PUBLIC POLICY INSTITUTE OF CALIFORNIA

PPIC WATER POLICY CENTER

Managing Water for the Environment During Drought

Lessons from Victoria, Australia

Technical Appendices

CONTENTS

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Appendix A: Environmental Water Management in Victoria, Australia

Introduction

Australia—the driest inhabited continent on earth—is also subject to some of the most variable patterns of rainfall and streamflow in the world. Southeastern Australia in particular has experienced extended periods of below-average rainfall—most notably, the Federation Drought (1885-1902), the World War II Drought (1936-1945), and the Millennium Drought (1997-2010), which was the most severe on record. The Millennium Drought tested the environmental water planning and management tools that were already in place and forced governments to come up with innovative solutions to protect the environment.

While Australian flora and fauna have adapted to this climate variability, development of water infrastructure to provide secure and reliable water supply to cities, towns, industry, and agriculture has placed an increasing strain on water-dependent ecosystems. These developments have altered the balance of water used between economic, social, and environmental conditions, with the environment being affected disproportionally. This strain is particularly significant in the most densely populated region of southeastern Australia and in particular the Murray-Darling Basin (Figure 1). For the past 30 years Australia has been on a journey to address this imbalance.

Since the late 1980s governments in Australia, including the state of Victoria, have made efforts to enable the sustainable management of water resources. In the past, water management was hampered by a perception of plentiful water resources (as a result of wet periods during the 1970s, '80s and early '90s) and incomplete understanding of environmental water requirements for rivers and wetlands. In addition, until the establishment of the Victorian Water Act of 1989, existing laws and regulations failed to recognize the environment's right to water.

The Murray-Darling Basin is influenced by two distinct rainfall patterns: the summer monsoonal rains in the northern region and the winter/spring-dominated rainfall in the south. The longer, more predictable periods of rainfall found in the south mean that the southern basin is better suited to development, and numerous dams and weirs were built over the past century. The Millennium Drought caused annual streamflow to drop by 44% relative to the long-term average (Potter 2010). With no relief in sight, commonwealth and state governments were compelled to act and there was a growing fear that the drought conditions were the new status quo.

This appendix investigates the way environmental water management has evolved in Australia, with a focus on the approaches and tools used by the state of Victoria during and after the Millennium Drought. There are two main sections: one that outlines the framework for providing water allocations for the environment, and a second that describes how environmental water is managed during times of water scarcity. The lessons learned described herein helped inform the main report, *Managing Environmental Water During Drought: Lessons from Victoria, Australia*.

Box 1: Australia's Murray-Darling Basin

The Murray-Darling Basin (MDB) covers 14 percent of Australia's land area (1.06 million km^2). Located in southeast Australia, it extends across the states of Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory. Its name is derived from its two major rivers, the Murray and the Darling.

Over two million people live and work in the basin, which has an annual economic output of AU$23 billion (US$16.79 billion). AU$10 billion (US$7.3 billion) of this is from agriculture, almost one third of the value of Australia's total annual agricultural output (Department of the Environment and Heritage 2004).

Ecosystems in the basin vary greatly from the monsoon-driven rivers and wetlands in the north to the winter-spring dominated environments in the south. Broad-scale management of the MDB is divided into the northern and southern basins.

The southern basin includes catchments in South Australia, Victoria and southern New South Wales, which are highly connected and influence the amount of water that flows from the Murray River into the sea. Agriculture and communities in the southern basin predominantly rely on surface water for their water needs, as large areas of groundwater in the basin are saline.

Environmental Water Allocation in Victoria

Water allocation in Victoria has evolved since the passage of the Victorian Water Act of 1989. This act guides both water management and allocation, and describes key aspects of water resources planning through a water entitlement and planning framework.

This statewide framework is designed to provide certainty and transparency to all water users, with all types of water supply systems and water sources. As such, a variety of planning mechanisms and entitlements are used based on the water source (surface or groundwater), the level of infrastructure to control flows in a system (regulated or unregulated), and purpose of use (urban, irrigation, rural domestic, commercial or environmental).

The current framework includes:

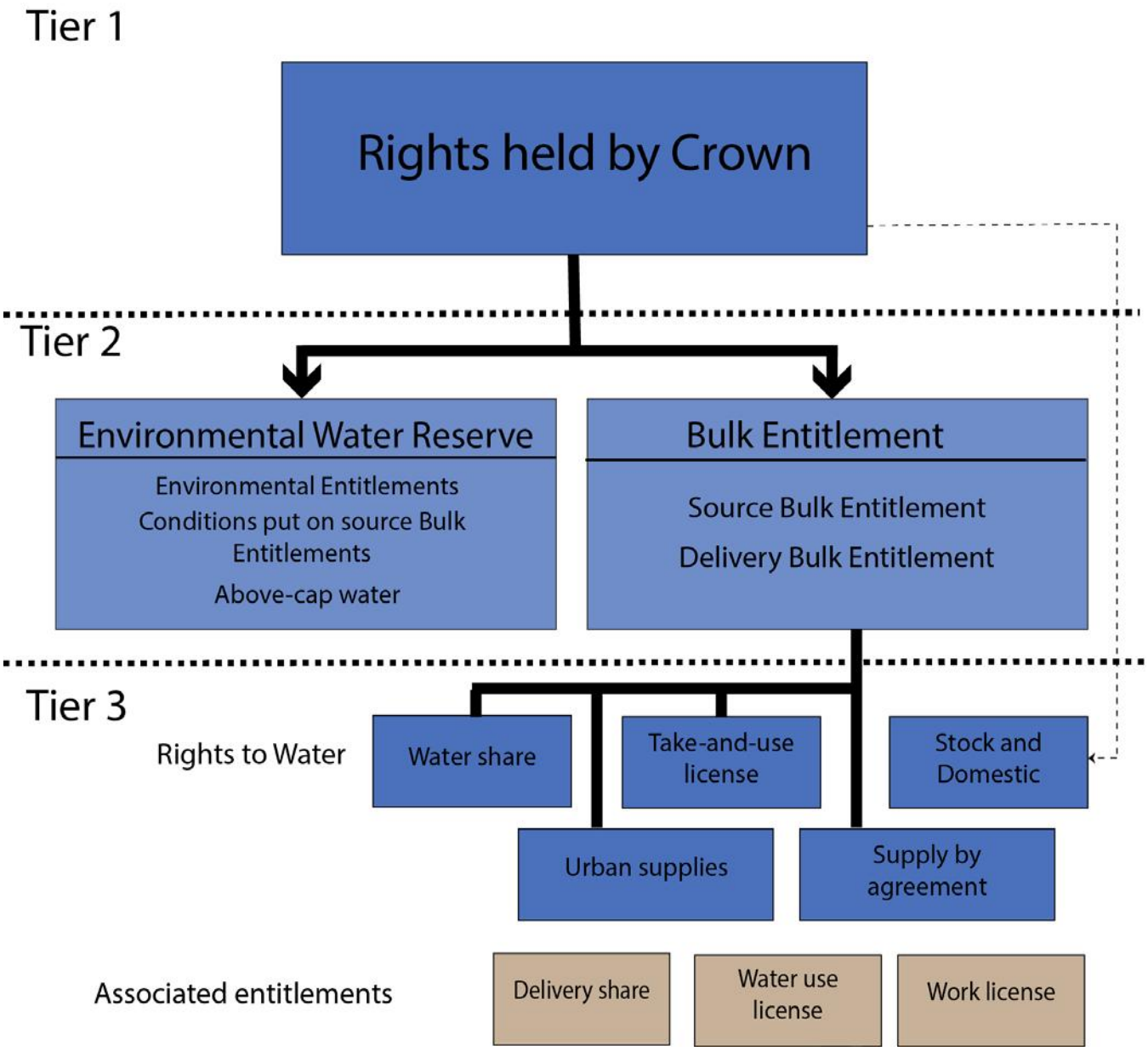
- An agreed balance between agricultural, urban, and environmental use in every water supply system, determined through water planning processes. This ensures there is a clear distinction between water available to agricultural and urban users and the environment, and provides a known limit (or cap) on agricultural and urban uses (known in Australia as "consumptive uses"). It may or may not meet the full needs of the environment.
- Secure entitlements (for all water users including the environment) are equivalent to property rights, with legal certainty and protection. These entitlements have a range of characteristics and obligations associated with them, depending on the water supply system.
- Annual processes to determine seasonal allocations to entitlements.
- The ability to trade, giving water users the flexibility to buy and sell their water entitlements (or seasonal allocation).
- Annual planning that reviews the balance between agricultural, urban, and environmental uses, including clear consultative processes before entitlements may be changed, and delineation of the respective roles and responsibilities of government authorities and individuals.

In this framework, water entitlements are based on three tiers of water rights (Figure 1). The foundation of the framework is that the state government retains overall right to the use, flow and control of all surface water and groundwater (Tier 1). The rights granted by the state form the second and third tiers of the Victorian entitlement framework.

