have been applied in the RIS which should be reconsidered in terms of their applicability. Similarly criterion 6 makes the statement, but no data is presented to support this – need to show the data/numbers. Criterion 7 should be reassessed.	

3.2 Criteria and justification

Information regarding which criteria are met and the justification is presented in a number of places in Phillips and Muller (2006). This needs to be consolidated and actual data presented to support the claims provided. For each criterion there needs to be a statement regarding if it was met at the time of listing and at the time of writing the updated ECD. A table showing the original listing criteria and the criteria used in 2006 should be included as well as the original justification for listing the site. Any discrepancies between the last ECD and the updated ECD should be captured (both in the updated ECD and RIS). The following summarises the key points relevant to each criterion.

Criterion 1: This is not well addressed and needs to be revisited. In particular the justification for meeting criterion 1 needs to be set in the context of the bioregion. Key points are that the site is the only large estuarine system which includes substantial terminal freshwater wetlands – highlight the geomorphic significance of the site.

Criterion 2: Only relates to wetland dependent international or nationally listed species. Provide a list (species and common names) and an assessment on the strength of evidence based on records. An extract from the ECD for Hattah Lakes is provided as an example (Table 1). Each species may not necessarily be considered a critical at the site. Where there are data, present this – for example orange-bellied parrot, get data from Birds Australia.

Table 1: Extract from Butcher and Hale (2011) - Threatened species recorded in Hattah-Kulkyne Lakes Ramsar site post 1960 (CE = critically endangered; E = endangered; V = vulnerable).

Species	IUCN	EPBC	Records	Strength of evidence
Australasian bittern - *Botaurus poiciloptilus*	E	E	Listed as occurring at the site in DSE (2010), recorded at Lake Yerang in 1994 (Birds Australia 2011b) and 2010 (DSE unpublished).	The preferred habitat of this species is not common at the site and it is unlikely that the site supports this species.
Australian painted snipe - *Rostratula benghalensis*		V	Two birds at Lake Yerang in 2007 (Birds Australia 2011a). Unknown number of birds recorded in 2009 (GHD 2009 cited Goulburn-Murray Water 2010).	Despite the cryptic nature of this species there are a number of records from within the site. There is a reasonable degree of certainty that the site is important for this species.

Criterion 3: Needs to be set in the context of the bioregion. Not only concerned with species of conservation significance. Each of the Ramsar sub-criterion should be assessed and comparisons to other Ramsar sites in the MDB should be made (Riverland, Narran, Bool Hacks, Hattah etc). Need to emphasis the site as supporting biodiversity values representative of the bioregion.

Criterion 4: This criterion is reasonably well covered, but the information presented needs to be consolidated into one section. Include details on the size of any notable waterbird breeding events.

Criterion 5: Information is spread throughout Phillips and Muller (2006) but actual count data supporting this criterion is poorly presented. Need to present actual data – graphed

preferably, to indicate the concept of regularly supports as defined in the Ramsar guidelines (Ramsar 2009).

Criterion 6: Justification should include illustration of each species 'regularly supporting' 1% of their population – best done as a series of graphs which illustrates the 1% estimate.

Criterion 7: Guidance from the Ramsar Convention (Ramsar Convention 2009) on the application of this criterion indicates that in order to meet this criterion, a site should have a high degree of endemism or biodisparity in fish communities. A site can potentially qualify based on the proportion of fish species present that are endemic to the site (must be greater than 10 per cent) or by having a high degree of biodisparity in the fish community. Biodisparity is the range of morphologies and reproductive styles in a community. The biodisparity of a wetland community is determined by the diversity and predictability of its habitats in time and space: "*i.e., the more heterogeneous and unpredictable the habitats, the greater the biodisparity of the fish fauna. For example, Lake Malawi, a stable, ancient lake, has over 600 fish species of which 92% are maternal mouth brooding cichlids, but only a few fish families. In contrast, the Okavango Swamp of Botswana, a palustrine floodplain that fluctuates between wet and dry phases, has only 60 fish species but a wider variety of morphologies and reproductive styles, and many fish families, and therefore has a greater biodisparity. Measures of both biological diversity and biodisparity should be used to assess the international importance of a wetland"* from Ramsar (2009).

The decision rules for this criterion as presented in the RIS in Attachment 6 of Appendix C (Phillips and Muller 2006) are not all relevant. In particular the argument that species which met criteria 2,3 and 4 automatically meet criterion 7 is incorrect. This criterion is about biodiversity as a whole, not about listed species. It is also targeted at identifying sites of global biodiversity value – not national, as such there are relatively few sites in Australia that would meet this criterion. Also having one or two endemic species in the site is not adequate to meet this criterion. This criterion is not about single species, but about the whole community.

The Coorong and Lakes may meet this criterion on the basis of biodisparity – the range of morphologies and reproductive styles present. In the strict sense, it's unlikely that any Australian sites actually meet this criterion as we do not have large freshwater fish faunas, despite this, cases have been made for Australian estuarine sites meeting this criterion. This criterion includes shellfish, but has rarely been applied to these in Australia. Overall measures of biodisparity should be included in the justification for meeting this criterion.

Criterion 8: The decision rules applied in the RIS for this criterion are acceptable.

Criterion 9: Need to make an assessment against this criterion – it is unlikely to be met as for most invertebrates, amphibians, fish reptiles and mammals we do not have population data on which to make the assessment. A statement to this effect is likely all that can be included at this point in time.

3.3 Essential elements and critical CPS

Recent guidance from SEWPaC regarding the preparation of ECD has acknowledged that not all components, processes and services are critical to the ecological character of the site. Essential elements are those considered important in supporting the critical components, processes, benefits and services of the site, but they may undergo change without a necessary change in ecological character.

> ***From SEWPaC Unpublished.***
>
> ***Background – Critical CPS***
> *Some conceptual models, when limited to critical components, processes or services/benefits (CPS), did not fully represent the wetland system. The alternative, in considering all CPS of the conceptual models to be critical CPS, can result in too many CPS for them all to be considered critical. It recognised that not all CPS can be critical, and that critical CPS can have dependencies and relationships with other CPS (that may not be considered critical).*
>
> ***Essential Elements***
> *An essential element is a component or process that has an essential influence on the critical CPS of the wetland. Should the essential element cease, reduce, or is lost, it would result in a detrimental impact on one or more critical CPS. Critical CPS may depend in part or fully on essential elements, but an essential element is not in itself critical for defining the ecological character of the site.*
>
> *LAC are not required to be established in an ECD for essential elements. The necessity for their existence or their maintenance is instead accounted for in an ECD through the requirement to have LAC for those critical CPS that depend on them.*
>
> *Essential elements should be identified and described for a wetland, including identification of what critical CPS are dependent on them. These relationships should be clearly outlined within the conceptual model(s).*
>
> *Essential elements may (depending on the wetland) include components or process such as tidal regime, salinity level, extent of a particular vegetation type depending on the site being considered. In other cases these might be critical CPS.*
>
> *Justification for the selection of what critical elements are identified should be included in the critical elements part of the ECD.*
>
> *Essential Elements in some ECDs may have a different terminology such as supporting CPS*

Identifying critical CPS

The critical CPS of a Ramsar site should be identified using criteria specified in DEWHA (2008). Critical CPS:

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

These are meant to be used as a guide only, often with expert site knowledge deciding the final list. With respect to threatened species, only those for which the site comprises important habitat and which meet all four of the DEWHA (2008) criteria should be included as critical CPS i.e have a LAC specified. Some ECD have been prepared with all nationally listed species being considered as critical components/service, but in recent cases SEWPaC has varied their advice. Species that have been recorded on single occasions, or for which the sites does not contain core habitat should not be considered to be “important determinants of the sites unique character” (see comments under criterion 2 in section 3.2).

Threatening processes should not be identified as critical CPS. Advice from SEWPaC is that climate should not be considered a critical CPS.

A summary of the components, processes and services identified in Phillips and Muller 2006), the Rolling Review and a proposed list for consideration are presented in Table 2.

Table 2: Components, processes and services. Divers, levers and primary determinants are based on those listed in section 3.1 of Phillips and Muller 2006).

	Drivers	Levers	Primary determinants	Essential elements	Critical components	Critical processes
Phillips and Muller 2006	• Climate • Geomorphology • Hydrology	• River Murray flow regulation • Water extraction • Regulated inflows from USE • Operation of the barrages • Operation of dredges • Discharges to land. Water and air	• Physio-chemical environment including salinity, turbidity and sedimentation) • Biota, particularly keystone aquatic plant species, other plant species and animal species and assemblages • Habitat availability – including type, accessibility, temporal and spatial connectivity, condition and variety of habitat.	Not identified	Not identified	Not identified
Rolling Review (based on Phillips and Muller 2006)	n/a	n/a	n/a	Not identified	• Salinity • Keystone species – Ruppia • Keystone species – freshwater aquatic plants • Water levels • Wetland type • Endangered and vulnerable species • Swamps of Fleurieu Peninsula • Gahnia vegetation associations • Mount Lofty emu	• Water regime • Turbidity and sedimentation • Habitat connectivity

	Drivers	Levers	Primary determinants	Essential elements	Critical components	Critical processes
					wren • Orange-bellied parrot • Southern bell frog • Breeding wetland dependent waterbirds • Wading birds, including migratory species • Cape barren goose • Obligate freshwater fish • Diadromous fish • Euryhaline or estuarine fish • Marine stragglers	
Proposed – for discussion (note that in many ECD components and processes are not clearly separated as this can be tricky).	n/a	n/a	n/a	• Climate • Geomorphology • Soils • Sedimentation • Water quality – nutrients, pH, turbidity • Tidal regime • Algae/phytoplankton • Invertebrates • Amphibians, reptiles mammals	• Water quality - salinity • Vegetation – *Ruppia*, freshwater aquatics • Waterbirds – diversity and abundance • Fish - diversity	• Hydrology – groundwater and surface water • Waterbird breeding • Fish breeding

	Critical services
Phillips and Muller 2006	• Not identified
Rolling Review (based on Phillips and Muller 2006)	• Not identified
Proposed – for discussion	Regulating services • Maintenance and regulation of hydrological regimes Provisioning • Drinking water • Irrigation • Provision of aquatic foods for human consumption • Wetland products such as animal and plant material Cultural services • Recreation • Tourism • Cultural heritage and identity • Spiritual and inspirational Supporting services • Supports a diversity of wetland types (extent and diversity) • Special physical, ecological or geomorphic features (critical life stages and drought) • Provides physical habitat for waterbird and fish breeding and feeding • Supports threatened species (national/internationally listed – not necessarily all critical – southern bell frog, southern emu wren, orange-bellied parrot) • Biodiversity (includes state listed species, but not limited to these) • Supports priority wetland species • Supports distinct or unique wetland species (Ruppia) • Ecological connectivity

4. Limits of Acceptable Change

4.1 Introduction

Limits of Acceptable Change are defined by Phillips (2006) as:

"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed".

Phillips (2006) suggested that LAC should be beyond the levels of natural variation. Setting limits based on natural variability is a complex concept. For example wetlands are complex both spatially and temporally with variability evident across all components and processes. Defining this variability such that trends away from "natural" can be reliably detected is far from straight forward (Butcher and Hale 2011).

Only considering the extreme maximum and minimum values observed of parameters and to setting LAC beyond those limits is too simplistic an approach for setting LAC. Change from natural variability can occur in a number of ways, not just exceeding maximum and minimum values. The pattern change and degree of change should be considered when setting limits that indicate a distinct shift from natural variability. This could include accounting for changes in the frequency and magnitude of extreme events, changes in the temporal or seasonal patterns and changes in spatial variability as well as changes in the mean or median conditions (Butcher and Hale 2011).

It is critical to note that LAC are not synonymous with management values or "trigger levels". LAC should be set to represent the point at which a possible change in ecological character has occurred in absolute terms with no regard for detecting change prior to irrevocable changes in wetland ecology (Butcher and Hale 2011). Detecting change with sufficient time to implement management actions to prevent an irrevocable change in ecological character is the role of wetland management and should be captured in the management plan for the site (Butcher and Hale 2011).

4.2 Guidance on setting LAC

Appendix B provides guidance from SEWPaC with regards to setting LAC and should be referred to for greater detail. The main issues with updating the LAC as presented in Phillips and Muller (2006) is to ensure they are not written for threats, as management triggers or goals and are measurable.

Minimum information required when presenting LAC
Include a table summarising LAC which includes the following information (from Butcher and Hale 2011):

Component / Process / Service	The component, processes or service for which the LAC is a direct measure.
Baseline / supporting evidence	Relevant baseline information (relevant to the time of listing) and any additional supporting evidence from the scientific literature and / or local knowledge.
Limit of Acceptable Change	The LAC stated as it is to be assessed against.
Confidence level	The degree to which the authors are confident that the LAC represents the point at which a change in character has occurred. Assigned as follows: **High** – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measurable. **Medium** – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific literature; or informed expert opinion; LAC is objectively measurable. **Low** – no site specific data or reliable evidence from the scientific literature or expert opinion, LAC may not be objectively measurable and / or the importance of the indicator to the ecological character of the site is unknown.

Table 3: Proposed table format for LAC

Component / Process/ Service for the LAC	Baseline/Supporting Evidence	Limit of Acceptable Change	Confidence level

When writing LAC, where possible keep the format the same – for example in Phillips and Muller (2006) salinity LAC were written as 'not to exceed' but the turbidity LAC are written as 'maintained below' and 'less than'. Be consistent in form so as not confuse reader.

Include all relevant information regarding how the LAC has been set. Explicitly state if the LAC is set on expert opinion or on data – cite all data sources, and explain any derivation of data used to arrive at a LAC – see below for further discussion on this.

Setting baselines

There are three types of data which can be used to set baselines for LAC.

- Pre listing data that can be used to describe natural range of variation.
- Post listing data for CPS that haven't undergone change since listing.
- Post listing data – only available – may or may not include a change since listing.

For each LAC how the baseline is set should be specified, where published material is used include the citation and as stated above include the rationale and derivation for each LAC.

Total number of LAC and surrogates
LAC are to be written for each critical CPS, however LAC for one component or process may act as a surrogate measure for other critical CPS. Hydrology as a driver of wetland ecology is often used as a surrogate for other processes and services which are either hard to measure, have no data or would repeat the basis of the hydrology LAC. For example a LAC for a hydrological regime may account for hydrology, diversity of wetland type and physical habitat.

The 'line in the sand' rule of thumb
In most cases identifying the point at which ecological character has changed is quite difficult and usually ends up being made based on expert opinion. Where baseline quantitative data exists statistical changes can be developed. However these are often reliant on comprehensive monitoring and are the rare exception. In setting all LAC, a useful rule of thumb to use is that the LAC should represent the line in the sand, beyond which you would notify the Convention that the site has changed. It is at the point, almost, of no return. So if you set a LAC conservatively, and you get a small short term change in a critical CPS, does this really constitute a change in character?

