

Yatco Wetland Management Plan



September 2009

Yatco Wetland Landcare Group



This management plan was prepared by the Yatco Wetland Landcare Group, assisted by Dr Bill Phillips (MainStream Environmental Consulting Pty Ltd), Jason Higham and Tony Sharley (Flow On Business). Dr Chris Gippel (Fluvial Systems) provided advice regarding hydrology and water savings. Dr Ivor Stuart (Kingfisher Research) provided expert input regarding native fish and carp management. Drafts of the plan were reviewed by a wide range of community and government stakeholders, prior to finalisation for implementation in September 2009. The plan was also reviewed and endorsed by the South Australian Murray Darling Basin Natural Resource Management Board.

The management plan has been prepared according to the *Guidelines for developing wetland management plans for the River Murray in South Australia 2003* (DWLBC 2003) and as such fulfils obligations under the Water Allocation Plan for the River Murray Prescribed Watercourse.

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The Yatco Wetland Landcare Group, or Loxton to Bookpurnong Local Action Planning.

Community consultation and support for this management plan

Several drafts of this plan were prepared and then made available to community members and other interested persons for comment before the plan was finalised. Frequent meetings of the Yatco Wetland Landcare Group were held across this period; these having an 'open door' policy for any interested or concerned landholders or community members to attend. Three public meetings were also convened to allow for any issues to be raised with the YWLG and the consultants drafting the plan.

Note:

As shown in section 2.1 this wetland management plan encompasses the wetland areas of the Yatco Lagoon, as well as those floodplain areas which lie between the two lagoons and the River Murray.

Within the text, 'Yatco Lagoon' refers to the wetland-floodplain complex as a whole, whereas 'wetland' and 'lagoon' refer only to the wetland area which is inundated at River Murray pool level and during small flood events. 'Floodplain' refers to the area of higher elevation, which is inundated during larger flood events.

1. Introduction

On the 1st of July 2002, the Minister for Environment and Conservation adopted the *Water Allocation Plan for the River Murray Prescribed Watercourse*. In so doing, a water allocation of 200 Gigalitres (GL) from South Australia's entitlement flow of 1850 GL per annum was endorsed for wetlands along the River Murray. To obtain a water allocation, individual community groups are required to submit a Wetland Management Plan that meets the criteria in the *Guidelines for Developing Wetland Management Plans for the River Murray in South Australia* ('Guidelines') (DWLBC and RMCWMB 2003).

This Yatco Wetland Management Plan has been prepared to meet the criteria set out in the 'Guidelines'.

1.1 Background

Yatco Lagoon lies on the floodplain of the River Murray with its major connection to the river being adjacent to the township of Moorook (see Plate 1). The wetland system comprises two lagoons connected through a narrow human-made causeway. The approximate total area of the two lagoons is 346 hectares.

With the construction of Lock and Weir 3 in 1925 the site became permanently inundated. This move from natural patterns of wetting and drying to permanent inundation, while allowing irrigation and domestic water supplies to be sourced from the lagoons, has also contributed to a gradual decline in water quality in the system and the health of fringing trees and other vegetation in some parts of the system (see Plate 12).

In response to the above concerns, the Yatco Wetland Landcare Group was formed in late December 2006. As detailed further in Section 1.6, the group took the initiative (with assistance from several individuals and organisations) in developing this plan, and pursuing several related activities needed in order to allow for the re-introduction of more natural patterns of water level variation at the site.

1.2 Vision

The following words, taken from the historical account of the site given to a community meeting at Moorook Hall on 17 January 2007, by long-time local Jeff Drogemuller, provides a vision statement for this management plan.

"...over the last 15 years we have noticed a sharp decline in the tree health, especially the red gums near the main highway and the big lagoon. If wetting and drying the lagoon can improve the quality of water, reduce carp numbers and encourage tree growth, aquatic plants, encourage more rare bird life and trigger the cycle of yabbies and native fish breeding, we believe it will make Yatco Lagoon a better place for future generations and possibly restore it to the condition of my great grandfathers time."

It is also hoped that through this initiative, the community that lives around, relies on, and enjoys Yatco Lagoon will come to better understand its workings as a natural asset and want to play an active role with implementing this plan.

1.3 Purpose of this management plan - Mission statement

While the individual landholders are ultimately responsible for the management of their respective portions of the site (see Section 3.3) the Yatco Wetland Landcare Group has responsibility for monitoring overall performance with the implementation of this Plan, and advising where adaptive management may be necessary.

This management plan has been prepared to set out a common vision and to justify, integrate and document the management actions. It is anticipated that elements of the plan may be modified over time based on the results of the ongoing monitoring of the site. This is consistent with the adaptive management approach being used (see Section 1.5).

It is also recognised that activities on the adjoining lands may have a significant direct, or indirect, impact on the health of Yatco wetland, and so this plan should be seen as a companion document to the Land and Water Management Plans for these areas.

A full review of this management will be undertaken in 2012. Thereafter, reviews will be done as considered appropriate by the Landcare Group (see section 6.3), but at least every five years. Where the suggested changes may impact on other stakeholders, such as the neighbouring properties etc, they will also be consulted. The Hydrological Operational Plan (see Section 5.1) is in place for three years from September 2009, unless monitoring indicates the need for amendments before then.

While some studies of Yatco Lagoon have been completed (see Section 7. References) there are some significant gaps in knowledge. As such, this first management plan applies the precautionary approach (see Section 1.5) when areas of uncertainty are encountered, and every effort will be made to see these information gaps addressed as soon as possible.

Consistent with the community-driven nature of this initiative, the **Mission statement** for this plan is as follows:

“To improve the overall health of Yatco Lagoon by reinstating a semi-natural watering regime while also protecting the environmental, social, economic and cultural values of the site.”

1.4 Broad management objectives

Good management plans specify medium to longer term objectives for the management efforts that will be applied through implementation of the plan. These objectives should look across the broad range of implications of the plan; environmental, social, economic and cultural, since managing a wetland as a community asset should provide benefits in all these areas. Importantly, these objectives should help to further define the ‘Vision’ for the site (see above).

Apart from broad, higher level objectives (as set out below) this plan also includes, in Section 5, more highly focused, and in some cases, short-term management objectives under each of its management themes.

The broad management objectives for Yatco Lagoon are as follows:

Ecological Objectives:

- 1) Manage the water levels of Yatco Lagoon to maintain and enhance native flora and fauna communities, and reduce the impact of salinity on the wetland.
- 2) Through these water level manipulations generate water savings that can help with revitalising the adjoining River Murray so it can, in turn, support a broader range of biodiversity being re-established and sustained in Yatco Lagoon.
- 3) Rehabilitate areas of salt scald and salt build-up by encouraging natural regeneration of salt tolerant species.
- 4) Eradicate or control the abundance of noxious weeds and pest plants, and control vermin and pest animals.
- 5) Reduce the abundance and impact of introduced fish species in Yatco Lagoon.
- 6) Increase understanding of surface water and groundwater interactions, and the impact of irrigation on wetland health.

Recreational Objectives:

- 7) Improve the aesthetic value of the area to encourage the use of Yatco Lagoon for sustainable recreation activities by the local community and visitors.
- 8) Improve the recreational facilities at Yatco Lagoon, including the possible development of information boards, a viewing area, walking trail, bike trail and bird hides.

Community Involvement Objectives:

- 9) Maintain and improve on the community capacity to manage the wetland.
- 10) Improve education and communication with local schools and the community about the management and importance of River Murray wetlands, including Yatco Lagoon.

Operational Objectives:

- 11) Ensure that implementation of this plan is done in close coordination with the Land and Water Management Plan for the adjoining area.
- 12) Maintain a strong working relationship with those organisations that assisted with the establishment of the Yatco Wetland Landcare Group and the development of this plan; namely, Banrock Station Wine and Wetlands Centre, Landcare Australia Limited, Nippy's Fruit Juices, the Loxton to Bookpurnong Local Action Planning group, South Australian Murray-Darling Basin Natural Resources Management Board and the South Australian Department of Water, Land and Biodiversity Conservation.

1.5 Guiding principles

Guiding principles are the agreed *modus operandi* or 'way we will do things' statements upon which implementation of this plan rests. For Yatco Lagoon these are as follows:

1. Adaptive management will be applied. This requires on-going monitoring of the responses by the wetland system to the management actions taken; this then helping to inform those coordinating implementation so that, as necessary, these actions can be adjusted or fine tuned.
2. The precautionary approach will be applied. This states as follows; "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (Rio Declaration, Principle 15). Appendix A explains this concept further.
3. Open, transparent and consultative decision making will apply to implementation of this plan.
4. Those implementing the plan will work with those responsible for managing ecologically or hydrologically-linked areas where activities may offer a potential risk to the environmental, social, cultural or economic values of Yatco Lagoon and, where such risks are identified, seek to have these minimised or mitigated.
5. Respect will be shown for the Indigenous Australian and early European settlers' cultural values of the site.
6. Recognition will be given to regional as well as broader State and Murray-Darling Basin policies, initiatives and obligations, especially in relation to water management, salinity and environmental flows. Of special note here is the Pyap to Kingston Land and Water Management Plan for the areas adjoining Yatco Lagoon.
7. It is recognised that the availability of resources, both human and financial, may limit the pursuit of the vision and implementation of this plan, and, where necessary, management actions will be prioritised to match available resources.

1.6 History surrounding preparation of this plan

Recognising the need to take action to rehabilitate the wetland, the Yatco Wetland Landcare Group was formed in late December 2006. The group, comprising the landholders and irrigators operating around the wetland, were supported in their efforts by Banrock Station Wines via Landcare Australia Limited, Nippy's Fruit Juices, the Loxton to Bookpurnong Local Action Planning group, the South Australian Murray-Darling Basin NRM Board and the South Australian Department of Water, Land and Biodiversity Conservation.

From the outset it was acknowledged that in order to revitalise the wetland it would be necessary to reintroduce greater variability to the water levels within the system, as had been the situation prior to 1925 when Lock and Weir 3 was operationalised. However, in order to achieve this goal it was essential that those

currently sourcing water for irrigation or domestic use from the wetland be provided with alternative supplies.

The formation of this Landcare group brought together landholders, community and business sector interests and government agencies in order to see water level manipulations reinstated to the system; to see eleven irrigators provided with a better quality water supply sourced from the River Murray, and three domestic users given more reliable and better quality water also.

Furthermore, through reintroducing drying phases to the wetland, this would not only help reinvigorate the ecology of the system but it would also generate water savings that could be provided to the River Murray, thus contributing to the recovery of the overall health of this 'parent' waterbody which is so vital for seeing a broader range of biodiversity re-colonise Yatco wetland. The opportunity exists here for a significant win-win outcome.

With this rationale the following were the stated objectives of the Yatco Wetland Landcare Group when it was formed.

1. To develop a Wetland Management Plan, including a Hydrological Operational Plan, for the Yatco Lagoon;
2. To improve the quality and efficiency of water supply to current users of the lagoon system by relocating irrigation and domestic water pumping infrastructure to the main channel; and
3. To investigate water saving through the reduction of evaporation from the Yatco Lagoon system.

In anticipation of this plan of management being developed, the Yatco Wetland Landcare Group undertook the initial scoping for the possible installation of a temporary earthen bank structure in the North lagoon system (see section 5.1). Such a structure designed to allow for complete or partial drying of the system; an action expected to also have significant benefits for the plant and animal communities, as well as the water quality of the Lagoon, through the re-introduction of an appropriate water manipulation regime.

On Tuesday 20th of March 2007 Minister for the River Murray, the Hon Karlene Maywald, in a press release, identified Yatco Lagoon among a number of floodplain waterbodies in South Australia that would be investigated for possible temporary disconnection from the River Murray as part of Drought Contingency measures. The following quotes from the Minister's press release explain the rationale, and proposed 'trigger' points for such disconnections.

"Temporarily disconnecting these nine water bodies from the river would save up to 46 gegalitres in evaporation a year and if the drought continues, which would be crucial to water security in 2007-08," Minister Maywald said.

"If weir pool levels drop, then highly saline and nutrient-rich water from these sites may flow back into the river, risking the water quality for the 90 percent of South Australians relying on the supply."

The triggers for decision-making on temporarily disconnecting the water bodies are:

1. If the 2007-08 water allocation announcement in mid-June was 50 percent or less, then disconnection of water bodies would begin. If, later

in the year, allocations increased, disconnections would be reviewed.

2. If weir pool levels in South Australia could not be maintained or needed to be lowered, and the rate of drawdown was greater than the rate of evaporation, then disconnection of water bodies would begin.

"If the first trigger occurs, then the water bodies would be temporarily disconnected by the beginning of October this year, to maximise water saved from evaporation," she said.

The above announcement overtook (in effect) the actions already taken by the Yatco Wetland Landcare Group, with the State government then moving to construct the earthen bank referred to above. This work being completed in January 2008.

In September 2007, the Yatco Wetland Landcare Group, with the Loxton to Bookpurnong Local Action Planning group and the South Australian Murray-Darling Basin NRM Board, applied for funding through the *National Plan for Water Security* to support the infrastructure adjustments needed to de-couple irrigation requirements from the wetland system. In October 2007 advice was received from the local Federal Member for Barker, the Hon Patrick Secker MP, that this application had been successful. The announcement confirming this included the following statements of note in this context:

"The Australian Government will provide funding of \$3.3 million from the \$5.9 billion modernising irrigation in Australia programme to improve river operations in the South Australian Murray through implementation of the Yatco Lakes Wetland Management and Pump Relocation project.

Currently the Yatco Lakes Wetland system is permanently inundated to provide water to irrigators who pump directly from the lagoons.

Under this project, Australian Government funding will contribute to the costs associated with disconnecting irrigators who currently pump directly from Yatco Lagoon, and connecting them to the main River Murray channel. This will enable the management of the Yatco wetland system to be returned to a more natural cycle of drying and wetting."

Access to these funds is now to occur via the Murray Futures initiative and is being negotiated at present.

After the installation of the earthen bank in November 2007-January 2008, Yatco Lagoon was kept disconnected from the River Murray until 18 March 2009, when it was refilled back to pool level. As of 8 September 2009 the wetland remained connected to the river, with the expectation it will again be disconnected in the coming weeks, and then (assuming water availability) managed in accordance with the Hydrological Operational Plan provided in Section 5.1.

Beginning in July 2007 the Yatco Wetland Landcare Group, guided and supported by the South Australian Murray-Darling Basin NRM Board, has been undertaking regular monitoring of water quality, groundwater, flora and fauna across the site. These data have been especially helpful in providing the most up-to-date information about this site in the plan.

In early 2009, with funds provided by the Loxton to Bookpurnong LAP, Dr Ivor Stuart (Kingfisher Research) was engaged to provide expert advice on native fish passage and carp control at Yatco Lagoon. The recommendations from that report have been taken into consideration in this plan.



At left – earthen bank installed in late 2007 allowed for the drying out of Yatco Lagoon for the first since 1925 when Lock and Weir 3 was completed.

Photograph: Bill Phillips

At right – as drying of the system proceeded Red gum recruits appeared in the riparian zone of the North lagoon.

Photograph: Bill Phillips



At left – regulator installed in the earthen bank.

Photograph: Bill Phillips

At right – the wetland drying out, with dead carp littering the scene.

Photograph: Bill Phillips



At left – the dry bed of the wetland in February 2009 taken from the “lookout”.

Photograph: Bill Phillips

At right – the dry wetland near the regulator in the earthen bank in February 2009.

Photograph: Bill Phillips

2. Site description

2.1 Location

Yatco Lagoon lies immediately upstream from the township of Moorook in the Riverland of South Australia (see Plate 1). The wetland system runs parallel with the River Murray for approximately 4 kilometres.

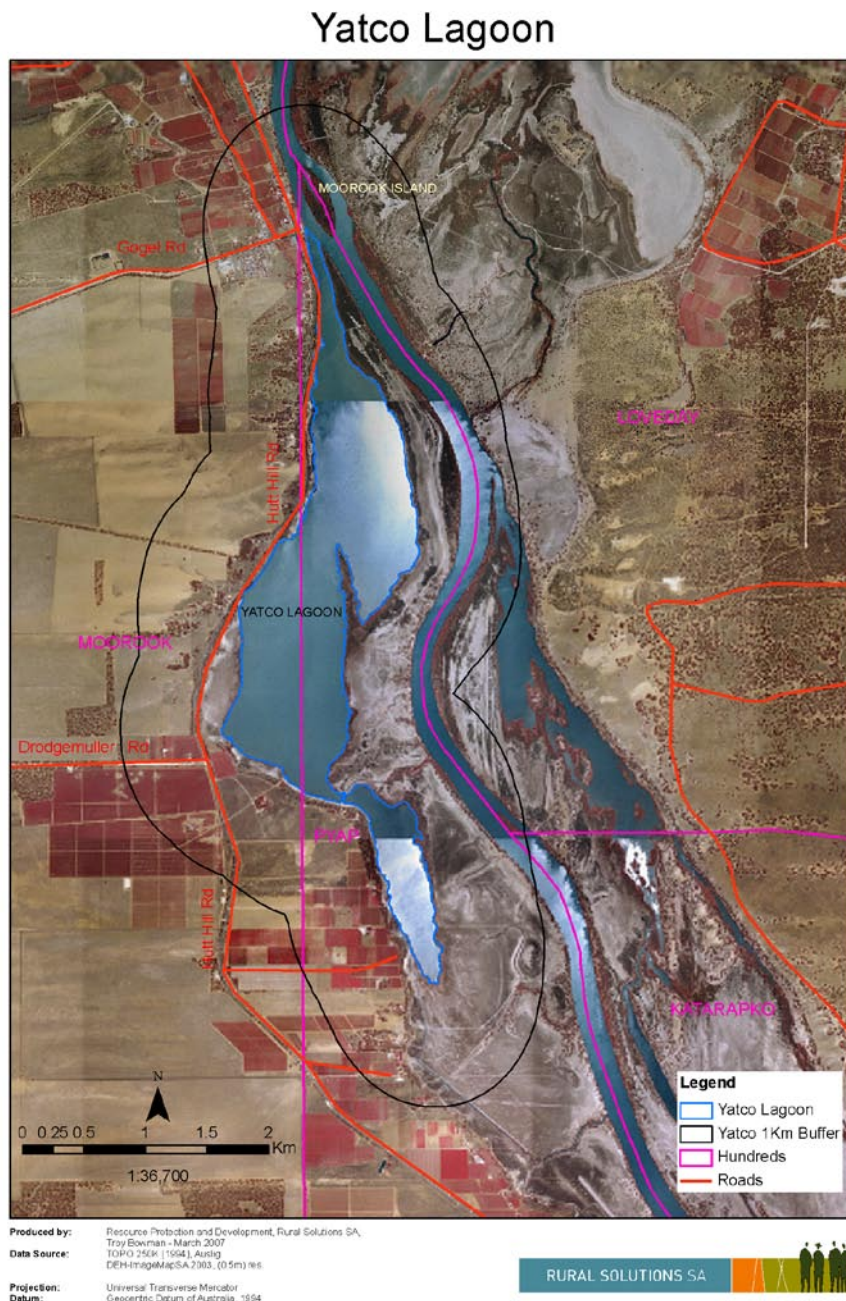


Plate 1: Aerial photograph showing location of Yatco Lagoon with respect to Moorook and the River Murray. (Courtesy of Rural Solutions SA)

2.2 Physical features

The Yatco wetland system comprises two lagoons (North and South) connected through a narrow human-made causeway (see Plate 2). The approximate total area of the two lagoons is 346 hectares (Wetland Baseline Survey, SKM, 2005). With the inclusion of the floodplain area which lies between the lagoons and the River Murray, the total area covered by this management plan is approximately 400 hectares.

The lagoons are shallow depressions with the deepest areas found near the north junction with the River Murray and the central 'basin' area of the North Lagoon adjacent to the peninsula. See Plate 4 which shows the Digital Terrain Model produced as part of the Wetlands Baseline Survey, SKM, 2005.



Plate 2 (at left): Regulator on pipes through causeway connecting the North and South Lagoons. **Plate 3 (at right):** Main connection of Yatco wetland to the River Murray, at the northern end of the North Lagoon, adjacent to Moorook. Photographs taken by Bill Phillips.

2.2.1 Wetland volume and surface area

The estimated volumes and surface areas of Yatco Wetland at differing river heights are as follows:

Table 1: Estimated volume and surface area of Yatco Lagoon at differing river heights

	Observed River RL.	Bank Full	$\frac{3}{4}$ bank full	$\frac{1}{2}$ bank full	$\frac{1}{4}$ bank full	10 cm
RLm (AHD)	9.84	9.90	9.19	8.48	7.76	7.15
Surface area (m ²)	3,331,699	3,444,989	2,253,506	855,109	27,078	815
Volume (m ³)	3,093,446.0	3,296,356.5	1,228,545.4	272,980.0	8,587.0	

Shaded cells = volumetric data. On day of recording height of river was 9.84 mAHD. (SKM, 2005)

The SKM (2006) report on *Water Recovery from the SA River Murray Wetlands – Stage 2*, indicates that the surface area of the South Lagoon is 48.1 ha.

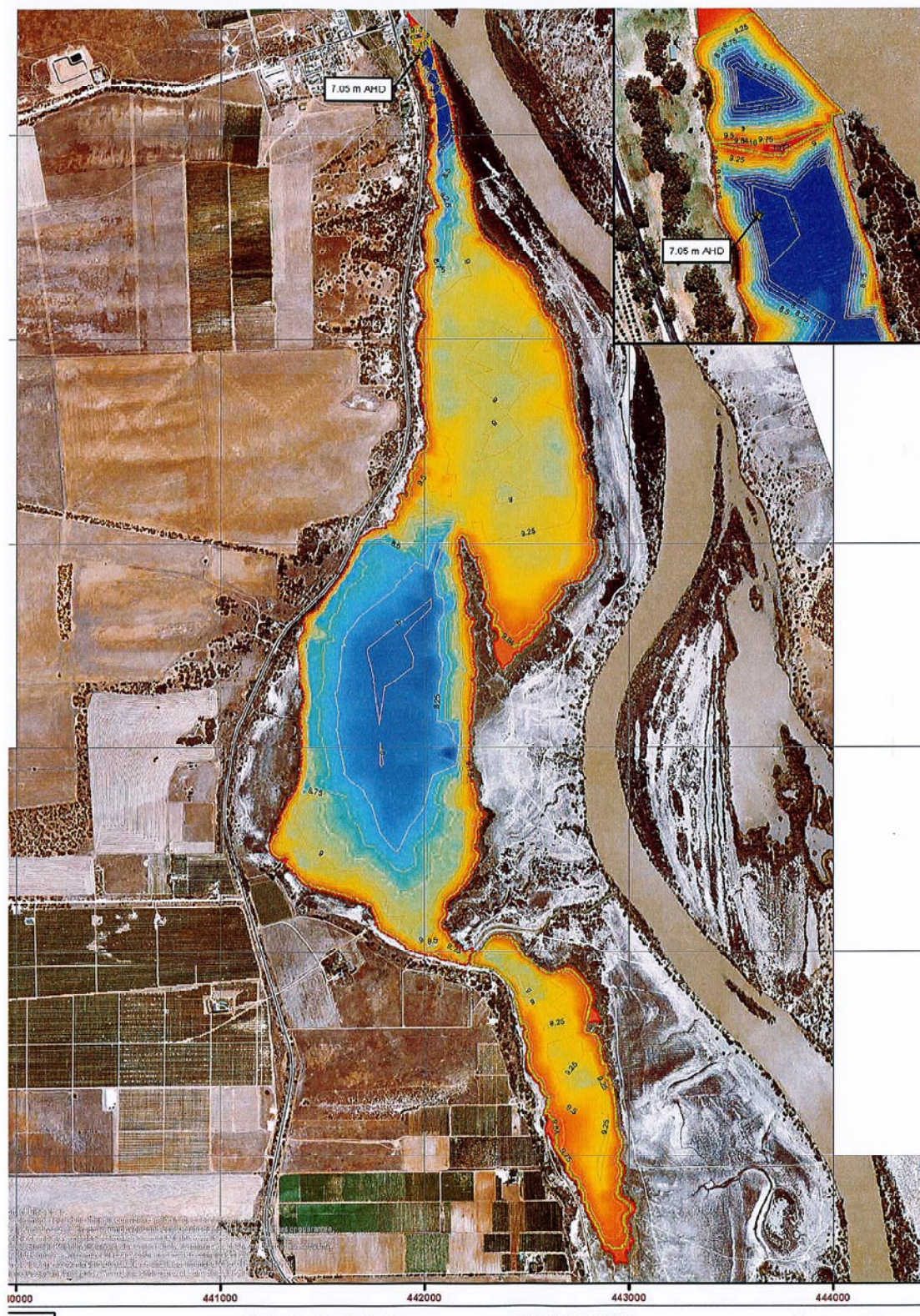


Plate 4: Digital Terrain Model produced as part of the Wetlands Baseline Survey, (SKM, 2005)

2.2.2 Geology and soils

Bores at the locations shown in Plate 5, reveal that Yatco Lagoon lie across a surficial clay layer (the Coonambidgal Formation) which is 1.5-3.0m thick. Underlying this is the Monoman Formation; a sandier sediments, although the Baseline Survey (SKM 2005) notes that this was not encountered at bore hole 03 at a depth of 2.5m below ground level.

