Environmental Response of Reconnecting Billabongs along the Yarra River

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Key Points

- Modifying inlet levels and managed environmental water have been successfully used to increase frequency of inundation of billabongs along the Yarra River.
- Ecological responses to the managed inundation of billabongs include increased aquatic native vegetation cover, decreased weed coverage and an increase in frogs and birdlife.
- Revegetation and weed control during the dry phase is required to complement the delivery of environmental water and maximise ecological outcomes.
- Pumping trials can be used to investigate uncertainties around the hydrological and ecological response of increased inundation and help to inform the feasibility of permanent environmental watering solutions.

Abstract

Over the past 6 years, Melbourne Water has been implementing a framework developed by SKM (predecessor to Jacobs) in 2012 to determine and implement water regime management options at high value billabongs in the Melbourne Water region. This paper presents the ecological and hydrological responses and key learnings of implementing water regime management options at 3 billabongs along the Yarra River; Spadoni's, Bolin Bolin and Banyule Billabongs. All 3 billabongs have experienced a decrease in frequency of inundation due to river regulation and extraction for water supply. As such, the preferred water regime is to increase the frequency of inundation events.

In 2016 capital works were undertaken at Spadoni's Billabong to modify the inlet level to allow for overbank flows from the Yarra River to enter the billabong more frequently. This has been successful with inflows from the river occurring in 2016 and 2017 that would have otherwise not entered the billabong. Determining water regime management objectives at Bolin Bolin and Banyule Billabongs were more challenging due to the billabong locations higher in the floodplain and greater impacts of river regulation on peak flow level. Pumping trials from the river were undertaken to provide information on seepage rates and billabong volumes, and feature surveys were completed on inlet/outlet areas to help inform the feasibility of permanent solutions. Based on the information collated, structural works to lower the inlet level at Bolin Bolin Billabong is recommended. For Banyule Billabong, the final solution is still to be determined as there are opportunities to be connected to the local stormwater catchment.

Keywords

Yarra River, billabongs, environmental water, wetlands

Introduction

Billabongs along the Yarra River are currently under threat due to a range of issues that cause changes in the hydrological regime of billabongs including land use change, river regulation and climatic conditions (e.g. millennium drought). As a result of this hydrological change, many billabongs now experience a reduction in the frequency of inundation compared to what would have occurred naturally. These drier conditions have a significant effect on a range of billabong values, such as the health and distribution of aquatic vegetation

(Dodo Environmental, 2010).
Environmental water and permanent water regime delivery options can be used to rehabilitate billabongs impacted by hydrological change through the delivery of a preferred water regime that in most cases reflects a regime similar to its natural regime. Environmental water, held by the Victorian Environmental Water Holder, is currently available within the Yarra catchment that may be used to supply or contribute to the delivery of the preferred water regime of selected high priority billabongs.

A framework for determining and implementing wetland water regime management objectives (SKM, 2012) has been adopted to guide the management of a number of high value billabongs along the Yarra River. The framework includes 4 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. This framework has been previously presented in Logan *et. al.* 2016, as such this paper will focus on the outcomes of the application of this framework, in particular delivery of environment watering events and a permanent water regime delivery option to improve the environmental outcomes of high value billabongs in the Melbourne Water catchment.

Case studies

A permanent water regime delivery option (Stage 3 of the SKM 2012 water regime management framework) has been implemented at Spadoni's Billabong via modification of the inlet channel to the Yarra River to provide increased frequency of inundation. Environmental water has also been delivered to two other high value billabongs along the river; Bolin Bolin and Banyule Billabong, by directly pumping from the river in to billabongs. Pumping trials were recommended (Jacobs, 2017b) to investigate key uncertainties around the response of each billabong to inundation, including inundation extent, seepage and drawdown rates. This information was used to inform the selection of a permanent water regime delivery option. The implementation of a permanent water regime delivery option and delivery of environmental water has resulted in hydrological and ecological responses that can be used to inform future management of floodplain billabongs and wetlands.

Spadoni's Billabong

Spadoni's Billabong sits within the Spadoni's Nature Reserve on the Yarra River Floodplain, at the confluence with Olinda Creek. There are two main sections of the billabong; a serpentine inlet channel and a deeper pool separated by a small ridge. The site was identified as having high habitat potential and that an increase in the frequency of inundation would improve the condition of the site. Prior to undertaking works, the vegetation in and around the pool was in good condition (e.g. good coverage of native species), however the vegetation in and around the inlet channel was degraded (e.g. reduced zonation and increase coverage of exotic species).