The second-tier rights are "bulk entitlements." Within this system, bulk entitlements can be held by urban and rural water authorities owned by the state (also known as water corporations) and by the environment. The environmental entitlements are part of the Victorian Environmental Water Reserve, which also includes "held environmental water" and surplus flows (described below).

The third tier of the Victorian water rights system is comprised of individual rights to water use. There are five types of rights: water shares, take-and-use licenses, stock and domestic rights, supplies to urban customers, and supply by agreements. There are also associated entitlements that give the right for water to be delivered (delivery share) and to be used on land (water-use licenses). There are also "works licenses" that give the right to construct, operate, or modify water extraction works, such as a pump.

FIGURE 1
Victoria's tiered water rights (entitlements)



SOURCE: Adapted from NRSWS (2009)

Tools for Managing Water Entitlements

Seasonal allocations

Entitlement holders own the rights to a portion of the available water stored in the system in any given year. Throughout the year the system operator determines how much water is available based on inflows, storage levels, and passing flow requirements. The system operator then allocates the available water to the entitlement holders based on the amount of water shares to which they provide water service. There are two classes of water shares: high-priority shares for irrigation of permanent crops, such as vineyards and orchards, and low-priority

shares for irrigation of seasonal crops. When there is a shortage of water, the high-priority shareholders receive water before the low-priority shareholders.

The volume of water allocated per water share is modeled over the long-term using the historic streamflow record, therefore providing a certain level of reliability for entitlement holders. Proposed changes to system operations or the adoption of management tools such as carry-over can be modeled to identify if they will have any impact on reliability. External environmental factors, such as climate change, can also be modeled to assess potential impact on reliability.

Carry-over

The ability for users to "carry-over rights" to water allocated to them from one year to the next was first introduced in 2006–07 as an emergency drought response measure. Before this, allocated water that was unused in any given year was "re-socialized" to all entitlement holders the following year. As a result, there was no incentive for users to improve water efficiency, as any water they saved was lost at the end of the year.

The introduction of carry-over enabled water entitlement holders to more easily manage their own water requirements and risks over time. Access to carry-over allows an irrigator to meet production requirements, urban water corporations to avoid severe water restrictions, and environmental water managers to provide important river flows during drought (Dept. of Sustainability and Environment 2009).

To ensure that carry-over does not reduce the reliability of entitlements, implementation of carry-over is conditional. Most importantly, the physical limitations of the system's reservoirs influence the ability to implement carry-over provisions. Carry-over cannot be provided until the system operator determines that there is a low risk of the storage facility reaching capacity. Too much carry-over risks filling storage facilities, thus reducing the ability to capture flows for the current season's allocation. Multi-year storage facilities (those which are large enough to capture multiple years of inflow) are well suited to carry-over as they are unlikely to spill annually, thus ensuring the carry-over can be used the following year. Annual storage facilities are prone to "fill and spill" each year, and therefore water carried over is more likely to be lost. If the storage does spill, the proportional volume of any spill is counted against all users that have carried over. In Victoria, the majority of multi-year reservoirs now have carry-over provisions, while systems with annual storage facilities do not have carry-over provisions, as the cost and complexity of implementing is high with little perceived benefit.

Water markets

Water trading has been available to Victorian entitlement holders since the late 1980s. Trading was initially small in scale for several reasons, including the tying of water entitlements to land parcels, administrative restrictions on undertaking trades (i.e., there was no functioning water register), and a lack of clear rights to water in excess of entitlement rights (also known as "sales water" or flood flows). In 2007–08, the state government "unbundled" most of the water entitlements from land and converted "sales water" to a low-reliability entitlement. It also implemented a single comprehensive state-based water register for all water shares and transfers. Trade volumes increased significantly in response to these initiatives, as irrigators became more receptive to using trade as another tool to manage risk to production. In the late 1980s a few hundred megaliters (ML) of temporary water was being traded, by 2014-15, there was 2,694 gigaliters (GL) traded in Victoria. A recent independent study identified that water trading has now become an essential way for water corporations, managers of environmental water, and individuals to manage their businesses (Cummins 2016).

Water Allocated for the Environment

Environmental water planning in Victoria has developed significantly over the past 30 years. The introduction of the Water Act of 1989 was a turning point, as it recognized the environment as a legitimate user of water with the same legal rights as other users. To achieve this, previously ill-defined rules and historic use were converted into legally defined entitlements, through a process known as "bulk entitlement conversion." The conversion process recognized all existing rights; it did not rebalance allocation between agricultural and urban users and the environment in over-allocated systems. It did, however, secure existing environmental rights to water through "planned entitlements" related to minimum "passing flows" (also called "planned environmental water"), and in some water supply systems it established an entitlement volume for environmental uses similar to irrigators' entitlements. These environmental entitlements are also known as "held environmental water" (described below).

Planned environmental water

Planned environmental water is water that is provided to the environment through set rules. It includes passing flows, which have been determined for all regulated water supply systems in Victoria. Passing flows can be as simple as a set flow-rate requirement all year round, or a flow rate delivered at a point in a river based on the time of year, or volume in storage. Passing flow rules are required to be met before the allocation of other water. As such it has the same priority as system operating water—for example, water required to cover conveyance losses to enable downstream systems to operate.

For unregulated systems (those without upstream reservoirs), the amount of planned environmental water is governed by rules that define when users can pump water from streams or aquifers. In regulated systems (those with reservoirs), the obligation to provide passing flows is determined at the level of storage operation. These mandatory passing flows are then included within the bulk entitlements. As a "cap" on the water that may be extracted from aquifers or released from storage to serve agricultural and urban users, planned environmental water ensures that there is water available for instream uses and wetlands during average and dry years. During wetter periods, passing flows augment streamflow as stored water that is above the cap; it is directed to the environment through unregulated flows and spills from storage.

Held environmental water

Water is also allocated each year to the environment through environmental entitlements that that can be used, traded, or carried over. Held environmental water is managed by environmental water holders (EWH). In the Victorian catchments of the MDB, the environment holds approximately 30 percent of Victoria's high reliability entitlements (Cummins 2016). Held environmental water is akin to a property right, which gives the holder a share of the regulated capacity of a system. Environmental water can either be held as Tier 2 or Tier 3 entitlements. Tier 2 entitlements are generally expressed as "water shares" comparable to Tier 3 entitlements that have varying levels of reliability according to the particulars of each system. There are a few instances where Tier 2 entitlements have different levels of reliability or triggers for allocations as a result of historical decisions, but these are the exception rather than the rule.

There are three major environmental water holders operating in the MDB: the Victorian Environmental Water Holder (VEWH), the Commonwealth Environmental Water Holder (CEWH), and the Living Murray Initiative. The VEWH was established to hold the environmental entitlements (at the Tier 2 level) and make decisions on their use, but it actually delivers its held environmental water through environmental waterway managers who work closely with the local water corporations. Upgrading irrigation systems to reduce water loss and converting the losses to environmental entitlements mostly created these Tier 2 entitlements.

With the intervention of the Commonwealth in the MDB, the CEWH also has purchased Tier 3 water shares from agricultural and urban users through the permanent water market. Although most of these acquired shares represent rights to water held in various reservoirs, they only confer the right to delivery and use; the CEWH therefore cannot instruct the system manager to release the water from any particular reservoir. The CEWH also does not have the ability to have associated entitlements as it does not own land, therefore it cannot request water delivery to a specific location. Because this limits flexibility in allocating the Tier 3 water to particular instream uses and wetlands locations, the CEWH works with the VEWH to coordinate and direct their environmental water deliveries. The CEWH also transfers water to the VEWH, which then delivers it as environmental needs require. This is highly efficient and effective for both parties.

Other groups such as environmental non-governmental organizations can also buy Tier 3 agricultural and urban water shares and use them for environmental purposes. To maximize the environmental outcomes from their water, these groups must deliver the environmental water through an arrangement with the VEWH or landholder. For example, the Australian Conservation Foundation has purchased some temporary water on the market (funded through a public campaign) and had it delivered in conjunction with VEWH environmental water through a local catchment management authority to an internationally recognized wetland (Ramsar).

The environment is a major player in Victoria's water markets, undertaking approximately half of all trades in 2014–15 (Dept. of Environment, Land, Water and Planning 2015). Although a majority of these are transfers between VEWH accounts, the three environmental water holders are increasingly acquiring water from agricultural and urban users. In 2014, for example, the VEWH purchased 300 ML of water on the temporary water market to provide sustained increase in flow during springtime (a "fresh") for fish spawning in the Loddon River, as its allocation of water in that system was insufficient. The participation of the environmental water holders in water markets (both temporary and permanent) concerns some users who recognize that environmental water entitlements have the potential to dominate both the market and system operations at the bulk entitlement level. While this unease may never be full erased, it is important to continue to reassure users that the market provides all users equal opportunities to access water. Both the CEWH and VEWH have trading strategies that recognize the importance of not having undue influence on the water market.