Setting the degree of change in a critical CPS is very difficult. It is often very hard not to set a management or early warning trigger. For example in a floodplain wetland with a critical plant species (i.e. RRG) setting LAC based on the water requirements for the floodplain plant is not a LAC, but a description of the water regime required to sustain the plant. The LAC should be the water regime beyond which the plant can not survive.

Setting a level of change
Many LAC are set as a proportion change in a measurable parameter – extent, number of species etc. There has been criticism in this approach but when faced with a poor understanding of the natural variability of critical CPS, it is often the only way of setting a LAC. However it is important to justify the basis of each level of change used. CPS with a large degree of natural variation should have a larger proportion of change used to set the LAC, similarly CPS that have a low likelihood of change and that any change that does occur would be considered serious, would have a small proportion of change used to set the LAC (see Table 4).

Percentiles can be used for parameters which can have some level of change, but still fall within the range of natural variability. Examples of this type of LAC include water quality and biological indicator guideline values derived from statistical analysis of reference datasets (Richardson et al. 2010).

Table 4: Measures for describing LAC (based on Richardson et al. 2010).

Degree of change	Examples
Large scale system changes – typically outside the range of natural variability.	• Ecological end points such as state changes – ie switch from freshwater to saline system; macrophyte to phytoplankton dominated.
Large – set at or outside range of natural variability. Used for CPS that have a high natural range of variability or that change may not automatically equate to a change	• Often surrogates rather than direct measures of a CPS – i.e. health or condition measures. • LAC may be set at a 20% change or

in character.	more.
Moderate – often would fall within the range of natural variability. Parameters are better understood and have moderate natural variability.	• LAC may be set at a 10% change.
Small – would fall within the range of natural variability but small changes from median baseline are acceptable.	• LAC may be set at a 5% change.
No change – used when any change is considered unacceptable.	Not a great option as no change is unrealistic in most cases – also difficult to measure.

4.3 Review of LAC from Phillips and Muller (2006)

Each of the LAC are presented in Table 25 of Phillips and Muller 2006) are presented in Table 5. In most cases the LAC fall into one or more of the following three categories:

- Not specified – no data is available and therefore no LAC has been set. Many of the biota fall under this category.
- Not measurable – no baseline provided or 0% change.
- Management triggers or goals.

This is a reflection of the time of writing the ECD, when interim LAC and management triggers were acceptable. In terms of complying with the national framework, the most significant issue is the LAC are not representative of the point at which the sites character would change – they are all set either to maintain, sustain, or provide an early warning of change/impact.

The precautionary approach has been applied to many of the LAC with a suggested 0% change being suggested as the basis for a LAC. In many cases this is not a realistic, or measurable, proportion of change, nor will it actually reflect a change in character as per current requirements.

Updating of the LAC should conform to the guidelines as per Appendix B and the notes presented in section 3.1 above. Once the list of critical CPS is established LAC can be rewritten. In many cases expert opinion will be needed to set LAC, but it is preferable to set an estimate of the point of change than to not specify a LAC. LAC are not necessarily static and there are avenues for capturing updates to LAC in the Ramsar Rolling Review process which reports on status of ecological character.

Key points to remember are that the LAC must be measurable, their derivation needs to be detailed, a confidence rating should be included, and they must represent the point at which ecological character would change. More often than not a temporal or spatial element should be included in the LAC. The LAC has to have enough information in it to be clear without reference to the justification/baseline data – for example when a LAC is specific to a species then that species must be named in the LAC (common and species name). A series of examples of LAC from recent ECD are reproduced in Appendix C.

Table 5: Review of LAC from Phillips and Muller (2006) with assessment of type of LAC and comments. MT = management trigger, MG = management goal, NM = not measurable, NS = not specified data insufficient, T = LAC for threat, , LAC = acceptable LAC.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
Salinity – freshwater units	**Lake Alexandrina** This allows for periods of higher salinity during low flows as would have been experienced naturally. Based on the data for Milang (see Appendix H), the 10 year average EC since 1971 have been as follows: 1971–1980: 672 EC; 1981–1990: 769 EC, 1991–2000: 693 EC, and the 2001–2005: 1062 EC. **Lake Albert** This allows for periods of higher salinity during low flows and for the fact that Lake Albert is always more saline than Lake Alexandrina since it has no flow-through. This LAC is based on the data for three sites in Lake Albert recorded in 1995–1997 (see Appendix H). **Tributary wetlands** LAC should be set for each tributary based on historical and other data. For the four tributaries where such data has been examined here (see above and Appendix H) it is apparent that each should be treated separately. For these, the following are recommended based on preliminary analysis only at this time. Monitoring salinities at point of discharge into the lake is recommended to confirm these limits:	**Lake Alexandrina** • Salinity maintained below 700 EC, based on a five year average. **Lake Albert** • Salinity maintained below 1400 EC, based on a five year average. **Tributary wetlands** • Tookayerta Creek: Salinity maintained below 500 EC at summer or drought peak, based on a five year average. • Finniss River: Salinity maintained below 1,200 EC at summer or drought peak, based on a five year average. • Currency Creek: Salinity maintained below 2,400 EC at summer or drought peak, based on a five year average. Bremer River: Salinity maintained below 2,500 EC at summer or drought peak, based on a five year average. • Groundwater salinities feeding the tributary wetlands not to exceed 1,500 mg/l (= approx. 3000 EC) to maintain the full complement of freshwater obligate fishes and plants (see Sections 5.6.1).	MT/T	• Method of development acceptable – but is likely set as a management triggers rather than a point of change. • Groundwater LAC is definitely a management trigger/goal. • Include all relevant data in the justification – do not cross reference to other sections of the ECD where possible. • Keep format of LAC consistent – for example write LAC as being either *maintained below* a specified level, or *not to exceed* a specified level – do not use both formats. • It is likely that a quantitative LAC can be set for salinity. Investigate use of percentiles to set LAC for salinity. • Include spatial and temporal bounds. For example the groundwater salinity LAC does not have a temporal boundary. Also the state (salinity/volume etc) of the receiving waters would need to be considered.
Salinity – estuarine/saline units	Murray mouth and Estuary - These are based on Table 21, for the period 1981–2000.	**Murray mouth and Estuary** • Salinity not to exceed 58,000 EC (sea water) with parts	MT/T	• See comments above. • Murray mouth LAC - Not well specified and probably a

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		below 39,000 EC. **North Lagoon** • Salinity ranging from 8,000–60,000 EC for most of the time, with the following limits: • Northern end: Salinity not exceeding 50,000 EC (at Long Point) in the summer peak. • Southern end: Salinity not exceeding 100,000 EC (at McGrath Flat) in the summer peak. **South Lagoon** • Seasonal and spatial variability: Salinities around 30,000 EC in some parts in winter/spring with the following limits: Northern end: Salinity not exceeding 100,000 EC (at Villa dei Yumpa) in the summer peak. Southern end: Salinity not exceeding 130,000 EC (at Sandspit Point) in the summer peak.		management trigger. Needs some guidance around how this is measured – timeframe. What constitutes 'most of the time'? • Spatial boundaries need to be clearly delineated. • 'Salinities around 30,000' needs to be clarified.
Turbidity – freshwater units	**Lake Alexandrina** Based on the data for Milang (see Appendix H), the average annual NTU level for the 18 years from 1983–2000 has been 76.2 NTU, with a range of <1 to 390 NTU. **Lake Albert** This is based on the historical and more recent data provided in Appendix H. **Tributary wetlands** Unlike salinities which seem to vary between tributaries, for the three tributaries able to be considered here (see above and Appendix H) turbidities were quite consistent, and low by comparison with the lakes.	**Lake Alexandrina** Turbidity maintained below 70 NTU based on a five year average. This allows for periods of higher turbidities during high flows. **Lake Albert** Turbidity maintained below 50 NTU based on a five year average. This allows for periods of higher turbidities during high flows.	MG/T	• Disagree with turbidity being a critical CPS. This is not something that makes the site significant internationally – it's a threat to other CPS. • These LAC are set as a management goals. • Baseline information is inadequate.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		Tributary wetlands Maintain turbidity in the tributaries at less than 12 NTU based on a five year average to allow for periods of higher turbidities during high flows.		
Turbidity – estuarine/saline units	There is relatively little long-term data available at present upon which to base LAC for turbidity, apart from that indicated above, and also what is known about the light transmission requirements for the reproduction and growth of the *Ruppia* keystone species (see above and the following section). LAC are set to encourage *R. megacarpa* return and expansion back to former distribution (see above and Section 6.3).	**Murray Mouth and Estuary** Secchi disc transparency depths of no less than 2 m. **North Lagoon:** Secchi disc transparency depths of no less than 90cm. **South Lagoon:** Secchi disc transparency depths of no less than 90 cm.	MG/T	• Disagree with turbidity being a critical CPS. This is not something that makes the site significant internationally – it's a threat to other CPS • LAC are set as a goal rather than a point that would represent a change in ecological character. • No temporal bounds are included – are they needed? • Spatial bounds – should a location be specified as per the salinity LAC?
Keystone species – freshwater units	**Areal extent:** Given their critical role in the functioning of the freshwater units, any further loss of these keystone species would be a matter for great concern. As such, the limit of acceptable of change is 0% of areal extent, even though it is acknowledged that at present we do not know that extent. Surveys and mapping to set that baseline should be a high priority. Ideally, the management target should be to reinstate these keystone species to areas they have been lost from during the past 20 years, at least. Consultations with long-term stakeholders should assist with gaining this understanding, and for target setting within the Ramsar plan for the site, similar to that done for the keystone species in the estuarine-saline units (see below). **Connectivity:** As noted above, these keystone	**Areal extent**: 0% change **Connectivity:** 0% change	NM/MG	• No baseline, so even if 0% change was an acceptable measure this is not measurable. • 0% change in *Ruppia* is unrealistic as this species fluctuates considerably in response to antecedent conditions. • The unit of measure for connectivity is not specified and as such is not measurable. It is also a management goal, not a point at which ecological character would change. • Need to consider if a LAC for extent or connectivity is the most appropriate measure. • LAC need to fully articulate the species involved, not just the

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	species are critical habitat for biota, and as such it is vital that efforts be made to reinstate connectivity between these areas so that the problem of habitat fragmentation can be addressed. The LAC is recommended as 0%, although, as with areal extent above, it acknowledged that surveys and gaining an historical perspective are high priority so that this LAC can meaningful, and used to set management targets.			measure.
Keystone species – estuarine/saline units	Given their critical role as keystones of the ecological character of the estuarine-saline units, the apparent loss of *Ruppia megacarpa* from the North lagoon and the significant decline of *R. tuberosa* in the South Lagoon is a matter of grave concern for this Ramsar site. The Asset Plan's interim targets provide a starting point for management action, and these will be verified or modified once further work is done on the predictive mapping for both *Ruppia* species (see Figure 24). As noted above, observations by local stakeholders and long-time researchers suggest that the predictive map produced for *R. megacarpa* may well reflect the former extent of the species in the North Lagoon. Irrespective of the estimates of the former areal extent and the targets set by the Asset Plan, the LAC for these keystone species has to be 0%. Any further loss cannot be tolerated if the ecological character of the estuarine and saline system units is to be recovered. As was noted for the keystone species of the freshwater units (see Section 6.3.1), these species are critical habitat for biota, and a primary food source for many of the Ramsar	**Areal extent**: 0% change **Connectivity:** 0% change	NM	• No baseline, so even if 0% change was an acceptable measure this is not measurable. • 0% change in *Ruppia* is unrealistic as this species fluctuates considerably in response to antecedent conditions. • The unit of measure for connectivity is not specified and as such is not measurable. It is also a management goal, not a point at which ecological character would change. • Need to consider if a LAC for extent or connectivity is the most appropriate measure. • If extent is used as basis of LAC, then a baseline has to be set and the size of the proportional change which would represent a change in character determined. In additional the LAC should specify a temporal scale.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	significant birds and fish of this site. As such, it is vital that efforts be made to reinstate connectivity between these areas so that the problem of habitat fragmentation can be addressed. The LAC for connectivity is recommended as 0%, although, as with areal extent above, it is acknowledged that surveys and gaining an historical perspective are high priority so that this LAC can meaningful, and used to set management targets.			
Water levels – freshwater units	Lake levels need to be drawn down in summer and raised in winter in order to mimic natural, seasonal variations, thereby reducing erosion and allowing for expansion of more complex ecological communities. The current proposal contained in the Asset Plan (DWLBC, 2005—see above) is to have a rate of rise and fall of no more than 2 cm per day in the pattern described below (see Figure 26). This is being tested at present and developed as on-going work of the Lakes and Coorong Environmental Flows Working Group (multi-agency, convened by DWLBC). Until this further work is done, no LAC is recommended.	Not specified.	NS	n/a
Water levels – estuarine/saline units	Coorong lagoon levels need to vary with a natural pattern of high water levels in winter and low in summer. Seasonal, short-term and tidal patterns are lost if there is insufficient inflow or connectivity to the Southern Ocean via the Murray Mouth and thus an open Murray Mouth at all times is essential.. In terms of LAC for water levels, variation across time and space and absolute depths at critical times, are the key parameters. The Lakes and Coorong Environmental Flows Working Group	Murray Mouth Open 100% of the time, preferably via river flows than dredges.	LAC/MG	• Should just specify the Murray mouth needs to remain open, not the means. • 100% open possibly too conservative – if the Murray mouth closes for a short time once every 5 years is this really a change in character? • This LAC should have temporal bounds specified. • Could also be considered a LAC

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	(multi-agency, convened by DWLBC) have developed the proposed ideal hydrograph (Figure 27). This proposal integrates the Asset Plan targets into an ecological envelope of target water depths throughout the year and will be tested in terms of capacity to achieve the hydrograph and observed ecological outcomes from delivery. Until this further work is done, no LAC is recommended.			for a threat. • Water levels may not be a critical CPS in the updated ECD; as such the opening of the Murray mouth may be a measure of another critical CPS or excluded altogether.
Habitat connectivity - Freshwater and Estuarine/saline units		**Lake Alexandrina** • No further reduction in habitat availability. Reduced turbidity and maintenance or restoration of habitat connections are considered critical for listed species and underrepresented habitats **Lake Albert** • No further reduction in habitat availability. Reduced turbidity is essential for plant growth and improved hydrological connectivity between the Lakes via the Narrung Narrows is essential for the integrity of this otherwise closed part of the system. **Tributary wetlands and Hindmarsh Island:** • No further reduction in habitat availability. Maintaining or restoring habitat connectivity is required to maintain and enhance isolated remnant fish, plant and bird populations and allow for migration of species	NM/MT	• Confuses/combines the primary determinant habitat connectivity and the components habitat availability. • Not measurable. No baseline is set against which to measure 'no further reduction'. • Management triggers are set for restoration not the point at which ecological character would change. • Includes desired management goals/ecological statements – i.e. reduced turbidity is essential – this is not a measurable LAC.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		between habitats to escape adverse local conditions. **Murray Mouth and Estuary, North Lagoon and South Lagoon:** • No further reduction in habitat availability. Appropriate management targets for restoring ecological character are: Reinstatement of the former estuarine habitats of the Coorong, which it is estimated currently sit at 25% of the former coverage (see Sections 6.3.2 and 6.4.2). This is a matter of some urgency Interim target for *Ruppia* as contained as interim targets in the Asset Plan (see above).		
Water regime - Inflows from the Eastern Mount Lofty Ranges (EMLR) tributaries of Lake Alexandrina	Patterns of inflows need to be protected. In particular, disconnection or untimely drying out of critical tributary habitats should be avoided, particularly given the high diversity and abundance of significant taxa utilising these habitats (see Section 6.6.3). Groundwater pumping policies (such as zones of influence) that limit pumping on a spatial and seasonal basis and improved delivery of low to medium flows are needed to prevent truncation of flow events and adverse changes in water regime and water quality.	No greater than 30% of winter run-off to be taken from each sub-catchment, as per the *River Murray Catchment Water Management Plan* (2003).	MT/T	• LAC is written as a management target, not a point of change to the water regime. • Need actual figures so as to be able to measure LAC – cross referencing to another document should be avoided. • The information regarding patterns of flow and groundwater pumping policies to the left – its not clear if this is meant to be a part of the LAC or is background commentary. • Consider developing LAC using river flow data – use hydrograph to establish range of variability at time of listing and then determine point at which change in flow would constitute a change in

