Making wetlands more fish friendly

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Introduction

The serious decline of health and biodiversity in floodplain ecosystems of the Lower Murray Valley in south-eastern Australia has been well documented. The primary causes of wetland decline in the aquatic ecosystems of the Lower Murray Valley downstream of Wentworth have resulted from a combination of water extraction, river regulation and changes in land management. Secondary factors compounding the decline include grazing, salinity and the introduction of exotic species. Wetland repair projects in the Lower Murray Valley are seeking to reinstate relatively natural water regimes, particularly to simulate the volume and frequency of spring floods, which are key triggers for recruitment in native plant, animal and fish species.

Background

The ecology of Lower Murray Valley ecosystems is closely tied to the spring flood pulse which creates overbank flows onto the floodplains (Walker 1986; Walker & Sheldon 1994). The Lower Murray Valley is the fully regulated 830 km downstream sector of the Murray-Darling Basin in south-eastern Australia. The slow-flowing turbid main-stream catches inflows from over 1,000,000 sq km, through a network of 20 sub-catchments of slow-flowing rivers which flow west from the Great Dividing Range through nearly 2000 km of semi-arid lowlands to the Murray Mouth in South Australia (**Figure 1**).

It is now relatively well understood at a regional scale that the loss of small to medium overbank flows during spring floods is a critical factor in the decline of biodiversity and wetland health in the Murray Valley (Thoms *et al*. 2000; Young 2001; Jones 2002; Whittington 2002). These overbank flows trigger breeding and regeneration responses in key floodplain species, and sustain the local salt and water balance in wetland hydrological regimes (Walker 1983, 1985, 1986; Walker & Sheldon 1994; Young 2001).

The primary causes of wetland decline in the aquatic ecosystems of the Lower Murray Valley have resulted from a combination of water extraction, river regulation and changes in land management (Close 1990; Jacobs 1990; Maheshwari, Walker & McMahon 1993; Mussared 1997; Jensen 1998, Walker, Thoms & Sheldon 1992, Young 2001). The specific factors are summarised below:

- changes in water regime
  - reduced flood frequency, duration and volume
  - increased permanent inundation
  - changed turbidity
  - changed groundwater conditions (increased salinity)
- introduction of exotic fish species
- loss and decline of riparian vegetation
- introduction of exotic animal species.

Serious wetland decline has been reported, with death or severe stress in key floodplain tree species, reduced recruitment of native fish and reduced populations of aquatic plants and waterbirds (Mitchell 1994; Walker & Sheldon 1994; Harris & Gehrke 1997; Young 2001). Extinctions and serious population decline have been reported in aquatic snails, river crayfish and river mussels (Walker 1986, 1990; Walker & Sheldon 1994).

Another consequence has been a major impact from introduced fish. In the Murray-Darling Basin, the common carp (*Cyprinus carpio*) breed annually regardless of flow conditions. This species has spread throughout the system since its introduction in 1968 to become the dominant fish species at the expense of native fish, which are greatly reduced in numbers and in some cases reduced to threatened status (Murray-Darling Basin Commission 1989; Brumley 1991; Olsen 1995; Harris 1995; Roberts & Tilzey 1997; Vilizzi 1998).

Repair techniques used

Projects in the Lower Murray to repair wetland sites target changed water regimes as their first priority (Wetlands Working Party 1989; Zalewski & McClain 1998; Jensen 2002a). Repair works in wetlands at higher elevations on the floodplain are designed to increase the opportunities for overbank floods to reach wetlands in spring and early summer. These projects include works to open up natural flow paths to carry floodwaters

