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Integrated Hydrological Operations Plan for the Billabong, Yanco and Colombo Creeks - Literature Review and Stakeholder Consultation

Murray Local Land Services

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The Billabong Yanco Project

The Billabong Yanco Project was initiated by Murray LLS with funding from the Federal Government's National Landcare Program. The Billabong Yanco Project is guided by the Billabong Yanco Project Steering Committee which is made up of local stakeholders. The project aims to promote a resilient, productive Billabong Yanco system with healthy ecosystems and communities.

The Hydrological Operations Plan

The scope of this study was to develop a hydrological operations plan for the Billabong, Yanco and Colombo Creeks that integrates the economic, social and ecological needs and aspirations of key stakeholders in a balanced and equitable way. This project involved identifying and liaising with key Billabong Yanco System stakeholders to:

- review social, ecological and environmental studies;
- identify critical knowledge gaps that may influence the development of the plan and recommend a way forward;
- incorporate the needs and aspirations of stakeholders into the plan; and
- develop a prescriptive and pragmatic hydrological operations plan that integrates the needs and aspirations of key stakeholders in a balanced and equitable way.

The project is presented in two reports:

- a literature review and stakeholder consultation findings (this report); and
- a hydrological operations plan.

The Billabong Yanco Region

The Billabong Yanco System is an anabranch complex that broadly connects the Murrumbidgee River near Narrandera with the Edward River at Moulamein. The main source of water is the Murrumbidgee, from which water is diverted into Yanco Creek at Yanco Weir. Unregulated flows enter from the Billabong Creek catchment and other tributaries. Drainage flows and regulated flows enter from adjacent irrigation areas. The system is extensive, with almost 800 km of natural channels over a region that stretches 250 km from east to west.

Water is central to the economic life of the Billabong Yanco region. The system supplies water for irrigated crops, pastures and for stock and domestic use. The system is the principal water supply for the towns of Morundah, Urana and Jerilderie. Water is important as a recreational resource and supports a popular fishery as well as water sports. Water is central to the culture of the traditional owners.

Hydrology and Water Management

Yanco Weir allows flow into Yanco Creek to be controlled over a range of Murrumbidgee discharge from 1,500 ML/d to 15,000 ML/d. Above that range approximately 10% of Murrumbidgee flow is diverted to Yanco Creek.

Flow within the Yanco system is regulated at key locations to manage water delivery. Weirs regulate the share of water between Colombo Creek and Yanco Creek (Tarabah Weir) and between Forest Creek and Billabong

Creek (Hartwood Weir and Forest Creek Regulator). The delivery of regulated water in Forest Creek terminates at Warriston Weir.

There are over 30 private licenced fixed crest weirs. Many of the weirs date from the early twentieth century and were constructed to provide a local store of water for stock and domestic use during low flow periods. The weirs continue to facilitate irrigation water supply and contribute to the recreational and amenity values of the region. However the weirs also fragment fish habitat and prevent the passage of migratory fish.

WaterNSW manages the Yanco System to deliver around 110 GL annually to 480 licences. Regulated flow in upper Yanco Creek is usually limited to 1,400 ML/day to prevent excessive losses from overbank flows. A minimum diversion of 500 ML/d is usually provided year-round for stock and domestic requirements. A minimum daily flow of 50 ML/d at Darlot is provided to maintain connectivity with the Edward River.

Outfall drains are used to supplement water supply and overcome capacity constraints. Water may be provided from the Coleambally Irrigation Area to Yanco Creek and from the Murray Irrigation District to Billabong Creek and Forest Creek.

Flows entering the top end of the Yanco system at the Murrumbidgee River typically take four to five weeks to reach the Edward River.

Water Management Initiatives

A range of initiatives are in progress to improve water management efficiency and flexibility.

The Sustainable Diversion Limit adjustment mechanism is a process of the Murray-Darling Basin Plan where the amount of water available to irrigators can be increased if environmental water needs can be met more efficiently. The three SDL offset projects proposed for the Billabong Yanco System are:

- Computer Aided River Management system (CARM), which uses advanced monitoring, control and modelling to improve water delivery;
- Upgrading the Yanco Regulator to provide greater control over a wider range of flows; and
- Modernisation of Effluent Systems, involving improved monitoring and new or upgraded flow regulation structures.

Two policy constraints on the use of environmental water are being reviewed under the Pre-requisite Policy Measure Implementation Plan. These are:

- the use of regulated water to augment the environmental benefits of unregulated tributary inflows (piggybacking)
- recognition of return flows from environmental watering events to allow that water to be used to water other environmental sites or outcomes.

The Constraints Management Strategy is an initiative of the Murray-Darling Basin Authority to identify ways to increase the frequency and duration of small overbank flows to sustain and improve floodplain health, while mitigating any effects this water may have on property and people. The strategy is investigating upper and lower thresholds for small overbank flows at the Yanco Creek offtake of 2,174 ML/d and 3,715 ML/d.

The Environmental Works and Measures Feasibility Project identified opportunities to contribute to the target for environmental water set out in the Murray-Darling Basin Plan. The project identified Forest Creek as a

highly inefficient water delivery system. A pipeline was proposed to deliver 24 GL/year of stock and domestic water supplies from the Hartwood Weir pool to the licensed users along Forest Creek.

Economic Values of Water

The Billabong Yanco System supports the economy of the region by providing town water, stock and domestic water and irrigation water.

The Billabong Yanco System supports the principal town of Jerilderie and smaller townships of Conargo, Morundah and Wanganella. Dryland agriculture is the most widespread economic enterprise and includes sheep, beef cattle and grain farming. Irrigated agriculture is the greatest contributor to economic productivity.

Cultural Values of Water

The Indigenous cultural groups associated with the Yanco Creek System are Wiradjuri, Yorta Yorta, Barapa Barapa and Wamba Wamba Nations.

For the Indigenous custodians of the region, the natural landscape features highly productive watercourses, wetlands and floodplains. These environments are culturally important and are traditional sources of food, shelter and other resources. The significance of the traditional values of the region is indicated by over 826 cutural heritage sites recorded along watercourses in the Yanco Billabong region (Aboriginal Heritage Indigenous Management System database).

The term Cultural Flows translates the complex relationship described by Traditional Owners into the language of water planning and management. This is in its early phase of development at the State and National level and only limited consultation with the local Indigenous groups on the cultural values of water has been conducted by Murray Local Land Services. There is much scope for further consultation and understanding of the value of water to the nations of this region.

Recreational and Social Values of Water

The presence of water in the Billabong Yanco System, the health of riparian vegetation and the existence of a healthy native fishery is highly valued by members of the community. Healthy river values are associated with reliable high flows and occasional overbank flood events.

Watercourses provide visual amenity in townships. Lake Jerilderie and the adjacent Luke Park is an important recreational asset in Jerilderie. Water skiing is an important recreational activity in the region.

Ecology

The Billabong Yanco ecosystem comprises:

- permanent aquatic habitats of the creek channels and weir pools;
- intermittently flowing channels and anabranches that become active at high flows or after heavy localised rainfall;
- riparian bank areas that regularly interact with flowing channels;
- wetlands that retain flood and rain water; and
- floodplains that shed water when flood levels recede or after heavy localised rainfall.

The dominant riparian vegetation is Red Gum Woodland. Frequently inundated or waterlogged areas support a sedgy understorey which includes Cumbungi, Common Reed, sedges and rushes. Less frequently flooded areas support Black Box Woodland which typically supports a grassy or shrubby understorey with Old Man Saltbush, Lignum and Nitre Goosefoot (SKM 2011).

Riverine aquatic habitats in the Riverina are listed as an Endangered Ecological Community under the *Threatened Species Conservation Act* 1995 (NSW). The community includes all native fish and aquatic invertebrates in all natural creeks, rivers and associated lagoons, billabongs, lakes

Key conservation values of the Billabong Yanco System include:

- Upper Yanco Creek supports one of only two known self-sustaining populations of the nationally endangered Trout Cod;
- The system supports populations of Murray Cod, Golden Perch and Freshwater Catfish;
- The system features extensive floodplain wetland systems including Dry Lake and Wanganella Swamp. These sites support large populations of breeding waterbirds and extensive and diverse aquatic plant communities
- Southern Bell Frog an endangered species in NSW were found in the Mid Yanco Creek in October 2017.

Important threats to conservation values include:

- weirs, which fragment fish populations, obstruct the movement of migratory fish species;
- low winter flows which provide poor quality habitat for fish and other aquatic fauna and may reduce the successful recruitment of young of year fish;
- infrequent overbank flows that are required to sustain floodplain vegetation and aquatic fauna habitat;
- grazing of riparian zones and floodplains;
- aquatic weeds, particularly species that benefit from the stable water levels upstream of weirs, including Sagittaria, Cumbungi and willow; and
- floodplain weeds including African Boxthorn and Lippia which compete with native plant species in intermittently flooded environments.

The community has invested significantly in weed control through willow and African Boxthorn removal programs.

Stakeholder Priorities

Stakeholder water management interests and concerns were identified through consultation. Priority issues for stakeholders were:

- Under current arrangements, stream flow is maintained by the delivery of water to meet irrigation demands and to meet stock and domestic water requirements. A reduction in flow will have a negative impact on stream health and should be prevented.
- Supplementary flows are important to the environment and critical to many farm businesses. The share and timing of suppementary flows between the Murrumbidgee and Yanco Creek should not be changed.
- Water entitlements have been sold out of the region to other irrigators and under the environmental buy-back projects Water for Rivers and The Living Murray. While the purpose of buy-backs has been to

improve environmental health, the perceived local effect has been a reduction in in-stream and overbank flows, with potential negative impacts for the environment.

- There is unused potential to improve water delivery using irrigation escapes and outfalls. These channels allow water to be introduced when supply in Upper Yanco Creek is constrained.
- Re-crediting end of system flows to the Murray catchment would improve water management. WaterNSW could operate the river at higher levels which would reduce the likelihood of gaps in river flow. OEH could also provide baseflows and freshes at a lower cost to environmental accounts because water could be re-credited.
- Overbank flows in the Upper Yanco and Mid Yanco are important to the environment. OEH is seeking amendments to the Water Sharing Plan so that flows over 1,400 ML/d at the Yanco Offtake may be provided for environmental purposes.
- River operations could incorporate environmental flow objectives including the delivery of baseflows and pulses or controlling rates of rise and fall. In many cases, these can be achieved by managing the delivery of consumptive water, without using environmental water.
- A new weir has been proposed at Conargo downstream of the Yanco-Billabong confluence. The weir would regulate some of the flow from the Billabong catchment which currently cannot be stored. The weir is considered to be problematic. The new weir would involve decommissioning Hartwood Weir which would make it impossible to deliver water to Forest Creek. A lower cost alternative would be to refurbish Hartwood Weir.
- Reliable delivery of water orders requires good information on the distribution of flow in the system at any given time. The existing flow gauging system is considered inadequate by several stakeholders.
- Opinions vary on the benefits and impacts of the weirs. Some stakeholders believe that most weirs are overtopped so frequently that they do not present a significant barrier to fish. Others, particularly fish ecologists, believe that the fish community would benefit significantly by the removal of the weirs. The position of OEH is that weirs are an environmental hazard and undesirable, except where they assist in environmental watering. If weirs are necessary, their impacts on fish passage should be mitigated by fishways.
- The system includes important wetland complexes but there is little information to describe the flora and fauna they support or their water requirements. Better information is required to support environmental watering decisions.
- The community supports improved monitoring and notification systems for water quality and supply disruption.
- Stop banks were constructed along the Forest Creek Anabranch to prevent stock and domestic water from escaping to Billabong Creek. Although the creek is no longer regulated, there are still many blockages in place. The blockages obstruct natural flow paths and should be removed.

Knowledge Gaps and Next Steps

High priority knowledge gaps to improve water management are:

- The environmental water needs of wetlands in the Billabong Yanco System should be investigated to support environmental watering decisions.
- The flows required to maintain or restore indigenous cultural values should be determined.
- Investigations to determine flows required to secure the Trout cod population in Upper Yanco Creek should be continued.

- An economic and water management investigation is required to understand the relationship between agricultural production and water supply.
- Complementary actions will improve the effectiveness of environmental watering and should be investigated. Complementary actions include control of grazing in high value riparian areas, rehabilitation of fixed crest weirs and control of weeds.

1 INTRODUCTION

1.1 THE BILLABONG YANCO PROJECT

The Billabong Yanco Project is an initiative of Murray Local Land Services (Murray LLS). The goal of the project is to collaborate with the local community in the Billabong Yanco region to identify and address issues relevant to local communities and environments. The project is being funded over four years by the NSW Government Catchment Action and the Australian Government's National Landcare Programme, and is being directed by a steering committee made up of various community stakeholder representatives. It focuses on the waterways in the project area and the environments, communities and production values these waterways support.

The project aims to promote 'a resilient, productive Billabong Yanco system, with healthy ecosystems and communities' by:

- improving the condition, diversity and connectivity of the ecological aspects of the system;
- increasing community cohesion and diversity; and
- improving the region's economic productivity and diversity.

The strategic plan for the Billabong Yanco Project explored opportunities to address these themes (Murray LLS, 2015) including the development of an "integrated management plan for water flows in the Billabong Yanco Creek System".

1.2 SCOPE OF WORK

The scope of this project is to develop a hydrological operations plan for the Billabong, Yanco and Colombo Creeks that integrates the economic, social and ecological needs and aspirations of key stakeholders in a balanced and equitable way.

More specifically, this project involves identifying and liaising with key Billabong Yanco System stakeholders to:

- conduct an extensive literature review of social, ecological and environmental studies relevant to the development of the plan;
- undertake a gap analysis of the literature and identify critical knowledge gaps that may influence the development of the plan and provide recommendations on a way forward;
- identify and liaise with key stakeholders and incorporate their needs and aspirations into the plan; and
- develop a prescriptive and pragmatic hydrological operations plan that integrates the needs and aspirations of key stakeholders in a balanced and equitable way.

1.3 METHODOLOGY

The literature describing water management objectives and operations was reviewed. The review was based on information provided by Murray LLS and other stakeholders and information available in the public domain.

A three-day inspection of the system was made from February 19 to 21 2017. The inspection was guided by Jim Parrett and involved visits to over 50 sites from the Yanco Offtake to Moulamein and discussions with landholders.

Other stakeholders were consulted after the inspection to identify concerns and priorities for water management in the Billabong Yanco System (Table 1).

Table 1. Stakeholders consulted in the preparation of this report

Name	Organisation / Interest
Rick Webster	Murray Wetlands Working Group
Jim Parrett	Environmental contractor, YACTAC member
Jason Epps	Riverina Water County Council
Russell Ford	Chair, Yanco Creek and Tributaries Advisory Council (YACTAC)
Rodney Anderson	Noxious Weeds Inspector, Federation Council
James Maguire	Office of Environment and Heritage (OEH)
James Dyer	OEH
Luke Pearce	Fisheries Manager, Aquatic Ecosystems, DPI Fisheries
Roslyn Lockhart	Aboriginal representative
Vince Kelly	WaterNSW
Max Bryce	Jerilderie Fishing Club
Sam Trinca	Landholder, Silver Pines
Phil Lenehan	Landholder, Wirrani (Mollys Lagoon)
Mark Rowe	Landholder, Narimba (Dry Lake Wetland)
Tanya Thompson	Executive Officer, YACTAC
Colin McCrabb	Landholder, Avenel
Digby Jacobs	NSW DPIWater
Dave Tamlyn	Murrumbidgee Council
Phil Maher	Bird Ecologist
Peter Beal	Riverina Local Land Services
Ken Crossley	Murray LLS Board Member, Yanco Irrigator
Jamie Anderson	Colombo Ski Club Committee Member
Sally Dye	Landholder between Billabong Creek and Edward River near Darlot, former Murray CMA board member
Andrew Brown	NSW DPI Water

Following completion of the literature review, a workshop was held for stakeholders on May 29 at the Jerilderie Civic Centre (Appendix A). The objectives of the workshop were:

- to review the operation of the system and its social, economic and environmental functions;
- for stakeholders to present their main values and needs for water management;
- to review good aspects of operations that should be preserved and aspects that should be improved; and
- to provide guidance on the development of the waterway operations plan.

The literature review and workshop identified water management issues that are important to the community. These issues were investigated further with the objective of providing the community with the data and other resources to engage with managers in water management planning.

2 REGIONAL SETTING

2.1 THE BILLABONG YANCO SYSTEM

The Billabong Yanco System is a braided anabranch complex that broadly connects the Murrumbidgee River near Narrandera with the Edward River at Moulamein. The main source of water in the system is the Murrumbidgee, where water is diverted into Yanco Creek at Yanco Weir via a cutting. The system receives unregulated inflows from the Billabong Creek catchment as well as drainage flows and regulated flows from adjacent irrigation areas. The system is extensive with almost 800 km of natural channels over a region that stretches over 250 km from east to west.

Water supply is central to the economic life of the Billabong Yanco region. Water maintains irrigated crops and pastures over an extensive area. The system is the principal water supply for the towns of Morundah, Urana and Jerilderie, and provides water for stock and domestic use throughout the region. Water is important as a recreational resource and supports a popular fishery as well as water sports. Water is also central to the culture of the traditional owners.

2.2 THE RIVERINA BIOREGION

The Billabong Yanco System lies within the Riverina Bioregion, a low relief plain of approximately 9 million hectares located west of the Great Dividing Range in south-central New South Wales and north-central Victoria. The bioregion extends from Narrandera in the east to Balranald in the west and from Bendigo in the south to Ivanhoe in the north (Eardley, 1999).

Soils and landforms derive from the drainage from Eastern Highlands into the Murray-Darling Basin. Millions of years of deposition have created a complex landscape system of alluvial fans, anastomosing channels, prior streams, floodplains, lakes and wetlands. The sediments are largely fluvial with some lacustrine and aeolian elements. The principal contemporary watercourses are the Murray River and the Murrumbidgee River (Eardley, 1999).

The climate is semi-arid, characterised by hot summers and cool winters. The highest rainfall months tend to be May and September. Summer rainfall tends to occur mainly from localised thunderstorms with more consistent rain occurring in winter. Annual rainfall decreases from east to west. Within the Billabong Yanco System rainfall ranges from 442.7 mm at Urana to 356.8 mm at Moulamein (BOM data). Elevation ranges from 173 m AHD at Narrandera to 74 m AHD at Moulamein.

The dominant vegetation types of the region are native grasslands and shrublands comprising Bladder Saltbush, Old Man Saltbush, Boree Woodland and Cotton Bush. These communities generally occur on sandy loams and poorly drained clays. Cypress Pine, Grey Box and Yellow Box woodlands occur on lighter textured soils and sandhills (Eardley, 1999).