Water Allocations During Drought

The environmental, political, and social challenges of the Millennium Drought in the MDB were broad-ranging (Table 1). Rivers and wetlands were drying out and some wetlands were observed to be increasingly acidic, risking the loss of threatened species. Existing water sharing rules for allocating water in the MDB failed and temporary rules were put in place to ensure that cities, such as Adelaide in South Australia, did not run out of water.

In 2007, concerned that the water management reforms undertaken by the states were not satisfactory, the Commonwealth used its powers under its obligations to international treaties to introduce the Water Act of 2007. The act created a policy outline for management of the MDB's water resources, and addressed other matters of national interest in relation to water and water information. The act was accompanied by significant investment by the Commonwealth in the MDB (over US$9 billion total, with approximately $2.25 billion used to purchase water from other users) to "fix" environmental conditions in the basin. The new initiative provided a welcome input of funds to increase the volume of water available to the environment. But it did not incorporate effective community consultation, which caused distrust and pitted agricultural and urban users against environmental uses of water. The responses to the Millennium Drought in Victoria were varied, but they concentrated on the

protection of existing rights, implementation of new tools to allow users to better manage their own risks, and recognition of the need (at least in some places) to qualify existing environmental water rights.

TABLE 1

Challenges and Responses to the Millennium Drought

	Challenges during the Millennium Drought	Victorian responses
Social	▪ Irrigators experienced severe water restrictions for the first time in decades ▪ Irrigators forced to de-stock or to pull out vines/fruit trees due to low water allocations ▪ Initial environmental water recovery targets suggested by government were anticipated to shut down large areas of irrigation, making many irrigators and broader community distrust any environmental programs ▪ A lack of understanding of the severity of the drought on the environment ▪ Local recreational lakes dried, causing loss of social amenities	▪ Adoption of water planning strategies ▪ Maintaining seasonal allocations against water shares ▪ Improved water markets ▪ Introduction of carry-over of water shares ▪ Qualification of rights as a last resort
Political	▪ Disagreement between three key states and the Commonwealth on the speed of water resource reform in the Murray-Darling Basin ▪ Release of the Commonwealth Water Act (2007) and subsequent Basin Plan (2012), with minimal state assistance or acceptance	▪ Protection of existing water entitlement framework
Environmental	▪ Threatened species (e.g., Murray Hardyhead) at greater risk of extinction ▪ 200-year-old river red gums dying due to lake of water ▪ Rivers drying up, and in some cases remaining dry for years ▪ River Murray mouth in South Australia closing, requiring dredging ▪ Floodplains not receiving water, dramatically reducing migratory bird breeding ▪ Acid sulphate soils (caused by drying wetlands) threaten species	▪ Adoption of water planning strategies ▪ Improved environmental flow studies ▪ Recovery of water for the environment ▪ Prioritization of environmental water ▪ Creation of the seasonally adaptive approach ▪ Improved annual environmental water planning ▪ Environmental works and measures ▪ Complementary use of agricultural and urban water ▪ Improved monitoring of water planning activities ▪ Qualification of rights as a last resort

Qualification of planned environmental water

In times where the existing water sharing arrangements present unacceptable risks to any user, the Victorian Water Act allows for applications to be made to qualify entitlements, which allows for a temporary change in water sharing arrangements in a system in order to ensure critical water supplies are maintained. This mechanism was first applied during the Millennium Drought when water resources were so low that the continued provision of passing flows, at a time when cities and irrigators were suffering severe shortages, became been socially and economically unacceptable. Water corporations requested a qualification of rights in 17 river systems in Victoria, which varied in severity from mild reductions to full cessation of passing flows. During the process to qualify rights, the potential environmental impacts of reducing passing flows were identified and where possible mitigation measures put in place (Box 2). In some instances the CMAs (the entities managing environmental flows prior to the creation of the VEWH) received funds from the qualification. In other cases the reduction in flows were recorded so they would be able to be made up when conditions improved.

In contrast, because held environmental water had similar properties to water shares, cities and irrigation users did not request its qualification out of concern for the precedent it would set for their own rights. It is also worth noting that the volume of water held by environmental managers during this time was very small compared to the volume required to meet passing flows, therefore any qualification of environmental water would have had little benefit to other users.

Box 2: Qualification of Rights on the Yarra River

Qualification of rights occurred across Victoria during the Millennium Drought. The Yarra River provides an excellent example of how Victoria dealt with the qualification of the environment's planned water.

Water rights for the Yarra River were qualified in 2007 and involved the reduction in passing flow requirements at several points along the river. The qualification had two phases:

Phase 1 reduced passing flows with estimated water savings of 37,000 ML on average per year. When water resource conditions improved and restrictions on urban customers were reduced, phase 2 would come into effect.

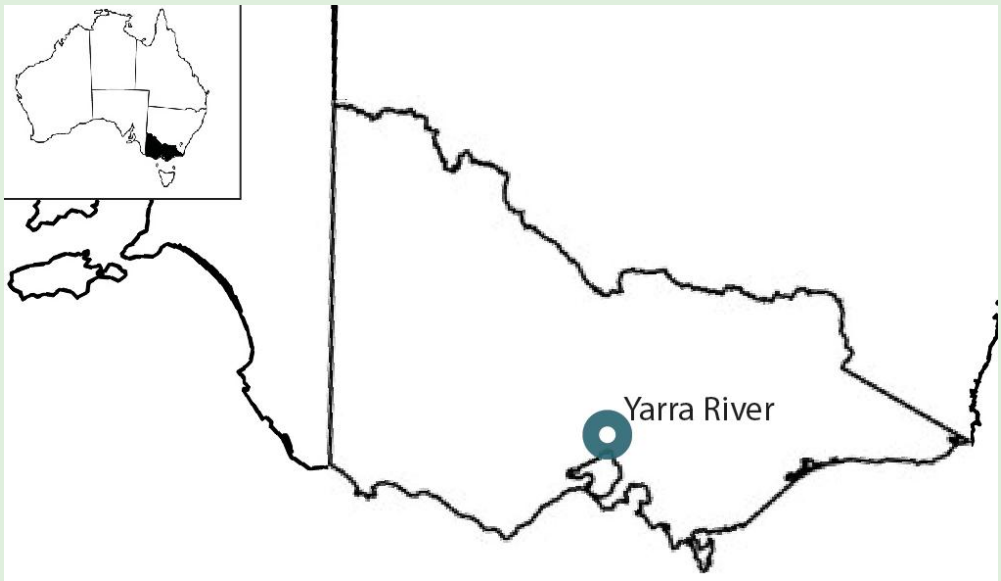
Phase 2 reduced passing flows with estimated water savings of 27,000 ML on average per year. Phase 2 qualifications would be removed when water restrictions for urban customers were reduced further (Melbourne Water 2007).

Mitigation measures

In response to the qualification, Melbourne Water—the water corporation that was benefiting from the reduction in passing flows—was required to:

- Undertake a detailed risk assessment of the impacts of the reduction of environmental flows;
- Set up an environmental water account to record withheld flows and provide them back to the river when conditions improved;
- Undertake mitigation works such as fencing to keep stock out of waterways, and
- Identify drought refuges for key at-risk species and monitor impacts of reduction in passing flows.

An audit by the Victorian Auditor General of the qualification process noted that the condition of the Yarra River did not deteriorate materially as a result of the temporary qualification of rights (Victorian Auditor General's Office 2010).



Managing Environmental Water in Victoria

Victoria's Water Planning Framework

Environmental water management in Victoria is closely integrated into broader water entitlement and planning frameworks, which were developed in the early 1990s. This integrated approach is critical because it places the environment at the negotiating table as a lawful user of water. All water users, including environmental water managers, must provide defensible evidence of their water requirements. This active management applies to held environmental water where decisions are required on the quantity and location of environmental deliveries, carry-over requirements, and trading options. The objective of environmental water management is to make the most efficient and effective use of the environmental entitlements.

The water entitlement framework provides the legal basis for water sharing and trading among all users in Victoria, including the environment. Building on the legal basis, Victoria created a water planning framework that aims to "promote the coordinated development and management of water, land and related resources, in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (UNEP-DHI Centre for Water and Environment 2009). Victoria's water planning framework uses strategic and operational planning documents (Table 2) to meet the above integrated water management objective.

Victoria's water planning framework incorporates the Environmental Water Reserve, and it provides clear and transparent planning and decision making. The framework embraces community consultation and engagement. Where possible it limits government to decisions at the strategic level (e.g., long-term water resource assessment and regional sustainable water strategies) while allowing agencies and individuals to make their own management decisions, both for agricultural and urban use or environmental purposes. The documents listed in Table 2 are the key to the Victorian water planning framework.

The environment must be considered in all strategic and operational planning documents, with the level of influence depending on the potential impact of any decision arising from the planning. Rural supply planning is important as annual decisions in the operation of storage and rivers have a large influence on environmental conditions. Urban water planning documents relate to their use of consumptive water, therefore it only moderately impacts the environment.