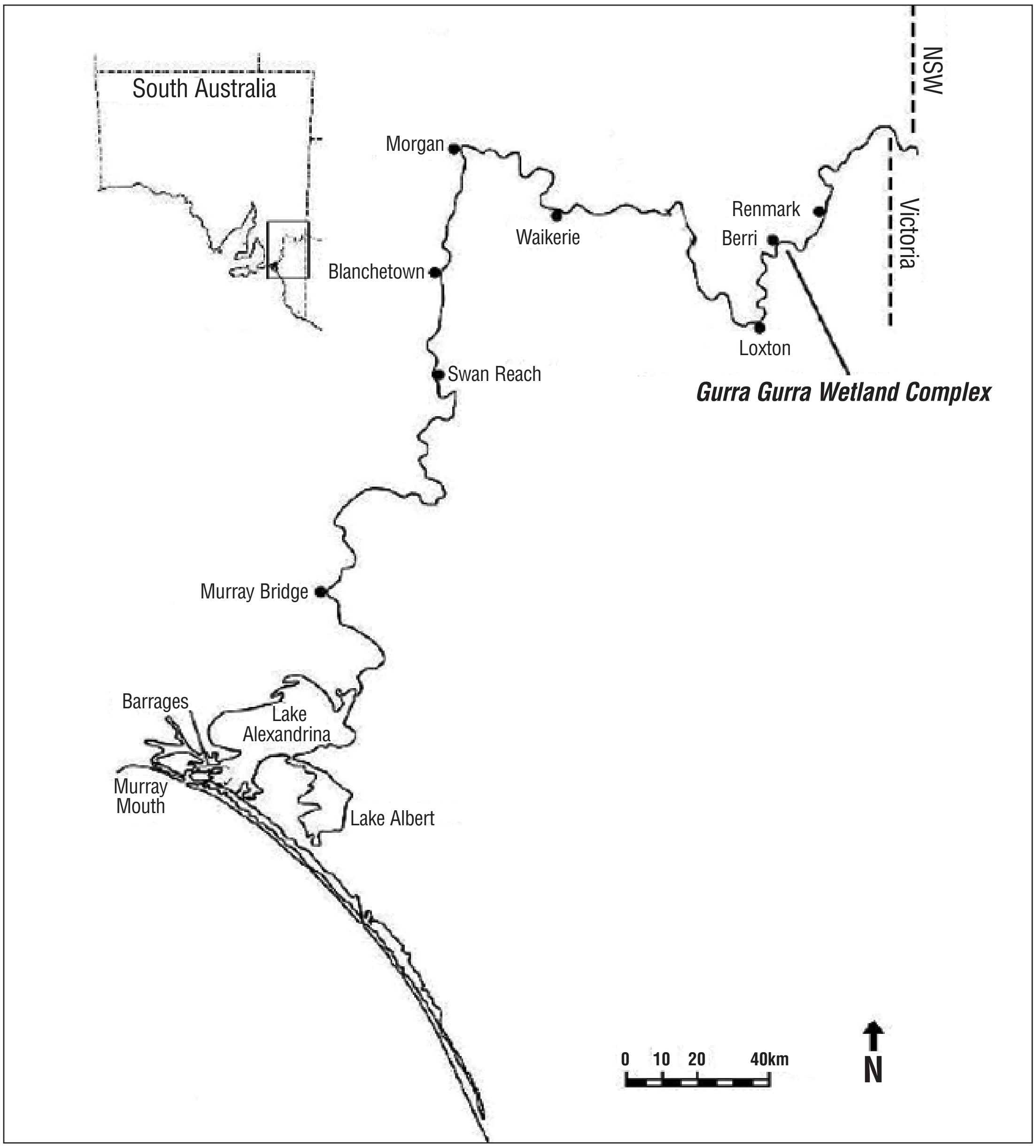


Figure 1. Location of Gurra Gurra Wetland Complex, Lower Murray floodplain, South Australia.

across the floodplain and into wetlands. Earlier and longer inflows will compensate for the reduced frequency, volume and duration of floods delivered from the upper catchment, due to river regulation and water diversion.

At sites of lower elevation, raised river levels due to regulation now permanently inundate wetlands which naturally had a temporary water regime, and repair works are directed towards the periodic exclusion of water. The timing and duration of these dry periods is based on the natural hydrograph, which indicates drying of 2–4 months in late summer-autumn, at least once every three years (Pressey 1987). This cycle has been gradually refined on the basis of monitoring results from demonstration sites to maximise desired ecological responses to changes in the water regime (Jensen 2002a, 2002b).

Secondary actions to repair wetlands include measures to reduce the impact of introduced common carp (Harper 1985). This technique combines drying out permanently inundated wetlands, and then installing fish screens on the inlet when the wetland is re-filled.

With the fish screens installed and operating:

- 7.5 cm mesh screen prevents entry of all adult fish, but allows juveniles and small natives to enter wetland
- there is a vertical or rotating gate (rotating gate easier to clean)
- regular cleaning is required to remove trapped debris and aquatic plants
- small carp which enter wetland tend to become prey
- the wetland can be dried every 2–3 years (removes any surviving carp before they can breed)
- screens can be operated during regulated flow conditions, when water level would remain static and no flood events occur (conditions favour carp and no cues for native fish to migrate or spawn)
- screens can be removed if river flows are sufficient to cue native fish breeding.