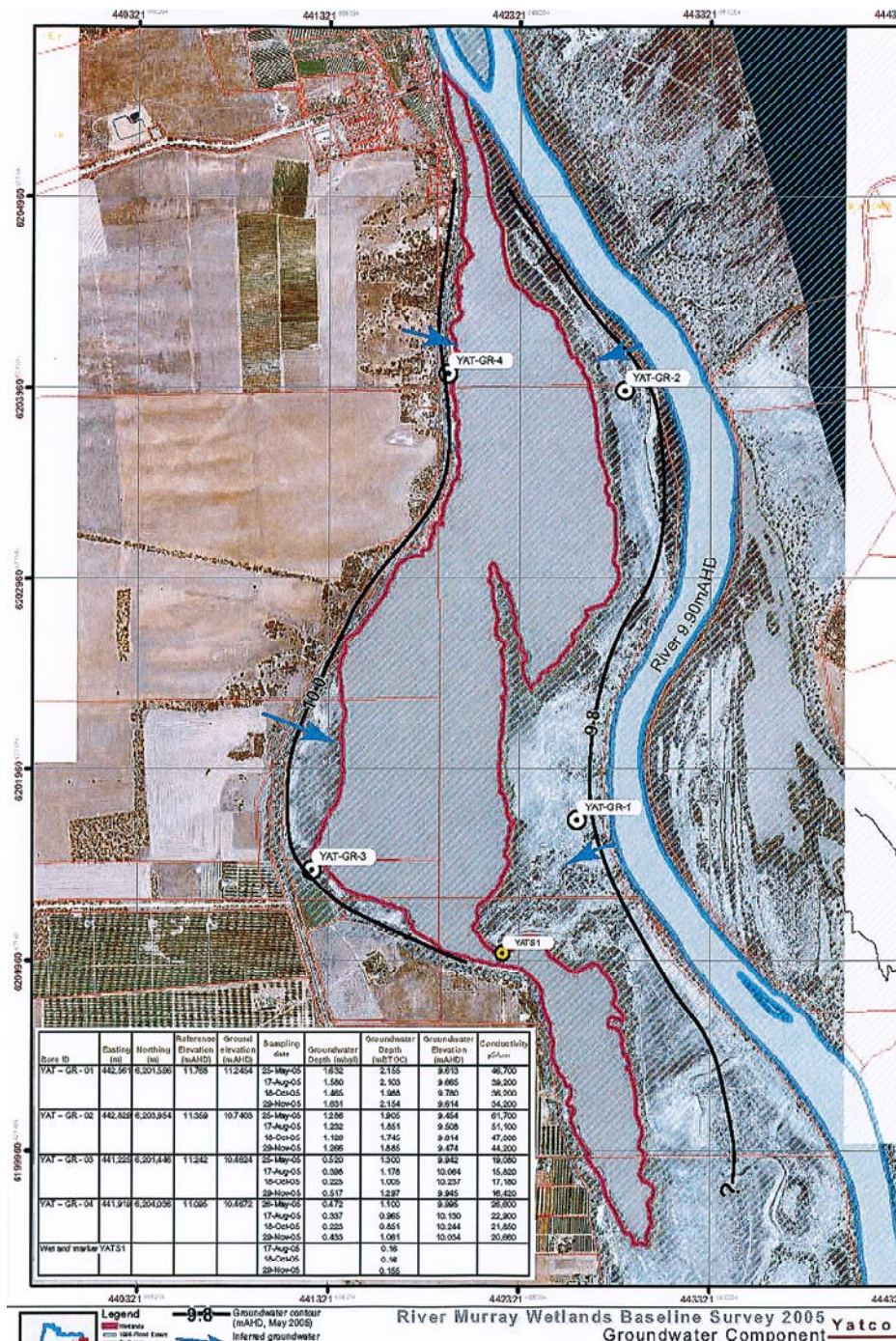


Plate 5: Monitoring bore sites around Yatco Lagoon and groundwater contours (SKM, 2005)

Also of interest from a soils perspective is the risk of acid sulfate soils being activated by drying of the wetland system after such a long period of inundation. In extreme cases drying the system can result in acidification of the water and fish kills.

Based on known pre-conditions for acid sulfate soils, Yatco Lagoon is considered a potential risk site. However, the latest data collected at the site in November 2007, and April and July of 2008 (Shand, Merry, Thomas and Fitzpatrick, 2008) clarified the situation somewhat. These authors concluded that while there is sulfidic material present in the samples taken there is also buffering capacity within the soils and *'Overall, the data imply that there is little risk in the northern part of the wetland, due to the high ANC [acid neutralising capacity], and a moderate risk locally in the southern part'*. These findings indicate the need for on-going monitoring to be undertaken.

2.3 Groundwater

Groundwater monitoring bores were established around Yatco Lagoon as part of the 2005 Baseline Survey (see Plate 5). These were monitored on four occasions; in May, August, October and November of that year. A full summary of the data can be found at Appendix C. In summary, notable findings are as follows:

- ❖ Groundwater levels ranged between 0.22m and 1.63m below ground level at these sites. These levels corresponded to elevation ranges of 10.24 mAHD to 9.61 mAHD.
- ❖ Hydrographs for all bores (see Appendix D) showed high levels in October 2005 although water levels in the wetland were unchanged from the previous measurements taken in August 2005. SKM (2005) suggests this indicates no seasonal influence at play.
- ❖ Groundwater levels in bores YAT-GR03 and 04 (on the western side of the North Lagoon – see Plate 5) are above river level suggesting a flow from adjoining higher areas into the wetland. SKM (2005) also contend that there is a groundwater gradient from the river back into the wetland also.
- ❖ The above suggest, according to the Baseline Survey, that their data “Indicates there is a strong potential for groundwater discharge to the wetland and resulting salinity increases to occur if wetland levels were to be decreased significantly below river pool level. In addition, Site physical survey data indicates the wetland base level is 7.05 mAHD while observed groundwater levels in the piezometers ranged between 9.4 mAHD and 10.2 mAHD. This supports the potential for significant discharge of saline groundwater to occur during periods of low or empty wetland.”
- ❖ SKM (2005) recommend (see pages 320-1) a number of followup investigations and actions to help further clarify and monitor the groundwater and salinisation impacts.

Groundwater salinity and levels

Water testing from the four bore holes referred to above indicated salinities in the range of 15,820 – 61,700 EC (see Appendix E). Across the May-October 2005 sampling period this trended downwards (by between 14-28%) at all four bore sites, for reasons not explained at this time.

Following on from the 2005 Baseline Survey, regular groundwater monitoring commenced in July 2007 at the sites shown in Plate 23 (C.Nickolai, pers. comm. 2009). This has allowed a more detailed picture of groundwater responses and salinity below and around the wetland to be built up over the period from when the site was disconnected from the River Murray (for the first time since 1925) at the end of 2007 until refilling in March 2009. Across this drying period, there was some variability in trends and groundwater gradients in different parts of the system. The general trend was for groundwater levels in the piezometers to gradually fall until re-filling took place, when recharging saw these elevated back to near the pre-drying state. Expert review of the gradient and water quality data (K.Holland, pers. comm., 2009) has identified future monitoring priorities, and reinforced the potential risks of salinisation if drying events are prolonged. Salt accumulation in the system is also a concern, especially given the relatively 'closed' nature of the site. The latter would be addressed, at least in part, with additional regulators in the North Lagoon's earthen bank (see Table 10).

Across the period from July 2007 to May 2009, the groundwater salinities recorded in the piezometers (see Plate 23 for locations) were as follows (C.Nickolai, pers. comm. 2009):

Site	EC in July 2007 (approx 4 months prior to start of drying)	EC in January 2009 (approx 12 months into drying event)	EC in May 2009 (approx 2 months after re-filling)
YATGW01	30,000	55,800	20,400
YATGW03	16,850	22,300	20,500
YATGW05	24,000	43,800	18,700
YATGW06	86,100	78,000	20,450
YATGW07	11,030	11,170	11,000
YATGW08	9,820	11,380	9,970
YATGW09	49,700	46,200	20,400
YATGW10	101,100	95,600	87,300

Note: the above emphasises the importance of the Pyap to Kingston Land and Water Land for this same area and this Wetland Management Plan being implemented in an integrated way. Landuse practices, and in particular irrigation practices on the adjoining lands, can play a mayor role in seeing the potential salinisation risks to the wetlands reduced.

2.4 Surface water quality

Water quality measurements were taken during the Baseline Survey (SKM, 2005) in the months of March, April, August and October of 2005. More detailed reporting on this is given in Appendix F. A summary of the findings is provided below.

Table 2: Water quality measurements at Yatco Lagoon
Baseline Survey (SKM, 2005)

Parameter	Average across four sampling times (see above) (=/- SE)	Range
EC ($\mu\text{S}/\text{cm}$)	1158 +/- 713	216 - 2170
Dissolved oxygen (mg/L)	10.0 +/- 1.3	7.8 – 12.6
pH	8.41 +/- 0.61	7.61 – 9.55
Turbidity (NTU)	103 +/- 90	16 – 400
Water temperature ($^{\circ}\text{C}$)	21.9 +/- 4.4	14.3 – 27.0
Nitrogen oxides ($\mu\text{gN}/\text{L}$)	9 +/- 1	3 - 13
Total Nitrogen ($\mu\text{gN}/\text{L}$)	788 +/- 112	320 – 1790
Filterable Reactive Phosphorus ($\mu\text{gP}/\text{L}$)	7 +/- 0*	< 5 – 8
Total Phosphorus ($\mu\text{gP}/\text{L}$)	88 +/- 12	38 – 205
Dissolved Organic Carbon (mgC/L)	3.87 +/- 0.40	1.95 – 5.15

* = means and SE calculated using approximate values

Observations made about these data in the Baseline report:

- ❖ Salinity - this average figure exceeds that recommended for lakes, reservoirs and wetlands in the ANZECC (2000) guidelines. It may be due to evapo-concentration, groundwater inflow, or both, although the latter is not confirmed.
- ❖ Overall water quality would be improved with flushing flows during high river levels with de-silting of both the constructed and natural channels into the southern end of the North Lagoon helping this flushing process.
- ❖ There is the possibility of acid sulphate soils being present or to develop, especially at the South Lagoon sites where there are salt scolds and black anoxic soils.
- ❖ Average values recorded for most parameters fell within the expected range.

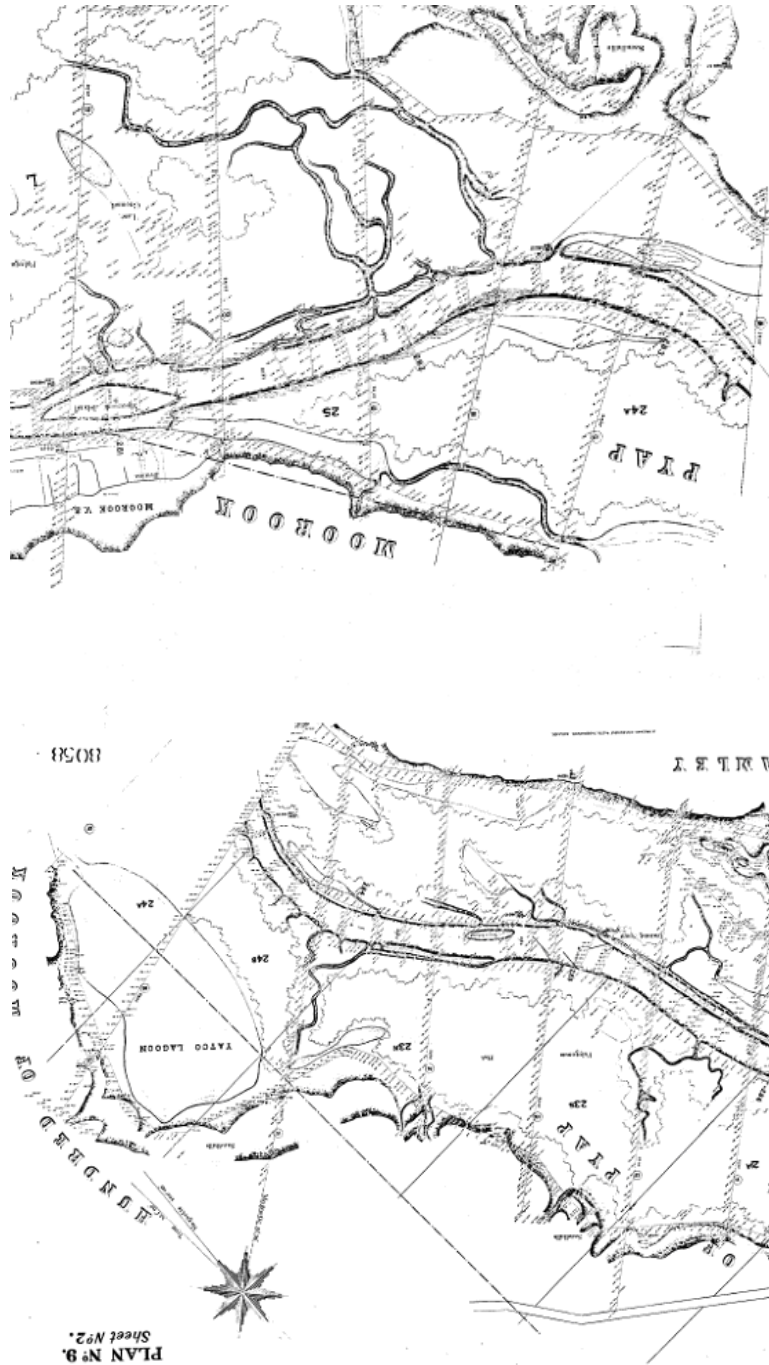
Following on from the 2005 Baseline Survey, regular surface water monitoring commenced in July 2007 at the sites shown in Plate 22 (C.Nickolai, pers. comm. 2009). These data (for pH, turbidity, dissolved oxygen and conductivity) in general fall within the ranges recorded by the Baseline Survey. Some lower pH readings were recorded at some sites throughout the drying phase for the wetland, and following the re-fill commencing in March 2009, levels were again mostly back to within the 7-8 range.

Across this period, surface water conductivity at the seven sites followed generally similar patterns. Prior to the disconnection of the wetland from the river all sites had EC's in the range 1099-1621 (recordings in July and September of 2007). During the drying out phase (December 2007 – March 2009) conductivities increased as expected, due either to evapo-concentration, groundwater inflow, or both. Following re-connection to the river and refilling of the wetland (in March

2009) EC's in general started to trend down for most sites, although as at 14 May 2009 five monitoring sites had EC's in the range 1994-2865, one was at 1577 EC and one was at 765 EC. These data reinforce the need to avoid prolonged dry phases in the wetland, and for a cautious approach to any further reductions in water levels so as to avoid the risk of salinising the bed.

2.5 Historical and current water flows

The historical connections of Yatco Lagoon are shown in the Plates below, taken from the 1917-18 surveys that investigated locations for the installations of the Locks.



Plates 6 and 7: 1917 River Charts courtesy of SA Water

Today the main connection of Yatco wetland to the River Murray is adjacent to Moorook (see Plate 3) at the northern end of the North Lagoon (see Plate 1). At the southern end of the North Lagoon, immediately adjacent to the causeway connecting the two lagoons, there is a constructed channel entering the North lagoon through a regulated triple barrel pipe culvert (see Plate 8). Close by there is also a natural creek (Middle Creek), that historically, and again now connects the Northern Lagoon with the river at 15,000-20,000 ML flows.

For the South lagoon, other than the connection it has to the North Lagoon through the causeway (see Plate 2), there is also a connection to the open, constructed irrigation channel (see Plate 9 and Section 5.1) which runs around the Lagoon on the dryland side (not the floodplain side), connecting to the River Murray about 2 kms upstream. The plan is for this open channel to be replaced by a pipe as part of this initiative by the Yatco Wetland Landcare Group.



Plate 8 (top): Constructed channel entering the North lagoon through unregulated twin barrel pipe culvert, immediately below the causeway connecting the two lagoons.

Photograph: Bill Phillips

Plate 9 (bottom): Connection between the currently open irrigation channel (which is to become an enclosed pipe) beside the South lagoon, where it connects to the lagoon.

Photograph: Bill Phillips

This plan has as part of its Vision to re-instate the former (or close to it), variations in water levels. This forms part of a package of initiatives to improve the ecological condition of the Yatco wetland, provide water savings to improve the health of the River Murray, and also to improve the reliability and quality of irrigation and domestic water. Section 5.1 provides the Hydrological Operational Plan to be implemented through this plan.

In their report of March 2006, SKM provide the following summary (Fig. 1) of the water regime that Yatco Lagoon has experienced between 1980 and 1999.

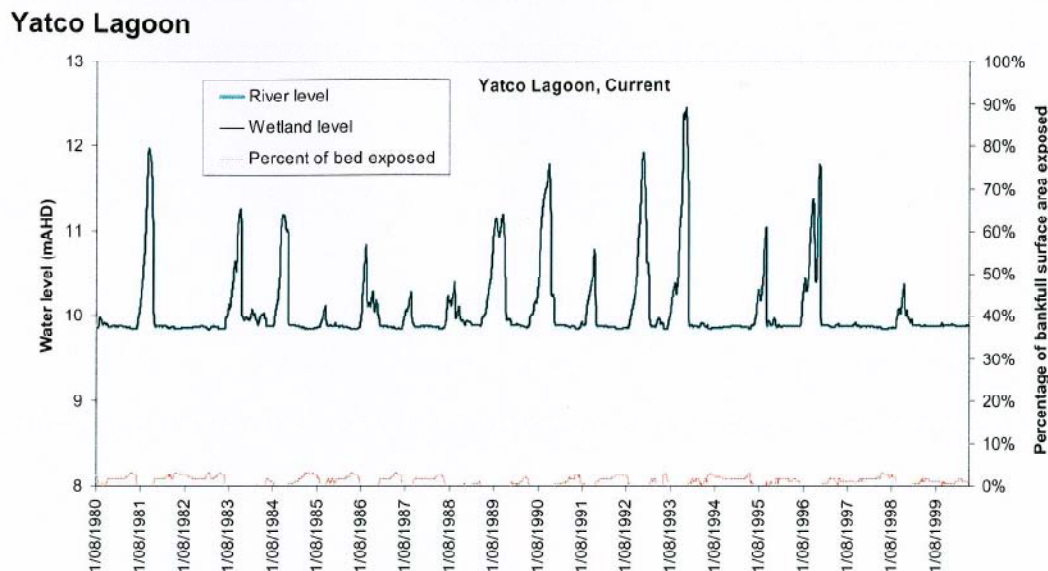


Figure 1: Summary of the water regime experienced by Yatco Lagoon between 1980 and 1999 (Baseline Survey, SKM, 2005).

2.5.1 Flood inundation modelling

The following describes and illustrates the extent of inundation in Yatco's two lagoons for different River Murray flows. These have been generated using the River Murray Flood Inundation Model (Overton *et al.* 1999) and so represents hypothetical information to assist planning.

North Lagoon (see Plate 10 below)

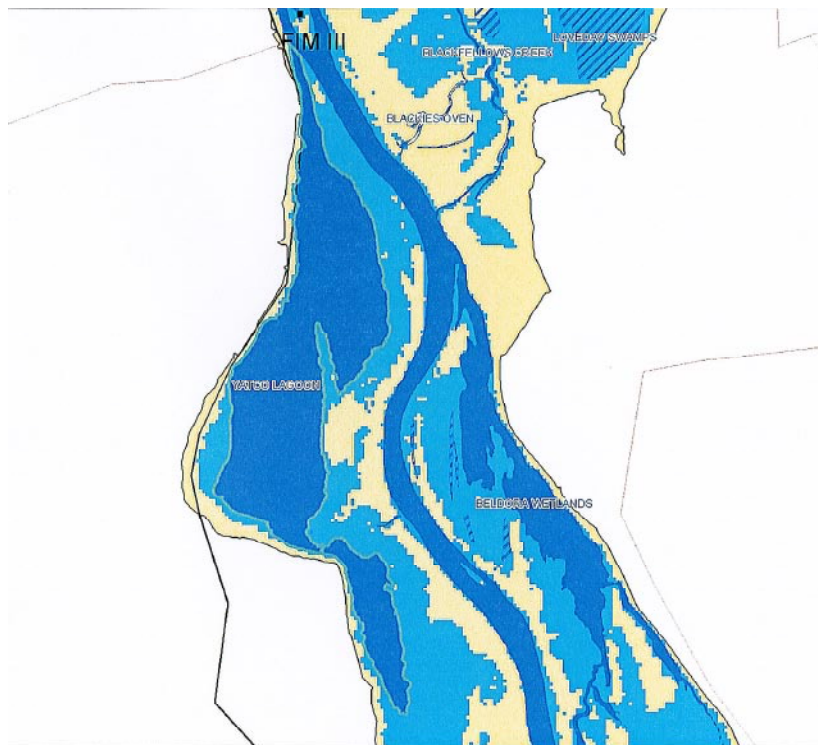
The connection between the North and South Lagoons is expanded with a flow of 39,000 ML/day at the Border. At this flow any control structure between the two lagoons would be bypassed unless banks are established on the floodplain. At this flow the floodplain surrounding the wetland is inundated.