Riverine forests form relatively narrow corridors along the major watercourses. They are particularly important habitat features in a landscape that largely lacks tree cover, providing habitat for fauna that depend on trees for food, cover and nesting sites. Significant fauna species known to inhabit riverine forests include the Superb Parrot, Sugar Glider, Feathertail Glider, Squirrel Glider, Brush-tailed Phascogale, Koala, Carpet Python, Freckled Duck and Peregrine Falcon (Eardley, 1999).

Water spilling from watercourses fills floodplain wetlands and swamps which are vegetated by Lignum and Nitre Goosefoot Shrublands. This community is important habitat for waterbirds, supporting breeding by large numbers of birds and providing habitat for migratory species (Eardley, 1999). It is a vegetation type that has been cleared extensively in irrigated areas.

Intermittently inundated areas support Black Box Woodland with a shrubby or grassy understorey that typically includes Lignum, Nitre Goosefoot, Old Man Saltbush and Bladder Saltbush. Black Box Woodlands provide habitat for a variety of birds of conservation significance including the Bush Stone-curlew and Superb Parrot (Eardley, 1999).

About 96% of the bioregion is freehold or leasehold. The remaining 4% is Crown Land and includes state forest, conservation reserves, travelling stock reserves and other public use areas (Eardley, 1999).

The bioregion supports broad-acre agriculture including dryland cropping and sheep and cattle production as well as intensive irrigated agriculture. The bioregion includes the irrigation districts of Murrumbidgee, Hay, Coleambally, Tullakool and Deniliquin (Eardley, 1999).

2.3 THE MURRUMBIDGEE CATCHMENT

The Billabong Yanco System is located in the Murrumbidgee River catchment.

The Murrumbidgee River catchment is part of the Murray-Darling Basin (MDB) and is located entirely in New South Wales (CSIRO, 2008). The catchment covers 87,348 km^2 or 8.2 percent of the MDB. The region is bounded to the east by the Great Dividing Range, to the north by the Lachlan region and to the south and west by the Murray region. The topography varies from the alpine regions of the Kosciuszko National Park to the low-lying plains of the western Riverina.

Major water resources in the region include the Murrumbidgee River and its tributaries, the Snowy Mountains Hydro-electric Scheme and its associated storages, alluvial aquifers, wetlands and water storages. The major irrigation water supply dams are Blowering on the Tumut River and Burrinjuck on the Murrumbidgee River.

The average annual rainfall for the region is 530 mm varying from around 1,500 mm in the east to 300 mm in the west. The Murrumbidgee region contributes 15.7 percent of the total runoff in the MDB, with nearly all of this originating from the highlands in the eastern half of the region (CSIRO, 2008).

The regional population is approximately 500,000. The larger urban centres are Canberra, Wagga Wagga, Leeton and Griffith.

The predominant land use is dryland pasture for broadacre grazing. Dryland cropping is also a major enterprise (CSIRO, 2008). Approximately 426,000 ha of land is irrigated (2000 data) with the principal crops being cereals (including rice), pastures and hay production (CSIRO, 2008). Approximately 17 percent of the region is covered by native vegetation.

Important ecological assets that depend on flow in the Murrumbidgee catchment are:

- Mirrool Creek system and Murrumbidgee Irrigation Area (including Fivebough Swamp, Tuckerbil Swamp, Barren Box Swamp and the Lower Mirrool Creek Floodplain);
- Murrumbidgee River channel;
- river-fed wetlands in the Murrumbidgee River system (from Gundagai to Maude, including the Mid-Murrumbidgee wetlands);
- Lowbidgee wetlands which covers 200,000 ha and includes the Nimmie-Pollen-Caira system and the Redbank-Yanga system;
- lowland floodplain wetlands in the Murrumbidgee River system (from Balranald to the Murray River junction, including 'The Junction' wetlands; and
- river-fed wetlands in the Yanco system (SKM, 2011).

Sixteen wetlands in the Murrumbidgee catchment are listed in the directory of nationally important wetlands (DEWHA, 2008). None of these wetlands are located in the Billabong Yanco System.

2.4 DRAINAGE SYSTEMS

2.4.1 MURRUMBIDGEE RIVER

The Murrumbidgee River flows south-eastwards to Cooma from its headwaters in the Snowy Mountains south-west of Canberra. From there it flows northwards to Yass and then westwards until it joins the Murray River upstream of Euston. The Tumut River is a major tributary that rises in the Snowy Mountains near Cabramurra (CSIRO, 2008).

Flow in the Murrumbidgee is greatly influenced by the dams of the Snowy Mountains Hydro-electric Scheme. The scheme releases water to the river subject to water storage levels and water savings diverted to the Snowy River.

The major irrigation dams are Burrinjuck on the Murrumbidgee River near Yass (constructed in 1928 and enlarged in 1957) with a storage capacity of 1,026 GL and Blowering on the Tumut River upstream of Tumut (constructed in 1968) with a storage capacity of 1,631 GL (CSIRO, 2008).

There are physical and operational constraints in the Murrumbidgee River that limit the volumes of water that can be delivered. These constraints are specified in the Murrumbidgee Regulated River Water Sharing Plan (2003). Capacity constraints are:

- 9,000 ML/d in Tumut River at Oddys Bridge;
- 9.300 ML/d in Tumut River at Tumut;
- 32,000 ML/d in Murrumbidgee River at Gundagai; and
- 1,400 ML/d in Yanco Creek at the offtake.

If flow exceeds these limits, water begins to break out of the main channels. This can impact public and private property and may significantly increase operational losses.

SKM (2011) documents a 600-650 ML/d capacity constraint in Colombo Creek before flooding of private land occurs. WaterNSW have recently adopted a flow limit of approximately 22,000 ML/d at Wagga Wagga which, following attenuation, equates to approximately 17,000 ML/d at d/s Yanco Weir and about 1,700 ML/d at Yanco Creek Offtake (pers. comm. James Maguire OEH).

2.4.2 BILLABONG YANCO SYSTEM

Yanco Creek is both a major effluent stream of the Murrumbidgee River and a tributary system of the Murray River. The Billabong Yanco System consists of four main creeks: Yanco, Colombo, Billabong and Forest creeks (Figure 1).

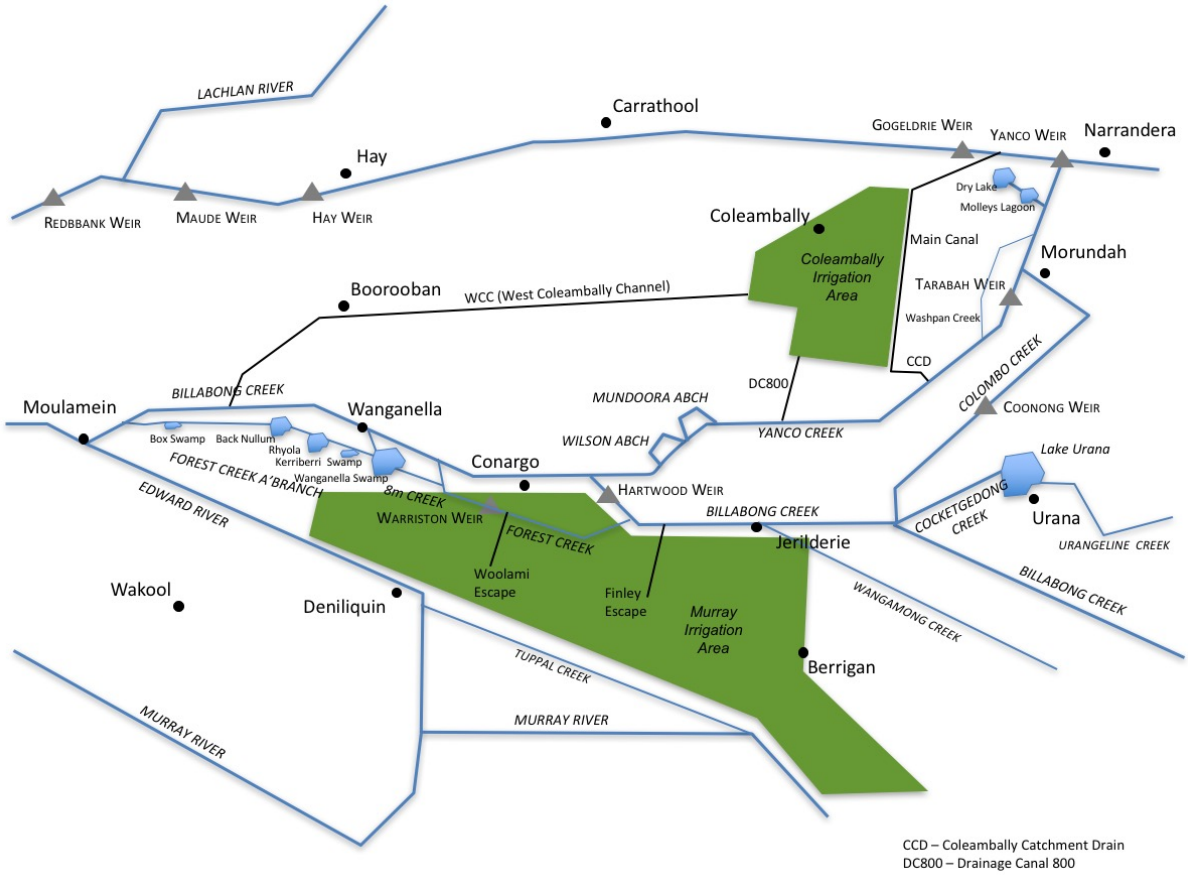

Figure 1. Schematic of Billabong Yanco System

Yanco Creek diverges from the Murrumbidgee River at Yanco Weir 15 km downstream of Narrandera (SKM, 2011). Yanco Creek flows in a south-westerly direction towards Morundah and then in a more westerly direction to Conargo. Colombo Creek is an anabranch that diverges from the left bank of Yanco Creek just north of Morundah and continues in a south-westerly course that is broadly parallel to Yanco Creek.

Washpan Creek is a small anabranch that diverts water around Tarabah Weir on the western side of Yanco Creek.

Billabong Creek is an unregulated tributary of the Yanco Creek system which drains a catchment of 791 km^2 to the east, rising in the western slopes of the Great Dividing Range near Holbrook. The creek is joined by Colombo Creek west of Urana and continues to flow in a westerly direction to Jerilderie.

Billabong Creek and Yanco Creek converge upstream of Conargo. The watercourse continues as Billabong Creek and flows west to join the Edward River at Moulamein (SKM, 2011).

Cocketgedong Creek is an unregulated tributary of Billabong Creek which joins the Billabong upstream of the Colombo Creek confluence. The creek drains the area to the east of Urana via Urangeline Creek, which fills Lake Urana and then continues to the Billabong (Alluvium, 2013).

Wangamong Creek is an unregulated tributary of Billabong Creek that rises near Buraja and flows in a north-westerly direction to join the Billabong near Jerilderie.

Forest Creek is a high-level anabranch of Billabong Creek that diverges from the left bank of Billabong Creek upstream of the Yanco Creek confluence. The anabranch complex includes Forest Creek, Eight Mile Creek, Box Creek, Estuary Creek, the Forest Creek Anabranch and Wanganella Swamp. The anabranch flows in a westerly direction and re-joins Billabong Creek upstream of Moulamein. A number of small effluents along the length of the Forest Creek System permit flow to re-enter Billabong Creek (SKM 2011).

2.4.3 MURRAY RIVER

The River Murray lies to the south of the Billabong Yanco System. The river flows in a westerly direction below Lake Hume at Albury until it reaches the Cadell Fault at Mathoura. The River Murray turns south to Echuca then flows to the north west.

The Edward River anabranch diverges from the right bank of the Murray at Mathoura and flows north to Deniliquin then north-west to Moulamein where it is joined by the Billabong Creek. The Edward River continues in a westerly direction to join the Wakool River and then re-join the River Murray near Balranald.

2.4.4 ADJACENT IRRIGATION AREAS

The Coleambally Irrigation Area (CIA) is located north of Jerilderie, to the west of Yanco Creek. The area was established between 1958 and 1970 when the Water Conservation and Irrigation Commission resumed a number of large pastoral holdings to make use of water from the Snowy Mountains Hydroelectric Scheme. The district is serviced by Coleambally Irrigation Cooperative Limited (CICL) which is Australia's fourth largest irrigation company. CICL delivers irrigation water to 79,000 ha of intensive irrigation and 42,000 ha of large, less-intensively irrigated farms (CICL, 2017). There is an area of 297,000 ha referred to as the Outfall District that access water from the Coleambally drainage channels. Irrigation water is used for crops such as rice, wheat, barley, oats, canola, soybeans, maize, sunflowers, lucerne, grapes, prunes, and pastures for sheep and cattle. The irrigation area is supplied with water from the Murrumbidgee River downstream of the Yanco Offtake.

The Murray Irrigation Area is located to the south of the Billabong Yanco System, between Lake Mulwala in the east and Moulamein in the west. Water is mainly supplied from the Mulwala Canal which flows from Lake Mulwala on the River Murray. The irrigation area is managed by Murray Irrigation Limited and comprises 724,000 ha of irrigated farmland (MIL, 2017).

2.4.5 REGULATION OF YANCO CREEK

Yanco Creek was originally a high-sill effluent of the Murrumbidgee River that flowed intermittently when Murrumbidgee discharge exceeded 40,000 ML/d (White et al. 1985 cited in (FCWG, 2000). Inflow events to Yanco Creek occurred 1 in 2 years with a duration of less than 10% of the time (Alluvium 2013). Billabong Creek, which has its own local catchment, contributed smaller but more frequent flows to the system (Alluvium, 2013).

Work to augment flow to the Yanco Creek system began in 1856 when the offtake at the Murrumbidgee was enlarged. Over the following decades, work to improve flows continued, by deepening and lengthening the cutting, but with limited success. Just before the turn of the century a joint government-settlers fund financed the new McKinney Cutting (Beal et al. 2004) which allowed water to enter Yanco Creek at Murrumbidgee flows exceeding 14,000 ML/d (30% of the time) (White et al. 1985 cited in (FCWG, 2000)). These works were complemented by weirs constructed along the Billabong Yanco watercourses to retain water between flow events.

Yanco Weir and Yanco Regulator were completed in 1928, allowing the Murrumbidgee River to be raised at the Yanco Offtake and to promote additional flow into Yanco Creek (Figure 2). In conjunction with Burrinjuck Dam (also completed 1928) and Blowering Dam (completed 1968) on the Murrumbidgee River, these works facilitated an almost continuous flow in Yanco Creek.

Figure 2. Yanco Weir on the Murrumbidgee River

Yanco Weir allows flow into Yanco Creek to be controlled over a range of Murrumbidgee discharge from 1,500 ML/d to 15,000 ML/d downstream of Yanco Weir (Alluvium 2013). Within that range, the weir may be opened to control the proportion of flow passing down the main stem of the river. Above that range the flow exceeds the capacity of the regulator and the share of flow between the Murrumbidgee and Yanco Creek is uncontrolled (James McGuire OEH pers. comm.). The hydraulics of the offtake directs approximately 10% of Murrumbidgee flow into Yanco Creek.

Flow within the Yanco system is regulated at key locations to manage water delivery (Green, Petrovic, Moss, & Burrell, 2011), (Vincent Kelly Water NSW pers. comm.).

- Tarabah Weir is a variable level weir with a fishway (completed 2011) located on Yanco Creek downstream of the Colombo Creek divergence. Tarabah Weir is operated to control the division of flow into the Mid Yanco and Colombo Creeks.
- Jerilderie Weir provides some storage and therefore assists with the regulation of inflows from Billabong Creek catchment.
- Hartwood Weir is a fixed crest structure on Billabong Creek upstream of the Yanco Creek confluence that provides the head to divert water to Forest Creek.
- The Forest Creek Offtake Regulator is located on Forest Creek downstream of the divergence from Billabong Creek and is used to regulate the flows entering Forest Creek. Uncontrolled flows are estimated to enter Forest Creek when discharge at Hartwood Weir exceeds 1,200 ML/d (Davidson and Webster (2007).
- Warriston Weir is located on Forest Creek Anabranch upstream of Wanganella Swamp. The delivery of regulated flow terminates at this point. Only excess water and flood flows pass Warriston Weir into the Forest Creek Anabranch.

In addition, over 30 private licenced fixed crest weirs or block banks are distributed throughout the system (Sharpe, Stuart, & Vilizzi, 2013). Many of the weirs date from the early twentieth century and were constructed to provide a local store of water for stock and domestic use during low flow periods over summer (Beal et al. 2004). The weirs continue to serve an important water delivery function by providing a buffer for local extractors in the event of disrupted supply (Vincent Kelly Water NSW pers. comm.). The weirs facilitate pumping for stock and domestic and irrigation by providing deep pools and reducing the head across which water must be pumped, thereby reducing power costs (Jim Parrett pers. comm.). The weirs contribute to the recreational and amenity values of the region by creating reaches that can be navigated by boat, by providing suitable conditions for water-skiing (specifically at Eight Mile Weir on Colombo Creek) and providing open expanses of water in townships and rural areas in an otherwise dry landscape.

Many of these structures are in poor repair and require refurbishment or removal to improve flow throughout the system (SKM 2011). State Water Corporation conducted a review of the Yanco Creek system weirs in 2007 and identified a number that require removal or maintenance (this report was not available to this study).

2.4.6 WATER SUPPLY

Water was originally supplied to Yanco Creek for stock and domestic purposes. Irrigation licences were granted during the 1970s, but there has been an embargo since 1982. Nevertheless, irrigation development continued, and from 1988/89, permission was granted to grow rice. Since then, demand for water increased as licence holders used more of their entitlement and inactive licences were sold or developed (FCWG, 2000).

Water NSW manages the Yanco System to deliver around 110 GL annually to 480 licences (DPI Water, 2017).

Under typical conditions, the Water Sharing Plan limits regulated flow in upper Yanco Creek to 1,400 ML/day (at offtake) to prevent excessive losses from overbank flows (see Water Sharing Plan). A minimum diversion of 500 ML/d is usually provided year-round for stock and domestic requirements (SKM 2011). However, outside of the irrigation season inflow can temporarily fall to around 70 ML/day (Sharpe et al., 2013).

Downstream of Tarabah Weir (Figure 3), Yanco Creek has a greater capacity than Colombo Creek. Yanco Creek carries the major portion of the unregulated flows that generally occur in winter-spring, whereas Colombo Creek carries the major portion of regulated flows in summer-autumn (Alluvium, 2013). The bankfull capacity of Colombo Creek is 600 to 650 ML above which flooding of private property may occur (SKM 2011).

Figure 3. Tarabah Weir and Fishway on the Yanco Creek

As demand has increased, outfall drains have become increasingly important in supplementing water supply to the Billabong Yanco System. Irrigation orders and supplementary flows may be provided by outfall drains from the Coleambally Irrigation Area (CIA) to Yanco Creek using the Coleambally Catchment Drain (CCD capacity 150 to 200 ML/d) and Drainage Channel 800 (DC800 capacity 50 ML/d) (pers. comm. Jim Parrett). Both channels enter Yanco Creek below Tarabah Weir.