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
				character. Include temporal and spatial bounds where necessary. • Specify elements of hydrograph deemed most important to this critical CPS and develop LAC accordingly. For example – 'untimely drying out of critical tributary habitat' – include this in a LAC.
Water regime – Inflows from the River Murray	It has been beyond the scope of this project to specify the minimum annual flow that is needed for retaining the ecological character of the Coorong and Lakes Ramsar site (refer to The Living Murray Foundation Report [MDBC, 2005] and work of the Expert Reference Panel [Jones et al., 2002]). The clear indications from the conclusions drawn and reflected throughout this report (see Section 8) is that the ecological character of this site has changed significantly since the time of Ramsar listing and that urgent remedial actions are needed. These changes are to a large extent flow-related and thus the following acts as a guide to river managers to reverse the change in ecological character: LAC 3 and 4 can be met most of the time under current river flows and with improved barrage operation strategies (see Section 6.6.3), and so could be implemented immediately. In the opinion of the authors, returning flows to the site that will provide for LAC 1 is the matter of greatest urgency in terms of ecological character restoration. The alteration to the ecological character of the site, and the Coorong lagoons in particular, is not a subtle change although it may have occurred incrementally over many years. Reversing the current change in ecological character will take time, careful management	1. The Coorong and Lakes is a site that is strongly influenced by water levels; these being a product, in large part, of freshwater inflows and tides. Keeping the Murray Mouth open at all times with barrage releases rather than dredging should be the first target to recovering the ecological character (see Section 6.6.4 below) of this site. To this end, a secure allocation of at least 2,000 ML/day needs to be made for the Murray Mouth at least during surplus flow periods to allow for the dredges to be intermittently stopped whilst river flows are great enough to keep the mouth open. This allocation should then build up over time to the point that dredges are no longer needed. 2. The site is also one that is adapted to the once highly variable flows of the unregulated River Murray, and some effort needs to be made to see those highs and lows in flow pattern	MT/MG	• All are actually management goals and management triggers – none represent the point at which the water regime has changed so as to represent a change in character. • Repetitive – LAC for the Murray mouth opening has already been set. • Consider developing LAC using river flow data – use hydrograph to establish range of variability at time of listing and then determine point at which change in flow would constitute a change in character. Include temporal and spatial bounds where necessary. • Recent drought conditions/flow may be useful in setting LAC.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	and, above all else, significant additional water. The 500 GL/year being pursued under the First Step Decision of The Living Murray Initiative is needed as soon as possible at this site to help slow this change in ecological character. However, the case presented above strongly suggests that the return of 500 GL/year will be insufficient to see the trend in ecological character change taking place at this site fully reversed. The health of this Significant Ecological Asset and Ramsar wetland will be reliant on further allocations within the next few years that can see the limits of acceptable change above, and the Asset Plan targets, achieved.	reinstated. It will only be with the return of environmental flows to the river, that medium-sized floods can be 'manufactured' by the river managers through the topping up of the more frequent small-floods. For recovering the ecological character of this site, the frequency of medium-sized floods (20,000–80,000 ML/day) needs to be at least once every five years and flows over 100,000 ML/day need to occur at least once in every ten years to 'reset' the system. 3. Periods of no or very low flow were very rare under natural conditions and are extremely detrimental to the ecosystem components and processes, and therefore, the ecological character. The period of no flows through the barrages for 630 days which ended in 2003 was likely to have precipitated the widespread loss of *Ruppia* spp. From the Coorong lagoons and thus the current shift in ecological character. To avoid further loss in ecological functionality of the system, it is imperative that periods of no flow through the barrages do not exceed 100 days between March and August and do not exceed 30 days between August and March (see Section 6.6.3 also).		

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		4. The fishways that have been installed in the barrages provide passage between the fresh and estuarine-saline units for more ecosystem components than just fish, and they also allow flow-related processes to occur. A baseflow of 120 ML/day is required for fishway operation, with optimal flows approaching 900 ML/day (Higham, pers. comm.). This water needs to be delivered in a pattern that mimics the natural pattern of early season tributary inflows, a lull, and then summer flows from the River Murray as water makes its way from the headwaters to the lakes. Flows need to be provided between August and February at least, but optimally all year round to allow for the full suite of flow-related ecosystem processes. 5. There is also a need to have water available for strategic on-site water manipulations to benefit ecosystem health and Ramsar Significant Biological Components. This may include specific allocations to freshen parts of the system when necessary, to support fish breeding or *Ruppia* recruitment. Specifying the volume needed for these outcomes is the role of the site managers through the		

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		development of the new site management plan. Once determined, these allocations should be formally recognised under The Living Murray Initiative as a 'Ramsar site contingency allocation'.		
Water regime – Barrage operating strategy	No limits of acceptable change are indicated here as it is assumed the new Barrage Operating Strategy (BOS) will accommodate all those that relate directly to the timing, duration and volumes of these releases. It is anticipated the new BOS will be based on the flow preferences of indicator species and the individual LAC recommended in this report. See also the LAC recommended in the preceding section relating to River Murray flows.	Not specified.	NS	n/a
Water regime – Murray mouth opening		• Murray Mouth to be kept open, preferably by flows discharging from Lake Alexandrina so that the other benefits from these freshwater inflows can be experienced through more natural functioning of the wetland complex. To achieve this, River Murray discharges to the sea need to be increased to a minimum of 1000 GL/year delivered at a minimum rate of 2,000 ML/day. See also LAC recommended in relation to River Murray flows in Section 6.6.2. • The Asset Management Plan (see above) proposes a diurnal tide ratio (cf. Victor	MT	• Repetitive – LAC for the Murray mouth opening has already been set. • LAC is written as a target to sustain character, not the point at which character would change.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		Harbor) of 0.5 at Goolwa and 0.2 at Tauwitcherie. Based on current understanding this is considered the absolute minimum required to sustain the ecological character of the Murray Mouth, Estuary and the Coorong.		
Water regime - Inflows from the Upper South East Drainage Scheme	No LAC is recommended here as the possible use of USEDS water would be aimed primarily at improvements to the salinity, turbidity and keystone *Ruppia* species in the South Lagoon in particular. The LAC recommended for salinity (Section 6.1.2), turbidity (Section 6.2.2) and keystone plants (Section 6.3.2) are relevant here. Any escalation of USEDS water discharges should be delivered in a natural seasonal pattern, peaking during late winter/spring. Inter-annual variation with large and smaller flow years would reflect former natural regime, although the related LAC (see above) should be the key driver for decision making.	Cross referenced to LAC for salinity, turbidity and keystone species.	-	• See comments above. • LAC for salinity, turbidity and keystone species as specified are not surrogate LAC for water regime/inflows from the USEDS. • If identified as a critical CPS, LAC for inflows should be volumetric (based on inflows) and include temporal bounds.
Wetland type – areal extent	*specifics not repeated here*	• Areal extent of 2%,5%, 10% change	LAC	• Baseline in main body of text – but not given when specifying LAC. • Degree of change is very conservative and would be expected to be easily triggered, in some cases annually. • If areal extent of wetland types is identified as a critical CPS then baseline extent for each type needs to be established. • May only need to have LAC for a subset – critical wetland types

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
				such as mudflats need to be determined and appropriate LAC developed.
Wetland type – habitat connectivity	*specifics not repeated here*	• Many are defined as 0% change in habitat connectivity. • Wetland type O cross ref to water regime LAC	NM	• Not measurable. – no baseline. • Surrogate not appropriate either. • Not considered a good measure for developing LAC – it will be very hard to measure and would most likely have a low confidence rating in terms of representing a change in ecological character if exceeded.
Wetland type – habitat availability	*specifics not repeated here*	• Wetland types Ts and Ss – 0% change.	NM	• Not written as LAC, but rather statements or requirements. • Not measurable, no baseline set. • Not considered a good measure for developing LAC – it will be very hard to measure and would most likely have a low confidence rating in terms of representing a change in ecological character if exceeded.
Wetland type – 4 and 6		• Not specified as not natural	NS	n/a
Endangered and vulnerable plant species	While there is an acknowledged gap of comprehensive survey data at present, these species are listed as endangered and vulnerable species either nationally or within South Australia. Therefore, applying a precautionary approach, the limit of acceptable change is recommended as 0%, meaning that any losses beyond natural population fluctuations should be considered unacceptable until such time as further surveys provide indications of a contrary view.	• 0% change	NM	• No baseline set therefore not measurable. • Suggest presence absence in surveys of a specified time frame may be more appropriate basis of a LAC. • LAC for biota - recommend that the sampling regime required be detailed in the baseline /justification column – give as much information as possible – especially for species that require

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
				specific techniques or sampling regimes.
Swamps of the Fleurieu Peninsula	It is not possible to establish the areal extent of this wetland type at or around the time the site was Ramsar listed, and even today there are strong caveats placed on the estimated areal extent currently (see above). Further work is urged to confirm the extent of this critically endangered ecological community within the Ramsar site so that appropriate planning and management can be provided. From the perspective of setting limits of acceptable change there are three primary considerations:	1. Areal extent—as a critically endangered ecological community this is recommended as 0%. 2. Condition of the wetland type—no suitable limit of change can be recommended at present. 3. Connectivity between wetland remnants or pockets—no further loss of dryland habitats connecting these should be allowed.	NM/NS	• States a baseline for areal extent at time of listing is not possible but is not clear about the figure to be used as the baseline. • Connectivity – not clear how this is measured and no baseline set therefore not measurable. • Hydrological connectivity may use the water regime/hydrology LAC as a surrogate – cross ref to appropriate LAC when developed.
Mount Lofty Ranges Southern Emu-wren	It is not possible to establish the size of the population of this species or the Fleurieu Peninsula swamp habitats it relies upon (see preceding section) at or around the time the site was Ramsar-listed. Even today there are strong caveats placed on the estimated areal extent of the Fleurieu Peninsula swamp habitat currently (see preceding section). Further work is needed to confirm both the population size and extent of the habitats required by this endangered species within the Ramsar site so that appropriate planning and management can be provided. From the perspective of setting limits of acceptable change there are four primary considerations:	1. Population size—the estimate is 80–160 and natural variability of this within the population is not known at present. Until such time as a more precise population estimate is possible and natural variations are better understood, the precautionary approach suggests a 0% limit of acceptable change. In this context this is intended to mean that no actions should be permitted that may threaten this small population. 2. Areal extent of Fleurieu Peninsula swamp habitat—see above. 3. Condition of the Fleurieu Peninsula swamp habitat—see above.	NM/NS	• No baseline set therefore not measurable. • Condition and connectivity LAC not appropriate. Suggest LAC is based on presence absence over a specified number of sampling events/temporal scale unless population data can be used.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
		4. Connectivity between wetland remnants or pockets—no further loss of dryland habitats connecting these should be allowed.		
Orange-bellied parrot	It is not possible to establish the size of the population of this species using the Coorong and Lakes Ramsar site at or around the time the site was Ramsar-listed. While there has been work done to estimate the extent of likely habitat (see above), the authors have not been able to gain authoritative advice on the veracity of this modeling, nor the size of the population that overwinters in the site today. Further work is needed to determine both the population size and extent of the habitats required by this endangered species within the Ramsar site so that appropriate planning and management can be provided. From the perspective of setting limits of acceptable change is appropriate: 1. Population size—no estimate of the population using the site today is available. Until such time as a precise population estimate is possible and natural variations within that population are better understood, the precautionary approach suggests a 0% limit of acceptable change. In this context this is intended to mean that no actions should be permitted that may threaten this small population. 2. Areal extent of primary habitats—no advice has been forthcoming on the primary habitat areas. Once this information is collected or provided, then this can be used to establish a robust limit of change. For an endangered	Not specified – but suggested 0% change in population and habitat extent.	NS	• Suggestion of 0% change is probably not a great LAC. Suggest reviewing actual site records from Birds Australia and see if an average number of birds over a specified time is a reasonable estimate. • Alternatively continued presence of the species within the site over a specified number of seasons/surveys may be more appropriate as the point of change. • Measures of condition of habitat are not a measure of the critical CPS – not necessarily a good surrogate. • Connectivity for this species is probably for habitat beyond the site – how would this be measured? Not recommended for inclusion in LAC.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	species with a total national population estimated at 150 birds, a 0% limit of acceptable change is appropriate. 3. Condition of the primary habitats—no suitable limits of acceptable change can be indicated until these habitats are known. 4. Connectivity between primary habitats—this may or may not be a factor. No suitable limits of acceptable change can be indicated until these habitats are known.			
Southern bell frog	There is so little known about the distribution, abundance and habitat preferences of this species in the Ramsar-listed area, thus it is not possible to make any recommendations on Limits of Acceptable Change at this time. Once this information is available, there are four primary considerations as follows: 1. Population size—a precise population estimate is needed and some understanding of the natural variations within that population. 2. Areal extent of primary habitats—mapping of the primary habitat areas is needed to ensure appropriate management of these. 3. Condition of the primary habitats—maintaining the condition of the primary habitats is vital for protecting this species within the Ramsar site. 4. Connectivity between primary habitats—this may or may not be a factor.	Not specified.	NS	• Continued presence of the species within the site over a specified number of seasons/surveys may be more appropriate as the point of change. • Extent of habitat is not likely to be established, nor condition of habitat. • Connectivity is not likely to be relevant to the maintenance of this species.
Gahnia vegetation association	It is not possible to establish the areal extent of this vegetation association (Type W) at or around the time the site was Ramsar-listed, and even today the area indicated (900 ha) is	Not specified.	NS	• Using extent of 900 hectares would be the best approach and then adopting a proportional change as the LAC. Suggest