Management objectives (Stage 1 of the framework) and water regime requirements (Stage 2 of framework) were identified for Spadoni's Billabong and from this a water regime delivery design was developed (Stage 3 of framework). The previous paper (Logan et. al. 2016) detailed the management objectives and water regime requirements for the billabong and identified several environmental water delivery options that could be implemented to increase the frequency of inundation of the billabong. These included pumping water directly from the Yarra River to the inlet channel, lowering of the river bank and modification of the existing inlet channel to allow river inflows to the billabong at a lower level than current, or connection of the billabong to an adjacent billabong that received inflows at a lower level. It was identified that lowering the river bank and modifying the existing inlet channel was the preferred option due to its effectiveness, low ongoing costs and no risk of vandalism.

In April 2016, Melbourne Water undertook the works to lower the inlet channel at Spadoni's Billabong. The lowered inlet channel is a grassed channel (up to 20 m wide), with rock embankments at the inlet and a low bank slope to facilitate foot traffic and vehicle access (Figure 1). Revegetation works were also undertaken at the inlet to help promote restoration of aquatic vegetation at the site.

Figure 1. Spadoni's Reserve Billabong – Left: inlet prior to works. Right: works undertaken to lower the inlet level and the lowered inlet in operation.

Since completion of the works at Spadoni's Billabong, the billabong re-engaged in 2016 and 2017, providing inflows that would have otherwise not entered the billabong prior to the works. This increase in inundation and associated measures (e.g. revegetation) has had significant ecological benefits to the site, including a deafening chorus of frogs 24 hours after inundation and increased aquatic native vegetation.

Revegetation undertaken at the inlet structure was successful with >95% survival. The use of geo-fabric to control weed growth in particular has been very successful and it is recommended that it should be utilised elsewhere in the reserve to minimise the risk of failure due to weed competition. Revegetation on the northern bank of the inlet channel was not as successful with competition from weeds and Common Reed (*Phragmites australis*). This has occurred despite evidence of weed control prior to planting. The new inundation regime has likely favored Common Reed, which is native to the area, so should not be considered a significant problem.

Monitoring of the vegetation within Spadoni's Billabong has been undertaken yearly since the completion of works and has shown that the vegetation cover has greatly improved as a result of the inundation, changing from a predominantly non-native vegetation community to a predominantly native Aquatic Herbland community dominated by Slender Knotweed (*Persicaria decipiens*) and Lesser Joyweed (*Alternanthera denticulate)*, and the exclusion of weeds such as Drain Sedge and Toowoomba Canary Grass, that were noted prior to the works being undertaken (Figure 2). The extent and condition of this community is likely to increase overtime with more inundation events. Common Reed on the boundaries of the billabong may creep into the Aquatic Herbland community in drier periods, but is expected to recede with frequent or prolonged inundation to maintain the boundary between the herbland and fringing swamp and floodplain communities.

Figure 2. Spadoni's Reserve Billabong – vegetation response over time. A - January 2015 pre works,

dominated by exotic species. E - April 2017 post works, increase in native vegetation

Other ecological responses observed by Melbourne Water and community members were an increase in frogs and birdlife at the billabong, this is likely due to the increase in available aquatic/ preferable habitat for these species (e.g. water source).

The hydrological and ecological response of Spadoni's Billabong to the modification of the inlet level to the Yarra River has been overwhelmingly positive, with the condition of the billabong expected to continue to improve over time with subsequent inundation events.

Bolin Bolin Billabong

Bolin Bolin Billabong is a high value ox-bow lake on the floodplain of the Yarra River in metropolitan north-east Melbourne. Under natural conditions the billabong has three distinct zones; a permanent pool, two wet-dry arms that are intermittently inundated and the floodplain that sits above the wet-dry zone (GHD, 2011).

Bolin Bolin Billabong has been identified as having high conservation and cultural heritage value. Up until the mid-late 1990s the billabong filled regularly with flood waters from the Yarra River. Inundation events during this time occurred at least once a year on average and rarely would the billabong go for successive years without being wetted with floodwaters. Since the mid-late 1990s, Bolin Bolin Billabong has only received flood waters from the Yarra River four times (2000, 2004–2005, 2010 and 2017) with the exception of the permanent pool at the deepest eastern end of the billabong. This altered hydrology has caused changes in vegetation (e.g. increase in terrestrial species) and habitat quality, changing the characteristics of the site.