The operational capacity of DC800 has declined. In the past up to 350 ML/d could be delivered to Yanco Creek. The capacity available to deliver water to Yanco Creek has been reduced to 50 ML/d to provide spare capacity for CIA irrigators to dewater crops during summer storms (pers. comm. Jim Parrett).

Water may also be supplied to Billabong Creek by Murray Irrigation Limited (MIL) from the Murray Irrigation District (SKM 2011). Finley escape enters Billabong Creek 30 km upstream of Hartwood Weir (Figure 4). Wollami Escape is used to supplement flows in Forest Creek. Three smaller MIL escapes can potentially deliver flows directly into Forest Creek upstream of Wanganella Swamp (including Blighty No. 17). These have a combined capacity of 50 to 60 ML/d. Algudgerie Weir, downstream of Jerilderie, backs water into Wangamong Creek, which prevents Wangamong Creek from receiving water from escapes (pers. comm. Jim Parrett).

An escape must be licenced for it to deliver environmental water. Not all escapes have been licenced (pers. comm. Jim Parrett).

Figure 4. Finley Escape at the junction with Billabong Creek

When inflows to Yanco Creek are limited, the supply of regulated water may terminate at McCaughey Weir on Billabong Creek. Consumers downstream of the weir may then be supplied with water from Finley Escape (pers. comm. Jim Parrett).

Western Coleambally Channel (WCC) is a CIA outfall drain that joins Billabong Creek downstream of Wanganella (Figure 5). The channel is 180 km long and has a capacity of 150 ML/d, subject to irrigation use. WCC is known as Coleambally Creek in the upper reaches and Eurolie Creek in the lower reaches (SKM 2011).

Murray Irrigation Limited and Coleambally Irrigation apply a charge for the delivery of water via its escapes into Billabong Creek.

Figure 5. West Coleambally Channel

2.4.1 TRAVEL TIMES

Flows entering the top end of the Yanco system at the Murrumbidgee River typically take four to five weeks to reach the Edward River (Table 2) (SKM, 2011).

2.4.1 SEEPAGE LOSSES

A study by Brownbill et. al. (2011), cited by Alluvium (2013), identified Billabong Creek as a losing-disconnected stream with an associated well-defined impervious layer of clay 0.5 to 2 m thick near or slightly below the streambed. Local river loss due to infiltration along Billabong Creek was estimated to be about 15 to 16 ML per kilometre per day for median and high (tenth percentile) river flows respectively. Regional losses were much lower at around 400 and 850 litres per kilometre per day for median and high river flows.

Table 2. Approximate travel times in Billabong Yanco System (Beal et al. 2004 data compiled by SKM 2011)

Reach	Watercourse	Days	Cumulative Days
Dams to Yanco offtake	Yanco Creek	7.5	7.5
Yanco offtake to Tarabah Weir	Yanco Creek	2.5	10
Morunda to DC800	Yanco Creek	7	17
DC800 to Puckawidgee	Yanco Creek	7	24
Tarabah Weir to Innes Bridge	Colombo Creek	8	18
Innes Bridge to Jerilderie	Billabong Creek	2	20
Jerilderie to Hartwood Weir	Billabong Creek	4	24
Hartwood Weir to Conargo	Billabong Creek	1.5	25.5
Conargo to Darlot	Billabong Creek	7	32.5
Darlot to Moulamein	Billabong Creek	7-10	39
Forest Creek off-take to Warriston Weir	Forest Creek	5-6	-

2.4.2 OPERATIONAL SURPLUS

There are few controls over flows within the 800 km creek system and there are very long order periods, of up to 26 days between releases from storage to delivery to the diverter. As a result, customers may place a generic order so that WaterNSW maintains high levels of flow in the Yanco system throughout the season to avoid risks of non-supply. The outcome is that flows within the system are greater than would be required to meet actual irrigation demand (DPI Water, 2017).

2.4.3 TRANSMISSION LOSSES

Operating the creeks at a high level creates high transmission losses. At high flows the creek width is larger and water spills into low-lying wetlands, flood runners and floodplain areas. The construction of weirs and block banks along the length of the creek system has increased the width of the creeks and backs up water in wetlands and flood runners, further increasing evaporation and seepage (DPI Water, 2017).

2.4.1 CUMBUNGI IN CHANNELS

Cumbungi has been recognised, particularly in the early 2000s, as a significant impediment to water supply in Colombo Creek and the Forest Creek System (Beal, Furness, Parrett, & Scriven, 2004). However the current extent of Cumbungi is much reduced due to the effects of the Millennium Drought (1997 to 2010), the cessation of stock and domestic water supply below Warriston Weir in 2007 and the scouring effects of major floods in 2011 and 2016.

2.4.2 TOPOGRAPHIC AND GEOMORPHOLOGICAL DATA

Topographic data are available from LiDAR, and bathymetric surveys. SKM (2008) undertook bathymetric surveys of each weir pool and combined these data with LiDAR data to identify commence to flow thresholds and produce rating tables of surface area, depth and volume as a function of water surface elevation.

2.4.3 HYDROLOGICAL DATA

A number of gauges are operational in the system (Table 3), and data is also available for some gauges that have been decommissioned (e.g. Billabong Creek @ Garyowen, operational from 1/01/1960 to 1/01/1990).

The gauge at Darlot measures end-of-system flows that discharge into the Edward-Wakool system.

Table 3. Active river flow gauging stations in Yanco, Billabong and Colombo Creek system. Source: DPI Office of Water, Real Time Data, http://realtimedata.water.nsw.gov.au/water.stm).

Gauge No.	Gauge name	Latitude	Longitude	Start () archived data	End
41000209	Yanco Creek @ Wiraki	−35.29485121	145.49174005	01/08/2006	present
41000213	Yanco DS Tarabah Weir	−34.88593374	146.27710923	18/05/2006	present
410007	Yanco Ck @ Offtake	−34.7061	146.4094	(01/01/1902) 10/01/1979	present
410015	Yanco Ck @ Morundah	na	na	(01/01/1913) 07/03/1977	Present
410169	Yanco Ck @ Yanco Bridge	−35.14838977	145.77312271	01/01/1995	Present
410012	Billabong Ck @ Cocketgedong	−35.3142	146.0355	01/11/1912	Present
410016	Billabong Ck @ Jerilderie	−35.3538	145.7356	01/08/1912	Present
410017	Billabong Ck @ Conargo	−35.2859	145.2091	1/01/1913	Present
410097	Billabong Ck @ Aberfeld	−35.645	147.4441	1/11/1967	Present
410091	Billabong Ck @ Walbundrie	−35.6927	146.7218	1/06/1965	Present
410091	Billabong Ck @ Wanganella	−35.2123	144.8165	16/11/1999	Present
410134	Billabong Ck @ Darlot	−35.0442	144.4464	24/04/1978	Present
410168	Billabong Ck @ DS Hartwood Weir	−35.3101	145.2884	21/09/1995	Present
410182	Billabong Ck @ Hillview	−35.717	146.8462	4/6/2001	Present
410183	Billabong Ck @ Parkside	−35.6972	146.8855	5/06/2001	Present
410186	Billabong Ck @ DS Ten Mile and Mountain Cks	−35.6855	147.185	30/8/2001	Present
410170	Billabong @ US Innes Bridge	−35.3223	145.9753	4/03/2017	Present
41000210	Colombo @ Coonong Weir	−35.1876	146.0418	1/08/2006	Present
410014	Colombo Ck @ Morundah	−34.9373	146.296	1/10/1978	Present
41010309	Forest Creek @ Offtake	−35.324	145.294	29/08/2014	Present
410148	Forest Creek @ Warriston Weir	na	na	1/09/1990	Present

An integrated water quantity and quality (IQQM) simulation model has been developed by NSW DPI, Office of Water, for the system under three scenarios:

(i) Unimpaired or no-Development,
(ii) Current, and
(iii) With proposed SDL adjustments and recommended environmental flows.

The IQQM models have been used to generate 100 years of flow data at various locations throughout the system under each scenario. Alluvium (2013) used the Unimpaired and Current scenario model runs to describe the hydrology of six reaches, although the points on the river that the flows represented were not identified. Andrew Brown, NSW DPI, has warned that the hydraulic modelling contains some unreliable results.

2.4.4 HYDROLOGY

The hydrology of the Billabong Yanco System reflects the management of both the creek system and the Murrumbidgee River.

The headwaters of the Murrumbidgee system are regulated by a number of large dams. The main structures are Tantangara and Burrinjuck on the Murrumbidgee and Talbingo and Blowering on the Tumut River. These structures have greatly modified flows. The Sustainable Yields Project (CSIRO 2008 cited in (MDBA, 2015)) found that after development, the frequency of flows of 28,999 ML/d at Narrandera has halved and the maximum period between flows of this size has more than tripled from 2.8 to 9.7 years (MDBA, 2015).

Before regulation, Colombo Creek was a high-level effluent that carried approximately 30% of the water passing down Yanco Creek. Tarabah Weir is operated to increase the proportion of flow passing down Colombo Creek to almost 50%. Combined with the greater inflows from the Murrumbidgee, flow is now seven times higher than pre-regulation in Colombo Creek (145 GL/year). Flow in Yanco Creek below the Tarabah Weir is now three times higher than pre-regulation (150 GL/year) (Alluvium 2013).

Prior to development, water entered Yanco Creek only during periods of elevated flow in the Murrumbidgee River. Inflow events occurred 1 in 2 years with flow occurring less than 10% of the time (Alluvium, 2013). Flow now occurs in greater volumes and more persistently due to the excavation of the Yanco Creek cutting, the construction of the Yanco Weir on the Murrumbidgee downstream of the cutting and the supply of regulated water from Burrinjuck and Blowering reservoirs. The creek now flows 100% of the time and rarely falls below 270 ML/d at the offtake.

Unregulated inflows from Billabong Creek contribute a further 60 GL/year to the system below the Colombo Creek confluence. Catchment runoff generates flow in Billabong Creek almost 90% of the time. With the contribution of regulated inflows via Colombo Creek, flow now occurs all the time and rarely falls below 100 ML/d (Alluvium 2013).

Under pre-regulation conditions Forest Creek diverted flow from Billabong Creek at relatively high flows of 1,500 ML/d, creating flow in the creek 30% of the time (Alluvium 2013). Inflows to Forest Creek are facilitated by Hartwood Weir (Figure 6) so that the frequency and duration of low flows has increased. Rules are in place to provide 80 ML/d in summer (Nov to Mar) and 60 ML/d in winter (Apr-Oct) (Davidson and Webster 2007). Note, however that the IQQM model reports that flows currently occur only 60% of the time with a total annual volume of 45 GL (Alluvium 2013). The difference most likely arises because the model was developed as a practical estimation of actual flows rather than as a representation of the flow rules.

A Department of Natural Resources model of Forest Creek inflows (Davidson and Webster 2007) estimated that Forest Creek below Warriston Weir receives:

- large flows (>10,000 ML/d) roughly 3 years in 10; and
- median flows (5,000 ML/d) roughly 4 years in 10; and
- small flows (>1,000 ML/d) roughly 6 years in 10.

Figure 6. Hartwood Weir on Billabong Creek

3 STATUTORY AND STRATEGIC ARRANGEMENTS

3.1 WATER SHARING PLAN

The Murrumbidgee Regulated River Water Sharing Plan (2003) is a statutory management plan under the *Water Management Act 2000 (NSW)*. Water sharing plans are prepared every ten years and define water sharing arrangements between the environment and water users, and amongst water user groups. The plans aim to protect rivers and aquifers and their dependent ecosystems, and to provide water users with clarity and certainty regarding water access rights.

The Murrumbidgee Regulated River WSP applies to the Murrumbidgee below Burrinjuck Dam and Blowering Dam and to the Yanco/Billabong Creek system. Objectives for Section 10, Part 2 of the Water Sharing Plan are to:

- protect and restore in-river and riparian habitats and ecological processes;
- provide for appropriate watering regimes for wetlands;
- sustain and enhance population numbers and diversity of indigenous species;
- protect Basic Landholder Rights, as specified in the *Water Management Act 2000 (NSW)*, including native title rights;
- maximise early season general security allocations;
- protect town water supply;
- protect end-of-system flows;
- provide for commercial consumptive use;
- provide for identified recreational water needs;
- protect identified Indigenous and traditional uses of water; and
- within the ability of the plan promote the recovery of known threatened species.

Included in the plan is a description of environmental water for the defined water source; landholder water requirements; water extraction requirements; water access arrangements and bulk water access regime; limits on the availability of water; access rules, consideration of the effects of climate variability; and rules for prioritising water allocations associated with reduced water availability (SKM, 2011).

The environmental flow provisions in the Murrumbidgee Water Sharing Plan do not specifically identify or target ecological outcomes in the Yanco Creek system.

Minimum daily flows (end of system flows) are specified in the Water Sharing Plan to maintain connectivity with the River Murray (Green, Petrovic, Moss, & Burrell, 2011). The WSP requires that a minimum daily flow of 50 ML/d must be maintained in Billabong Creek at Darlot gauge throughout the water year (Part 6, Division 1, Clause 30). Any regulated flow above the 50 ML/d target is counted as a loss across the entire Murrumbidgee system and treated as an unregulated tributary inflow (Vince Kelly pers. comm. WaterNSW 13 Sep 2017).

The Water Sharing plan defines a range of water licence types which vary in terms of their priority for fulfilment and management arrangements (Table 4).

Table 4. Summary of water entitlement characteristics in the Murrumbidgee catchment. Adapted from the Water Sharing Plan (Water NSW 2017) by SKM (2011).

Licence Type	Purpose	Water Determination Period Announcement	Basis of Diversion
Stock and Domestic and Native Title Rights	Fulfilment of basic landholder rights	Annual	System must be managed so that if worst historical inflow occurs 100% of volume can be supplied.
Local Water Utility Access	Town water supply	Annual	System must be managed so that if worst historical inflow occurs 100% of volume can be supplied.
High Security	High reliability demands such as permanent plantings, cultural, research and some town water supply	At periods less than or equal to a month, unless 1 ML/unit share	High security licences must be supplied with a minimum of 0.95 ML/unit share before general security is supplied.
General security	Low reliability demands such as annual cropping	At periods less than or equal to a month, unless 1 ML/unit share	High security licences must be supplied with a minimum of 0.95 ML/unit share before general security is supplied.
Murrumbidgee Irrigation Conveyance	Provision for conveyance losses in the MIA canals	As required	Based on general security water determination.
Coleambally Irrigation Conveyance	Provision for conveyance losses in the CIA canals	As required	Based on general security water determination.
Regulated River Conveyance	Unknown		Unknown
Supplementary	Volumes available when other environmental and licence uses are satisfied	Annual	Supplementary events announced on the conditions that arise during the year.

3.2 COMMONWEALTH ENVIRONMENTAL WATER

The Commonwealth Environmental Water Holder is an independent statutory position established by the *Water Act 2007 (Cwth)* to manage the Commonwealth Environmental Water Office (CEWO), a division of the Australian Government Department of the Environment and Energy.

Under the *Water Act 2007,* Commonwealth environmental water must be managed to protect or restore environmental assets, so as to give effect to relevant international agreements and the Murray-Darling Basin Plan.

A review of opportunities for the use of Commonwealth environmental water (SKM, 2011) established five overall goals for the Murrumbidgee catchment:

- restore the extent and condition of riverine, riparian, wetland and floodplain vegetation communities;
- maintain known colonial waterbird breeding sites in 'event ready' condition;
- maintain seasonal habitats for migratory waterbirds;
- maintain known southern bell frog breeding sites in 'event ready' condition; and
- restore longitudinal and lateral connectivity between as many of the components of the Murrumbidgee River as possible to protect and restore the "aquatic ecological community in the natural drainage system of the Lower Murray River catchment", including its threatened species.

The review identified ecological assets to which environmental water could be delivered in the Billabong Yanco system:

- Dry Lake and Mollys Lagoon;
- Upper Yanco Creek floodplain wetland complexes;
- Mundoora/Wilson Anabranch complex;
- Forest Creek;
- Wanganella Swamp;
- Kerribirri Swamp;
- Rhyola depressions and floodrunners;
- Back Nullum low-lying areas; and
- Box Swamp on Blue Gate.

A plan for managing the Commonwealth environmental water portfolio in the Murrumbidgee Catchment has been prepared for the period 2016-2017 (CEWO, 2016). A multi-year approach was adopted to maximise environmental outcomes using portfolio management tools such as use, carryover and trade. The plan identifies potential watering actions for the Murrumbidgee Catchment including one relating to Yanco Creek:

- Mid Yanco Wetlands - provide 40 GL to contribute to flows that reconnect and refill the anabranch creeks and lagoons.

3.3 LONG TERM WATERING PLANS

Environmental watering in the Murray-Darling Basin is guided by the Environmental Watering Framework set out in Chapter 8 of the Murray-Darling Basin Plan. The framework establishes the Basin-wide Environmental Watering Strategy, which is prepared by the MDBA to provide a long-term plan at the Basin scale. Long-term Watering Plans are prepared by the Basin States and provide for long-term planning for the Water Resource Planning Areas within the Basin. Together these documents guide the development of annual watering priorities by the states and Commonwealth.

The development of the Murrumbidgee Long-term Watering Plan for the Murrumbidgee Water Resource Planning Area is being led by the NSW Office of Environment and Heritage.

3.4 ANNUAL ENVIRONMENTAL WATERING PRIORITIES

The Basin Plan Environmental Water Framework requires Basin States to prepare Annual Environmental Watering Priorities (AEWP) for each Water Resource Planning Area (OEH, 2016). The AEWP reviews previous water provisions and sets out watering proposals for a range of future water availability scenarios.

In New South Wales the plan is being developed by the Office of Environment and Heritage in consultation with the Murrumbidgee Environmental Water Advisory Group (EWAG).

The statement for 2016-17 reports that in 2015-16:

- 22.8 GL was delivered to Yanco Creek to provide a wetland fresh that provided low-level wetland connections and anabranch flows and improved fringing vegetation condition; and
- 8.1 GL was released to stabilise the hydrograph in Yanco Creek during Trout Cod spawning.

3.5 ENVIRONMENTAL WATER RESERVES

The Commonwealth Environmental Water holder holds entitlements in the Murrumbidgee Catchment that can be used in the Billabong Yanco System (Table 5).

Table 5. Commonwealth Environmental Water Holdings in the Murrumbidgee River System (Commonwealth Environmental Water Holder website 21 Nov 2017)

Security	Registered Entitlements (ML)	Long Term Average Annual Yield (ML)
High	10,088	9,853
General	276,887	177,208
Conveyance	26,874	25,530
Supplementary	21,986	3,078
Supplementary (Lowbidgee)	393,117	178,475
Groundwater	5,077	5,077
Unregulated	164	110

New South Wales holds water entitlements in the Murrumbidgee and Murray basins which can be delivered to the Billabong Yanco system. Adaptive or licenced holdings as of June 30 2014 are 26,508 GL general security and 5.68 GL supplementary allocation. This does not include planned water holdings which is allocated under Water Sharing Plans (NSW Government, 2017).