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	considered an estimate until further detailed ground surveys are completed. From the perspective of setting Limits of Acceptable Change there are three primary considerations: 1. Areal extent—while the full areal extent is yet to be confirmed the association is provisionally listed as a vulnerable ecosystem within the agricultural district of South Australia. Given this, the precautionary approach indicates that a limit of acceptable change of 0% is appropriate until further information is obtained that may or may not alter this. 2. Condition of the vegetation association—no suitable limit of acceptable change can be recommended at present. 3. Connectivity between the vegetation associations—this may or may not be a consideration depending on the findings of future research to establish the full ecological roles.			either 10 or 20% change sustained over a five year period as a possible LAC. • Condition and connectivity are not understood and therefore not a good choice for the basis of setting LAC.
Breeding – wetland dependent birds	At present there is no systematically collected information to indicate the size, distribution, annual or seasonal variations and success of these breeding populations within the Ramsar site, thus making it impossible to set meaningful limits of acceptable change across this range of species. Once more systematic surveys are conducted to map and assess the full extent of breeding areas it should be possible to set limits of acceptable change. Depending on the species this may set LAC of between 0 and 10%. For species such as Australasian Bittern and Hooded Plover, that are threatened species, either nationally or at State level, it is expected the LAC would be 0%.	Not specified but suggested LAC is set at 0 to 10% depending on the species.	NS	• This should be able to be set based on expert opinion. • Alternatively a surrogate LAC for physical habitat and or water regime could be used under the assumption that if these critical CPS are maintained waterbird breeding should be maintained. • Number of successful breeding events in a specified time frame, i.e. *successful breeding events (as evidenced by recruitment to adult population – or some other means) in at least 2 of every 3 years*, or *3 of every 5 years in which data is available* would be

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	An important element of these surveys will be to determine if species breed there every year, two or three years out of five, or only very occasionally. This will allow LAC to be developed that can indicate when managers need to be concerned should a certain species discontinue breeding activities at the site. Surveys will also identify the primary breeding habitats and allow LAC to be developed that consider, for example the areal extent and condition of inland shrublands, reedbeds, rushes, tussocks and grasslands etc. At present, LAC have been set for each wetland type found within the Ramsar site (in Section 4) and these will provide an interim indication for managers until more detailed breeding habitat data is collected. The data from Paton (2005b) suggest that for several fish-eating species, breeding effort in the South Lagoon has declined considerably in recent years, apparently coincident with declines in the population of hardyhead fish. This includes Australian Pelican, Fairy Tern and Hoary-headed Grebes. Oral history accounts from the Ngarrindjeri community and three of the long-term fishing families also raise concerns about pelicans, Black Swans, oystercatchers and Silver Gulls. On face value these may seem not to allow for the setting of robust limits of acceptable change. However, the reduction and possible cessation of pelican breeding in the South lagoon is notable in this context, as are Paton's (2005b) observations for Fairy Tern and Hoary-headed Grebe; indicative as they seem to be of the loss of hardyhead fish from this part of the Coorong. Equally, the observed reduction in swan numbers and breeding success, linked to the			an acceptable means of setting the LAC. • A proportional change in total number of breeding species is also a possible means of setting the LAC. Depends on if number of breeding species or target species are the focus of the critical process/service. For example a general LAC for number of breeding species could be *in any 15 year period at least X of the Y spp breeding at the Ramsar site recorded breeding at the site.*

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	documented decline in 'swan weed' (*Ruppia tuberosa*) (see Sections 5.4 and 6) is also strongly indicative of a major change in the ecological character of the South Lagoon. For these species, the limits of acceptable change need to reflect a continuation of their breeding effort and success at or near that witnessed around the time the site was Ramsar-listed in 1985. It has not been possible for this project to source any such data and so it is recommended that this be part of the followup actions. At the very least it should be recognised that the decline or cessation of breeding activities by these species in the South Lagoon indicates the need for urgent remedial action to recover the former ecological character.			
Wading birds including migratory species	For this assemblage of wading species within the wetland-dependent bird community of the Coorong and Lakes Ramsar site, there are a number of limits of acceptable change that need to be considered: 1. Population sizes—survey data to date can be used only to indicate trends and it is not possible to use it to set robust limits of acceptable change. The data is also, in most cases, highly variable and this wide natural variation also hinders the setting of LAC. It is recommended that future surveys focus on the following wader species: Sharp-tailed Sandpiper, Red-necked Stint, Curlew Sandpiper, Banded Stilt, Greenshank, Red-necked Avocet and Red-capped Plover, to establish meaningful LAC. In the interim, the LAC should be to see these populations retained at or better than their 2000 levels as recorded in Paton (2005b). For these species, those population estimates for the	1. Sharp-tailed Sandpiper, Red-necked Stint, Curlew Sandpiper, Banded Stilt, Greenshank, Red-necked Avocet and Red-capped Plover, to establish meaningful LAC. In the interim, the LAC should be to see these populations retained at or better than their 2000 levels as recorded in Paton (2005b). 2. Distribution and breeding success of certain species—see Section 5.3. 3. Habitat/food availability and condition—There are a number of levers, components and processes that impact on the availability and condition of habitat and food items for these	LAC/NS	• Need to specify baseline for each species, not refer to other document. • LAC for distribution and breeding success are not likely to be feasible. These are better accounted for with surrogate LAC – ie LAC for habitat. • Same for habitat/food availability – no need for a separate LAC here. • Counts for species should be set with spatial and temporal bounds and be based on a large proportional change from Paton (2005b) if agreed this is the most appropriate baseline.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	Coorong were as shown below (see page 135). It is recognised that these are somewhat arbitrary but they are provided in the interest of providing an interim LAC until more systematic surveys can provide stronger data on which to base them.	species. These are considered in Section 6. •		
Cape barren goose	The species breeds away from the Coorong, on Kangaroo Island and other offshore islands further to the west. It is not possible to establish the size of the population of this species at or around the time the site was Ramsar-listed in 1985. In recent years, the population size of the Ramsar site and immediately adjacent areas has been estimated at approximately 4,000 (Tim Wilson, pers comm.). Further work is required to determine both the population size and extent of the habitats required by this rare species within the Ramsar site so that appropriate planning and management can be provided. From the perspective of setting limits of acceptable change, there are four primary considerations: 1. Population size—the estimate is approximately 4,000 however natural variability of this figure is not known at present. Until such time as a more precise population estimate is possible and natural variations are better understood, the precautionary approach suggests a 5% limit of acceptable change, noting the generalist foraging behaviour of the species. 2. Areal extent of primary habitats used by the species. Not known at present. 3. Condition of the primary habitats used by the species. Not known at present, although see wetland type 4 in Section 4.1.4 (page 24).	• Population size—the estimate is approximately 4,000 however natural variability of this figure is not known at present. Until such time as a more precise population estimate is possible and natural variations are better understood, the precautionary approach suggests a 5% limit of acceptable change, noting the generalist foraging behaviour of the species.	LAC/NS	• Population change is set at 5% change – reasonable, but possibly a bit conservative. • LAC for areal extent of habitat used, condition of habitat and connectivity are not set, but are not likely to add anything to the assessment of this species.

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	4. Connectivity between primary habitats used by the species assuming this is an important factor in sustaining the population. Not known at present.			
Obligate freshwater fish species	It is not possible to establish the population sizes for these species either around the time the site was Ramsar listed or today. Further survey work is needed to provide robust estimates of population sizes and the extent of the habitats each rely upon. From the perspective of setting limits of acceptable there are four primary considerations: 1. Population sizes—these cannot be determined at present although of concern are the suggestions by Wedderburn and Hammer (2003) that a number of the smaller species either have patchy or quite restricted distribution, making them potentially vulnerable. Until such time as a more precise population estimate is possible and natural variations are better understood, the precautionary approach suggests a 0% limit of acceptable change for those species with restricted or patchy distribution, and 5% for those are more widespread and less specialised in niche requirements. 2. Areal extent of primary habitats—see Section 4.1 where these are identified by wetland type and LAC indicated. 3. Water quality—see Sections 6.1 and 6.2 where LAC are indicated in relation to salinity and turbidity, respectively. 4. Connectivity between primary habitats—as noted above, for some of these species there is	• Until such time as a more precise population estimate is possible and natural variations are better understood, the precautionary approach suggests a 0% limit of acceptable change for those species with restricted or patchy distribution, and 5% for those are more widespread and less specialised in niche requirements.	NM/NS	• No baseline is presented so the suggested LAC is not measurable. • Species of concern should be listed (common and species names) with associated baseline. • As with previous comments a 0% change is not realistic as populations fluctuate. Alternative LAC might be to have continued presence of x number of species recorded from 3 of every 5 fish surveys in which selected habitats were sampled. Will depend on the species of interest. • Note that for fish LAC it is advisable to specify required sampling methods and frequency required to assessment against LAC. For example – *must have at least x number of surveys undertaken in a 10 year time period. Survey method must include x, y and z, and include habitats 1, 2 and 3.* • Option of developing LAC for areal extent of habitat is a duplication of previous LAC – cross reference. • Water quality LAC could be used as a surrogate but need to be set at the point at which water quality would cause a change in the fish population to the point of

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	concern that habitat patches are becoming isolated and some types are becoming less common due to the simplification of the lake environments caused in large part by the lack of flow and water level variations. This means that areas showing greater habitat diversity, such as the upper reaches of the Finniss River, the entrance to Waltowa Swamp, and drains entering Lake Alexandrina, are becoming more and more important for some species. In Section 4.1.4 (and see also Sections 6.3–6.5) this is noted under the relevant wetland types and LAC have been indicated.			constituting a change in ecological character – cant be set as a maintenance of condition or as a threat level. • A connectivity LAC needs to be written in terms of key aspects of connectivity required to sustain key fish species – i.e. access to key habitats. Connectivity as described to the left has more to do with loss of habitat, rather than maintaining connectivity. Surrogate LAC may be adequate here – those for hydrology, wetland type and opening of the Murray mouth.
Diadromous fish species	It is not possible to establish the population sizes for these species either around the time the site was Ramsar listed or today. Further survey work is needed to provide robust estimates of population sizes and the extent of the habitats each rely upon. From the perspective of setting limits of acceptable change there are four primary considerations: 1. Population sizes—these cannot be determined at present although, as noted above, six of these seven species are being considered for inclusion on the South Australian list of species of conservation concern. Given this, the precautionary approach suggests a 0% limit of acceptable change for these species, meaning they warrant consideration in the operations of the barrages and fishways to ensure passage, either upstream or down, when it is required. 2. Areal extent of primary habitats—too little is known of the habitat needs of these species at	• Population size - Precautionary approach suggests a 0% limit of acceptable change for these species	NM/NS	• Not measurable as no baseline set. • Species need to be listed • 0% change is unrealistic. • Is population size the key aspect, or species richness? If the latter set LAC on *X number of species encountered 3 of every 5 surveys*. Number of species should represent a loss of sustained loss of one or more species. Could choose to focus on the common species, or habitat specialists and specify a proportional change that would represent a clear change in character. • If population characteristics are important – set LAC on recruitment, having a range of size classes in samples, must have YOY in 2 of every 5 sampling events – or something to

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	present to allow a LAC to be recommended. 3. Water quality—see Sections 6.1 and 6.2 where LAC are indicated in relation to salinity and turbidity, respectively. 4. Connectivity between primary habitats—as noted above, the primary consideration for these species is to be able to move through the barrages at certain times. The fishway and barrage operating strategy make some allowance for these needs at present.			this effect. • Do not set LAC for barriers/threats to movement. Similarly water quality LAC need to be at the point at which the fish change so as to represent a change in ecological character for the site. • Surrogate LAC may be adequate here – those for hydrology, wetland type and opening of the Murray mouth.
Euryhaline or estuarine species	It is not possible to establish the population sizes for these species either around the time the site was Ramsar listed or today. Further survey work is needed to provide robust estimates of population sizes and the extent of the habitats each rely upon. From the perspective of setting limits of acceptable change there are three primary considerations: 1. Population sizes—these cannot be determined at present although, as noted above, several of these species appear to have undergone considerable declines over the past 30–40 years and some, such as the Small-mouthed Hardyhead, more recently. Given this, the precautionary approach suggests a 0% limit of acceptable change for these species, meaning they warrant priority consideration in the management of this site and actions are needed to address apparent population reductions. The decline of Small-mouthed Hardyhead is of special note given its key role as a food item for waterbirds. This decline, associated with the loss of the keystone *Ruppia* aquatic plant species is considered further in Sections 5.4 and 6.3.	• Population size - Precautionary approach suggests a 0% limit of acceptable change for these species	NM/NS	• Comments as above

Primary determinant	Baseline/justification – from Phillips and Muller (2006)	Limit of Acceptable Change	Type	Comment
	2. Areal extent of primary habitats—too little is known of the habitat needs of these species at present to allow a LAC to be recommended. However, as noted above, the decline of keystone *Ruppia* aquatic plant species is likely to be a primary factor in the declines of these species, and so warrants immediate management intervention. LAC in relation to *Ruppia* have been provided in Section 6.3. 3. Water quality—see Sections 6.1 and 6.2 where LAC are indicated in relation to salinity and turbidity, respectively.			
Marine stragglers	No limits of change are recommended due to knowledge gaps. As noted, the increased presence of these species in the system probably indicates a change in ecological character within the Coorong. As the system becomes more saline with Murray Mouth restrictions and reduced freshwater in-flows over the barrages, it may become more conducive to marine species visitation. There is anecdotal evidence that this is the case (see Section 7.2).	Not specified.	NS	• If criterion 7 is actually met by the site then a LAC which addresses biodisparity may be required – one that covers off on fish diversity in terms of breeding strategies, feeding strategies and taxonomic diversity.

5. Conceptual models

The use of conceptual models in natural resource management is becoming more prevalent (e.g. Davis and Brock 2008; Price and Gawne 2009) and can be used for a number of purposes including (Price and Gawne 2009):

- Synthesis of knowledge and to identify knowledge gaps.
- Identification of key links between drivers, stressors, and system responses.
- Understanding of how the processes, threats and system dynamics differ between wetland types.
- Facilitate in the selection and justification of indicators.
- Interpretation of monitoring data (specific to different wetland types) and identification of acceptable levels of change.
- Education and communications tools.

Price and Gawne (2009) illustrate how four different types of conceptual models are being used to develop an understanding of wetland ecosystems (Figure 1).

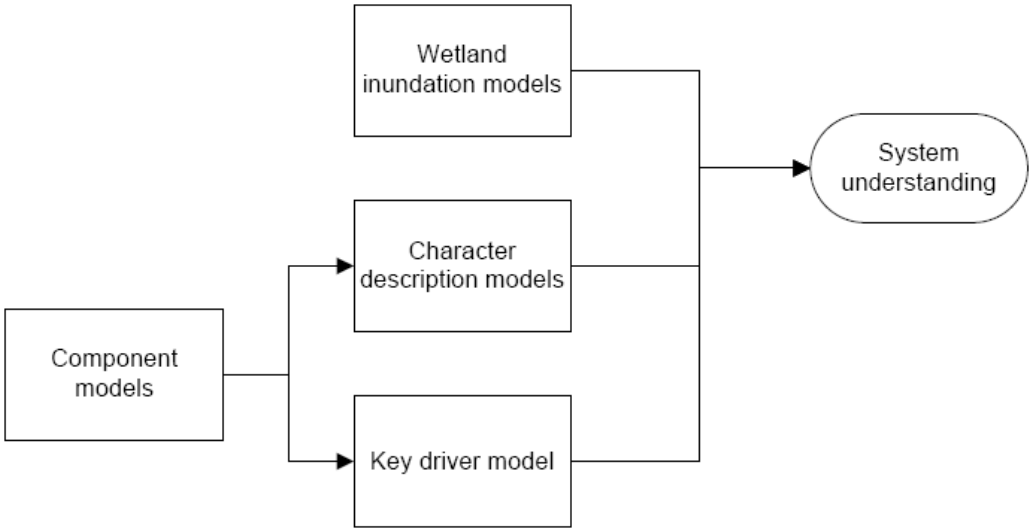


Figure 1: The relationship between the four types of conceptual model used in wetland management (from Price and Gawne 2009). Component models can be used to illustrate individual components, processes and services. Key driver models can equate to stressor models or control models.

