Goulburn River

Seasonal Watering Proposal 2013 - 2014

Goulburn Broken Catchment Management Authority

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

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Executive summary

This is a proposal to use available environmental and other water to maximise the environmental outcomes in the Goulburn River in 2013-2014 (and partly 2014-2015). The plan focuses on the Goulburn River between the Goulburn Weir and the Murray River, which has the most altered flow regime within the regulated reaches of the Goulburn River. Delivering flows to this reach can also provide benefits to the reach between Lake Eildon and Goulburn Weir in dry winters and springs.

The Goulburn River and its associated floodplain and wetland habitats support intact river red gum forest, and numerous threatened species such as Murray Cod, Trout Cod, Macquarie Perch, Squirrel Glider, and Eastern Great Egret. The river and its associated floodplain and wetland habitats also contain many important cultural heritage sites, provide water for agriculture and urban centres, and support a variety of recreational activities such as fishing and boating.

The conditions leading into the 2013-2014 year have been characterised by several years of extended drought with low river flows (particularly in the Goulburn River between Goulburn Weir and the Murray River) followed by extremely wet conditions in 2010-2011 where all environmental flow objectives have been met by natural catchment runoff. A summer flood and blackwater event resulted in a significant number of fish and crustacean deaths. In 2011-2012 flows were close to average in winter and drier in spring, with a flood in March 2012. In 2012-2013, conditions have been dry, particularly during the spring and summer. Environmental water releases have allowed most priority environmental flow components to be met.

Importantly, terrestrial vegetation lost from the lower river bank during the 2010-2011 floods has only started to return in the 2012-2013 summer. With bare river banks, bank slumping and notching has been an issue in 2012-2013. Some recovery of vegetation on the upper river banks has occurred. Macrophytes and macroinvertebrates continue to struggle to recover from the floods in 2010. Floodplain vegetation generally remains in good condition.

The focus for the 2013-2014 year is to continue to pursue fish, macroinvertebrate and vegetation ecological objectives established for the Goulburn River by implementing minimum and fresh flow recommendations, particularly in winter and spring. Fish objectives are pursued by providing a minimum flow of 500 and 540 ML/day at Murchison and McCoys Bridge respectively throughout the year as well as a spring fresh to stimulate Golden Perch breeding. Spring freshes in 2011-2012 and 2012-2013 have failed to produce significant fish breeding. It is therefore proposed to increase the size of the fresh and to provide two to maximise the chances of breeding. Macroinvertebrate objectives are pursued by providing a minimum flow of 830 and 940 ML/day at Murchison and McCoys Bridge respectively and winter, spring and summer/autumn freshes of 5,600 ML/day. The terrestrial vegetation objectives are provided for by implementing the above fish and macroinvertebrate flow recommendations, particularly the duration of the freshes. Avoidance of environmental damage (bank slumping and biota stranding) from rapid falls in water level from environmental freshes or other flows is provided by using environmental water to reduce rate of fall. Freshes to 6,600 ML/day also achieve geomorphic and planktonic algae objectives. Improved environmental health also improves the passive recreational uses of the lower Goulburn River in the longer term, including improved fishing opportunities.

Importantly, the proposal notes the difficulty in providing flow components in winter due uncertainty around environmental water availability and the need for environmental water in the coming season. Therefore, the continuation of the minimum flow recommendation of 500 and 540 ML/day at Murchison and McCoys Bridge respectively from July to September 2014 for native fish is seen as a higher priority than the macroinvertebrate driven higher minimum flows in the 2013-2014 year's summer and autumn. Reserving water for a 2014 winter fresh (June/August) is listed as the second last priority for this proposal.

Overbank flows occurred in 2010-2011 and 2011-2012 and are therefore not required in 2013-2014. The feasibility of delivering overbank flows, including how best to deliver or supplement flows whilst avoiding damage to public and private assets requires further investigation. Therefore, overbank flows will not be delivered in the immediate future.

The proposal considers environmental water management under a range of possible climate scenarios from extremely dry to wet. Under the extreme and very dry scenarios, all of the environmental entitlements are used to provide improved winter/spring flows and progressively summer/autumn low minimum flows, while Inter-Valley Transfers help provide improved summer/autumn flows. However, unlike the drought years, Inter-Valley Transfers may not reliably provide all required summer flows and some environmental water will need to be reserved to fill gaps left in the flow regime. Under the average to wetter scenarios, winter/spring flow needs are mainly provided by catchment runoff, resulting in the environmental entitlements progressively transitioning to lower priority flow components later in the year.

The volumes of environmental water assumed to be available in 2013-2014 under each scenario are summarised in the following table, consisting of the water use possible under the existing Goulburn environmental entitlements and carryover if all water is allocated to the Goulburn River. The scenarios also show how any additional water could be used if more water available.

Summary of environmental water volumes assumed to support this proposal (GL)

REACHES 4 & 5	WORST DROUGHT	VERY DRY	DRY	AVERAGE	WET
Total environmental water planned	192	289	289	289	270
Additional water usable	257	148+	148+	110+	110+

In summary, the Goulburn Broken CMA is seeking access to, or be involved in the timing of releases of, all the water available under environmental entitlements in the Goulburn system (Commonwealth, Living Murray and Victorian), and preferably additional water, under all climates.

The proposal specifies bulk water volumes required to achieve various environmental objectives under specified climatic scenarios. However, climatic conditions do not follow one climate scenario throughout the year. Therefore, as the season unfolds the design of specific flow regimes to optimise outcomes will be required, requiring flexible and adaptive water deployment, and changing estimated water volumes required for events.

This proposal does not take account of competing needs for environmental water use from other river/creek systems or downstream along the Murray River.

As all of the flows proposed are well within the river channel, there is very low risk of adverse outcomes from releasing environmental water. However, special attention is required to proposed spring freshes at higher flow rates than in past years.

Water delivery through the lower Goulburn River to meet downstream consumptive and environmental targets is possible, but raises risks which need to be managed.

Contents

Tables

Figures

Glossary and acronyms

Bankfull - carrying capacity of the stream before spilling out onto adjacent land

Baseflow – low flows sufficient to maintain fish passage, water quality, and pool and riffle habitats

Catchment management authority (CMA) – statutory authorities established to manage regional and catchment planning, waterways, floodplains, salinity and water quality

Channel - that part of a river where water flows at some time and includes the bed and banks, taken to mean the whole of the depression in which the water flows before it rises sufficiently to spill over onto adjacent lands as flood water

Commonwealth Environmental Water Holder (CEWH) – (part of the Department of Sustainability, Environment, Water, Populations and Communities) holds and manages the water entitlements purchased through the Restoring the Balance water recovery program

CMA – catchment management authority

Environmental flow regime – the timing, frequency, duration and magnitude of flows for the environment

Environmental flow study – a scientific study of the flow requirements of a particular basin's river and wetlands systems used to inform decisions on the management and allocation of water resources

Environmental water entitlement – an entitlement to water to achieve environmental objectives in waterways (could be an environmental entitlement, environmental bulk entitlement, water share, Section 51 licence or supply agreement)

Flow - movement downstream of water confined in the channel. The term **lotic** applies to flowing or moving water

Flow component – components of a river system's flow regime that can be described by timing, seasonality, frequency and duration (for example, cease to flow and overbank flows)

Flow regime - pattern of seasonal flow variations in any one year, usually consisting of periods of low flow during summer-autumn then high flows during winter-spring

Freshes - flows that produce a substantial rise in river height for a short period, but do not overtop the river bank. Freshes help maintain water quality and serve as life cycle cues for fish

GB CMA - Goulburn Broken Catchment Management Authority

Geomorphology - the physical interaction of flowing water and the natural channels of rivers including erosion and sedimentation

Gigalitre (GL) – one billion (1,000,000,000) litres or 1,000 megalitres

High flows - high flow within channel capacity. High flows allow full connection between all habitats in the river, which is important to fish passage during migration

High reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected in most years)

Instream - refers to that area of a waterway below the surface of the water

Inter-Valley Transfers (IVT) – means bulk transfers of water from the Goulburn water supply system to supply water users in the Murray water supply system

Low reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected only in some years)

Macroinvertebrates – aquatic invertebrates whose body length usually exceeds 1 mm (included insects, crustacean, aquatic worms and aquatic snails)

Macrophytes – an aquatic plant that grows in or near water and is either emergent, submergent, or floating

Megalitre (ML) – one million (1,000,000) litres

Overbank flow – flood flows that overtop the banks and spill onto the floodplain

Passing flow – water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits

Planktonic algae – floating microscopic plants that are an important food source for aquatic fauna

Pool - a significantly deeper area in the bed of a river

Reach - a length of stream that is reasonably uniform with respect to geomorphology, flow and ecology

Riffle – a stream section with fast and turbulent flow over a pebble bed with protruding rocks (characterised by a broken water surface)

Riparian vegetation - vegetation growing on the water line, up the bank or along the very top of the bank. It is the vegetation which has the most direct effect on instream biota.

Seasonal allocation – the volume of water allocated to a water share in a given season, expressed as a percentage of total entitlement volume

The Living Murray (TLM) – an intergovernmental program, which holds an average of 500,000 ML of environmental water per year, for use at six icon sites along the River Murray

Unregulated entitlement – an entitlement to water declared during periods of unregulated flow in a river system, that is, flows that are unable to be captured in storages

Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) – assesses the effectiveness of environmental flows in delivering ecological outcomes

Victorian Environmental Water Holder (VEWH) – an independent statutory body responsible for holding and managing Victorian environmental water entitlements and allocations (Victorian Water Holdings)

Water entitlement – the right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions

Water Holdings – environmental water entitlements held by the Victorian Environmental Water Holder

Waterway manager – agency responsible for the environmental management of waterways (includes catchment management authorities and Melbourne Water)

Waterways – can include rivers, wetlands, creeks, floodplains and estuaries

1 Background and system overview

1.1 Background

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The reserve includes minimum river flows, unregulated flows and specific environmental entitlements.

Environmental entitlements can be called out of storage when needed and delivered to streams or wetlands to protect or enhance their environmental values and health. Environmental entitlements are held by the Victorian Environmental Water Holder (VEWH), the Commonwealth Environmental Water Holder (CEWH), and the Murray Darling Basin Authority (MDBA). Catchment Management Authorities (CMAs) are responsible for determining the environmental water requirements of streams and wetlands, developing and submitting seasonal watering proposals to the VEWH for consideration, and managing the delivery of environmental water in accordance with the VEWH's Seasonal Watering Plan.

The VEWH prepares seasonal watering plans based on each of the CMA's seasonal watering proposals. The plans describe the desired environmental water use for rivers and wetlands across Victoria in the coming year. To help facilitate the desired environmental water use outlined in the plans, the VEWH negotiates access to environmental water managed by the CEWH and the MDBA. The VEWH then prepares seasonal watering statements that authorises CMA's to undertake the agreed watering activities, including the use of CEWH and MDBA water. As more environmental water becomes available during the season the VEWH may prepare additional seasonal watering statements. Where possible, the VEWH, CEWH and the MDBA seek to coordinate the delivery and management of environmental water to maximise ecological benefits.

1.2 Purpose

The purpose of this Goulburn River Seasonal Watering Proposal is to:

- identify the environmental water requirements of the Goulburn River (below Lake Eildon) in the coming year under a range of climatic scenarios to protect or improve its environmental values and health; and
- inform the development of environmental water priorities in the VEWH's seasonal watering plan.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the river. This proposal was prepared in consultation with key stakeholders and partners, and was approved by the Goulburn Broken CMA board.

1.3 System overview

The Goulburn River is 570 km long, flowing from the Great Dividing Range upstream of Woods Point to the Murray River east of Echuca. It has a mean annual discharge of approximately 3,040 GL representing 13.7% of the total state discharge (GB CMA 2005).

The Goulburn River has been identified as a high priority waterway in the Goulburn Broken Regional River Health Strategy due to its significant environmental values (GB CMA, 2005). The river and its associated floodplain and wetland habitats support intact river red gum forest, and numerous threatened species such as Murray Cod, Trout Cod, Macquarie Perch, Squirrel Glider, and Eastern Great Egret. The river and its associated floodplain and wetland habitats also contain many important cultural heritage sites, provide water for agriculture and urban centres, and support a variety of recreational activities such as fishing and boating.

1.3.1 Flow Regime

Flow along the Goulburn River has been modified by two major features, Lake Eildon and Goulburn Weir. Lake Eildon is located in the river's upper catchment, immediately below the confluence to the Delatite River. It has a capacity of 3,334 GL. On average, 91% of water released from Lake Eildon is diverted for irrigation purposes and supplies about 60% of water used in the Goulburn Murray Irrigation District (G-MW website). With such a large storage capacity, operation of the lake fully regulates downstream flows in all but wet years (GB CMA 2008).

Lake Eildon and its operation have significantly affected the flow regime of the Goulburn River. Lower flows in the mid Goulburn River (below Lake Eildon to Lake Nagambie) now occur in winter and spring due to water storage, and higher flows now occur in summer and autumn due to releases to meet irrigation and consumptive demands. However, below Lake Eildon flows do increase progressively moving downstream due to tributary inflows, particularly in winter and spring.

Goulburn Weir is approximately 235 km downstream of Lake Eildon, and north of Nagambie. It holds 25 GL and is usually held close to full capacity to facilitate the diversion of water into irrigation channels and to supply Waranga Basin. Waranga Basin has a capacity of 432 GL and is used to store winter and spring flows from tributaries downstream of Lake Eildon (GB CMA 2008).

Goulburn Weir and its operation have reduced the average annual downstream flow to 1,340 GL, less than half of the estimated pre-regulated flow (GB CMA 2005). In addition, significant flows may be released in summer and early autumn from Goulburn Weir to the Murray River as Inter-Valley Transfers (IVT) to supply water entitlements traded from the Goulburn River system to the Murray River system. However, below Goulburn Weir the river does retain the natural seasonal flow pattern due to the influence of tributaries such as the Broken River and the Seven Creeks, and the diversion of irrigation water at the Goulburn Weir during summer and autumn. However, the flow is substantially reduced in volume from natural conditions.

The Goulburn River flow regime is also affected by a range of activities within the catchment, including alterations to vegetation, construction of small dams and drainage schemes. In addition, along the riverine plain downstream of Shepparton, artificial levees and other structures obstruct flood flows (Cottingham et al 2003).

1.3.2 Priority reaches and measuring points

An environmental flow study for the Goulburn River downstream of Lake Eildon to the confluence of the Murray River was completed in 2003 (Cottingham et al 2003). To facilitate the development of environmental flow recommendations the river was divided into five reaches with similar channel morphology, flow regimes, and ecological values (Figure **1**). The reaches are:

1. Lake Eildon to Molesworth (63 km);
2. Molesworth to Seymour (69 km);
3. Seymour to Nagambie (101 km);
4. Nagambie to Loch Gary (110 km); and
5. Loch Gary to the Murray River (125 km).

In summer and autumn there are limited opportunities to manage water for environmental purposes in reaches 1, 2 and 3 due to high flows to meet downstream irrigation and consumptive demands. During winter and spring, environmental flows delivered to reaches 4 and 5 can also benefit reaches 1, 2 and 3. Therefore, the priority reaches for environmental water management are reaches 4 and 5.

The key measurement points for environmental flows are at Eildon for reach 1, Trawool for reach 2, Seymour for reach 3, Murchison and Shepparton for reach 4 and McCoys Bridge for reach 5 (Figure **1**).

1.3.3 Delivery constraints

Delivery of environmental water down the Goulburn River is primarily constrained by the risk of flooding private and public assets. Bureau of Meteorology minor flood levels at each flow measurement point along the Goulburn River are as follows:

- 14,500 ML/d at Eildon (reach 1);
- 21,700 ML/d at Trawool (reach 2):
- 24,850 ML/d at Seymour (reach 3):
- 33,100 ML/d at Murchison (reach 4): and
- 28,300 ML/d at McCoys Bridge (reach 5).

However, constraints are expected at lower flows than these. Downstream of Lake Eildon, the river channel capacity is approximately 9,000 to 10,000 ML/day. At Shepparton, bankfull flow is estimated to be approximately 18,000 ML/day.

The delivery of irrigation water may also use some of the available spare channel capacity and so limit the delivery of environmental water.

1.3.4 Water sources

Water available for use in the Goulburn River (listed in Table 1) includes:

- minimum passing flows and a water quality allowance established in the Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995 and subsequent amendments;
- environmental entitlements held by the VEWH, the CEWH and the MDBA; and
- unregulated flows.