Case study

At Gurra Gurra Wetland Complex, near Berri in the South Australian Riverland, a wetland management plan has been prepared by Wetland**Care** Australia for the Gurra Wetland Care Group, which includes 32 landholders with an interest in the 3000 ha site (Zalewski & McClain 1998; Jensen, Marsh & Nichols 1999; Jensen 200b).

This complex project includes the following features:

- 3000 ha floodplain, including 700 ha of waterbodies
- 32 landholders, including freehold, leasehold and Crown Land
- major issue is blockages to cross-floodplain flows, preventing effective spread of floods into wetlands
- salinisation due to rising groundwater and reduced flooding
- drowning and droughting effects in different sections of the complex due to altered flow regime in main-stream
- 17 construction sites to remove blockages and increase the effectiveness of flooding
- $750,000 NHT funding (1999–2002)
- $1.2 m in-kind grants & community effort.

Blockages in the flow paths across the Gurra floodplain are a major cause of decline in floodplain vegetation and salinisation of the soils (**Figure 2**). Project works have placed culverts in major roads and causeways, to allow high flows to follow natural paths across the floodplain into the wetlands. Flood frequencies have effectively been increased through lowering inlet thresholds, removing blockages and increasing flow capacity in key flow paths.

Three small demonstration wetlands at Little Duck Lagoon, Causeway Lagoon and Old Loxton Road Lagoon are used to provide evidence of the ecological responses to three different hydrological regimes (**Figure 3**). Changes to the hydrological regime in the demonstration wetlands are showing rapid positive results in increased biodiversity. The management issues being tackled include increasing the effectiveness of floods, re-introducing drying cycles, and reducing the impact of introduced exotic fish, particularly common carp.

Water has been excluded from a permanently inundated wetland to create intermittent drying phases to consolidate the wetland bed, allowing re-establishment of aquatic plants, and reducing areas of soft silt suitable for carp feeding. Increased inflows of freshwater into a saline wetland and a droughted wetland have been followed by positive responses to the changed water regime. Adult carp have been reduced in all three wetlands.

All three demonstration wetlands have 7.5 cm mesh fish screens on their inlet channels, for the purpose of excluding adult fish. The target species is common carp, to prevent major disturbance of the wetland habitat through their mode of feeding. Carp suck up soft silt from the wetland bed and expel unwanted sediment through their gills, increasing the turbidity of the wetland and knocking over aquatic macrophytes attached to the wetland bed. The drying process consolidates wetland sediments, making them unsuitable for the feeding mode used by carp. As aquatic plants re-establish on the wetland bed, there is also less exposed sediment, and the wetland becomes a more favourable habitat for native fish species, and less favourable for carp (van der Wielen 2003).