3.6 WATERNSW

WaterNSW is a statutory authority of the Government of New South Wales and was established under the *Water NSW Act 2014 (NSW).* WaterNSW is responsible for the management and supply of surface water and groundwater across much of New South Wales. The principal objectives of WaterNSW are to:

- provide for the planning, design, modelling and construction of bulk water infrastructure;
- supply water in compliance with appropriate standards of quality;
- protect public health, safety and environment and provide for the management of declared catchment areas;
- maintain and operate the works of Water NSW efficiently in accordance with sound commercial principles; and
- capture, store and release water in an efficient, effective and safe manner.

In the Murrumbidgee catchment, WaterNSW is responsible for water delivery and retail. WaterNSW manages licences, receives orders and arranges delivery, is responsible for accounting. WaterNSW owns structures on the Billabong Yanco System including the Yanco Weir and Regulator on the Murrumbidgee River, Tarabah Weir on the Yanco Creek, Hartwood Weir on the Billabong Creek, Forest Creek Offtake and Warriston Weir on the Forest Creek.

WaterNSW recovers its operational costs through water delivery charges. The level of water charge depends on several factors including the type of licence (general or high security), the catchment and the volume.

3.7 YACTAC

The Yanco Creek and Tributaries Advisory Council (YACTAC) represents irrigators and other diverters supplied by Water NSW. YACTAC is funded by a 90c/ML levee that is collected by WaterNSW. The funds raised are used to support natural resource management projects such as willow removal, weed control and other on-ground works, as well as advocacy work with government agencies and other organisations (pers. comm. Russell Ford YACTAC).

3.8 LOCAL LAND SERVICES

The Billabong Yanco System lies mainly within the Murray Local Land Services region. The upper Yanco Creek, from just north of Morundah to Narrandera is within the Riverina Local Land Services.

Local Land Services are statutory authorities established under the *Local Land Services Act 2013 (NSW)*. Regional Local Land Services are funded by the NSW and Federal Governments and by landholders through the collection of rates. The organisations provide biosecurity, natural resource management and agricultural services.

3.9 SUSTAINABLE DIVERSION LIMIT ADJUSTMENT MECHANISM

The Murray-Darling Basin Plan protects the water needs of the environment by specifying a Sustainable Diversion Limit (SDL). This is the maximum water volume that can be diverted from the Basin for consumptive uses, including irrigation, industry and town supply, so that the remainder is available for the environment.

The Basin Plan allows the SDL to be increased (providing more water to consumers) if environmental needs can be met using less water than was first anticipated or if water savings can be found to provide more water. These outcomes could be achieved by operating infrastructure more efficiently or achieving environmental outcomes more efficiently. The Commonwealth government and state governments are currently investigating possible SDL adjustment projects.

Three SDL Offset projects related to the Billabong Yanco system have been submitted by DPI Water (Water NSW, 2016).

1. CARM Murrumbidgee
2. Yanco Regulator
3. Modernisation of Effluent Systems

The CARM (Computer Aided River Management system) project aims to make better use of contextual management data to allow operators to more accurately make releases to meet downstream orders. The CARM system integrates real time data in the form of meteorological forecasts, pump extraction rates, future irrigation orders, metering, inundation models and more accurate loss estimates as well as control structure releases and gate settings (van Kalken, Mackay, Nachiappan, Madsen, & Falk, 2016). The saved operational loss may then be calculated and set aside to achieve environmental outcomes (MDBA, no date). CARM includes a MIKE 11 model of the Murrumbidgee River and Yanco-Billabong Creek system, which will help characterise the distribution of water through the system under a range of flow conditions. CARM should allow more efficiency in meeting irrigation demands as well as targeted environmental flow regimes. This should reduce losses and lead to improved management of Yanco Creek offtake inflows.

The Yanco Weir and Regulator proposal aims to return the Yanco Creek system closer to a pre-development wetting/drying regime, while improving infrastructure that supplies irrigation and stock and domestic water. Upgrades to Yanco Weir on the Murrumbidgee would provide more control over flows through the proposed Yanco Creek regulator (DPI Water, 2017). The existing regulator controls inflows to Yanco up to a Murrumbidgee discharge below Yanco Weir of about 14,000 ML/d. At higher discharge Yanco Creek diverts approximately 10% of Murrumbidgee flow. The proposed new regulator will control Yanco inflows up to a Murrumbidgee discharge of 45,000 ML/d (DPI Water, 2017). The intended benefits are: (i) to be able to meet Yanco Creek environmental water requirements without the need for high flows in the Murrumbidgee River, and (ii) better control and precise delivery of irrigation water into the Yanco system (control over high and low Murrumbidgee flows (Water NSW, 2016).

The proposed operating guidelines for the new Yanco Weir and regulator involve (Water NSW, 2016):

- Guidelines to maximise SDL while reinstating equivalent flows in Yanco (at other times);
- Murrumbidgee Flows < 15 GL/d – no change in Yanco diversion;
- Murrumbidgee Flows > 15 GL/d – new regulator operated to reduce flow down Yanco Creek;
- Sep to Dec, when the Murrumbidgee River is in recession, release:

- up to 1,500 ML/d for 3 days every year;
- Up to 2,500 ML/d for 5 days every second year;

- Aug to Dec, release:
  - Up to 4,000 ML/d for 5 days to coincide with Billabong Creek bankfull flows.

The delivery of irrigation supply through the natural creek system involves high transmission losses from the extensive surface area of creeks and weir pools. An elevated operational surplus arises from a combination of the 26 day ordering period, poor monitoring, inefficient control and lack of capacity for re-regulation (Water NSW, 2016). The Modernisation of Effluent Systems proposal involves returning parts of the Yanco system closer to a pre-development wetting/drying regime, while improving infrastructure that supplies irrigation and stock and domestic water. This project, along with the Yanco Weir and Regulator proposal, has been stated as potentially providing Commonwealth Environmental Water Holder/Office of Environment and Heritage with more flexibility in managing flows within the Murrumbidgee system (MDBA, no date).

The Yanco Creek System has been identified to contain 36 regulating structures, many of which are in various states of repair and require refurbishment or removal to improve flow throughout the system (SKM, 2011). A review of the Yanco Creek system weirs in 2007 identified a number of weirs that require removal and/or maintenance (SKM, 2011).

The Modernisation of Effluent Systems involves updates to infrastructure, improved monitoring and changes to river operation rules to allow more flexibility and control in water delivery to effluent creeks (DPI Water, 2017). Project areas in the Billabong Yanco System are:

- Forest Creek from Billabong Creek to Warriston Weir;
- Yanco Creek from the Yanco offtake to the Billabong confluence; and
- Colombo and Billabong Creeks from Yanco Creek to the confluence with the Edward River.

The proposal is a package of measures that includes:

- More monitoring capability, and
- Additional regulation and control offered by:
  - 3 creek regulators with fish-passage:
    - Hartwood weir – rebuild
    - Lower Billabong weir – possibly upgrade Wanganella
    - Yanco/Billabong – new structure downstream of creek junction
  - 6 weir-pools on Colombo and Yanco creeks fitted with flow control to re-regulate and deliver flows downstream.

3.10 PRE-REQUISITE POLICY MEASURE IMPLEMENTATION PLAN

When setting the SDL, the MDBA assumed that government policies would be in place to allow the maximum environmental benefit to arise from the use of the Commonwealth's licensed environmental water. Pre-requisite Policy Measures (PPMs) will allow the use of licensed environmental water at multiple sites (environmental flow re-use) and the opportunity to order licensed environmental water from a headwater

storage during a natural flow event (piggybacking). These measures aim to maximise the efficient use and beneficial outcomes derived from licensed environmental water while ensuring that the licenced access rights of other water users are protected (DPI Water, 2017).

In standard regulated river operations, water orders are met from the most efficient supply, including from downstream tributaries. By contrast, piggybacking allows the release of water from a nominated headwater storage to raise the height and reach of environmental flows, and hence make the most effective use of all available water. These releases may occur during regulated or unregulated flows and would likely be timed to achieve specific environmental outcomes, for example improved stream connectivity or overbank flows in the target area.

Under current legislation, water that returns to the river downstream of an environmental site is re-regulated or used to meet other water orders. The PPM for Environmental Flow Reuse would formally recognise the return flow of water to a river downstream of an environmental watering event to allow that water to be reused to water other environmental sites or outcomes further downstream. These return flows would be protected from extraction and re-regulation into downstream storages for the length of the river. River operators will endeavour to deliver the environmental water to other downstream environmental sites and protect return flows.

The two PPMs will be implemented through the development of Water Sharing Plans as part of the Water Resource Plan process and the development of valley-specific PPM Implementation Procedures Manuals. These documents will be developed from 2017 to 2019 for implementation from 1 July 2019.

Initially the tools and mechanisms to enable PPMs will be best suited to environmental water delivery, however it is intended that the flexible delivery offered by PPMs will eventually be able to be used by all licensed water users.

3.11 CONSTRAINTS MANAGEMENT STRATEGY

The Constraints Management Strategy is an initiative of the Murray-Darling Basin Authority to identify ways to increase the frequency and duration of small overbank flows to sustain and improve floodplain health, while mitigating any effects this water may have on property and people (MDBA, 2015). For the purposes of the Strategy, constraints are river rules, practices and structures that restrict or limit the volume and/or timing of regulated water delivery through the river system.

The Strategy is investigating seven regions in the Murray-Darling Basin, one of which is the Murrumbidgee. The investigations included constraints on small overbank flow events in the Upper Yanco.

The Strategy is investigating upper and lower thresholds for small overbank flows at the Yanco Creek offtake of 2,174 ML/d and 3,715 ML/d.

These flows could affect the community in ways that represent constraints that need to be mitigated, including:

- inundation of low-lying land;
- infrastructure including damage to fences, inundation of pumps;
- flooding of roads and restrictions on access; and
- erosion and tree fall.

3.12 NSW ENVIRONMENTAL WORKS AND MEASURES FEASIBILITY PROJECT

In 2011 the NSW Government began investigations into increasing the supply of water for environmental purposes by increasing the efficiency of water use. The Environmental Works and Measures Feasibility Project identified opportunities to contribute to the target for environmental water set out in the Murray-Darling Basin Plan. The project focussed on water savings and efficiency measures as a preferable alternative to buying water back from consumers (NSW Office of Water, 2013).

The project identified Forest Creek as a highly inefficient water delivery system with approximately 35 GL of water used annually to deliver the licenced entitlement of 22 GL (NSW Office of Water, 2013). A pipeline was proposed to deliver 24 GL/year of stock and domestic water supplies from the Hartwood Weir pool to the licensed users along Forest Creek. The project recognised that potential issues of Basic Landholder Rights to stock and domestic water may undermine any water savings achieved as part of the proposal, and that the proposal may not be well received by landholders.

The project noted the proposals to improve water management and delivery efficiency in Yanco Creek that were made in the Yanco Creek System Natural Resource Management Plan (Beal, Furness, Parrett, & Scriven, 2004). These proposals focused on reducing excessive flooding in wetlands caused by high irrigation delivery flows and provided flow regulating structures at Dry Lake, Molly's Lagoon and Wilson's Anabranch.

4 ECONOMIC, SOCIAL AND CULTURAL VALUES

4.1 LOCAL GOVERNMENT

The Billabong Yanco System lies within the former shires of Conargo, Jerilderie and Urana.

Murrumbidgee Council was established in 2016 after a merger of Jerilderie Shire Council and Murrumbidgee Shire Council. The local government area covers an area of 6,680 km^2, has a population of 4,047 and includes the townships of Jerilderie, Coleambally and Darlington Point.

Edward River Council was established in 2016 from the merger of Deniliquin Council and the surrounding Conargo Shire. The Billabong Yanco System to the west of Coree lies within the Edward River Council encompassing the towns of Conargo, Wanganella and Moulamein.

Federation Council was established in 2016 from the merger of Corowa Shire and Urana Shire councils. The council covers the south east of the Billabong Yanco System, to the south of Morundah and to the east of Jerilderie. The towns in the Billabong Yanco area include Urana and Morundah.

4.2 ECONOMY

A socioeconomic baseline for the Billabong Yanco area was prepared by Minato (2016). Data was not generally available specifically for the study area, so information was presented mainly in relation to the three former local government areas of Jerilderie, Urana and Conargo. A small proportion of Billabong Yanco system also lies in the Greater Hume Shire and Narrandera Shire, however data from these regions was not included in the analysis.

The population of the former Jerilderie Shire is 1,504 and is largely concentrated in the township of Jerilderie. The population of the former Urana Shire is 1,157. The principal centres are Urana, Morundah, Oaklands, Rand and Boree Creek. The population of the former Conargo Shire is 1,543. There are no major townships in the district, with minor townships located at Conargo, Blighty, Mayrung, Pretty Pine, Wanganella and Boorooban.

Agriculture, forestry and fishing is the largest sector of the economy, comprising 65.1 and 90.2% of gross regional product in the former Urana and Conargo shires, respectively. In the former Jerilderie Shire this sector makes up 23.4% of gross regional product where the township of Jerilderie contributes to a more diverse economy (2014-15 data sourced from Murray Now Regional Profile, cited by Minato 2016).

The largest component of the economy of the Billabong Yanco System is agriculture and agriculture support services. Sheep, beef cattle and grain farming contribute the most jobs to the local economy (Table 6). Jerilderie provides retail and service industry jobs.

Table 6. Employment by industry in the former local government areas of Urana, Conargo and Jerilderie. 2011 and 2013 data compiled from ABS by (Minato, 2016)

Industry	Jerilderie	Urana	Conargo
Population	**1,504**	**1,157**	**1,543**
	Percent of Population		
Sheep, beef cattle and grain farming	38.4	38.3	44.2
Dairy cattle farming			12.1
Road freight transport		10.3	
School education	3.9	5.8	4.7
Residential care services			1.8
Local government administration	5.4	5.8	
Fuel retailing	2.7		
Pubs, taverns and bars		2.2	
Building installation services	2.1		
Other social assistance services			1.8

The local economy and communities are largely dependent on irrigation.

Irrigated agriculture in the broader Murrumbidgee Valley covers 4% of the area but contributes 41.6% of the total production. Across the valley, agriculture is the second largest employer after retail, providing jobs for nearly 12% of the population (Beal, Furness, Parrett, & Scriven, 2004).

In the Coleambally Irrigation Area rice, soybeans and corn are grown in summer while wheat, oats and barley are produced over winter. Irrigated pasture for grazing is grown throughout the year (Green, Petrovic, Moss, & Burrell, 2011). Important crops in the Murray Irrigation Area include dairy, rice, cereals, wool, beef and lamb with areas of horticulture, viticulture, nuts and stone fruit (MIL, 2017).

4.3 WATER SUPPLY REQUIREMENTS

4.3.1 TOWN WATER SUPPLY

Regulated water from the Billabong Yanco System provides town water supply to several centres.

Riverina Water County Council (RWCC) is the rural water supply authority for the 15,400 km^2 County District. The district lies mainly to the east of the Billabong Yanco System and includes Wagga Wagga, Holbrook, Culcairn, Lockhart and Urana. The Council holds an 805 ML Township Allocation for Water NSW to supply water to a piped water supply offtake on Colombo Creek, upstream of the Eight Mile Weir which supplies Urana and Oaklands. Morundah is also supplied with water from Colombo Creek by Riverina Water.

Water supply from WaterNSW to the diversion points is planned by RWCC by monthly pre-orders and known patterns of use. The Colombo Creek supply point is used seasonally, generally from November to February (pers. comm. Jason Epps, engineer, RWCC).

The Colombo Creek offtake was upgraded during the Millennium Drought by replacing the open channel with a pressurised pipeline.

Figure 7. Urana water supply offtake on Colombo Creek

Murrumbidgee Council is the water authority that supplies water to Jerilderie from Billabong Creek. The town has a dual water supply of treated potable water and raw water for gardens.

Edward River Council provides non-potable water to Wanganella.

4.3.2 STOCK AND DOMESTIC WATER SUPPLY

The majority of land adjacent to Billabong Yanco watercourses is managed for dryland grazing and cropping. Stock and domestic water supply is the most widespread and persistent requirement for water in the system. Stock and domestic water supply is essential to stock production and to supply water for human consumption to dwellings. Water is also used to maintain gardens.

Water is accessed by pumps which distribute water to trough systems or direct access by stock to watercourses.

Stock and domestic water is accessed under Basic Landholder Rights (*Water Management Act 2000 NSW*) which are available to properties fronting prescribed watercourses.

Weirs in the Billabong Yanco system contribute to the reliability of stock and domestic water supply. When flow is interrupted, weirs act as a local store of water that can maintain local water supply until flow is restored.

Stock and domestic water supply is maintained by the base flows in the watercourses. Water is not specifically ordered from WaterNSW.

Landholders downstream of Darlot rely on Billabong Creek for stock and domestic supply. Their requirements are met by the 50 ML/d end of system flow mandated in the Water Sharing Plan.

4.3.3 IRRIGATION WATER SUPPLY

Water licences allow licence holders to order water from Water NSW. There are two levels of security. High security licences are mainly used for permanent plantings. There are few high security licences in the Billabong Yanco System. General security licences are less reliable than high security and are used for seasonal crops such as rice. General security makes up the majority of water licences in the Billabong Yanco System.

Water is ordered 14 days in advance in Upper Yanco Creek, increasing to 26 days in advance in Lower Billabong Creek. If it has rained locally before the order arrives, the water may no longer be needed and may be unused by the diverter.

When flow exceeds the regulated capacity of the Murrumbidgee / Yanco system Supplementary Water Access Licences (SWAL) may be exercised. In years when water supply is limited and full entitlements are not available under general security licences, supplementary water is important in meeting irrigators' water needs. With certain conditions, SWAL is accounted as part of the general security allocation.

4.4 INDIGENOUS CULTURAL VALUES AND FLOWS

4.4.1 INDIGENOUS CULTURAL GROUPS AND HERITAGE

The Indigenous cultural groups associated with the Yanco Creek System are Wiradjuri, Yorta Yorta, Barapa Barapa and Wamba Wamba nations (Minato, 2016).

The boundary of the Wiradjuri Nation extends from Coonabarabran in the north and crosses the Great Dividing Range down to the Murray River and extends to western New South Wales. Wiradjuri traditional country includes the townships of Dubbo, Condobolin, Orange, Bathurst, Wagga Wagga, Albury, Narrandera and Griffith (MLDRIN, 2017).

The Yorta Yorta Nation is centred on the riverine plains of southern New South Wales and Northern Victoria. Yorta Yorta traditional country includes the townships of Echuca, Shepparton, Mooroopna and Kyabram and includes significant cultural and geographic features such as Barmah-Millewa Forest and parts of Gunbower-Koondrook-Perricoota Forest (MLDRIN, 2017).