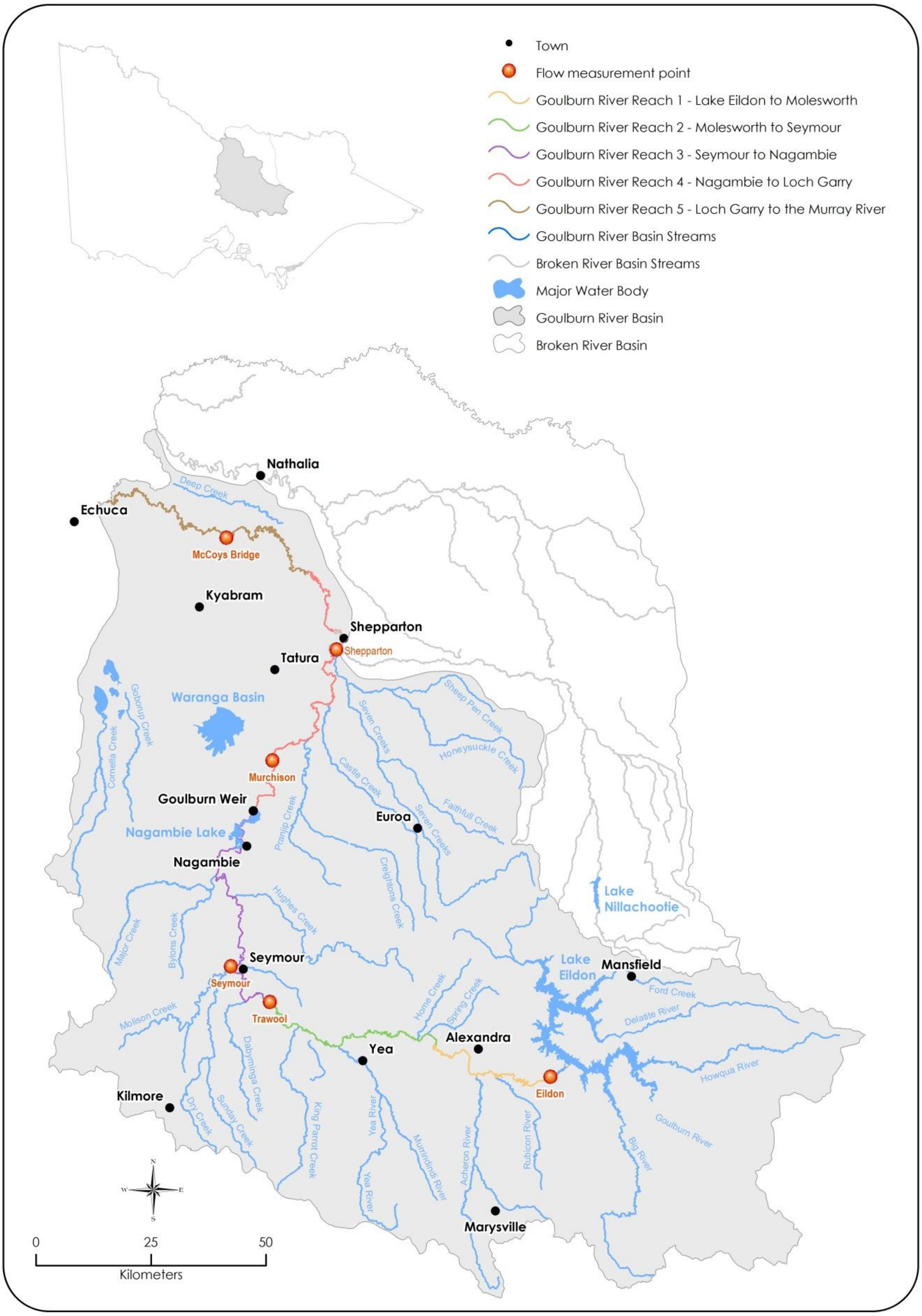
Table 1: Environmental water available for use in the Goulburn River

ENVIRONMENTAL WATER	RESPONSIBLE AGENCY	DESCRIPTION	CONDITIONS
Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995			
Minimum Flow	G-MW	Minimum flow of 120 ML/d at Eildon Pondage Weir.	1
Minimum Flow	G-MW	Minimum average weekly flow of 250 ML/d at the Goulburn Weir.	The daily rate is to be no less than 200 ML/d.[1]
Minimum Flow	G-MW	Minimum average monthly flow of 350 ML/d from November to June inclusive at McCoys Bridge gauging station.	The daily rate is to be no less than 300 ML/d.[1]
Minimum Flow	G-MW	Minimum average monthly flow of 400 ML/d from July to October inclusive at McCoys Bridge gauging station.	The daily rate is to be no less than 350 ML/d.[1]
Goulburn Water Quality Allowance	G-MW	30 GL per year.	Maintenance of water quality.
Additional Passing Flow below Eildon Pondage Weir	G-MW	Minimum passing flows at Eildon Pondage Weir increased to 250 ML/d.	Inflows to Lake Eildon for previous 24 months must reach a specified volume.[1]
Additional Passing Flow below Eildon Pondage Weir	VEWH	Up to 80 GL to provide up to 16,000 ML/d peak flow for 1 day.	Inflows to Lake Eildon from previous 12 and 24 months must reach specified volumes and the Secretary of DSE confirms the need for a release.[1]
Environmental Water Entitlements			
Victorian River Murray Flora and Fauna Entitlement	VEWH	27,600 ML high reliability entitlement.	Murray System
Goulburn Environmental Water Savings Supply Deed	VEWH	One-third of water savings created in the Goulburn System as a result of modernisation works completed as part of Stage 1 of the Northern Victorian Irrigation Renewal Project. 22GL is assumed to be available for 2013-2014.	Volume based on works implemented and water losses saved in previous year's climate.
Environmental Entitlement (Goulburn-System – Living Murray) 2007	MDBA	39,625 ML high reliability entitlement and 156,980 ML low reliability entitlement, and 5 GL of carryover from 2012-2013	Water allocated to this entitlement must be used for the Living Murray 'icon sites'. However, this water can provide environmental benefits in the Goulburn River en route to the Murray River.
Commonwealth Environmental Water Holdings	CEWH	203,539 ML Goulburn high reliability water share and11,765 ML Goulburn low reliability water share as at 31 January 2013, with 10 GL of carryover from 2012-2013.	Water use is subject to agreement with the CEWH.

1 Minimum flows in the Goulburn Bulk Entitlement can be reduced under drought conditions and banked for later use.

Inter-Valley Transfers can also provide flows through Reaches 4 and 5 in summer, and can be utilised to meet desirable minimum flows. This reduces the need to deploy water from environmental entitlements.

Figure 1: Goulburn River Basin



2 Flow objectives and recommendations

This section outlines the environmental flow objectives established for the Goulburn River, and the corresponding flow recommendations including the volume, timing, duration and frequency of flow components.

2.1 Objectives and recommendations

An environmental flow study for the Goulburn River was completed in 2003 (Cottingham et al 2003) and another in 2007 (Cottingham et al 2007). The 2003 study was one of the earliest flows studies in Victoria and focused on the Goulburn River downstream of Lake Eildon to the confluence of the Murray River. The 2007 study was undertaken specifically to assess the impact and management of high summer flows resulting from Inter-Valley Transfers in the lower Goulburn River (i.e. from Goulburn Weir to the Murray River). Further studies were undertaken in the drought years between 2007 and 2010, including a fresh objectives study. Overbank flow recommendations in the Cottingham et al 2007 study were updated in a study by the Department of Sustainability and Environment in February 2011 (DSE 2011). These flows studies developed flow objectives and recommendations for the delivery of environmental flows in the five reaches of the Goulburn River as described in section 1.3.2.

The 2003 flows study is used in this proposal primarily for flow recommendations in Reaches 1 to 3 inclusive, and the 2007 study, the 2010 fresh objective study and the 2011 overbank flow study provide the flow objectives and recommendations in Reaches 4 and 5.

The 2003 flow study recommended targeting the following objectives:

- Vegetation:
  a) enhance the extent and diversity of aquatic vegetation;
  b) increased contribution to processes such as river productivity;
  c) maintain diversity of riparian vegetation;
  d) reduce the extent and impact of weeds; and
  e) maintain continuity and cover of riparian vegetation.

- Floodplain:
  a) enhance the extent and diversity of aquatic vegetation;
  b) increased contribution to processes such as river productivity;
  c) flood regime has all elements of a natural floodplain in terms of seasonality, frequency and duration; and
  d) connection of floodplain ecosystem components (e.g. grasslands, wetlands).

- Invertebrates;
  a) biomass and trophic structures closely resemble local tributaries;
  b) dynamic and diverse food webs; and
  c) diverse resilient communities through full range of physical conditions.

- Fish:
  a) suitable thermal regime for spawning, growth and survival stages;
  b) suitable in channel and off channel habitat for all life stages;
  c) fish passage for all life stages;
  d) cues for adult migration during spawning season;
  e) access to floodplain and off channel habitats for spawning/larval rearing;
  f) low flows for spawning and recruitment; and
  g) floodplain and bench inundation for exchange of food and organic material.

Based on these objectives, specific flows were developed to address channel attributes, reaches and flow components. In particular, the study focused on flow changes required to the then current regime, rather than on the total regime required. The study did not take into consideration social or economic constraints and has recommended flows based purely on achieving an environmental outcome.

In 2007, the second environmental flows study (Cottingham et al 2007) was completed for Reaches 4 and 5 (between the Goulburn Weir and Murray River). This study primarily looked at the issues and appropriate limits of high summer flows resulting from the potential need for large Inter-Valley Transfers, but also specified desirable environmental flow regimes for the whole year. The method used in the 2007 study altered significantly from that used in the 2003 study. The changes included:

- Specifying the flow required for each objective instead of identifying a single flow to meet several environmental objectives.
- Providing for inter-annual flow variability (dry, medium and wet years).
- Specifying two levels of environmental flow recommendations (the recommended environmental flow to achieve the environmental flow objective with a high degree of confidence (low risk) and a flow that represents a moderate risk to achieving the environmental flow objective. These two levels are provided in recognition of the inherent uncertainty in flow-ecology linkages and the need to trade of environmental risks with consumptive water use (Cottingham et al 2007).

As such, the 2007 study provides a complex range of flow recommendations for each environmental objective for different times of year, in different years, and with different levels of risk to the environmental outcomes. Environmental objectives are established for planktonic algae, macrophytes, terrestrial bank vegetation, macroinvertebrates, native fish and geomorphology.

Both studies made recommended a desirable maximum rate of rise and fall in river flows or water levels to minimise bank slumping and flushing or stranding of biota. These guide the shaping of flow freshes and intervention in impacts of water management.

In 2007, 2008, 2009, and 2010, the drought conditions and very low flows raised ecological questions not previously considered in the 2003 and 2007 flow studies. In response a panel of ecologists and hydrologists assessed the impact of low flows to the ecosystem and developed recommendations for water management to minimise the ecological risk in times of drought. These recommendations are included in a number of separate reports with recommendations specific to climatic conditions. Importantly, in Cottingham et al (2010), the panel provided additional advice on the objectives for flow freshes in the lower Goulburn River for 2010-2011. This report drew and expanded on the information provided in the 2007 flow study to design freshes. Further, the overbank flow study in 2011 (DSE 2011) set flow objectives for ecological features of the river and floodplain adapted from the 2003 flow study.

Table 2 outlines a selection of the environmental objectives and flow recommendation for all 5 reaches of the Goulburn River and the report they came from. In addition, environmental objectives met by the same flow recommendation (nested ecological objectives) are also listed. As outlined in section 3.2 there are limited opportunities to manage water in reaches 1, 2 and 3 for environmental purposes due to high flows to meet downstream irrigation demands in summer and autumn. Therefore, the priority reaches for environmental water management are reaches 4 and 5. In addition, the feasibility of delivering the overbank flow recommendations, including how best to deliver or supplement flows whilst avoiding damage to public and private assets is also an issue requiring further investigation. Therefore overbank flow recommendations are only provided by natural events. The selected environmental objectives and flow recommendations for reaches 4 and 5 are currently considered a priority. All of the environmental objectives and flow recommendations for reaches 4 and 5 set out in the 2007 study are listed in Appendix 1.

Experience in the 2012-2013 year has indicated some of these flow recommendations should be varied (see section 3).

Table 2: Environmental objectives and flow recommendations for the Goulburn River (ML/day)

FLOW COMPONENT	ECOLOGICAL VALUE	ECOLOGICAL OBJECTIVES	NESTED ECOLOGICAL OBJECTIVES	SEASON	FLOW (ML/DAY)					REPORT
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Base flow	Macroinvertebrates	Provide near natural levels of riffle habitat for macroinvertebrates and small bodied fish	• Increase riffle habitat for macroinvertebrates and small bodied fish	Summer Autumn	<1,000	<1,000	<1,000	NA	NA	2003
Base flow	Macrophytes	Provide velocities suitable for in channel macrophyte recruitment and growth	• Provide velocities suitable for in channel macrophyte recruitment and growth	Summer Autumn	<3,000	<3,000	<3,000	NA	NA	2003
Base flow	Native fish	Provide suitable in-channel habitat for all life stages.	• Provide slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish	Summer Autumn Winter Spring	NA	NA	NA	400	540	2007
			• Provide deep water habitat for large bodied fish	Summer Autumn Winter Spring	NA	NA	NA	500	320	2007
Base flow	Macroinvertebrates	Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone	• Provide conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates • Provide slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates • Entrain litter packs available as food/habitat source for macroinvertebrates • Maintain water quality suitable for macroinvertebrates	Summer Autumn Winter Spring	NA	NA	NA	830	940	2007
			• Provision of conditions suitable for the establishment of aquatic vegetation (for macroinvertebrate habitat) • Provision of slackwater habitat favourable for planktonic production (food for macroinvertebrates) and slackwater habitat	Summer	NA	NA	NA	1,500	NA	2007
Base flow/fresh	Geomorphology	Maintain pool depth	• Maintain natural rates of sediment deposition	Summer	NA	NA	NA	856,1186,1660, 2223,3142,4490, 6590	1096,1509,1993, 2711,3800,5240, 6060	2007

FLOW COMPONENT	ECOLOGICAL VALUE	ECOLOGICAL OBJECTIVES	NESTED ECOLOGICAL OBJECTIVES	SEASON	FLOW (ML/DAY)					REPORT
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Fresh	Native fish	Initiate spawning, pre-spawning migrations and recruitment of native fish (preferably late spring early summer for native fish)	• Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	Summer Autumn Winter Spring	NA	NA	NA	5,600 14 days (winter/ spring) 2-4 days summer/ autumn 1-4 events	5,600 14 days (winter/ spring) 2-4 days summer/ autumn 1-4 events	2010
Fresh	Riparian vegetation	Remove terrestrial vegetation and re-establish amphibious vegetation		Winter Spring Summer/Autumn				5,600 ML/day 14 days (winter/spring) 2-4 days summer/autumn	5,600 ML/day 14 days (winter/spring) 2-4 days summer/autumn	2010
Overbank (only provided by natural events)	Floodplain and wetland vegetation	Increase the extent and diversity of flood dependent vegetation communities	• Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	Winter Spring	15,000+ Annual	15,000+ Annual	15,000+ Annual	25,000 5+ days 2-3 events in a yr 7-10 event yrs in10	NA	2003 2011
Overbank (only provided by natural events)	Floodplain and wetland vegetation higher in the landscape	Increase the extent and diversity of flood dependent vegetation communities	• Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	Winter Spring	Up to 60,000 Annual	Up to 60,000 Annual	Up to 60,000 Annual	40,000 4+ day 1-2 events in a yr 4-6 event yrs in 10	NA	2003 2011
Rate of flow rise	Native fish and macroinvertebrates	Reduce displacement of macroinvertebrates and small/juvenile fish		All year	Max rate 1.80 of previous days flow	NA	NA	Max rate of 0.38/0.38/1.20/0.80 metres river height in summer/autumn/ winter/spring	NA	2003 2007
Rate of flow fall	Geomorphology, native fish and macroinvertebrates	Reduce bank slumping/erosion and stranding of macroinvertebrates and small/juvenile fish		All year	Max rate 0.76 of previous days flow	NA	NA	Max rate of 0.15/0.15/0.78/0.72 metres river height in summer/autumn/ winter/spring	NA	2003 2007

The lower Goulburn River also has significant social values associated with passive recreation, fishing, and boating. These revolve around enjoying the natural environment. These values are enhanced by the improvements in environmental river health achieved by the targeted environmental objectives above. In particular, the enhancement of large-bodied fish populations including Golden Perch supports improves fishing outcomes over the longer term.

3 Current situation

3.1 Historical review

The last decade has been one of prolonged and extreme drought, and in 2010, the breaking of the drought. 2010 saw the first overbank flow event since a partial overbank event in November 2000 and a full overbank event in October 1996. River flows in the lower Goulburn did not get above minimum flows for much of 2005 to July 2010.

In 2010-2011, several floods were experienced – with flows at Shepparton reaching 90,000 ML/day in September, 71,000 ML/day in December, 32,000 ML/day in January, and 24,000 ML/day in February. Flows through the autumn averaged 2,100 ML/day, above the recommended environmental minimum flows. The December 2010 flood produced a major blackwater event with dissolved oxygen levels dropping to zero at McCoys Bridge, and associated fish deaths.

In 2011-2012, flows were lower, with several peaks between 10,000 and 20,000 ML/day, and one March peak at Shepparton of 35,000 ML/day.

3.2 Mid Goulburn River (Reaches 1-3)

In July and August 2012, river flows were again high at Seymour (10,000 to 15,000 ML/day) due to pre-releases from Lake Eildon and some catchment runoff. Conditions dried up in September/October, with catchment runoff and pre-releases reducing, and eventually releases for water supply increasing significantly from early November. Flows then varied between 5,000 and 10,000 ML/day over the summer.

The summer and autumn base flow recommendations of <1,000 ML/day and <3,000 ML/day were not met on any day (to mid-March). These base flow targets have been set to provide shallow water habitat for native fish, macroinvertebrates and macrophytes. 2012-2013 Mid Goulburn (Reaches 1-3) river flows are shown in Figure .

3.3 Lower Goulburn River (Reaches 4-5)

The recommended winter/spring/summer base flow target of 500 ML/day at Murchison and 540 ML/day at McCoys Bridge was met throughout the year. The higher recommended base flow target of 830 ML/day at Murchison was met on all but 2 days, and the 940 ML/day at McCoys Bridge was always met. The minimum flows were met as a result of pre-releases from Lake Eildon, unregulated flows in response to rainfall events, CEWH program water from October 2012 and Inter-Valley Transfers in December and January.

High flows up to bankfull occurred during July and August as a result of unregulated flows and Eildon pre-releases. This effectively provided a desirable winter fresh.

In early October, both TLM Program and CEWH water were used on route to South Australia to create a short duration fresh. The fresh reached 4,700 ML/day at Murchison and 4,500 ML/day at McCoys Bridge, but less than the desired maximum flow of 5,600 ML/day for 14 days.

In November, a fresh was released using both TLM Program and CEWH water, targeting the lower Goulburn and flows required in South Australia. The fresh varied between 5,100 and 5,600 ML/day for 13 days at Murchison and 5,300 and 5,500 ML/day for 10 days at McCoys Bridge, reasonably close to the desired 5,600 ML/day for 14 days. The variation was related to flow release control issues and flow attenuation along the river.

In December and January, Inter-Valley Transfers were released at flow rates between 1,400 and 2,500 ML/day at Murchison, and 1,500 and 2,700 ML/day at McCoys Bridge. From late January, CEWH water was released to provide flows to South Australia, at flow rates varying from 950 to 2,900 ML/day at Murchison and 810 to 2,800 at McCoys Bridge. For the summer and early autumn, the flow rates met or exceeded the desirable higher minimum flows of 830 ML/day at Murchison, and 940 ML/day at McCoys Bridge except for 5 days. For the Inter-Valley Transfers and the following environmental flows, flow rates were varied to stay within the maximum flow rates provided in the Goulburn 2007 Environmental Flows Study to avoid environmental damage to the river geomorphology, and would have been beneficial for geomorphological objectives not listed as priorities in 2012-2013. Flow rates were also varied to limit potential bank notching damage.

