

# Improving environmental water delivery to degraded wetlands

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## Key Points

- Flow regulation and land use change has affected the condition of wetlands along the Yarra River.
- Environmental watering can be delivered through a range of infrastructure options.
- Watering options should be developed with a view to the key issues and criteria specific to each site.
- Ongoing stakeholder consultation is critical for understanding site issues, and where the site is managed by a third party their buy-in to the process and solution is essential.
- As these sites are often isolated, simple solutions, with low ongoing cost and maintenance requirements, are preferred.

## Abstract

Flow regulation and land use change has impacted on the condition of wetlands along the Yarra River. Following an initial review of the ecology and water requirements of numerous wetlands in the Yarra River catchment by Melbourne Water (MW), Jacobs developed a framework for determining and implementing wetland water regime management objectives. The framework is based on four stages; development of management objectives; determination of water regime requirements; identification and implementation of water regime delivery options; and monitoring, evaluation and adaptive management.

This paper presents an overview of the framework and its application to three sites of differing complexity; Yering Backswamp, Spadoni's Billabong and Cockatoo Swamp. The purpose of these projects has been to further develop an initial conceptual understanding of the site, identify a preferred watering regime and determine a suitable environmental watering solution that could enable the preferred regime to be delivered. The environmental watering solution has now been implemented at Yering Backswamp and Spadoni's Billabong, and is in the design stage at Cockatoo Swamp.

## Keywords

Yarra River, billabong, environmental watering, wetland

## Introduction

Flow regulation and land use change has impacted on the condition of wetlands along the Yarra River. In many cases these wetlands are not receiving their preferred watering regime, and are consequently losing habitat and environmental values. A framework for determining and implementing wetland water regime management objectives (SKM, 2005) has been adopted for these types of sites. The framework includes four stages of assessment: development of management objectives; determination of water regime requirements; identification and implementation of water regime delivery options; and monitoring, evaluation and adaptive management.

The stages of the framework, key tasks, inputs and technical studies are summarised in Table 1. The inputs and technical studies listed in this table are generic and may not be required in each instance. The program of work is tailored to each individual site and will vary according to the sites' complexity.

**Table 1. Framework stages, key tasks and information required**

Stage	Key tasks	Example input data and technical studies
1. Management objectives	<ul style="list-style-type: none"> <li>Characterise wetland - consolidate background information to form a clear picture of the influences on water movement across the site.</li> <li>Determine desired management objectives – workshop with key stakeholders to identify site specific values</li> </ul>	<ul style="list-style-type: none"> <li>Topography</li> <li>Climate data</li> <li>Streamflow and gauge data</li> <li>Groundwater level data</li> <li>Vegetation survey</li> <li>Ecological survey</li> </ul>
2. Water regime requirements	<ul style="list-style-type: none"> <li>Determine water regime required to meet management objectives (generally through a combination of vegetation assessment and hydrologic modelling)</li> <li>Does the existing water regime support the management objectives?</li> <li>Assess the change required to meet the management objectives.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation assessment</li> <li>Hydrologic modelling</li> <li>Hydraulic modelling</li> </ul>
3. Water regime delivery	<ul style="list-style-type: none"> <li>Identify a range of water delivery options and workshop with stakeholders, to identify a preferred option. Consider factors such as cost, maintenance, vandalism, safety, etc.</li> <li>Develop infrastructure design</li> <li>Construction/implementation of option</li> </ul>	<ul style="list-style-type: none"> <li>Geotechnical assessment</li> <li>Acid sulfate soil analysis</li> <li>Construction review</li> <li>Operational rules</li> <li>Costing (opex and capex)</li> </ul>
4. Monitoring, evaluation and adaptive management	<ul style="list-style-type: none"> <li>Ongoing monitoring to assess the performance and suitability of the adopted watering option.</li> <li>Feedback to refine the option &amp; implementation</li> </ul>	<ul style="list-style-type: none"> <li>Water level monitoring</li> <li>Groundwater monitoring</li> <li>Vegetation and ecological surveys</li> </ul>

## Case studies

The framework has been applied at three sites in the Yarra catchment (Yering Backswamp, Spadoni's Billabong and Cockatoo Swamp), where water regime management has been identified as critical to improving environmental value. At each site, management objectives, water regime requirements and water delivery options have been identified. These were reviewed in light of key issues identified by stakeholders, which were generally around access, safety, and operational and maintenance requirements (Table 2).