With a flow of 59,000 ML/day at the Border overbank flooding can be anticipated to occur at the northern end of Yatco Lagoon. At this flow level a creek connecting at the Northern end of the South Lagoon through to the River Murray is connected. The two lagoons are at this time well connected. Most of floodplain is inundated (wide connection) with 70,000ML/day at the Border with virtually all of floodplain inundated at a flow of 80,000 ML/day.

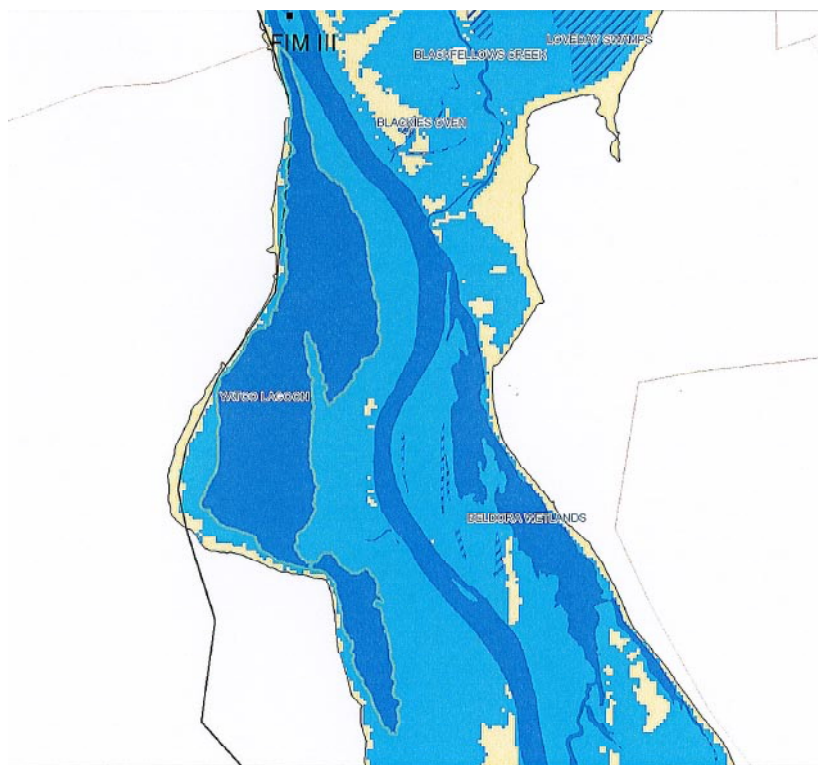
South Lagoon (see Plate 10 below)

The South Lagoon surface area doubles when compared to pool level at a flow of 39,000 ML/day at the Border. This is the flow at which the connection between the North and South Lagoons widens as described above. That is, any flow control

C at flows of 70,000 ML/day at the NSW-SA border



D. at flows of 80,000 ML/day at the NSW-SA border



2.6 Ecological features and values

2.6.1 Vegetation

The Baseline surveys report (SKM, 2005) records the following about the dominant vegetation types:

"The southern lagoon contained patches of *Vallisneria spiralis* and occasional individuals of *Potamogeton crispus* and *Myriophyllum verrucosum*. The riparian edge was characterised by alternating monospecific stands of *Muehlenbeckia florulenta*, *Schoenoplectus validus*, *Phragmites australis* and *Typha* sp.

The main lagoon contained patches of *Vallisneria spiralis* and had a riparian edge dominated by *Phragmites australis* and *Typha* sp. Behind this riparian zone there was usually *Muehlenbeckia florulenta* closed shrubland, particularly on the eastern edge of the lagoon. The western shoreline was much steeper and was generally characterised by *Eucalyptus camaldulensis* var. *camaldulensis* / *Eucalyptus largiflorens* open woodland. The floodplain between the lakes and the river was characterised by *Halosarcia pergranulata* ssp. *pergranulata* shrubland in the centre and *Eucalyptus camaldulensis* var. *camaldulensis* / *Eucalyptus largiflorens* woodlands along the edge of the main river channel. The lower lying areas at the tip of the peninsula and along the lake edge were dominated by *Muehlenbeckia florulenta* closed shrubland. The artificial inlet channel between the main river channel and the southern part of the main lagoon contained a very dense localised patch of *Ludwigia peploides* ssp. *montevidensis* at the junction with the river channel.

Large woody debris covered less than 5% of the wetland perimeter and bed.

Surveyed quadrats

Five different vegetation associations were quantitatively surveyed (see Plate 11):

1. *Schoenoplectus validus* / *Phragmites australis* / *Typha* sp. sedgeland on edge of southern lagoon
2. *Vallisneria spiralis* submerged herbland in southern lagoon
3. *Vallisneria spiralis* submerged herbland in main lagoon
4. *Phragmites australis* grassland on edge of main lagoon
5. *Typha* sp. sedgeland on edge of main lagoon"

Appendix G provides the full plant species list. Note that the Baseline Survey did not record the River coobah (*Acacia stenophylla*) which is found in the area (J.Drogemuller, pers. comm. 2008).

Notable from the perspective of this plan are the following:

- ❖ 11 exotic plant species recorded at the site (scientific names given in Appendix G):
 - Bearded oat;
 - Flax-leaf fleabane;
 - Couch grass;
 - False caper;
 - Smooth heliotrope;
 - Wild lettuce;
 - Common iceplant;
 - Scotch thistle;
 - Annual Beard-grass;
 - Yellow marsh-cress; and
 - Weeping willow.

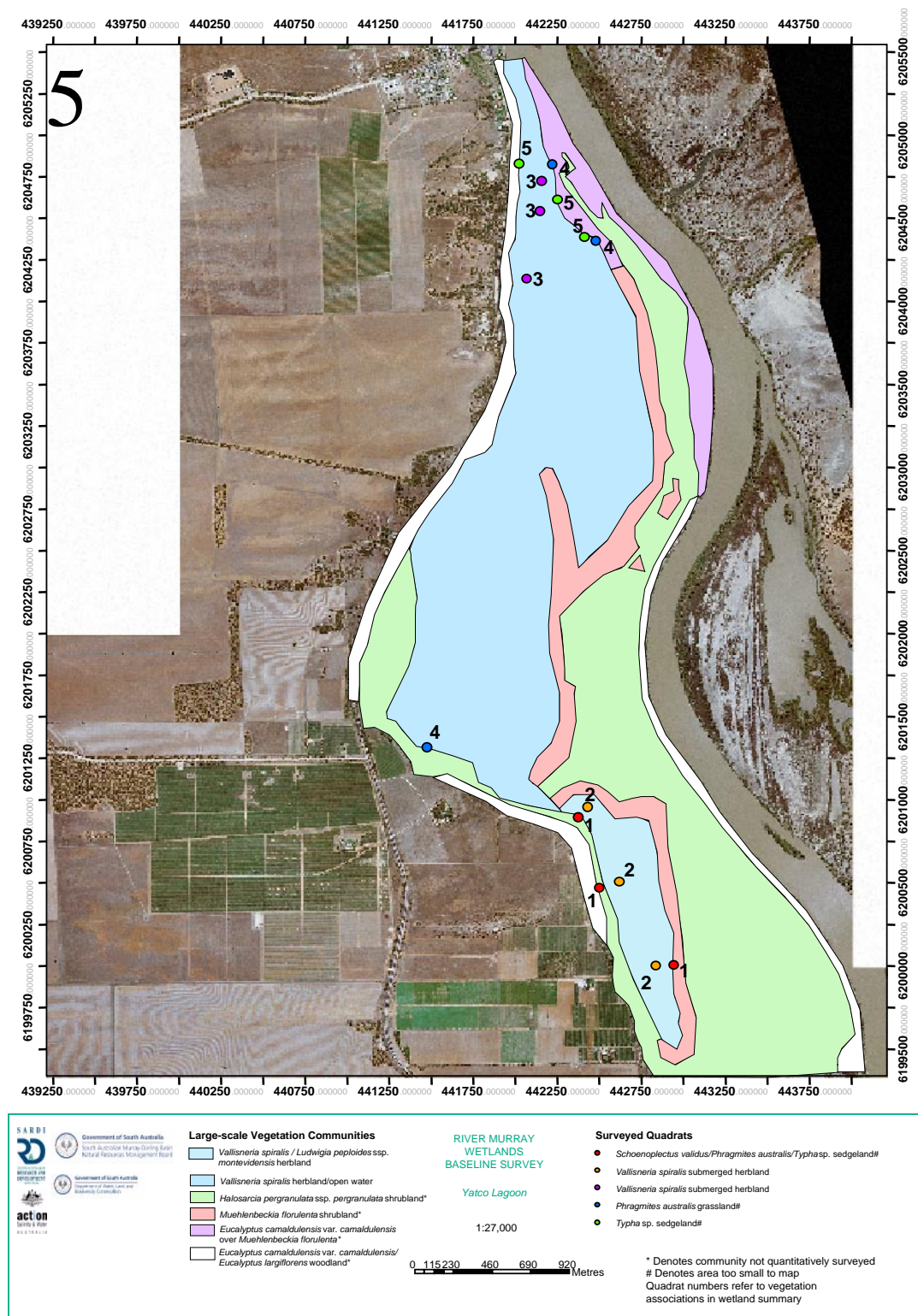


Plate 11: Vegetation communities at Yatco Lagoon, also showing other survey locations (Baseline Survey, SKM, 2005).

- ❖ Tree health was highly variable, with River Red gums (*Eucalyptus camaldulensis*) in poor condition mostly found along the western shoreline of the North Lagoon (see Plate 12) or on the floodplain along the River. For River box (*E. largiflorens*) those in poor to moderate condition were along the edge of salt flats on the peninsula within the North Lagoon, with another

group on the western side of the South Lagoon. The condition of the floodplain vegetation was also noted as being in “fairly poor condition”. All of these problems being attributed to the lack of flooding in the past decade.

- ❖ “The dense submerged shrublands in the southern lagoon need to be protected” (SKM, 2005).



Plate 12: Unhealthy riparian trees and vegetation along the western margin of the North Lagoon. Photograph: Bill Phillips

2.6.2 Macroinvertebrates

Sampling of macroinvertebrates was undertaken during the Baseline survey (SKM, 2005) in April and October at three locations in the North Lagoon. One site at each end and one in the middle of the Lagoon. (See Plate 11 for locations). Appendix H provides the full results.

The survey recorded nearly 4,000 macroinvertebrates from 41 taxa. The Baseline Survey notes that the richness of taxa found at Yatco Lagoon was slightly less than is typical of sites in this geographic region, but was higher than any other site examined in the 2005 survey.

While the sampling was dominated by ‘pollution tolerant’ taxa this is attributed to nutrient enrichment of the wetland at these times (SKM, 2005). The survey also noted that the higher salinity at two of the collection sites was not reflected in the comparative findings.

2.6.3 Frogs

The Wetlands Baseline Survey of 2005 (SKM, 2005) recorded five frog species at Yatco Lagoon from surveys conducted at four times of the year (March, June, September and November at three locations (see Plate 11); near the (1) Yatco Huts causeway, (2) near the road half-way along the length of the Lagoon and (3) adjacent to Moorook.

The species recorded were as follows: Eastern Banjo Frog, Spotted Grass Frog, Eastern sign-bearing Frog, Peron’s Tree-frog and the Southern Bell Frog.

Of these species, the Southern Bell Frog, a species listed as vulnerable nationally under the EPBC Act 1999, was the most common at Site 1 (see Plate 13). The distribution and abundance of this species is still being clarified, with surveys in 2000 (Walker, 2001 & Herbert, 2001) both suggesting it may not be as rare as once thought.



Plate 13: The Southern Bell Frog. Source: www.deh.com.au

About the Southern Bell Frog:

Litoria raniformis is usually found in association with dams, ponds and marshes, either amongst sedges and other semi-aquatic vegetation, or sheltering under logs and rocks (Gillespie *et al.* 1995). The species appears to be associated with permanent waterbodies though it is unclear whether, like *L. aurea*, the species also utilises ephemeral pools (Mahony 1999). The species occurs both in woodland and areas of improved pasture (Gillespie *et al.* 1995). Adults are opportunistic predators, preying on other frogs and are also known to be cannibalistic (Hero *et al.* 1991; Gillespie *et al.* 1995). Extract from DEH web site (www.deh.com.au)

Surveys undertaken by the SA MDB NRM Board with members of the YWLG between October 2007 and April 2009 have confirmed the presence of Eastern Banjo Frogs, Spotted Grass Frogs and Peron's Tree-frogs at the site (C.Nickolai. pers. comm. 2009).

2.6.4 Fish

Fish surveys were conducted as part of the Baseline Survey (SKM, 2005) in the autumn and spring. Ten sites were surveyed using a mixture of techniques. Full details of findings can be found in Appendix H.

In addition there have since been surveys at Yatco Lagoon by Smith (2006), Hollis (November 2007 and August 2008, pers. comm.) and Nickolai (pers. comm. 2009). These surveys have not revealed any further species present in the wetland.

In summary, 12 species have been recorded; eight being native species and four exotic or alien species. These are listed below. Notable among these are two species (indicated below) that are proposed for listing as 'threatened' (rare) under the revised *National Parks and Wildlife Act 1972*.

The Baseline Survey recorded small young of several species, indicating breeding activity, although it is noted that this may or may not have taken place in the wetland itself. The ratio of native species to alien species caught was 2:1. The most abundant species recorded in these surveys were Bony herring, Australian smelt and Unspecked hardyhead.

Being a large shallow wetland Yatco is not ideal habitat for larger native fish, although the Baseline survey did record two Golden perch in each season of sampling.

Native fish species recorded:

- ❖ Bony herring
- ❖ Flathead gudgeon
- ❖ Carp gudgeon complex
- ❖ Golden perch
- ❖ Australian smelt
- ❖ Unspecked hardyhead*
- ❖ Dwarf-flathead gudgeon*
- ❖ Murray rainbowfish*

Alien fish species recorded:

- ❖ Carp
- ❖ Goldfish
- ❖ Redfin
- ❖ *Gambusia*

* = Proposed for listing as 'threatened' (rare) under the revised *National Parks and Wildlife Act 1972*

2.6.5 Birds

The 2005 Baseline Survey (SKM, 2005) took bird records at four sites around Yatco Lagoon (see Plate 11); surveys being conducted in autumn and spring. Two different survey techniques were used. At two sites fixed location surveys were undertaken and at the remaining two, transect surveys. It should be noted that survey times were not ideal, being at 3.00 pm for the autumn survey and 12.30pm for that in spring. Despite this, 28 waterbird species two non-waterbird species were recorded. Full details are in Appendix H.

At Yatco Lagoon, the highest numbers and diversity of species were recorded in autumn; 3,352 individual birds of 26 species being noted.

Of note in the context of this plan are the following:

- ❖ Greatest abundance and species diversity were recorded on open water areas (13 species), mud areas (8 species) and roosting on dead logs (16 species);
- ❖ 300 Freckled duck were observed at Yatco in autumn. This species is rated as 'vulnerable' in South Australia. The Baseline survey recommends further survey to establish if Yatco is more than a drought refuge site for this species.
- ❖ Two Australasian shoveler were recorded in the autumn survey. This species is considered 'rare' in South Australia, as is the Peregrine falcon, one of which was recorded in autumn also;
- ❖ Thirteen species were recorded at Yatco that are listed as 'migratory' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, as species listed under Australia's bilateral migratory bird agreements with Japan and China. It is likely that partial or complete drying of Yatco lagoon will see the numbers of these species increase as the areas of exposed mud habitats increased and then is re-invigorated over time as a consequence of the wetting-drying regime.

Surveys undertaken by the SA MDB NRM Board with members of the YWLG in October 2007 and January 2008 have also recorded two further species considered rare in South Australia; the Australian darter and the Intermediate egret. Other

species of note include Black-winged stilt, Royal spoonbill, Straw-necked ibis and Yellow-billed spoonbill (C.Nickolai. pers. comm. 2009).

2.7 Economic, social and cultural features and values

2.7.1 Importance of Yatco Lagoon to the Moorook community

The township of Moorook sits with Yatco Lagoon on its doorstep. The lagoon is the first thing people see when they enter the town, and the last thing they see when they leave. It is these first and last impressions that count. An unhealthy lagoon, as it is at present, really detracts from possible tourism potential and also for the area to be viewed by visitors as a viable horticultural area (in terms of the environment and quality produce). A healthy wetland should allow Moorook to promote itself as a place where "clean and green" fruit is produced (Based on comments from Sheridan Alm, July 2007).

To the locals, and those that visit, Yatco Lagoon also offers a large body of water to relax by and a safe, shallow place for toddlers to paddle in and enjoy.

In addition, the Vision for this plan (see Section 1.3) and three of the management objectives - see below - indicate the aspirations that the Yatco community have in relation to this site, and its importance to them.

Management objectives (from section 1.4):

- 6) Improve the aesthetic value of the area to encourage the use of Yatco lagoon for sustainable recreation activities by the local community and visitors.
- 7) Improve the recreational facilities at Yatco Lagoon, including the possible development of information boards, a viewing area, walking trail, bike trail and bird hides.
- 8) Maintain and improve on the community capacity to manage the wetland.

2.7.2 Yatco Lagoon and water supply for irrigation and domestic users

As noted in section 1.1, integral to the realisation of this project will be providing alternative water supply arrangements to eleven irrigators on the Yatco Channel (see Plate 9) and a small number of domestic consumers currently drawing water from the system. Eliminating the current permanent reliance on the Lagoon system for irrigation and domestic water supplies not only helps achieve ongoing water savings for the River Murray, but will also allow for complete lagoon management by way of implementing the proposed wetting and drying regime (see Section 5.1).

The irrigators reliant on Yatco Lagoon have invested significant time and resources into reducing their impacts on the system, as is reflected in the following drawn from the first meeting of irrigators to consider this initiative.

Thoughts of one Yatco irrigator as provided at the first meeting to consider this initiative in late 2006:

"Birdlife is amazing on the lagoon; my parents have a full house of visitors every weekend and visitors from other areas.

The Baseline Survey identifies Yatco as an exceptional lagoon and I agree it is but I also know its dying, let's not let it get any worse, lets make it better!

Our property has a 10ha Heritage Scrub area, some on sand hills fringing the lagoon, we have been spending time removing box thorns, bone seed, bridal creeper. There is much regeneration since previous owners grazed this land around 5 years ago.

When we first bought the property every time we turned on the irrigation, water would seep from the ground near the lagoon. There wasn't even any samphire growing on the shore adjacent to the lagoon directly in front of our property. The seepage has entirely stopped through upgrades in irrigation and careful monitoring of soil profiles and floating flag test wells on irrigated areas. There is also regeneration of samphire along the shores."

2.7.4 Tourism associated with Yatco lagoon

The entry to Yatco Lagoon at Moorook offers a grassed picnic and bar-b-que area shaded by large Black box trees, easy entrance to the river for skiing, and also a mooring area for houseboats.

The Yatco Holiday Cabins (Plate 14) have been in existence for approximately 20 years. They are used by holiday makers for various reasons including: fishing, yabbing, canoeing, boating and safe swimming for small children. One of the main reasons for the return of cabin users is the quiete-ness and tranquility of the lagoon and its surrounding areas. The abundance of birdlife is also a draw card.



Plate 14: Yatco cabins near the causeway between the North and South Lagoons.
Photograph: Bill Phillips

2.7.5 Cultural values of Yatco Lagoon for the Riverland Indigenous community and early European settlers

Riverland Indigenous community

Aboriginals occupied the Moorook area, including Yatco Lagoon, for thousands of years prior to European settlement. The indigenous culture is evident throughout the landscape with scar trees, middens, cooking ovens, burial sites, cutting tools and other artifacts scattered throughout the area.

Many of the plants around the wetland and floodplain had uses such as canoes, shields, spears, rope, baskets, cooking, medicine, food, etc.

Of particular significance were:

- ❖ Putch-it-up (Coobah or *Acacia stenophylla*) which was used extensively for wooden artifacts because of the three colour timber.
- ❖ Panpandi (Native Cherry or *Exocarpus cupressiformis*) bark was used as an antidote to snake bite and the timber was burnt to attract cod to the surface for easy spearing.
- ❖ Pee-al (River Red Gum or *Eucalyptus camaldulensis*) fruit and seeds were eaten and the timber used extensively for wooden artifacts particularly large item such as shields and canoes.

Animals also provided a source of food and clothing, and significance to the spiritual beliefs of the indigenous people.

Early European settlers

"The first European settlers arrived in Moorook in 1894 on the paddle steamer 'Gem'. They formed a village settlement to grow produce for them to live on and any excess was sold and sent via paddlesteamer to Morgan then by train to Adelaide.

The first pumping station was established about 200 metres south of the start of Yatco Lagoon. To sustain water for irrigation in pre-lock times during drought conditions, a stone levy bank was built across the entrance to Yatco to hold back water for their crops that needed irrigation.

Dry land farmers arrived in 1895 and settled south of Moorook. They used the southern end of the lagoon in a similar way. In drought years, as the lagoon receded, they planted fodder (that is, sorghum) in the fertile mud and would harvest it for hay and chaff to feed their stock. They considered Yatco Lagoon a valuable resource to sustain farming in the area.

In good river flow years wild horses were trapped and yarded in the peninsular between Yatco lagoon and the River Murray. The horses were broken in and sold to the Australian Army - this is just another way to show the resilience of the first settlers. (Jeff Drogemuller, 2008)"

Table 3: Owners of sections and allotments at Yatco Lagoon

Section/Allotment number	Owner
S188	Crown Land under the control of the District Council of Loxton Waikerie
S333	Crown land (on Lagoon spit)
A316	Stasinowsky
A101	Stasinowsky
S336	Stasinowsky
S61	Schulz
S60	Schulz
S244	Mitolo
S269	Schober
S266	Stivahtaris
S265	Schulz
S457	Schulz
S106	Schober
No number shown	Johnson
S275, S506, S460	George
S468, S469, S270, S271	Mason
S268	Stasinowsky
S462, S711, S451	Burdon
S234 (Drodogemuller Rd)	Drodogemuller
S660	Drodogemuller
Q2	Stasinowsky
Block within Q2	Wegner
S363	Peitrolaj

3.2 Legislation, planning controls etc applicable to this site

Table 4 below summarises those Acts, controls, strategies, guidelines of relevance to the Yatco Lagoon site.