Figure 3 shows Lower Goulburn (Reaches 4-5) flows in 2012-2013.

Figure shows the Goulburn River flows at McCoys Bridge with and without environmental flow and inter-Valley Transfer releases.

ANZECC guidelines recommend dissolved oxygen concentrations should not fall below 5 mg/L or 80-90% saturation to maintain suitable conditions for oxygen dependent aquatic species. Throughout most of the year, dissolved oxygen concentrations in the lower Goulburn River have averaged between 6 mg/L and 10 mg/L in surface water at McCoys Bridge and between 4 mg/L and 10 mg/L at mid-depth (Figure).

3.4 Current ecological conditions

Riparian vegetation is considered to be in moderate to good condition overall, with areas not subject to extended periods of stock grazing in the past supporting a healthy ground storey dominated by native tussock grasses and forbs. This is particularly so for the lower reaches (below Goulburn Weir), much of which is now gazetted as the Lower Goulburn National Park. Where grazing continues as a land-use (e.g., between Eildon and the Goulburn Weir), the ground-layer is generally quite degraded - whilst mature River Red Gums and Manna Gums exist along much of the banks, recruitment is limited to areas where grazing is excluded.

Littoral vegetation (between the bank toe and top) was 'reset' by the floods between 2010 and 2012, with extended periods of inundation eliminating much of the terrestrial vegetation that had encroached the stream-zone during the preceding drought. Associated with the floods was extensive deposition of sediments that effectively smothered herbaceous vegetation with a 5cm 'mud-drape' which, together with high-velocity flows and / or extended inundation, resulted in considerable bank exposure and collapse. These exposed areas remained effectively bare throughout 2011, with some recovery at upper levels becoming evident in 2012 (Figure). Macrophytes observed during pre-flood surveys (eg Phragmites, Potamogeton, Triglochin - Ecowise 2008) remain largely absent within the river channel, although in-stream macrophyte cover in the system was considered depauperate prior to flooding (Instream Solutions 2012) .

Figure 6: The Goulburn River at Loch Garry in 2010 (left) and 2012 (right), with an arrow pointing out a drowned Silver Wattle. Note partial restoration of vegetation cover on upper bank (from WaterTechnology 2013).

The ecological condition of the macroinvertebrate community within the Goulburn River has been assessed as AUSRIVAS Band C (well below reference condition), falling from Band B (slightly below) in 2008–2009 (Instream Solutions, 2012). Whilst there is clear evidence of decline attributed to floods since 2008–2009, it is notable that community recovery is more evident in the Broken River and Broken Creek (which experienced similar major floods) where in-stream macrophyte cover is relatively healthy. The lack of macrophyte cover as habitat for macroinvertebrates in the Goulburn River contributes to a less diverse community structure and reduced capacity to recover from stresses (less resilience) such as major floods.

Following flooding, the opportunity was taken to do limited sampling of two small floodplain wetlands (at Moss Rd). These were found to be in excellent condition, supporting at least 19 families (c.f 13 – 14 at in-stream sites), with notable groups such as snails, beetles and dragonflies being in abundance, but largely absent from the main channel (Instream Solutions, 2012). This suggests that floodplain wetlands are likely to have benefitted substantially from recent flooding.

The lower Goulburn River provides habitat for at least 4 listed fish species - Trout Cod, Murray Cod, Silver Perch, and River Catfish, plus Golden Perch, with breeding in all populations being recorded between the years 2003 and 2012. Additionally, populations of non-native species such as European Carp, Redfin Perch, Weatherloach and Mosquitofish have self-sustaining populations within the river. Substantial spawning of Golden Perch was detected for the first time during 2010–2012 high flows / floods, whilst Murray Cod and a number of other fish species appear to breed annually in the lower Goulburn, regardless of low levels (Koster et al, 2012). The EPBC-listed Murray River Spiny Crayfish also occurs in the River.

Despite the substantial spawning of Golden Perch in 2010, there was relatively little recruitment (detection of juveniles). A major blackwater event occurred in the lower reaches during the December 2010 flood, and substantial fish deaths were associated with this event. There may have been immediate impacts to Golden Perch juveniles (if present), and residual effects are apparent as Murray Cod have not been recorded since at one site (Yambuna) where it was previously abundant.

Changes to the physical form of the river have occurred as a result of flooding and flow management during the past few years. Deposition of sediments at multiple levels during floods and its impacts on vegetation and macroinvertebrate habitat has already been discussed. It is reasonable to assume that the poor condition of macroinvertebrate communities may be impacting recovery of fish populations as well. Floods have also both re-arranged existing, and introduced new, large woody debris throughout the channel. Landholders and CMA staff have observed a number of instances of bank under-cutting at various levels, and tree-falls which may or may not be associated with the under-cutting. Notable bank-notching appears to have been associated with an environmental flow that was sustained at level for 14 days.

3.5 Flow components delivered

Catchment runoff and Lake Eildon pre-release dominated flows during July, August and September, with environmental water being used to maintain desirable flows from October onwards. Inter-Valley Transfers provided flows during December and January. Additional flows above those required for Goulburn River environmental outcomes were provided in the lower Goulburn River in October, and December to March. The achievement of environmental flow components in 2012-2013 is given in Table 3, along with how the flow was provided.

Table 3 Priority flow component achievement in 2012-2013

PRIORITY WATERING ACTION	COMMENT
Baseflow – winter/spring	Provided by unregulated flows and pre-releases in July to September, and environmental releases in October and November.
Fresh - spring	Provided in November by environmental releases. Flows not precisely 5,600 ML/day for 14 days. (A second short duration fresh was also released in October to meet Murray River needs.)
Baseflow - summer	Provided by Inter-Valley Transfers in December and January, and by environmental releases in February. Flows exceeded minimum baseflow due to water transfers to Murray River,

PRIORITY WATERING ACTION	COMMENT
Baseflow – autum/winter	Provided in March by environmental releases, and expected to be provided by environmental releases or unregulated catchment runoff through April to June.
Higher Baseflow – winter/spring	Provided by unregulated flows and pre-releases in July to September, and environmental releases in Ocotober and November.
Baseflow – winter/spring 2013	Water not reserved. Decision taken to use allocations in 2013-2014 to provide this flow.
Higher Baseflow – summer	Provided by Inter-Valley Transfers in December and January, and by environmental releases in February. Flows exceeded minimum baseflow due to water transfers to Murray River,
Fresh – summer/autumn	Provided by environmental releases in March, but not to planned peak flow of 5,600 ML/day. Peak flow reduced to 3,800 ML/day (next lowest macroinvertebrate objective flow) to avoid exacerbating bank notching from the spring fresh.
Higher Baseflow – autumn/winter	Provided in March by environmental releases, and expected to be provided by environmental releases or unregulated catchment runoff through April to mid-May.
Fresh - winter	Planned for delivery using environmental releases in June/July.
Recession slowing	Not used in 2012-2013. Bank slumping was reported in September/October as river flows fell after cessation of catchment runoff and Lake Eildon pre-releases, despite rates of fall being within environmentally recommended levels.

The key flow components that have occurred in the lower Goulburn River since 2001-2002 at Murchison, Shepparton and McCoys Bridge gauging stations as a result of environmental water delivery and unregulated and regulated flows are summarised below in Table 4. In summary:

- Baseflow targets at Murchison and McCoys Bridge have generally only been consistently met in the last 3 years (2010-2011 to 2012-2013).
- Higher baseflow targets at Murchison and McCoys Bridge have generally only been consistently met in the last 3 years (2010-2011 to 2012-2013).
- Fresh targets at Murchison have only been met in 2004-2005 (summer - partially), in 2010-2011 (spring, summer/autumn and winter), in 2011-2012 (spring, summer/autumn and winter), and in 2012-2013 (spring, and partially in summer/autumn).
- Overbank flows greater than 25,000 ML/day at Shepparton have only occurred in 2010-2011 (spring and summer).
- Overbank flows greater than 40,000 ML/day have only occurred once in spring 2010-2011 (spring and summer).

Table 4: Historical achievement of flow component values for the lower Goulburn River

Flow component	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013
Murchison												
Baseflow (winter/spring)												
Baseflow (summer)												
Baseflow (autumn/winter)												
Higher Baseflow (winter/spring)												
Higher Baseflow (summer)												
Higher Baseflow (autumn/winter)												

Flow component	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013
Fresh (spring)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Complete
Fresh (summer/autumn)	Not achieved	Not achieved	Not achieved	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Partial
Fresh (winter)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Complete	
Shepparton												
Low Overbank (winter/spring)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Not achieved	Not achieved
High Overbank (winter/spring)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Not achieved	Not achieved
McCoys Bridge												
Baseflow (winter/spring)	Partial	Not achieved	Partial	Partial	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Complete
Baseflow (summer)	Partial	Not achieved	Partial	Partial	Partial	Not achieved	Partial	Not achieved	Complete	Complete	Complete	Complete
Baseflow (autumn/winter)	Not achieved	Not achieved	Not achieved	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	
Higher Baseflow (winter/spring)	Not achieved	Not achieved	Partial	Not achieved	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Partial	Partial	Complete
Higher Baseflow (summer)	Not achieved	Not achieved	Not achieved	Not achieved	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Partial	Complete
Higher Baseflow (autumn/winter)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	
Fresh (spring)	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Complete
Fresh (summer/autumn)	Not achieved	Not achieved	Not achieved	Complete	Not achieved	Not achieved	Partial	Not achieved	Not achieved	Complete	Complete	Partial
Fresh (winter)	Not achieved	Partial	Partial	Not achieved	Not achieved	Not achieved	Not achieved	Not achieved	Complete	Complete	Complete	

No significant part of the flow component achieved (target flow met for less than 50% of the required duration)
Flow component partially provided (target flow met for more than 50% of the required duration)
Flow component completely provided (target flow met for the required duration)

3.6 Key observations and learnings from 2012-2013

While the weather in 2012 winter was dryish, the pre-releases from Lake Eildon provided a 2 month period of high flows close to bankfull in the lower Goulburn River. When the flows declined back to minimum flows through September, there were several reports of bank slumping and lots of trees falling into the river. While, the rates of fall in the river level were consistent with those recommended in the 2007 environmental flow study, these recommended rates may need to be reduced when following a prolonged high flow wetting up the river bank.

There were also reports of bank slumping/erosion in the mid Goulburn River, presumably at the same time.

The fresh of 5,600 ML/day provided in November 2012 was more erratic in delivery than planned, especially at McCoys Bridge. This is due to difficulties in flow regulation along the river and flow attenuation. In future, more water may need to be released (especially under dry conditions) to provide more certainty of the required flow regime further downstream.

The November 5,600 ML/day fresh has not achieved the desired stimulation of Golden Perch breeding over the 2011 and 2012 springs. The only successful breeding event was in 2010 on a fresh of approximately 10,000 ML/day, following a floodplain inundation event in September. In 2013, it is proposed to try to deliver fresh flows that are as high as possible to give the strongest cue, and preferably 2 freshes. These would not be long duration freshes. Given the uncertainty in weather, these higher freshes will be opportunistic in nature, needed alignment of conditions to achieve maximum flow rates.

A second concern is the lack of river bank vegetation. The 2010 floods removed all the lower bank vegetation. An objective of the 2010 freshes recommendations was to remove the terrestrial vegetation that had moved down the bank during the prolonged drought and replace it with amphibious vegetation (tolerant of being wet and dry). However, little vegetation had re-established on the lower banks before the summer of 2012-2013. Following the 2012 spring fresh, some vegetation has re-established, but it is unclear whether these are the appropriate species. This re-established may have been the result of the fresh (as this is one of the ecological targets for the fresh). The slow rate of re-establishment is also a concern.

A further result of the 2012 fresh was bank notching. In the lower Goulburn, but particularly at McCoys Bridge and further downstream, a line of erosion occurred at the peak water level of the fresh. This would appear to be related to the lack of bank vegetation leaving the banks exposed to erosion. Even so, the fresh duration was not particularly long or the flow velocity very high. Landowners also noted windy conditions during the fresh, which would have caused wave action and therefore contributed to erosion at the waterline. To counter this impact, flows from December 2012 onwards were fluctuated so that the flow did not remain constant for more than roughly 5 days, and flows were not returning to the same flow rate. Erosion lines have still occurred but are relatively superficial. In addition, the March 2013 fresh peak flow was reduced from 5,600 ML/day to 3,800 ML/day (the next lowest macroinvertebrate objective flow rate) to avoid further exacerbating the notching that had already occurred at the 5,600 ML/day level.

Given the importance of the lower bank vegetation and erosion issues, an expert panel is being consulted to provide further advice on how best to manage the erosion risk and to encourage the re-establishment of amphibious vegetation. This advice could to lead to changes to the planned flows in this 2013-2014 Seasonal Watering Proposal.

Dissolved oxygen measurement also proved problematic at both Shepparton and McCoys Bridge. Changes are now being made to move both monitoring sites to more permanent and reliable locations and configurations. These should both be in operation by the start of the 2013-2014 year.

3.7 Climatic outlook for 2013-2014

According to the latest weather outlook information from the Bureau of Meteorology, the Goulburn and Broken Catchments are likely to receive average rainfall from March to May 2013. Conditions in the Pacific Ocean are normal. Lake Eildon is currently 78% full and G-MW is continuing to release to meet irrigation and environmental demands. Overall, other than the state of the water storages, the climate outlook provides no particular guidance for 2013-2014 flow management.

Figure 2: Mid Goulburn River flows for 2013-2013 at measurement points downstream of Lake Eildon

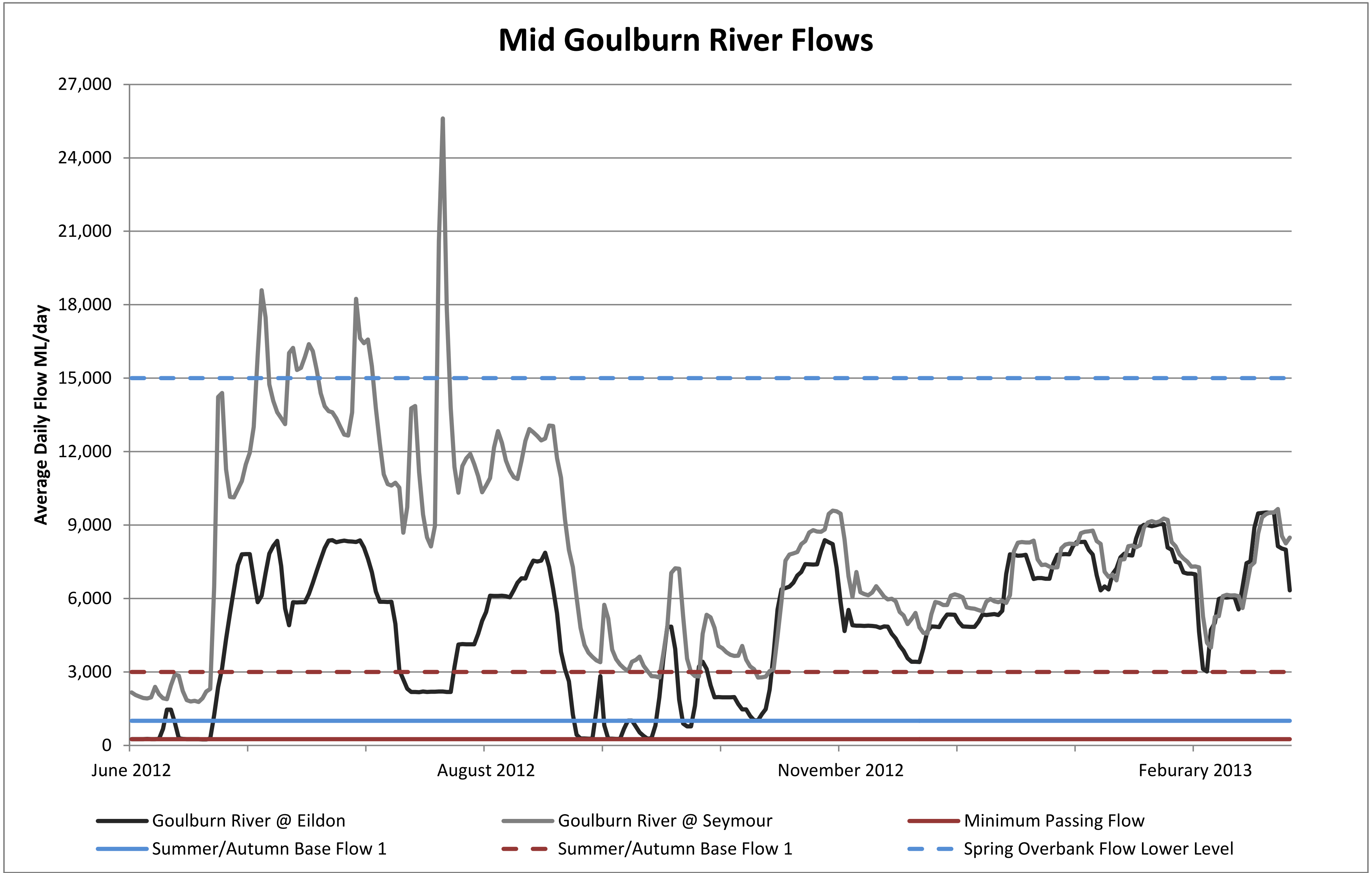


Figure 3: Lower Goulburn River flows for 2012-2013 downstream of the Goulburn Weir