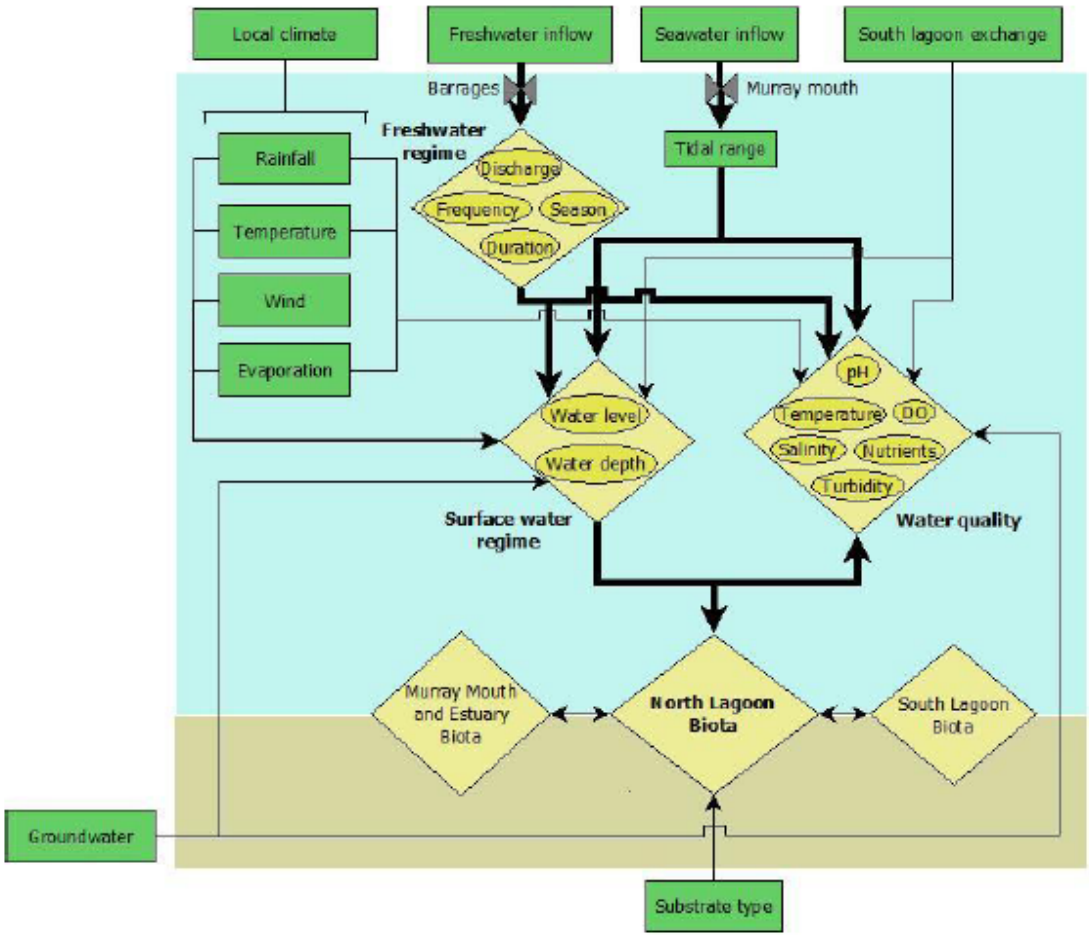
A requirement of the national framework for preparing ECD is to provide a conceptual model/s representing the key features/relationships of the ecological character of the site. A number of conceptual models exist for the Coorong and lower lakes including state-transition and control models (see Figure 2) developed by Souter (2009a-c) and a series of stressor models for imminent threats developed as part of the Ramsar Rolling Review amongst others. Both control and stressor models (see Figure 3) are suitable for inclusion in an ECD and the existing models could easily be adapted for inclusion in the updated ECD. In addition component and an overarching character model(s) may also be of use.

Souter (2009 b and c) describes control models as including system:

- Drivers - major external factors that have large-scale effects on the ecosystem.
- Stressors – physical, chemical or biological agents that cause significant changes in ecological components, patterns and relationships.
- Ecosystem attributes – complex ecosystem components that respond to drivers/and or stressors (these can also act as stressors).
- Control points – points where management intervention can mitigate a stressor to have an impact upon the conservation priority species.
- Summing points – points were a number of conditions must be met before a phenomenon can occur. For example a number of conditions may need to be met before breeding can occur i.e. for birds sufficient food in the appropriate season with available nest sites.

Linkages and feedbacks between these elements are included in the models and can be used to identify major system stressors (Souter 2009 b and c). DEWHA (2008) adopt the definitions of Goss (2003) for control and stressor models. In this case control models depict the major system components, drivers and feedbacks of the system and are intended to be an accurate representation of the system at a particular level of aggregation. Stressor models are an abstraction of a particular system or part of a system focused on the linkages between stressors, ecosystem response, and effects and in some cases, indicators. Stressor models do not incorporate all relevant system components, feedbacks or interactions and therefore are simpler than control models.

Key driver/control and stressor models are recommended for use in the determination of limits of acceptable change (Davis and Brock 2008) and the identification of indicators for inclusion in monitoring programs (Butcher et al. 2009).



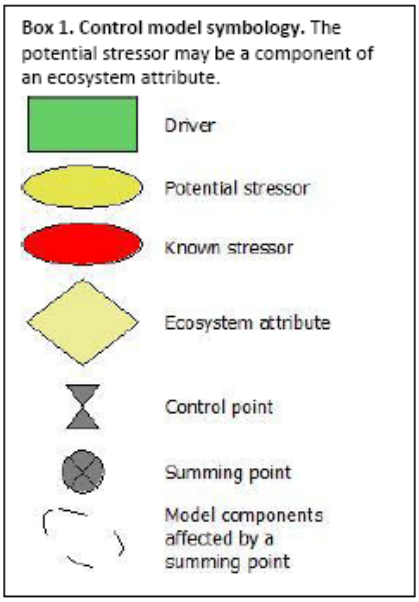


Figure 2: Example of a control model from Souter 2009b – North Lagoon. Thickness of line indicates importance of each process/driver with thicker lines showing greater influence.

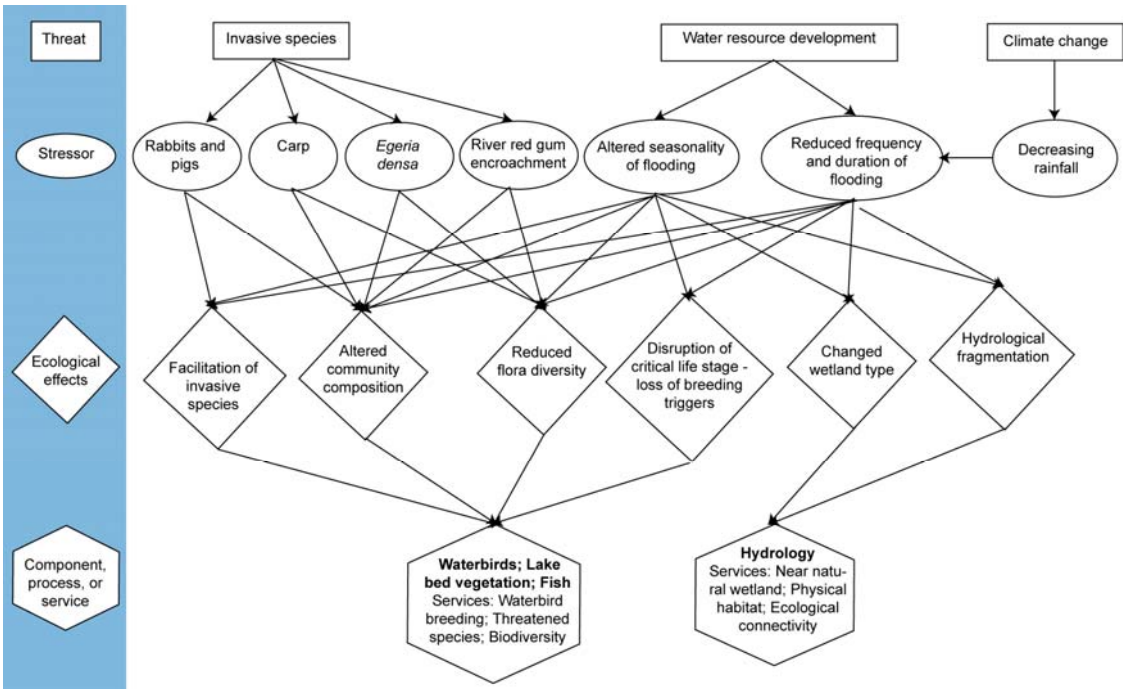


Figure 3: Example of a stressor model: major threats and stressors operating at Hattah-Kulkyne Lakes Ramsar site (from Butcher and Hale 2011).

Component (see Figure 4) and character models (see Figure 5) are frequently used in ECD to help illustrate the key elements of the ecological character of a site. Accompanying a character conceptual model there should be a written description summarising the relationships/interactions between the critical CPS. The models are intended to help synthesis the description of individual/separate components, process and services into an overall picture of how the wetland works – of its ecological character.

Character models are more descriptive in nature, or provide a general illustration, of the relationships between critical CPS (see Figure 6 for a simple character model) than either a control or stressor model. There is no hard and fast rule as to what type/s of model should be included in an ECD.

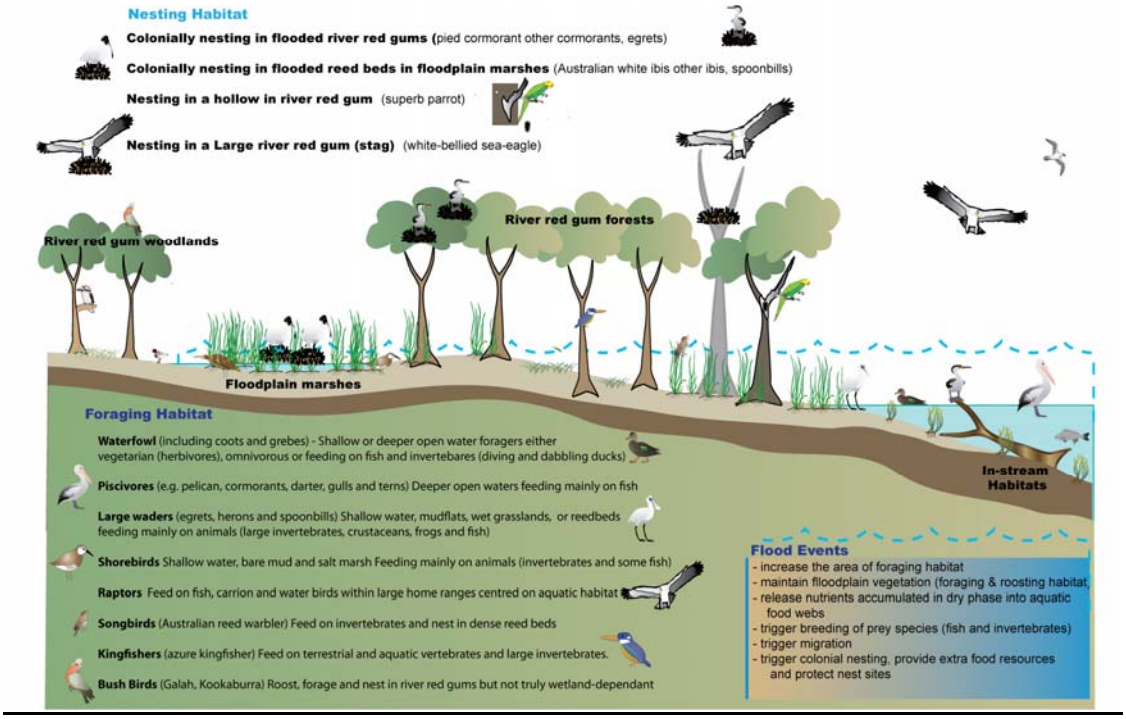
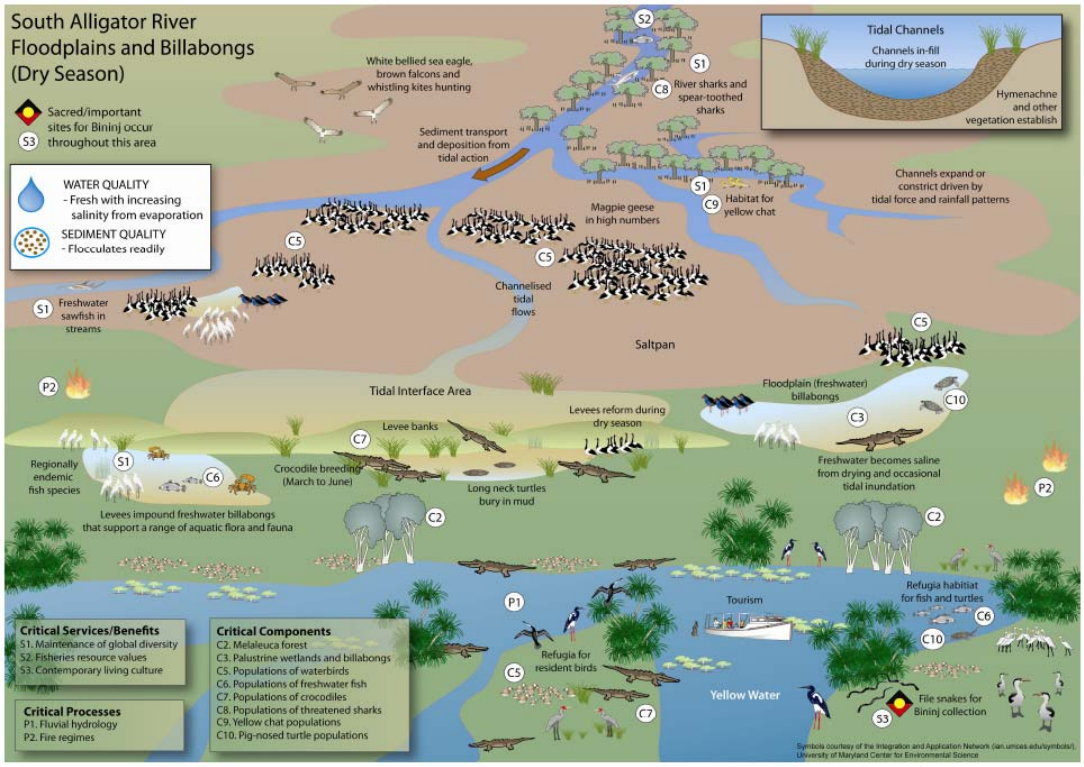


Figure 4: Example of a component model: Conceptual diagram illustrating the variety of habitats for wetland birds within the Barmah Forest Ramsar site (from Hale and Butcher 2011).