**Table 2. Study sites – key issues and proposed solutions**

Site	Managed by	Key issues	Solution
Yering Backswamp	Melbourne Water	Site access via a steep dirt track. Safety risk, particularly if carrying equipment.	The adopted solution should require minimal staffing & setup
Spadoni's Billabong	Yarra Ranges Council	Isolated, but with regular public access. High risk of vandalism YRC staff unlikely to be available for operation or maintenance	The adopted solution should be difficult to vandalise, with no/low ongoing requirement for operation or maintenance
Cockatoo Swamp	Parks Victoria	Isolated and some areas of the swamp are very difficult to access. Due to inadequate resourcing (staff and funding), the solution needs to consider requirements for Parks Victoria to take on ownership of the asset. Some areas of very high value vegetation and habitat. Vulnerable areas of habitat downstream of the project area.	The adopted option should be low maintenance and easy to operate Construction must minimise the impact to high value vegetation and habitat. The adopted solution must pose no risk to downstream habitat.

### Yering Backswamp

Yering Backswamp (~4.8 ha) is situated on a narrow elevated terrace between the Yarra River and the foot of Sugarloaf Reservoir, in the middle Yarra Catchment 35 kms northeast of Melbourne (Figure 1 and Figure 3). The swamp remains largely intact due to its isolation within a protected catchment and is one of Melbourne Water’s sites of biodiversity significance, supporting a range of rare or threatened fauna (Beardsell, 1997). The backswamp forms part of an area listed as Category 1 (very high habitat significance), as it supports six reference stand habitats and a very high diversity of regionally significant plant species (over 90, including 14 regionally endangered species) (Beardsell, 1997).

The site experienced artificially wet conditions from the 1980s to 2007 due to leakage from the Maroondah Aqueduct (upslope from the wetland), supporting the establishment of regionally threatened plants and animals from Eastern Victoria (Beardsell, 1997). In 2007 the aqueduct was lined and leakage ceased, and since then the water regime of the wetland has changed and is now more closely linked to variation in river level. This change in water regime may eventually result in changes in vegetation communities as they adjust to the new, drier, water regime. However, the management objective for Yering Backswamp is to maintain the current ecological values at the site, given its very high habitat significance. In 1997, the stands of swamp scrub, seasonal wetland and permanent wetland at the site were classed as the most intact and representative known to remain in North East Melbourne (Beardsell, 1997), a position which has not changed as the backswamp has been preserved since then while surrounding catchments have been developed.

At the start of the project a conceptual understanding of the site was developed (Figure 1b), based on topographic data, geology, hydrogeology, and hydrology.