Stage 1 and Stage 2 of the framework were undertaken for Bolin Bolin Billabong and a number of uncertainties were identified including the stratigraphy of floodplain (i.e. varying gravel, sand, clay layers), seepage rates and billabong volume and how these may influence the delivery of an environmental watering solution at the billabong. If the source of the water that maintains the permanent pool is sub-surface flow from the Yarra River through the sand/ gravel lens beneath the billabong (Figure 3), there is potential that any environmental water delivered to the permanent pool may drain to the Yarra River through the lens (when the river height is below the water level in the pool). This sub-surface connection to the Yarra River would not have been an issue prior to the regulation of the river as the river water level was higher and therefore the river height would have always been above water level in the pool.

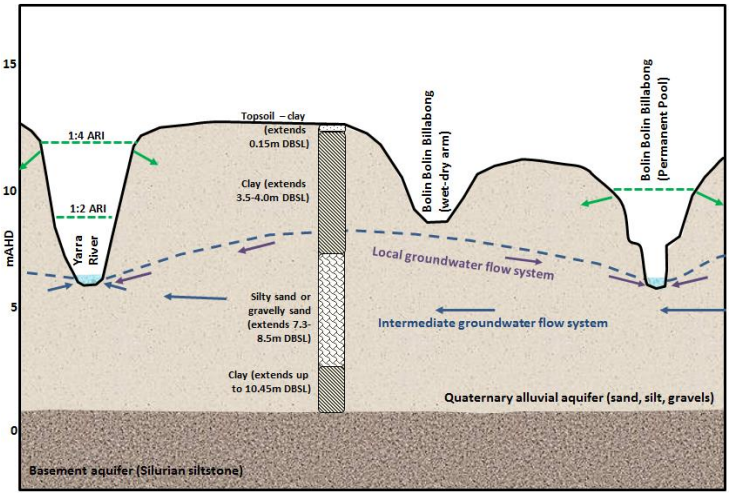

Figure 3. Conceptual diagram of Bolin Bolin Billabong including stratigraphy.

In order to understand the potential relationship between Bolin Bolin Billabong and the Yarra River and how this might influence the delivery of an environmental watering solutions, it was recommended that a trial watering event be undertaken. The aim of the trial watering event was to provide information on the likely

drainage rate and also determine if there are any characteristics of the billabong that may restrict the draining (e.g. layer of silt in the base of the billabong may limit draining).

In October 2017, Melbourne Water undertook a trial watering event to investigate the uncertainty around the billabong substrate and seepage rates and to inform the development of a water regime delivery design (Stage 3 of framework). Water was pumped directly from the Yarra River at the natural inlet on the southern arm using around 70 ML of water from the Yarra's Environmental Entitlement. Monitoring was undertaken pre, during and post the watering event to monitor water levels and vegetation response in the billabong. Monitoring included vegetation assessment before and after, photopoints before, during and after, surface water and groundwater level monitoring and time lapse photography (Jacobs, 2018).

Figure 4 Bolin Bolin Billabong pre and post environmental watering event (November, 2017). Left – permanent pool prior to watering. Right – permanent pool post watering.

The monitoring data collated during the environmental watering event is not yet available, however site observations included increased number of frogs, positive vegetation response (e.g. increase in native aquatic species coverage) and increased usage by waterbirds. A fish survey was undertaken of the permanent pool prior to watering which found many short finned eels.

Incidentally, approximately 1 month after the trial environmental watering event (early December 2017), high flows in the Yarra River resulted in the billabong being inundated naturally through the inlet to the Yarra River on the southern arm of the billabong. The whole billabong was inundated, with the southern arm draining within a week and the northern arm holding water for an extended period of time (e.g. >1 month). It is likely that the billabong held water in it for a longer period of time during this natural event than recorded in the trial environmental watering event because during the trial watering the soils and underlying storage was saturated to enable the billabong to hold additional water during the natural event rather than draining to the sub surface storage or back into the river via the sandy/ gravel lenses.

This site is of significant cultural value to the Wurundjeri People and the inclusion of cultural learnings will be incorporated into identifying the long term solution. As monitoring data collated during the environmental watering event and natural high flow event is not yet available, a permanent environmental water delivery option is not yet confirmed. It is likely however that from site observations and the hydrological response of the billabong from the trail environmental watering event and the natural high flow event, that the preferred option will include formalising (e.g. clearing, lowering and widening) the current inlet channel from the Yarra River to allow greater volumes of flow into the billabong.