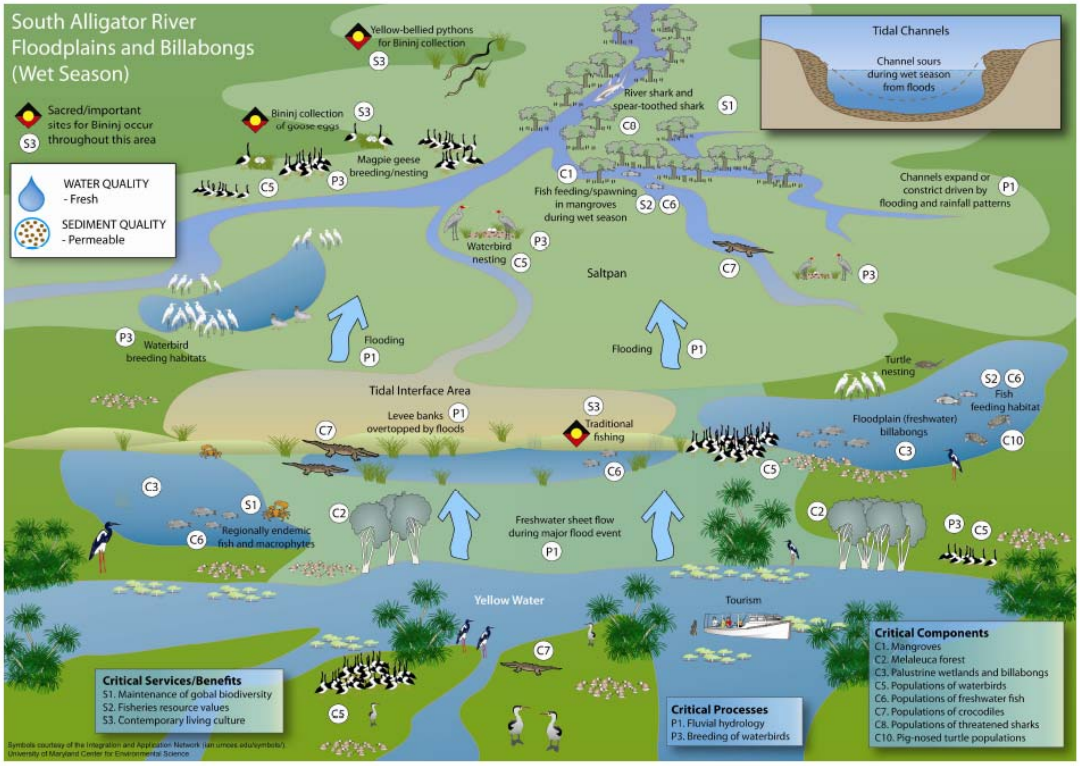


Figure 5: Example of character model: Wet and dry season models for part of Kakadu (from Richardson et al. 2010).

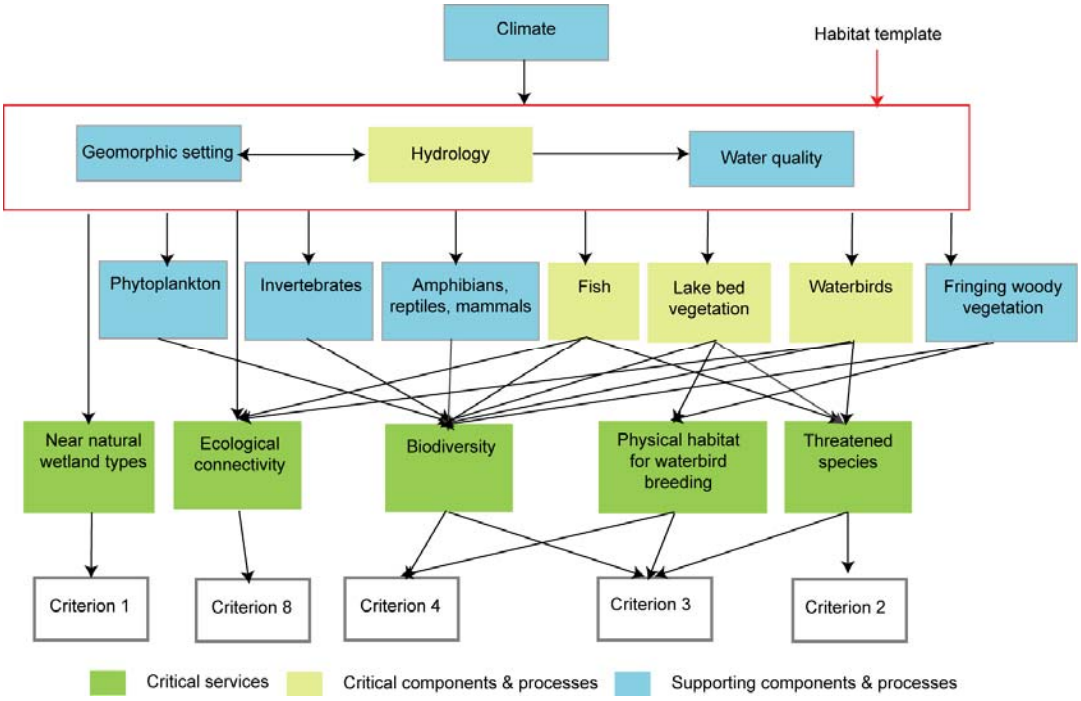


Figure 6: Simple conceptual model for Hattah-Kulkyne Lakes Ramsar site (from Butcher and Hale 2011).

6. References

Butcher, R., Hale, J., Muller, K., and Kobryn, H. 2009. Ecological character description for the Banrock Station Wetland Complex. Prepared for DEWHA.

Butcher, R., and Hale, J., 2011. Ecological Character Description for Hattah-Kulkyne Lakes Ramsar site. Draft report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Davis, J. and Brock, M. 2008. Detecting unacceptable change in the ecological character of Ramsar wetlands, Ecological Management and Restoration, 9: 26-32.

DEWHA (Department of the Environment, Water, Heritage and the Arts), 2008, National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of Australian National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia.

Gross, J., 2003. Developing Conceptual Models for Monitoring Programs http://science.nature.nps.gov/im/monitor/docs/Conceptual_Modelling.pdf

Hale, J. and Butcher, R., 2011. Ecological Character Description for the Barmah Forest Ramsar Site. Draft report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Lester, R., Fairweather, P.G., Heneker, T.M., Higham, J.S., and Muller, K.L. 2011. Specifying an environmental water requirement for the Coorong and Lakes Alexandrina and Albert: A first iteration; summary of methods and findings to date. Department of Environment and Natural Resources, South Australia.

Phillips, B. and Muller, K., 2006. Ecological Character Description of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance, Department of the Environment and Heritage, Adelaide, South Australia.

Price, A., and Gawne, B. 2009. The development of wetland conceptual models for the semi-arid zone. A report prepared for the Murray-Darling Basin Authority by the Murray-Darling Freshwater Research Centre.

Ramsar Convention, 2009. Strategic Framework for the List of Wetlands of International Importance, Third edition, as adopted by Resolution VII.11 (COP7, 1999) and amended by Resolutions VII.13 (1999), VIII.11 and VIII.33 (COP8, 2002), IX.1 Annexes A and B (COP9, 2005), and X.20 (COP10, 2008).
http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-31-105^20823_4000_0__#V

Richardson, D., Fisk, G., Ward, M., Agnew, L., McKerney, Bilerbeck, M. 2010. Ecological Character Description for Kakadu National Park Ramsar Site. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Souter, N. 2009a. A conceptual state-transition model for Lake Alexandrina. Report to the Department for Environment and Heritage, South Australia.

Souter, N. 2009b. Control models for the Coorong, Lakes Alexandrina and Albert Wetland of International Importance 1. Freshwater system unit and inland wetland types. Report to the Department for Environment and Heritage, South Australia.

Souter, N. 2009c. Control models for the Coorong, Lakes Alexandrina and Albert Wetland of International Importance 2. Estuarine-saline system unit and marine/coastal wetland types and Coorong State and Transition model. Report to the Department for Environment and Heritage, South Australia.

Appendix A: Proposed Table of Contents

Glossary
List of Abbreviations
Executive Summary

1. Introduction
1.1 Site details
1.2 Statement of purpose
1.3 Relevant treaties, legislation and regulations
1.4 Preparing the ECD

2. General Description of the Coorong and Lakes Alexandrina and Albert Ramsar Site
2.1 Location
2.2 Overview of the site
2.3 Land tenure
2.4 Wetland types and extent
    2.4.1 – 2.4.23 Subsection for each wetland type.
2.5 Ramsar criteria
2.5.1 Criteria under which the site was designated
2.5.2 Assessment based on current information and Ramsar criteria

3. Critical Components and Processes
3.1 Identifying critical components and processes
3.2 Essential elements
    3.2.1 Climate
    3.2.2 Geomorphological setting
    3.2.3 Soils
    3.2.4 Sedimentation
    3.2.5 Water Quality – nutrients, pH, turbidity
    3.2.6 Tidal regime
    3.2.7 Algae/phytoplankton/diatoms
    3.2.8 Invertebrates
    3.2.9 Vertebrate fauna – amphibians, reptiles, mammals

3.3 Critical components and processes
    3.3.1 Hydrology – groundwater and surface water
    3.3.2 Water quality - Salinity
    3.3.3 Vegetation - *Ruppia*, freshwater aquatics
    3.3.4 Fish – diversity and breeding
    3.3.5 Waterbirds – abundance, diversity, and breeding

4 Critical Ecosystem Services
4.1 Overview of benefits and services
4.2 Identifying critical ecosystem services and benefits
4.3 Critical services - summary
4.4 Critical regulating and provisioning services
    4.4.1 Maintenance and regulation of hydrological regimes

4.4.2 Drinking water
4.4.3 Irrigation
4.4.4 Provision of aquatic foods for human consumption
4.4.5 Wetland products such as animal and plant material

4.5 Critical supporting services
4.5.1 Supports a diversity of wetland types (extent and diversity)
4.5.2 Special physical, ecological or geomorphic features (critical life stages and drought)
4.5.3 Provides physical habitat for waterbird and fish breeding and feeding
4.5.4 Supports threatened species (national/internationally listed – not necessarily all critical – southern bell frog, southern emu wren, orange-bellied parrot)
4.5.5 Biodiversity (includes state listed species, but not limited to these)
4.5.6 Supports priority wetland species (migratory waterbirds)
4.5.7 Supports distinct or unique wetland species (*Ruppia*)
4.5.8 Ecological connectivity

4.6 Critical cultural services
4.6.1 Recreation
4.6.2 Tourism
4.6.3 Cultural heritage and identity
4.6.4 Spiritual and inspirational

4.7 Ecological character conceptual models

5. Limits of Acceptable Change

5.1 Process for setting Limits of Acceptable Change (LAC)

6. Threats to Ecological Character

6.1 Water resource development
6.2 Climate change
6.3 Pollution
6.4 Invasive species
6.5 Recreational activities
6.7 Barriers
6.8 Resource use
6.9 Summary of threats

7. Current Ecological Character and Changes since Designation

7.1 Site changes since listing
7.2 Changes to critical CPS
7.2.1 Current condition – assessment against LAC
7.2.2 Hydrology
7.2.3 Salinity
` 7.2.4 Vegetation – Ruppia
7.2.5 etc
7.3 Change in ecological character – summary statement

8. Knowledge Gaps

9. Monitoring needs

10. Communication and Education Messages

References

Appendix A: Methods
A.1 Approach
A.2 Consultant/project Team
Appendix B: Wetland birds recorded the Coorong and Lakes Alexandrina and Albert Ramsar Site
Appendix C: Fish
Appendix D: Dryland birds, mammals, amphibians and reptiles recorded in the Coorong and Lakes Alexandrina and Albert Ramsar Site
Appendix E: Listed species

Appendix B: Limits of Acceptable Change – for the purpose of development of ECD for Australian Ramsar Wetlands

SEWPaC unpublished.

Purpose
To summarise advice additional to the ECD Framework on limits of acceptable change (LAC) for critical components, processes and services/benefits for the purpose of development of ECDs for Australian Ramsar Wetlands.

Background
The ECD Framework requires that limits of acceptable change (LAC) be set for the critical components, processes, benefits and services of the wetland, and provides guidance for describing and setting LAC considering natural variability, and including where limited information is available.

The ECD Framework defines LAC, as described by Phillips (2006), as:
…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameters, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character …
In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed.

The Ramsar Convention recognises upper and lower limits or sometimes both, with upper limits usually applied to undesirable factors (defining the maximum tolerance), and lower limits to positive factors. Strong linkages are suggested with site management plans.

In Australia, where there are often extreme ranges of variability over time, defining LAC is difficult; the methodology for determining limits will be refined as LAC are implemented and trialled. The problem is further compounded by lack of long-term datasets for many components, processes and benefits/services.

Issues
Background and recommendations are outlined below for each issue that has been raised in the development of LAC for ECDs.

1) Confidence levels for LAC
The ECD Framework states the need to provide justification for the limits of acceptable change.

Rather than doing this through labels or new terminology, this should be provided by qualifying statements. Against each LAC we would like an indication of confidence for the LAC. Indications of quality (e.g. site specific data if sufficient quality and quantity to determine statistically valid LAC; site specific data of lesser quality; expert opinion; information from literature for similar systems), and the data sources should be included to give confidence and define the arguments for the LAC. Referencing and data sources need to be clearly recorded against each LAC. This should, in most cases, replace the need for additional terminology for the LAC heading, reduce the confusion, and will allow for better explanation of each individual LAC. This should also provide advice on what confidence should be placed on a LAC if it is breached, indicating a possible change in ecological character.

Provision of additional information around confidence of LAC must be provided in the LAC table for an ECD

2) Terminology for LAC

Various terms have emerged to describe and qualify LAC, for example 'interim LAC', 'early warning LAC', 'optimum LAC', 'short term LAC' and 'long term LAC'. This additional qualifying terminology is leading to confusion and a lack of consistency between ECDs.

LAC should simply be referred to as 'limits of acceptable change'

3) LAC values

LAC should be self explanatory and contain all the information required to understand the measure without the need to reference other material for explanation. Where exact figures are available for the LAC these should be part of the LAC rather than the LAC referencing information elsewhere. If the LAC relates to an external document that cannot be placed in the LAC table, such as a map, precise referencing must be made to avoid confusion, subjectivity or disagreement).
Additional reference to background material either within the ECD or elsewhere can be provided for justification (see above).