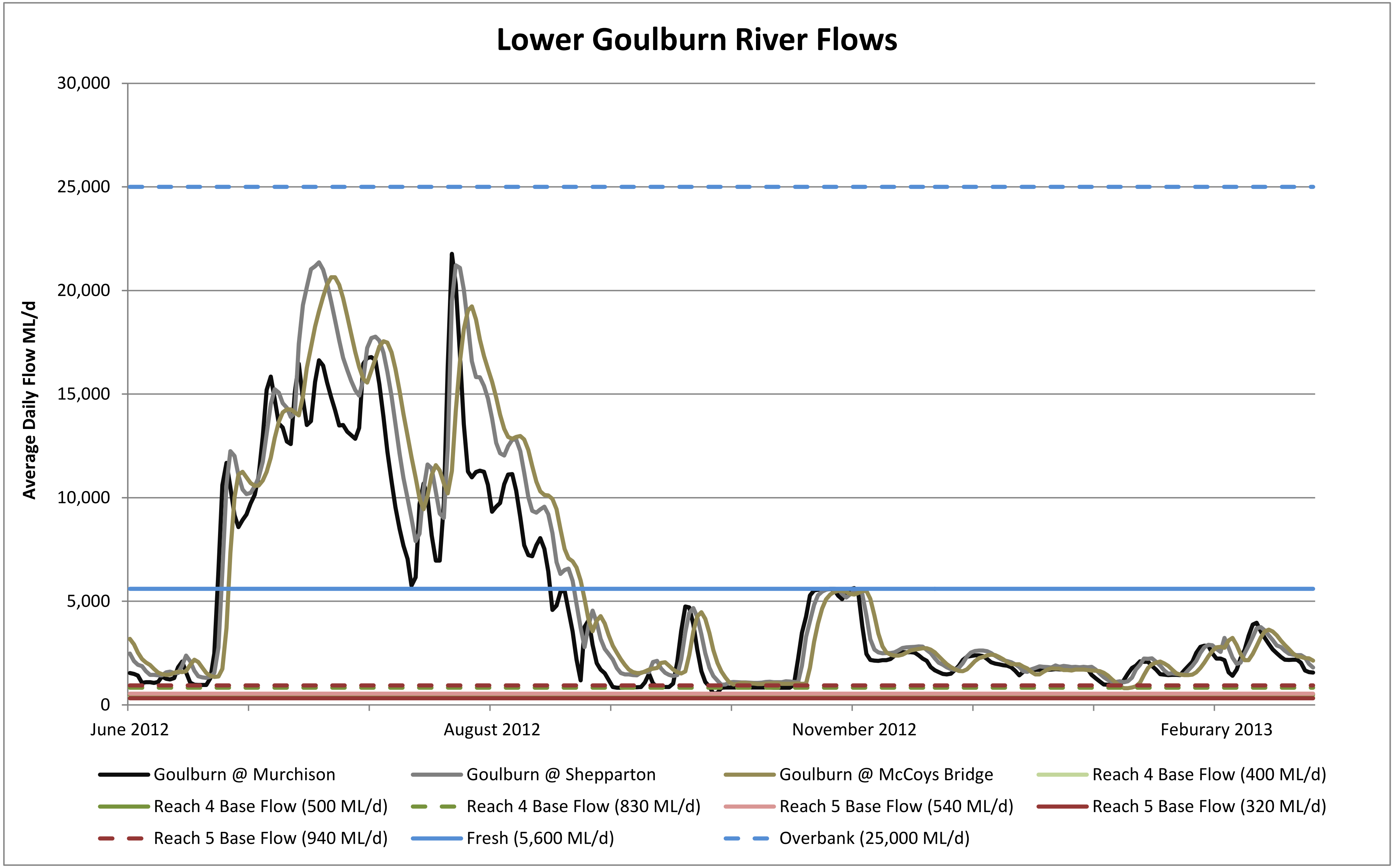


Figure 4: Goulburn River Flows at McCoys Bridge – with and without environmental flows and Inter-Valley Transfers

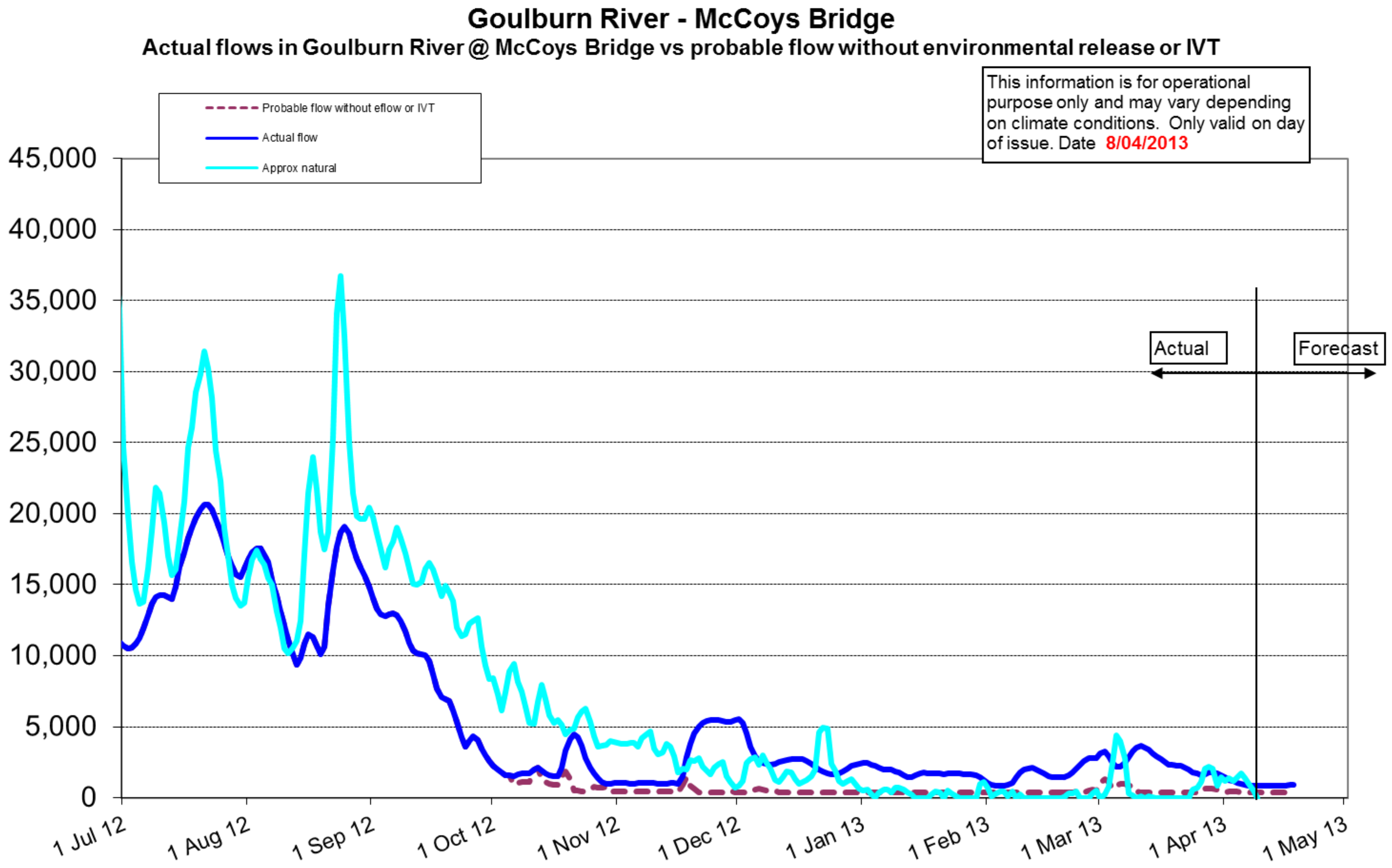
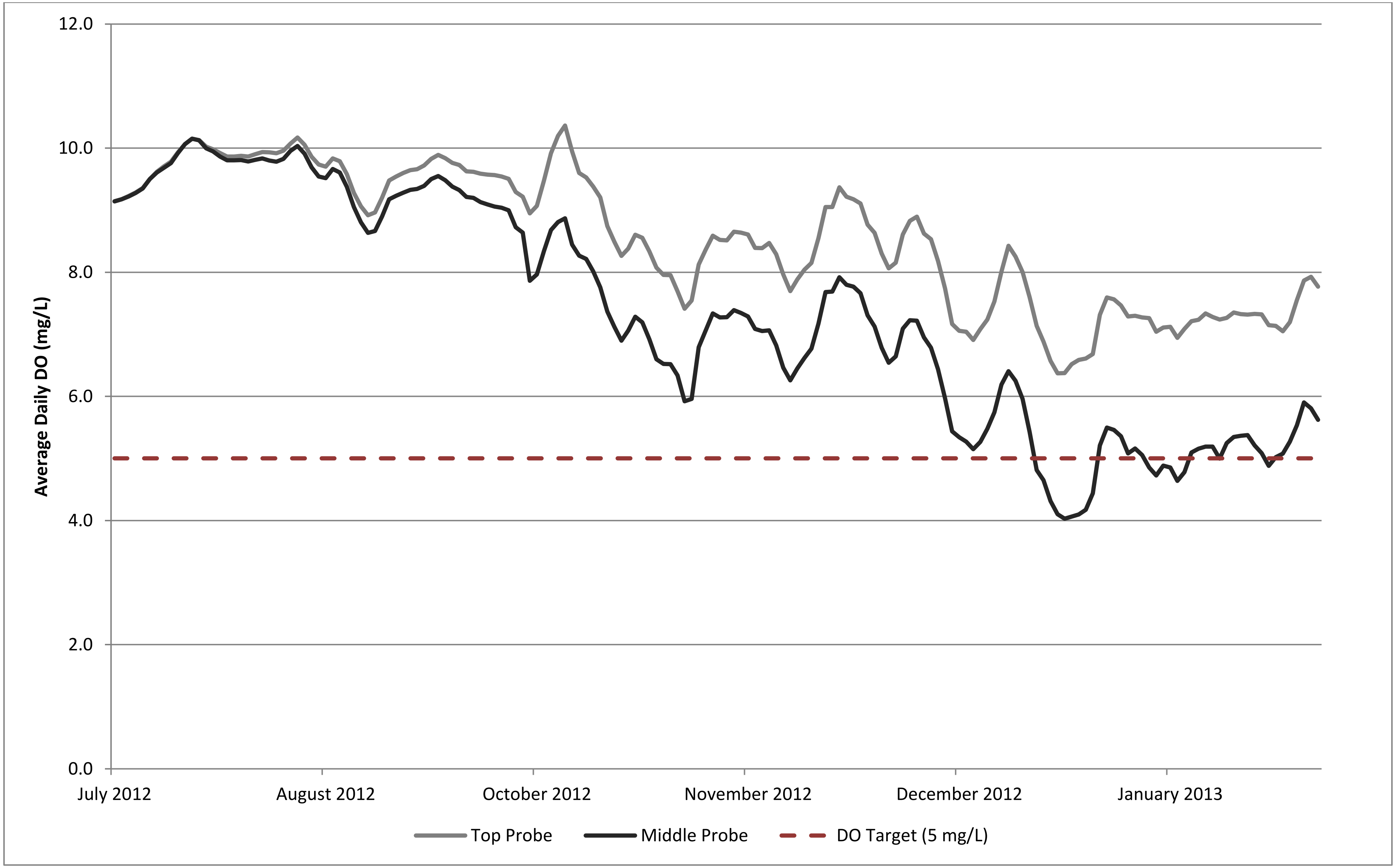


Figure 5: Dissolved oxygen concentrations for 2012-2013 at McCoys Bridge.



6 Priority watering actions

For the purposes of this plan, the needs of the Goulburn River between the Goulburn Weir and the Murray River drive the plan, with reaches 1-3 between Lake Eildon and Goulburn Weir benefiting from flows being passed to the lower reaches 4-5 or being unaffected by them.

The Goulburn Weir to Murray River has two ecologically different reaches, reach 4 upstream of Loch Garry and reach 5 downstream of Loch Garry. The key environmental water measurement point for reach 4 is Murchison (Shepparton for overbank flows) and the key environmental water measurement point for reach 5 is McCoys Bridge. As a general rule, when there is limited tributary inflows and high extraction rates to meet irrigation and consumptive demands (mainly in spring, summer and autumn), the plan aims to meet flow targets for McCoys Bridge. This ensures adequate flow moves through Murchison to meet the targets for reach 4. Alternatively, when lower catchment runoff contributes more flow to reach 5 (mainly in winter and spring), the plan aims to achieve flow targets for Murchison to ensure both reaches meet their flow targets.

The focus for the 2013-2014 year is the same as in 2012-2013, that is to continue to encourage the long term improvement in the distribution, abundance and diversity of native fish, macroinvertebrates and vegetation. This will be achieved by implementing minimum and fresh flow recommendations, particularly in winter/spring. However, additional emphasis is required on bank stability and lower bank vegetation re-establishment.

For minimum flows, the priority is to provide for all of the fish objectives (providing for fish habitat and passage) with flows of approximately 500 ML/day and 540 ML/day at Murchison and McCoys Bridge respectively. This also provides for many macroinvertebrate objectives (encouraging aquatic vegetation for habitat, submergence of snags for habitat and food, and encouraging planktonic production for food). The next minimum flow priority is to provide for more macroinvertebrate objectives (submergence of additional snags, and in Reach 5 the entrainment of litter packs and disruption of biofilms) with flows of approximately 830 ML/day and 940 ML/day at Murchison and McCoys Bridge respectively.

Higher minimum flow rates for geomorphic objectives (aimed at maintaining pool depths) and macroinvertebrates (for improving aquatic vegetation and planktonic production) are a lower priority.

Where water is limited, the 2013 winter/spring period is most important, followed by the 2013-2014 summer period (summer is potentially more biologically productive then autumn/winter) and then the 2014 autumn/winter period. The lower minimum flows of 500 and 540 ML/day throughout the year are more important to meet fish objectives and some macroinvertebrate objectives, with minimum flows then increased if more water is available.

For freshes, the priority is to provide freshes in spring/early summer. In a change to the recommended flows, it is proposed to provide one or two freshes at the highest flow possible up to 15,000 ML/day under ideal weather conditions to stimulate Golden Perch breeding. Given the difficulty and risks of providing these higher flow peaks, it will be somewhat opportunistic in what can be achieved. Associated with these freshes would be to aim for inundation of approximately 14 days at a flow of somewhat greater than 5,600 ML/day to encourage the germination of riparian vegetation on the stripped lower slopes of the bank and allowing macroinvertebrates to respond to the inundation of snags.

The next fresh priority is an earlier winter/spring fresh. Vegetation responses on the lower bank would be maximised by a winter (non growing season) fresh and a spring (growing season) fresh, each of a minimum 2 weeks duration, with preferably 2 to 3 months between events. A winter 2013 fresh is also a priority in the 2012-2013 Seasonal Watering Proposal, and the fresh could be delivered between June and August.

A summer/autumn fresh would target macroinvertebrate objectives, including resuspension of fine sediment from macroinvertebrate habitat.

The 2007 environmental flow study provides for the meeting of specified flows to be for more or less proportion of the time, to allow for climate variability. Given the sequence of drought years, and the flow variability in recent years, in 2013-2014 it is planned to again aim for the proportion of time appropriate for a median year, but with tolerance for some variability to wetter or drier conditions.

A further element of freshes is to add environmental water to unregulated flows or managed flow releases. This could provide the desirable fresh with less environmental water, or merely slow the flow recession to reduce ecological damage from rapid rates of water level fall. Given the recent bank slumping and the relatively unvegetated banks, slowing recessions is more important in the next few years.

The priority flow components are summarised in Table 5 and illustrated in Figure 7. This prioritises between minimum flows and freshes, with the spring freshes seen as a high priority for its multiple benefits, particularly riparian vegetation germination and golden perch spawning.

In considering priority flow components in 2013-2014, the potential needs for 2014-2015 were also considered (and whether any flow components would be foregone in 2013-2014 in preference for a flow component in 2014-2015). There is no major important need in 2014-2015 than in 2013-2014. The main trade-offs occur under the dry scenarios, and it is generally more important to maximise the ecological outcomes in 2013-2014 in a known dry year than hold water back in case 2014-2015 is also a dry year. The highest 2014-2015 priority would be to continue winter baseflows for fish objectives.

The movement of Inter-Valley Transfers and or environmental flows for the Murray River can create summer/autumn flows that are too high causing ecological damage to the lower Goulburn River, and the design of the summer and autumn flow regime will need to take this into account.

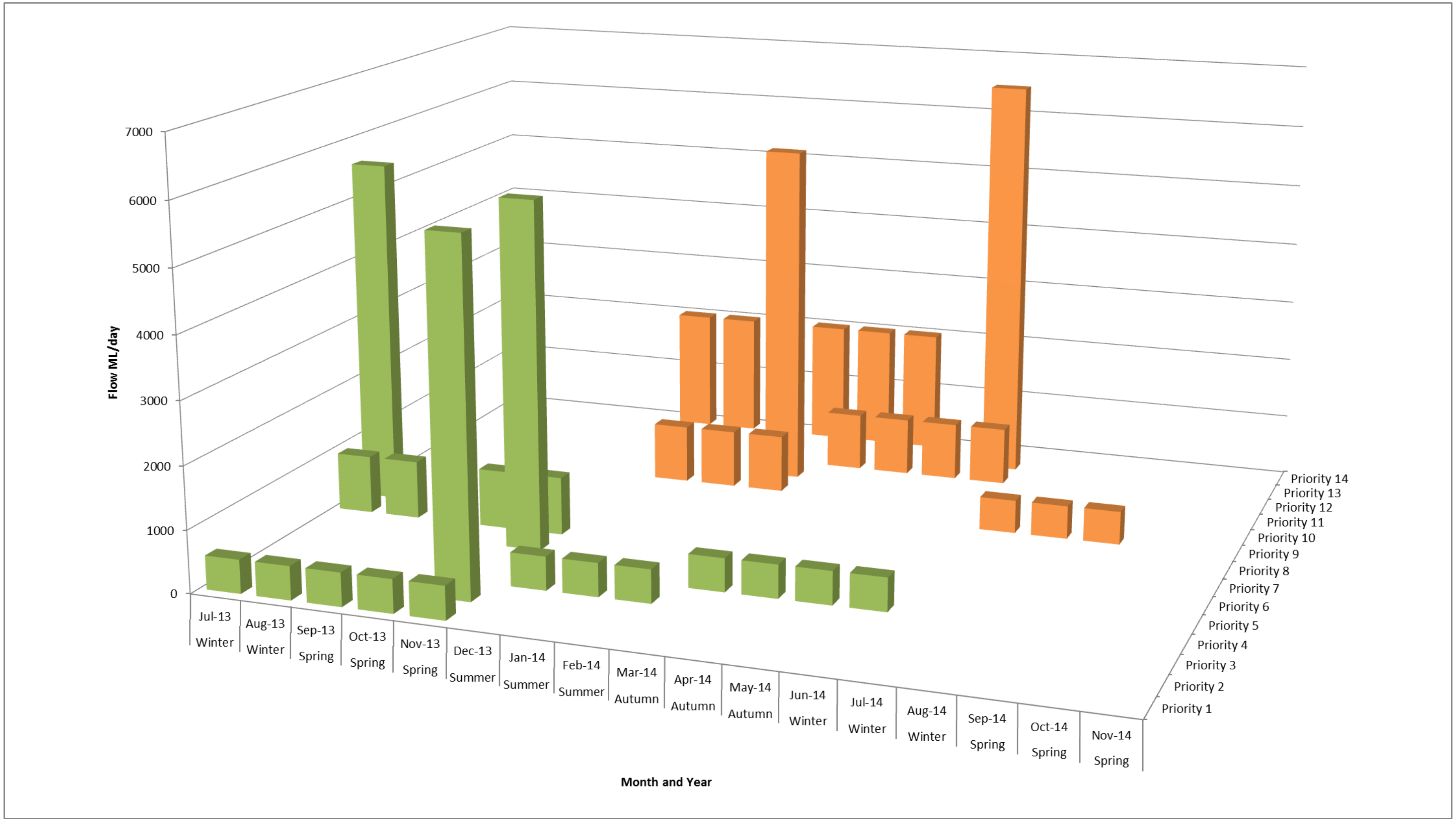
Having had major floodplain inundation in 2010-2011 and some lower floodplain inundation in 2011-2012, no further floodplain inundation is required in 2013-2014. With the risk of flooding private land still unresolved, overbank flooding is not to be attempted in the immediate future in any case.