TABLE 2

Water planning framework key documents

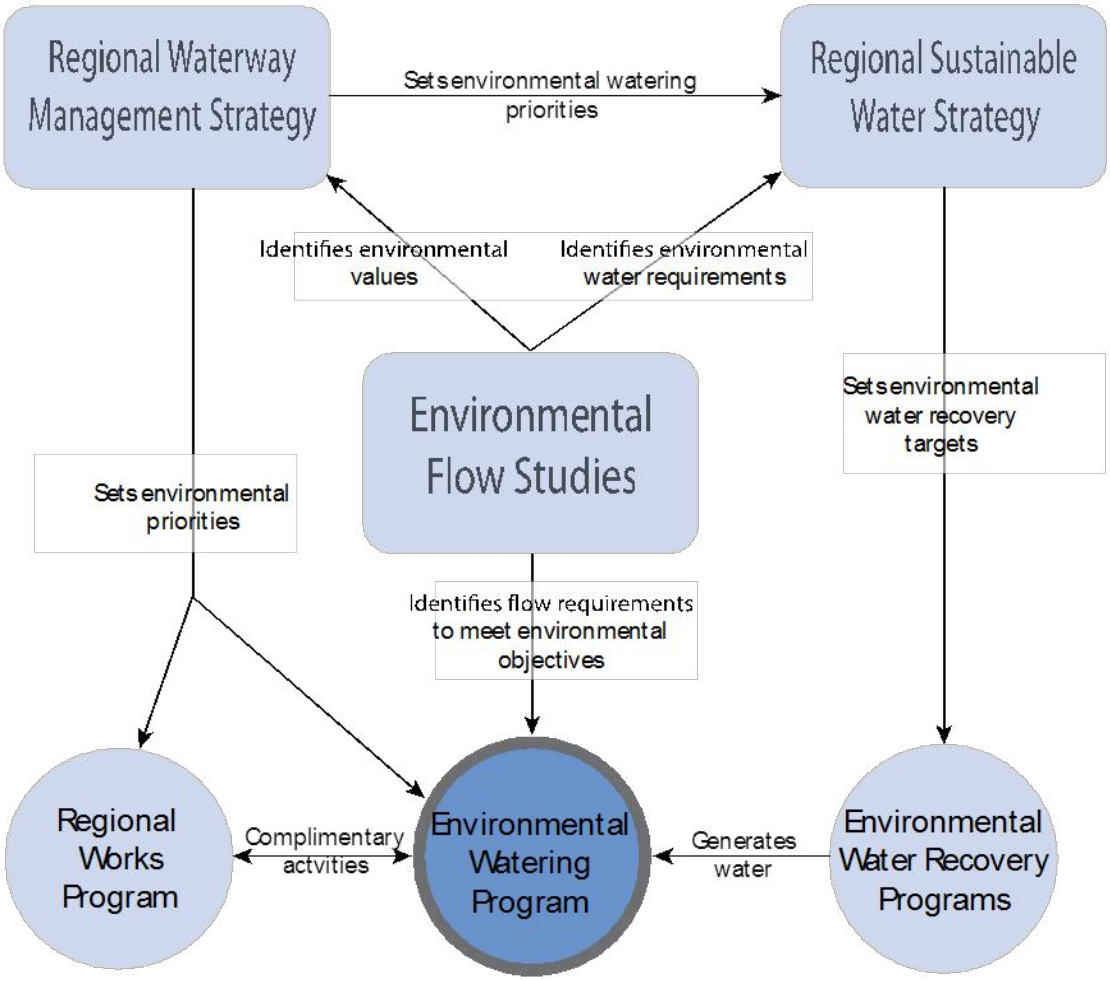
Planning Documents	Timeframe	Environmental Influence	Responsibility	Description
Long-term water resource assessment	15 years	High	Government	Determine whether there has been a decline in the long-term availability of surface water or groundwater in each system, and whether the impacts of the decline have fallen disproportionately on the environment or agricultural and urban users. Can be used to redefine and /or reallocate available water resources in a system. First assessment planned to be undertaken in 2019.
Regional Sustainable Water Strategies (RSWS)	10 years	High	Government	Provide options to improve water management under dry conditions, particularly in light of climate change projections. Also provide clear direction on actions to be delivered by agencies to improve water management within defined timeframes. Specifically for the environment, provide the agreed target condition and the associated water recovery required for the priority waterways. First implemented in 2009.
Regional Waterway Management Strategy (RWMS)	8 years	High	Waterway Managers	A regional planning document for rivers, wetlands, and estuaries that sets objectives for the system and guides future investment in waterway management. This is guided, in part, by the RSWS, which sets the environmental conditions for priority waterways and the associated water recovery requirements. Also guides the regional works program, which works toward achieving environmental objectives outlined in the RSWS. Two cycles, second undertaken in 2015.
Urban water supply-demand strategies	5 years	Medium	Urban Water Corporations	Identify long-term supply augmentations and demand management measures required to maintain an acceptable level of service in urban areas (i.e., the frequency, severity, and duration of water restrictions) and water supply security into the future (i.e., ensuring towns do not run out of water), taking into account population growth and changes in demand. They also indicate if the environment will have additional competing demand for water from urban water users. Two cycles, second undertaken in 2012.
Rural water supply planning	Annually	High	Water Corporations	Provide information and tools to users to make the most effective decisions about their water resources, such as access to carry-over and the water market. The water corporations provide relevant information to their different customers, including environmental water managers. Water shareholders, for example, receive bi-monthly water resource information that is adequate for irrigators to make individual decisions on their business. Environmental managers receive additional information on how a river may be operated to inform environmental water planning. Has been undertaken in some form since irrigation districts where created 100 years ago.
Environmental Watering Plan	Annually	High	Victorian Environmental Water Holder	Detail the specific uses of environmental water planned over the year. Watering plans developed during the drought aimed to protect key pockets of the environment to provide refuges, and avoid critical losses of species and irreversible damage to the environment. First begun in 2002.
Urban Drought and Emergency Response Plans	As required	Medium	Water Corporations	Document contingency measures the water corporation will implement to secure urban supply during drought. Include demand reduction measures—in particular, restrictions and other contingency measures to further reduce demand or augment supplies. Provide guidance in response to sudden and severe water shortages due to emergencies such as bushfire or terrorism. First implemented during the Millennium Drought.

SOURCES: Adapted from Northern Regional Sustainable Water Strategy (2009) and Department Environment Water Land Planning website

The use of held environmental water in rivers, wetlands, and floodplains (referred to as the environmental watering program) is integrated into the broader water planning framework. The Regional Waterway Management Strategy (RWMS) and Regional Sustainable Water Strategy (RSWS) set the strategic direction and boundaries of the environmental watering program (Figure 2). These strategies are informed by environmental flow studies, which provide scientifically defendable information on the ecological and geomorphological requirements of rivers and wetlands. They are also important in annual planning for the environmental watering program, providing a reference tool for the flows required to meet specific objectives.

In Victoria, an environmental contribution is added to the water price (5% for urban use and 2% for rural use). It is paid to the government to fund work that "promotes the sustainable management of water or addresses adverse water-related environmental impacts." These contributions, along with revenues from water trading (which currently is relatively small), generally pay for environmental water management in Victoria.

FIGURE 2
Integration of environmental water management into planning framework



Prioritization of Environmental Water

The Millennium Drought increased pressure to provide a strong rationale for the use of environmental water at a time when many irrigators were not watering farms or were removing crops due to low water allocations and high water prices. Environmental water managers were under similar pressure, with many systems in stress or nearing ecological collapse.

To maximize the benefits from environmental water and justify its use, environmental water managers adopted criteria to assess individual sites and to set priorities for the allocation of available water supplies. The prioritization criteria adopted across Victoria are:

- *Extent and significance of the environmental benefit expected from the watering action:* May include the area watered, the size of the breeding event to be triggered, and/or the conservation status of the species that will benefit. If a species' conservation status is threatened or endangered, this is taken into account and would rank as a high priority.
- *Certainty of achieving the environmental benefit from the watering action and ability to manage other threats:* For example, a flow has been provided in the past with demonstrated benefits and relevant complementary measures are being undertaken at the site.
- *Ability to provide ongoing benefits at the site where the watering action is to take place:* This is for situations where the management arrangements provide for watering over the long term.
- *Implications of not undertaking the potential watering action at the site:* This covers situations where there is potential for critical or irreversible loss of important environmental values.
- *Feasibility of the watering action:* Factors include the flexibility of the timing of the delivery, operational requirements and constraints, and infrastructure capacity.
- *Overall cost-effectiveness of the watering action:* For example, considers the likely benefit to be achieved against the cost of the watering action (including the volume of water to be used and any delivery and risk-management costs).