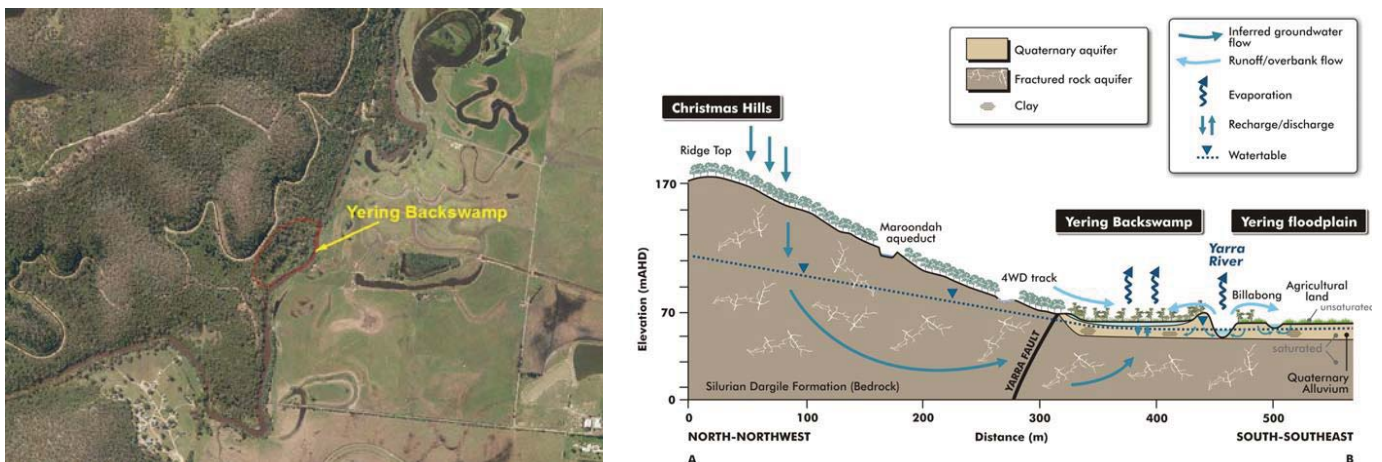


Figure 1. Yering Backswamp: landscape setting (SKM, 2013)

A site inspection and vegetation survey was carried out, identifying distinct zones of vegetation within the backswamp; a *central zone* (aquatic species that prefer wetter conditions) and a *fringing zone* (vegetation tolerates temporary inundation). Based on the vegetation types, the recommended regime is for annual inundation with water persisting in the *central zone* for 3-6 months over the winter/spring period. This difference in the vegetation types suggested that once water enters the backswamp it drains out of the *fringing zone* relatively quickly. This contradicted the surveyed bank and inlet levels and indicated that the bank itself may have a high permeability.

A trial environmental watering event was conducted over May and June 2014 (Figure 2), in order to assess the behaviour of the swamp during a filling event, to confirm key information (e.g. inlet level and location, leakage rates, flow paths, time to fill, and volume of water required) and to identify any constraints to water

delivery. Water was delivered via a pump and temporary pipeline from the Maroondah Aqueduct. The trial confirmed the suspected high bank permeability.



**Figure 2. Yering Backswamp: before and after an environmental watering event (May-June 2014)**

Under current arrangements, flows in the Yarra River are unlikely to provide the preferred regime (annual inundation). Hence, either an alternative source of water or delivery system is required, and/or a regulating structure is required between the swamp and the river in order to retain flows once they enter the backswamp, extending the inundation period.

Given the high bank permeability, a hydraulic structure to hold water levels within the swamp would not work unless the river bank along the length of the swamp was completely reconstructed. This would be extremely expensive and difficult to implement, and any hydraulic structure options were therefore discounted. Instead, two general options were identified; either artificial watering of the swamp (via permanent or temporary infrastructure, gravity feed from Maroondah Aqueduct or pump from river), or improved river flow to the swamp (pipe between the river and swamp). These options were workshopped with MW and a range of factors were considered, including effectiveness, cost, ease of installation, maintenance, response time, staffing, and safety.

At this site key issues were effectiveness, access and safety (the site is accessed from a steep dirt track). On this basis a permanent pipeline and outlet works at the swamp were installed, gravity fed from Maroondah Aqueduct. This option allows for effective watering whenever required (not limited by Yarra River flows) and is easy to operate, with no risk to staff. A watering event would completely fill the backswamp, then drain out naturally over 3-6 months. MW staff will monitor the effectiveness of the watering event and consider whether supplementary watering may be required.

### ***Spadoni's Billabong***

Spadoni's Billabong sits within a nature reserve in the mid Yarra Catchment, 37 kms northeast of Melbourne and just 1.7 kms northeast of Yering Backswamp. While the surrounding landuse is predominantly agricultural, the reserve is listed as a site of botanical significance under the Yarra Ranges Planning Scheme and contains a population of the endangered Buxton Gum. The overarching management objectives for Spadoni's Billabong are to support and improve the existing ecological values at the site, protect existing threatened species and revegetate degraded areas.