Banyule Billabong

Banyule Billabong sits within the Yarra Valley Parklands at Banyule Flats, Heidelberg and is recognised as a priority area for fish, vegetation, frog and social values in Melbourne Water's Health Waterways Strategy. The billabong has a number of distinct zones (Figure 5). The main billabong (9.2 Ha) is comprised of two

different habitats, a deep freshwater marsh and a shallow freshwater marsh. It is typically inundated seasonally, but may dry out for extended periods every 4-5 years. A smaller associated billabong is located to the east of the main billabong (1.9 Ha) and comprises a freshwater meadow which is typically <0.3 m deep and inundated for <4 months/yr. Both billabongs are remnants of river channel migration across the Yarra River Floodplain. A lack of inundation from the Yarra River compared what would have occurred naturally natural is affecting a range of wetland values, such as the health and distribution of wetland vegetation (e.g. increased terrestrialisation of the billabong) (Jacobs, 2017).

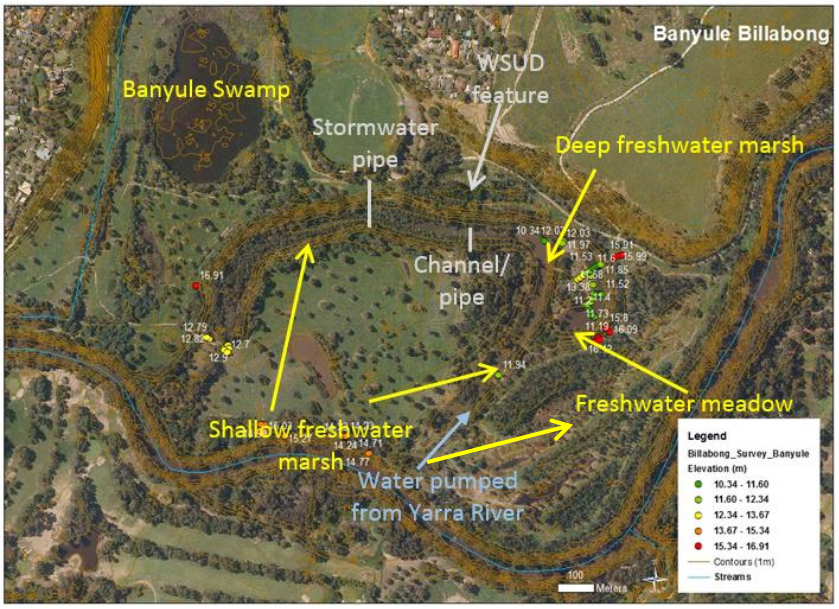

Figure 5. Banyule billabong zones – freshwater meadow and deep and shallow freshwater marsh

A storm water fed wetland is located to the north west of the billabong, Banyule Swamp, which is a broad, shallow wetland fed from drains entering the swamp at the northeast corner. In 1984 Heidelberg Council converted the site to a wildlife sanctuary and in 1999 the Banyule City Council blocked the southern drain and built up the level of the west bank, enabling the swamp to hold water permanently (Context Pty Ltd, 2014).

Management objectives (Stage 1 of framework) and water regime requirements (Stage 2 of framework) for Banyule Billabong have been identified (SKM, 2012), however similar to Bolin Bolin Billabong there were a number of uncertainties around the subsurface connection with the Yarra River, seepage rates and billabong volume. In November/ December 2016 Melbourne Water undertook a trial environmental watering event to address these uncertainties and inform the development of a water regime delivery design (Stage 3 of framework). Water was pumped directly from the river at the eastern arm, using around 65 ML of water from the Yarra's Environmental Entitlement. The same suite of monitoring that was undertaken at Bolin Bolin Billabong was undertaken with the exception of groundwater as there was no existing bore in the area

Prior to watering (December 2016), vegetation across the bed of the billabong was dominated by weeds, including Fat Hen (*Chenopodium album*) and Spear thistle (*Circuim vulgare*): 70-75% of the bed was covered by Spear Thistle (Melbourne Water, 2017, Figure 6a). Native species present prior to watering included Shrub Nettle (*Urtica incisa*), Lesser Joyweed (*Alternanthera denticulate*), Tall Sedge (*Carex appressa*) and Pale Rush (*Juncus pallidus*). Post watering (April 2017), the native Knot Weed, (*Persicaria* sp.) became dominant with overall weed coverage reduced to <1% cover (Figure 6b). However, more recent observations December 2017 (Figure 6c) show that the weed coverage has returned to a level comparable to that observed prior to the watering. A key learning for the delivery of environmental water for these sites is that a follow up inundation event or targeted weed control after watering may be required to prevent recolonisation by weeds. Similar to Spadoni's Billabong, other ecological responses observed by Melbourne Water and community members as a result of the trial watering included an increase in frogs and birdlife at the billabong.