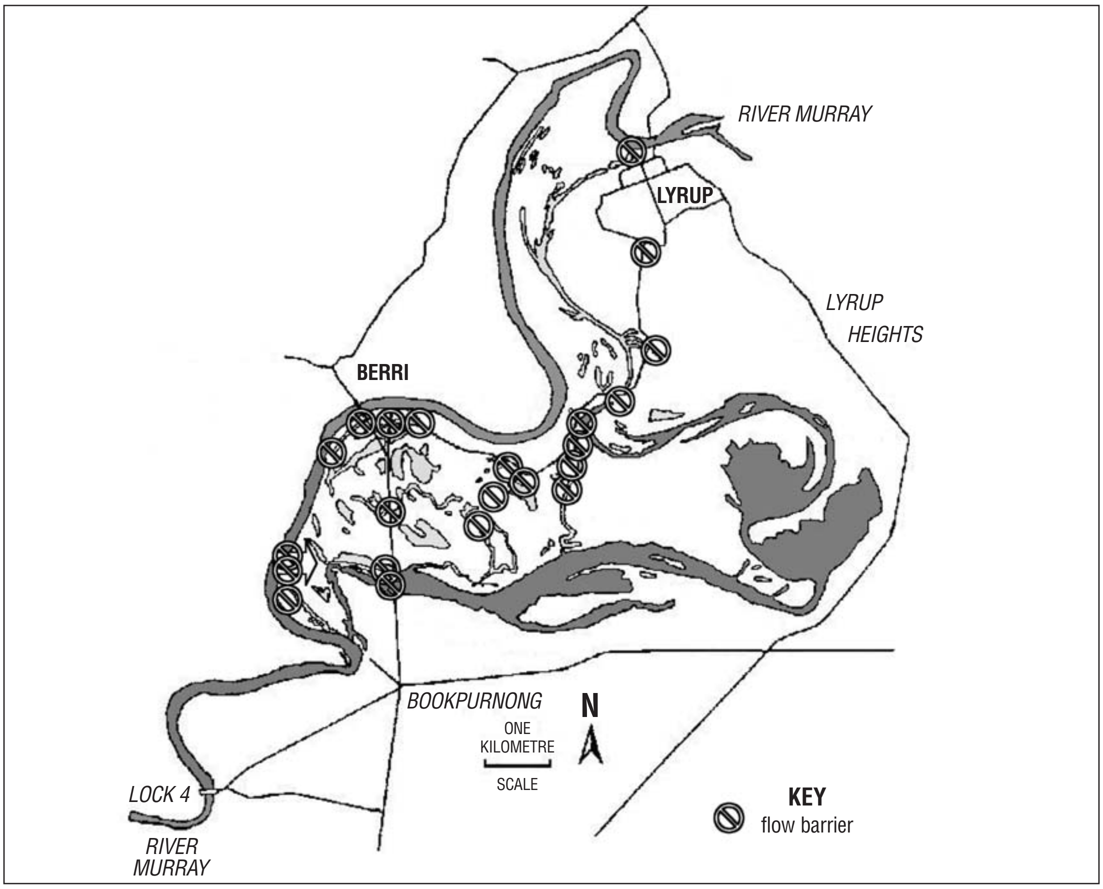


Figure 2. Blockages in floodplain flow paths through Gurra Gurra Wetland Complex prevent effective spread of flood flows into wetlands (Source: Jensen, Marsh & Nichols 1999).

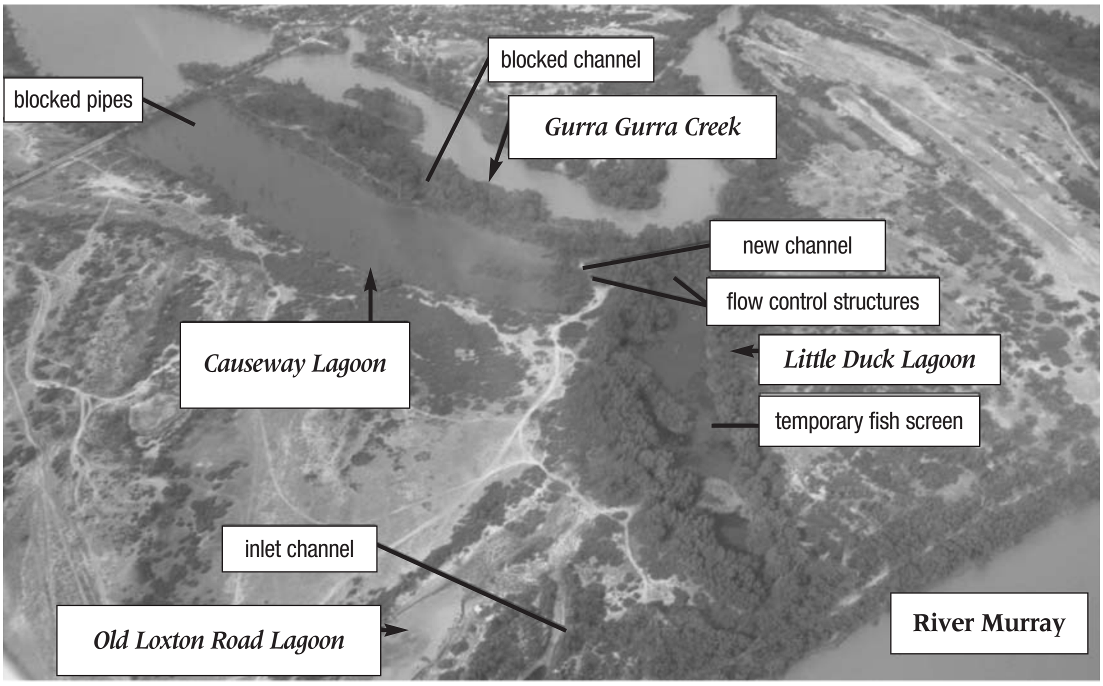


Figure 3. Demonstration sites at Little Duck Lagoon, Causeway Lagoon and Old Loxton Road Lagoon in Gurra Gurra Wetland Complex each have different water regimes and repair treatments (Photo: Anne Jensen)