A desktop conceptual understanding of the site was developed (similar to Figure 1b), based on topographic data, geology, hydrogeology, and hydrology. A site inspection and vegetation survey were then carried out, and identified two main sections of the billabong; a Serpentine Channel and a deeper Pool separated by a small ridge (Figure 3). The Pool is directly connected to the Yarra River and is in good condition. In contrast, the Serpentine Channel only receives water when the Yarra River is in flood and water backs up and overflows via Olinda Creek, and is in a degraded condition.



**Figure 3. Spadoni's Billabong – a) key locations and b) Serpentine Channel when filled**

Long term hydrologic modelling (100+ years) of the catchment indicates that the frequency of inundation under current conditions has decreased compared to natural (SKM, 2005). Daily water balance modelling of the site was then carried out, based on recent historic Yarra River flow levels (2004-2015) and observed wet and dry periods. The wet and dry periods were identified from a range of reports, aerial and on ground photographs, and advice received from MW and Yarra Ranges Council (YRC). The modelling indicated that the Serpentine Channel would have experienced an inundation event in five of the last eleven years, while the Pool area would have been watered every year.

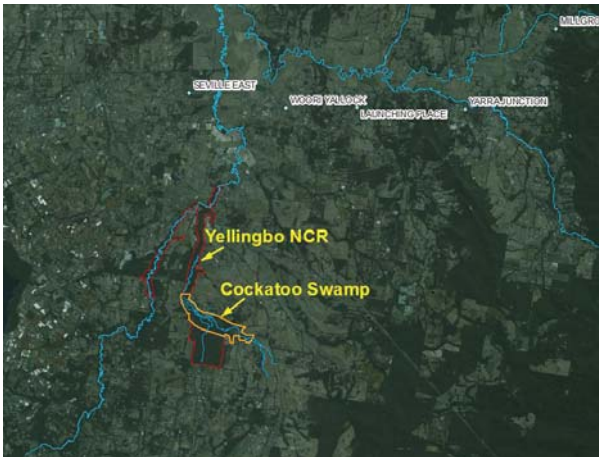
A preferred watering regime was developed based on a review of the topography of the area, the site visit, vegetation survey and information in the Victorian wetlands database. The preferred watering regime is for an annual inundation event, occurring during spring and filling the billabong for at least three months, before gradually drying out. The billabong could withstand the occasional year when this watering regime is not achieved but would begin to suffer after three or four years without an inundation event. After this point, a loss of seed banks and decline of regenerative ability would be expected amongst the wetland vegetation.

The modelling indicates that the current watering regime is not meeting the preferred watering regime at the Serpentine Channel, although it is being met at the Pool. Several options were therefore identified which could be implemented to increase the frequency of inundation, including pumping water directly from the Yarra River to the Serpentine Channel, construction of an inlet which would allow river inflows to the Serpentine Channel at a lower level than current, or connection of the Serpentine Channel with the Pool (which currently receives inflows at a lower level).

These options were workshopped with MW and YRC and considered issues such as effectiveness, cost, flexibility, operational requirements, ongoing maintenance, vandalism, and safety. Of the options considered, the lowered inlet channel was preferred, for the following reasons: effectiveness (this option has a proven effectiveness, based on the condition in and around the northern Pool), low ongoing costs (low maintenance and no operational requirements), and low risk of vandalism. This option was implemented in April 2016.