Act, control, strategy or guideline	Scope	Implications for this plan
Federal laws		
Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>	The EPBC Act provides, among other things, that Federal Government approval must be gained for any action that may have a significant impact on a matter of " <i>national environmental significance</i> ". These matters include nationally listed threatened species and ecological communities, listed migratory species and Ramsar-listed wetlands.	The presence on the site of the nationally 'vulnerable' Southern Bell Frog means this Act applies.
<i>Native Title Act 1993</i>	This Act set out processes for the determination of native title rights where Aboriginal or Torres Strait Islander people have maintained a continuous connection with their traditional lands or waters. Many wetlands have special cultural significance to Indigenous Australians, and their knowledge of sustainable management practices developed over centuries is also important in the context of this Strategy.	Undertaking of a cultural clearance at this site will assist in two ways 1. Improved relations with local aboriginal community due to recognition of their prior custodianship of the site; 2. Identification of important aboriginal artifacts, significant sites etc to ensure they are not disturbed during any proposed on ground works
Intergovernmental arrangements		
Murray-Darling Basin Agreement	This collaborative arrangement between the Commonwealth, NSW, Victorian and South Australian Governments is for the regulation and sharing of water within the Murray-Darling Basin and has existed since 1914. The Governments of Queensland and the ACT are now also part of what has become known as the Murray-Darling Basin Initiative. A number of important strategies have been endorsed by the MDBCs Ministerial Council, including those for salinity and drainage, fish management and algal management. The Commission adopted its Integrated Catchment Management (ICM) Strategy 2001-2010.	This remains unclear at present given current discussions between the Commonwealth Government and State/ACT governments.
National Water Initiative	Water for the environment and security of water for consumptive users also.	This program offers a potential funding source for short-term financing of this project, and also in the longer term.
South Australian Acts, controls, plans etc		
<i>Natural Resource Management Act, 2004 (previously Water Resources Act 1997)</i>	The <i>Water Resources Act 1997</i> came into operation on 2 July 1997 and is based on the requirements of the COAG Water Reform framework (see above). The Act has a number of key features including: - devolution of water resources management responsibilities to local communities, primarily through the establishment of Catchment Water Management Boards (CWMBs) and water resources planning committees in any area of the State; - a more holistic and ecologically sustainable approach to water resources management, including the provision of water for the environment; and - management of water resources through a hierarchy of catchment water management plans, water allocation plans and local water management plans prepared and regularly reviewed through a	This management plan has been prepared according to the <i>Guidelines for developing wetland management plans for the River Murray in South Australia 2003</i> (DWLBC 2003) in order to fulfil obligations under the Water Allocation Plan for the River Murray Prescribed Watercourse, and thereby gain a permanent water licence.

	comprehensive process of community involvement.	
<i>State Water Plan 2000</i>	The <i>State Water Plan 2000</i> provides a contemporary assessment of the state and condition of South Australia's water resources and sets out the Government's strategic policy directions for their sustainable use and management. It sets the policy framework for water resources management and use throughout the State, with catchment water management plans, water allocation plans and local water management plans providing the regional and local focus. The <i>State Water Plan 2000</i> contains a package of policy principles for the management of all water-dependent ecosystems, including wetlands.	The South Australian Wetland Strategy prepared under the State Water Plan provides a strong mandate for the Yatco Lagoon Wetland Management Plan. The Act requires regional and local plans to be consistent with the State Water Plan and provides for regular reviews to ensure consistency through a comprehensive process of community involvement.
<i>Environment Protection Act 1993</i>	The <i>Environment Protection Act 1993</i> came into operation on 1 May 1995 and is the primary pollution control and prevention legislation in South Australia.	This Act provides for standards of care that apply to industry and the community, by means of general environmental duty of care, offences under the Act; and Environment Protection Policies and regulations.
<i>Native Vegetation Act 1991</i>	The <i>Native Vegetation Act 1991</i> controls the clearance of native vegetation in South Australia, with clearance generally requiring the consent of an independent authority, the Native Vegetation Council. The Act provides an existing legal mechanism to protect wetlands, and their surrounding vegetation.	This Act provides controls in relation to clearance of native vegetation, including those on the floodplain or within the riparian zone.
<i>Soil Conservation and Landcare Act 1989</i>	The <i>Soil Conservation and Landcare Act 1989</i> encourages landholders to manage land sustainability.	The Act provides for the establishment of Soil Conservation Boards whose tasks are to develop District Plans, supported by education and promotion programs, and to provide regulatory enforcement when appropriate.
<i>Local Government Act 1999</i>	The <i>Local Government Act 1999</i> establishes the system of local government and provides for councils' functions and powers.	The Act gives local councils powers in relation to flood management, including power to acquire land in order to carry out flood mitigation or prevention works and power to act in an emergency. Councils also have powers to establish and manage drainage infrastructure in relation to roads, including the appointment of drainage authorities. Section 196 of this Act relating to community land and the preparation of management plans is especially relevant, particularly for wetlands in the coastal and estuarine areas.
<i>Development Act 1993</i>	The <i>Development Act 1993</i> has as its overall objective the proper, orderly and efficient planning and development of the State.	This Act makes provision at the highest level for the preparation and maintenance of the planning strategy that sets the framework for an integrated approach to development.
<i>National Parks and Wildlife Act 1972</i>	The <i>National Parks and Wildlife Act 1972</i> provides protection for many wetlands through their inclusion in various reserves set aside for conservation purposes.	This Act also provides guidelines on conservation management and the status of native plants and animals, which rely on wetlands.
<i>Fisheries Act 1982</i>	This Act has among its stated objectives "ensuring, through proper conservation, preservation and fisheries management measures, that the living resources of the waters to which this Act applies are not endangered or overexploited."	This Act provides a legal mechanism for a range of fishery-related activities, including protection of threatened species, establishment of aquatic reserves etc.
<i>Pastoral Land Management and Conservation Act 1989</i>	The <i>Pastoral Land Management and Conservation Act 1989</i> seeks to ensure that all pastoral land in South Australia is well managed and utilised prudently so its renewable resources are maintained and its yield sustained.	The Act aims to provide for monitoring of the condition of pastoral lands, to prevent degradation of the land and its native plant and animal life, and for the rehabilitation of those lands where damage has occurred.

<i>Aboriginal Heritage Act 1988</i>	This Act provides a legislative basis for recognising and protecting Aboriginal heritage, be that culturally significant sites, objects or remains.	See <i>Native Title Act 1993</i> above.
Regional Biodiversity Plans for South Australia	The Department of Environment and Heritage prepares Biodiversity Plans for the various regions of the State.	The Regional Biodiversity Plan identifies significant species and ecological communities for attention in planning processes.
Guidelines for developing wetland management plans for the River Murray in South Australia 2003 (DWLBC 2003)	Guidelines developed to assist those preparing management plans for floodplain wetlands along the River Murray in South Australia.	This plan must conform with these guidelines in order to qualify for a permanent licence to access environmental flows under the Water Allocation Plan for the River Murray Prescribed Watercourse.

3.3 Management arrangements

As noted in Section 1.2, while the individual landholders are ultimately responsible for the management of their respective portions of the site, these landholders have agreed that the Yatco Wetland Landcare Group has the primary responsibility for coordinating and monitoring overall performance with the implementation of this Plan, and advising where adaptive management may be necessary.

In undertaking implementation of this plan the YWLG will take advice from representatives of the Loxton to Bookpurnong Local Action Planning group, the SA MDB NRM Board, the Department Water, Land and Biodiversity Conservation, the Department of Environment and Heritage, the Riverland Indigenous community and others with relevant local expertise.

Meetings of the group will be convened at least quarterly to review progress, plan and coordinate activities, monitor system responses etc. A summary of the conclusions from each meeting will be made available through appropriate avenues such as a website, the Yatco Wetland Landcare Group and the Loxton to Bookpurnong Local Action Planning newsletters to the community of Moorook, and articles in the local print media for the wider region.

4. Threats and risks

At the heart of effective site management is recognising and responding to those threats which could have detrimental impacts on the site. In this situation it is vital that potential threats to the Yatco wetlands are also identified for management responses.

Twenty-one known or possible threats to the ecological and other values of Yatco Lagoon have been identified and subjected to risk assessment as presented below. Section 5 then considers these threats and responds to them in ways that are appropriate to the perceived severity or immediacy of the risk or threat.

It is acknowledged that new threats may emerge in the future, and it will be through vigilance and ongoing monitoring at the site (see Sections 5 and 6) that these are assessed for the risks they pose, and appropriate responses formulated by the Yatco Wetland Landcare Group, and other community members as necessary.

4.1 Known and prospective threats

Table 5 presents the identified threats or risks for the Yatco wetlands. These are a compilation of known threats, as well as threats or risks associated with the re-introduction of wetting and drying of the lagoons.

Table 5: Identified threats or risks for Yatco wetland

Threats or risks Known = K or Potential = P	Cause	Anticipated or real impact on wetland	Summary of response proposed, if any at this stage (see Section 5 for further details)
A. Wetland wetting- drying and salinity management			
1. Saline groundwater inflows leading to increased salinities (P)	Elevated groundwater table under Yatco wetland due to impact of Lock 3 weir pool and changed land uses in the region (i.e. irrigated agriculture). Reduced frequency and duration of flood events. Seepage of saline groundwater into the underlying water table. Reducing the water level in the lagoon and disconnecting it from the river may result in increased salinity of water in the wetland due to evaporation and interception of saline groundwater. The latter may already be occurring but is not obvious given the river connection 'flushing' the wetland and maintaining salinity at lower levels. Keeping the system dry for too long may see freshwater lens sitting under the bed of the lagoon diminish, allowing groundwater to rise further upwards and be intercepted by the wetland, salinising the bed of the wetland and altering its character.	'Slug' of highly saline water seeps into the lagoon as it dries. Following drying the re-filling of the wetland could result in a significant salt load to the river, as measured at Morgan, possibly preventing its re-connection. Degradation of wetland environments. Degradation of habitat quality for native fish and frogs. Less macroinvertebrate, native fish, frog and aquatic plant diversity due to low salinity tolerance of many species. Degradation of bird habitats.	Ideally, cautious, staged water level reductions over several years to monitor the situation. If monitoring indicates a gradual increase in surface water EC's at comparable stages and water levels over successive years then this will require a review of future water level manipulations. This could indicate lack of flushing as a problem requiring attention, that surrounding land uses are exacerbating groundwater dynamics and salinity, or both. Either way, a climbing EC profile for surface water is not wise or sustainable in the long-term. Pyap to Kingston Land and Water Plan aims to address groundwater problem by minimising inflows as much as practicable through changes to land use practices.
2. Risk of exposing acid sulfate soils (P)	Sulfidic sediments in the soil which may be activated by drying wetland.	Acidification of lagoon with resultant fish kills etc, odour released as a result of drying.	Investigate potential for acidification and sulphurous odours to be produced in Yatco Lagoon in the future, and, if potential is high, identify management options to reduce the threat such as a precautionary hydrological management regime and rigorous monitoring. Ideally, sampling of the sediments within the wetland prior to drying it in order to determine the sulfur loads and risk
3. Odour during drying phases (P)	Drying sediments can releases 'sulphurous' smelling odours – plus see acid sulphate soils above too.	Annoyance for local residents.	See acid sulphate soils above.
4. Increases in water turbidity (P)	Sometimes following a first dry down and re-filling, sediment suspension can occur. Soil erosion due to stock or rabbit activity can also exacerbate this problem - see below.	Can impact on regenerating submerged, and emergent aquatic vegetation, biofilm productivity, fish etc as light penetration through the water column is reduced.	Successional drying down, incrementally and slow rate of filling can help avoid this phenomenon.
5. Increased incidence of	Nutrient-rich in-flows, slow moving warm	Algal blooms can be harmful	Flushing flows and drying out should both help

algal blooms (P)	waters etc, can result in algal blooms.	(depending on the type of algae), unsightly etc, and if severe can result in fish kills etc. and make the water in the lagoon unfit for human contact.	reduce likelihood of blooms. Some increased algal activity may occur on re-filling but this is natural, and drying will reduce the likelihood of toxic algae blooming post-filling as they are not resistant to drying. Only those algae that come in with water when re-filling the lagoons are likely to respond.
6. Increased abundance of mosquitoes & midges (P)	Drying mudflats and riparian areas can sometimes promote increased levels of mosquitoes and midges.	Annoyance for local residents. Possible risk of Ross river fever.	This is not common, and if it does occur is not likely to persist once drying out of substrate occurs.
B. Feral pests, weeds and fire management			
7. Impact of introduced fish (carp, <i>Gambusia</i>) on native fish, water quality etc. (K)	Large pest fish populations in river, specifically carp and their free movement between the river and wetland, where spawning may occur.	Carp may be the partial cause of increased turbidity and therefore reduce the extent of aquatic vegetation within Yatco wetland. Other introduced fish cause reductions in native fish populations by competing for prey and habitat ie aggressive interactions with native fish by <i>Gambusia</i> and consumption of native fish by species such as redfin.	Basin-wide carp and pest fish control measures. Involvement in carp management and fishery management plans. Control carp and other pest fish through use of 'carp' screens on wetland regulators and engagement of commercial fishers to harvest aggregations of carp in the vicinity of the wetland and on wetland closure. Implementation of the wetland management plan at Yatco to reduce pest fish numbers.
8. Impact of foxes on native fauna. (K)	Predation on turtles, birds, small mammals etc.	Reduced numbers of their prey species.	Regular control measures on the site can keep population levels low, but can never eradicate. Coordinated, regular regional control of foxes by NRM Board and local landholders is necessary to have an effect on the local population in the vicinity of Yatco Lagoon.
9. Impact of feral or domestic cats/dogs on native fauna. (K)	Predation on turtles, birds, small mammals etc.	Reduced numbers of their prey species.	Regular control measures can keep level low, but can never eradicate. Regional control of feral cats and dogs by NRM Board and local landholders. Development of guidelines on areas for dogs in wetland and rules such as 'on a leash' or designated 'no leash areas' Changes to management of cats in local area by community.
10. Impact of rabbits on water quality and plant communities. (K)	Soil erosion, resulting in elevated turbidity in runoff water to the lagoon. Loss of vegetation cover on the floodplain and surrounding high country	Can impact on regenerating submerged, and emergent aquatic vegetation, fish etc as light penetration through water column is reduced	Regular control measures can keep level low, but never eradicate. Control rabbits regionally through NRM Board activities – engage with pest plant and animal control officers. Undertake re-vegetation activities within and around the site
11. Impact of weeds on native plants. (K)	Weed species out-compete native species resulting in loss of native plant species and	Impacts on habitat diversity and availability for native species	Regular control measures needed to eradicate weeds from site.

	habitats		Control pest plants regionally through NRM Board activities – engage with pest plant and animal control officers. Undertake re-vegetation activities within and around the site
12. Fire impact on native species and habitats. (K)	Bush fires	These can have a major impact on riparian and floodplain plants	A fire control plan for the site can help reduce this threat. Designated fire sites within the boundary or a rule of no fires permitted within the site
C. Biodiversity conservation and habitat restoration			
13. Continuing lack of recruitment and declines in health and death of floodplain trees. (P)	Lack of flooding, or permanent inundation (depending upon where located).	Reduced recruitment of trees leads to loss of aesthetics and habitats. Loss of existing trees reduces aesthetics and habitat for existing fauna reliant upon healthy, living trees for foraging, nesting sites, shelter and protection from predators.	Reintroducing wetting and drying (with the occasional natural flood) should result in improved recruitment of floodplain trees. Failing this, undertake re-vegetation activities within and around the site to improve recruitment and succession. If the health of existing trees continues to decline, determine the underlying cause, ie elevated groundwater, increased salinity etc
14. Continuing loss of fringing vegetation – no regeneration or recruitment of new fringing vegetation. (P)	As above.	As above in relation to trees. For smaller riparian plants and emergents, the loss of these impacts on many bird species, reptiles and frogs especially who rely on these habitats for feeding, breeding and refuge.	As above. This also applies to smaller riparian plants and emergent species.
15. Invasion of the wetland bed by fringing vegetation such as <i>Typha</i> or <i>Phragmites</i> (P)	Can occur where these riparian zone plant species are encouraged to move further into the wetland bed by a favourable hydrological regime.	Can out-compete submerged aquatic plants in fringing areas, altering habitat and therefore species composition of riparian and nearby areas.	Warrants attention as part of monitoring, particularly as the riparian zone is re-invigorated through water level variations. Physical control can be used, or 'tweeking' of the watering regime may be required to disadvantage these species.
16. Loss of species diversity, especially plants, fish, frogs, birds. (P)	Caused by several of the above problems. Inappropriate hydrological management – stable elevated water levels for too long – leads to habitat simplification and declining biodiversity then follows.	Loss of species diversity and population numbers. Reduced amenity and tourist value to site	As for 14., above.
D. Other human uses in and around the wetland			
17. Impact of livestock grazing on fringing vegetation, exposed mudflats. (K)	Grazing riparian edges or onto the mudflats as they dry.	Can cause loss of vegetation, and 'pugging' of edges and mudflats leading to accelerated erosion.	Carefully managed stocking rates and access to riparian areas.
18. Impact from nearby developments. (P)	Inappropriate nearby activities may threaten the ecological and other values of the site. Such activities may include a range of agricultural practices, tourism ventures, etc	Impact will depend on the form of the activity.	Those implementing this plan need to be vigilant and to seek impact assessments for any new, potentially threatening activities. The 'sister' Land and Water Plan should also help regulate or modify such activities.

E. Protecting social and cultural values			
19. Loss of recreational uses, such as tourism (cabins, etc). (P)	Drying out of lagoon will reduce access and aesthetic outlook at times.	Drying out won't affect water skiing etc near Moorook end of North lagoon, but will possibly reduce use of eco-cabins at times	The wetting and drying should see revitalisation of the lagoons, making the cabins more popular over time. Use cabins as an opportunity to tell the story of ecology and requirements for varying water levels/ <u>wetting and drying</u>
20. Loss of aesthetics. (P)	Drying out the system will change the views many Moorook people have of the lagoon, albeit temporarily.	As indicated above there is the possibility of odour and mosquitoes and midges, although it is unlikely this will occur, or if it does, for very long.	A change of the view is something residents will have to adjust to in order to reap the benefits of wetting and drying.
21. Loss of places of Indigenous and early European cultural heritage through increased tourism at site. (P)	Damage to places or artefacts.	Either deliberate (vandalism) or accidental through ignorance.	Raising awareness of these things and being vigilant. Improved relationship with Aboriginal community and determine how to protect significant sites within site boundary Provision of appropriate access to sites within Yatco lagoon area

4.2 Risk assessment

In carrying out a threat analysis, the risk criteria shown in Table 6 below were applied.

Table 6: Risk criteria

Category	Guideline	Score
Consequence of threat	Unrecoverable/severe	3
	Moderate	2
	Minor	1
Likelihood of threat	Certain/High	3
	Medium	2
	Low	1
Timing of impact	Immediate/short term	3
	Medium term (5 years)	2
	Long term (decades)	1
Control of threat/mitigation	Local - within the boundary of the wetland and floodplain	4
	Sub-regional – within the LAP region	3
	Within the Riverland	2
	Within the Murray-Darling Basin - uncontrollable	1

The consequence, likelihood, timing and mitigation score for each threat are multiplied to give a score between 1 and 108. The known and possible threats to Yatco Lagoon can then be ranked, as shown in Table 7 below. How the management will respond to each threat is presented in Section 5, and direct references within that section are given in the far right hand column of Table 7.

Table 7: Risk assessment and threat prioritisation

Threat	Consequence	Likelihood	Timing	Control	Total	Rank	Action Plan Ref (Section 5)
A. Wetland wetting- drying and salinity management							
1. Saline groundwater inflows	3	2	3	3	54	2	5.1
2. Risk of exposing acid sulphate soils	2	2	3	4	48	3	5.1
3. Odour during drying phases	2	2	3	4	48	3	5.1
4. Increases in water turbidity	1	1	3	4	12	8	5.1
5. Increased incidence of algal blooms	1	1	3	4	12	8	5.1
6. Increased abundance of mosquitoes and midges	1	1	3	4	12	8	5.1
B. Feral pests, weeds and fire management							
7. Impacts of introduced fish (carp, <i>Gambusia</i>)	2	3	3	3	54	2	5.2
8. Impacts of foxes	1	3	3	3	27	6	5.2
9. Impacts of feral or domestic cats/dogs	1	3	3	3	27	6	5.2
10. Impacts of rabbits	1	3	3	3	27	6	5.2
11. Impacts of weeds	1	3	3	4	36	4	5.2
12. Impacts of fire	2	1	3	4	24	7	5.2
C. Biodiversity conservation and habitat restoration							
13. Continuing declines in health and death of floodplain trees	3	3	3	4	108	1	5.3
14. Continuing loss of fringing vegetation	3	3	3	4	108	1	5.3
15. Invasion of the wetland bed by fringing vegetation such as <i>Typha</i> or <i>Phragmites</i>	2	2	2	4	32	5	5.3
16. Loss of species diversity	3	3	2	4	108	1	5.3
D. Other human uses in and around the wetland							
17. Impact of livestock grazing	1	3	3	4	36	4	5.4
18. Impact from nearby developments	2	2	2	3	24	7	5.4
E. Protecting social and cultural values							
19. Loss of recreational uses	2	2	3	4	48	3	5.5
20. Loss of aesthetics	2	2	3	4	48	3	5.5
21. Loss of places of Indigenous and early European cultural heritage	3	1	2	4	24	7	5.5

Using Table 7, it is then possible to rank the threats for relative priority in the implementation of the management plans actions – as set out in Section 5. Table 8 presents the risks and threats in their ranked order from Table 7.

Table 8: Risk and threat prioritisation (based on Table 7)

Threat	Total	Rank	Action Plan Ref (Section 5)
Continuing declines in health and death of floodplain trees	108	1	5.3
Continuing loss of fringing vegetation	108	1	5.3
Loss of species diversity	108	1	5.3
Saline groundwater inflows	54	2	5.1
Impacts of introduced fish (carp, <i>Gambusia</i>)	54	2	5.2
Risk of exposing acid sulphate soils	48	3	5.1
Odour during drying phases	48	3	5.1
Loss of recreational uses	48	3	5.4
Loss of aesthetics	48	3	5.4
Impacts of weeds	36	4	5.2
Impact of livestock grazing	36	4	5.4
Invasion of the wetland bed by fringing vegetation such as <i>Typha</i> or <i>Phragmites</i>	32	5	5.3
Impacts of foxes	27	6	5.2
Impacts of feral or domestic cats/dogs	27	6	5.2
Impacts of rabbits	27	6	5.2
Impacts of fire	24	7	5.2
Impact from nearby developments	24	7	5.4
Loss of places of Indigenous and early European cultural heritage	24	7	5.5
Increases in water turbidity	12	8	5.1
Increased abundance of mosquitoes and midges	12	8	5.1
Increased incidence of algal blooms	12	8	5.1

5. Management issues and actions

In this section of the management plan the actions that will be undertaken are set out and prioritised. These actions are designed to help pursue the broad management objectives for Yatco Lagoon, as presented in section 1.4, and also respond to the risks and threats identified in the preceding section.

This section is organised according to the same themes used in section 4; namely:

- 5.1 Hydrological Operational Plan
- 5.2 Feral pests, weeds and fire management
- 5.3 Biodiversity conservation and habitat restoration
- 5.4 Other human uses in and around the wetland
- 5.5 Protecting social and cultural values

5.1 Hydrological Operational Plan

In late 2007-early 2008, as part of South Australia's Drought Contingency measures, an earthen bank was installed at the northern end of Yatco Lagoon to allow for its disconnection from the River Murray (see Plate 16 below, and page 7 also). At the same time regulators were installed in the causeway between the North and South lagoons and also where the North lagoon joins middle creek (Plate 17).

During the following, almost 15 months, the wetland was allowed to dry out for the first time since the installation of Lock and Weir 3 in 1925 (Plates 19 and 20). On 18 March 2009, it was refilled back to pool level.

Implicit in being able to operate this hydrological plan for the wetland is that alternative water supply arrangements are in place for the irrigators and domestic users of water from the site.



Plate 16: Permanent bank installed on the North Lagoon to allow water level variations.
Photograph: Bill Phillips



Plate 17: Regulators installed on pipes connecting the North Lagoon with Middle Creek.

Photograph: Jason Higham

Note: See Plate 2 also which shows regulators installed on the causeway connecting the North and South Lagoons.