The Wamba Wamba Nation lies on both sides of the River Murray and includes the Edward River and Wakool River anabranches. The traditional area includes the townships of Deniliquin, Moulamein and Swan Hill (MLDRIN, 2017).

The Barapa Barapa Nation is centred on the River Murray and riverine plain from above Hay in the north to Kerang in the South and included the localities of Cohuna, Gunbower, Conargo and land south of Carathool. The Barapa Barapa has extensive shared country with their traditional neighbours, the Wamba Wamba and Yorta Yorta in the region of Deniliquin, Kow Swamp and Gunbower-Koondrook-Perricoota Forest (Tindale, 1974).

For the Indigenous custodians of the region, the natural landscape features highly productive environments including watercourses, wetlands and floodplains. These environments are culturally important and are traditional sources of food, shelter and other resources. The significance of the region and the traditional values it supports is indicated by the high number of cultural heritage sites identified to date in the Yanco Billabong region. A search of the AHIMS database (Aboriginal Heritage Indigenous Management System) for Murray LLS reported 826 cultural sites within the region. Recent investigations at Hartwood, Old Coree and Upper Yanco Creek identified a high density of cultural heritage sites at the local scale (Table 7).

Table 7. Aboriginal cultural heritage sites (AHIMS searched 8/8/2017; Webster, 2007; Crew, 2010; Zeschke, 2013).

Feature	Hartwood	Old Coree	Upper Yanco Creek	Yanco-Billabong System
Oven Mound	103	1	8	
Open Camp Site			4	
Ceremony and Dreaming				72
Resource and Gathering				72
Artefact (e.g. grinding stone)	20	1		64
Burials	10		1	79
Earth Mound				109
Hearth	2			41
Modified Tree (carved or scarred)	112	26		160
Non-human Bone and Organic Material				77
Potential Archaeological Deposit				73
Shell				77
Stone Arrangement				1
Stone Quarry				1

It should be noted that the region has not undergone an extensive cultural heritage assessment and the surveys so far have been opportunistic and limited to small spatial scales. Therefore the numbers of cultural heritage sites in the region are likely to be grossly underestimated.

4.4.2 THE CULTURAL IMPORTANCE OF WATER

Water has cultural significance for Aboriginal people.

Aboriginal people within the Murray-Darling Basin talk of how the rivers sustain their life and identity (MDBA, 2017). Aboriginal people not only view water as connected to the land, but also view themselves as an integral part of the river system. It is because of this holistic understanding and connection that Aboriginal people feel a strong responsibility for the health of rivers. Healthy waterways enable Aboriginal communities to continue their cultural and economic activities including fishing, hunting, ceremonies, following songlines and harvesting medicinal plants (National Cultural Flows Research Project, 2017). Thus water and flow are critically important to Aboriginal people and involving them in flow management is a key goal of State and Federal government water management policy.

The term 'cultural flows' translates the complex relationship described by Traditional Owners into the language of water planning and management. Cultural flows are defined as follows.

Cultural Flows are water entitlements that are legally and beneficially owned by Indigenous Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, natural, environmental, social and economic conditions of those Indigenous Nations. This is our inherent right.

This definition was endorsed at a joint meeting of the Murray Lower Darling River Indigenous Nations (MILDRIN) and the Northern Basin Aboriginal Nations (NBAN) in The Echuca Declaration of September 2010. MILDRIN is a confederation of Indigenous Nations or traditional owners in the southern part of the Murray-Darling Basin. The group comprises delegates from the nations related to the Billabong Yanco region: the Wiradjuri, Yorta Yorta, Barrapa Barrapa and Wamba Wamba (Minato, 2016) (http://www.mldrin.org.au).

This definition is acknowledged in Schedule 1 of the Murray-Darling Basin Plan.

4.4.3 THE STATUS OF INDIGENOUS RIGHTS TO WATER

Historically, Indigenous peoples' rights to water have largely been excluded from Australia's water planning and management frameworks. Although the *Native Title Act 1993 (Cwth)* includes water rights as part of native title rights, only rights to use water for domestic and personal purposes have been recognised by the courts. In 2004 the National Water Initiative was the first time that Indigenous rights to water were formally recognised in national water policy (National Cultural Flows Research Project, 2017).

The Murray-Darling Basin Plan provides a framework to incorporate Indigenous interests and rights for water. The Basin Plan requires that key components of the plan, including the Basin-wide Environmental Watering Strategy, Annual Environmental Watering Priorities and Water Resource Plans, are prepared with regard to Indigenous values and Indigenous uses. This must include the social, spiritual and cultural values of Indigenous people as determined through active and informed participation of Indigenous people.

Schedule 1 of the Basin Plan states that:

The provision of cultural flows will benefit Indigenous people in improving health and wellbeing and provides empowerment to be able to care for their country and undertake cultural activities.

4.4.4 EVALUATING AND IMPLEMENTING CULTURAL FLOWS

The National Cultural Flows Research Project is an initiative of the Commonwealth Government (NCFPRC, 2013). The project explores how to embed Indigenous water allocations within Australia's water planning and management regimes to deliver cultural, spiritual and social benefits as well as environmental and economic benefits to communities in the Murray-Darling Basin and beyond. The project draws on a range of scientific research methodologies and generations of cultural knowledge to:

- provide a greater understanding of Indigenous values relating to natural resources, including water;
- equip Aboriginal people with information to ensure that Aboriginal water requirements and preferences are reflected in water policy; and
- inform the development of new governance approaches to water management that incorporate aspects of Aboriginal governance and capacity building.

The project aims to develop a methodology to articulate the cultural water values and needs of Indigenous communities to inform water planning processes, i.e. through water volumes and water quality.

The NCFRP is expected to provide methodologies and tools to empower Indigenous Nations to participate in the water planning process for the recognition and delivery of cultural flows. The project will report in 2017 and the products of this project have not yet been released. However it is anticipated that they will include:

- methods to describe cultural water values and needs;
- methods to describe and measure cultural water uses, values and needs;
- methods to quantify water volumes to meet cultural values and needs; and
- a monitoring methodology of the ecological and socioeconomic, health and wellbeing outcomes of cultural flows.

4.5 RECREATIONAL AND SOCIAL VALUES

4.5.1 VISUAL AMENITY

The presence of water in the Billabong Yanco System, the health of riparian vegetation and the existence of a healthy native fishery is highly valued by members of the community. The health of the river is generally attributed to reliable high flows and occasional overbank flood events.

Watercourses provide visual amenity in townships. Lake Jerilderie and the adjacent Luke Park is an important recreational asset in Jerilderie.

4.5.2 FISHING

The Billabong Yanco System supports a recreational fishery that has a high value in the community. There are active fishing clubs based in Jerilderie, Lockhart and Narrandera that make use of Billabong Yanco watercourses. Fishing takes place throughout the regulated system including downstream of Wanganella (pers. comm. Max Bryce, Jerilderie Fishing Club). Yanco Creek to Morundah is a popular fishing reach (pers. comm. Peter Beal, Riverina LLS).

The most sought after fish in the system are Murray Cod and Yellowbelly (Golden Perch). Murray Cod abundance has increased dramatically in recent years since willows have been removed; however there has been a corresponding decline in Freshwater Catfish (pers. comm. Max Bryce, Jerilderie Fishing Club). The Jerilderie Fishing Club restocks the river with Murray Cod and Golden Perch (pers. comm. Max Bryce, Jerilderie Fishing Club). The club introduced 47,000 fingerlings in the six year period to February 2017 (Southern Riverina News, 2017).

Flooding in spring 2016 has produced large numbers of young Carp, 40 to 50 mm in length (pers. comm. Max Bryce, Jerilderie Fishing Club).

Recreational fishing throughout inland NSW in 2012 is estimated to contribute $360.86 m to the NSW economy. Recreational fishing contributes significantly to rural economies through accommodation, petrol and other supplies and discretionary expenditure (McIlgorm & Pepperell, 2013; Water NSW, 2016).

4.5.3 WATER SKIING

Water skiing is an important recreational activity in the region. The main water-skiing sites are on the Colombo Creek and at Lake Jerilderie. Some skiing is also undertaken on private property upstream of Chesneys Weir.

The Colombo Ski Club began in 1968 under a lease arrangement with the Conargo Station to use land alongside the Eight Mile Weir pool on Colombo Creek. The Colombo Ski School was established in the adjoining land in the 1980s (Hunt & Gooden, 2002).

A Public Recreational Reserve was gazetted for the Colombo Ski Club area in 2009. The reserve is managed for the Crown by Urana Shire Council. In addition to water skiing, the reserve is used by the general public for fishing and camping (Urana Shire Council, 2015)

The club has 100 registered boats and operates upstream of the Eight Mile Weir on Colombo Creek (Figure 8). The ski club area has been improved with toilet facilities, tree planting, establishment of lawn and barbecue areas, a boat ramp and a fenced off area with a watering system. The club is particularly important in providing activities for youth (pers. comm. Jamey Anderson). Water skiing competitions bring in visitors and contribute to the economy.

Figure 8. Colombo Ski Club (photo supplied by Colombo Ski Club)

A review of the Yanco, Colombo and Billabong Water Trust Districts in 1973 proposed the removal of weirs from Colombo Creek. The Colombo Ski Club appealed for the retention of the Eight Mile Dam, which was retained in the creek to retain the recreational value of the Colombo.

Lake Jerilderie was opened in 1979 following its construction by a group of enthusiasts now known as the Jerilderie Aquatic Club. The lake is 5.3 ha and is used for water sports including skiing. The lake is filled by a pipe from Billabong Creek (Sharpe, Stuart, & Vilizzi, 2013). Water skiing activities moved from Billabong Creek upstream of Algudgerie Weir to the lake when the lake was completed.

5 ECOLOGY

5.1 ECOSYSTEM

The Billabong Yanco ecosystem comprises:

- permanent aquatic habitats of the creek channels and weir pools;
- intermittently flowing channels and anabranches that become active at high flows or after heavy localised rainfall;
- riparian bank areas that regularly interact with flowing channels;
- wetlands that retain flood and rain water;
- floodplains that shed water when flood levels recede or after heavy localised rainfall; and
- groundwater dependent ecosystems, which may include saline wetlands.

The dominant riparian vegetation is Red Gum Woodland. More frequently inundated or waterlogged areas support a sedgy understorey which includes Cumbungi, Common Reed, sedges and rushes. Less frequently flooded areas support Black Box Woodland which typically supports a grassy or shrubby understorey with Old Man Saltbush, Lignum and Nitre Goosefoot (SKM 2011).

Riparian woodlands contribute organic matter to the aquatic ecosystem and support microbial and invertebrate productivity, which in turn supports vertebrate productivity, including fish. The foliage, branches, bark and hollows of woodland trees provide physical habitat for waterbirds, bush birds and arboreal mammals and reptiles. The woody debris they create provides habitat for terrestrial vertebrates such as carpet python. Flooding of riparian woodlands promotes understorey growth including the production of foliage, flowers and seeds on which a range of herbivorous and granivorous insects, birds, reptiles and mammals depend.

Riparian woodlands contribute to the habitat requirements of terrestrial fauna through the provision of habitat components that are relatively rare in the surrounding landscape. Tree hollows provided by large mature red gum and black box trees are particularly important for reptiles, owls, parrots and arboreal mammals.

Open wetland habitats such as Dry Lake and Wanganella Swamp support large numbers of waterbirds and waterbird breeding. Smaller wetlands and anabranches, within floodplain complexes such as Arrawidgee and Silver Pines, are expected to be important habitat for frogs and small fish ecological data to support this claim is sparse (SKM 2011, Webster 2007, Walcott, 2017).

5.2 REACHES

The watercourses have been broadly classified into six reaches by Alluvium (2012) on the basis of their hydrology, ecology and geomorphology.

5.2.1 UPPER YANCO CREEK

Upper Yanco Creek flows from the Yanco Offtake on the Murrumbidgee River to Tarabah Weir (Figure 9). The creek is lined by River Red Gum woodland but the understorey is sparse due to stock grazing over much of the

reach. Flows are sustained close to the channel capacity of 1,400 ML/d at the offtake in periods of peak irrigation demand. At higher flows water spills into adjacent wetlands.

The creek features deep pools and small benches with a high density of snags. There are no weirs within the reach and the confined channel creates relatively high stream velocities.

Figure 9. Upper Yanco Creek

High snag density and complexity, together with deep, perennial fast flowing water is associated with the presence of Trout Cod and abundant Murray-Darling Rainbowfish (Sharpe, Stuart, & Vilizzi, 2013). The creek is operated close to bank-full, which provides regular connection with floodplain wetlands and contributes to habitat diversity for floodplain fish species.

A fishway was installed on Tarabah Weir in 2011 (Alluvium 2012).

A regulator has been installed on Mollys Lagoon (9 ha) to exclude high flows and facilitate a managed watering regime (Figure 10). High water levels in Mollys Lagoon spills into Dry Lake a broad 410 ha wetland which supports breeding by large numbers of waterbirds when flooded (Figure 11) (SKM 2011). Dry Lake is normally filled by peaks in flow (e.g. 2,300 ML/d at the offtake in Yanco Creek) but water can enter the lake at bank full flows (1,400 ML/d) if they are sustained long enough. A drain has been cut at the outlet of Dry Lake which has reduced the area where water is retained to 200 ha.

Figure 10. Mollys Lagoon in upper Yanco Creek

Figure 11. Dry Lake in upper Yanco Creek

A regulator was installed on Gum Hole (7 ha) to support a managed water regime but was later removed. Other wetlands in this reach include the Possum Creek complex (Webster 2007 cited in Alluvium 2012).

Bankfull flows in this reach are estimated to occur at 1,500 ML/d at Yanco Creek offtake with floodplain inundation at 2,500 ML/d (Alluvium 2012).

5.2.2 MID YANCO CREEK

Mid Yanco Creek extends from Tarabah Weir to the confluence with Billabong Creek. The CCD and DC800 drainage channels from the Coleambally Irrigation Area discharge to this reach. Four Mile Weir is located just downstream of DC800. Nine Mile Dam and McCaughey Block Dam direct water around Mundoora Anabranch and WIlson Anabranch.

The riparian zone is vegetated by River Red Gum and River Cooba. The understorey is sparse at many locations, possibly due to stock access to the watercourse.

There are a number of floodplain wetlands in this reach. Cheverells Wetland is an effluent stream of 32 ha. The vegetation comprises mostly lignum and wallaby grass fringed by River Red Gum. The Silver Pines complex is comprised of Silver Pines, Arrawidgee and Bundure which together cover 58 ha (Figure 12). The Frontage is an

8 ha complex of six wetlands upstream of the Kidman Way. In addition, there is a large number of smaller wetlands in the riparian zone. The understorey is dominated by Common Reed (Alluvium 2012).

Figure 12. Arrawidgee Wetland Complex in mid Yanco Creek

Bankfull flows are estimated to occur at 800 ML/d with floodplain inundation at 1,000 ML/d (Alluvium 2012).

5.2.3 COLOMBO CREEK

Colombo Creek is an anabranch that diverges from Yanco Creek above Tarabah Weir. Before the weir was constructed Colombo Creek only flowed in response to high discharge in Yanco Creek. The weir raises the Yanco Creek level and allows flows to be directed down either channel over a range of discharges.

Due to the original intermittent flow regime, the older trees along the creek are mainly Black Box. Many of the trees in the deeper part of the channel have been drowned, and a new riparian community dominated by River Red Gum has developed at the edge of the channel.

Colombo Creek supports a distinctive fish community with few large-bodied fish and high abundances of Australian Smelt, which are associated with high densities of aquatic macrophytes (Sharpe, Stuart, & Vilizzi, 2013).

Colombo Creek has a series of weirs which create broad, stable pools of slow flowing water. Weirs include Sheepwash Weir, Two Mile Weir, Six Mile Weir, North Urana Water Users Weir, Eight Mile Weir, Chesneys

Weir, Coonong Weir (Figure 13) and Cocketgedong Weir. The stable water regime contributes to a simple, narrow riparian zone and supports the growth of Cumbungi in the channel.

Figure 13. Coonong Weir on Colombo Creek

In contrast to Yanco Creek, where the channel has relatively steep banks, Colombo Creek is shallow and broad.

Overbank flows are estimated to occur at 1,600 ML/d at Morundah (Alluvium 2012).

5.2.4 MID BILLABONG CREEK

The Mid-Billabong reach extends from the Colombo Creek confluence to the Yanco Creek confluence. Flow is augmented by regulated water entering from Colombo Creek, but the watercourse remains free-flowing upstream of the Jerilderie Town Weir. Weirs below Jerilderie include Algudgerie Weir, McCaughey Institute Weir, Hartwood Homestead Weir, Road Paddock Weir, Lower Woolshed Weir and Hartwood Weir.

The channel is broad with deep pools separated by shallower runs and benches at a variety of elevations in the channel. Riparian vegetation comprises Red Gum Woodland with Black Box Woodland on higher ground and inside meander bends. Sections of the reach are heavily grazed but where stock have been excluded a dense understorey of native grasses and Nitre Goosefoot is present (Alluvium 2012). Downstream of Jerilderie Weir the riparian vegetation grades into Black Box Woodland with an understorey of Lignum, River Cooba and Canegrass (Water Technology, 2012).

The lack of aquatic plants at most sites in Billabong Creek was associated with low diversity and abundance of small-bodied fish species (Sharpe, Stuart, & Vilizzi, 2013).

A survey of riparian condition in this reach was conducted in May and June 2012. The survey did not find strong linear patterns in vegetation and habitat, instead reporting that patches of good and poor riparian habitat were interspersed along the reach. Weed cover was low (Water Technology, 2012).

The estimated bankfull threshold is 2,500 ML/d with floodplain inundation at 3,000 ML/d (Alluvium 2012).

5.2.5 LOWER BILLABONG CREEK

Lower Billabong Creek extends from the Yanco Creek confluence to the Edward River confluence at Moulamein. Weirs in this reach include Boonoke Homestead Weir, Piccaninny Weir, Traceys Weir, Chinamans Weir, Four Mile Weir - Boonoke, Wanganella Homestead Weir, Wanganella Town Weir, Caroonboon Weir and Windouran Weir.

The channel is deep with steep 1 to 2 m high banks. The creek has deep pools connected by shallow runs. Large woody debris is present on the banks and in the channel. Reed beds are present on benches in the channel. River Red Gum closely line the channel but Black Box Woodland is the dominant vegetation along the watercourse.

Figure 14. Billabong Creek at Zara Station

A survey of riparian condition was conducted in this reach in May and June 2012 (Water Technology 2012). The survey reported a distinct decline in tree health from upstream to downstream which may reflect the sustained impacts of the Millennium Drought and surface water extraction. On the whole the tree canopy was continuous and wide, usually extending 10 to 30 m from the watercourse and frequently extending to more than 50 m.