The use of a standard set of criteria provided greater ability to select sites that should receive environmental water in a resource-constrained environment. These criteria were used extensively during the Millennium Drought, including in the planning and delivery of water to avoid critical loss of threatened species (Box 3).

Box 3: Using Held Environmental Water to Avoid Critical Loss of Species

In 1999, the Victorian Murray Flora and Fauna Entitlement (VMFFE) was created as part of the bulk entitlement conversion process. A relatively small held environmental water entitlement, the VMFFE was created to recognize the pre-existing use of water to manage wetlands in northern Victoria. Before the VMFFE's creation, water was delivered to the wetland based on advice from local interest groups and environmental managers.

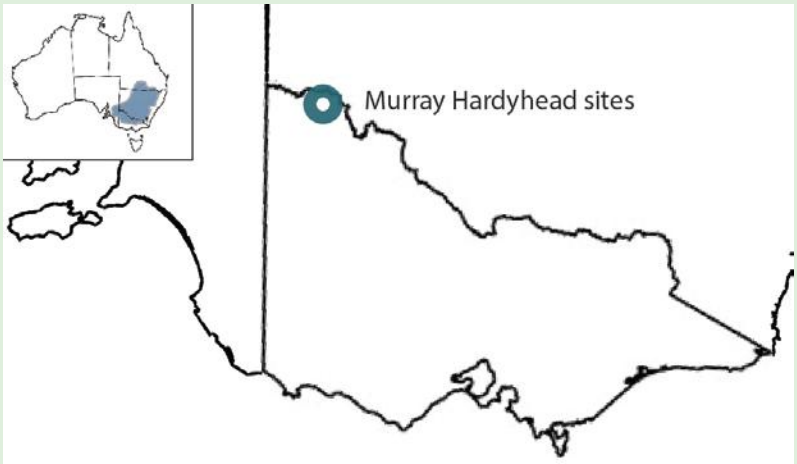
During the mid-2000s water allocations dropped below 100 percent for high reliability entitlements and tensions rose among certain irrigator groups angry at the use of environmental water. In one case this resulted in vandals damaging pumps used by environmental managers to deliver water into areas to protect river red gums. As a result of the increasing conflict, it was decided to centralize management of the entitlement to Melbourne to provide a regionally independent approach to the prioritization. This was later formalized into the Victorian Environmental Water Holder (VEWH). In addition, an environmental watering group of key management agencies was created to inform decision making, waterway managers were asked to provide watering proposals, and an assessment was undertaken using the prioritization criteria.

This response was important in two ways: it allowed waterway managers to prioritize sites for watering, and it provided the community with a clear explanation of why water was needed.

The benefit of the approach taken in the VMFFE was particularly evident in the protection of wetlands containing the Murray Hardyhead, a small, endangered species found in saline environments in northwest Victoria along the Murray River. During this time water allocations were the lowest on record, and there was significant community angst and media coverage portraying an environment-versus-irrigator conflict. In response, managers adapted environmental objectives to manage during drought (i.e., to avoid critical loss, avoid catastrophic events, and maintain key refuges) and used the prioritization process to select environmental watering sites.

A regional prioritization process identified the watering of Murray Hardyhead sites as a high priority. To protect genetic diversity, several wetlands were required to be watered. Waterway manager were able demonstrate they were protecting a key species extremely efficiently through the construction of earthen levees to minimize water use and the decision not to water sites where the likelihood of success was deemed to be low.

As a result of these efforts the community came to recognize the efforts environmental water managers were undertaking to protect the environment. When the drought broke in 2011, all protected wetland sites had viable breeding populations and captive-bred Murray Hardyhead were located to new sites. Importantly, the lessons from this experience have been used by environmental water managers across the Murray-Darling Basin in prioritizing and delivering environmental water.



Seasonally adaptive approach

Water managers traditionally justified environmental water requirements with studies that identified preferred flow regimes for rivers based on long-term average conditions. These "environmental flow studies" were designed to calculate the amount of water required to sustain aquatic ecosystems, with a minimum risk of degradation (Dept. of Natural Resources and Environment 2002). The reliance on long-term averages proved to be problematic when applied to annual activities, as the recommended flows did not factor in the variability in flow conditions.

These issues became more evident during the Millennium Drought when reliable baseline flows from catchment runoff ceased, putting further pressure on the limited held environmental water. In response, environmental water holders developed a new "seasonally adaptive approach," which identified a suite of management objectives set around different water resource scenarios, from drought through to floods (Table 3). To achieve the objectives, environmental managers can utilize a variety of tools, including the water market to buy or sell water.

This new approach does not change the long-term ecological objectives of the sites, only the management response. Adoption of the seasonally adaptive approach in Victoria led to refinements in river health planning and environmental flow methodologies (Doolan et al. in press). In particular, environmental managers are now required to identify important drought refuges, and scientists are better able to provide more comprehensive advice on the water requirements of rivers and wetlands under a range of climate conditions. One of the first systems to which these requirements were applied was the Loddon River (Box 4).

TABLE 3

Application of the seasonally adaptive approach

Objectives	Extreme Dry	Dry	Average	Wet/Flood
Long-term ecological objective	Move toward ecologically healthy waterways as defined in Regional Sustainable Water Strategies and Regional Waterway Management Strategies			
Short-term ecological objectives	Priority waterways avoid irreversible losses and retain capacity to recover	Priority waterways able to maintain basic functions	Priority waterways maintained or improved	Priority waterways condition improved
Annual management objectives	▪ Avoid critical loss ▪ Avoid catastrophic changes ▪ Maintain key refuges	▪ Maintain waterway function with reduced reproductive capacity ▪ Manage within dry-spell tolerances	▪ Improve ecological health and resilience	▪ Maximize species recruitment opportunities in waterways ▪ Restore key floodplain linkages ▪ Minimize impact of flooding on human communities
Environmental watering priorities	▪ Water crucial refuges ▪ Undertake emergency watering to avoid catastrophic changes ▪ Carry-over water for critical environments in the following year	▪ Provide priority flow components to waterways ▪ Carry-over water for critical environments in the following year	▪ Provide all in-bank flow components to waterways ▪ Provide out-of-bank flows if reach dry-spell tolerance ▪ Carry-over water to accrue water for large watering events	▪ Provide all flow components ▪ Deliver water in a way which minimizes impact on human communities
River and wetland catchment activities	▪ Protect refuges (including stock exclusion) ▪ Increase awareness of the importance of refuges ▪ Enhance monitoring of high risk waterways ▪ Relocation of species (if feasible) ▪ Protect waterways through fencing, re-vegetation, pest plant and animal management, and water quality works ▪ Implement post-bushfire waterway recovery plans	▪ Protect refuges ▪ Protect waterways through fencing, re-vegetation, pest plant and animal management, and water quality works ▪ Improve waterway connectivity ▪ Implement post-bushfire waterway recovery plans	▪ Protect and restore waterways through fencing, re-vegetation and pest plant and animal management and water quality works ▪ Improve waterway connectivity	▪ Protect and restore waterways through fencing, revegetation, pest plant and animal management, and water quality works ▪ Improve waterway connectivity ▪ Implementation of post-flood waterway restoration activities

NOTES: Adapted from Northern Regional Sustainable Water Strategy (DSE 2009)

The seasonally adaptive approach provides a clear message to the community on how environmental managers operate, without which they risk their "social license" (Doolan et al. in press). The approach was widely accepted by the community as it demonstrated changes in environmental water management objectives that mirrored the decisions irrigators were making during drought. This was evident in subsequent years when, even though water allocations were still low, there was no significant public opposition to the environmental watering decisions.

Box 4: Protecting Refuges During Drought in the Loddon River

In 2006, the North Central Catchment Management Authority identified that passing flows delivered in the lower reaches of the Loddon River were not flowing to the end of the system. Moreover the flows that were being delivered were encouraging water reeds to choke the channel, impacting channel form and limiting open water for fish species.

At this time the water corporation was experiencing severe water shortages and was requesting the government to qualify environmental water rights to meet critical human needs. Irrigators and other users also started to question why water was being delivered to the lower reaches of the Loddon River, when it was producing observed negative environmental impacts.

It became increasingly evident that planning based on average conditions in the Loddon was not effective. An expert panel was formed to consider the needs of the environment under extreme drought conditions. The panel of scientific experts and water resource managers were asked to identify management actions to protect the environment during severe water shortage.

The panel recommendations resulted in a shift in management focus to the protection of drought refuges in order to ensure species were resilient enough to recover in wetter years. In the Loddon River, the recommendations resulted in the end of passing flows to the lower reaches as upstream refuges were considered adequate to repopulate the lower reaches when conditions improved. Ceasing flows in the lower reaches reduced in-stream vegetation growth, and increased open water available for fish when water returned. The recommendations also led to the identification of refuges along the length of the Loddon and complimentary works such as fencing to prevent domestic stock drinking from these areas. Lastly, monitoring the river system was increased to better understand the threshold of these systems.