5.1.1 Specific management objectives

For this Hydrological Operational Plan the specific management objectives are to:

1. Manage water levels to enhance native plant and animal communities within and surrounding the wetland, and ;
2. Through managed drying and re-wetting events, improve water quality in Yatco Lagoon.

As identified in the previous section, the re-introduction of a variable water regime to Yatco Lagoon does come with some risks. These need to be taken into consideration within the management framework, with appropriate monitoring being undertaken to allow early warning of any of these risk factors becoming a concern. These primary risk factors are as follows:

1. Saline groundwater in-flows to the lagoons during drying phases;
2. Exposure of potential acid sulfate soils and associated acidification of the water in the Lagoon;
3. Saline surface water exchange from the lagoon to the River Murray;
4. Unpleasant odour during drying phases; and,
5. Increased abundance of mosquitoes and midges.

Because of these risks, this Hydrological Operational Plan is deliberately cautious, and incremental, so that monitoring can advise if progressing to a more extensive drying of the system in sequential years is a wise course to follow. If this monitoring begins to show unacceptable impacts from the re-introduction of variable water levels, then adaptive management-based responses will be introduced.



Plate 18: Fish-friendly regulator installed in the North Lagoon's earthen bank.
Photograph: Bill Phillips



Plates 19 and 20: North lagoon drying out, February 2008
Photograph: Bill Phillips

5.1.2 Flow control structures

Yatco Lagoon presently has three primary and one secondary flow control points (as follows) located as shown in Plate 21:

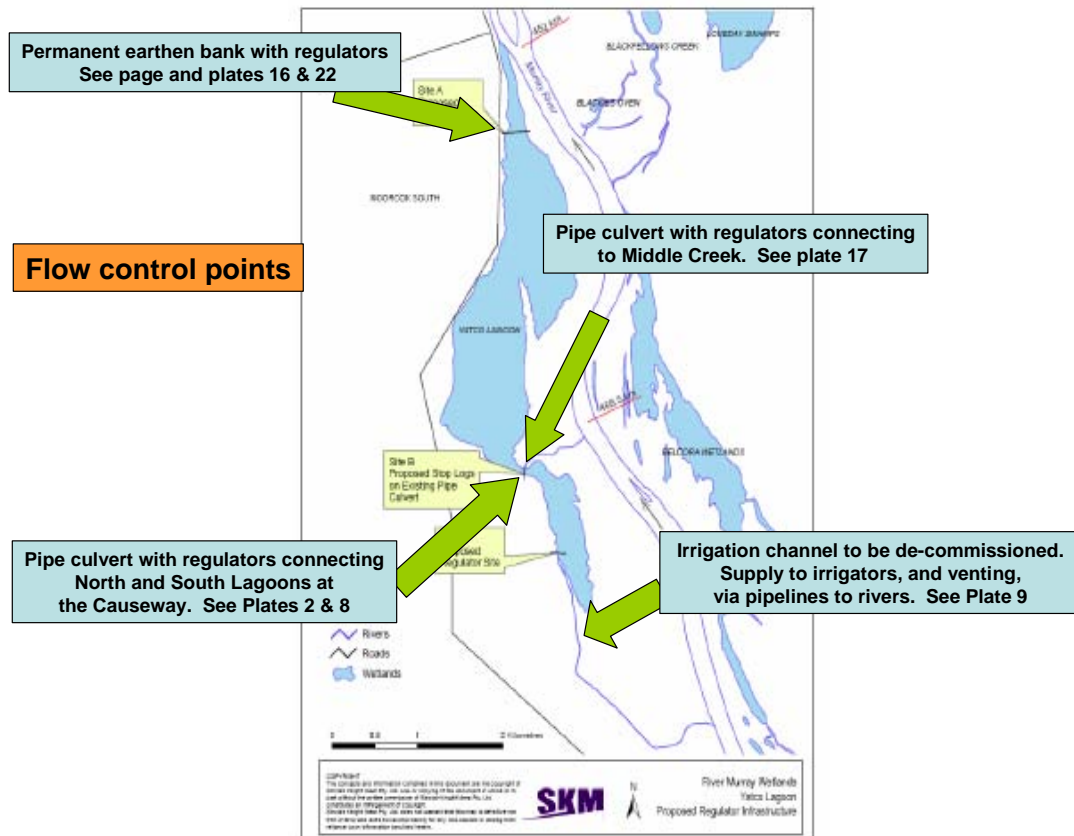
Primary flow control points (regulate flows between Yatco Lagoon and the River Murray):

1. Earthen bank at the northern end of the North Lagoon. This currently has three box culverts located together near the centre of the structure, and fitted with carp screens. See Plate 18.
2. Triple pipe culverts with regulators at the southern end of the North Lagoon, where the North Lagoon connects with Middle Creek. See Plate 17.
3. Pipe culvert with regulator from the irrigation channel into South Lagoon. This channel is to be de-commissioned once the necessary infrastructure is in place to allow the surrounding irrigators to source their water direct from the River Murray, and also to vent irrigation disposal water back to the river.

Secondary flow control point (regulate flows within the site):

4. Double pipe culvert with regulators connecting between North and South lagoons through the 'causeway'.

The report by Stuart (2009) recommends some alterations to the above structures to make them more native fish-friendly and to assist with carp management. These recommendations are included in the Hydrological Management Plan below.



Plates 21: Flow control points for Yatco Lagoon

5.1.3 Description of the Hydrological Operational Plan

This Plan, as shown graphically in Figure 2 and set-out in more detail in Table 9 is intended to cover the period from 1 July 2009 to 31 December 2012.

A deliberately cautious and conservative approach is taken to minimise the primary risk factor: salinisation of the wetland from groundwater in-flows.

The strategy recommended is therefore to progressively extend the drying phases over the 3.5 years of this plan to allow for ecological recovery to continue (following the drought-enforced 15 month drying event from late 2007 to April 2009) without risking salinisation. This strategy should also encourage re-establishment and maintenance of a freshwater lens under the wetland bed to improve its long-term resilience.

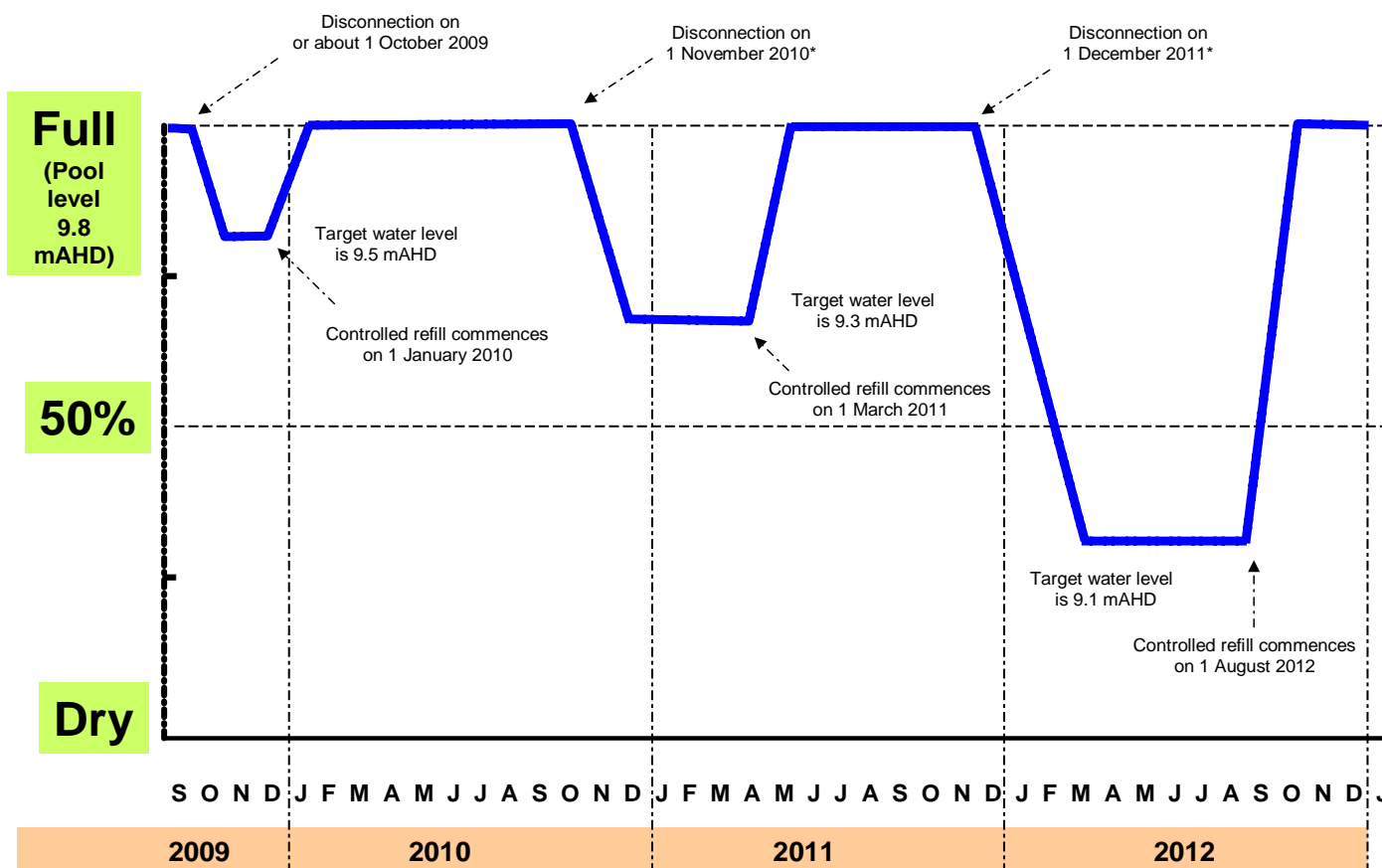
As set out in the Plan, in year one (2009) the site is to be disconnected from the River Murray on or about 1 October, and kept disconnected until it reaches 9.5m AHD, 30 centimetres below pool level. It is then to be kept at that level until refilling

commences on 1 January 2010, assuming water is available to allow this to occur (see Table 9). If possible, refilling should be a controlled process as specified in Table 9.

In year two, unless ground and surface water monitoring indicates otherwise, disconnection is to occur on 1 November. In this drying phase the target is to reach 9.3m AHD (50 centimetres below pool) or remain disconnected until 1 March whichever comes first. As with year one, if this level is reached before 1 March (as expected) then it will be kept there until this date before refilled to pool level, again via a controlled process. Should ground and surface water monitoring through year 1 indicate salt accumulation in the wetland then consideration should be given to either repeating the more modest year 1 drawdown (i.e. 30 centimetres below pool) or no drying event at all in order to assess the situation more fully.

In year three, with the same caveats as above regarding monitoring, the aim is to extend the drying phase until a water level of 9.1m AHD (70 centimetres below pool) is achieved, or remain disconnected until 1 August, whichever comes first. Again, if this water level is reached before this date (as expected) then that level will be maintained before again, controlled re-filling to pool level starting on 1 August. This spring re-filling is designed to help further accelerate ecological recovery because wetlands filled naturally at this time in late winter/spring prior to the construction of lock and weir 3.

Thereafter, monitoring data will need to be applied to establish the best pattern of water level variations for future years.

Figure 2: Hydrological Operational Plan for Yatco Lagoon: July 2009 – December 2012

* See caveats regarding target drawdowns above and in Table 8

Table 9: Yatco Lagoon Hydrological Operational Plan: July 2009- December 2012

Year	Timing	Action	Rate	Activity	Expected responses	Total Water use
2009	J	Wetland remains connected to River Murray, level retained at y pool level - 9.8m AHD	Level remains at 9.8m AHD	All regulators open.	Limited exchange of water between wetland and river unless river flows exceed entitlement flow. Aquatic habitats available. Water temperatures increase particularly in shallow wetland areas along shoreline. Release of nutrients from wetland bed. Likely drop in turbidity following complete drying in 2008/2009. Germination of emergent aquatic plants. Small native fish to colonise aquatic plant beds. Waterbirds and frogs to commence breeding in riparian zones. Increased surface water salinity level (due to increased evaporation). Ongoing recharge of freshwater lens under the wetland. Growth flush in Red Gum canopies as soil temperatures increase.	344 ML inflow to replace evaporation
	A					
	S					
	O	Commence drying phase on (or about) 1 October until level of 9.5 m AHD reached. Water level held here until 1 January 2010. 30 cm drawdown is estimated to take approx. 60 days under typical condition.	30cm drawdown	Close all regulators on (or about) 1 October 2009. Once target level reached (approx 30 November) re-open North lagoon regulators (earthen bank and Middle creek) with boards to keep level at 9.5m AHD. Hold level at 9.5m AHD until 1 January	Reduced surface water habitat Consolidation of wetland bed sediment around dried edges. Cracking of exposed bed clays. Exposure of new shallow water feeding areas around shorelines increasing suitability for waders and dabbling ducks. Spread of riparian vegetation such as <i>Typha</i> and sedges onto the exposed wetland bed. Increase in surface water salinity due to evaporation. Red gum recruitment in moist riparian areas.	564 ML inflow to replace evaporation
	N		Disconnection from river			
	D		Reduced evaporation losses Reconnect to river on 1 January – in-flows required to hold at 9.5 m AHD across this period estimated to be 564 ML			
2010	J	Refill wetland to pool level and hold there until 1 November 2010	2-3 cm/day rise if practical.	1 January 2010 – North lagoon regulators (earthen bank and Middle creek) opened with boards in place to regulate refill rate. Causeway regulators fully open.	Initial dilution of surface water salinity as wetland fills with river water. Minor increase in wetland salinity due to high evaporation rates in summer. Discharge salt load to river with small increase in river salinity due to river dilution. Recharge groundwater with freshwater. Reduce groundwater salinity and increase groundwater level.	Refill volume 949 ML
	F					
	M		Refill volume – fill plus infiltration in January = 949 ML	Hold regulators open until 1 November.		
	A					
	M					
	J					
	J					
	A					

2011	S		in January = approx. 603 ML Evaporation loss March to end October = approx. 2222 ML		Native fish passage between river and wetland. Emergent aquatic plant growth in refilled areas provide habitat for small native fish. Water level rise and warm temperatures stimulate aquatic animals such as yabbies and shrimps. Increased habitat and food availability for water birds, frogs, reptiles, Important summer/autumn/winter refuge for waterbirds. Increased riparian cover provides spring breeding habitats for waterfowl, frogs.	
	O					
	N					
	D	1 November - commence drying event until level of 9.3 m AHD reached or for four months, whichever comes first*. The monthly net evaporation rate should see the level reduced to this target in approx. 78 days, that is, by around by January 18 th . *Note – if ground and surface water monitoring in year 1 indicate salt accumulation in the wetland consideration should be given to either repeating the more modest 30 cms drawdown or no drawdown at all so that the situation can be assessed.	50cm drawdown Disconnection from river Reduced evaporation losses Estimated inflow to maintain level at 9.3m AHD is 679 ML	Close all regulators on 1 November 2009. If target water level reached before 1 March, re-open North lagoon regulators (earthen bank and Middle creek) with boards to keep at this level.	Reduced surface water habitat Consolidation of wetland bed sediment around dried edges. Cracking of bed clays. Well established groundcovers on previously dried wetland bed. Exposure of new shallow water feeding areas around shorelines increasing suitability for waders and dabbling ducks. Spread of riparian vegetation such as Typha and sedges onto the exposed wetland bed. Increase in surface water salinity due to evaporation. Red gum and sedge recruitment in moist riparian areas.	679 ML inflow to replace evaporation.
	J					
	F					
	M					
	A	1 March - commence controlled refilling wetland to pool level, and hold it there for 9 months.	2-3 cm/day rise, Refill volume – fill plus infiltration in March = approx. 1442 ML Estimated evaporation loss in March = 422 ML Estimated evaporation loss April to end November = 1706 ML	1 March 2011 – North lagoon regulators (earthen bank and Middle creek) opened with boards in place to regulate refill rate. Causeway regulators fully open.	Initial dilution of surface water salinity as wetland fills with river water. Minor increase in wetland salinity due to high evaporation rates in summer. Discharge salt load to river with small increase in river salinity due to river dilution effect. Recharge groundwater with freshwater. Reduce groundwater salinity and increase groundwater level. Native fish passage between river and wetland. Emergent aquatic plant growth in refilled areas provide habitat for small native fish. Water level rise and warm temperatures stimulate aquatic animals such as yabbies and shrimps. Increased habitat and food availability for water birds, frogs, reptiles, Important summer/autumn/winter refuge for waterbirds. Increased riparian cover provides spring breeding	Refill volume 1442 ML 2128 ML inflow to replace evaporation
	M					
	J					
	J					
	A					
	S					
	O					
	N					

					habitats for waterfowl, frogs, reptiles.	
2012	D	1 December - commence drying event until level of 9.1 m AHD reached or for eight months, whichever is reached first*. The monthly net evaporation rate should see the level reduced to this target in approx. 109 days, that is, by around 19 th March. * see caveat under year 2	70 cm drawdown	Close all regulators on 1 December 2009. If target water level reached before 1 August 2012, re-open North lagoon regulators (earthen bank and Middle creek) with boards to keep at this level.	Reduced surface water habitat Consolidation of wetland bed sediment around new dried edges. Cracking of bed clays. Well established groundcovers on previously dried wetland bed. Exposure of new shallow water feeding areas around shorelines increasing suitability for waders and dabbling ducks. Spread of riparian vegetation such as Typha and sedges onto the newly exposed wetland bed. Increase in surface water salinity due to evaporation. Red gum and sedge recruitment in moist riparian areas.	382 ML inflow to replace evaporation
	J		Disconnection from river			
	F		Reduced evaporation losses			
	M		Estimated inflow to maintain level at 9.1m AHD is 382 ML			
	A					
	M					
	J					
	J					
	A	1 August – commence controlled refill of wetland to pool level, and hold it there for at least 4 months. Estimated that wetland refills in 1 month at 2.5 cm per day.	2-3 cm/day rise	1 August 2012 – North lagoon regulators (earthen bank and Middle creek) opened with boards in place to regulate refill rate. Causeway regulators fully open.	Increased riparian cover provides spring breeding habitats for waterfowl, frogs, reptiles. Refilling coinciding with natural spring flood events likely to stimulate significant breeding in waterbirds, frogs, reptiles, native fish and yabbies. Initial dilution of surface water salinity as wetland fills with river water. Minor increase in wetland salinity due to high evaporation rates in summer. Discharge salt load to river with small increase in river salinity due to river dilution effect. Recharge groundwater with freshwater. Reduce groundwater salinity and increase groundwater level. Significant reduction in wetland turbidity after 4 months, significantly increasing submergent aquatic vegetation. Native fish passage between river and wetland. Emergent aquatic plant growth in refilled areas provide habitat for small native fish.	Refill volume 1859 ML 1238 ML inflow to replace evaporation
	S		Refill volume – fill plus infiltration in August = 1859 ML			
	O		Evaporation loss in August = 80 ML			
	N		Evaporation loss September to end November 1158 ML			
	D	Water manipulations hereafter determined as part of review				

Note – all volumes and timing of actions adapted from information contained in Gippell 2007.

Table 10: Additional hydrological management objectives and aims and their associated actions

Specific management objectives	Management aims	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Improve flushing flows, fish passage and carp control	To improve water quality in Yatco Lagoon. To increase native fish populations and reduce carp populations (see Table 12 also).	Install an additional two native-fish friendly regulators in the earthen bank on the North Lagoon. Use latest best practice guidelines to enhance native fish passage (see Stuart, 2009) and incorporate carp control measures. Retro-fit existing regulator to improve carp control and native fish passage. See Table 12 also.	H	As soon as resources can be allocated. NRM Board and LAP.	Once installed, a suitable monitoring regime for these structures will need to be developed and implemented.	Unknown.
		Replace the pipe outlets and regulators on the Middle Creek connection to the North Lagoon, and in the causeway connecting the Lagoons, to make them native-fish friendly. See above re using latest best practice guidelines.	H	As soon as resources can be allocated. NRM Board and LAP.	Once installed, a suitable monitoring regime for these structures will need to be developed and implemented.	Unknown.
		Maintain flow paths along Middle Creek by regular control of aquatic vegetation.	H	As required. YWLG.	Establish and maintain regular monitoring of the fish communities along Middle Creek, if resources allow.	Control measures likely to be done by volunteers and/or landholders. SA MDB NRM Board guidance and support monitoring.
To improve understanding of salinisation risks and groundwater	To be able to detect with greater precision the 'behaviour' of the groundwater under and surrounding the site, and how it responds to drying and re-filling events.	Install additional bores and piezometers in strategic locations to allow closer monitoring of the groundwater and freshwater lens under and around the site.	H	ASAP, NRM Board and LAP	Once installed, a suitable monitoring regime to be developed and implemented.	Unknown.

5.2 Feral pests, weeds and fire management

Introduction and rationale:

Some **introduced weed species** can out-compete native species, seeing them eventually dominate the vegetation communities of the wetland. Depending on the species the results of this can be minor, ranging through to devastating for some aquatic weed species. Over time, if left unmanaged, weed species can alter habitats making them less suitable for wildlife.

The Baseline Survey (SKM, 2005) recorded 11 exotic plant species on the site as follows (see section 2.6.1). For scientific names see Appendix G.

- Bearded oat
- Flax-leaf fleabane
- Couch grass
- False caper
- Smooth heliotrope
- Wild lettuce
- Common iceplant
- Scotch thistle
- Annual Beard-grass
- Yellow marsh-cress
- Weeping willow

In addition, advice has been provided (Nikolai, *pers comm.* 2008) that the weed species Spiny rush (*Juncus acutus*) is found at Yatco Lagoon.

Land-based feral animals and domestic pets can also impact on the wetland, on native fauna in particular. Ground-dwelling birds or those that forage or breed in low vegetation, turtles, frogs and small native mammals are those that suffer most from these introduced predators. At Yatco Lagoon it is assumed there are foxes, as well as feral and domestic cats and dogs.

Another land-based feral species impacting on the wetland ecosystem are rabbits. In large numbers they have a major impact on native vegetation, particularly on regenerating native grasses on the floodplain and around the wetland. They can also exacerbate soil erosion and this may result in elevated soil-loads in run-off, and turbidity in the water of the wetland. Grazing stock can also have similar impacts if not managed sympathetically to the wetland environment, especially the wetland fringes (see section 5.4).

Yatco Lagoon also has four **introduced, non-native fish species**; carp, goldfish, redfin and Mosquito fish (or *Gambusia*). Carp (in high densities) are well known for the damage they do to wetland habitats; stirring up bottom sediments and removing aquatic plants most notably. Redfin are considered an aggressive predator of all other species. The impacts of goldfish in the wild are not well known, although they don't accumulate in large numbers. *Gambusia* interrupt the breeding of native fish species and breed rapidly themselves, competing with native species. They also feed on tadpoles and frogs eggs, deplete dragonfly larva populations, and are attributed to the decline of a number of native frog and fish species.

Fire poses a risk to most places across the Australian landscape, especially in times of drought, and Yatco Lagoon is no different. Having procedures in place to combat any bushfire outbreak is an important element of site planning.

Threats and their priority ranking:

In the risk assessment and threat ranking in section 4 (see Tables 7 and 8), these various introduced species (and fire) were rated as follows in terms of the relative threats they pose: from highest priority to lowest for management attention (1) introduced fish species and (2) weed encroachment, followed by (3) foxes, (also 3) feral/domestic cats and dogs, (also 3) rabbits and then (4) fire.