The estimated bankfull threshold is 1,500 ML/d with floodplain inundation at 3,000 ML/d (Alluvium 2012).

5.2.6 FOREST CREEK SYSTEM

Forest Creek is a high level effluent of Billabong Creek that has been regulated (Figure 15) to provide perennial regulated flow as far down as Warriston Weir. Downstream of the weir the creek only flows in response to unregulated events and environmental flows. The creek lies approximately 4 m higher in elevation than Billabong Creek and breakout channels from Forest Creek can divert flow north to Billabong Creek at several locations including Piccaninny Creek, Back Creek, Flood Creek and Estuary Creek. Clarkes Creek conveys high flows to the Edward River.

Figure 15. Forest Creek Offtake Regulator

The regulated section of Forest Creek extends to Warriston Weir (Figure 16). Hartwood Weir raises the Billabong Creek level so that water enters when flow exceeds 100 ML/d. Weirs in the regulated section of Forest Creek include Parry Weir, Drivers Weir and Quiamong Weir.

Figure 16. Warriston Weir on the Forest Creek

Stock and domestic water was supplied to the Forest Creek Anabranch downstream of Warriston Weir at approximately 100 ML/d for almost 100 years (pers. comm. Jim Parrett). From 1990 to 2007 26.2 GL/year was provided from May/June to October/December. Landholders relied on tanks to hold water over summer. This flow, and persistent summer flooding, supported extensive and dense Cumbungi growth. After stock and domestic supply ended in 2007 much of the Cumbungi in the lower reach died (Webster & Davidson, 2010).

The vegetation of the system is dominated by Black Box Woodland with a shrubby understorey of Lignum and Nitre Goosefoot.

Wanganella Swamp, located downstream of the Cobb Highway, is the largest single wetland in the Forest Creek system, occupying 470 ha (Figure 17). The wetland is shallow and basin-shaped with sandhills on the eastern margin. McCrabbs Regulator and Spillway controls outflows, although this structure is in poor repair (Figure 18). In the past the supply of stock and domestic water every summer supported the growth of extensive Cumbungi beds. Since these flows were terminated Cumbungi growth has declined. Wanganella Swamp is an important waterbird breeding habitat, with over 64 waterbird species recorded and breeding by 30 species including Australasian Bittern and Blue-billed Duck and Brolga (Webster & Davidson, 2010). Thirty seven plant species have been identified at the wetland, of which over 80% were native. Taxa include Ribbonweed, Giant Rush, Cumbungi, Common Reed, Common Spike Rush and Lignum (Webster and Davidson 2010).

Figure 17. Wanganella Swamp near the township of Wanganella, showing Water Pepper in the foreground and Common Reed in the background. Higher ground with Nitre Goosefoot is visible on the left.

Figure 18. McCrabbs Regulator (right) and stop bank (left).

Downstream of Wanganella Swamp Forest Creek becomes Forest Creek Anabranch. The watercourse features a number of wetlands, mostly former watercourses, including Kerribirri Swamp, Rhyola Depressions and Floodrunners, Back Nullum Low-lying Areas, Black Box Swamp on Blue Gate.

No data describing the conservation values of the wetlands downstream of Wanganella Swamp has been reviewed.

Figure 19. Forest Creek Anabranch on Zara, downstream of Wanganella Swamp

5.3 CONSERVATION VALUES

5.3.1 ECOLOGICAL COMMUNITY

Riverine aquatic habitats in the Riverina are listed as an Endangered Ecological Community under the *Threatened Species Conservation Act* 1995 (NSW) (TSC Act). The community includes all native fish and aquatic invertebrates in all natural creeks, rivers and associated lagoons, billabongs, lakes and regulated portions of the Murray River below Hume Weir, the Murrumbidgee River below Burrinjuck Dam and the Tumut River below Blowering Dam. The ecological community includes all native fish and aquatic invertebrates within these river reaches and includes 23 native fish species and over 400 recorded native invertebrate species.

5.3.2 FISH

Upper Yanco Creek (incorporating upper Colombo Creek and the Murrumbidgee River near the Yanco Creek offtake) supports one of the only two remaining self-sustaining populations of Trout Cod, a species listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999 (Cwth)* (EPBC Act) and as Endangered under the *Fisheries Management Act 1994 (NSW)* (Sharpe & Stuart, 2014) (Sharpe, Stuart, & Vilizzi,

2013). The other self-sustaining Trout Cod population is in the River Murray between Yarrawonga and Tocumwal (Trout Cod Recovery Team, 2008).

The creeks, particularly the Upper Yanco Creek, are thought to support Trout Cod because they are some of the few remaining sites in the lowland Murray-Darling Basin which provides fast, perennial flow and dense woody debris. Before settlement, this habitat was widespread but has been reduced through the construction of weirs, the removal of snags and the regulation of flows.

Table 8. Yanco-Billabong fish fauna (Sharpe & Stuart, 2014)

Common name	Scientific name	EPBC Act	FM Act
Native			
Silver Perch	*Bidyanus bidyanus*		V
Un-specked Hardyhead	*Craterocephalus stercusmuscarum fulvus*		
Carp Gudgeon	*Hypseleotris spp.*		
Trout Cod	*Maccullochella macquariensis*	E	E
Murray Cod	*Maccullochella peelii peelii*	V	
Golden Perch	*Macquaria ambigua*		
Murray-Darling Rainbowfish	*Melanotaenia fulviatilis*		
Bony Herring	*Nematalosa erebi*		
Australian Smelt	*Retropinna semoni*		
Freshwater Catfish	*Tandanus tandanus*		End. Pop.
Alien			
Goldfish	*Crassius auratus*		
Common Carp	*Cyprinus carpio*		
Eastern Gambusia	*Gambuisa holbrooki*		
European Perch	*Perca fluviatilis*		

Elsewhere, the Billabong Yanco System provides good habitat for fish including perennial flow, abundant woody debris, an intact canopy and aquatic vegetation. A baselining survey of the system in 2013 reported ten native species (Sharpe & Stuart, 2014).

Murray Cod (Vulnerable - EPBC Act, Vulnerable - Fisheries Management Act) is distributed throughout the system. Murray Cod is more abundant in Billabong Creek than Yanco Creek. The population includes fish of a range of ages with some adults over 700 mm and some young-of-year juveniles. Sharpe, Stuart, & Vilizzi (2013) did not refer to the Murray Cod stocking program undertaken by the Jerilderie Fishing Club.

Golden Perch is a migratory fish that is present throughout the system and benefits from flood flows that connect the weir pools and allow fish to disperse. Silver Perch (Vulnerable - Fisheries Management Act) is a similar species that is present in Billabong Creek and Colombo Creek but not Yanco Creek. While most of the Silver Perch were adults, juveniles of Golden Perch are present. Golden Perch is stocked by the Jerilderie Fishing Club.

Freshwater Catfish (Endangered Population - Fisheries Management Act) is present throughout the system, although few young of year were detected in the survey. This is very significant as the species has suffered widespread declines in range and abundance outside of the Billabong (throughout MDB in Victoria, southern NSW and Murray in SA (Fisheries Scientific Committee, 2008). There is some concern that the willows were providing a critical habitat and now they are removed the catfish have further declined in certain reaches. Some fish ecologists have suggested weirs may provide habitat for catfish, however others argue that good quality fish habitat would be available in the system if the weirs were removed.

Small-bodied fish species, which benefit from vegetated waterways and wetland habitat, include Australian Smelt, Murray-Darling Rainbowfish, Carp Gudgeon and Un-specked Hardyhead. These species are present throughout the system.

The exotic fish Goldfish, Common Carp, European Perch and Eastern Gambusia were all present in Billabong Creek, Yanco Creek and Colombo Creek. Common Carp made up by far the largest proportion (63.3%) of the total large-bodied fish biomass. The waterways with the highest Carp biomass proportion were Colombo Creek (89.6%) and Yanco Creek (86.4%). The proportion of biomass was 54.1% in Billabong Creek.

Survey data for Dry Lake indicates it is an important off-channel habitat for native fish with very high abundances recorded in 2011, with the population comprising mainly Carp Gudgeon. Other native species present in Dry Lake and Mollys Lagoon were Australian Smelt, Murray-Darling Rainbow Fish and Un-specked Hardyhead. The alien fish Carp, Gambusia, Goldfish and Oriental Weatherloach were also recorded (Wassens, et al., 2011).

5.3.3 WATERBIRDS

Wanganella Swamp is the most significant waterbird site in the Billabong Yanco System, supporting large numbers of a diverse range of waterbirds, with many species breeding. Sixty four species have been recorded from the site of which thirty species have been recorded breeding (Webster & Davidson, 2010). Many of the birds at Wanganella Swamp are listed under the EBPC Act as threatened or migratory, or are listed under the TSC Act (Table 9).

Dry Lake is also an important waterbird habitat that supports a high species richness with 22 species observed in the 2011-2012 period. The majority of the birds at Dry Lake were fish eating species and dabbling ducks. The species richness at Mollys Lagoon was 13 species with most abundant bird groups being fish eating species, grazing waterfowl and large waders (Wassens, et al., 2011).

5.3.1 VEGETATION

Data describing the composition and structure of plant communities in the Billabong Yanco System is generally poor. A complete species list and vegetation description is available for Wanganella Swamp (Webster & Davidson, 2010). Water Technology (2012) prepared 'rapid species lists' when surveying sites for vegetation condition on Billabong Creek. Species lists may have been collated for Travelling Stock Reserves (Elisa Tack Murray LLS pers. comm.). Elsewhere vegetation is usually only described in terms of plant communities.

There is limited coverage of in-stream aquatic vegetation in the Billabong Yanco system, with areas of *Vallisneria* and *Potamogeton* common only in Forest Creek. This has been attributed to the effects of Carp and riparian grazing (Alluvium 2013). Emergent aquatic macrophytes are also sparse where watercourses are

accessed by stock. *Typha* sp. (Cumbungi) and *Phragmites australis* (Common Reed) are common where grazing is restricted, and particularly where weirs stabilise water levels.

Table 9. Waterbirds of conservation significance known from Wanganella Swamp. Records from 1978 to 2000 (Webster & Davidson, 2010)

Common name	Scientific name	EPBC Act	CAMBA	JAMBA	ROKAMBA	TSC Act
Australasian bittern	*Botaurus poiciloptilus*					V
Australian painted snipe	*Rostratula australis*	V	*			E
Blue billed duck	*Oxyura australis*					V
Brolga	*Grus rubicunda*					V
Cattle egret	*Ardea ibis*	M	*	*		
Common greenshank	*Tringa nebularia*		*	*	*	
Curlew sandpiper	*Calidris ferruginea*		*	*	*	
Eastern Great Egret	*Ardea modesta*		*	*		
Fork-tailed swift	*Apus pacificus*	M	*	*	*	
Freckled duck	*Stictonetta naevosa*					V
Glossy ibis	*Plegadis falcinellus*	M	*			
Lathams snipe	*Gallinago harwickii*	M	*	*	*	
Marsh sandpiper	*Tringa stagnatilis*	M	*	*	*	
Pectoral sandpiper	*Calidris melanotos*	M				
Red-necked stint	*Calidris ruficollis*	E	*	*	*	
Ruff	*Philomachus pugnax*	M				
Sharp-tailed sandpiper	*Calidris acuminata*	M	*	*	*	
White-bellied sea-eagle	*Haliaeetus leucogaster*	M	*			
White-throated needletail	*Hirundapus caudacutus*	M	*	*	*	
Wood Sandpiper	*Tringa stagnatilis*		*	*	*	

Notes
CAMBA - China Australia Migratory Bird Agreement
JAMBA - Japan Australia Migratory Bird Agreement
ROKAMBA - Republic of Korea Australia Migratory Bird Agreement

Descriptions of floodplain wetland systems such as Silver Pines, Dry Swamp and Puckawidgee are brief (Alluvium, 2013). When inundated they support semi-emergent aquatic macrophytes in open water (e.g. *Myriophyllum* spp.), emergent reeds and rushes in shallow areas (e.g. *Juncus* sp. and *Eleocharis* sp.) with an overstorey of River Red Gum in frequently flooded areas. Higher ground that is less frequently flooded supports an overstorey of Black Box (*Eucalyptus largiflorens*) with River Cooba (*Acacia stenophylla*) and an understorey of Lignum (*Duma florulenta*) and Nitre Goosefoot (*Chenopodium nitrariaceum*).

There are four broad vegetation zones in the Forest Creek system (Davidson & Webster, 2007):

- Open Water (Ribbonweed)
- Tall Grassland (Cumbungi and Common Reed)
- Wet-Dry Zone (herbs, sedges and aquatic grasses)
- Occasionally Flooded Zone (shrubs)

The open water zone contains mostly submerged plants such as Ribbonweed (*Vallisneria sprialis*). The tall grass zone is dominated by Cumbungi which benefits from sustained annual inundation. This zone also supports areas of *Phragmites australis* and rushes including Giant Rush (*Juncus ingens*). The wet-dry zone consists of mostly herbs, sedges and grasses and lies at a slightly higher elevation than the reeds. This zone is seasonally inundated and is favoured by stock. It provides palatable species such as Spiny Mudgrass (*Pseudoraphis spinescens*) and Water Couch (*Paspalum distichum*). This zone contains hardy drought-tolerant shrubs such as Lignum and Nitre Goosefoot.

The fringes of the waterways and wetlands support woodlands of Black Box and River Cooba.

The stable water levels created by weirs and water supply has strongly affected vegetation in the Billabong Yanco system (Beal, Furness, Parrett, & Scriven, 2004). Stable water levels favour the growth of Cumbungi and Willow (*Salix* sp.) which have formed extensive stands in and around weir pools. In the past Cumbungi has also grown along the Forest Creek system and particularly in Wanganella Swamp. Dense growth of these plants reduced channel capacity and became a significant problem in the late 1990s and early 2000s. In the Forest Creek system the extent of Cumbungi declined after regulated water supply below Warriston Weir ended. The former beds of Cumbungi in Wanganella Swamp, which were important waterbird breeding habitat, have now largely gone. Elsewhere in the Billabong Yanco system Cumbungi growth was reduced by low flows in the Millennium Drought and further disturbed by strong flood flows since 2011 which uprooted and removed the vegetation. YACTAC undertook a willow control program over several years which has significantly reduced the density and extent of willows (Beal, Furness, Parrett, & Scriven, 2004).

Sagittaria montevidenis (Arrowhead) is an aquatic weed that forms dense infestations in waterways and is also a pest plant of irrigation channels and rice crops. Arrowhead is present in the Billabong Yanco System and its further spread from irrigation outfalls is a cause for concern (Beal, Furness, Parrett, & Scriven, 2004).

Phyla nodiflora (Lippia) is an introduced groundcover plant that benefits from seasonal waterlogging and is very drought tolerant. It is an invasive understorey species that diplaces native plants. Lippia is present in Upper Yanco Creek (Alluvium, 2013).

Lycium ferocissimum (African Boxthorn) is a widespread weed in the region and frequently occurs in aquatic and floodplain habitats in the Yanco Billabong System. Over the past three years Murray LLS has provided funding and support to YACTAC to conduct a trial of mechanical and chemical control methods for African Boxthorn in conjunction with Central Murray Council.

Yellow Water Lily (*Nymphaea mexicana*) is present in Colombo Creek and grows readily in the stable water levels provided by weir pools (Beal, Furness, Parrett, & Scriven, 2004).

Other aquatic weeds that are present in the region and potentially occur in the Billabong Yanco System include *Alternanthera philoxeroides* (Alligator Weed), *Eichhornia crassipes* (Water Hyacinth) and *Cabomba caroliniana* (Cabomba) (SKM 2011). (Murray WAP and Riverina WAP, 2016).

5.3.2 OTHER BIOTA

Four species of frog have been reported from Wanganella Swamp (Ecosurveys, 2012):

- Perons Tree Frog;
- Plains Froglet;
- Spotted Marsh Frog; and
- Barking Marsh Frog.

Frogs reported from Dry Lake and Mollys Lagoon are Plains Froglet, Barking Marsh Frog, Inland Banjo Frog and Spotted Marsh Frog (Wassens, et al., 2011).

Southern Bell Frog (Endangered - TSC Act, Vulnerable - EPBC Act) occurs in the Coleambally Irrigation Area.

A recent survey of frogs (Walcott, 2017) found seven species across the system:

- Barking Marsh Frog;
- Spotted Marsh Frog;
- Eastern Sign-bearing Froglets;
- Peron's Tree Frog;
- Eastern Banjo Frog;
- Sudell's Frog; and
- Southern Bell Frog (in Mid Yanco Creek).

Long-necked Turtles and Murray River Turtles have been observed in Mollys Lagoon.

Platypus is present in Upper Yanco Creek and Colombo Creek (pers. comm. Max Bryce, Jerilderie Fishing Club).

Murray LLS has contracted Charles Sturt University to undertake frog surveys at 15 wetland complexes within the Billabong Yanco System in 2017/18, including using acoustic survey technology. This will provide further data on the frog population within wetlands in the region.

5.4 ENVIRONMENTAL WATER REQUIREMENTS

A study to evaluate the environmental water requirements of the Billabong Yanco System was undertaken by Alluvium (2013). This study formulated a number of objectives to address flow-related issues identified on the Yanco Creek System. The objectives were determined in the context of current water resource management, and the social and economic values of the region:

- maintain riparian vegetation condition, extent and composition;
- rehabilitate riparian vegetation condition, extent and composition;
- maintain diversity and abundance of instream vegetation;
- maintain a mosaic of wetlands;
- maintain channel form and promote habitat diversity;
- maintain drought refuge habitat;
- support self-sustaining populations of macroinvertebrate taxa from the endangered Lower Murray Aquatic Ecological Community;
- support self-sustaining populations of macroinvertebrate taxa found in mid-Murrumbidgee wetlands;
- maintain and/or improve large-bodied native fish community;
- maintain and/or improve medium-bodied native fish community;
- maintain and/or improve small-bodied generalist native fish community; and
- maintain and/or improve small-bodied native fish – floodplain specialists;

Water delivery principles were developed to meet these objectives:

- maintaining stable, high water levels is generally incompatible with the maintenance of high ecological values;
- water levels need to fluctuate seasonally;
- temporary wetlands require periodic inundation with periodic drawdown of water levels and complete drying;
- wetlands should be flooded in late winter or early spring, and remain inundated for at least three to eight months;
- rates of inundation and drawdown need to be controlled;
- multiple wetting-drying cycles may be required for environmental rehabilitation; and
- ecological connectivity among wetlands should be acknowledged and maximised.

Sharpe et al. (2013) summarised the main hydrological threats in Yanco Creek with respect to recovery of native fish populations as:

- reversed seasonality with high flows in summer and low flows in winter;
- weir pools that lack fast flowing reaches interspersed with slow-flowing reaches;
- much greater daily variation in water height;
- high winter weir pool levels but with little passing flow; and
- reduced end-of-system flow.