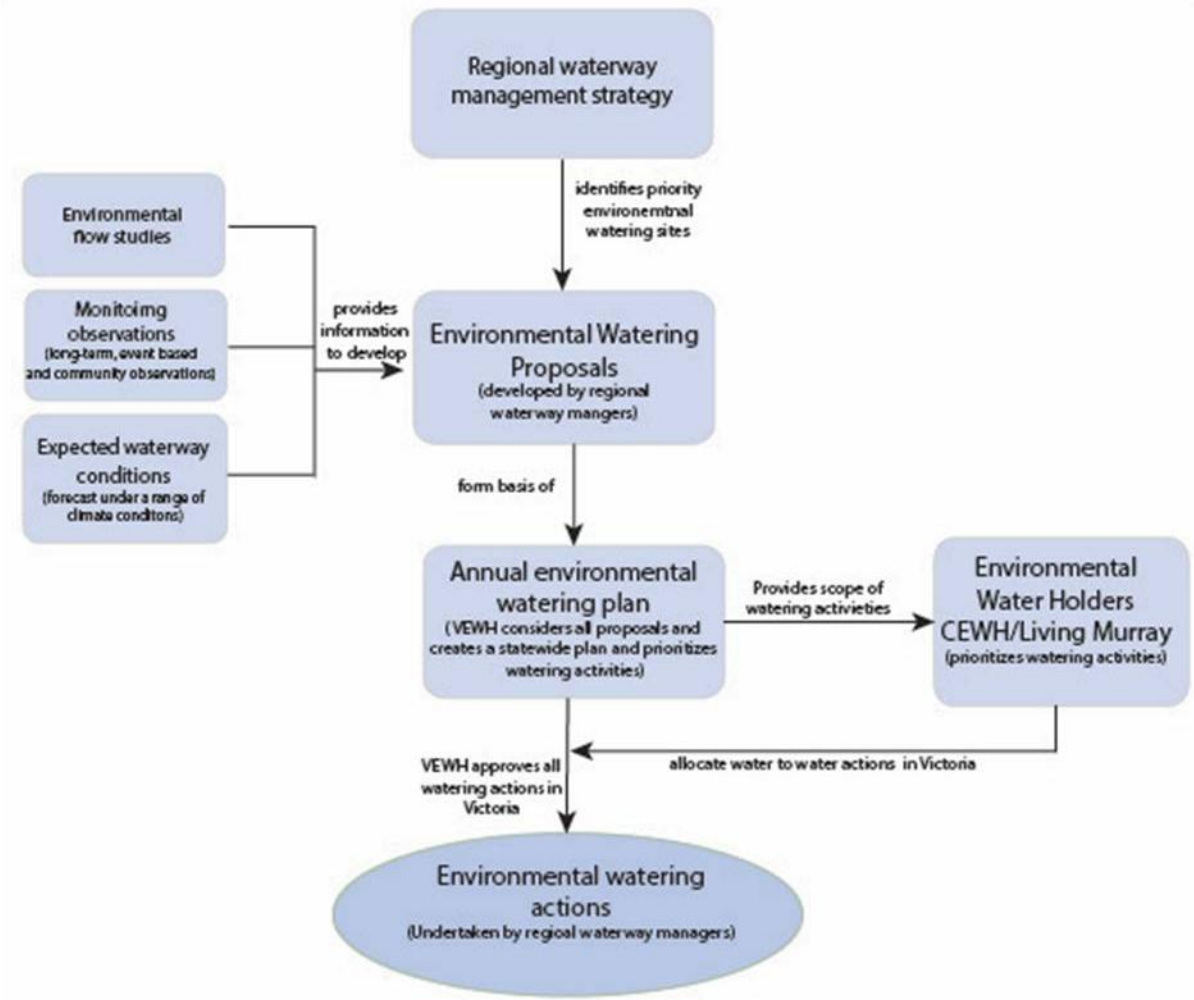
Annual Environmental Water Planning

Annual planning has been done in all catchments that receive planned environmental water since the early 2000s. Environmental waterway managers (Melbourne Water or Catchment Management Authorities) develop environmental watering proposals in close consultation with the community, either through the establishment of formal advisory groups or through consultation with existing groups (Doolan et al. in press). These proposals

must be consistent with RWMS and are informed by environmental flow studies, monitoring observations, and expected waterway conditions under a range of climate scenarios.

The proposals are provided to the VEWH and form the basis of the annual environmental watering plan, which guides all watering decisions in Victoria. As noted above, the VEWH is the only entity that can deliver environmental water in Victoria. Other environmental water holders can make independent decisions about their annual watering objectives, which are strongly aligned with the annual watering plan (Figure 3).

FIGURE 3
Environmental water annual planning process



SOURCE: Adapted from Victorian Environmental Water Holder Seasonal Watering Plan (2015)

Developing watering proposals

Environmental waterway managers lead the annual planning process to develop environmental watering proposals for their areas. This is done in close consultation with water corporations, land managers, and the community to ensure the proposed actions are achievable, do not have significant adverse impacts, and are in line with community expectations. They also consult with the water entitlement holders to identify the potential water available for each catchment.

As a first step, waterway managers consider previous watering actions and the current condition of the waterway to identify environmental objectives and associated environmental watering actions for the year (Table 4).

TABLE 4

Environmental objectives for the Campaspe Regional Waterway Management Strategy

Potential environmental watering in the Campaspe River	Environmental objectives
Summer/autumn low flows (10–50 ML/day during December–May)	Maintain aquatic vegetation Maintain fish habitat and reinstate slack waters (areas with minimal water movement) Limit the effect of cold water pollution from Lake Eppalock on fish Maintain access to riffle habitat and water quality for macroinvertebrates Maintain permanent connectivity for water quality Maintain permanent connectivity for platypus movement
Winter/spring high flows (up to 4 events at 1,000–1,800 ML/day for up to 7 days each during June–November)	Reduce encroachment of exotic and terrestrial vegetation Enhance river red gum recruitment Stimulate fish movement, allow movement to downstream reaches, and provide spawning triggers Flush and mix river pools for water quality Flush organics from bank and benches to reduce the risk of blackwater events in summer Mix and flush river pools for macroinvertebrates Inundate additional snags and flush sediment off biofilms (groups of microorganisms) for macroinvertebrates
Winter/spring low flows (50–200 ML/day [or natural], during June–November)	Provide longitudinal connectivity for fish Maintain access to riffle habitat and water quality for macroinvertebrates Maintain permanent longitudinal connectivity of river for improved water quality Facilitate platypus breeding opportunities
Summer/autumn freshes (up to 3 freshes of 50–200 ML/day for up to 3 days each during December–May)	Maintain riparian and in-channel recruitment vegetation Maintain or increase extent of in-stream aquatic vegetation Provide longitudinal connectivity for fish during periods of low flow Maintain macroinvertebrate habitat and wash organic matter into river to drive aquatic food webs Respond to blackwater events as required

SOURCE: Victorian Environmental Water Holder 2015

Next, environmental waterway managers work with water corporations to understand the expected river conditions and water availability under a range of climate conditions, to outline how this might change management decisions, and to understand what practically can be achieved. The waterway managers then prioritize watering actions based on the objectives outlined in the seasonally adaptive approach (Table 1) and produce a scenario plan of watering activities under a range of climate conditions (Table 5).

TABLE 5

Scenario planning, Campaspe River, 2015-16

Planning scenario for the Campaspe River	Extreme Dry	Dry	Average/Wet
Expected river conditions	No unregulated flows High agricultural/urban water deliveries in reach 2 and moderate deliveries in reaches 3 and 4 during summer	Some unregulated flows in winter/spring High agricultural/urban use water deliveries in reach 2 and moderate deliveries in reaches 3 and 4 during summer	Frequent unregulated river flows particularly during winter/spring Moderate summer agricultural/urban use water flows in all reaches
Expected availability of environmental water	10,200 ML VEWH 2,700 ML CEWH 50 ML Living Murray 6,800 ML carry-over 19,750 ML total	11,300 ML VEWH 3,300 ML CEWH 75 ML Living Murray 6,800 ML carry-over 21,475 ML total	20,700 ML VEWH 6,500 ML CEWH 125 ML Living Murray 0 ML carry-over 27,325 ML total
Potential environmental watering	Summer/autumn low flows Winter/spring high flows Winter/spring low flows Summer/autumn fresh		Summer/autumn low flows Winter/spring high flows Winter/spring low flows Summer/autumn fresh Additional winter high flows
Possible volume of environmental water required to achieve objectives	15,300 ML	17,700 ML	29,100 ML

SOURCE: Victorian Environmental Water Holder 2015

Making environmental watering decisions

As the season unfolds, environmental water holders are required to make decisions on where to allocate their water. They must respond to changing water conditions and in some instances reallocate water as appropriate. A priority watering action may coincide with unanticipated rainfall early in the season, for example, and therefore enable lower-priority areas to be watered.