Table 11: Management objectives and aims and their associated actions - Feral pests, weeds and fire management

Specific management objectives	Management aims	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Control introduced fish species, with reducing carp numbers in Yatco a priority	<p>Gradually reduce the carp population within Yatco Lagoon, as evidenced by reduced numbers observed through on-going surveys, during each successive drying phase and improved water quality (turbidity especially) in the wetland.</p> <p>To keep other introduced fish species at no worse than current levels based on on-going results.</p>	<p>Use water level variations (drying events) and carp screens on regulators (see section 5.1) to reduce adult carp numbers in Yatco Lagoon.</p> <p>If feasible, undertake 'carp buster' events targeting areas of high carp aggregation.</p> <p>For others species, water level variations may disadvantage certain of them, but control opportunities are limited</p>	H	<p>See Hydrological Management Plan (section 5.1), in conjunction with carp screens on regulators.</p> <p>'Carp buster' events, in conjunction with commercial anglers at key times.</p> <p>Responsibilities sit primarily with YWLG</p>	Record mortalities of carp with each drying event to detect (hoped for) declines in population	<p>Carp screens = cost estimate required for each regulator.</p> <p>Monitoring cost = \$0/year (volunteers to assist).</p> <p>SA MDB NRM Board guidance and support</p>
Control, and if feasible, eradicate, weed species from the management area	Systematically remove and then control re-infestations of weed species across the site, starting with those of greatest threat to biodiversity and habitats.	<p>Map the occurrences of all weed species within the Yatco Lagoon management plan area and prioritise for attention.</p> <p>In conjunction with NRM Board and LAP activities and pest plant and animal control officers, remove weed infestations using physical techniques, appropriate chemicals etc, giving first priority to Scotch thistle and Spiny rush.</p> <p>Monitor re-growth, new outbreaks etc</p>	H	Ongoing YWLG with NRM Board, LAP and pest plant and animal control officers, landholders, volunteers	Twice yearly surveys to update records (or GIS – see section 7.1), or opportunistic records.	<p>Initial survey costs.</p> <p>Followup control measures = to be determined once extent of weed problem documented</p> <p>Monitoring cost = \$0/year (volunteers to assist).</p> <p>SA MDB NRM Board guidance and support</p>

Reduce the abundances of foxes, feral cats and dogs and domestic cats and dogs, and keep them as low as possible.	<p>Keep fox, feral cat and dog populations as low as possible across the site.</p> <p>Minimise predation of wildlife on the site by domestic cats and dogs</p>	<p>Document known dens, localities of regular sightings, signs of fox, feral a d dog presence such as dead turtles etc.</p> <p>In conjunction with the relevant Animal and Plant Control Board, undertake control measures such as baiting, spot-lighting etc.</p> <p>If required, undertake community awareness raising about the impacts of uncontrolled domestic cats and dogs on the wetland fauna with the Moorook community and neighbouring landholders.</p> <p>Monitor occurrences of foxes and respond as necessary</p>	M	Ongoing YWLG with NRM Board, LAP and pest plant and animal control officers, landholders, volunteers	Opportunistic records submitted to YWLG, or spot-light surveys	<p>Control measures likely to be done by volunteers.</p> <p>Monitoring cost = \$0. (volunteers to assist).</p>
Reduce rabbit abundance and keep it as low as possible	Gradually reduce the rabbit population surrounding Yatco Lagoon, as evidenced by reduced numbers observed, reduced burrow activity etc.	<p>Document known burrows and regular sightings of rabbits, signs of rabbit presence etc.</p> <p>In conjunction with the relevant Animal and Plant Control Board, undertake control measures such as burrow ripping, trapping, baiting, spot-lighting etc.</p> <p>Monitor occurrences of rabbits and respond as necessary</p>	M	Ongoing YWLG with NRM Board, LAP and pest plant and animal control officers, landholders, volunteers	Opportunistic records submitted to YWLG. Surveys of areas with known high densities to locate new burrows for attention.	<p>Control measures likely to be done by volunteers.</p> <p>Monitoring cost = \$0. volunteers to assist).</p>

Be well placed to respond to bushfire threats to the site	<p>Fire control plan in place and necessary preparations taken to implement it if necessary.</p> <p>Pre-emptive measures to reduce fire risk is indicated.</p>	<p>In conjunction with relevant local and regional fire control officers, develop a fire control plan.</p> <p>Review plan on a regular basis, and especially if the rejuvenation of the wetland ecosystem increased fire fuel loads around the wetland.</p> <p>Maintain access tracks for rapid response.</p>	L	Ongoing YWLG with local and regional fire control officers NRM Board, LAP and landholders, volunteers	Monitoring of fuel loads undertaken as part of vegetation monitoring – see section 5.3	Monitoring cost = \$0.
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5.3 Biodiversity conservation and habitat restoration

Introduction and rationale:

The primary driver for introducing water level variations to Yatco Lagoon is to see the health of the system restored to what it once was (see Vision in section 1.3). The symptoms of declining health in the system are the deaths of fringing tree species, the bare, open areas along some parts of bank where fringing vegetation was once present, and relatively low densities and patchy distribution of submerged and emergent aquatic plant species normally associated with systems like this. The decline in these vegetation communities is a fore-runner to reduced numbers and diversity of animal species.

While it is expected that varying water levels will see almost immediate improvements to the vegetation communities, this in turn encouraging the return of some fauna, it is important to note that managing feral species (weeds and animals – see section 5.2) needs to go hand-in-hand with the measures outlined below for encouraging a biodiversity ‘fight back’ at Yatco lagoon.

Equally, systems like Yatco once experienced regular, medium-sized floods and occasional large floods. With water diversions up-stream and drought, these have not been enjoyed by Yatco for many years, and the symptoms of this lack of flooding are very clear, especially among the River Red Gums on this floodplain. While this plan cannot address this lack of regular flooding it is hoped that additional water can be returned to the river in the near future to enhance the chances of such flood events becoming more frequent again. While it may not be feasible, consideration should be given to whether or not it is possible through weir pool manipulations at Lock 3 to ‘manufacture’ increased inundation of Yatco Lagoon in the future.

Notable among the species known to occur at Yatco Lagoon (as recorded by the Baseline Survey, SKM, 2005) are the following (see sections 2.6.3-5):

- ❖ Southern Bell Frog (listed as vulnerable nationally)
- ❖ Three native fish, Unspecked hardyhead, Dwarf-flathead gudgeon and Murray rainbowfish (all proposed for listing as ‘threatened’ (rare) under the revised *National Parks and Wildlife Act 1972*)
- ❖ Freckled duck, Australian darter and Intermediate egret (all listed as vulnerable in South Australia)
- ❖ Australasian shoveler and Peregrine falcon (both listed as rare in South Australia)
- ❖ Thirteen migratory bird species (listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, because they are listed under Australia’s bilateral migratory bird agreements with Japan and China).

It seems likely that more detailed surveys will reveal more ‘species of interest’ and also clarify whether or not the above records represent truly significant sightings or one-off opportunistic occurrences.

Threats and their priority ranking:

In the risk assessment and threat ranking in section 4, these various biodiversity conservation-related issues rated as medium to high (see Tables 7 and 8), relatively, in the threat prioritisation. Ranking of the relative threats faced by biodiversity was as follows from greatest to least concern: (1) Continuing declines in health and death of floodplain trees, Red gums and River box, especially (1 also) Continuing loss of fringing vegetation – no regeneration or recruitment of new fringing vegetation, and (1 also) Loss of species diversity, especially plants, fish, frogs etc.

Table 12: Management objectives and aims and their associated actions - Biodiversity conservation and habitat restoration

Specific management objectives	Management aims	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Pursue opportunities to increase inundations of Yatco Lagoon to benefit biodiversity and overall wetland health	To achieve increased frequency of 'manufactured' flood events at Yatco Lagoon through weir level manipulations.	Investigate the feasibility of whether or not it is possible through weir pool manipulations at Lock 3 to 'manufacture' increased inundation of Yatco Lagoon's floodplain	H	As soon as feasible. YWLG with the SA MDB NRM Board and LAP	Report back on findings.	Unknown at present.
Maintain and restore River red gum and Black box tree communities	<p>Observe no decline in tree health scores at the established monitoring sites (see section 6) over the next 3 years.</p> <p>Record the establishment of River red gum recruits in at least 5 locations around the wetland over the next 3 years (and beyond).</p>	<p>Implement Hydrological Operational Plan.</p> <p>See above re 'manufactured' floods.</p> <p>Identify areas where, through weed species, rabbit impacts, stock impacts, salt scalding etc, native vegetation has been lost or greatly reduced, and undertake suitable restorative actions (plantings, exclusion fencing etc.)</p> <p>Monitor the condition of older, established trees and recruitment of new trees across the floodplain.</p>	H	<p>YWLG with experts as necessary and local community</p> <p>SA MDB NRM Board</p>	Photopoint and transect monitoring to show trends and 'before' and 'after' at each site.	Photopoint and transect monitoring is low cost.
Maintain and restore understorey riparian vegetation	Observe an increase in the diversity and extent of emergent plants around the fringes of the wetland over the next 3 years (and beyond).	<p>Implement Hydrological Operational Plan.</p> <p>See above re 'manufactured' floods.</p> <p>Identify areas where, through weed species, rabbit impacts, stock impacts, salt scoulding etc, riparian vegetation has been lost or greatly reduced, and undertake suitable restorative actions (plantings,</p>	H	<p>YWLG with experts as necessary and local community</p> <p>SA MDB NRM Board</p>	Photopoint and transect monitoring to show trends and 'before' and 'after' at each site.	Photopoint and transect monitoring is low cost.

		exclusion fencing etc.) Monitor the condition and extent of riparian vegetation.				
Monitor, and if necessary, control invasion of the wetland bed by fringing vegetation such as <i>Typha</i> or <i>Phragmites</i>	Avoid large scale invasion of the wetland bed by fringing vegetation such as <i>Typha</i> or <i>Phragmites</i>	Monitor the distribution of these species over the next three years to establish if the variable water regime is encouraging wetland bed invasion. If required, undertake physical control works to limit extent.	L	Ongoing. YWLG with experts as necessary and local community SA MDB NRM Board	To be done as part of transect monitoring – see above and Section 6.	Transect monitoring is low cost.
Gain a comprehensive understanding of the plant and animal biota of the site including other threatened species which may occur there, and, as necessary, modify management approaches to suit.	Comprehensive documentation of the biodiversity of the site in hand, and being maintained through regular monitoring and surveys.	Assemble existing survey data (possibly in simple database and GIS – see section 6.1) and through expert (if necessary) and community input, continue to add to this resource information through survey and monitoring. If indicated by surveys, introduce to this plan appropriate management actions designed to benefit 'species of interest'.	M	Ongoing. YWLG with experts as necessary and local community SA MDB NRM Board	Regular (half yearly) updates of 'what's known'	See section 6. Part of this comes from the ongoing monitoring work.
Support national measures to protect the vulnerable Southern Bell Frog, and seek to maintain and further diversify the frog population at the site.	Protect, and where feasible enhance, important habitat areas for Southern Bell Frogs. Within the scope of this plan, ensure the population of Southern Bell Frogs continues at the site. Maintain populations of the other four recorded frog species (see section 2.6.3), and seek to increase their abundances.	Participate in national recovery effort for Southern Bell Frog. Identify the key habitats of Southern Bell Frogs, and other frog species, around Yatco Lagoon, and as necessary introduce intensive management or protection of these areas. Monitor these sites during lagoon drying events (at least initially) to establish the impact this has on the species at these sites.	M	YWLG with experts as necessary and local community. SA MDB NRM Board	Regular surveys, coinciding with rain events, breeding season and wetland drying times	Unknown at present. Likely to include survey time and some habitat management. Part of this comes from the ongoing monitoring work.
Encourage native vegetation to grow in areas affected by salt	Re-vegetation of three salt-affected areas over the next three years.	Remove vehicle access from three areas affected by salt and undertake re-vegetation works.	M	YWLG with experts as necessary and local community	Photopoint and transect monitoring to	Photopoint and transect monitoring is low cost.

build-up					show trends and 'before' and 'after' at each site.	
Maintain the native fish populations within the system, and, where feasible seek to increase these.	Maintain populations of eight native fish species (see section 2.6.4), and seek to increase their abundances.	Implement Hydrological Operational Plan. Implement key recommendations in the Stuart 2009 report relating to improving native fish passage – avoid scouring and perched culverts, provide plunge pool environments etc. In conjunction with on-going government-funded programs, monitor native fish populations at key locations around the lagoons.	M	YWLG with experts as necessary and local community. SA MDB NRM Board	Fyke, dip, seine net and shrimp traps used during regular surveys.	To be done in collaboration with relevant government programs.
Maintain wetland bird populations within the system, and, where feasible, seek to increase and diversify these.	Maintain the abundance and diversity of wetland bird species, and seek to increase both over time. For the next 3 years the aim is to record at least 25 species annually, with total numbers of individuals recorded exceeding 3,000 for any one monitoring event per year.	Implement Hydrological Operational Plan. Establish a 'bird list' for Yatco Wetland and undertake routine surveys to establish habitat preferences, breeding areas etc. Where possible, enhance habitat and breeding area availability through management interventions, such as vegetation restoration, control of feral predators, restrictions to stock grazing etc	M	YWLG with experts as necessary and local community. SA MDB NRM Board	Regular transect surveys of key areas.	Expected to be undertaken by volunteers.
Maintain reptile and turtle populations in and around Yatco Lagoon.	Establish details of the reptile and turtle populations and then seek to retain or enhance these populations.	Through opportunistic sightings, build a better understanding of these species in and around the lagoons. Control of feral pests and domestic animals will assist these efforts (see section 5.2).	L	YWLG with experts as necessary and local community	Opportunistic recording of sighting, including mortalities of turtles (possibly due to feral predators), road kills etc	Expected to be undertaken by volunteers.
Maintain macroinvertebrate	Establish details of the macroinvertebrate	Implement Hydrological Operational Plan.	L	YWLG with experts as necessary and local	Dip net sampling at several	Expected to be undertaken by

communities within Yatco Lagoon.	communities and then seek to retain or enhance these populations.	Undertake regular sampling of macroinvertebrates at a range of locations – in conjunction with water quality monitoring, to track seasonal changes in these, and how they are impacted by varying water levels.		community. SA MDB NRM Board	locations, conducted across the seasons.	volunteers.
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5.4 Other human uses in and around the wetland

Introduction and rationale:

In order to allow for the introduction of water level variations at Yatco Lagoon it is intended to provide an alternative, piped, water supply arrangement for eleven irrigators on the Yatco channel and a small number of domestic consumers. This decouples the management of the water regime in the wetland from these water supply requirements. The significant other product from these re-arrangements is the water savings (for the benefit of the River Murray's health) that come from reduced evaporative losses across the wetland during its dry times, and in the former open irrigation channel (see section 5.1).

Other notable human uses associated with Yatco Lagoon are the township of Moorook itself, irrigated and other agriculture on the lands surrounding the wetland, grazing of stock on the floodplain lying between the wetland and the River Murray and tourist cabins on properties overlooking the South lagoon.

It is important to note that in relation to these activities on the surrounding areas, the Pyap to Kingston Land and Water Management Plan addresses the priority issues, and has been developed as a complimentary companion to this plan.

Threats and their priority ranking:

In the risk assessment and threat ranking in section 4, these various human uses in and around the wetland were assessed and then ranked through a threat prioritisation process.

Relative to other risks and threats, those associated with other human uses were rated as medium to high (see Tables 7 and 8). Ranking of these relative threats was as follows: (1) impact of livestock grazing on fringing vegetation and mudflats followed by (2) impact from nearby developments.

Table 13: Management objectives and aims and their associated actions - Other human uses in and around the wetland

Specific management objectives	Management aims	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Minimise impacts from surrounding land-uses on Yatco Lagoon	Ensure any threats to the health of the wetland are mitigated or minimized either through the implementation of this plan, implementation of the Pyap to Kingston Land and Water Management Plan, or contact with those responsible for the threat.	Work to see the Pyap to Kingston Land and Water Management Plan implemented hand-in-hand with this plan to ensure any threats (real or potential) to the health of the wetland are mitigated or minimised. Of particular interest are those measures, current and future, that will address rising groundwater, and the risk this poses to the wetland during drying phases (see section 5.1)	H	Ongoing. YWLG with NRM Board and LAP, landholders, Moorook community	Reporting under the Land and Water Management Plan will assist here. Monitoring of groundwater is vital, especially in the first years of wetting and drying (section 6.2)	Unknown at present.
Minimise impacts from grazing on the adjoining floodplain on fringing vegetation, exposed mudflats areas etc	<p>Fence stock away from fringing vegetation areas of greatest importance to wildlife and wetland health (once the latter are established).</p> <p>Restrict access by stock to the wetland during drying phases.</p> <p>Maintain stocking rates that keep good ground cover across floodplain.</p> <p>If required, provide alternative water supplies away from the wetland etc.</p>	<p>Seek funding to then work with and assist the landholder(s) to fence stock away from priority (for wildlife in particular) fringing vegetation.</p> <p>Control other times and places of stock access to riparian areas, especially during drying phases.</p> <p>Continue to manage sustainable stocking rates.</p> <p>If required, provide alternative water supplies away from the wetland etc.</p>	M	Review before the end of 2009. If necessary, seek resources to take appropriate actions. YWLG with the landholder(s) in question.	Ongoing monitoring once measures out in place to ensure stock restrictions are working. Plus quadrat vegetation and photopoint sampling of areas where stock have been excluded.	To be advised. May require some fencing or provision of water supplies away from the wetland.
Minimise impacts from tourism cabins.	Ensure cabins are not providing any form of pollution (waste water for example) into the wetland that could elevate nutrient levels and cause eutrophication, algal blooms etc.	<p>Undertake review of how waste water, litter and other by-products are managed, and, if required introduce reforms to reduce impacts on the wetland.</p> <p>Provide awareness raising information</p>	L	Review before the end of 2009. If necessary, seek resources to take appropriate actions. YWLG with the landholders in question.	Ongoing monitoring to ensure cabins not having any negative impacts on the wetland, including water	Expected to be done by volunteers as part of regular water quality monitoring.

		to those using the cabins, explaining the values of the wetlands that the plan is trying to restore, and seeking their cooperation to avoid impacts.			quality monitoring in wetland zones close to cabins.	
Management of litter or vandalism of eco-tourism infrastructure	Ensure litter is kept to a minimum and any acts of vandalism are dealt with appropriately.	As required undertake clean-up days to remove litter. Repair any damage caused by acts of vandalism.	M	On-going.	Opportunistic observations.	Clean-ups or repairs expected to be done by the YWLG and community.
See also control the abundance of domestic cats and dogs in section 5.2						

5.5 Protecting social and cultural values

Introduction and rationale:

The move to re-introduce water level variations to Yatco Lagoon does carry with it some risks, as set out in section 4 of this plan. Among them are the risks of odour, mosquitoes and midges as a by-product of the drying events. Naturally, the community of Moorook, and adjoining landholders of the wetland have expressed concern about this possibility and that it will be of nuisance value if it occurs.

Equally, drying out a system that has been permanently wet for more than a generation, will also change the visual amenity of many who currently overlook, or pass by the wetland. This loss of aesthetics however, is essentially part of the trade-off made to improve the health of the system, create water savings for helping the recovery of the River Murray, and providing irrigators and domestic users with more permanent, and better quality water sourced from the river.

Also, as noted in section 5.1's Hydrological Operational Plan, the incremental approach to the initial drying events in years 1 and 2 is used, this will allow for an assessment of whether or not odour, mosquitoes and midges are an ancillary problem to be dealt with, or not a problem at all.

Related to these same issues is the potential loss of income for the tourism operators near the wetland due to the change in hydrology (see section 5.4). However, this will hopefully be offset in future years, as a revitalised wetland brings more people to Moorook, and the cabins, than occurs at present. Promoting this initiative is an important part of seeing attitudes change and people adjusting their perspectives to understand and appreciate that wetlands like Yatco are healthier, and more aesthetically pleasing as a result of re-introducing drying phases.

Section 2.7.5 described the Indigenous and early European cultural 'assets' of the area, and it is intended that the YWLG work with the Riverland Aboriginal community to ensure places, or artifacts important to them in the area surrounding Yatco, and on the exposed wetland bed, are given appropriate recognition and protection.

As discussed in section 2.7.5, the Moorook area, and in particular Yatco Lagoon, has played a significant role in both Indigenous and early European history. This history is evident throughout the landscape from the numerous scar trees, middens and aboriginal artifacts to the historical linkages with current irrigation practices.

Local Aborigines still have a very close connection with the landscape both physically and spiritually. Although this connection has been disturbed through settlement, Aboriginal people continue to pass down the stories and practices of generations. There is an eagerness to work in partnership with the broader community at sites like Yatco Lagoon to 'care for country'.

In the context of this section, it is also important to recall those management objectives given in section 1 of this plan, relating to social and culture considerations. These are as follows:

Recreational Objectives

7) Improve the aesthetic value of the area to encourage the use of Yatco lagoon for sustainable recreation activities by the local community and visitors.

8) Improve the recreational facilities at Yatco Lagoon, including the possible development of information boards, a viewing area, walking trail, bike trail and bird hides.

Community Involvement Objectives

9) Maintain and improve on the community capacity to manage the wetland.

10) Improve education and communication with local schools and the community about the management and importance of River Murray wetlands, including Yatco Lagoon.

Threats and their priority ranking:

In the risk assessment and threat ranking in section 4, the various social and cultural values of Yatco Lagoon were rated (see Tables 7 and 8), relatively.

Ranking of these relative threats was as follows from greatest to least concern:

(1) loss of recreational uses, (1 also) loss of aesthetics, followed by (2) loss of places of Indigenous and early European cultural value. These concerns are clearly also partly related to the issues of possible odour during drying phases and increased abundance of mosquitoes and midges (see section 5.1)

Table 14: Management objectives, aims and their associated actions – Protecting social and cultural values

Specific management objectives	Management aims	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Manage water level manipulations for the wetland to minimise odours, mosquitoes and midge 'plagues'	Avoid any problems and complaints about odours, mosquitoes and midge 'plagues' through carefully planned water level manipulations (see section 5.1).	See section 5.1's Hydrological Operational Plan. Should these problems occur, there are control options available.	H	Ongoing. YWLG with assistance from LAP and SA MDB NRM Board in relation to water management and monitoring.	If mosquitoes and midges become a problem, consideration could be given the some form of standardized monitoring program to document the extent and severity of the problem.	Unknown if this will be necessary at this time
Improve the recreational facilities and raise awareness of Yatco Lagoon's new found vitality	Install a walking and/or bike trail with viewing areas, bird hides, and environmental and cultural heritage interpretive boards. Develop a web site for this initiative, plus other awareness raising materials and publications for distribution.	Seek funding assistance or sponsorships to develop a range of awareness raising and promotional products, such as, information boards, a viewing area, walking trail, bike trail and bird hides. If resources secured, proceed to undertake works.	M	Ongoing YWLG with local businesses, landholders, volunteers etc	Regular reports back on the installation of new infrastructure. Surveys of visitor usage and attitudes, as appropriate.	Expected to be done by volunteers.
Seek to engage local people and schools to become 'Yatco-carers', involved with implementing this plan where able, and with regular monitoring of wildlife, water quality etc	To have regular involvement in monitoring and other hands-on activities by local stakeholders, and schools.	Identify a range of activities from within this plan that locals and nearby schools could undertake or assist with, such as monitoring through the Waterwatch program, and foster these involvements.	M	Ongoing YWLG with local businesses, landholders, schools, volunteers etc	Document time and effort contributed by locals with implementing the plan, plus the involvement of those helping the monitoring effort..	May be some costs associated with the monitoring effort in terms of equipment etc.