In the past, bank full flows in Yanco Creek have created undesirable persistent flooding in low-lying wetlands and floodplain areas. Wetlands subject to excessive flooding were surveyed between the Yanco Creek offtake and DC 800 (Webster, 2007). This study identified and mapped wetlands greater than 2 ha in size and evaluated their hydraulic connection to the creek and condition. The study identified 176 wetlands. The most widespread threat to the conservation values of the wetlands was weed infestation. Other threats included cropping, water storage, waterlogging and roads and tracks. Forty one wetlands were evaluated as providing potential water savings by regulating the connection to the creek channel.

A management plan has been developed for Wanganella Swamp that aims to promote waterbird habitat and vegetation condition and diversity (Webster & Davidson, 2010). The plan recommended a water regime comprising three operational components:

1. Allow natural flood flows in the Murrumbidgee River and Billabong Creek to enter Forest Creek and fill Wanganella Swamp;

2. Establish an environmental flow to be used in extensive dry periods (>4-5 years in duration) and delivered via Forest Creek; and

3. Establish an environmental flow to be used during extensive dry periods (>4-5 years in duration) and delivered directly into Wanganella Swamp via pumping from Billabong Creek.

Since the plan was completed, more frequent low flows have been proposed to maintain the extent and condition of Cumbungi and Common Reed in the wetland (pers. comm. Phil Maher – Ecologist and James McGuire OEH).

Murray Catchment Management Authority investigated barriers to fish passage in the Murray Catchment including dams, weirs and road crossings. The primary aim of the project was to identify priority structures that could be targeted for remediation, either by modification or removal. The study identifies three priority watercourses for strategic investment in fish passage:

- Billabong Creek;
- Bullatale Creek and Edward River; and
- Coppabella Creek and Lankey's Creek.

The study identified 100 fish passage barriers as a high priority for remediation in the Murray CMA region. Thirty four of the 100 highest priority barriers were located in the Billabong Yanco System, with 14 of the top 20 barriers located on Billabong Creek (DPI NSW, 2008).

6 STAKEHOLDER PRIORITIES

6.1 ENVIRONMENTAL HEALTH IS LINKED TO IRRIGATION SUPPLY

It is a widely held opinion that the supply of water for stock and domestic use and for irrigation provides benefits for the environment and is critical in maintaining the current condition of the system . The passage of water supports aquatic biota by providing aquatic habitat in the channel, maintaining water quality, maintaining aquatic refuge, providing flows to overtop weirs and allow free movement of fish and to inundate low-lying floodplain areas to maintain riparian vegetation and wetland habitat.

The supply of irrigation and stock and domestic water at the end of the system is important to ensure aquatic habitat is available throughout Billabong Creek. Any reductions to the amount of water flowing down the creeks is considered a threat to the health of the system by stakeholders.

6.2 UNREGULATED FLOWS AND THE YANCO REGULATOR UPGRADE

The Billabong Yanco System becomes unregulated when flow exceeds the capacity of upstream storages to capture and control water. Unregulated flows originate from the Murrumbidgee catchment and the Billabong catchment.

Although they are not entirely predictable, unregulated flows are critical to many farm businesses. Unregulated flows in winter and spring may be pumped to tanks where they allow farmers to plan summer crops such as rice, corn and cotton. The decision to plant summer crops is based on the availability of unregulated flows in the period August to November. The economic importance of unregulated flows is illustrated by the recent investments in on-farm storage: approximately 5,000 ML in the last few years (pers. comm. Russell Ford). Large on-farm storages have no function except to store unregulated flows.

Unregulated flows provide inundation to low-lying floodplain areas. Important floodplain ecosystems that benefit from overbank flows include the woodlands and wetlands in the Upper Yanco, Mid Yanco and Forest Creek System. High flows within the channel allow fish to move between reaches that are isolated by weirs, provide access to high channel benches and provide spawning and migration cues for some fish species.

The Yanco Creek Regulator upgrade, which has been proposed under the SDL adjustment mechanism, has the potential to eliminate unregulated flows in Yanco and Colombo Creek and greatly reduce unregulated flows in Billabong Creek. The new structure would provide some re-regulation capacity in the Murrumbidgee River and would allow peaks in flow up to 45,000 ML/d to be directed down the main stem of the Murrumbidgee River. The existing structure only provides control up to flows of 14,000 ML/d, with approximately one tenth of higher flows entering Yanco Creek. A proposed benefit of the structure is to restore flooding to the Mid-Murrumbidgee Wetlands which have a high conservation value.

The proposal has been developed on the basis that the Yanco system will retain its current share of unregulated flows. However there is concern in the Billabong Yanco community that this policy could be revised after the weir is constructed and the share sent to the Billabong Yanco System reduced. There is also concern about the effects changing the timing of water delivery may have on the health of the system. Unregulated flows currently mimic the natural flow regime (i.e. high flows occur in late winter- spring) and therefore may be more beneficial to the native biota that have evolved with the natural regime.

There is a strong perception among stakeholders that the process to develop the Yanco Offtake proposal has been secretive and that claims that stakeholders have been consulted are dishonest. The overall opinion of the proposal is strongly negative and that it will have severe environmental and economic impacts. Stakeholders do not believe that the proponents have provided a forum for this view to be presented.

There are concerns that the operational and maintenance costs of the proposed structure will be funded by higher water costs from consumers who did not want it.

6.3 TROUT COD HABITAT CONTINUITY AND THE YANCO REGULATOR UPGRADE

The Trout Cod population in Upper Yanco Creek extends into the Murrumbidgee River upstream and downstream of the Yanco junction. The proposed Yanco Regulator upgrade involves a fishway between Yanco Creek and the Murrumbidgee River. The fishway will be designed specifically to accommodate Trout Cod, however some loss in habitat connectivity will be inevitable. Many stakeholders believe that the potential impact on Trout Cod habitat connectivity is not acceptable.

6.4 WATER BUY-BACKS AND WATER EFFICIENCY

Over the past 15 years, irrigators have sold entitlements under government buy-back programs including Water for Rivers, The Living Murray and Commonwealth environmental water recovery.

The reduction in licences has resulted in a system that can be operated at lower flows and more efficiently. The frequency of overbank flows has decreased and evaporation and seepage losses have declined. The end of system target of 50 ML/d at Darlot is exceeded by a smaller margin.

While the purpose of water buy-backs has been to improve environmental health, the local effect has been a reduction in in-stream and overbank flows, with perceived negative impacts for the environment. Overall the programs are considered as harmful to the local environment with the benefits being delivered elsewhere, i.e. a 'robbing Peter to pay Paul' scenario.

The Water for Rivers project to end the delivery of stock and domestic water downstream of Warriston Weir is considered by some to have harmed the environment. The reduced flows have resulted in deterioration in waterbird habitat in Wanganella Swamp with poorer waterbird breeding outcomes. Aquatic habitat in the Forest Creek Anabranch has also deteriorated (pers. comm. Phil Maher).

6.5 ESCAPES AND IRRIGATION OUTFALLS

Many stakeholders believe that there is unused potential to improve water delivery using CIA and MIL escapes and outfalls. These channels allow water to be introduced to the mid-sections of the Yanco and Billabong Creeks when supply in Upper Yanco Creek is constrained.

There is a perception that WaterNSW is reluctant to pursue escapes as a source of water. This is based on the opinion that WaterNSW has a conflict of interest when acting as both a retailer and resource manager. As a resource manager their role is to arrange efficient water delivery to consumers. However as a retailer it is not in their interests to promote the supply of water from alternative retailers such as MIL.

There are a number of other concerns associated with the use of escapes and outfalls including:

- not all escapes are licenced to provide environmental flows;
- the irrigation areas are a source of weeds, particularly Sagittaria from MIL;
- the introduction of additional Carp;
- the irrigation areas can be a source of blue green algae; and
- the fees charged by MIL to deliver water are too high, even though WaterNSW does not charge equivalent fees for MIL to dispose of excess water in the Billabong Yanco System.

6.6 END OF SYSTEM FLOWS

When water leaves Billabong Creek and enters the Edward River it is no longer considered a regulated water resource. It is treated as a loss to the Murrumbidgee catchment. Therefore efficient management of the Billabong Yanco System requires minimising flows in excess of the 50 ML/d target at Darlot mandated in the Water Sharing Plan.

The rules create water supply problems because in trying to minimise losses, Water NSW runs the river as low as possible, which can create gaps in flow when several landholders pump water on the same day.

The end of system rules create difficulties for environmental watering. Environmental water is written off when it enters the Edward, so it cannot be re-used in wetlands or other assets downstream.

Flows can be credited under Intervalley Transfer rules (IVT). However these require that there is an order downstream and are difficult to arrange.

Stakeholders widely agree that re-crediting end of system flows to the Murray catchment water balance would improve water management in the Billabong Yanco System. WaterNSW could operate the river at higher levels which would reduce the likelihood of gaps in river flow. OEH could also provide baseflows and freshes at a lower cost to environmental accounts because water could be re-credited.

6.7 OVERBANK FLOWS IN UPPER YANCO CREEK

The Water Sharing Plan sets a limit of 1,400 ML/d on controlled diversions at the Yanco offtake. The limit is designed to minimise inundation of private property and to reduce losses associated with overbank flows.

Overbank flows in the Upper Yanco and Mid Yanco are an important component of the environmental water requirements of the system, as these reaches contain high value wetlands and floodrunners. In order to promote the delivery of water to these assets, OEH is seeking amendments to the Water Sharing Plan so that the 1,400 ML/d limit on flows only applies to irrigation flows, and that higher flows may be permitted for environmental purposes.

The constraints management strategy of the MDBA aims to create easements for floodplain inundation with compensation for landholders. The current flow limit in the water sharing plan is 32,000 ML/d at Gundagai however WaterNSW has recently adopted a flow of 22,000 at Wagga Wagga which, following attenuation, corresponds to approximately 17,000 ML/d downstream of Yanco Weir and 1,700 ML/d at the Yanco Creek offtake (pers. comm. James Maguire OEH). A trial flow of 2,500-2,600 ML/d has been proposed. In general the community is supportive but some landholders have objections.

6.8 INTEGRATING ENVIRONMENTAL WATER WITH RIVER OPERATIONS

There are opportunities to achieve environmental outcomes with less water through forward planning and negotiation between OEH and Water NSW (pers. comm. Vince Kelly Water NSW).

In-channel environmental objectives may involve the delivery of baseflows and pulses or controlling rates of rise and fall. In many cases, these can be achieved by managing the delivery of consumptive water, without using environmental water. The use of environmental water to achieve these outcomes is sometimes unnecessary and wasteful.

To better integrate environmental water requirements in river operations, forward planning is required to determine the hydrograph characteristics that should be promoted or avoided. The preferred approach would be for OEH to request Water NSW to provide a particular hydrograph, rather than requesting Water NSW to deliver a volume of environmental water in a particular way.

6.9 SHARE OF FLOWS BETWEEN YANCO AND COLOMBO CREEK

There are high value environmental assets in the Mid Yanco reach that benefit from bank full and overbank flows. However, during the irrigation season Tarabah Weir diverts most flow down Colombo Creek and into Billabong Creek where riparian values are relatively poor. One landholder has proposed that irrigation water supply would have greater environmental benefits if it were directed down the Mid Yanco Creek.

The reason for the diversion of water to Colombo Creek is because there is a higher irrigation demand on the Billabong than on the Yanco (pers. comm. Russell Ford).

OEH recognises the importance of the Mid Yanco Wetlands and are seeking to promote inundation by raising the 1,400 ML/d operational constraint on water delivery at the Yanco Offtake and using CIA outfalls to introduce water below Tarabah Weir. In general environmental water will be directed to the Mid Yanco, except when Forest Creek and Wanganella Swamp are targeted.

6.10 RE-REGULATION WEIR

A new weir has been proposed at Conargo downstream of the Yanco-Billabong confluence. The weir would regulate some of the unregulated flow from the Billabong catchment which currently cannot be stored.

The weir is considered to be problematic. The new weir would involve decommissioning Hartwood Weir which would make it impossible to deliver water to Forest Creek. A lower cost alternative would be to refurbish Hartwood Weir. While this structure could not re-regulate Yanco flows, it is a higher priority to regulate flows from the Billabong catchment.

6.11 GAUGING

Reliable delivery of water orders requires good information on the distribution of flow in the system at any given time. The existing flow gauging system is considered inadequate by several stakeholders. The system does not allow the location of water extraction to be clearly identified or the inflows from escapes to be

accurately measured. Gaps in the system make it difficult to use the escapes and outfalls to effectively supplement flows.

It has been suggested that telemetered water level gauges could be added to irrigators' pumps and plugged into the existing telemetered system to provide a widely distributed and comprehensive flow monitoring network.

6.12 MONITORING AND ENFORCEMENT

In general, diverters only pump the water that they have ordered but occasionally water is pumped without orders. This needs to be policed more actively. As the system is now being more efficiently managed and with less excess water, the impacts on downstream consumers of pumping unordered water are higher.

6.13 MANAGEMENT PLANS FOR WETLANDS

Mollys Lagoon and Dry Lake are high value environmental assets and have been targeted several times for environmental water delivery.

A regulator was installed on Mollys Lagoon under the Water for Rivers project to allow excess flows to be excluded and environmental water delivery to be controlled. Dry Lake is filled by water spilling into a floodway connected to Mollys Lagoon.

There is concern about the water regimes that are being applied to the system, in particular that Dry Lake is being flooded more than would occur naturally and to achieve this, water is being held too high in Mollys Lagoon. This is perceived to be threatening the health of River Red Gums at the lagoon and degrading Dry Lake. Nevertheless, a near-permanent water regime in Mollys Lagoon is considered appropriate.

Central to these concerns are that there are no agreed operating plans for the wetlands.

OEH bases decisions for watering on the environmental values of the wetlands and long-term watering requirements. Even so, much of the water entering the wetlands in recent years has resulted from uncontrolled high flow events.

It is hoped that the Constraints Management Strategy will provide a comprehensive and long-term framework to manage floodplain and wetland inundation, with the agreement of landholders.

6.14 WEIRS

There are over 30 significant weirs in the Billabong Yanco System. Altogether there are over 100 structures that interrupt flow to some extent, including weirs, regulators, block dams and by-wash dams (Molino Stewart 1999 cited in Alluvium 2013). Weirs vary from low level disused structures that are readily overtopped to large structures with a head difference of more than 2 m that are rarely overtopped.

Weirs provide operational benefits but also have environmental impacts.

Many weirs were constructed in the early twentieth century to provide a source of stock and domestic water in a system that flowed intermittently. The weirs now assist with pumping by raising the creek water level and

reducing pumping costs. The weirs also provide a local store of water in the event of temporary interruptions to flow. Weirs have recreational and amenity value by creating large bodies of water and supporting boating and water skiing.

Many weirs only serve one or two pumps.

Weirs have significant impacts on the aquatic ecosystem. Weirs block upstream passage of native fish. For species that do not migrate, such as vegetation-dependent species (Carp-Gudgeon, Murray-Darling Rainbowfish and Murray Cod), weirs reduce the extent of their home range, reduce dispersal, restricting access to alternative habitats and refuge from local disturbances such as poor water quality. Weirs have severe impacts on migratory species such as Golden Perch and Silver Perch, which are unable to move upstream in response to breeding flows in spring and early summer. They may provide respite immediately downstream during blackwater events by oxygenating the water as it passes over the weir.

Weirs impact on riparian vegetation productivity and diversity. By stabilising water levels, weirs create a narrow riparian zone that comprises only a few species. One of the native species that benefits from stable water levels is Cumbungi. In the past this has spread to such an extent that flow has been restricted. An exotic species that benefits from stable water levels is Willow which degrades habitat and disrupts flow. While most of the Willow has been removed from the system, the conditions remain for it to recolonise.

Opinions vary on the benefits and impacts of the weirs.

Some stakeholders believe that most weirs are overtopped so frequently that they do not present a significant barrier to fish passage. Others, particularly fish ecologists, believe that the fish community would benefit significantly by the removal of the weirs.

Some stakeholders have said that weirs may play an important role in providing refuge habitat for fish during drought. It has been suggested that weir pools and Willows may be important for catfish. Other fish ecologists disagree with this view, saying that the creeks naturally contain deep pools which, with an appropriate water regime, could provide these benefits without the need for weirs.

The position of OEH is that weirs are an environmental hazard. Weirs are undesirable, except where they assist in environmental watering. If weirs are necessary, their impacts on fish passage should be mitigated by fishways.

6.15 ECOLOGICAL DATA TO SUPPORT WATER MANAGEMENT

The system includes important wetland complexes. Important systems on Yanco Creek include the Upper Yanco wetlands and on the Mid Yanco: Silver Pines, Arrawidgee, Bundure, The Frontage and the Mundoora/Wilson Anabranch.

While many stakeholders are aware of the conservation values of these sites, there is very little data to describe the flora and fauna they support or the habitats they comprise. Some stakeholders have expressed concern that the higher value given to the Mid Murrumbidgee Wetlands than wetlands in the Billabong Yanco System is because more work has been done to identify their conservation values and determine their water requirements.

To address this knowledge gap, Murray LLS has engaged Charles Sturt University to investigate ecological dependencies on water over the period 2017-2018. The project will investigate riverine and floodplain systems in the Yanco-Billabong system to better guide investments in land and water management.

6.16 ORDERING TIME

Ordering times range from 14 days in Upper Yanco to 26 days on the Lower Billabong. Long ordering times create supply inefficiencies and poor farming outcomes.

Often water that is ordered is not used because rain has fallen before the order arrives and it is no longer needed on the farm. There is no requirement for irrigators to use water that they have ordered, so it can pass through the system to be recorded as a loss. Conversely, spells of hot weather can create a demand for water that cannot be met in time, leading to crop damage or creating an incentive to access water without an order.

A range of proposals have been put forward in the Effluent Creeks SDL proposal to improve delivery times and operational flexibility. These include constructing a new weir downstream of the Yanco-Billabong confluence to re-regulate flows, making full use of CARM, better gauging and making greater use of irrigation outfalls and escapes.

6.17 FOREST CREEK PROPOSAL

The regulated section of Forest Creek is highly inefficient. Approximately 35 GL of water is used each year to supply the licensed entitlement of 22.4 GL in the regulated section of Forest Creek (NSW Office of Water, 2013).

A pipeline has been proposed to deliver 24 ML/year of stock and domestic water supplies from the Hartwood Weir pool to the licensed users along the creek. With a reduction in Stock and Domestic water use due to more efficient delivery, the high-security water savings available are 102 ML/year.

This proposal is problematic for Forest Creek landholders. Potential difficulties include:

- it would end the availability of unregulated flows which are used by irrigators;
- stock and domestic water would have to be replaced with a reticulated system including stock troughs - many farms do not have stock troughs or pipework because stock access water from the creek;
- the creek acts as a fenceline to control the movement of stock and fencing would be required if the creek became dry.