4) Some LAC will require timeframes to account for variability over time

Wetlands, particularly ephemeral wetlands, are expected to show a range of variability over time. These may be seasonal or longer (multi-year) cycles. For these features, LAC will require incorporation of temporal range where known.

Some cases a LAC requires incorporation of a timeframe reflecting the acceptable time range for the variation.

5) Minimum data for LAC

Where minimal or no data exist to enable a LAC to be set with any level of confidence, there is still a requirement to identify that there is a need for a LAC for this critical component, process or service (CPS). In these instances, the additional information around confidence should note that minimal or no data currently exist to set a LAC for this particular CPS with any level of confidence. The 'knowledge gap' and 'monitoring needs' section of the ECD should elaborate further.

Because a LAC cannot be set for this particular CPS so then it goes that no assessment can be made on whether or not the LAC has been exceeded (because there is no baseline provided in the ECD). Knowledge gaps should be prioritised to give baseline/benchmark data highest priority. If data is not available at the time of listing but data is available for a later period that is representative of the time of listing, define what date the data is from and advise that it is the best available knowledge, provide a robust argument why this data is representative and then create the LAC from this data.

Where data isn't available, LAC can also be created from comparative studies where other sites are representative of the site of interest, provided that in doing so it is also consistent with the former mentioned LAC advice. This type of LAC is a surrogate but should not being labelled as such, but explained through explanatory text.

Where no or little data or method exists to support a LAC, or no method exists to identify a LAC, the identification of the LAC is still required in the ECD, with explanatory information around confidence.

6) Indirect measures for LAC

Direct measures should be used for LAC. In some cases there is no direct data available for a LAC. It is likely that in these instances, it may be possible to have indirect measures identified against the critical CPS, provided they adequately represent the critical CPS of interest and can be justified. The indirect measures would be things that influence the critical CPS, for example habitat (vegetation, invertebrates, water availability or quality etc) that contributes to a species using the site. LAC based on indirect measures should be identified within the table via explanatory text, with a brief explanation of why direct measures were not used, why the indirect measures were used, and how they relate to the critical CPS.

Direct measures should be used where available to measure critical components processes and services/benefits

Where no direct measure is available, the LAC would still be a measure for the critical component, process or service/benefit, but indirect measures can be used. A link to this indirect measure should be clearly established with clear evidence for its use. The indirect measure(s) needs to be clearly a surrogate for the value.

7) Setting LAC in a changing baseline

As described in the ECD Framework, and although challenging in many cases, LAC for ecological character descriptions of Ramsar sites should aim to be identified for the time of Ramsar listing of the site.

In the case of some Ramsar wetlands, the system was already declining when the site was listed, sometimes as a result of activities that were undertaken decades prior to listing (for example land clearing). In some cases the site continues to degrade as a result of past activities.

Other sites have been actively managed or restored since listing, and setting LAC at the time of listing would theoretically mean we are trying to maintain a wetland in poorer condition than the current condition.

ECDs should reflect the ecological character at the time of listing, and LAC should be set to that time, so that change since the time of listing can still be guided by LAC for this period.

Detrimental changes

Where detrimental change as a result of human activity results in a LAC being exceeded, the site can be assessed for possible Article 3.2 notification.

Positive change

Improvements to a Ramsar site should be outlined in the ecological change section of an ECD.

There may be instances where the development of an ECD identifies that the site has a new stabilised state that differs to that at the time of listing. In instances where the stabilised state is positive, following discussion with the project steering committee (including the jurisdictional site manager), LAC could be provided for time of listing in the LAC section and a clearly separate and second set of LAC reflecting the new stabilised system also provided in the “Change in Ecological Character since listing” section of the ECD or as an appendix to the ECD.

All sites should aim to have LAC set at time of listing

For sites where the ecological character has improved and a new stable system has established, new LAC can be provided in the ECD (or a subsequent ECD) in addition to those provided for time of listing

For sites where the ecological character has changed for the positive since listing and the system is not yet stabilised, new LAC cannot be identified or justified and this should be noted in the ECD. Only LAC set at time of listing are to be provided. In these instances, this should also be identified in the knowledge gap and monitoring needs section of the ECD document.

For sites where the ecological character has declined and/or LAC have been exceeded, no new LAC are to be included (irrespective of whether the site appears to have stabilised or not). This situation should be noted in the ECD.

8) Management triggers

Definition of a LAC:

- The natural variation around the equilibrium level of a wetland component, process or service (3.2 guidelines)
- The ECD framework states that 'Limits of acceptable change (LAC) are the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland . . . the inference is that if the particular measure or parameter moves outside the LAC then this may indicate a change in ecological character. . .'.

Management triggers differ from LAC. Management triggers represent smaller/earlier change points within the range bounded by LAC. Management decisions and resulting action based on management triggers should influence the management outcome, and prevent a breech in LAC and change in ecological character.

Confusion has arisen as some of the examples used in Table 7 in the ECD Framework could be considered to be management triggers. LAC need to be in accordance with the definition of LAC in the ECD Framework (rather than following the examples in the ECD Framework), to give a clear indication of when the ecological character may have changed since time of listing.

Management triggers are appropriate to the purpose of a management plan because they directly relate to an associated action. Management triggers are not required as part of the development of an ECD, but could potentially be developed or discussed in tangent with the LAC. It is recognised that during the development of an ECD it is helpful to identify what CPSs should be managed for, and identify management triggers around these. If management triggers are identified during the development of an ECD, these could be provided as a supplementary document/progress report to the land managers, or may be presented in an appendix of the ECD. However, they are not a requirement for the development of an ECD. They should not be provided in the LAC section.

LAC section of an ECD should not include management triggers

The ECD Framework will be adjusted to suggest the optional development of management triggers as part of the ECD development process, and allow for the inclusion of management triggers in appendices to the ECDs

9) Critical CPS and LAC

The ECD Framework requires LAC for all critical components, processes and services/benefits.

Note that the ECD Framework defines LAC in terms of change in character of the site, rather than LAC for listing criteria.

The ECD Framework (Section 4.3, page 18) states that, as a minimum, the critical component, process and/or service/benefit (CPS) should include:

- Important determinant of the site's unique character,
- Important for supporting the Ramsar or DIWA criteria under which the site was listed,
- For which change is reasonably likely to occur over short or medium time frames (<100 years),

- That will cause significant negative consequences if change occurs.

The ECD Framework does not state whether the above points should all be met (i.e. 'and' after each comma) or whether only one or more of the criteria need to be met ('or' after each comma). Some of the above criteria are broad and any element of the system could be considered to be critical. If all have to be met then there will not be many critical CPS.

The Australian Government has been advising that the ECD Framework criteria (dot points) should be considered 'and', but that the use of 'as a minimum' in the opening sentence allows for additional elements that characterise the site to be considered critical.

This still provides an element of ambiguity on what the critical CPS should include. While conceptual models should assist in identifying critical components, processes and services, as well as relationships, dependencies, drivers, feedbacks, stressors of the system, the ambiguity and inconsistency remains.

Noting:
1) The ultimate need for management triggers and LAC for management purposes;
2) that the Convention recognises the need for guidance around the unqualified magnitude or significance to which Article 3.2 notification is required (COP20 DOC27); and
3) that the ECD Framework definition of a LAC is in reference to indication of change in ecological character,
it is suggested that critical CPS are limited to those CPS for which, if a change outside its acceptable range of variability occurs, a change in character of the site would be considered. A critical component, process or service/benefit is one which, if the LAC is breached, an assessment for the purpose of a possible 3.2 notification will be undertaken.

It is recognised that there are components, processes and services on which other CPS depend.

For instance, some birds identified as critical components of a site may be dependent on an invertebrate at the site. While these birds are considered a critical CPS, if the site would not be considered to have changed in character if the invertebrates changed without the birds also changing, it is proposed that the invertebrates are not be considered a critical CPS.

However, recognising the importance of the invertebrate to the critical CPS (bird), it is suggested that the invertebrate be identified as an 'essential element'. A proposed definition of 'essential element' is at Attachment A.

In recent advice we have suggested three levels of description for a site's components, processes and services:
I. basic site description,
II. essential elements (or supporting CPS), and
III. critical CPS (those for which loss would constitute a change in ecological character of a site and trigger an assessment for potential 3.2 notification.

Of these, LAC are required in an ECD for critical CPS (III) only.

Management planning should pick up management triggers for (II) and (III) as it is these features that require management to prevent a breach of LAC and change in character.

ECDs define the ecological character and indicate where change in character may occur. Management plans should identify management triggers relative to the LAC so that management actions can prevent approaching or exceeding a LAC.

That critical components, processes and services (and required LAC) be limited in Ramsar site ECDs to those CPS for which, if a change outside its acceptable range of variability occurs, a change in character of the site would be considered.

A critical component, process or service/benefit is one which, if the LAC is breached, an assessment for the purpose of a possible 3.2 notification will be undertaken

10) Number of LAC in an ECD

The ECD Framework requires LAC for all critical components, processes and services/benefits.

There has been considerable variation in the number of LAC presented in ECDs to date, ranging from three to over eighty. That said, the unique character of a site should determine the number of LAC.

It is desirable to limit repetition of LAC for a site. If exceeding one LAC also means that other LAC are automatically exceeded, then there may be an argument to reduce the LAC to that one to reduce repetition.

This can be undertaken by the development of a flow hierarchy (or cascading LAC) for the site: LAC are first developed for components, then processes, and finally services (CPS). For example, if a LAC identified for a component is found to also sufficiently suffice for a process or a service, then the LAC for the processes or services would not also be required.

A LAC is required for all identified critical CPS, unless the particular CPS was already 'picked up' earlier. In such cases, reference to the existing LAC should be made. This will mean that many services at the end of the flow hierarchy will not require a specific LAC as they will have been addressed earlier in the LAC for components and/or processes, i.e. the particular components and processes enable the wetlands to provide particular services. However, these relationships must be made clear in the ECD.

It is worth noting that not all critical services may be addressed by LAC at the critical component or process level, and will need their own LAC.

The result of using a flow hierarchy for the development of LAC means that there will be fewer LAC per site, as many critical CPS will be captured at the component and process level. A ballpark figure of maximum 20 LAC should be considered, noting that some sites are very complex and will have a large number of LAC.

That LAC numbers be minimised where possible, possibly using a cascading LAC system

11) Writing LAC for services

Using the flow hierarchy LAC method will limit the number of LAC set for services.

The Ramsar Convention's broad aims are to halt and where possible reverse the loss of wetlands and conserve those that remain through wise use and management. In some situations, the identification of a LAC to maintain critical services of a site may conflict with maintaining other critical components and processes e.g. services such as sites created or maintained to provide consumptive water. This may lead to the possibility of a breach in LAC for other critical component or process and an Article 3.2 assessment. This circumstance would not be considered wise use. Noting the Ramsar Convention wise-use principles, such services should not be provided by the site at the expense of others that maintain the functioning ecosystem. LAC should be set under sustainability principles and wise use.

A LAC for a critical CPS needs to be set regardless of potential conflicting service requirements

No LAC should be identified for critical services that conflict with another LAC important for the sustainability of the site.

12) Setting LAC for complex mosaic wetlands

Many Australian Ramsar sites contain complex mosaics of wetlands, some of which contain disconnected areas of wetlands within the site. In some sites this has lead to the development of several conceptual models within the ECD, one for each of the major types of wetland systems within the site.

Critical CPS can be identified for different parts of the Ramsar site and, as a result, LAC can be set for a subset of the site. Even when the wetland systems are connected within the site, LAC can be set for part of the system noting the location and area of the site that the LAC applies to.

In these cases the critical CPS relating to the entire site will usually have site level LAC, whereas the critical CPS relating to part of the site would have LAC relating to that part of the site. A breach of a LAC in part of a site would still be considered a potential change in character for the whole site for the purposes of the ECD, and would be considered through the Article 3.2 assessment process.

Note that a LAC can be set for part of a site, and that a breached LAC for that part of a site may be a trigger for an Article 3.2 assessment

13) Effects of catchment level changes to systems or LAC

In many cases activities that can impact on a critical CPS, and potentially lead to a change in character, occur outside of the Ramsar site, and cannot be managed by the site manager. In these cases a LAC still needs to be set for the critical CPS within the site. Article 3.2 assessment would determine the cause of the exceeded LAC, and then determine if a notification is required. Conceptual models could potentially include or acknowledge elements that occur outside the site, provided it is made clear within the conceptual model that the activity is not within the site.

Note that LAC are set for ecological character within a Ramsar site, regardless of where the management influences occur

14) LAC and threats

Although threats should be considered as part of the development of the ECD and in the conceptual models, LAC should not be set for threats. Threats may be considered for use as indirect measures for LAC (see 6).

LAC are not set for threats

Appendix C: Limits of Acceptable Change examples.

This appendix lists LAC from two recent ECD for Hattah-Kulkyne Lakes and Barmah Forest Ramsar sites (Butcher and Hale 2011 and Hale and Butcher 2011). **These ECD are at draft stage and the information presented below may be subject to change and should not be circulated. Additional examples are available for several sites with completed ECD and accessible at http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl.**

Table 6: LAC for Hattah-Kulkyne Lakes (from Butcher and Hale 2011).

Critical CPS	Baseline/Supporting Evidence for LAC	Limit of Acceptable Change	Confidence level
Hydrology	The hydrology of the site, at the time of listing in 1982, can be characterised in terms of annual return intervals of Murray River flows at Euston, which are considered important for the critical components of the site and which produce filling events for the lakes (Ecological Associates 2007; MDBA 2010): • ARI of 1 in 3 of 40 000 megalitres per day for 60 days at Euston fills Lake Lockie, Hattah, Yerang, and Mournpall. • ARI of 1 in 5 of 50 000 megalitres per day for 60 days at Euston fills Lake Cantala, and Bulla. • ARI of 1 in 8 of 70 000 megalitres per day for 42 days at Euston fills Lakes Arawak, Brockie, Bitterang, Konardin and Yelwell. • ARI of 1 in 16 of 152 000 megalitres per day for 30 days at Euston fills Lake Kramen. Filling events can also be achieved by delivery of environmental water via pumping. LAC are set based on groupings of lakes with similar annual return intervals under current conditions as this represents the best available data. However as water delivery options are available at this site, the LAC are expressed in terms of number of filling events not a river flow. The LAC are assessed over a 10 and 20 year time spans to account for the variability in hydrology	No less than three filling events for Lakes Lockie, Hattah, Yerang and Mournpall in any 10 year period. No less than two filling events for Lakes Cantala and Bulla in any 10 year period. No less than one filling event for Lakes Arawak, Brockie, Bitterang, Konardin and Yelwell in any 10 year period. No less than one filling event at Lake Kramen in any 20 year period.	Medium

Critical CPS	Baseline/Supporting Evidence for LAC	Limit of Acceptable Change	Confidence level
	at the site (i.e. to allow for several occurrences of the specified flow events within the assessment period) and can be measured based on overbank flows (as above) or by delivery of environmental water via pumping.		
Lake bed herbland vegetation	The extent of lake bed herbland vegetation at the time of listing was 862 hectares indicated by EVC mapping (data supplied by DSE) Although there is information on extent for part of the Ramsar site, there is no indication of variability in this measure. In addition information on variability in these ecosystems from comparable sites could not be sourced. As such, an objective, statistically based LAC cannot be determined and a figure of 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee.	Extent of lake bed herbland vegetation to be no less than 776 hectares.	Low
Fish	Data for native fish are limited to a small number of surveys, most in recent years in relation to pumping. Native fish species dominate the system with 12 species recorded from several surveys (Walters et al. 2010; MDFRC in prep). Survey results indicate that the fish species present are relatively predictable, with a reasonable probability that all common species recorded to date would be encountered over several sampling events. This LAC is set on expert opinion and assumes annual monitoring under the Living Murray Icon Site condition monitoring and that rare fish may not be recorded (freshwater catfish, flat-headed galaxias). It excludes consideration of flood spawners (golden and silver perch) and main channel specialists (Murray cod) and focuses on wetland specialist species.	Presence of the following wetland specialist species of native fish recorded over any three sampling events over a five year period in which at least three of the lakes are inundated. • Australian smelt *Retropinna semoni* • Bony herring *Nematalosa erebi* • Carp gudgeon *Hypseleotris* spp. • Western carp gudgeon *Hypseleotris klunzingeri* • Flyspecked hardyhead *Craterocephalus fluviatilis*	Medium.
Waterbirds – number of species	The site supports a diversity of waterbirds with a total of 70 species recorded from the site. Data from Lake Hattah for the period 1990 to 2001 has species richness ranging from 13 to 36 with an average of 22 (data supplied by DSE). Using data from	Presence of at least 8 of the following species in at least 10 years of any 20 year period in which at least three of the lakes are inundated:	Medium.