Little Duck Lagoon was naturally a semi-permanent freshwater wetland, which was permanently flooded from 1927 when river regulation raised local water levels. Since 1998 it has been has been changed from a permanent freshwater wetland to a semi-permanent system, through the introduction of short drying cycles.

The wetland can be refilled at any time, by opening the control structure and allowing water to gravity feed from the regulated level of the River Murray. Operating rules are being developed to use this management control to create a more natural hydrological cycle similar to the normal cycle of high spring flows and low summer levels, with occasional drying cycles.

Causeway Lagoon was naturally a semi-permanent freshwater wetland, which was permanently flooded from 1927 when river regulation raised local water levels. Changes in floodplain conditions since 1975 turned it into a land-locked permanent lagoon fed by highly saline groundwater seepage and winter rainfall run-off. Since June 2000 it has been changed into a permanent freshwater lagoon. The new inlet channel has a control structure that will allow inflows to be shut off if required. The present proposal is to maintain freshwater inflows for at least two years, or until there is evidence of the creation of a freshwater lens in the water table beneath the lagoon.

Old Loxton Road Lagoon was formerly a temporary wetland on the higher floodplain. Due to increasing diversion of water from the river and decreased flood frequencies, it became a droughted and salinised temporary lagoon. The sill of the inlet channel has now been lowered and a control structure installed to replace a collapsed causeway that severely restricted inflows. This lagoon can now fill with freshwater at relatively high flood frequencies, creating a temporary fresh to brackish water system again.

Community participation

The Gurra Gurra project has required the cooperation of landholders over a period of five years to date, to participate in and remain committed to the project through frustrations and delays, and to weather some serious misunderstandings. The motivation for the landholders was their personal experience of the decline of the Gurra floodplain in their own lifetimes. They remembered healthy clear floodplain creeks, lined with thriving black box trees (*Eucalyptus largiflorens*) and full of native fish such as callop (*Macquaria ambigua*) and yabbies (*Cherax destructor*). Their vision is to see these conditions return to areas where currently even the salt-tolerant black box are struggling to survive, with creeks reduced to saline pools of groundwater, salt crusts and dead trees.

Some important lessons have been learned along the way. It was found that many of the community members who attended initial planning sessions to prepare project bids and coordinate early stages of the project were replaced by others once the project commenced on-ground activities. Works on the ground generated much more interest in the community, and the local television station was very interested to film a story on each construction job as the project progressed.

Wetland**Care** Australia played an essential role as driver of the project, providing coordination and technical advice for the many complex steps in overseeing 17 construction sites.

Landholders formed the Gurra Wetland Care Group to operate as a steering committee for the project. Membership was open, and attendance at meetings ranged from 8 to 25 landholders and community members. Members of this group provided valuable in-kind support, loaning equipment, undertaking monitoring and developing additional related projects. Support for the project was not consistent throughout, highlighting the important factor that support can vary significantly at various stages.

Initial support for the Gurra project was strong, but after 12 months, three landholders suddenly announced that they would do anything they could to stop it, because of their concerns about the impact of drying out the Gurrra Gurra Lakes. At that time 18 other landholders were actively in favour of the project. However, after a further 12 months, the same three landholders who had been objecting were getting impatient because of delays on works to improve flood flows into the Gurra Gurra Lakes. By the end of the project, these three landholders had fenced off riparian zones, undertaken fox baiting, and reintroduced bettongs and poteroos. They were also actively participating in salinity investigations and fish surveys.

Other volunteers from the community were providing bird counts, turtle and reptile counts, and water turbidity samples. One landholder donated use of his seaplane to obtain aerial photographs during critical phases of the project. All landholders continue to maintain a possessive interest in the progress of bank stabilisation works and vegetation projects at key sites. The name of the main flow path through the complex is now Gurra Gurra Creek, following a formal name change from Salt Creek, as recommended by the group. The names 'Little Duck Lagoon' (formerly Salt Creek wetland), 'Tortoise Crossing' (Site J) and 'Echidna Crossing' (Site K) came from group members, and proved to have lasting positive effects in promotion of the project.