6.18 WATER QUALITY, MONITORING AND NOTIFICATION

In general stakeholders believe that water quality in the Billabong Yanco System is good. When problems do occur, the three main issues are turbidity, blackwater and blue-green algae.

Turbidity is a major issue for water treatment at Jerilderie (pers. comm. Dave Tamlyn, Murrumbidgee Council). Turbidity levels of 40 to 50 ppm (suspended sediment) were normal in past years, but levels now frequently reach 120 ppm. Turbidity is higher in summer and is driven by inflows from the Billabong catchment. High flows in Colombo Creek contribute low turbidity water from the Murrumbidgee and dilute suspended sediment. To

manage high suspended sediment the council has upgraded filtration works, but these now operate at full capacity.

Blackwater events occur during floodplain inundation events in the Billabong Yanco System or in the upstream Murrumbidgee and Billabong catchments. The inundation of organic matter, mainly leaf litter, supports high rates of microbial decay which consumes dissolved oxygen and releases tannins, creating a dark tea colour to water. Anoxic water is harmful to aquatic life and can lead to mass fish kills, which is of concern from an environmental aspect and to recreational fishers. Blackwater is also considered undesirable for stock drinking water.

Blue-green algal blooms occur naturally in lowland river systems, but are made more frequent and severe by artificially high nutrient loads and low flows, particularly in summer. Water contaminated by blue-green algae is toxic to humans and stock.

There is concern that WaterNSW does not have clear policies and procedures to manage water quality problems. Initiatives suggested by stakeholders to improve water quality management were:

- a water quality monitoring network to identify issues;
- the development of policies and procedures for Water NSW to manage water quality problems;
- a notification system to consumers, such as SMS alerts, to warn of water quality problems; and
- greater use of Murrumbidgee flows to dilute water quality problems originating in the Billabong catchment, particularly turbidity.

6.19 DISRUPTION TO FLOW AND NOTIFICATIONS

Flow into the Billabong Yanco System may be interrupted for operational reasons or by intensive pumping by upstream landholders.

Flow interruptions can impact diverters. Low flows can also affect recreational uses of the system, particularly water skiing. Low flows in Colombo Creek can cause water levels in the Eight Mile Weir pool to fall by 30 to 45 cm, creating a safety hazard for boats and skiers.

Creek users can access flow information on the internet. However a more pro-active approach from WaterNSW would be appreciated by many stakeholders. This could involve sending SMS alerts about changes in flow that significantly affect users.

6.20 SUSTAINED FLOOD FLOWS

High flows in 2011 and 2016 created widespread and sustained inundation of the Billabong Yanco System.

Positive landholder responses focussed on the improved health of the river, drawing attention to the recovery of riparian vegetation including the canopy cover of riparian trees. Another positive aspect was that Cumbungi had been cleared out from the creek channels.

The sustained 2016 floods presented several difficulties for landholders including sheep (ovine) footrot, River Red Gum sucker proliferation (seedlings), the spread of weeds (particularly Bathurst Burr and Lippia), lack of access through flooded areas and increased abundance of kangaroos.

One landholder said that environmental water should be released from storage when dams are nearly full to create air space and mitigate flooding risk.

6.21 BANKS ON FOREST CREEK

Stop banks were constructed along the Forest Creek Anabranch to prevent stock and domestic water from escaping to Billabong Creek and to conserve water within the channel. Although the creek is no longer regulated, there are still many blockages in place. The blockages obstruct natural flow paths and should be removed (pers. comm. Jim Parrett).

7 INFORMATION GAPS

7.1 AGRICULTURAL ACTIVITY AND PRODUCTION

The relationship between agricultural activity and production in the Billabong Yanco System is poorly understood. Economic information is required to characterise existing water needs, to predict future demands for water and to evaluate the impacts of alternative water management arrangements.

An economic and water management investigation would collate information on the times, quantities and locations of water demands in relation to farming activities such as crops grown and their economic value. The study would assess the impacts of proposals such as reducing the supply of unregulated water on farm production. The study would investigate likely future farming activities under current and alternative water supply arrangements, such as reduced order times or with more regulation within the system.

A recent socio-economic review of the region only provided a very general summary of economic activity and did not evaluate dependencies on water supply.

The lack of socio-economic information will constrain the development of a hydrological operations plan. It is difficult to make recommendations on the management of unregulated flows without information on the location, volume and timing of demand. An economic study would help prioritise options for unregulated flow management by identifying the highest value uses of water.

7.2 CONSERVATION VALUES AND ENVIRONMENTAL WATER REQUIREMENTS

The Billabong Yanco System supports important conservation values, but supporting data is patchy and inconsistent. Ecological investigations are required to provide a more complete and detailed assessment of the conservation values of the system and their dependence on water.

Detailed ecological data is only available for two components of the ecosystem. Detailed surveys of the in-channel fish community have determined the distribution of native and exotic fish in the channel system and made some initial recommendations on habitat management. The surveys did not investigate floodplain habitat use by native fish. Detailed information is available on the vegetation composition of Wanganella Swamp and the waterbird outcomes it provides. Recommendations have been made for water management.

Some monitoring data is available for some aspects of Mollys Lagoon and Dry Lake including waterbirds, fish and frogs. Vegetation data for these sites has not been reviewed. Elsewhere ecological descriptions of ecological assets are very general, providing summary assessments of plant communities and environmental water requirements.

The Billabong Yanco System provides complex and well-preserved floodplain and wetland ecosystems, particularly in the Upper Yanco and Mid Yanco. Field investigations are required to provide plant species lists and to determine fauna habitat use. The investigations should determine the waterbirds and bushbirds that use these habitats and their importance to fish, frogs and other aquatic fauna. To address this knowledge gap, Murray LLS has engaged Charles Sturt University to investigate the role of water in supporting these values over the period 2017-2018.

The Forest Creek System also provides potentially important wetland habitat values that have not been documented.

The habitat use of Murray Cod and Trout Cod is a significant knowledge gap. It is likely, though not yet confirmed, that Murray Cod and Trout Cod breed in Upper Yanco Creek and Colombo Creek. An investigation into cod breeding would provide more information about how flows should be managed in these reaches. The location of breeding habitat is also poorly understood. The Alluvium (2013) environmental flows study identified an in-channel bench that is inundated by flows between 600 and 700 ML/d in Upper Yanco Creek and is potentially suitable for cod nesting. Additional cross sections and nest identification is required to provide reliable recommendations.

These information gaps limit the development of a hydrological operations plan. Our understanding of several important aspects of environmental water needs is too poorly understood to make specific recommendations on hydrological operations. Alluvium (2013) provides general recommendations on the timing, frequency and duration of particular flow events based on general ecological characteristics and principles. It is not possible to progress these recommendations further without more detailed hydro-ecological information.

7.3 ENVIRONMENTAL PRIORITIES FOR WEIR MANAGEMENT

Weirs impact on the conservation values including riparian productivity and diversity and aquatic fauna, particularly fish.

An investigation of the purpose and functionality of weirs, together with their environmental impacts, would provide a prioritised list for rehabilitation, modification or removal.

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APPENDIX A STAKEHOLDER WORKSHOP OUTCOMES

Jerilderie Civic Centre

29th May, 2017

Attendees

Marcus Cooling - Ecological Associates

Chris Gippel - Fluvial Systems

Els Tack - Murray Local Land Services

Rex Conallin - Murray Local Land Services

Peter Beal - Riverina Local Land Services

Frances Cory - Riverina Local Land Services

James Maguire & James Dyer - Office of Environment and Heritage

Max Bryce - Jerilderie Fishing Club

Ruth McRae - Murrumbidgee Council

Erin Lennon - Commonwealth Environmental Water Office

Ken Crossley - Murray Local Land Services, Billabong Yanco Steering Committee member

Colin Bull - Mid-Yanco Landholder, Billabong Yanco Steering Committee member

Russell Ford - Rice Growers, Billabong Yanco Steering Committee member

Gaila Smith - Jerilderie resident

Helene Mortlock - Jerilderie business owner & resident, Billabong Yanco Steering Committee member

Tanya Thompson - YACTAC, Billabong Yanco Steering Committee member

Apologies

Vince Kelly - WaterNSW

Richard Brown - WaterNSW

Sophie Gatacre - WaterNSW

John Skinner - WaterNSW

Digby Jacobs - DPI Water

Luke Pearce - NSW Fisheries

Katherine Cheshire - NSW Fisheries

Jim Parrett - YACTAC

Sarah Commens - Murray-Darling Basin Authority

Linda Duffy - Commonwealth Environmental Water Office

Barbara Browne - Indigenous representative

Roslyn Lockhart - Billabong Yanco Steering Committee member, Rumbalara Health

Carmen Amos - Office of Environment and Heritage

Joanne Lenehan - Office of Environment and Heritage

Paul Childs - Office of Environment and Heritage

Rodney Anderson - Federation Council

Susan Appleyard - Murrumbidgee Council

Michael Todd - Edward River Council

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Workshop Objectives

The objectives of the workshop were to:

- to review the operation of the system and its social, economic and environmental functions;
- for stakeholders to present their main values and needs for water management;
- to review good aspects of operations that should be preserved and aspects that should be improved; and
- to provide guidance on the development of the waterway operations plan.

Workshop Program

1. Welcome from Els Tack and Rex Conallin

2. Overview of the region, waterways and land and water uses by Marcus Cooling

3. Stakeholder discussion - current values and uses of the system

    Participants broke into three small groups to discuss:

    - how does flow and water supply support the region?

    - how is water used?

    - what water supply services do you depend on?

    - what aspects of water operations are working well?

4. Overview of hydrology, modelling and monitoring data by Chris Gippel

5. Stakeholder discussion - problems and solutions

    Participants broke into three small groups to discuss:

    - weaknesses and problems with existing water management

    - possible solutions

    - actions needed to progress the solutions

Workshop Outcomes

Stakeholder Input 1 - Current Values and Uses

Uses and Dependencies on water:

- Ecological values. The waterways provide a wildlife corridor, support native fish, support platypus and provide habitat for birds.
- Farming. Water supports irrigation, stock and domestic water supply.
- Town supply. Water from the creeks is the only supply of potable and non-potable supply in townships.
- Social and recreational uses. Activities supported by the creeks include recreational fishing, water skiing, kayaking, birdwatching. Yanco-Billabong is a peaceful environment compared to the Murrumbidgee and Murray. The creeks contribute to the amenity of the townships and surrounding areas.
- Security. A sense of security in the community is strongly associated with confidence in the reliability of water supply and good management of the resource.
- Growth. A secure and well-managed water supply is important to growth in the community, including social and community growth and investment in future business growth.
- Floods and variable flows are important in promoting pasture growth and removing cumbungi.
- Identity and education. Flow in the waterways and the economic and social values it supports is central to the identity of the community
- Tourism. Tourism is related to bird watching, water skiing, recreational fishing. The quality and duration of visitors stay is related to the amenity of the landscape in and around towns due to flow in the creeks.
- Cultural values. There is not yet much documented about Indigenous cultural values, but it is accepted that these are important and are a high priority to learn more about and incorporate into management.

What is good about the current system operations?

- Overall the waterways are managed as a good working system
- Yactac is an effective representative body for the community in waterway management. The committee has stakeholder confidence. Good representation through Yactac is a strength of water management. Stakeholders are invested through the levy.
- Variable flows are an important part of the hydrology and should be maintained. They are important for riparian health, for clearing out cumbungi and maintaining fish communities
- It is very important that stakeholder

What represents good management of the resource?

- Consistent and reliable management.
- Confidence that stakeholder needs are considered in management. This requires effective communication and consultation with resource managers and stakeholders.
- Managing the waterways for a balance of ecological health, productive and social values.
- There should be a long term plan for the system so that people have confidence that the system is being managed in a coordinated way that represents an appropriate balance of interests.
- Incorporating environmental water requirements into consumptive water delivery.
- A sound monitoring program to support decisions.

- Sharing monitoring data with stakeholders in straightforward and effective ways. Data is needed for stakeholders to make operational and investment decisions. Data is needed for stakeholders to have confidence in waterway managers.
- Communication, engagement and trust between WaterNSW and waterway users is very important. Words used include consistency, reliability, security, assurance, balance, good representation.

Stakeholder Input 2. - Problems and Solutions

Aspects of Resource Management to Improve

Incidental Water Needs

Water is delivered to the system to meet water orders, which may be from irrigators, towns or the environment, and to meet the end-of-system target. If there are other social, amenity, consumptive or environmental needs that are met incidentally they are vulnerable to increases in delivery efficiency.

For example:

- End of system flows used to be higher because WaterNSW had less control of flow and had to maintain a bigger buffer at Darlot. The higher flows associated with this buffer contributed to environmental outcomes.
- The buyback of water from irrigators for the environment has resulted in less flow in the system which has harmed the local environment. To re-instate the former flows, a specific environmental need in the Yanco-Billabong system has to be identified as the basis of an environmental flow.
- Surplus flows are relied on by many growers, but there is no guarantee on their supply. If new infrastructure at the Yanco offtake provides control of higher flows, there is potential for surplus flow in the Billabong Yanco system to decline.

Work is required to identify the water needs associated with these values and, where possible, incorporate them in management and water delivery.

Incorporating Environmental Outcomes into Water Delivery

Irrigation delivery contributes to environmental water needs by maintaining flow, overtopping some weirs and contributing to overbank flows. These benefits should be identified and promoted by incorporating environmental water requirements into water supply arrangements. This could include:

- maintaining high regulated flows at times when catchment runoff has the potential to create overbank flows
- a moratorium on extraction during the first part of a flow peak to promote overbank flooding.
- identifying environmental benefits to the Edward River from Yanco Creek flows such as refuge from blackwater or blue-green algae.
- timing irrigation deliveries at times when the ecosystem is vulnerable to low flows, e.g. during fish breeding.

Monitoring

There is a strong concern that flow and water quality monitoring is inadequate to support timely, sound and efficient water management. There is concern that infrastructure decisions are made with poor data, for example that inaccurate estimates of losses and use in the system are used to guide investments in water delivery and control infrastructure. Poor monitoring data gives the impression of a lack of accountability for water managers, because they do not have a sound basis to make decisions.

Better data is needed on water level, flow, water quality, biological monitoring. Flow monitoring is needed for:

- end of system loss
- evaporation and seepage estimates
- to support an earlier response to water quality problems
- to improve control

Better data access is needed to engage the community in decision-making. Timely access to data would also assist in diverter operations, for example in timing their pumping based on anticipated flows and managing water quality issues.

A system that provide access to monitoring data is required. Urgent information and updates could be shared by SMS. An information sharing system, like Sharepoint, could be used to provide access to other monitoring data and operational status.

There needs to be a strategy for how blue green algae or blackwater events will be managed when they occur.

End of System Rules

The current arrangements where excess flows are Darlot are treated as a loss should be changed. End of system flows should be recredited to the Murray system and incorporated in regulated Edward River flows to contribute to environmental or consumptive needs.

The end of system flow needs to increase

- to benefit the environment
- to provide a bigger buffer for irrigation supply against simultaneous pumping, interruption to supply

Unregulated Billabong flows should be distinguished from regulated flows when calculating losses at Darlot. If unregulated flows are included in the calculations it looks like water is being wasted and the system is less efficient than it really is.

Operating Approach

"Run Billabong Yanco more like a river and less like an irrigation channel." This statement summarises the expectation that water is managed to meet social, amenity, cultural and environmental outcomes and not just irrigation supply needs.

A comprehensive long-term plan for the system would give stakeholders confidence that there are clear objectives for management and that operations and investments are targeted toward that long term goal.

Operational Flow Limits

The operational flow limits at the Yanco Creek offtake need to be raised to support better environmental water delivery.

- Arrangements are required to allow flooding of ecological assets on private land. Agreements are needed with private landholders.
- The cap at the Yanco offtake needs to increase from 1,400 ideally to 2,500 ML/d to allow overbank flooding of ecological assets.

- To provide a long term solution the flood prevention rules on the Murrumbidgee at Collingullie.

Cooperative Management

Participation of DPI Water and WaterNSW in community consultation needs to improve. Their representatives do not attend when invited. Yactac would welcome their input and a chance to have them hear their concerns.

Yactac meetings could sometimes be held lower down in the system to make it easier for people living in the west.

Proposed Initiatives

Initiative	**Problem addressed**	**Work needed to progress the initiative**
Reinstate the natural sill on Dry Lake	The lake would be reinstated to its natural 400 ha size from the current 200 ha using very minor and inexpensive works.	Landholder cooperation and legal arrangements (easements).
Investigate water requirements of ecosystem	Better information is needed on the conservation values and water requirements of the watercourses, wetlands and floodplains. This information is needed to support the delivery of environmental water.	Ecological surveys and environmental flow assessments. These are currently being undertaken by Charles Sturt University for Murray LLS.
Dilute Billabong Creek water with Murrumbidgee water	Turbidity at Jerilderie causes water supply problems to the township	Investigate the source of the sediment and effectiveness of dilution
Shepherd surplus flows. Put a moratorium on extractions for the first few days of a flow peak. Ideally target the hydrograph between 1,400 and 2,500 ML/d at Yanco Offtake.	Meet environmental needs for overbank flows.	Need to get diverters to agree through communication and negotiation. Need agreement of those whose land would be affected. Note that this proposal was unsuccessful on the Murrumbidgee due to high rates of pumping. But a moratorium is more likely to gain cooperation through Yactac.
Additional re-regulation capacity is needed in Billabong Creek to store one or two days of water supply.	Billabong Creek experiences short term water supply shortages for 1 or 2 days each year, usually in January. Re regulation would reduce losses and wastage in Darlot.	Alternatives to new lower Billabong weir need to be considered, such as a variable level weir at Algudgerie.
Better education, promotion, awareness raising, appreciation of the creek	Cultural and environmental and social values of creek are taken for granted	Values need to be investigated, documented and promoted.
Need to investigate what the cultural values of the creek are the role of water in supporting them	Cultural values not well known	Document stories, values. Find people who know stories.
Use plain language in key documents	Complicated water management language inhibits communication with stakeholders	Documents intended to engage the community must be written with the audience in mind.
Make a strong case for environmental flows at end of system	End of system flows are too low	Investigate environmental water needs in the Lower Billabong and Edward River that can be supported with Yanco/Billabong flows.
Deliver irrigation water to minimise environmental harm and to promote ecological outcomes	River operations can have unintended impacts on the environment. Rapid changes in flow and low flow can impact fish, vegetation, waterbirds and invertebrates	Develop guidelines for how irrigation water can be delivered to promote ecological objectives.

Initiative	Problem addressed	Work needed to progress the initiative
Yanco could provide refuge and alternative habitat to Edward River for aquatic fauna during periods of blackwater, blue green algae. Local wetlands and channels could provide refuge in Yanco / Billabong.	Water quality threats to aquatic fauna in Edward River.	Investigate feasibility. The time taken to get samples analysed to confirm blue green algae makes management response slow