Table 5: Summary of priority environmental flow components

PRIORITY	FLOW COMPONENT	YEAR	SEASON	FLOW (ML/DAY)	
				REACH 4	REACH 5
1	Baseflow	2013	July-Nov	500	540
2	Fresh	2013	Oct-Dec	As high as possible, up to 15,000 ML/day, with flows above 5,600 for 14 days	As high as possible, up to 15,000 ML/day, with flows above 5,600 for 14 days
3	Baseflow	2013-2014	Dec-Feb	500	540
4	Baseflow	2014	Mar-Jun	500	540
5	Fresh	2013	Oct-Dec	As high as possible, up to 15,000 ML/day for 2 days	As high as possible, up to 15,000 ML/day for 2 days
6	Baseflow	2013	July-Nov	830	940
7	Fresh	2013	Jun-Aug	Up to 6,600 for 14 days	6,600 for 14 days
8	Recession Flows	2013-2014	Any time	As required	As required
9	Baseflow	2014	Jul-Sep	500	540
10	Baseflow	2013-2014	Dec-Feb	830	940
11	Fresh	2013-2014	Feb-Apr	Up to 5,600 for 2 days	Up to 5,600 for 2 days
12	Baseflow	2014	Mar-Jun	830	940
13	Fresh	2014	Jun-Aug	Up to 6,600 for 14 days	6,600 for 14 days
14	Baseflows/fresh	2013-2014	Jul-Jun	Up to 5,000 ML/day	Up to 5,000 ML/day

Note flow components shaded in green are high priorities. Delivery of components shaded in orange will depend on the seasonally adaptive allocation process.

Figure 7: Priority environmental flow components



The lower Goulburn River's social values associated with passive recreation, fishing, and boating should benefit from the improvements in environmental river health achieved by the targeted environmental objectives above. In particular, the enhancement of large-bodied fish populations including Golden Perch supports improves fishing outcomes over the longer term.

7 Scenario planning

The Goulburn River has a highly variable flow, depending on catchment runoff and on the operation of the water supply system to deliver water for consumption. Environmental flow planning aims to allow catchment runoff and water system operation to meet as many environmental flow objectives as possible, and then deploy water from environmental entitlements into the highest priority gaps that remain. However, under different possible climatic conditions (from very dry to very wet), the environmental flow gaps move dramatically, and the priorities for deployment of environmental water change.

Therefore, plans are prepared for a range of possible climatic scenarios to understand how the priorities and required volumes for deployment of environmental water change.

The scenarios are based on current conditions within the water supply system such as the volumes of water stored in the reservoirs. They then assume the availability of all environmental water entitlements and their associated water allocations in the Goulburn system, and determine how best to maximise the environmental outcomes from their use. They assume TLM water can be released precisely to meet Goulburn targets, whereas in practice TLM water will meet Murray targets and therefore may be only partially effective in meeting Goulburn targets.

Importantly, the planning is not concerned with the probability of any particular climate scenario (or in picking the most likely scenario) – it merely ensures there is a plan if any scenario does occur. For the Goulburn system, while various indicators are available, predicting climatic conditions in the current autumn/early winter for the coming season (both winter/spring and summer/autumn) has little reliability.

The scenarios have been picked to highlight the key decisions that will need to be made about environmental water deployment for 2013-2014, and hence can change from year to year. Typically they cover the worst conditions, when allocations increase, when catchment runoff increases significantly, and when Eildon spills. Importantly, the actual management of water through the season needs to be adaptive, with water deployment decisions adjusting as the season unfolds, particularly in response to timing issues within the season. Table 6 outlines the range of scenarios for water use in the lower Goulburn River in the 2013-2014 year.

Table 6: Scenario summary descriptions for the Goulburn River

REACHES 4 & 5	SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
Water Supply	64% HRWS allocations Perhaps 60% available as private carryover	100% HRWS allocations Perhaps 60% available as private carryover	100% HRWS allocations Perhaps 60% available as private carryover	100% HRWS allocations Perhaps 60% available as private carryover	100% HRWS allocations Perhaps 20% available as private carryover
Expected River Flow and Water Management	Effectively no unregulated flows in winter/spring	One or two freshes (2000 to 14000 ML/d) in winter/spring of short duration	One or three freshes (3,000 to 20,000 ML/d) in winter/spring of short duration, and strong baseflows in Sept/Oct,	For most of period, strong baseflows, several freshes and overbank flows in winter/spring	Very strong baseflows and one to three overbank flows (30,000 to 80000) in winter/spring
	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October
	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June
	137 GL of IVT available	186 GL of IVT available	186 GL of IVT available	186 GL of IVT available	156 GL of IVT available

REACHES 4 & 5		SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
WQ Reserve Volumes Available		30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available
Environmental Entitlement Volumes Available		CEWH – 140 GL VEWH – 22 GL TLM - 30 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 207 GL VEWH – 22 GL TLM - 41 GL
Environmental Objectives		Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles
		Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability
		Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding
		Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumping
		Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation
		Maintain pool depth	Maintain pool depth	Maintain pool depth	Maintain pool depth	Maintain pool depth
Preferable Inter-Valley Transfer (IVT) Water Use		Release IVT water for as long as possible (probably January to March) at 940 ML/d (53 GL)	Release IVT water for as long as possible (probably January to March) at 940 ML/d (53 GL)	Release IVT water for as long as possible (probably January to March) at 940 ML/d (53 GL)	Release IVT water for as long as possible (probably January to March) at 940 ML/d (53 GL)	Release IVT water for as long as possible (probably January to March) at 940 ML/d (53 GL)
		May contribute to a low summer/autumn fresh (up to 26GL)	May contribute to a low summer/autumn fresh (up to 26GL)	May contribute to a low summer/autumn fresh (up to 26GL)	May contribute to a low summer/autumn fresh (up to 26GL)	May contribute to a low summer/autumn fresh (up to 26GL)
Preferable Environmental Water Use		Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)
Priority watering actions	1	Increase minimum July to November flows to 540 ML/d at Murchison (38GL)	Increase minimum July to November flows to 540 ML/d at Murchison (33GL)	Increase minimum July to November flows to 540 ML/d at Murchison (29GL)	Increase minimum July to November flows to 540 ML/d at Murchison (7GL)	Increase minimum July to November flows to 540 ML/d at Murchison (7GL)
	2	Provide October to December fresh up to 15,000 ML/d (>5600 for 14 days) (92GL)	Provide October to December fresh up to 15,000 ML/d (>5600 for 14 days) (92GL)	Provide October to December fresh up to 15,000 ML/d (>5600 for 14 days) (92GL)	Provide October to December fresh up to 15,000 ML/d (>5600 for 14 days) (88GL) if required	Provide October to December fresh up to 15,000 ML/d (>5600 for 14 days) (88GL) if required
	3	Increase December to February minimum flows to 540 ML/d at McCoys Bridge (6GL)	Increase December to February minimum flows to 540 ML/d at McCoys Bridge (6GL)	Increase December to February minimum flows to 540 ML/d at McCoys Bridge (6GL)	Increase December to February minimum flows to 540 ML/d at McCoys Bridge (6GL)	Increase December to February minimum flows to 540 ML/d at McCoys Bridge (6GL)
	4	Increase March to June minimum flows to 540 ML/d at McCoys Bridge (23GL)	Increase March to June minimum flows to 540 ML/d at McCoys Bridge (23GL)	Increase March to June minimum flows to 540 ML/d at McCoys Bridge (23GL)	Increase March to June minimum flows to 540 ML/d at McCoys Bridge (23GL)	Increase March to June minimum flows to 540 ML/d at McCoys Bridge (23GL)
	5		Provide 2 day October to December fresh up to 15,000 ML/day (46GL)	Provide 2 day October to December fresh up to 15,000 ML/day (46GL)	Provide 2 day October to December fresh up to 15,000 ML/day (46GL)	Provide 2 day October to December fresh up to 15,000 ML/day (46GL)

REACHES 4 & 5		SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
	6	Increase July to November minimum flows to 830 ML/day at Murchison (27GL) 1*	Increase July to November minimum flows to 830 ML/day at Murchison (28GL) 1*	Increase July to November minimum flows to 830 ML/day at Murchison (28GL) 1*	Increase July to November minimum flows to 830 ML/day at Murchison (10GL)	Increase July to November minimum flows to 830 ML/day at Murchison (10GL)
	7	2*	2*	2*	Provide June to August 2013 fresh to 6,600 ML/day (0GL) 2*	Provide June to August 2013 fresh to 6,600 ML/day (0GL) 2*
	8		Provide recession flow management (say 40GL)	Provide recession flow management (say 40GL)	Provide recession flow management (say 40GL)	Provide recession flow management (say 40GL)
	9		Increase July to September 2014 minimum flows to 500 ML/d at Murchison (23GL)	Increase July to September 2014 minimum flows to 500 ML/d at Murchison (23GL)	Increase July to September 2014 minimum flows to 500 ML/d at Murchison (23GL) 3*	Increase July to September 2014 minimum flows to 500 ML/d at Murchison (23GL) 3*
	10				Increase December to February minimum flows to 940 ML/d at McCoys (12 GL)	Increase December to February minimum flows to 940 ML/d at McCoys (12 GL
	11				Provide February to April fresh up to 5,600 ML/day (26GL)	Provide February to April fresh up to 5,600 ML/day (26GL)
	12					Increase March to June minimum flow to 940 ML/day at McCoys Bridge (30GL)
Environmental water carried over into 2013/14		10	23	23	23	23
Desirable priority watering actions		Provide 2 day October to December fresh up to 15,000 ML/day (46GL)	Increase December to February minimum flows to 940 ML/d at McCoys (12 GL)	Increase December to February minimum flows to 940 ML/d at McCoys (12 GL)	Increase March to June minimum flow to 940 ML/day at McCoys Bridge (30GL)	
		Provide recession flow management (say 40GL)	Provide February to April fresh up to 5,600 ML/day (26GL)	Provide February to April fresh up to 5,600 ML/day (26GL)	Provide June to August 2014 fresh to 6,600 ML/day (80 GL)	Provide June to August 2014 fresh to 6,600 ML/day (80 GL)
		Increase July to September 2014 minimum flows to 500 ML/d at Murchison (23GL)	Increase March to June minimum flow to 940 ML/day at McCoys Bridge (30GL)	Increase March to June minimum flow to 940 ML/day at McCoys Bridge (30GL)	Provide higher summer baseflows and freshes from 1,186 to 5,000 ML/day	Provide higher summer baseflows and freshes from 1,186 to 5,000 ML/day

1 The timing of water availability may reduce the period over which this component can be provided.
2 Usually unable to be supplied as enough water becomes available too late. Provided in average and wetter scenarios by catchment runoff.
3 May not be needed if volumes reserved for allocations in 2014-2015 are high enough.

Under very wet conditions, no carryover would be available from 2012-2013, but good low reliability entitlement allocations would be available. This could provide up to an additional 150 GL of water under TLM entitlements. In addition, catchment runoff is very high. This largely means that all priority environmental flow components can be met and not all of the environmental water available would be required in 2013-2014.

In 2010-2011 and 2011-2012, summer storms produced significant runoff events. These events are sporadic in nature, and not correlated with the climate scenarios above (which are based on winter/spring rainfall). The scenarios above therefore assume these events do not occur. If one or more events do occur, they will potentially reduce the need for release of environmental water, and so result in water being able to meet subsequent autumn and winter priorities, or be carried over for potential use in 2014-2015 season. However, they may also require additional water for flow recession management or dissolved oxygen improvement after the summer runoff flow peak.

8 Triggers for action

This Goulburn Broken CMA proposal is based on using the carryover and allocations of all environmental entitlements expected to be available in the Goulburn system in 2013-2014, as outlined in Table 1. Of these, the Commonwealth Environmental Water Holder water volumes are the major driver of this proposal.

The highest priority is to meet all fish related flow targets for the whole year, and particularly those in the 2013 winter/spring.

Under drier conditions, the majority of the available water is targeted to the 2013 winter/spring. As conditions become wetter and unregulated flows increase, more of the water is deployed after the 2013 winter/spring. Inter-Valley Transfers offer the opportunity to meet some of the summer/autumn flow needs, particularly minimum flows.

A key issue is the deployment of The Living Murray water, which aims to provide environmental outcomes in the Murray River, not the Goulburn River. How well this Murray deployment meets Goulburn needs is an important issue for how many Goulburn priorities can be achieved. A similar issue can exist with Commonwealth water.

Given the potential for dry conditions to occur, it is proposed that in July 2013 water would be deployed to maintain a 500 ML/day minimum flow at Murchison (and 540 ML/day at McCoys Bridge).

Given uncertainty about the coming winter/spring and whether enough water would be available, a winter fresh in July/August 2013 is less likely, and would only be deployed if required for environmental outcomes downstream along the Murray River or could utilise additional water available in 2012-2013.

With some inflow from July onwards, the next decision is when to increase the minimum flow to 830 ML/day at Murchison (and 940 ML/day at McCoys Bridge) based on allocations being likely to reach 100% to provide enough environmental water.

By October, decisions on when to release the 2 freshes to stimulate fish breeding would be made. Even in wet conditions, water would continue to be reserved for the spring fresh until after an appropriate event occurs at the right time to stimulate fish breeding. If there was still significant catchment runoff producing freshes, one or both of these fresh releases may not be required. The peak flow achievable for these events will be somewhat opportunistic, depending on conditions at the time.

Throughout winter/spring (and for the rest of the year), the recessions after natural events would be monitored to determine the need to add water after specific events to reduce the rate of fall in the river level to minimise bank slumping, particularly after prolonged high flows.

At the end of November, December to February minimum flows would be started at 540 ML/day at McCoys Bridge (and 500 ML/day at Murchison), or 940 ML/day at McCoys Bridge (and 830 ML/day at Murchison), depending on the remaining available environmental water for release.

The proposal prioritises provision of a minimum flow of 500/540 ML/day at Murchison/McCoys Bridge respectively in July to September 2014 before a summer fresh and higher summer minimum flows. A review of the water allocation outlook for the 2014-2015 year may determine that there is enough water in that year's allocations to provide that flow, and hence release the water reserved to summer/autumn/winter uses in 2013-2014.

In October/November/December, the potential availability of Inter-Valley Transfers will become clearer, but given the supply conditions possible in the Murray, it could provide a useful but unreliable supply of environmental flow needs. Hence it will be important to have clarified the environmental water available to fill flow gaps in the Inter-Valley Transfers. Planning to minimise the potential impacts of these flows and maximise their value where possible would be undertaken at this time.

In February, release of the February to April fresh would be planned. This only occurs under average to wetter winter/spring conditions or if the water reserved for July to September 2014 minimum flows is not required.

Over the summer months, unseasonal floods onto the floodplain (as in 2012-2011 and 2011-2012) could be an issue requiring a response to flush out the water remaining after any blackwater event. If summer floods occur, this would reduce the use of environmental water during those events for later use.

From March/April onwards when Inter-Valley Transfers cease, maintaining minimum flows at 540 ML/day at McCoys Bridge (and 500 ML/day at Murchison) would occur, or 940 ML/day at McCoys Bridge (and 830 ML/day at Murchison) if adequate environmental water was available.

If environmental water is available for a June to August 2014 fresh, it would be planned in April/May 2014.

The provision of most of these flows should be quite feasible as they are well within the sort of flows normally regulated within the Goulburn system. The spring freshes however are aiming to maximise the peak flow that can be achieved for the first time. While still within bank, these peak flows will need careful planning and monitoring. It is likely that lower peaks will be deployed in the first instance to monitor their behaviour and potential impacts.

The environmental flows leaving the Goulburn system have potential to be used again for downstream environmental benefits in the Murray system, including the Lower Lakes.

Importantly, the Goulburn environmental flow study defines a range of flow components that need to be optimised. This proposal specifies bulk water volumes required to achieve various environmental objectives. However, as the season unfolds, the design of specific flow regimes to optimise outcomes will be required, requiring flexible and adaptive water deployment. In particular, adding to existing freshes and slowing flow recessions will respond to circumstances at the time.

In summary, this proposal suggests the use of the available environmental entitlements held in the Goulburn water supply system, the seasonal allocations and any carryover associated with those entitlements. Table 7 below outlines the environmental water assumed to be available to support this proposal under a range of climatic scenarios. It assumes the Commonwealth holding is 204 GL of High Reliability Water Shares (HRWS) and 12 GL of Low Reliability Water Shares (LRWS), Living Murray holding is 40 GL of HRWS and 157 GL of LRWS, and NVIRP savings of 22 GL. Additional water can be used if available and this is also listed in Table 7. However, given the lower volumes of Inter-Valley Transfer water available, any proposal for water to be traded into the Goulburn system would need to be assessed for the potential impacts of reduced summer flows. Less water can be used than proposed by not delivering flow components under each scenario in Table 6.