Celebrations of progress on the project included a formal opening of Tortoise Crossing by former federal Environment Minister Senator Robert Hill, followed by afternoon tea at the nearby Lyrup Club. An activity was held on each World Wetlands Day and World Environment Day throughout the project, with volunteers from Origin Energy in Adelaide attending each of these in 2003 to assist with on-ground activities. The project was also consistently publicised on local radio and television, and an information bay was installed near the main regional road between Berri and Loxton.

The landholders are continuing to keep a watchful eye on their floodplain, waiting for the beneficial effects of the next flood.

Results

Preliminary monitoring results from the demonstration sites indicate the nature of specific ecological responses of species and family groups to the altered hydrological regimes. These results are being applied through adaptive management to refine the operating rules for the hydrological regime at each site. The results form the basis for the development of operating guidelines for hydrological control and monitoring (Tucker *et al*. 2002).

Little Duck Lagoon

This small wetland of 2.5 ha has completed two drying and re-filling cycles. In the first cycle, it was dried out to a cracked clay bed, then re-filled with a fish screen in place halfway along its length (**Figure 4**). The section without adult carp had relatively clear, tannin-coloured water with water plants showing intact habits. In the section with adult carp present, the water was turbid and the water plants were significantly disturbed, with few still attached to the substrate.

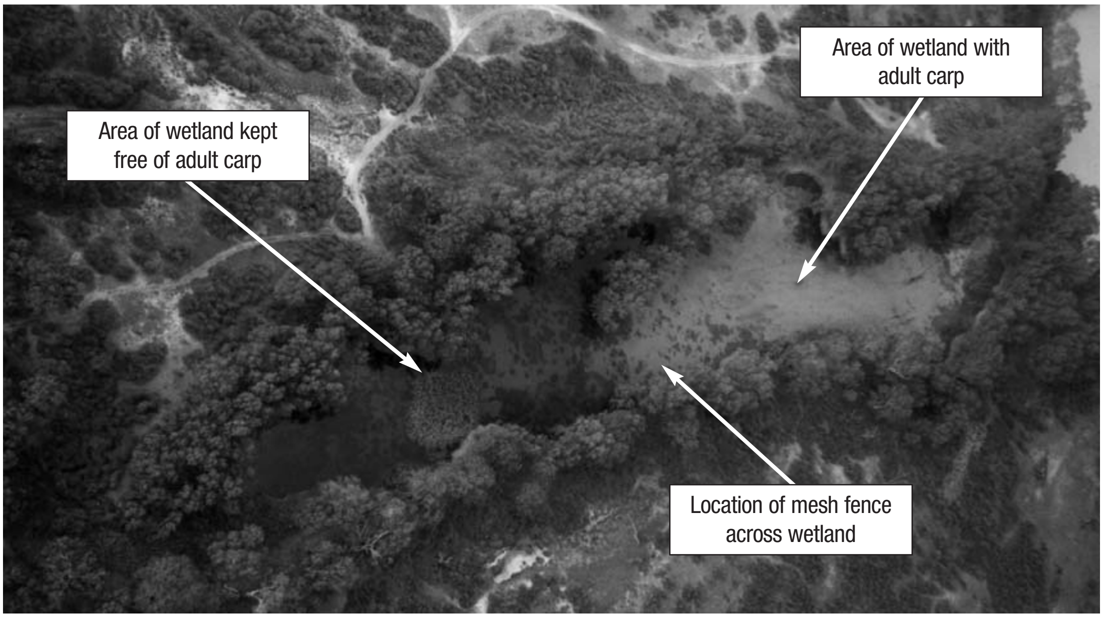


Figure 4. Demonstration of benefits of excluding adult carp in Little Duck Lagoon, with free entry to the first section of the wetland (right), where waterplants have been uprooted, but only small fish allowed into the upstream section (left), where waterplants remain intact and attached to the substrate. (Photo: Anne Jensen).

The general management objectives for this site are to manage to achieve maximum water plant diversity (Tucker 2003). Initial results indicate that a diverse water plant community will support a diverse range of macroinvertebrates and small native fish (Souter *et al*. 2000).