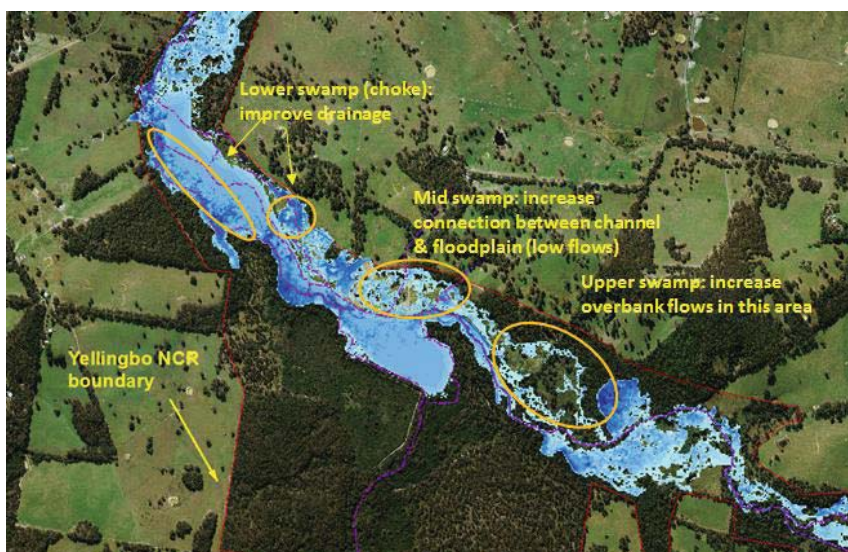
### Cockatoo Swamp

The Cockatoo Swamp is located within the Yellingbo Nature Conservation Reserve (NCR), 48 kms east of Melbourne, in a predominantly peri-urban setting (Figure 4). The swamp is a site of high biodiversity significance, providing habitat for the endangered Helmeted Honeyeater and Leadbeater’s Possum, both listed under the *Environment Protection and Biodiversity Act 1999*. It is also home to the *Flora and Fauna Guarantee Act 1988* listed ‘sedge rich *Eucalyptus camphora* swamp’ vegetation community. The *Eucalyptus camphora* (*E. camphora*) vegetation community is a key food resource and habitat for both the Helmeted Honeyeater and Leadbeater’s Possum. Since the 1990s there has been significant die back of *E. camphora* within Cockatoo Swamp, threatening the long term viability of these populations at Yellingbo NCR.



**Figure 4.a) Yellingbo NCR and Cockatoo Swamp location and b) an area of dieback (J.Greet, 2015)**

The long term management objectives for the site are to maintain the high species richness and abundance of streamside and wetland bird populations. Jacobs was engaged to identify options to improve hydrological conditions within the swamp, in order to encourage the return of natural regeneration and growth of the *E. camphora* vegetation community and the broader riparian environment. This project focused on the area of the swamp along Cockatoo Creek between the upstream landholder boundary and the “choke”, an area of sediment accumulation which reduces the flow downstream and creates a zone of saturation (project area is outlined in orange in Figure 5).



**Figure 5. Cockatoo Swamp – areas of concern and hydraulic modelling of a moderate flood event (purple line shows the watercourse alignment)**

A conceptual understanding of the site was developed to inform the project, based on topographic data, geology, hydrogeology, and hydrology (similar to Figure 1). The site is complex and contains areas which are currently receiving too much water alongside areas which are not receiving enough water. There are now areas of standing/elevated water, which is believed to have caused extensive dieback and prevented regeneration (Greet, 2012). Other areas are now too dry for *E. camphora* to become established. These changes are due to a range of historic activities at the site including land clearing, channel enlargement and erosion, levee construction and sediment accumulation (Carr 1998, Craigie et al. 1998).

Upstream of the swamp the watercourses have been channelised, with built up edges, so that they are now perched above the floodplain. In the upper swamp the channels have been modified and enlarged so that much higher flows are now required before water gets out onto the floodplain. A number of levees have also been constructed along the north side of the main channel, hindering water movement in and out of certain areas. In the lower swamp, sediment has built up at a narrow point in the creek forming a 'choke' which restricts drainage through the area.

As a result of these modifications, the upper swamp does not receive inundation from low to medium-high flows. Floodwaters that do reach the floodplain are often trapped and result in extended inundation and die back of *E. camphora* habitat. The choke also prevents the lower swamp from drying out after flood events.

In order to manage and improve the hydrologic regime of the overall swamp, the channels, floodplains and 'choke' should be altered. In the upper swamp the capacity of the previously enlarged channels should be reduced to base flows only, so that water and sediments get onto the floodplain more easily. In the mid swamp the channels and floodplain need to be reconnected, so that flow can enter and leave areas more easily. This will restore the natural function for flow distribution, flood attenuation, and ecology. In the 'choke' area conveyance for low flows from south to north should be increased, allowing the lower swamp to drain and dry out, particularly after high flow events.