A review of the water level monitoring data from the trial environmental watering event found that Banyule Billabong was filled to a depth of 1.81 m over 10 days which is consistent with the requirements for billabong inundation in the Yarra River catchment, as recommended in Dodo Environmental (2010). It then took 77 days to dry out at an average decline of 0.02 m/day. The hydrological information was used to determine the feasibility of implementing the preferred water regime SKM (2013) comprising permanent inundation of the deep freshwater marsh and seasonal inundation of the shallow marsh and meadows for up to 6 months in winter and spring. The review of the hydrological information found that higher than predicted drawdown rates mean it is unlikely that a permanent deep marsh zone could be maintained, probably due to permeable gravels underlying the billabong (similar to Bolin Bolin Billabong).

Figure 6. Banyule Billabong Permanent photo monitoring points. a) November 2016 looking east, b) April 2017 looking east (Melbourne Water, 2017), c) September 2017 looking north.

Under current conditions, water commences to enter the billabong through a pipe buried in the river bank when flow in the Yarra River reaches 16,000 ML/d (11.4 m AHD). Overbank flow then enters the billabong when flow reaches approximately 24,000 ML/d (12.2 m AHD). The deepest part of the billabong is at 11.0 m AHD (~12,400 ML/d). Hence, if the inlet to the billabong was lowered in an attempt to increase the frequency of duration of inundation the lowest that level could be is 11.0 m AHD. An analysis of the flow regime in the Yarra River suggests that flow in this range (12,400 ML/d to 24,000 ML/d) is significantly higher than is currently experienced in the Yarra River and therefore there is limited opportunity to lower the inlet to the billabong to increase the frequency of inundation (Figure 7).

Given that lowering the inlet level in its own right will not achieve increased inundation of Banyule Billabong, the most feasible option for a water regime delivery for the billabong is an alternate water source. A potential option is to connect the billabong to the Banyule Swamp, a stormwater wetland. Further investigation into the volume and availability of excess water from Banyule Swamp, and water quality analysis to determine potential ecological impacts, is required to conclude whether this preferred option is feasible.

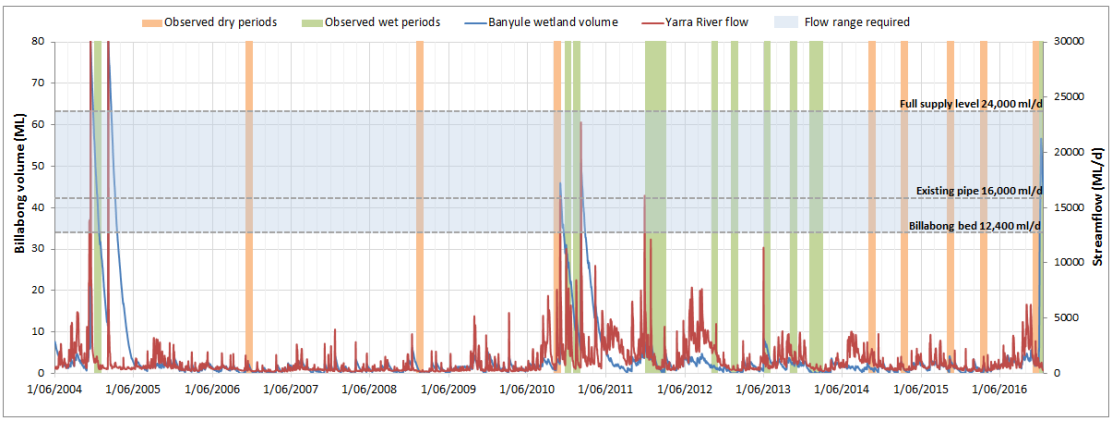

Figure 7. Banyule billabong – modelled volume of water in the billabong (blue line), Yarra River streamflow (red line), and aerial imagery and historical observations showing wet or dry conditions (orange and green shading).

Conclusions

The implementation of permanent water regime delivery options and the delivery of environmental water has been successfully undertaken to reconnect and rehabilitate three billabongs along the Yarra River that have historically experienced changes to their hydrological regime.

At Spadoni's Billabong the permanent modification of the inlet to the Yarra River has been successful in increasing the frequency of inundation of the billabong, with additional inundation occurring a number of times in 2016 and 2017 as a direct results of the works. This increase in inundation has resulted in observable ecological benefits to the site including increased aquatic native vegetation coverage, decreased weed coverage and increased frog and birdlife. Associated measures such as revegetation of aquatic vegetation at the site and geo-fabric to control weeds have also aided the ecological outcomes of these works.

At both Bolin Bolin and Banyule Billabong, the delivery of a trial environmental watering event has provided valuable information in relation to the hydrological and ecological response of the billabongs, which will be used to inform the preferred permanent water regime delivery option. The response of these billabongs is an emerging story as not all monitoring data is yet available.

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