Critical CPS	Baseline/Supporting Evidence for LAC	Limit of Acceptable Change	Confidence level
	2007 to 2009 species richness ranges from 14 to 24 with an average of 20 (data from Annual summer waterfowl counts and Living Murray Icon Site condition monitoring). However, trends in species richness since listing are not discernable due to differences in wetting and drying, as well as sampling effort across lakes and years. As such the LAC is set on a 20 percent decline in the presence of a subset of common species identified by DSE (2010). These species were encountered in at least 10 of a 20 year period. LAC is based on expert opinion.	• Australian pelican *Pelecanus conspicillatus* • Australian wood duck *Chenonetta jubata* • Black-winged stilt *Himantopus himantopus* • Australian darter *Anhinga novaehollandiae* • Great cormorant *Phalacrocorax carbo* • Great crested grebe *Podiceps cristatus* • Little black cormorant *Phalacrocorax sulcirostris* • Masked lapwing *Vanellus miles* • Pacific black duck *Anas superciliosa* • White-faced heron *Egretta novaehollandiae* • Yellow-billed spoonbill *Platalea flavipes*	
Waterbirds – number of species breeding	The Ramsar site supports breeding for a total of 34 waterbird species; however the number of species recorded breeding in any single year is highly variable and is not well documented. Many of the records which do exist are for single breeding events only. Multiple year records are only available for seven species. A long term monitoring program with annual records for breeding is required before setting LAC.	Data insufficient to set a LAC	Not applicable.
Near natural wetland type	This critical service is linked principally to changes in the hydrology as well as changes in extent and condition of wetland vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the frequency and duration of flow events.	No direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology, see LAC above.	Not applicable.

Critical CPS	Baseline/Supporting Evidence for LAC	Limit of Acceptable Change	Confidence level
Physical habitat which supports waterbird breeding.	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland and floodplain vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the hydrological regime and lake bed herbland vegetation.	No direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and lake bed herbland vegetation see LAC above.	Not applicable.
Physical habitat which supports waterbird feeding.	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland and floodplain vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the hydrological regime and lake bed herbland vegetation.	No direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and lake bed herbland vegetation see LAC above.	Not applicable.
Threatened species – Australian painted snipe	Australian painted snipe has been reliably recorded from Lake Yerang in 2007. The species is known to be cryptic and not easily detected. Currently there is inadequate data to set a LAC.	Data insufficient to set a LAC	Not applicable.
Threatened species – regent parrot	Limited data is available for regent parrot (*Polytelis anthopeplus monarchoides*) for within the bounds of the Ramsar site. Continued presence is considered an appropriate LAC for this species as it will be utilising the floodplain as well as the surrounding mallee habitat. Large river red gum trees with hollows in the branches are preferred roosting and nesting habitat. This LAC is set on expert opinion.	Presence within Ramsar site on an annual basis.	Low.
Threatened species – Winged peppercress	Winged peppercress, *Lepidium monoplocoides* is listed as occurring in the site. The species is located between Lake Hattah and Lake Bulla in an area covering approximately 0.1 hectares (Mavromihalis 2010). Mavromihalis (2010) reports the population to be in decline at the site, however due to the fact that this species exhibits a highly variable population size in response to wetting and drying, the LAC is based on presence absence data only. This LAC is set on expert opinion.	Presence of winged peppercress, *Lepidium monoplocoides,* between Lake Hattah and Lake Bulla in years when conditions are suitable.	Low
Biodiversity	The site is hydrologically connected between the river and a series of interconnected floodplain lakes in which wetland	No direct LAC has been developed and instead the critical service will be	Not applicable.

Critical CPS	Baseline/Supporting Evidence for LAC	Limit of Acceptable Change	Confidence level
	dependent species establish. The wetting and drying of the lakes promotes diversity and this service is maintained by hydrology. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology. Changes in LAC for fish and waterbirds could also be used as surrogate measures for this service.	assessed indirectly through changes in hydrology, see LAC above.	
Ecological connectivity	The site is hydrologically connected between the Murray River and a series of interconnected floodplain lakes in which fish populations and other aquatic biota establish. This service is maintained by hydrology and can also be indicated by the species richness of native fish. The key elements of connectivity are unimpeded flow and reconnection to the Murray River to allow recruitment of species into the regional population. Natural overbank flows of greater than 50 000 megalitres per day at Euston are considered the critical magnitude for sustaining this service. The relative importance of connectivity and timing of connecting flows remains a knowledge gap for the site. No direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and native fish populations.	See LAC for hydrology and native fish.	Not applicable.

Table 7: LAC from Barmah Forest (from Hale and Butcher 2011).

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Critical components and processes			
Hydrology	For establishing the LAC, the hydrology of the site can be characterised in terms of frequency and average duration for river flow thresholds that are considered important for critical components of the site. These are presented below for the time of listing (adapted from modelled 1984 level of development in Leitch 1989): • 10 400 megalitres a day (commence to flow into forest) - frequency is eight years in 10 and average duration is 100 days and longest dry period is 3.7 years; • 16 000 megalitres a day (moira grasslands) - frequency is seven years in 10, average duration is 90 days and longest dry period is 3.7 years; • 35 000 megalitres a day (overbank flow inundating approximately 60 percent of river red gum forest and 30 percent of river red gum woodland) - frequency is 11 years in 20, average duration is 63 days and longest dry period is 9.6 years; • 60 000 megalitres a day (inundation of all river red gum forest and woodland and black box woodland - frequency is 12 years in 50, average duration is 21 days and longest dry period is 16.7 years. Ideally a LAC would be based on frequency and extent of inundation directly measured within the forest, but this is difficult to apply and more difficult to assess against. What is proposed is a LAC based on the frequency, and duration of flow events considered important for maintaining ecological character (Murray River at Yarrawonga). In addition, as the interval between floods is also critical for maintaining critical components, an ARI based on the maximum intervals between events is also proposed. This is based on	*Minimum of 10 400 megalitres a day (Murray River at Yarrawonga) no less than seven years in any 10 year period, with a mean duration no less than 100 days; and a maximum interval of four years between the flow threshold.* *Minimum of 16 000 megalitres a day (Murray River at Yarrawonga) no less than seven years in any 10 year period, with a mean duration no less than 90 days; and a maximum interval of four years between the flow threshold.* *Minimum of 35 000 megalitres a day (Murray River at Yarrawonga) no less than 10 years in any 20 year period, with a mean duration no less than 60 days; and a maximum interval of 10 years between the flow threshold.* *Minimum of 60 000 megalitres a day (Murray River at Yarrawonga) no less than 12 years in any 50 year period, with a mean duration no less than 21 days; and a maximum interval of 12 years between the flow threshold.*	Medium

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
	modelled conditions at the time of listing (as detailed above) with the exception of the 60 000 megalitres a day threshold, for which the 16.7 year maximum duration was considered to be too high to sustain the forests and woodlands (Jane Roberts, floodplain vegetation expert, personal communication). The LAC is assessed over time spans to account for the variability in hydrology at the site (i.e. to allow for meaningful means to be calculated for each of the specified flow thresholds within the assessment period).		
Vegetation – River red gum forests and woodland	The extent of river red gum forests and woodlands at the time of listing was (Chesterfield et al. 1984): • 21 500 hectares of river red gum forest • 2700 hectares of river red gum woodland In addition, there are benchmarks for tree condition (Cunningham et al. 2009) with 96% of the red gum forest and woodland in moderate or better condition in 2003. Although there is information on extent and condition for part of the Ramsar site, there is no indication of variability in either of these measures. In addition information on variability in these ecosystems from comparable sites could not be sourced. As such, an objective, statistically based LAC cannot be determined and a figure of 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee.	*Extent vegetation to be no less than:* • *19 350 hectares of river red gum forest* • *2400 hectares of river red gum woodland* *River red gum condition to be "moderate" (according to the method of Cunningham et al. 2009) or better for at least 80 percent of forest.*	Low
	Forest structure and structural diversity is an important characteristic of river red gum forests in terms of habitat value (Horner et al. (2010). The number of hollow bearing trees within the forest has been estimated at 15 per hectare (Thomson et al. undated). However variability is extremely high with a range from zero to over 60 trees per hectare. As such it is not possible to set a LAC based on this information.	*Insufficient information to develop a LAC for forest structure at this point in time.*	Not applicable

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Vegetation – Floodplain marshes	Extent of floodplain marshes (Chesterfield et al. 1984): • *1500 hectares moira grass* • *500 hectares of giant rush* As with the river red gum extent above, there is no indication of variability, but extent of inundation and community composition will vary considerably over wetting and drying cycles. As such an objective, statistically based LAC cannot be determined and a figure of 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee. Ideally a LAC would also be set for vegetation community composition. However, there is insufficient data at this stage upon which a LAC can be based.	*Extent of floodplain marshes to be no less than:* • *1350 hectares moira grass* • *450 hectares of giant rush*	Moderate
Vegetation – threatened species	The site supports the nationally threatened Mueller daisy (*Brachyscome muelleroides*) and swamp wallaby-grass (*Amphibromus fluitans*). There is no indication of the extent of location of these species at the time of listing and there are only ad hoc records from more recent times. The species are both perennial and as such a LAC is proposed based on presence only.	*Presence of* Mueller daisy (*Brachyscome muelleroides*) and *swamp wallaby-grass (Amphibromus fluitans) in permanent and intermittent wetlands within the site.*	Low
Native fish (species richness)	Data for native fish are limited from the Ramsar site. Quantitative data are available for the Barmah-Millewa Forest with an average abundance of native fish (2003 to 2006) of 12 000 ± 2700 (mean ± standard deviation; n=3; King et al. 2007). A total of 15 native fish species were recorded in 2002 – 2006 (King et al. 2007). The survey areas were however, not limited to the Ramsar site and this is insufficient to develop a quantitative LAC. There is a lack of underlying knowledge of variability in fish species richness and the relationship with ecological character. As such the LAC has been developed based on expert opinion (L. Beesley, DSE, personal communication May 2010) with respect to fish that	*Presence of the following species in no less than two in five annual surveys:* • *Australian smelt (Retropinna semoni)* • *Carp gudgeons (Hypseleotris spp.)* • *Dwarf flat-headed gudgeon (Philypnodon macrostomus)* • *Flat-headed gudgeon (Philypnodon grandiceps)* • *unspecked hardyhead (Craterocephalus*	Low

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
	are characteristic of the site and would be expected to be present.	*stercusmuscarum fulvus)* *Murray-Darling rainbowfish (Melanotaenia fluviatilis).*	
Native fish (threatened species)	Three threatened native species of fish are known from the site (Jones 2006; King et al. 2007; Davies et al. 2008). Population size, dynamics and distribution not fully understood.	*Presence of Murray cod, trout cod and silver perch in three out of five of annual surveys.*	Low
Wetland birds (abundance)	A total of 64 species of wetland bird have been recorded from within the site. However, there is no indication of the number of species that regularly utilise the habitats within the site. There is evidence that the site "regularly" supports thousands of colonial nesting waterbirds during significant flood events with successful breeding occurring on 10 occasions between 1962 and 1981 (DSE 2008). LAC set based on the findings of Leslie (2001) and a definition of successful breeding of 80 percent of chicks fledged (Rick Webster, NPWS, personal communication).	*Successful breeding (80 percent chicks fledged) of colonial waterbirds in at least five years in 10.* *Thousands of colonial nesting birds in no less than two years in 10.*	Low
Wetland birds (threatened species)	The site supports at least two threatened species of wetland bird (Australasian bittern and superb parrot, with regular records of both species (MDBC 2007) However, there are no population estimates for either species. Insufficient data from the Ramsar site to set a quantitative LAC.	*Presence of Australasian bittern when Tall Marsh is inundated.* *Presence of superb parrot and evidence of breeding annually.*	Medium High
Critical Services			
Diversity wetland types	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the frequency and duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes.	*See LAC for hydrology and vegetation*	Not applicable

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Biodiversity	This critical service relates not only to species richness, but also to the presence and extent of moira grasslands within the site. A LAC based on a total species census is not sensible in terms of assessment, and it is likely that all species that use the site have yet to be recorded. As such, surrogates in terms of fish, vegetation and waterbirds will be used to assess against this service.	*See LAC for wetland birds, fish and vegetation.*	Not applicable
Physical habitat	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. In addition, wetland bird abundance can be used as a surrogate measure. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the frequency and duration of specific flow events, extent and condition of river red gum forests and woodlands, extent of floodplain marshes and abundance of wetland birds.	*See LAC for hydrology, vegetation and wetland birds.*	Not applicable
Threatened species	This critical service is indicated by the presence of threatened species at the site. Therefore no direct LAC has been developed and instead the critical service will be assessed through presence of threatened species.	*See LAC for wetland birds, fish and vegetation*	Not applicable
Ecological connectivity	The site maintains connectivity between the river and floodplain wetlands and channels for fish spawning and recruitment. This service is maintained by hydrology and can also be indicated by the species richness and abundance of native fish. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and native fish populations.	*See LAC for hydrology and native fish.*	Not applicable
Carbon cycling	This service is provided by the uptake of carbon by vegetation, the deposition of organic matter (coarse woody debris and litter) on the floodplain and the mobilisation of particular and dissolved organic carbon to receiving river systems with flood return waters. This service is maintained by vegetation extent, forest structure and hydrology. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through	*See LAC for hydrology and vegetation*	Not applicable

Critical CPS	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
	changes in hydrology and floodplain forest extent.		