A range of hydrologic and hydraulic modelling has been conducted testing combinations of infrastructure options in locations across the swamp (e.g. levee removal, siphon/bypass pipeline, in-stream grade control structures and downstream channel enlargement). Several of these options were found to be feasible in terms of improving the flow regime, but were not pursued due to construction risks such as sediment mobilisation, acid sulfate soils and removal of high value vegetation. In particular, the material through the choke area (lower swamp) is unconsolidated sediment, which would provide a poor base for construction. Any hydraulic structures which are constructed in this area run a high risk of outflanking and structural failure. A final solution is yet to be determined.

## **Conclusions**

The framework described in this paper provides a structure for determining and implementing wetland water regime management objectives. In each case the technical program of work must be tailored to the site and will vary according to the sites' complexity.

A range of technical investigations were undertaken for each of the case studies outlined above, including vegetation surveys, hydrologic modelling, hydraulic modelling, groundwater analysis, risk assessments and geotechnical analysis. The outputs from these investigations were used to develop a number of environmental watering options for each site. These options were workshopped with the key stakeholders for each site and the final option was selected based on a consensus, considering the key risks and management issues unique to each site.

At Yering Backswamp the key management issue related to safety risks for staff accessing the site, particularly during wet weather or when carrying heavy machinery. The adopted solution (permanent pipeline) requires minimal staffing and is easy to implement with little notice. It is anticipated that the pipeline will be operated

once every two or three years, depending on climatic conditions and the ecological condition of the backswamp. The response of the backswamp will be monitored after the watering event, in order to assess if a second watering event or top-up volume is required. This allows for an adaptive management approach to the conditions of the backswamp.

At Spadoni's Billabong the key management issues related to risk of vandalism and lack of staff to carry out operational or maintenance activities. The adopted solution (lowered inlet) was selected as it has no ongoing operational or maintenance requirements, and is extremely difficult to vandalise. While this option does not provide a flexible management approach (as at Yering Backswamp) it does have the advantage of mimicking the known flow regime at the neighbouring Pool, which supports the preferred vegetation type.

At Cockatoo Swamp the management issues are complex and somewhat conflicting. The site is isolated and it is difficult to access some areas, making operation and maintenance of infrastructure difficult. Simple solutions, with low operational and maintenance requirements are therefore preferred. Construction in a number of areas has also been ruled out as it will either directly impact on areas of very high value vegetation or habitat, or poses a risk to downstream habitat. Although several options have been identified, Melbourne Water is working to identify a preferred solution which will balance effectiveness, ecological outcomes, risk and cost.

## Acknowledgments

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## References

- Beardsell, C. (1997). *Sites of Faunal and Habitat Significance in North East Melbourne: Volume 1 - Introduction and Overview*. Prepared for the North East Regional Organisation of Councils.
- Carr, G. W. (1998). *Brief investigation of Eucalyptus camphora (Mountain Swamp Gum) dieback, Yellingbo Nature Conservation Reserve*. A report to Department of Natural Resources and Environment. Ecology Australia.
- Craigie, N. M., S. O. Brizga and P. Condina (1998). *Assessment of proposed works to ameliorate the effect of hydrological processes on vegetation dieback at Cockatoo Creek Swamp, Yellingbo Reserve*. A report to Parks Victoria. Neil M Craigie Pty Ltd, Australia.
- Greet, J. (2012). Report on scoping study into the water regime requirements of *Eucalyptus camphora* subsp. *humeana* (Mountain Swamp Gum). Report prepared for Melbourne Water. The University of Melbourne.
- Jacobs (2015). *Spadoni's Billabong: improving environmental water delivery – options analysis*. Prepared for Melbourne Water, March 2015.
- SKM (2013), *Billabong Conceptualisation for Environmental Watering*. Prepared for Melbourne Water, June 2013.
- SKM (2005). *Guidelines – Ecologically sound design of regulators and management of artificially inundated wetlands*. Prepared for the Murray Darling Basin Commission, February 2005.