Table 7: Summary of environmental water volumes assumed to be available to support this proposal (GL)

REACHES 4 & 5	WORST DROUGHT	VERY DRY	DRY	AVERAGE	WET
Planned environmental water use	192	289	289	289	270
Additional water use	257	148+	148+	110+	110+

The 80 GL additional passing flows available from Lake Eildon under the Goulburn Bulk Entitlement for a flush to 16,000 ML/day for one day is only available in a narrow window of climatic conditions and is called out at the discretion of the VEWH. In 2013-2014, it would appear that the conditions probably do not occur where it is possible for a release to be triggered (possibly around 50% POE inflows in 2013-2014). In any event, there is currently no need for its deployment.

Under the Goulburn bulk entitlement, minimum flows specified in the bulk entitlement can be reduced under drought conditions, with the saved water banked for later use. There is no scenario in 2013-2014 that would require this to be undertaken.

9 Implementation arrangements

No formal operating arrangements exist in the Goulburn River. Capacity constraints in supplying water at Goulburn weir are possible, and Goulburn-Murray Water will consult with Goulburn Broken CMA when such circumstances could occur.

9.1 Notice and time required

A notice period of one to two days minimum and preferably four days is required for environmental water orders from Goulburn system storages. If constraints in making environmental water available are foreseen by G-MW, the Environmental Water Manager will be advised accordingly. Releases from Lake Eildon take approximately 2½ days to reach Goulburn Weir. Releases from Goulburn Weir take one day to reach Murchison, four days to reach Shepparton, and seven to eight days to reach McCoys Bridge (near the Murray River). However this can be influenced by existing conditions in the river channel and seasonal conditions. If flows are being harvested at Goulburn Weir into Waranga Basin, releases can be made from Goulburn Weir by reducing harvesting, hence saving travel time from Lake Eildon.

9.2 Costs

The Environmental Water Manager does not have to make any payment for headworks costs relating to the environmental entitlements or the Goulburn Bulk Entitlement. If chargeable, these costs are met by the entitlement holders. There are no water delivery costs.

10 Risk management

10.1 Environmental Water Delivery

The risks associated with the proposed water delivery of each flow component include: current environmental flow recommendations are inaccurate which may result in ecological objectives not been met; limited CMA resource to deliver environmental release; improving conditions for non-native species such as European carp; environmental releases interfering with irrigation pumps and pumping; environmental water releases causing flooding of private land; unable to provide evidence environmental objectives were met from the environmental water releases; and key stakeholders not supportive of environmental water releases. These have been assessed as a medium risk while remaining risks have been assessed as low (Table 8). The flow components and associated risks and risk ratings are the same for each season.

Table 8: Risk assessment of the proposed Goulburn River water delivery

RISK CATEGORY	Risk #	Risk type	FLOW COMPONENT	
			Low flow	Fresh
Quality issues lead to non-achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	Low	Low
	1.1	Current recommendations on environmental flow inaccurate	Medium	Medium
	1.2	Storage operator maintenance works affect ability to deliver water	Low	Low
	1.3	Resource manager cannot deliver require volume or inflow rate (outlet/capacity constraints, insufficient storage volume)	Low	Low
Time	2.0	Limited CMA resource to deliver environmental release	Low	Medium
Cost	3.0	Cost of delivery exceeds available funding	Low	Low
Human	4.0	Environmental release causes personal injury to river user	Low	Low
	4.1	Environmental releases interfere with irrigation pumps and pumping	Low	Medium
Environmental	5.1	Releases cause water quality issues (e.g. blackwater, low DO, mobilisation of saline pools, ASS etc.)	Low	Low
	5.2	Improved conditions for non-native species (e.g. carp)	Medium	Medium
Compliance	6.0	Environmental water account is overdrawn	Low	Low
	6.1	Environmental releases causes flooding of private land	Low	Medium
	6.2	Environmental releases causes flooding to public infrastructure	Low	Low
	6.3	Environmental releases causes flooding of Crown land	Low	Low
Reputation	7.0	Unable to provide evidence in meeting environmental objective	Medium	Medium
	7.1	Key stakeholders not supportive of environmental water release	Low	Medium

Table 9 below outlines the mitigation strategies that will be employed by the GB CMA to address the medium risks identified above.

Table 9: Mitigation action plan

RISK #	RISK TYPE	FLOW COMPONENT	RISK MITIGATION STRATEGY	IMPACT OF RISK MITIGATION
1.1	Current recommendations on environmental flow in inaccurate	Low flow and fresh	Keep focus on monitoring outcomes from flow management and reassess recommendations as necessary	Adaptively improves recommendations and lowers risk over time
2.0	Limited CMA resource to deliver environmental release	Fresh	Seek resources to manage flows	Low if extra resources provided
4.1	Environmental releases interfere with irrigation pumps and pumping	Fresh	Provide public information on fresh release intentions, and alter fresh management if possible	Reduces risk by allowing issue avoidance
5.2	Improved conditions for non-native species (e.g. carp)	Low flow and fresh	None available	
6.1	Environmental releases causes flooding of private land	Fresh	Consider potential catchment runoff from forecast rainfall in deciding when to commence releases and whether to prematurely cease releases	Becomes low risk
7.0	Unable to provide evidence in meeting environmental objective	Low flows and freshes	Seek involvement, contributions and results from monitoring and research programs	Progressively lower risk over time
7.1	Key stakeholders not supportive of environmental water release	Freshes	Keep key stakeholders aware of fresh plans and timing	Lowers risk somewhat now, and increasingly over time

The key management activity with immediate outcomes includes:

- to manage reduce flooding risk associated with delivering freshes by considering potential catchment runoff from forecast rainfall events in deciding when to commence releases and whether to cease releases prematurely.
- To keep key stakeholders advised of flush release plans.

Importantly risks associated with our current level of knowledge need attention now, but will take time to reduce the associated risks.

10.2 Other Water Delivery

While this proposal focuses on how to use available water to maximise environmental benefits to the lower Goulburn River, water supply and environmental releases can be made to the Murray River for other purposes. In particular, The Living Murray water is targeted at environmental outcomes at the six Murray icon sites, and Inter-Valley Transfers are targeted at meeting consumptive water demand in the Murray River. These releases can pose a risk to the Goulburn River environment and increase the risk of flooding private and public infrastructure.

Releases of water in winter/spring generally pose little risk to the environment, provided flow rates are not varied at greater rates than specified in the Cottingham et al 2007 environmental flows study. Cottingham recommended maximum rates of river level rise in reach 4 of 1.2 and 0.80 metres/day for winter and spring respectively, and maximum rates of river level fall of 0.78 and 0.71 metres/day for winter and spring respectively. Experience in 2012-2013 indicates that even slower rates of fall may be required under some circumstances.

Releases in summer/autumn can pose a significant environmental risk from persistent high flows as defined in the Cottingham et al 2007 environmental flows study. Key impacts are: bank notching and erosion; bank slumping; filling of pools from transported sand; loss of macrophytes; reduced phytoplankton production; and reduced macroinvertebrate growth. Essentially this limits the maximum flow to 5,240 ML/day at McCoys Bridge for a maximum of 2 days to pose a low risk to the environment, with greater durations allowable for lower flow rates. As a guide, flows of greater than approximately 2,500 ML/day can occur for less than 50% of the time. Rates of rise and fall also pose a risk, and Cottingham recommended maximum rates of river level rise of 0.38 metres/day for summer, and maximum rates of river level fall of 0.09 metres/day for both summer and autumn.

The risk of flooding arises from rainfall-induced runoff adding flow on top of an environmental release. The key issue is the unpredictability of the amount of rainfall and the associated runoff. Flooding of land occurs at a flow of approximately 18,000 ML/day at Shepparton, although inundation of some assets (such as irrigation pumps) occurs at much lower flows.

Management of the risk of flooding is a balance of how much spare capacity is left in the river to carry the rainfall runoff and the reduction/suspension of environmental releases when rainfall is forecast to increase the river's spare capacity to carry rainfall runoff. The highest flow that could be provided is 9,000 to 10,000 ML/day under dry conditions, as this is the river capacity downstream of Lake Eildon, and assumes no irrigation water supply demand. This leaves 9,000 to 8,000 ML/day of spare river capacity in the lower Goulburn to carry runoff from rainfall on a dry catchment. Under wet conditions, lower releases (with higher spare river capacity) would be needed to deal with the potentially higher runoff downstream of Lake Eildon. However, following a rainfall runoff event, short duration releases of 9,000 ML/day could be added to the recession of the runoff event to achieve higher flow rates when no rainfall is forecast in the 7 day outlook. The higher the flow rate, the more likely the flow would be reduced or ceased due to the uncertain response to rain, making provision of the environmental or water supply flow erratic and potentially unreliable.

11 Monitoring and reporting

11.1 Current monitoring programs

A number of programs are currently conducted by the Goulburn Broken CMA to monitor environmental flow and river and ecological conditions. The main program for environmental flow monitoring is the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP). This program is being undertaken at 12 sites in the Goulburn River from Goulburn Weir to the Murray River and is monitoring vegetation, fish, macroinvertebrates, channel features, physical habitat. Not all parameters are measured at each site. These assessments are carried out on a range of timeframes (varying from annually, to when a channel changing event occurs) and are a long term assessment (5 - 10 years) of the impacts of and changes from environmental flows. The analysis of this data is based on statistical methods rather than before-after style monitoring. Monitoring commenced in 2008 and to date no data analysis has been completed. Additionally, 2010/11 was the first year of the monitoring to have significant flows, and hence the first year that any response to flows may occur with previous years providing base line data only.

River flows are currently monitored through the North East Monitoring Partnership at Lake Eildon, Killingworth, Trawool, Seymour, Murchison, Shepparton and McCoys Bridge. Goulburn-Murray Water also monitors releases from Goulburn Weir.

Water quality monitoring on the Goulburn River has been in place for a number of years. This monitoring includes continuous monitoring (i.e. 30 minute intervals) that has been occurring for approximately 3½ years (primarily in response to drought) and monitoring on a monthly basis that has been occurring for more than 10 years. Table 10 lists the sites, frequency and parameters that are used for environmental flow monitoring. This monitoring is used frequently (sometimes daily) in short term management of environmental flows to assist decision making in terms of minimising the risk of dissolved oxygen sags and potential fish kills or other water quality issues.

Table 10: Monitoring sites on the Goulburn River

Site	Parameter
Continuous monitoring	
Goulburn River@McCoys Bridge	Dissolved oxygen, electrical conductivity, temperature
Goulburn River@Shepparton Golf Club	Dissolved oxygen, temperature,
Goulburn River@Trawool	Turbidity, level
Goulburn River@Goulburn Weir	Dissolved oxygen, temperature, turbidity
Goulburn River@Tabilk	Dissolved oxygen, temperature, electrical conductivity
Non continuous monitoring	
Goulburn River@Murchison	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN
Goulburn River@Trawool	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN
Goulburn River@Eildon	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN

Goulburn-Murray Water monitors dissolved oxygen and turbidity in Goulburn Weir.

Additional fish monitoring has also been carried out in the lower Goulburn River from 2003. This monitoring includes boat electrofishing, drift net surveys, including larval drift sampling and acoustic tracking. This monitoring provides extra data on fish assemblages, fish movement and recruitment. Where feasible this has been undertaken to coincide with flow events such as freshes and overbank flows. However, its implementation is dependent upon annual funding.

In 2012-2013, the Commonwealth Environmental Water Holder has funded additional monitoring at four sites for one year, including production/respiration/nutrients/turbidity, vertical temperature and dissolved oxygen profiles, organic matter movement, snag habitat inundation, algal biomass and composition, macroinvertebrate composition and biomass, and fine sediment accumulation. Results should be available in mid 2013.

11.2 Monitoring 2013-2014 environmental flow outcomes

In 2013-2014 the VEFMAP will monitor fish and macroinverebrates along the lower Goulburn River (reaches 4 and 5). However, as stated above the program generally aims to detect environmental improvement over some years and the frequency and timing does not necessarily coincide with flow events to assess the effect of environmental water in isolation.

If funds are available the Goulburn Broken CMA will continue to monitor fish assemblages, movement and recruitment in the lower Goulburn River (reaches 4 and 5). Where feasible this will be coordinated to coincide with planned freshes to test the hypothesis that they initiate spawning, pre-spawning migrations and recruitment of native fish.

In 2013-2014, the Commonwealth Environmental Water Holder plans to commence a longer term environmental monitoring program. No details of this program are available at the time of preparing this proposal.

11.3 Reporting

The first level of reporting is on use of environmental entitlements. Weekly reporting advises environmental entitlement holders of progressive water use, and on any adaptive water deployment decisions made.

The second level of reporting is on flows occurring in the river system. Weekly reporting is planned to advise environmental entitlement holders of current flows and the effectiveness of environmental water deployed in achieving desired flows.

The third level of reporting is on environmental outcomes achieved. This will tend to more anecdotal in nature. An annual report will be prepared after the end of the 2013-2014 year to collate all information on the use of environmental water, the river flows achieved, and the environmental outcomes recorded.

11.4 Knowledge gaps and limitations

There are two key knowledge gaps associated with the environmental water management in the Goulburn River.

The first is there are no ecological objectives and flow recommendation for reaches 1-3 for winter and spring. The 2003 flow study only made summer and autumn flow recommendations and following studies did not make any recommendations for reaches 1-3. This requires a new environmental flow study to set objectives for the river (given its flow regime is highly artificial with cold, high summer flows).

Secondly, there has been no monitoring results available to assess whether a number of key ecological objectives are met by the recommended flows in reaches 4 and 5. These are listed below in Table 11.

Table 11: Ecological objectives not assessed

FLOW COMPONENT	ECOLOGICAL VALUES	ECOLOGICAL OBJECTIVES	FLOW (ML/DAY)	
			Reach 4	Reach 5
Base flow	Macroinvertebrates Planktonic algae	• Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone Provide conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates • Provide slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates • Entrain litter packs available as food/habitat source for macroinvertebrates • Maintain water quality suitable for macroinvertebrates	830	940

FLOW COMPONENT	ECOLOGICAL VALUES	ECOLOGICAL OBJECTIVES	FLOW (ML/DAY)	
			Reach 4	Reach 5
Fresh	Native fish Macrophytes Macroinvertebrates	• Initiate spawning, pre-spawning migrations and recruitment of native fish (preferably late spring early summer for native fish) • Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	5,600+	5,600+
Fresh	Bank vegetation Bank erosion	• Establish amphibious riparian vegetation along the lower river banks • Minimise excessive erosion of the river bank	5,600	5,600

Significant new knowledge on these Reach 4 and 5 knowledge gaps should become available from the Commonwealth 2012-2013 monitoring program, and from the Commonwealth 2013-2014 program.

Spring freshes have been modified in this proposal to better target Golden perch breeding, and the GB CMA's fish monitoring program should identify associated responses.

Further advice is currently being sought from an expert panel on riparian vegetation establishment and bank erosion/slumping issues. This will guide flow event design in 2013-2014, and potentially influence monitoring program design to see associated ecological responses.

13 Stakeholder engagement

In developing the proposal , discussions have been held with key stakeholdrs, which is summarised in Table 12.

Discussions have been held with Goulburn-Murray Water on the seasonal outlook and the deliverability of the proposal.

The Goulburn Broken CMA's Goulburn Environmental Water Advisory Group has met to provide advice on planning environmental water use (including this seasonal watering proposal and water management plans) and on environmental health trends occurring in the rivers, creeks and wetlands. The group raised two issues in relation to this proposal. The first was the proposed spring fresh up to 15,000 ML/day, noting that Hancocks Regulater starts to flow water at 14,300 ML/day and takes water out through the forest, cutting access tracks in the forest. This will be monitored in 2013-2014 to understand the thresholds of flow rate and duration more precisely, with a conservative approach taken to targeted peak flow rates.

The second issue was how to provide timely advice to river irrigation pumpers about the planned release of freshes. This will be explored with Goulburn-Murray Water early in the 2013-2014 season.

Parks Victoria and Yorta Yorta have been consulted on this seasonal watering proposal.

Table 12: Seasonal watering proposal development and implementation consultation process

STAKEHOLDER	PURPOSE	ENGAGEMENT TYPE	METHOD	TIMING
		Proposal development		
G-MW	Seek information on water system outlooks and river management, and feasibility of proposal	Involve/consult	Personal discussion with key staff	March – April 2013
VEWH	Seek confirmation that proposal provides information required for Seasonal watering Plan	Inform/consult	Review of draft proposal by VEWH staff	March – April 2013
Parks Victoria	Inform Parks Victoria of proposals and seek land management advice on impacts	Involve/consult	Personal discussion with key staff	March – April 2013
Goulburn Environmental Water Advisory Group	Inform the Goulburn Environmental Water Advisory Group on the proposal and seek advice on community and river health related issues	Inform/consult	Meetings	26 March 2013
Indigenous Groups	Inform Indigenous Groups on the proposal and seek advice on indigenous related issues	Inform/consult	Personal discussion with key representatives	May 2013 – April 2014
CMA Board	Approval of the proposal	Approve	Board Meeting Paper/Presentation	26 April 2013

14 Communications

There are three key audiences for communications under the proposal. The primary audience is the agencies involved in delivering the proposed flow management and included Goulburn-Murray Water, River Murray Water, the Victorian Environmental Water Holder and the Commonwealth Environmental Water Holder.

Goulburn-Murray Water is the key water delivery agency. When the final proposal for 2013-2014 is agreed, communications with Goulburn-Murray Water are aimed at making clear what the intended environmental flow release plans are and their intended purpose. Then, throughout the season, there will be regular communications (phone, email) directly with the water resource management group to understand unregulated flows, Goulburn-Murray Water planned consumptive use releases, and to organise environmental flow releases.

River Murray Water is responsible for calling out Inter-Valley Transfers. Communications (phone, email) will be aimed at initially planning Inter-Valley Transfers to achieve Murray system operational objectives and lower Goulburn River environmental objectives, and then regularly throughout the season, adjusting the plans to conditions as they unfold. Most communications will be via Goulburn-Murray Water.