Work with the Riverland Aboriginal community to see significant places and artifacts recognised and protected	<p>Identify places and artifacts of cultural significance, and work to have these recognised and protected.</p> <p>Undertake a range of activities to raise awareness of the Indigenous cultural values of the site, and how the Aboriginal community 'read the land' and used its resources.</p>	<p>Identify places and artifacts of cultural significance, and then work to have these recognised and protected.</p> <p>Raise awareness of the Indigenous cultural values of the site through the activities under the above two management objectives.</p>	M	Ongoing YWLG with the Riverland Aboriginal community	Regular reports back to the YWLG	Unknown at present.
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6. Monitoring, evaluation, review and reporting procedures

6.1 Collection and maintenance of adaptive management data

In order to guide management decision-making and the ongoing monitoring specified in the preceding section, it is desirable (resources permitting) to draw together into one database and Geographic Information System (GIS) the various existing baseline datasets and those that will be gathered through ongoing monitoring or other surveys and research at the site. Table 15 summarises the proposed actions.

Table 15: Management objectives and targets and their associated actions - Collection and maintenance of adaptive management data

Specific management objectives or targets:	Actions	Priority (H,M or L)	Timelines and responsibilities	Monitoring	Resources needed
Maintain monitoring data and provide regular feedback to help guide adaptive management.	House on-going monitoring data and provide regular feedback to YWLG.	H	SA MDB NRM Board supports key monitoring. Additional monitoring may be undertaken by the YWLG members and arrangements will be needed to store this data also.	Update on progress at regular meeting of Yatco Wetlands Landcare Group (YWLG).	\$10,000 approx.
Establish GIS system for the Yatco Lagoon (resources permitting).	Review GIS data holdings held by other sources, and seek access to, or rights to use these for Yatco Lagoon.	L	As above.	Landcare Group to monitor progress against specified milestones.	\$10,000 approx.
Develop reporting and feedback proforma.	Based on the monitoring elements presented in section 5 develop a simple feedback/reporting proforma to allow the Yatco Wetlands Landcare Group to keep landholders, community members, the LAP, SA MDB NRM Board, State Government Departments etc, informed of progress with implementing the management plan at regular intervals.	M	GIS layers assembled by end of 2008, or sooner if resources and expertise available.	Landcare Group monitor progress against specified milestones.	\$15,000 approx.

6.2 Monitoring and evaluation

Table 16: Summarised monitoring framework for this management plan

Monitoring Activity	Technique	Time required	Month												Priority	Responsibility/Coordination
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hydrological Operational Plan (Section 5.1)	Surface water	Water quality sampling (salinity, turbidity, temperature) ^			✓			✓			✓			✓	H	Yatco Wetland Landcare Group (YWLG) with SA MDB NRM Board
		Water levels	On-going												H	YWLG
	Groundwater	Water quality sampling (salinity, temperature) ^			✓			✓			✓			✓	H	YWLG with SA MDB NRM Board
		Depth ^			✓			✓			✓			✓	H	YWLG with SA MDB NRM Board
		Assessment of freshwater lense			✓			✓			✓			✓	H	YWLG with SA MDB NRM Board
Feral pests, weeds and fire (Section 5.2)	Infrastructure management	Record all management actions taken (date, time, conditions, reasons for action etc)	As appropriate												H	YWLG with SA MDB NRM Board
	Weeds	Mapping and monitoring of weed species	✓									✓			M	SA MDB NRM Board
	Carp	Record details of carp strandings, deaths during dry down events (including photographs)	✓											✓	M	YWLG with SA MDB NRM Board
	Foxes, feral cats and dogs	Foxes, feral cats and dogs - opportunistic sightings or spot light surveys	As appropriate												L	YWLG
	Rabbits	Rabbits - opportunistic sightings or surveys of known high density areas	As appropriate												L	YWLG
Biodiversity conservation & habitat restoration	Fire	Bushfire fuel loads – done with vegetation surveys										✓			L	SA MDB NRM Board
	Vegetation	Photopoint assessments			✓			✓			✓			✓	M	YWLG with SA MDB NRM Board
		Quadrat based surveys & line intercept method													M	SA MDB NRM Board
		Visual health assessment of long lived vegetation (e.g. Red gums)			✓			✓			✓			✓	M	YWLG with SA MDB NRM Board
	Birds	Fixed area surveys										✓			M	YWLG with SA MDB NRM Board
		Transect walk surveys										✓			M	YWLG with SA MDB NRM Board

		Bird breeding sites	4 hours		✓							✓			M	SA MDB NRM Board
	Native fish	Fyke, dip, seine net and shrimp traps	2 days *	✓											L	YWLG with SA MDB NRM Board
	Frogs	Surveys using call identification-recordings, coinciding with rain events, breeding season and dry down times	4 hours *								✓			✓	M	YWLG with SA MDB NRM Board
	Turtles and reptiles	Recording (where and when) of opportunistic sightings of live or dead specimens	-	As appropriate											L	YWLG
	Macro-invertebrates	Dip net sampling	2 days *												M	YWLG
Other human uses in & around the wetland (Section 5.4)	Grazing	Monitoring of impacts from stock removal from key areas. Quadrat sampling of vegetation, plus photopoints.	1 day *	✓		✓		✓		✓		✓		✓	M	YWLG with SA MDB NRM Board
	Run-off etc from tourist cabins	Water quality monitoring of nearby wetland areas – see Surface water above.	-			✓			✓			✓		✓	L	YWLG & SA MDB NRM Board
	Domestic cats and dogs	See under feral cats and dogs above.	-	As appropriate											-	YWLG
	Litter and vandalism of signage and infrastructure	Opportunistic monitoring of litter requiring clean-up, and any future vandalism of eco-tourist infrastructure	-	As appropriate											L	YWLG
Protecting social and cultural values (Section 5.5)	Mosquitoes and midge	If necessary institute monitoring of extent and severity of problem	6 hours	✓	✓	✓	✓								L	YWLG
	Visitors to Moorook	Visitor surveys to document return for investment on changes to wetland and promotional activities, infrastructure etc. Best done as 'before and after' surveys.	2 days	On-going											M	YWLG
	Involvement of locals	Document time and effort contributed by locals with implementing the plan, plus the involvement of those helping the monitoring effort.	2 days	On-going											H	YWLG

Collection and maintenance of management data (Sections 6.1, 6.3 & 6.4)	Data management	Update and file all data – copies maintained at different locations	6 days *	On-going	H	SA MDB NRM Board
	Analysis of data	Analyse biological and water quality data to provide feedback to YWLG, adaptive management etc	6 days *	On-going	H	SA MDB NRM Board
	Log book	Maintain monitoring log book	2 days	On-going	H	SA MDB NRM Board
	Reviewing plan	Review Wetting and Drying Operational Plan	1 day *	As required – minimum of annually	H	SA MDB NRM Board
	Reporting	Report to NRM Board and DWLBC of any changes proposed for Wetting and Drying Operational Plan and management plan	2 hours *	As required – minimum of annually	H	SA MDB NRM Board

* = more than one person required for this activity

^ = increased frequency of monitoring recommended during drying and refilling times.

Monitoring activities already underway at Yatco Wetland

With the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board, monitoring of some priority elements set out above began in mid 2007. The plates following show the locations where these monitoring efforts have been commenced.

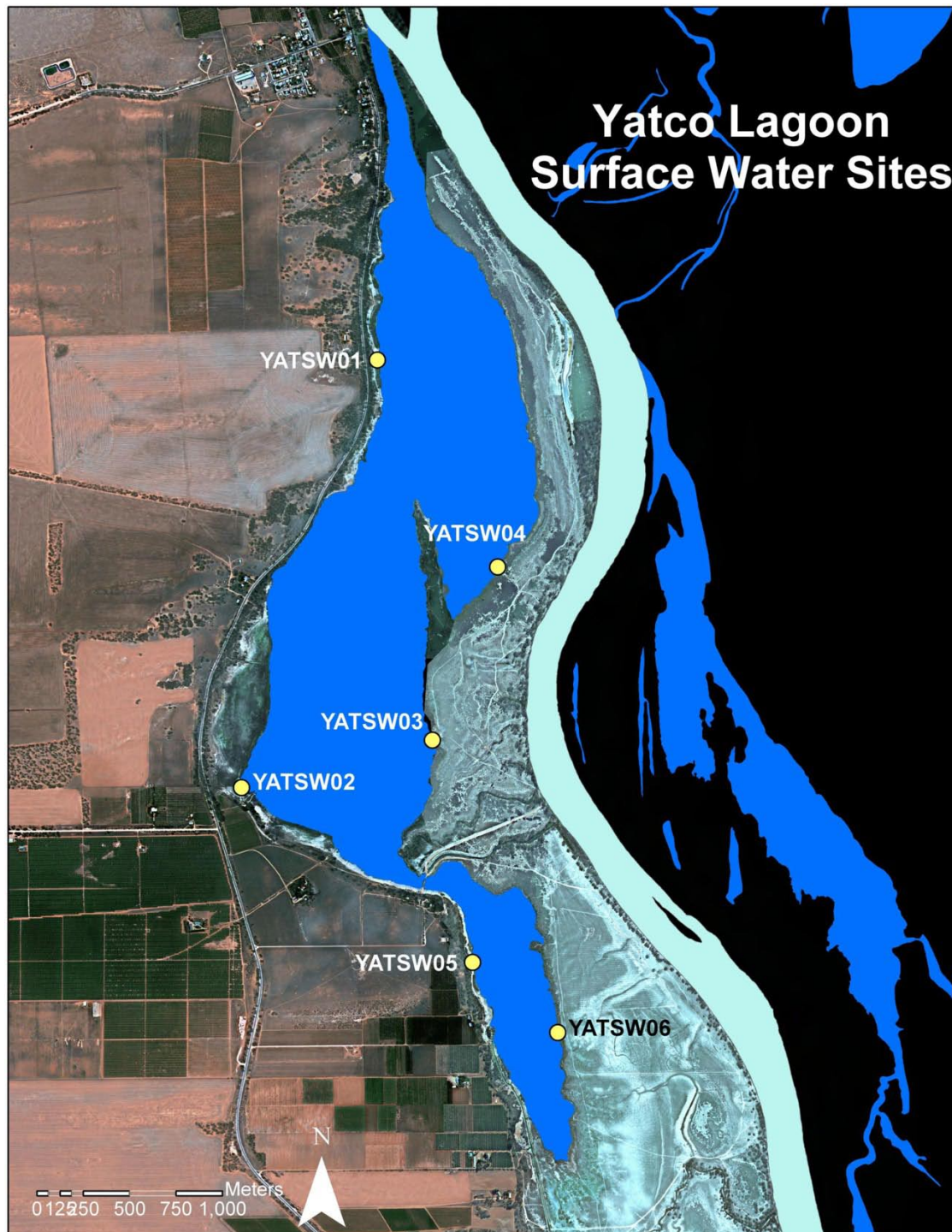


Plate 22: Locations of surface water sampling sites (July 2007). Provided by Callie Nickolai, SA M-DB NRM Board.

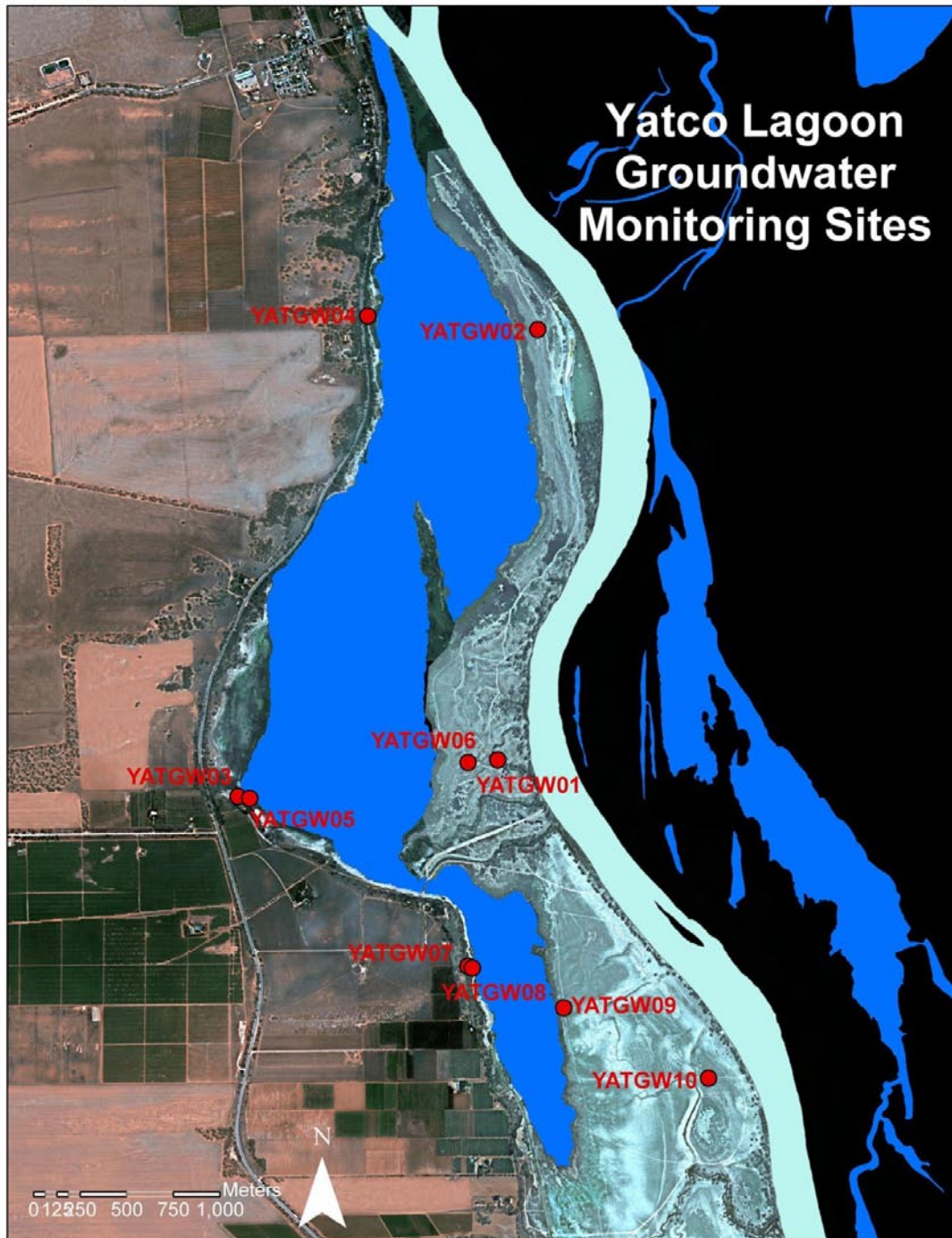
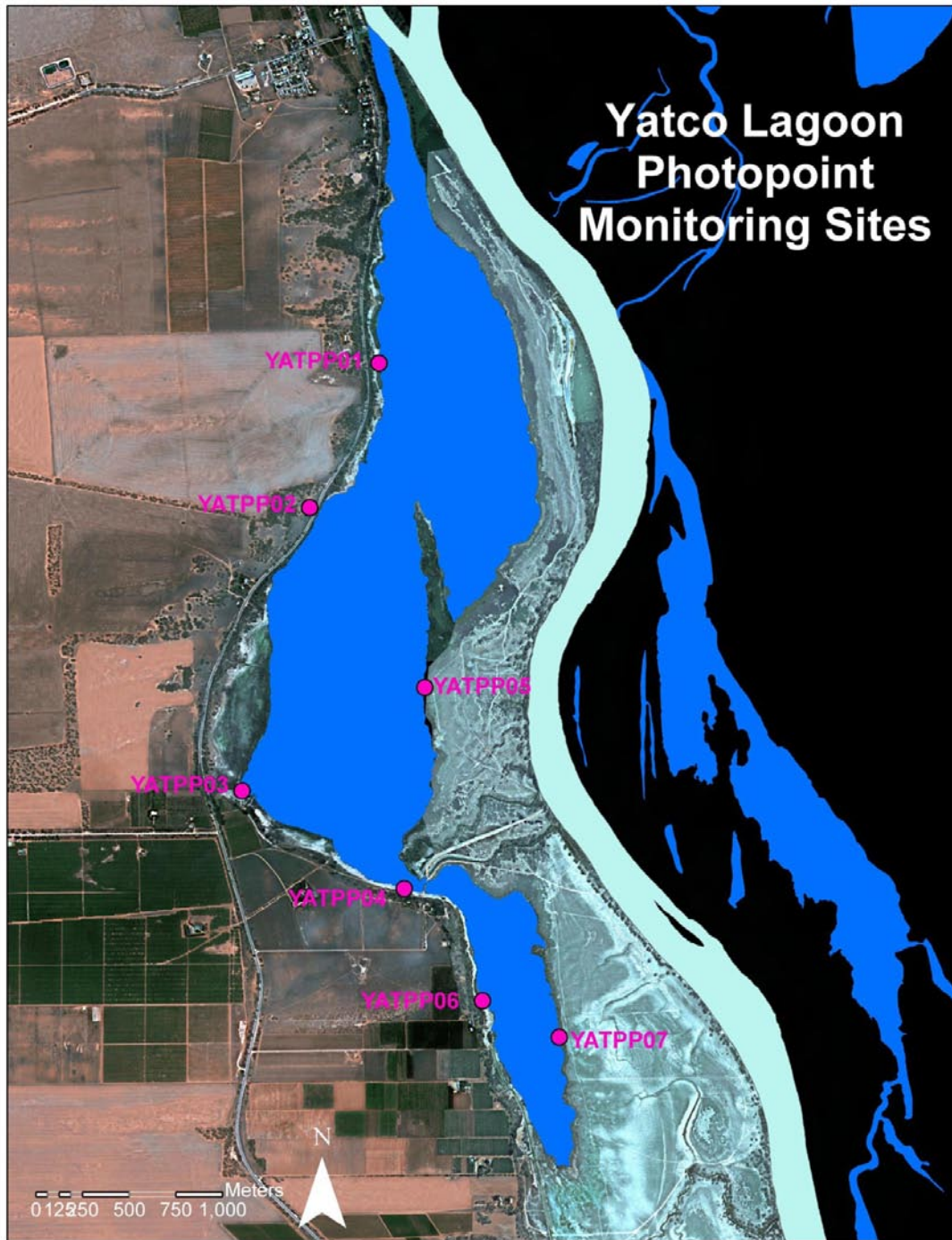


Plate 23: Locations of ground water sampling sites (July 2007). Provided by Callie Nickolai, SA M-DB NRM Board.



24: Locations of vegetation photo point monitoring sites (July 2007). Provided by Callie Nickolai, SA M-DB NRM Board.

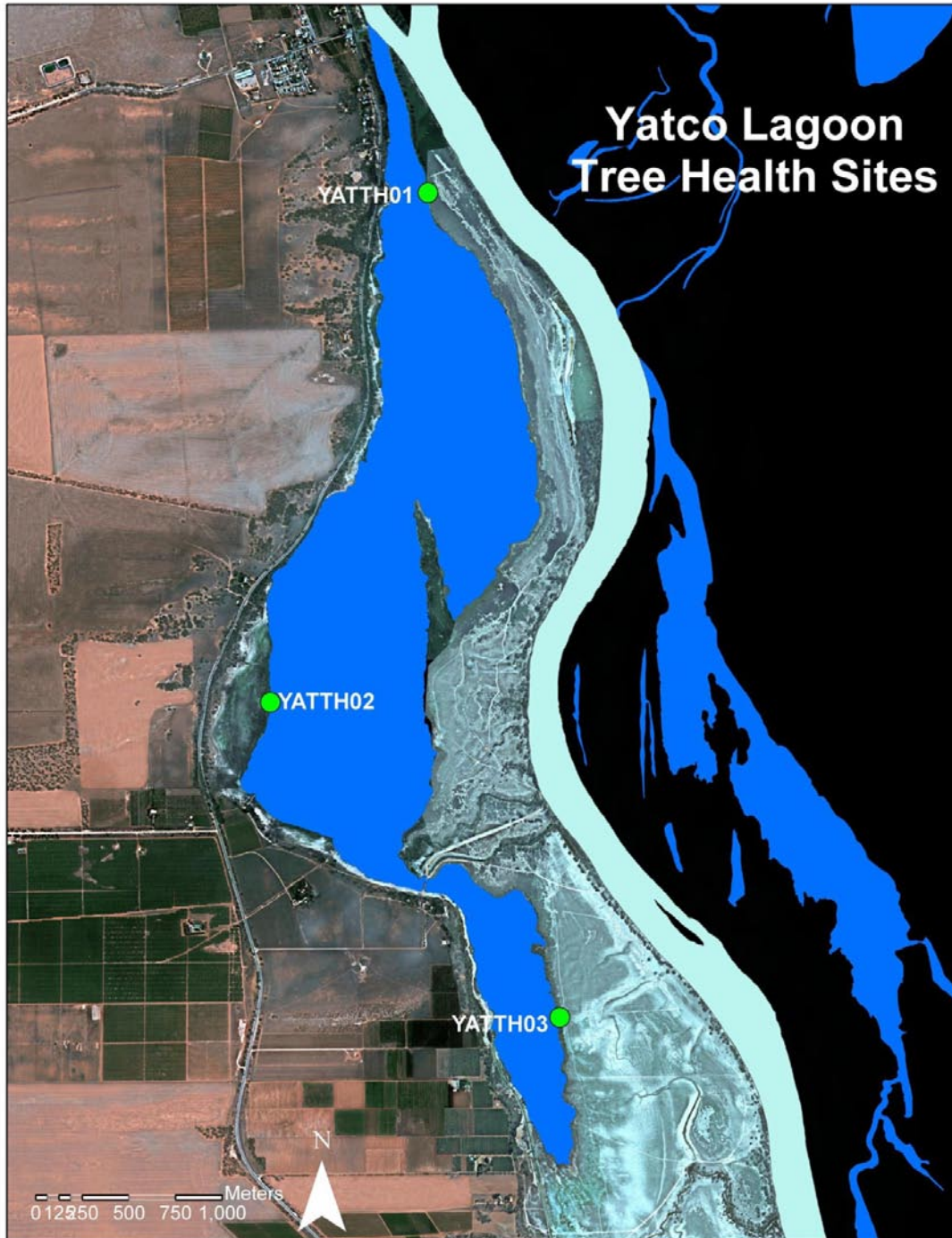


Plate 25: Locations of tree health monitoring sites (July 2007).
 Provided by Callie Nickolai, SA M-DB NRM Board.

6.3 Review procedures

See Section 3.3 in relation to management roles and responsibilities. Further, as outlined in Section 1.2, this plan will be reviewed by the Yatco Wetland Landcare Group in 2009. Thereafter reviews will be done as considered appropriate by the Group, but at least every five years. In keeping with the adaptive management approach being used (see Section 1.5), it is anticipated that elements of the plan may be modified based on the results of the ongoing monitoring of the site.