Monitoring of Little Duck Lagoon over 18 months has resulted in the following findings:

- deep cracking and consolidation of the wetland bed occurred within two months of drying, allowing aeration of soils and increased bio-availability of nutrients
- macroinvertebrates showed a series of distinct population peaks by different families linked to the type of food available, with gatherers and scrapers the most abundant functional feeder groups (Tucker 2003)
- prolonged flooding leads to a reduction in macroinvertebrate abundance, in this case after 14 months (Tucker 2003; Boulton & Jenkins 1997)
- turbidities were lower in the segment of the wetland with adult fish excluded (Tucker 2003)
- aquatic vegetation diversity and abundance appear to be related to the length of the dry phase (Tucker 2003; Siebentritt 2003)
- relative numbers of native fish declined compared to introduced fish after 12 months of filling (Tucker 2003).

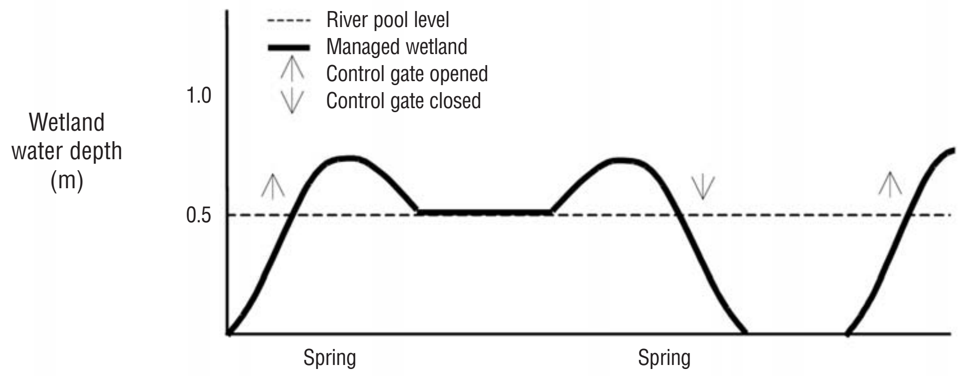
From these results, the operating regime has been modified, with a wet phase of 14 months starting in spring, and a dry phase of 6 months through autumn/winter on a 2 year cycle (Jensen 2002b; **Figure 5**). This will be varied in response to river flow conditions and flood events, as well as responding to ongoing monitoring feedback.

Causeway Lagoon

The general management objectives for this site are to establish and maintain a range of habitats through time, including dry wetland bed species and aquatic species. In the short term, this requires maintenance of a permanent freshwater pool to counteract the effect of saline seepage into the wetland. The hydrological objective is to create a freshwater lens beneath the wetland as a buffer between the surface water and the highly saline regional groundwater. Once the freshwater lens has been created, it is intended to re-introduce short drying cycles to create a temporary freshwater wetland habitat.

Monitoring of Causeway Lagoon over 18 months has resulted in the following findings:

- salinity in the lagoon was significantly reduced, from over 45,000 EC (saline) prior to filling, to under 5,000 EC (upper limit of freshwater range) within 5 months (Tucker 2003).



ADAPTIVE MANAGEMENT REGIME

Wetland managed on a 2-year cycle with increased period of inundation to maximise invertebrate production

Figure 5. Wetting and drying cycle for Little Duck Lagoon provides a maximum of 14 months wet and 6 months dry over a 2 year period, timed to coincide with natural cycles in the main-stream. (Source: Jensen 2002b).

- turbidities in the lagoon are highly variable, and are likely to be due to a combination of salinity, amount of silt present, feeding activity by carp, and wind.
- the first vegetation response was a moderate bloom of green filamentous algae (Jensen pers. obs.).
- following filling from a spring flood in October 2000, riparian species responded with fresh growth and flowering (Jensen pers. obs.).
- during a dry phase in autumn 2000 salinities rose again as groundwater seepage accumulated, reaching a peak of 25,000 EC (Tucker 2003).
- adult carp were able to enter the wetland during two high flow events in October and December 2000, by-passing the fish screens (Jensen pers. obs.).
- waterbird use of the lagoon for feeding and roosting has significantly increased, with higher than normal numbers of waterfowl reported (Osborne pers. comm.).
- hardhead duck were reported on the lagoon for the first time in 15 years (Osborne pers. comm.).