Scenario planning allows environmental water holders to provide environmental waterway managers with volumes of water to meet ecological objectives without having to approve each individual watering action. This enables environmental waterway managers to respond to changing catchment and river conditions, while giving environmental water holders certainty about how their water will be used.

The approach also allows for the identification of issues and risks that may occur in undertaking the watering action. These can be addressed beforehand to reduce or mitigate adverse environmental impacts, community concerns, and potential litigation.

Other Measures for Achieving Environmental Watering Outcomes

The use of environmental water is not the only way to achieve improved outcomes for waterways. In a resource-constrained environment, other measures may need to be considered.

Environmental works and measures

It is not always economically feasible to provide environmental water to maintain desired flows and waterway conditions. In some waterways—especially those with hydrologically disconnected wetlands—the natural flows may have been diverted to allow for agricultural production. In others, natural floodplains may be dewatered because overbank flows are reduced due to upstream storage facilities. Using the same techniques as irrigators, environmental water managers can install weirs, levees, and pumps to transport water to important environmental waterways.

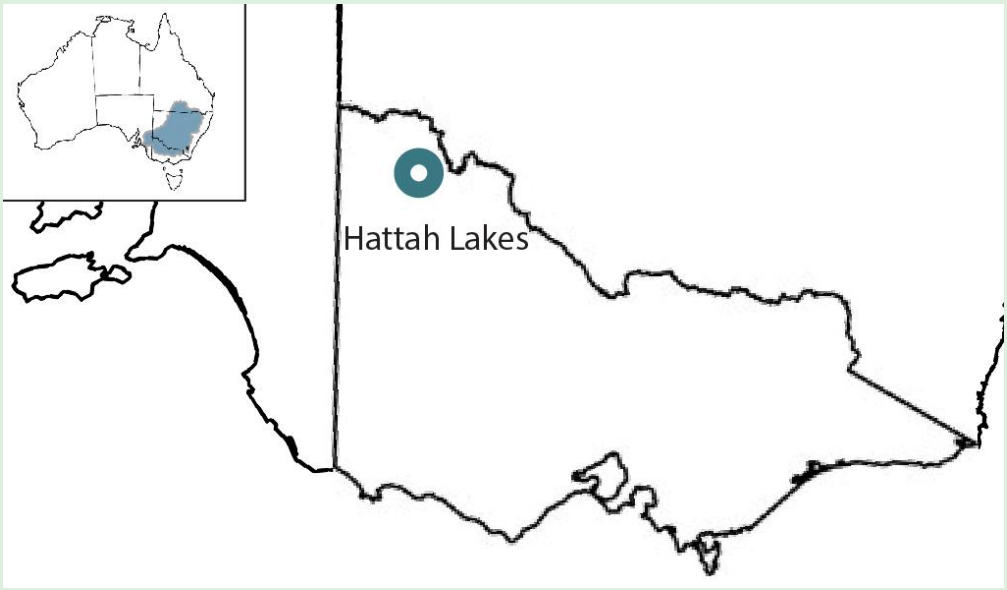
In 2004, the MDB states agreed to fund the Living Murray Works and Measures Program, which was designed to protect six internationally significant wetland sites along the Murray River. The program took an engineering approach, employing a range of environmental works and measures to provide water. Some of these projects are now in operation or in the final stages of commissioning. They have been successful in protecting and enhancing these waterways while using significantly less water—for example, Hattah Lakes used less than 0.002% of the natural flow requirement (Box 5).

The regional works program and the environmental water recovery program also directly affect the environmental watering program. The regional works program undertakes river and wetland catchment activities including riparian fencing programs, salinity management, and erosion control. These activities are planned and undertaken with environmental watering in mind and use the same seasonal planning approach as described in the next section. The environmental water recovery program either generates water by undertaking works to reduce water losses in the system or buys water on the market to meet water recovery targets. These programs take years to complete, and the environmental watering program therefore needs to factor in additional water recovery required each year.

Box 5: Using Infrastructure to Meet Ecological Objectives in the Hattah Lakes

The Hattah Lakes system is part of the 48,000 hectare Hattah-Kulkyne National Park, located 60 kilometres south of Mildura. The lakes are classified as Wetlands of International Importance under the Ramsar Convention, supporting many threatened and rare native plants and animals.

The 18-kilometre-long Chalka Creek, which connects the lake system to the Murray River, was subject to infrastructure works including the construction of a permanent pump station, regulators, and environmental levees. The works deliver water to achieve environmental benefits that would otherwise require a natural flood with river flows of nearly 100,000 megalitres a day over several months. In contrast, filling the lakes using the infrastructure required only 106 megalitres, with approximately 50 percent being returned to the Murray River as part of the operation (MDBA 2012).



Complementary use of agricultural and urban water

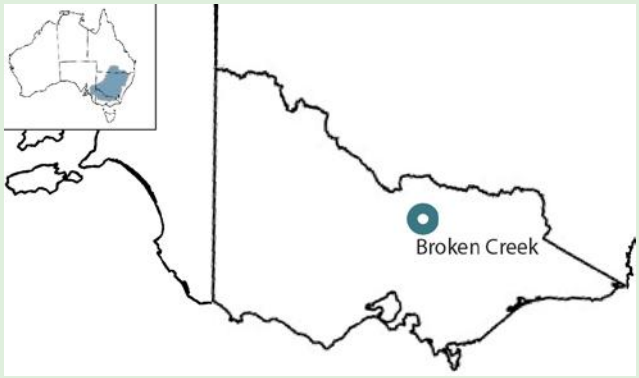
System operators are responsible for delivering water to all customers. They have flexibility to meet the water demands of customers from any storage facility and through any river or channel, as long as it fits in with the principle of maximizing water availability.

Before the Millennium Drought, the system operators' focus was on delivering water to customers as reliably and quickly as possible. This typically meant using the most direct route down a channel or river and, as water resources were plentiful, releasing slightly more than required in order to ensure all customers received their water.

As the drought continued, water corporations looked for additional water efficiencies, including reducing the size of releases and requesting the qualification of environmental rights. The tightening of system operations, combined with the reduction of catchment run-off, seriously reduced flows. Waterways began to show signs of stress, with major fish kills recorded in some areas. In response, water corporations, system operators, and waterway managers began to coordinate their planning and operational decisions to prevent events like these recurring. They identified opportunities to limit the impact of reduced flows on rivers, while not increasing losses from the "consumptive pool" or water for agricultural and urban uses. One of the first prospects identified was the redirection of water that needed to be delivered to customers in another catchment (known as "inter-valley

Box 6: Using Water en Route for Other Uses to Mitigate Fish Kills in Broken Creek

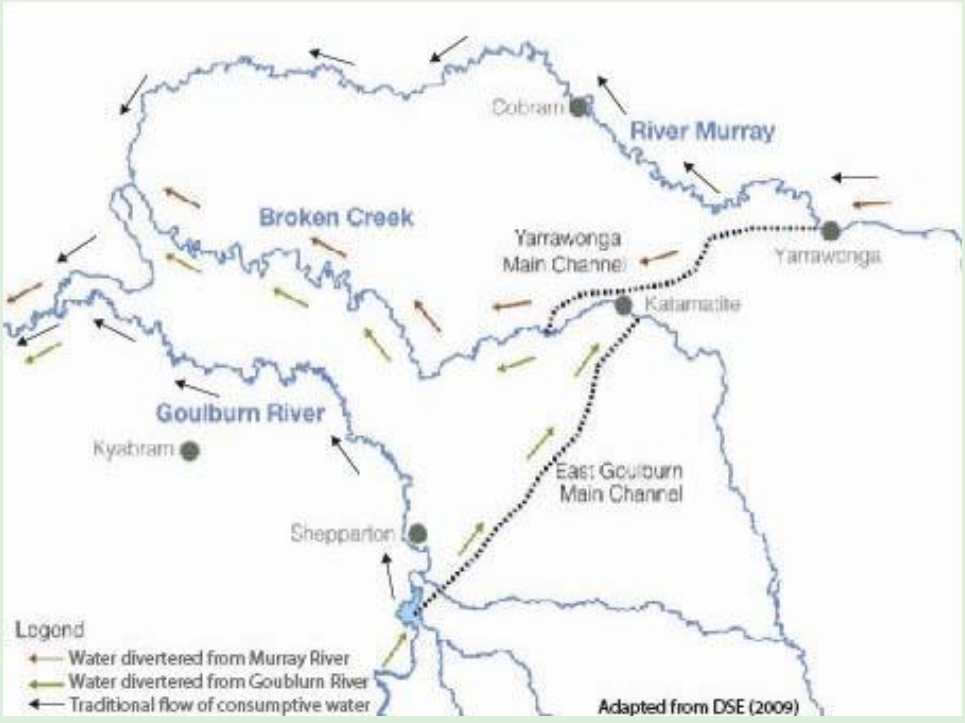
In 2002, a lack of flow in Broken Creek contributed to a major fish kill of over 179 iconic Murray cod (Koehn 2004). In response to the fish kills and recognizing continuing drought conditions, a new policy direction was developed by the Victorian state government to encourage the use of water en route for agricultural/urban uses to protect and enhance environmental values.