The Victorian Environmental Water Holder will use this proposal as the basis (in whole or part), in developing the Seasonal Watering Plan. Water allocated is to be delivered in accordance with the plan and the plan is used to seek agreement from other water holders for the use of their water. Routine communication (phone, email) will report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds.

Commonwealth Environmental Water Holder may have allocated water to the Seasonal Watering Plan which is based on this proposal, and are responsible for achieving further benefits from the water at downstream environmental sites. The Murray Darling Basin Authority is responsible for delivery of TLM water to the Murray River, with potential benefit to the Goulburn River. Routine communication will be via the Victorian Environmental Water Holder, particularly highlighting risks of summer releases and optimising achievement of lower Goulburn River and Murray River environmental objectives.

The second audience is those potentially affected by or interested in environmental flows and/or the health of the river environment. This includes Parks Victoria and Department of Sustainability and Environment (public land managers), water users along the river (Goulburn-Murray Water diversion licence holders), campers and recreation users, local government, environment groups, and the general public. These groups have a direct interest in river flows as they may influence their activities. The primary objective is to make them aware of intended flow regimes so they can plan their activities around particularly fresh events. A secondary objective is to build an understanding of the change from past flow regimes to a future one managed to achieve improved river health. Communications will primarily through media releases and Goulburn-Murray Water communication channels.

The third audience is the broader public. The communication objective for this audience is to provide information about the decision to provide environmental flows and what it is trying to achieve. These communications will be through media articles of newsworthy actions, and potentially through talks and local newsletters directly with special interest groups.

Table 13 outlines the communication process that will be implemented.

Table 13: Seasonal watering proposal communication approach

STAKEHOLDER	PURPOSE	ENGAGEMENT TYPE	METHOD	TIMING
		Proposal implementation		
Goulburn Environmental Water Advisory Group	Advise of flow release proposals and seek advice on community and river health related issues	Inform/consult	Meetings, telephone and email	May 2013 – May 2014
Goulburn Environmental Water Advisory Group	Advise of flow release proposals and seek advice on community and river health related issues	Inform/consult		
VEWH	Present contents of proposal to VEWH	Inform	Presentation	May 2013
	Report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds	Inform/consult	Telephone and email	May 2013 – May 2014
River Murray Water	Planning Inter-Valley Transfers to achieve Murray system operational objectives and lower Goulburn River environmental objectives, and adjusting the plans to conditions as they unfold	Inform/consult	Telephone and email	May 2013 – April 2014
G-MW	To understand unregulated flows, planned consumptive use releases, and to organise environmental flow releases	Inform/consult	Telephone and email	May 2013 – May 2014
Parks Vic, DSE	Inform of future flow events for potential impact on their activities	Inform/consult	Telephone and email	May 2013 – May 2014
Interest Groups	Build understanding of environmental flow objectives and changes in flow regime	Inform	Media, possibly newsletters and talks	May 2013 – May 2014
General public	Build understanding of environmental flow objectives and water management to achieve objectives	Inform	Media, talks, videos	May 2013 – May 2014

15 Approval and endorsement

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Goulburn River 2013-2014.

SIGNED FOR AND ON BEHALF OF THE GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Signature of authorised representative

Chris Norman
Chief Executive Officer
Goulburn Broken Catchment Management Authority

Name of authorised representative

Date: 30 April 2013

16 References

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Appendix 1: Reach 4 & 5 flow recommendations

The following provides the flow recommendations outlined in Cottingham et (2007).

Flow duration bounds identified for Reach 4 ecological objectives.

Note: The values in the table represent the proportion of time that discharge may exceed a particular bound (e.g. 0.85 = 85%). The various percentile years provide opportunities for inter-annual variability, providing different exceedence levels for dry (min, 10th and 30th percentile years) median and wet years (70th, 90th and max years).

			RECOMMENDED						
Ecological Objective	Flow Element Code	Discharge (ML/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
Summer - Lower Bound									
MI4	F003b	540		0.90	0.95	0.95	0.98	0.99	
MI1	F007a	310	0.70	0.80	1.00	1.00			
MI3	F007a	310	0.99	0.99	0.99	0.99	0.99		
MI2	F008b	400	0.90	0.93	0.95	0.98	0.98		
n. fish	F008b	400	0.74	0.95	0.99	0.99	0.99		
n. fish	F007b	500	0.97	0.98	0.99	0.99	0.99		
MI6	F003b	540		0.80	0.90	0.95	0.99	0.99	
MI2	F008c	830	0.70	0.93	0.95	0.98	0.98		
Geo3	F026i	856	0.36	0.71	0.94	1.00	1.00	1.0	1.00
Geo3	F026h	1186	0.11	0.57	0.75	0.88	0.96	1.0	1.00
MI1	F007c	1500		0.10	0.30	0.45	0.75		
MI3	F007c	1500		0.15	0.30	0.40	0.70		
Geo3	F026g	1660		0.30	0.47	0.63	0.74	0.94	1.00
Geo3	F026f	2223		0.11	0.25	0.40	0.60	0.71	1.00
Geo3	F026e	3142		0.01	0.06	0.20	0.43	0.55	0.86
Geo3	F026d	4490				0.05	0.24	0.37	0.64
Geo3	F026c	6590					0.08	0.16	0.42
Geo3	F026b	10700						0.04	0.27
Geo3	F026a	19000							
Summer Upper Bound									
Geo3	F026i	856	0.36	0.71	0.94				
Geo3	F026h	1186	0.11	0.57	0.75	0.88	0.96		
MI1	F007c	1500			0.70	0.90	0.90		
Geo3	F026g	1660	0	0.30	0.47	0.63	0.74	0.94	
Geo3	F026f	2223	0	0.11	0.25	0.40	0.60	0.71	
Geo3	F026e	3142	0	0.01	0.06	0.20	0.43	0.55	0.86
Geo3	F026d	4490	0	0	0	0.05	0.24	0.37	0.64
Geo3	F026c	6590	0	0	0	0	0.08	0.16	0.42
Geo3	F026b	10700	0	0	0	0	0	0.04	0.27
Geo3	F026a	19000	0	0	0	0	0	0	0.07
Autumn Lower Bound									

			RECOMMENDED						
Ecological Objective	Flow Element Code	Discharge (ML/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
MI2	F008b	400		0.90	0.93	0.95	0.98	0.98	
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	540		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.50	0.65	0.80	0.95	0.98	
Winter Lower Bound									
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	500		0.80	0.86	0.88	0.90	0.96	
MI4	F003b	540		0.85	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.80	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.90	0.93	0.95	0.98	0.98	
Spring Lower Bound									
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
MI2	F008b	400		0.90	0.93	0.95	0.98	0.98	
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	500		0.81	0.85	0.91	0.95	0.99	
MI4	F003b	540		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.90	0.93	0.95	0.98	0.98	
n. fish	F027a	24000				0.05	0.13	0.31	
Spring Upper Bound									
n. fish	F027a	24000		0	0	0.08	0.19	0.47	

Flow duration bounds identified for Reach 5 ecological objectives.

The values represent the proportion of time that discharge may exceed a particular bound (e.g. 0.85 = 85%). The various percentile years provide opportunities for inter-annual variability, providing different exceedence levels for dry (min, 10th and 30th percentile years) median and wet years (70th, 90th and max years).

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
Summer - Lower Bound									
MI1	F007a	240		0.70	0.80	1.00	1		
MI3	F007a	240		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	320		0.90	0.90	0.99	0.99	0.99	
MI2	F008b	540		0.90	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.90	0.95	0.95	0.98	0.99	
MI6	F003b	770		0.80	0.90	0.95	0.99	0.99	

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
MI2	F008c	940		0.70	0.92	0.95	0.98	0.98	
Geo3	F026i	1096	0.38	0.75	0.88	0.96	1.00	1.00	1.00
Geo3	F026h	1505	0.17	0.53	0.64	0.82	0.94	1.00	1.00
Geo3	F026g	1993	0.02	0.17	0.40	0.60	0.73	0.97	1.00
Geo3	F026f	2711	0	0.09	0.21	0.35	0.60	0.87	1.00
Geo3	F026e	3800	0	0	0.05	0.20	0.40	0.66	1.00
Geo3	F026d	5240	0	0	0	0.02	0.22	0.43	0.71
Plankt. Algae	F002c	6060				0	0.17		
Geo3	F026c	7560	0	0	0	0	0.08	0.18	0.47
Geo3	F026b	13000	0	0	0	0	0	0.03	0.38
Geo3	F026a	23900	0	0	0	0	0	0	0.09
Summer - Upper Bound									
Geo3	F026i	1096	0.38	0.75	0.88	0.96	1.00	1.00	1.00
Geo3	F026h	1505	0.17	0.53	0.64	0.82	0.94	1.00	1.00
Geo3	F026g	1993	0.02	0.17	0.4	0.60	0.73	0.97	1.00
Geo3	F026f	2711	0	0.09	0.21	0.35	0.60	0.87	1.00
Geo3	F026e	3800	0	0	0.05	0.20	0.40	0.66	1.00
Geo3	F026d	5240	0	0	0	0.02	0.22	0.43	0.71
MI2	F004c	5610		0.01	0.01	0.02	0.30	0.50	
MI4	F004c	5610		0.01	0.01	0.02	0.25	0.45	
Plankt. algae	F002c	6060					0.19	0.30	
Geo3	F026c	7560	0	0	0	0	0.08	0.18	0.47
MI2	F002b	8910		0.01	0.01	0.01	0.05	0.15	
Geo3	F026b	13000	0	0	0	0	0	0.03	0.38
Geo3	F026a	23900	0	0	0	0	0	0	0.09
Autumn - Lower Bound									
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	
MI2	F008b	540		0.90	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	770		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	940		0.50	0.65	0.80	0.95	0.98	
Autumn - Upper Bound									
MI2	F004c	5610		0.01	0.01	0.02	0.30	0.60	
MI4	F004c	5610					0.03	0.10	
MI2	F002b	8910		0.01	0.01	0.01	0.01	0.05	
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.85	0.9	0.95	0.98	0.99	
MI6	F003b	770		0.8	0.9	0.95	0.99	0.99	
MI2	F008c	940		0.9	0.92	0.95	0.98	0.98	
Winter - Upper Bound									
MI2	F002b	8910		0.2	0.3	0.65	0.8	0.9	
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day))	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
MI2	F008b	540		0.9	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	770		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	940		0.90	0.92	0.95	0.98	0.98	
Plankt. algae	F002c	6060							
MI4	F004c	5610		0.42	0.70	0.85	0.95	1.00	
Plankt. algae	F002c	6060		0.35	0.66	0.73	0.86	1.00	
MI2	F002b	8910		0.10	0.40	0.65	0.80	1.00	
n. fish	F027a	24000		0	0.05	0.13	0.26	0.54	

Flow stressors and their components

CODE	DESCRIPTION	ELEMENTS
F001	Mean hydraulic residence time (hours/km)	-
F002	Proportion of time when euphotic depth is less than n times the mean depth	n = 0.2, 0.25, 0.3
F003	Proportion of time when mean shear stress is less than n N/m2 - leading to deposition of fine sediments	n = 1, 2, 3
F004	Proportion of time when mean shear stress is more than n N/m2 – leading to possibly biofilm instability	n = 5, 6, 7
F005	Water level fluctuation characterised by the amphibious habitat index calculated at euphotic depth for the n% exceedence flows (in the pre-regulation regime)	n = 10, 20, 30, …, 90
F006	Maximum inundation duration at heights up the bank corresponding to the water surface levels for the n% exceedence flows (in the pre-regulation regime)	n = 10, 20, 30, …, 90
F007	Proportion of time when there is less than n m2/m slow shallow habitat (d<0.5 m, v<0.05 m/s).	n = 1, 2, 3, …, 5
F008	Proportion of time when there is less than n m2/m deep water habitat defined as d>1.5 m	n = 5, 10, 15, 20
F009	Maximum continuous rise in stage (m)	-
F010	The distribution of daily change in stage characterised by the n th percentile values (m)	n = 10, 90
F011	mean illuminated volume of water (m3 per m length of channel)	-
F012	mean ratio of euphotic depth to mean water depth	-
F013	mean ratio of fall velocity (n m/s) to mean water depth	n = 0.2, 0.4 and 0.94
F014	mean illuminated area of benthos (m2 per m length of channel)	-
F015	mean illuminated area of benthos with velocity less than n m/s (m2 per m length of channel)	n = 0.2, 0.3, 0.4 and 0.9
F016	proportion of time when benthos has been in euphotic zone for at least n days, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F017	Number of independent events when benthos has been in euphotic zone for at least n days, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F018	Mean water depth (m) during periods when benthos is in euphotic zone for at least n days calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F019	proportion of time benthos is in the euphotic zone, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F020	Proportion of time benthos is below the euphotic zone, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F021	number of overbank events	

CODE	DESCRIPTION	ELEMENTS
F022	The distribution of daily rises in stage characterised by the n th percentile values (m)	n = 10, 90
F023	The distribution of daily falls in stage characterised by the n th percentile values (m)	n = 10, 90
F024	The distribution of daily falls in stage characterised by the n th percentile values (m) for flow bands defined by the flows Qi ML/day	n = 10, 50, 90 = 0, 4000, 100000
F025	Proportion of time water level is within a range defined by water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F026	Proportion of time water level is above a specified depth above bed corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F027	Proportion of time flow exceeds 24000 Ml/day	

Summary of relationships between flow-related objectives and flow stressors (see Appendix 1 and 2 for further details of flow objectives)

Ecological Value	Code	Ecological Objective	Stressor code(s)	Seasons	Stressor mechanism
Source of food for fish and invertebrates and influence on river nutrient and chemical conditions	Planktonic algae	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F001	Su, Sp	Increased channel retention due to reduced water velocity and/or hydraulic retention zones allows accumulation of biomass if growth rates exceed loss rates.
			F002	Su, Sp	Proportion of time planktonic algae spend in the euphotic zone determines whether net production is possible or not
			F012	Sp	Proportion of time planktonic algae spend in the euphotic zone multiplied by mean surface irradiance determines the relative level of production
			F013	Su, Sp	Water depth influences the rate of deposition of planktonic algae (It takes longer for settling in deeper water)
Source of food for fish and invertebrates, habitat, and influence on river nutrient and chemical conditions	Periphytic algae	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F014	Su, Sp	Bethic production is restricted to wetted perimeter within the euphotic zone (i.e. where light penetrates to the channel bed and banks)
			F015	Su, Sp	High velocities influencing biofilm stability. Area of colonization determined by extent of light zone - use euphotic depth, but limited by velocity.
			F016	Sp	Establishment of biofilms requires that the wetted surface remains wet and within the euphotic depth for a period of some time. Drying and submersion below the euphotic depth will adversely affect biofilms
Contributes to primary production, habitat for macroinvertebrates and native fish	Macrophytes	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F014	Su, Au, Wi, Sp	Bethic production is restricted to wetted perimeter within the euphotic zone (i.e. where light penetrates to the channel bed and banks)
			F015	Su, Au, Sp	High velocities influencing biofilm stability. Area of colonization determined by extent of light zone - use euphotic depth, but limited by velocity.
			F016	Su, Au, Sp	Establishment of aquatic macrophytes requires that the wetted surface remains wet and within the euphotic depth for a period of some time. Drying and submersion below the euphotic depth will adversely affect macrophytes
Natural gradient of native terrestrial vegetation up the river banks	Terrestrial bank vegetation	Maintain native terrestrial cover at top of banks and reduce cover of terrestrial vegetation in areas of the bank influenced by flow regulation	F006	Dec-Apr	Duration of submergence (inundation) has potential to drown out terrestrial vegetation, due to carbon and oxygen starvation; critical values for duration tolerance expected to vary between seasons, being much longer in cool (autumn-winter) than in warm growing (spring-summer) season.
Diverse and resilient aquatic macroinvertebrate fauna	MI1	Provision of conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates	F007	Su	Slow shallow velocities required for establishment of aquatic vegetation
			F010	Wi	Short-term flow fluctuations can adversely affect aquatic vegetation growing along the channel margins
			F022	Su, Au, Wi, Sp	Short-term flow fluctuations can adversely affect aquatic vegetation growing along the channel margins
			F023	Su, Au, Wi, Sp	Short-term flow fluctuations can adversely affect aquatic vegetation growing along the channel margins
	MI2	Submersion of snag habitat within the euphotic zone to provide habitat and food source for macroinvertebrates	F002	Su, Au, Wi, Sp	Quantity and variety of snags dependant on volume (possibly modified by biodiversity and productivity of snag biofilm - depth and variability of light climate).
			F004	Su, Au	High shear stresses can lead to biofilm instability

Ecological Value	Code	Ecological Objective	Stressor code(s)	Seasons	Stressor mechanism
			F008	Su, Au, Wi, Sp	Loss of pools
			F025	Dec-Apr	Reduction in flow result in drying of large woody debris
	MI3	Provision of slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates (MI3)	F007	Su	Increased flow velocity and rapid rates of rise and fall affect availability of shallow, slackwater habitat for macroinvertebrates.
			F023	Su, Au, Wi, Sp	daily fall in stage
			F024	Dec-Apr	daily fall in stage
	MI4	Entrainment of litter packs available as food/habitat source for macroinvertebrates (MI4)	F003	Su, Au, Wi, Sp	Shear stress required to disrupt (refresh) biofilms and entrain organic matter.
			F004	Su, Au, Sp	Shear stress required to disrupt (refresh) biofilms and entrain organic matter.
			F021	Su, Au, Wi, Sp	Overbank events may entrain organic matter
	MI6	Maintenance of water quality suitable for macroinvertebrates	F003	Su, Au, Wi, Sp	Temperature, nutrients and salinity assumed not significant, pollution effects (toxicants) not known. Sediment deposition noted and known to remove susceptible taxa.
Diversity of native species, naturally self-reproducing populations of native fish, threatened and iconic native species.	Native Fish	Suitable in-channel habitat for all life stages	F007	Su, Aut, Wi, Sp	Slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish
			F008	Su, Au, Wi, Sp	Deep water habitat for large bodied fish
		Cues for adult migration during spawning season	F022	Su, Sp	Flow variation required as a cue for migration and spawning
			F023	Su, Sp	Flow variation required as a cue for migration and spawning
		Suitable off-channel habitat for all life stages	F027	Sp	Inundation of floodplain required by some species and for transport of nutrients and organic matter to drive food webs
Natural Channel Form and Dynamics	Geo1	Avoid notching	F025	Dec-Apr	Long duration of stable flow followed by rapid draw-down. Impact likely to be exacerbated by loss of bank side vegetation.
	Geo2	Avoid slumping	F023	Su	Excessive rates of fall in river level.
	Geo3	Maintain pool depth	F026	Su	Unseasonal events that fill pools with sediment but do not flush them.
	Geo6	Maintain natural rates of geomorphic disturbance	F006	Dec-Apr	High velocity discharge increases disturbance of sand substrates and aquatic macrophytes.