Some modifications have been made to the inlet channel and flow control structure to reduce the opportunities for carp to gain access to the lagoon. Options for removing the carp from the lagoon will be pursued, including selective fishing when carp accumulate at the inlet control structure trying to get out of the lagoon. Full drying of the lagoon will only be introduced once a freshwater lens has been developed, to buffer the impact of saline groundwater seepage during drying phases.

Old Loxton Road Lagoon

The general management objectives for this site are to establish and maintain a range of habitats through time, including dry wetland bed species and aquatic species. This requires increasing the frequency of small to medium floods reaching the wetland. The hydrological objective is to double the flooding frequency by lowering the threshold for filling the wetland on rising river levels. This changed hydrology will allow the re-creation of a temporary freshwater wetland habitat, and reduced the impact of salinisation from regional groundwater.

Monitoring of Old Loxton Road Lagoon during high flow events in 2000 has resulted in the following findings:

- salinity in the lagoon was initially high as it filled, reduced during the first period of full levels to match river salinities, and then gradually increased again into the brackish range as inflows ceased and evaporation became significant (Turner pers. comm.).
- the lagoon commenced to fill at 33,000 ML/day flow in the main-stream, but a barrier in the feeder creek limited inflows and prevented access by carp during the October 2000 event (Jensen pers. obs.).
- carp entered the wetland during the higher December 2000 event (Turner pers. comm.).
- raptors and fish-eating water birds were attracted to the lagoon in significant numbers, preying on the abundant food source of common carp, plague minnow and native carp gudgeon (Jensen pers. obs.; Osborne pers. comm.).
- water continued to persist in the lagoon at approximately 20% capacity up to July 2001, with the small pool maintained by local rainfall run-off (Jensen pers. obs.).
- no significant growth of aquatic plants occurred, thought to be due to the accumulated salinity and loss of structure in the wetland bed (Tucker 2003).
- turbidities in the lagoon were low, probably due to high salinity levels recorded (Tucker 2003).

Fish screens have since been installed on the inlet structure, and deep pools in the feeder creek have dried up, removing pockets of adult carp.

Lessons learnt in making wetlands more fish friendly

Over a succession of wetting and drying cycles, wetland beds are more consolidated, aquatic and semi-aquatic plant communities cover more of the bed area in wet phases, and conditions become more friendly to small native fish.

Fish screens are operated during regulated flow conditions, when there are no breeding cues for native fish (approximately 90–95% of conditions).

The screens are removed when river flows are sufficient to cue migration and spawning in native species, and all fish species can enter the wetlands. This occurs approximately one year in three, in spring to early summer.

The key steps to making wetlands more fish friendly include:

- return of wetland substrate to consolidated state, instead of deep silt
- encouragement of a greater variety and biomass of native aquatic plants
- clearer water due to consolidated bed and increased plant cover
- less adult carp to compete and disturb
- better habitat for successful breeding in spring floods.

With each sequence of wetting and drying, the wetland habitat becomes more favourable to native fish, and less favourable to carp. A better habitat is available for spawning when a flood event occurs.

Future management and research

The Gurra Gurra Wetland Project was funded by Stage 1 of the Natural Heritage Trust, which did not provide funding for ongoing monitoring or management. Wetland**Care** Australia has engaged a part-time project manager from its own resources to continue a watching brief on the project. The Gurra Gurra Wetland Complex is flow-ready, and only requires very limited checking of structures and regular monitoring of conditions. All major flow paths are self-managing without any management action, provided that no blockages occur. The flow regimes in the demonstration sites will require infrequent adjustments to maximise benefits of floods, or to simulate flooding in regulated conditions (about once annually, on average).

Monitoring to date indicates that several small native fish species are present in the wetland complex, and their abundance relative to introduced species is being closely observed. The majority of small native species noted are those most likely to be found in stable, slightly saline water regimes, particularly gudgeons and hardyhead.

The habitat changes at the Gurra Gurra demonstration sites are designed to make these sites more friendly to native fish when breeding cues occur, and to increase the chances of successful recruitment when any floods reach the wetlands. Further detailed monitoring, coupled with natural flood events, will be required to demonstrate the long term success of this management approach. This type of monitoring will need to be included in agency-managed monitoring programs, which now cover a selection of Murray Valley wetlands, or further academic research projects.

There is an excellent opportunity at Gurra to create an example of adaptive experimental management, in order to obtain maximum value from the investment in improvements to the water regime.

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