6.4 Reporting

In order to comply with the water license issued by the Department of Water, Land and Biodiversity Conservation (DWLBC), a reporting element to the management plan is required.

DWLBC require that they be informed of any changes to the management objectives, wetland water operational plan and/or the monitoring program. This is to ensure that any such changes are in agreement with their wetland management plan guidelines, and to ensure that the water allocation arrangements for the wetland are still appropriate.

For this reporting purpose, it is important that records be kept of all monitoring data and management actions, indicating dates, times, actions carried out and results. This data should be stored in an easy to use and accessible format in a central location.

7. References (and further reading)

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Appendix A. Precautionary approach explained

From: 'THE PRECAUTIONARY PRINCIPLE IN A NUTSHELL'

By Peter Montague, Environmental Research Foundation, August 27, 2005

"The precautionary approach suggests five actions we can take:

- (1) Set a goal (or goals);
- (2) Examine all reasonable ways of achieving the goal, intending to choose the least-harmful way;
- (3) Monitor results, heed early warnings, and make mid-course corrections as needed;
- (4) Shift the burden of proof -- when consequences are uncertain, give the benefit of the doubt to nature, public health and community well-being. Expect responsible parties (not governments or the public) to bear the burden of producing needed information. Expect reasonable assurances of safety for products before they can be marketed – just as the Food and Drug Administration expects reasonable assurances of safety before new pharmaceutical products can be marketed.
- (5) Throughout the decision-making process, honor the knowledge of those who will be affected by the decisions, and give them a real "say" in the outcome. This approach naturally allows issues of ethics, right-and-wrong, and justice to become important in the decision.

In sum: Faced with reasonable suspicion of harm, the precautionary approach urges a full evaluation of available alternatives for the purpose of preventing or minimizing harm."

Appendix B. Decision-support scheme (Baldwin et al, 2007) for assessing likelihood of acid sulfate soils being present at levels that could cause ecological harm

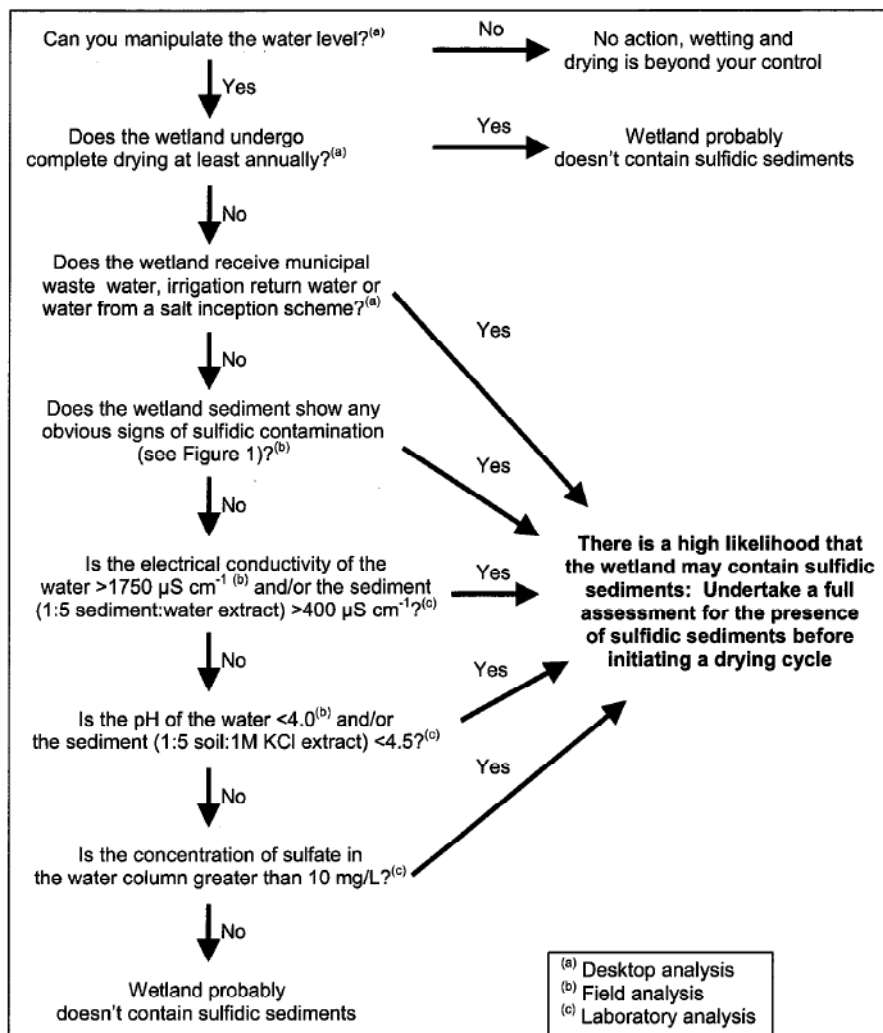


Figure 1. Decision-support scheme developed by Baldwin *et al.* (2007) for initial assessment of the likelihood that an inland wetland contains sulfidic sediments at levels that could cause ecological damage.

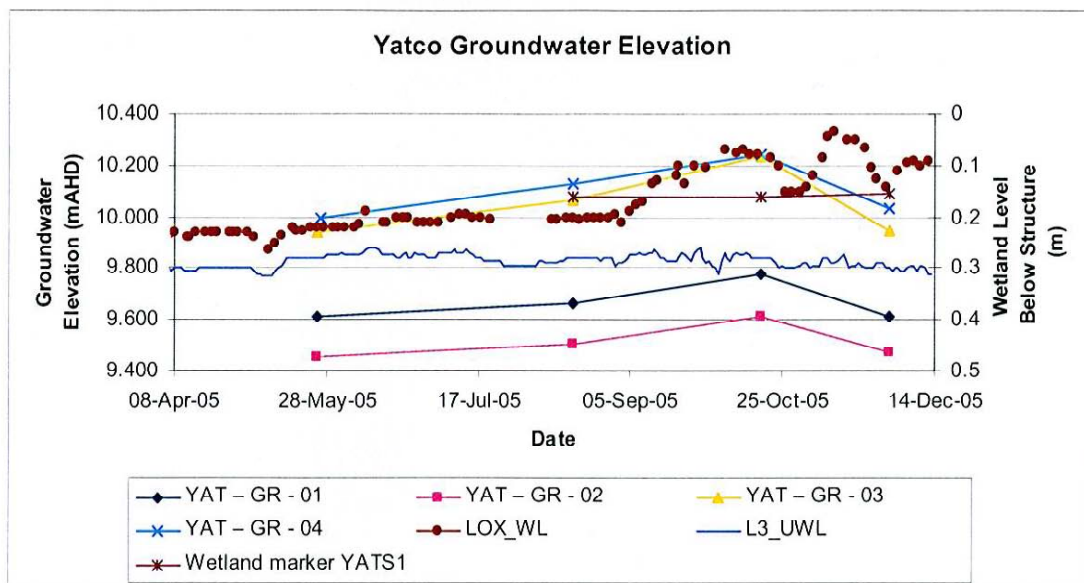
Appendix C.

Groundwater monitoring data from the River Murray Baseline Survey, SKM, 2005)

Table 8-3 Yatco Groundwater Monitoring Data (River Murray Wetlands Baseline Survey 2005).

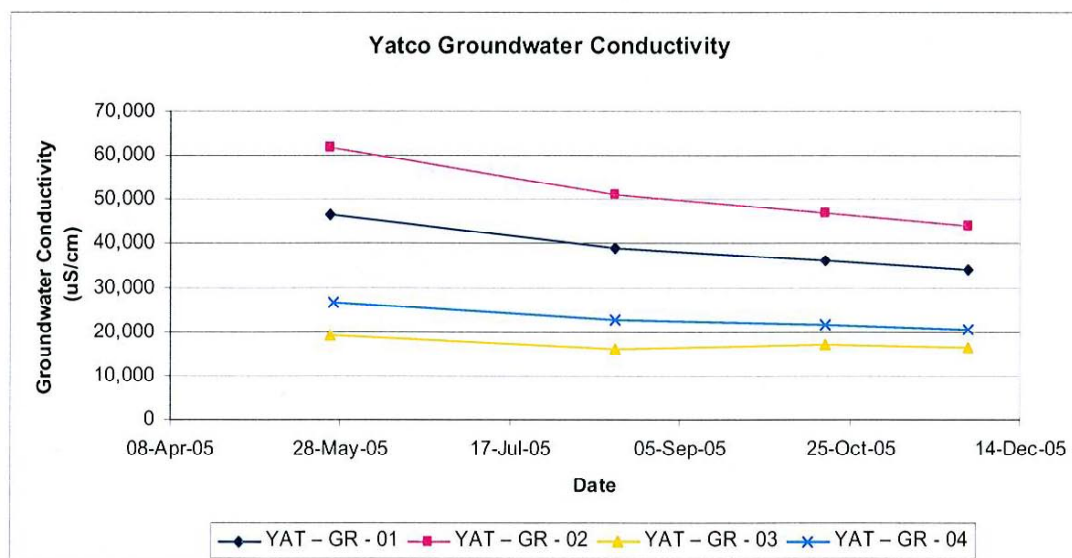
Bore ID	Easting (m)	Northing (m)	Reference Elevation (mAHD)	Ground elevation (mAHD)	Sampling date	Groundwater Depth (mbgl)	Groundwater Depth (mBTC)	Groundwater Elevation (mAHD)	Conductivity $\mu\text{S/cm}$
YAT - GR - 01	442,561	6,201,596	11.768	11.2454	25-May-05 17-Aug-05 18-Oct-05 29-Nov-05	1.632 1.580 1.465 1.631	2.155 2.103 1.988 2.154	9.613 9.665 9.780 9.614	46,700 39,200 36,200 34,200
YAT - GR - 02	442,829	6,203,954	11.359	10.7403	25-May-05 17-Aug-05 18-Oct-05 29-Nov-05	1.286 1.232 1.126 1.266	1.905 1.851 1.745 1.885	9.454 9.508 9.614 9.474	61,700 51,100 47,000 44,200
YAT - GR - 03	441,225	6,201,446	11.242	10.4624	25-May-05 17-Aug-05 18-Oct-05 29-Nov-05	0.520 0.398 0.225 0.517	1.300 1.178 1.005 1.297	9.942 10.064 10.237 9.945	19,080 15,820 17,180 16,420
YAT - GR - 04	441,919	6,204,036	11.095	10.4672	26-May-05 17-Aug-05 18-Oct-05 29-Nov-05	0.472 0.337 0.223 0.433	1.100 0.965 0.851 1.061	9.995 10.130 10.244 10.034	26,600 22,900 21,850 20,660
Wetland marker YATS1					17-Aug-05 18-Oct-05 29-Nov-05		0.16 0.16 0.155		

Appendix D. Yatco groundwater elevation (River Murray Baseline Survey, SKM, 2005)



■ Figure 8-4 Yatco Groundwater Elevation (River Murray Wetlands Baseline Survey 2005).

Appendix E. Yatco groundwater conductivity (River Murray Baseline Survey, SKM, 2005)



■ Figure 8-5 Yatco Groundwater Conductivity (River Murray Wetlands Baseline Survey 2005).

Appendix F. Yatco water quality data at four times of the year (River Murray Baseline Survey, SKM, 2005)

■ Table 8-5 Minimum, maximum and mean (S.E.) electrical conductivity (EC), dissolved oxygen (DO), pH, turbidity and water temperature values at Yatco Lagoon during Stages 1, 2, 3 and 4. (River Murray Wetlands Baseline Survey 2005).

Parameters		Stage 1 March 1 st 05	Stage 2 April 8 th 05	Stage 3 Aug 22 nd 05	Stage 4 Oct 17 th 05	Average over survey period
EC $\mu\text{S.cm}^{-1}$	Mean	1219 \pm 433	1231 \pm 441	1250 \pm 383	934 \pm 292	1158 \pm 713
	Min.	405	281	318	216	216
	Max.	2170	2030	2110	1510	2170
DO mg.L^{-1}	Mean	8.8 \pm 0.5	10.1 \pm 1.0	11.1 \pm 0.2	9.9 \pm 0.2	10.0 \pm 1.3
	Min.	7.8	8.3	10.6	9.6	7.8
	Max.	10.4	12.6	11.4	10.3	12.6
pH	Mean	8.51 \pm 0.30	8.96 \pm 0.38	8.12 \pm 0.12	8.04 \pm 0.18	8.41 \pm 0.61
	Min.	7.74	7.84	7.79	7.61	7.61
	Max.	9.21	9.55	8.38	8.51	9.55
Turbidity NTU	Mean	169 \pm 81	71 \pm 14	62 \pm 19	110 \pm 23	103 \pm 90
	Min.	40	54	16	48	16
	Max.	400	114	106	155	400
Water Temperature $^{\circ}\text{C}$	Mean	24.8 \pm 0.7	23.9 \pm 1.2	15.1 \pm 0.3	23.7 \pm 1.2	21.9 \pm 4.4
	Min.	23.5	21.4	14.3	21.8	14.3
	Max	26.5	26.7	15.6	27.0	27.0
n		4	4	4	4	16

Appendix G. List of flora recorded at Yatco Lagoon
(Baseline Survey, SKM, 2005)

- **Table 8-7 Species list for Yatco Lagoon (includes opportunistic observations not surveyed in quadrats) (*denotes exotic species) (River Murray Wetlands Baseline Survey 2005).**

Species	Common Name	Association number				
		1	2	3	4	5
<i>Acacia stenophylla</i>	River cooba					
<i>Atriplex nummularia</i>	Old Man Saltbush					
<i>Atriplex prostrata</i>	Creeping Saltbush					
<i>Atriplex semibaccata</i>	Berry Saltbush					
<i>Atriplex stipitata</i>	Bitter saltbush					
<i>Avena barbata</i> *	Bearded Oat					
<i>Azolla filiculoides</i>	Pacific Azolla	x				
<i>Carpobrotus ?rossii</i>	Angular Pigface					
<i>Chenopodium pumilio</i>	Small Crumbweed					
<i>Conyza bonariensis</i> *	Flax-leaf Fleabane					
<i>Cotula coronopifolia</i>	Water Buttons					
<i>Craspedia</i> sp.	Billybuttons					
<i>Cynodon dactylon</i> *	Couch grass					
<i>Cyperus gymnocaulos</i>	Spiny Flat-sedge				x	
<i>Danthonia caespitosa</i>	Wallaby grass					
<i>Eleocharis acuta</i>	Common Spike-rush					
<i>Enchylaena tomentosa</i>	Ruby Saltbush					
<i>Eucalyptus camaldulensis</i> var. <i>camaldulensis</i>	River Red Gum					
<i>Eucalyptus largiflorens</i>	River Box					
<i>Euphorbia terracina</i> *	False Caper					
<i>Halosarcia pergranulata</i> ssp. <i>pergranulata</i>	Black-seed samphire					
<i>Heliotropium curassivicum</i> *	Smooth Heliotrope					
<i>Juncus usitatus</i>	Common Rush					

<i>Lactuca saligna</i> *	Wild Lettuce					
<i>Ludwigia peploides</i> ssp. <i>montevidensis</i>	Water Primrose					
<i>Mesembryanthemum crystallinum</i> *	Common Iceplant					
<i>Muehlenbeckia florulenta</i>	Lignum					
<i>Myoporum parvifolia</i>	Creeping boobialla					
<i>Myriophyllum verrucosum</i>	Red Milfoil		x			
<i>Onopordum acanthium</i> *	Scotch Thistle					
<i>Paspalum distichum</i>	Water-couch				x	
<i>Phragmites australis</i>	Common reed	x			x	
<i>Polypogon monspeliensis</i> *	Annual Beard-grass					
<i>Potamogeton crispus</i>	Curly Pondweed		x			
<i>Potamogeton tricarlinatus</i>	Sago Pondweed					
<i>Rorippa palustris</i> *	Yellow Marsh-cress					
<i>Salix babylonica</i> *	Weeping Willow					
<i>Schoenoplectus validus</i>	River Club-rush	x			x	
<i>Sporobolus mitchellii</i>	Rat-tail couch					
<i>Stipa</i> sp.	Spear grass					
<i>Suaeda australis</i>	Austral Seablite					
<i>Typha</i> sp.	Bulrush	x			x	x
<i>Vallisneria spiralis</i>	Ribbon weed		x	x		
<i>Wahlenbergia fluminalis</i>	River Bluebell					
TOTAL		4	3	1	5	1

Appendix H. List of fauna recorded at Yatco Lagoon (Baseline Survey, SKM, 2005)

- Table 8-9 Summary table indicating the number of species captured per season and length data at Yatco (River Murray Wetlands Baseline Survey 2005), together with length data.

Common Name	Species Name	Count	Yatco						
			Autumn			Spring			
			Length (TL, mm)			Length (TL, mm)			
			Ave	Min	Max	Count	Ave	Min	Max
Native Fishes									
bony herring	<i>Nematalosa erebi</i>	101	280	47	405	113	317	80	422
flathead gudgeon	<i>Philypnodon grandiceps</i>	28	45	31	59	37	58	40	75
carp gudgeon complex	<i>Hypseleotris spp.</i>	6	32	27	36	108	38	28	55
golden perch	<i>Macquaria ambigua ambigua</i>	2	391	384	398	2	403	400	405
Australian smelt	<i>Retropinna semoni</i>	100	45	35	66	970	51	39	70
Threatened Native Fishes									
unspecked hardyhead ^v	<i>C. s. fulvus</i>	133	33	17	54	120	35	23	55
dwarf-flathead gudgeon	<i>Philypnodon sp.</i>	2	35	33	37	6	44	40	45
Murray rainbowfish	<i>Melanotaenia fluviatilis</i>	32	36	23	54	5	42	30	50
Exotic / Invasive Fish									
common carp	<i>Cyprinus carpio</i>	6	400	320	525	27	124	16	660
goldfish	<i>Carassius auratus</i>	2	70	55	84	1	170	170	170
redfin	<i>Perca fluviatilis</i>	4	309	268	345	6	137	36	364
eastern gambusia	<i>Gambusia holbrooki</i>	26	32	20	49				
Number of fish			442			1395			
Count of species			12			11			
Native to Invasive ratio						2.0			
Overall fish						1837			
Overall Species						12			

■ **Table 8-11 Abundance of macroinvertebrate taxa collected from Yatco Lagoon (River Murray Wetlands Baseline Survey 2005).**

Higher taxa	Family	Subfamily/Genus	Autumn			Spring			Total abundance
			Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	
Bryozoa				4		370	4	2	380
Cnidaria	Hydridae	Hydra				50	2	5	57
	Clavidae	Cordylophora	25		4				29
Turbellaria	Dugesilidae		5	4	4		1		14
Nemertea	Tetrastemmatidae	Prostoma	5						5
Nematoda			20			20	1	1	42
Gastropoda	Ancylidae	Ferrissia	10		4				14
	Physidae	Physa			8				8
Oligochaeta			395	24	56	43	8	2	528
Acariformes: Oribatida				4	4				8
Acariformes: Astigmata	Histiostomatidae	Histiostoma		8	4				12
Amphipoda	Hyalidae	Austrochiltonia			16	3	1	4	24
		immature	5			17		23	45
Isopoda	Corallanidae	Tachaea		4					4
Decapoda	Atyidae	Caridina	120	312					432
		immature				23	21	44	88
		Paratya	10	272	20	7	25	32	366
	Palaemonidae	Macrobrachium		8	4		1		13
Collembola	Sminthuridae	Katianna	10	64			7		81
Coleoptera	Dytiscidae	larvae			4				4
Diptera	Ceratopogonidae	Ceratopogoninae	20			17	2	1	40
		Dasyheleinae	5						5
	Psychodidae					3			3
	Ephydriidae			4					4
	Chironomidae	Tanypodinae	35			77	11		123
		Orthocladiinae	50	4	8		7	9	78
		Chironominae	260	92	108	73	19	10	562
Ephemeroptera	Baetidae	Cloeon	15						15
		immature	55	4	4		1		64

	Caenidae	Tasmanocoenis	25	4	72	3	4	2	110
Hemiptera	Mesoveliidae	Mesovelia	10	8			1		19
	Hebridae	Merragata	5						5
	Corixidae	immature		8					8
		Micronecta	20		548	80	2	5	655
	Naucoridae	Naucoris	5			3			8
	Notonectidae	Anisops	5						5
		immature						3	3
Odonata	Coenagrionidae		70	16	4	3	1		94
Trichoptera	Hydroptilidae	Hellyethira		12		7	4		23
		Hydroptila			4			1	5
	Leptoceridae	Trienodes					1		1
Total abundance			1185	856	876	800	124	144	3985
Total number of taxa			24	19	18	17	21	15	41

■ **Table 8-14 Abundance and conservation status of bird species identified at Yatco Lagoon (River Murray Wetlands Baseline Survey 2005).**

Common Name	Scientific Name	Autumn	Spring	Total abundance	Conservation status
Water Bird Species					
Freckled Duck	<i>Stictonetta naevosa</i>	300	-	300	State V, M
Black Swan	<i>Cygnus atratus</i>	254	110	364	M
Australian Shelduck	<i>Tadorna tadornoides</i>	8	-	8	M
Australian Wood Duck	<i>Chenonetta jubata</i>	7	-	7	M
Pacific Black Duck	<i>Anas superciliosa</i>	2	3	5	M
Australasian Shoveler	<i>Anas rhynchos</i>	2	-	2	State R, M
Grey Teal	<i>Anas gracilis</i>	920	35	955	M
Darter	<i>Anthinga melanogaster</i>	3	4	7	
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	24	1	25	
Pied Cormorant	<i>Phalacrocorax varius</i>	10	9	19	
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	61	7	68	

Common Name	Scientific Name	Autumn	Spring	Total abundance	Conservation status
Great Cormorant	<i>Phalacrocorax carbo</i>	15	-	15	
Australian Pelican	<i>Pelecanus conspicillatus</i>	40	44	84	
White-faced Heron	<i>Egretta novaehollandiae</i>	1	-	1	
Great Egret	<i>Ardea alba</i>	5	2	7	M
Australian White Ibis	<i>Threskiornis molucca</i>	3	1	4	
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	9	-	9	
Purple Swamphen	<i>Porphyrio porphyrio</i>	3	2	5	
Black-tailed Nativehen	<i>Gallinula ventralis</i>	2	-	2	
Eurasian Coot	<i>Fulica atra</i>	1640	282	1922	
Black-fronted Dotterel	<i>Euseyonis melanops</i>	2	2	4	M
Red-kneed Dotterel	<i>Erythronyx cinctus</i>	5	-	5	M
Masked Lapwing	<i>Vanellus miles</i>	4	3	7	M
Silver Gull	<i>Larus novaehollandiae</i>	10	-	10	
Caspian Tern	<i>Sterna caspia</i>	20	3	23	
Whiskered Tern	<i>Chlidonias hybridus</i>	-	1	1	
Clamorous Reed-warbler	<i>A. crocecephalus australis</i>	-	4	4	M
Little Grassbird	<i>Megalurus gramineus</i>	2	9	11	M
Total	Individuals	3352	522	3874	
	Species	26	18	28	
Non Water Bird Species					
Peregrine Falcon	<i>Falco peregrinus</i>	1	-	1	State R
Fairy Martin	<i>Petrochelidon ariel</i>	2	-	2	
Total	Individuals	3	0	3	
	Species	2	0	2	