Appendix 2: Summary Table

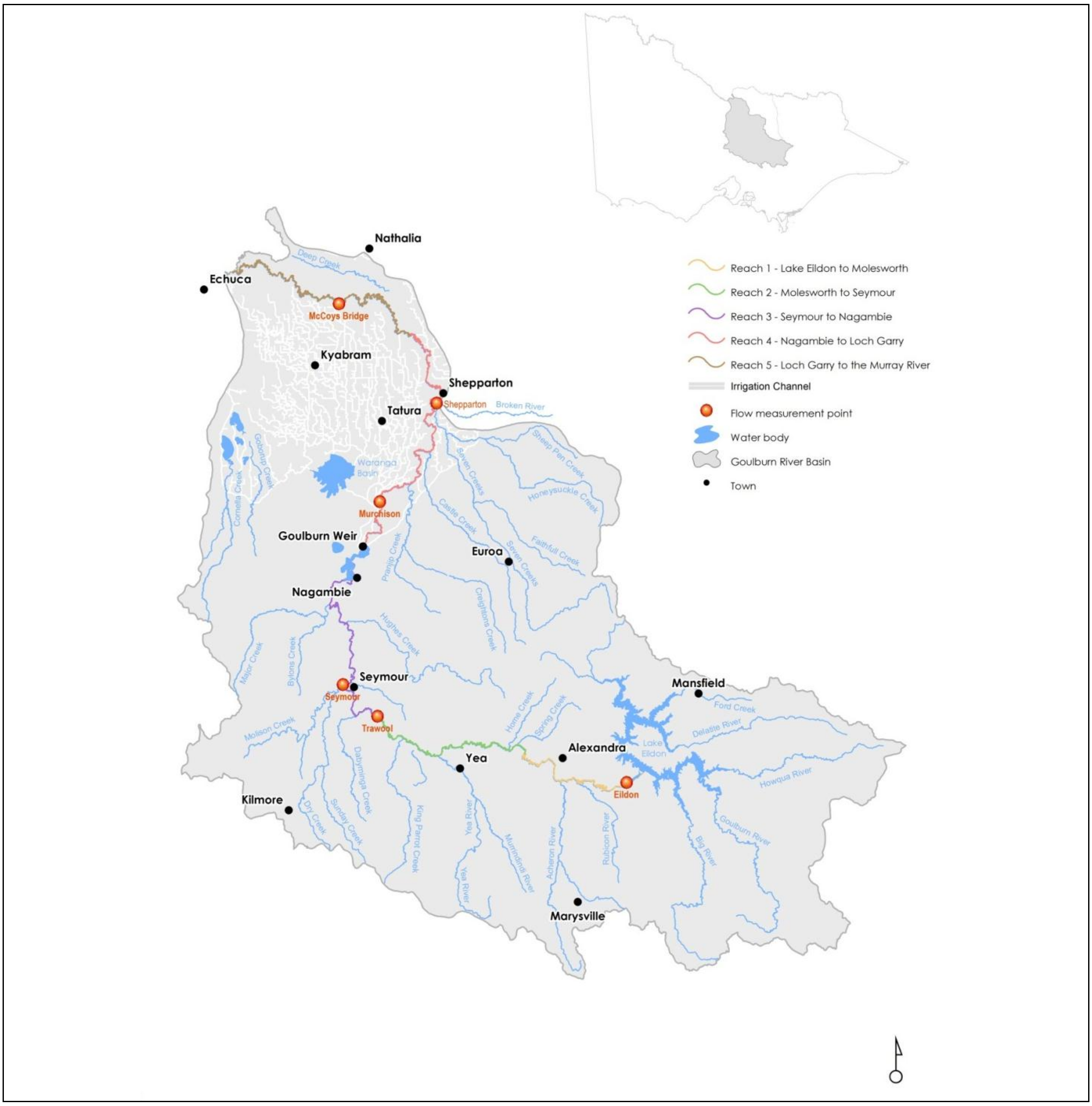
System name	Goulburn River

Waterway manager	Goulburn Broken Catchment Management Authority
Storage operator/s	Goulburn-Murray Water
Land manager/s	Parks Victoria, Department of Sustainability and Environment

System summary
The Goulburn river basin is Victoria's largest, covering 1.6 million hectares or 7.1 perccent of the State's total area. The Goulburn river is an iconic heritage river because of its significant environmental, recreational and cultural values. It supports areas of intact river red gum forest, and provides habitat for threatened and endangered species such as the great egret, Murray cod and Macquarie perch. It also contains many important cultural heritage sites, provides water for agriculture and supports recreational activities such as fishing and boating.

Summary of planned environmental water use in 2013-14
The priority environmental objectives in the Goulburn system in 2013-2014 are: providing appropriate habitats and cues for fish including for spawning, recruitment and migration; enhancing the extent and diversity of aquatic vegetation; enhancing the extent and diversity of riparian vegetation; improving the abundance and diversity of macroinvertebrate communities; and minimising river bank slumping and erosion. To achieve these objectives, environmental watering will focus, in priority order, on: July to November baseflows; an October to December fresh, December to February baseflows, March to June baseflows; a second October to December fresh; increased July to November baseflows; a June to August 2013 fresh, and flows to reduce the rate of fall in river levels. If additional water is available or catchment runoff conditions are average to wet, environmental watering will focus on: carrying water over for July to September baseflows in 2014; increased December to February baseflows; a February to April fresh; increased March to June baseflows; a June to August 2014 fresh; and further increased baseflows (particularly summer/autumn). The priority reaches for environmental watering are reaches 4 and 5, from Goulburn Weir to the River Murray. Reaches 1 to 3, between Lake Eildon and Goulburn Weir, benefit from (or are not adversely impacted by) the flows being passed to the lower reaches.

System overview
The regulated Goulburn River is divided into two key reaches: from Lake Eildon to Goulburn Weir, and from Goulburn Weir to the Murray River (see map below). Lake Eildon is a major water storage with a capacity of 3,334 GL. At Goulburn Weir, flows are diverted for irrigation and to fill Waranga Basin, a storage with a capacity of 432 GL. The water supply system operates to store water from the Goulburn River, reducing winter/spring river flows, and to supply irrigation demands which increases summer/autumn river flows between Lake Eildon and Goulburn Weir. The river and its associated floodplain and wetland habitats also contain many important cultural heritage sites, provide water for agriculture and urban centres, and support a variety of recreational activities such as fishing and boating. From Goulburn Weir to the Murray River is the key reach for environmental flow planning, being the most flow stressed and with significant environmental values. Environmental flows are measured at Murchison and McCoys Bridge (and Shepparton for overbank flows). These reaches provide important habitat for a range of native fish species, including small-biodied fish such as carp gudgeon and large bodied fish such as Golden perch and Murray cod. Environmental flows can be released from Lake Eildon or Goulburn Weir. Significant catchment runoff can occur between Lake Eildon and Goulburn Weir, and downstream of Goulburn Weir. Environmental outcomes are achieved by catchment runoff, irrigation water deliveries, and environmental releases.



Current situation
The impacts of 12 years of drought, followed by floods in 2010-2011, have left fish, aquatic and bank riparian vegetation, and macroinvertebrates in reduced condition. Floodplain vegetation is generally in good condition. Almost all priority watering actions were achieved in 2012-2013. There were no overbank flows. Targeted Golden perch breeding largely did not occur. Murray Cod continue to be absent at Yambuna since the 2010 blackwater event. However, Murray cod fish larvae were detected there this year. Bank vegetation re-establishment has progressed on the upper river banks, but made limited progress on the lower banks. River bank damage issues were recorded in the year, with bank notching occurring during the November fresh, and bank slumping report after the drop in the winter catchment runoff flows.

Environmental objectives
The environmental objectives being targeted continue to be providing fish habitat and movement opportunities and Golden perch breeding, improved macroinvertebrate habitat condition and quality, encouraging macrophytes recruitment and growth, and encouraging lower bank vegetation establishment. A particular

emphasis in 2013-2014 is on lower bank vegetation and associated bank stability management.

Priority watering actions

To achieve the environmental objectives detailed in the previous section, the high priority watering actions to be undertaken in 2013-14 in the Goulburn system, in priority order, are as follows:

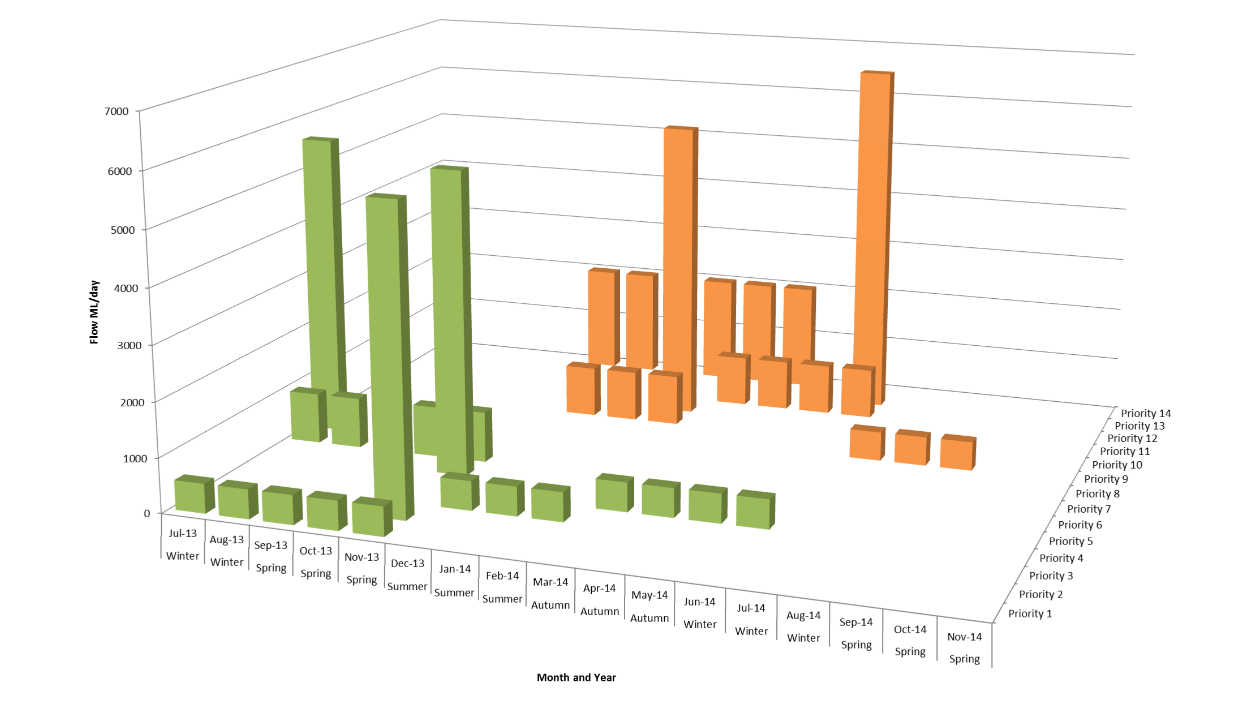
- Winter/spring baseflows (500 ML/ day at Murchison and/or 540 ML/day at McCoys Bridge from July to November)
- A spring fresh (up to 15,000 ML/day peak flow including 14 days at or above 5,600 ML/day between October and December)
- Summer baseflows (500 ML/ day at Murchison and/or 540 ML/day at McCoys Bridge from December to February)
- Autumn/winter baseflows (500 ML/ day at Murchison and/or 540 ML/day at McCoys Bridge from March to June)
- A second spring fresh (up to 15,000 ML/day peak flow between October and December)
- Increased winter/spring baseflows (830 ML/ day at Murchison and/or 940 ML/day at McCoys Bridge from July to November)
- A winter 2013 fresh (up to 6,600 ML/day for 14 days between June and August)
- Recession management flows (anytime)

If additional water is available, environmental watering will also focus on these low priority flows:

- Carryover for winter/spring baseflows in 2014-2015 (500 ML/ day at Murchison and/or 540 ML/day at McCoys Bridge from July to September 2014)
- Increased summer baseflows (830 ML/ day at Murchison and/or 940 ML/day at McCoys Bridge from December to February)
- Summer/autumn fresh (up to 5,600 ML/day for 2 days between February and April)
- Increased autumn/winter baseflows (830 ML/ day at Murchison and/or 940 ML/day at McCoys Bridge from March to June)
- A winter 2014 fresh (up to 6,600 ML/day for 14 days between June and August)
- Increased baseflows/freshes (up to 5,000 ML/day during the year, but particularly between December and April)

Bankfull flows are also identified as an important flow component for maintaining channel shape and preventing in-filling of pools, while overbank flows are important for wetlands, forest watering and bringing food resources into the river. They are not priority watering actions at this stage due to the recent high and overbank flows. In addition, the feasibility of delivering overbank flow recommendations, including how best to deliver or supplement flows while avoiding damage to public and private assets requires further investigation. Therefore overbank flows will only occur naturally.

The following figure shows the priority watering actions for the year.



The table below outlines the environmental watering objectives and priority watering actions under a range of climatic scenarios.

Priority watering actions for the Goulburn River under a range of planning scenarios

PLANNING SCENARIO					
	WORST DROUGHT	**VERY DRY**	**DRY**	**AVERAGE**	**WET**
Expected availability of Water Holdings	CEWH – 140 GL VEWH – 22 GL TLM - 30 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 223 GL VEWH – 22 GL TLM - 44 GL	CEWH – 207 GL VEWH – 22 GL TLM - 41 GL
Environmental Objectives	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles
	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability
	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding
	Encourage bank vegetation establishment and minimise bank erosion/slumpin g	Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumping	Encourage bank vegetation establishment and minimise bank erosion/slumpin g	Encourage bank vegetation establishment and minimise bank erosion/slumping
	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation
	Maintain pool depth	Maintain pool depth	Maintain pool depth	Maintain pool depth	Maintain pool depth

Preferable Environmental Water Use		Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)
Priority watering actions	1	Winter/spring baseflows	Winter/spring baseflows	Winter/spring baseflows	Winter/spring baseflows	Winter/spring baseflows
	2	Spring fresh	Spring fresh	Spring fresh	Spring fresh	Spring fresh
	3	Summer baseflows	Summer baseflows	Summer baseflows	Summer baseflows	Summer baseflows)
	4	Autumn/winter baseflows	Autumn/winter baseflows	Autumn/winter baseflows	Autumn/winter baseflows	Autumn/winter baseflows
	5		Second spring fresh	Second spring fresh	Second spring fresh	Second spring fresh
	6	Increase winter/spring baseflows 1*	Increase winter/spring baseflows 1*	Increase winter/spring baseflows 1*	Increase winter/spring baseflows	Increase winter/spring baseflows
	7	2*	2*	2*	Winter 2013 2*	Winter 2013 2*
	8		Recession management flows	Recession management flows	Recession management flows	Recession management flows
	9		Winter/spring 2014 baseflows	Winter/spring 2014 baseflows	Winter/spring 2014 baseflows 3*	Winter/spring 2014 baseflows 3*
	10				Increased summer baseflows	Increased summer baseflows
	11				Summer/autumn fresh	Summer/autumn fresh
	12					Increase autumn/winter baseflows
Environmental water carried over into 2013/14		10	23	23	23	23

1 The timing of water availability may reduce the period over which this component can be provided.
2 Usually unable to be supplied as enough water becomes available too late. Provided in average and wetter scenarios by catchment runoff. May be provided by flows released forMurray River benefits, or in association with 2012-2013 water available.
3 May not be needed if volumes reserved for allocations in 2014-2015 are high enough.

Environmental water wil be adaptively managed as conditions unfold throughout the year. Given the potential for dry conditions, the winter/spring baseflow would commence in July. The winter fresh may aloo be delivered if adequate water is available from 2012-2013 or there is a Murray River release need. When there has been adequate inflow during the winter/spring, an increased winter/spring baseflow can be started. Spring freshes would be released between October and December if catchment runoff was not providing the required freshes. By the end of the winter/spring (main catchment runoff period), water available for priorities throughout the rest of the year can be planned and then delivered.

When required, environmental water may also be used to slow the rate of river level fall from catchment runoff events. This will reduce risks associated with bank slumping and macroinvertebrates and fish becoming stranded in small pools on the banks following higher flows.

Over the summer months, unseasonal floods onto the floodplain could cause adverse impacts requiring use of Goulburn water quality reserve water to flush out water remaining after any blackwater event.

Risk assessment and management

The following significant risks have been identified. Strategies to reduce risks as also shown.

RISK #	RISK TYPE	FLOW COMPONENT	RISK MITIGATION STRATEGY	IMPACT OF RISK MITIGATION
1.1	Current recommendations on environmental flow in inaccurate	Low flow and fresh	Keep focus on monitoring outcomes from flow management and reassess recommendations as necessary	Adaptively improves recommendations and lowers risk over time
2.0	Limited CMA resource to deliver environmental release	Fresh	Seek resources to manage flows	Low if extra resources provided
4.1	Environmental releases interfere with irrigation pumps and pumping	Fresh	Provide public information on fresh release intentions, and alter fresh management if possible	Reduces risk by allowing issue avoidance
5.2	Improved conditions for non-native species (e.g. carp)	Low flow and fresh	None available	
6.1	Environmental releases causes flooding of private land	Fresh	Consider potential catchment runoff from forecast rainfall in deciding when to commence releases and whether to prematurely cease releases	Becomes low risk
7.0	Unable to provide evidence in meeting environmental objective	Low flows and freshes	Seek involvement, contributions and results from monitoring and research programs	Progressively lower risk over time
7.1	Key stakeholders not supportive of environmental water release	Freshes	Keep key stakeholders aware of fresh plans and timing	Lowers risk somewhat now, and increasingly over time