The Goulburn River catchment has water that is allocated to users in the Sunraysia district in the Murray River catchment. Goulburn Murray Water (the system operator) and Goulburn Broken Catchment Management Authority (the waterway manager) identified that water could be redirected from the Goulburn River through an irrigation channel to protect and enhance Murray cod populations in Broken Creek, en route to Sunraysia users. Previously the system operator (Goulburn Murray Water) would deliver this water via the Goulburn River, as it was the most efficient in time, water loss, and management costs.

Water could also be re-diverted from the Murray River in the same way. Importantly, in both cases the volumes needed were low (50ML/day) and therefore the diversion did not have any impact on the rivers the water was being diverted from.

The costs of redirecting the water were recognized, with additional losses covered by held environmental water. Additional management and delivery costs were covered by the system operator as part of its responsibility to protect and enhance environmental conditions in accordance with its statement of obligations. This approach allowed the environment to benefit while using a relatively small volume of environmental water.

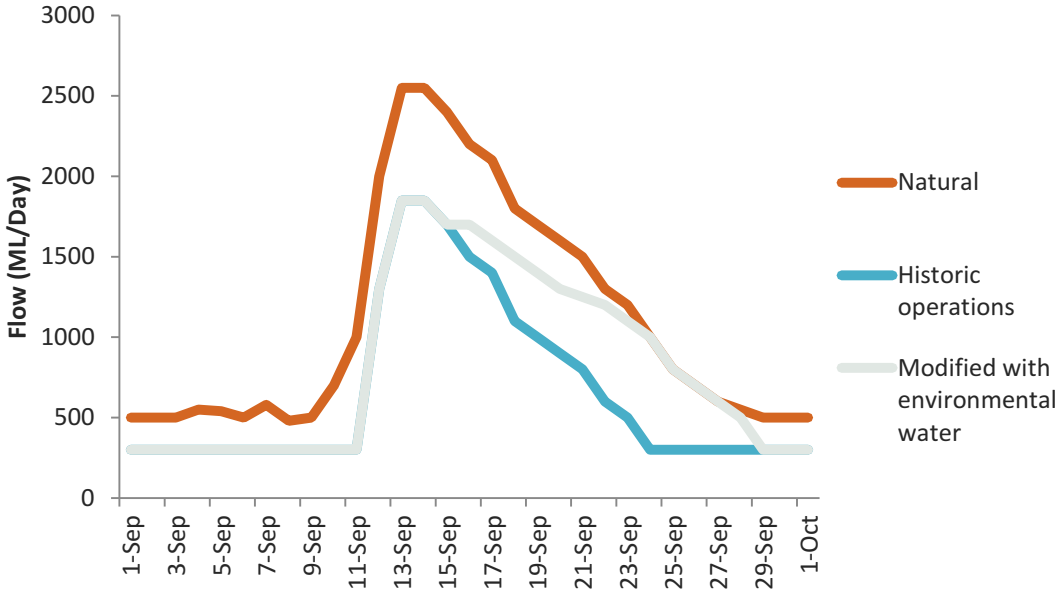


transfer water"). In these cases environmental water would often be used to cover any water losses that occurred from seepage or evaporation as the result of redirection.

The redirection of agricultural and urban water to meet environmental objectives has been very successful (Box 6), and its application has expanded to improving environmental conditions under all climate conditions.

The waterway managers' better understanding of what could be achieved with this water enabled them to provide more natural hydrographs during rainfall events by modifying historic system operating rules. Previous rules created sharp falls, as the system operator looked to maximize the capture of water. Waterway managers now negotiate with system operators to use environmental water to shape the flow. A hypothetical example is shown below (see Figure 4), where an environmental manager would call out environmental water to modify a dam release during a spring flow event. This reduces the environmental water required to create a high-flow event and delivers water to the environment at a time when it is already responding to natural cues associated with this type of event.

FIGURE 4



Modifying dam releases using environmental water

The redirection of water to meet environmental objectives has raised very little concern by the public, as there were no direct impacts on water availability to other users. In a small number of cases, individuals have tried to claim compensation for the extended height of rivers caused by environmental watering, arguing that it prolongs flooding risk. The full implication of these cases is yet to be seen.

Monitoring the Effectiveness of Environmental Water Management

Victoria's environmental water management program uses a range of monitoring and assessment methods, including large-scale monitoring, validation of conceptual models, and event-based monitoring. A clear understanding of exactly *how* these data will be used to achieve stated objectives is critical to inform the effective investment of usually limited funds in any one of these methods.

Large-scale monitoring

Victoria monitors resource conditions and assesses the impact of implementing the Victorian Waterway Management Program using three indices designed specifically for Victoria (Dept. of Environment and Primary Industries 2012). These are the Index of Stream Condition (ISC), the Index of Wetland Condition (IWC), and the Index of Estuary Condition (IEC). The indices were developed at different times and are therefore at different levels of advancement. The ISC was the first condition index developed in 1999, having now been used for three assessments. The IWC was implemented in 2005 and has been used to set the baseline condition. The IEC was piloted in 2009, but has not been applied to date.

These indices are not designed to measure the local-scale effects of particular management activities. Rather, they provide a snapshot of catchment condition at larger scale, such as river reaches and individual wetlands. They provide a useful input to high level strategic planning and for engagement with the community (Dept. of Environment and Primary Industries 2012).

Ideally, these indices would also help to assess the impacts of environmental water management interventions. However, the amount of data required to accurately identify the impacts of management actions outside the range of natural variability is very large. While the methodologies continue to be refined with a view to being able to provide trends through time in the future, investment programs specifically for the monitoring of environmental water management interventions are unlikely to be the most effective use of funds.

Validation of conceptual models

Environmental flow studies are the key source of information regarding the environmental water requirements of rivers and wetlands. The studies use current scientific literature and expert scientific opinion to develop conceptual models of the water requirements needed to meet the ecological requirements of the particular waterway. The Victorian Environmental Flows Monitoring and Assessment Program is designed to validate the hypotheses used in flow studies so that they can be applied across similar systems, reducing the need for monitoring. Experience has shown that these types of programs are highly complex and difficult to implement (Webb et al 2010). Therefore, it is important to target monitoring to areas where there is the greatest uncertainty, the highest risk to investment, or the greatest community concern. While the results to date have not been published, benefits have already been observed through the sharing of monitoring information by waterway managers.

Event-based monitoring

The provision of environmental water can often be controversial. Just the act of holding water entitlements does not automatically mean that an environmental water holder can use the water practically on the ground (Doolan et al. in press*)*. The ability to assess results from specific watering actions is important for two reasons. From a management perspective, it enables rapid updating of planning and delivery to improve outcomes. It also allows

environmental water managers to demonstrate the impacts of public investment in environmental water management to the community.

Event-based monitoring aimed at improving planning and delivery is only effective if the desired outcomes are measurable—e.g., fish spawning. It is therefore important to design and implement event-based monitoring experiments carefully, with a clear focus on the questions to be answered and the effective use of the data acquired.

Monitoring the effects of intervention can also create important community support for environmental watering programs and increase the "social license" for waterway managers to operate. The connection to local communities can be achieved in a number of ways, including the use of local community groups as volunteer monitors to create connection with the water management actions. Using local stories of the effects of watering, from both an ecological and social perspective, provides a broader view of the importance of environmental watering programs. In addition, improving access to information can provide a greater focus on community involvement and outcomes. During the middle of the Millennium Drought, Victoria started to focus on providing accessible information on the results of environmental watering, with the first statewide annual watering report released in 2008; this has continued every year since.

Conclusion

Australian water resource development over the past 200 years has had large and potentially long-term detrimental effects on the environment. While some reforms to address ecological imbalances were already in place, the Millennium Drought sped up the process and forced the Australian federal and Victorian state government to act. The federal and state governments responded differently to the environmental, political, and social challenges of ecological degradation in the MDB. Victoria focused on improving existing frameworks and creating tools that provided individuals and environmental managers with flexibility in managing the drought as well as investing in infrastructure that reduced water losses in irrigation systems—water that could then be converted to environmental entitlements.

The Victorian environmental entitlement and planning frameworks were developed over a relatively recent period in the history of water resource management. Some of the major frameworks and management tools were created before the Millennium Drought took hold, but their effectiveness was tested and proven during this time. Others were created or expanded during the drought, and their full effects on environmental conditions may take decades to understand. An evaluation of these tools is provided in Table 6, outlining the benefits and risks, but also the uncertainties of implementing such a broad array of tools in a short timeframe.

With the exception of the entitlement framework, the planning framework and new water management tools were delivered or created during the Millennium Drought. These frameworks and tools enabled environmental water managers to manage the drought without any significant long-term impacts on the environment. However, a major flood that ended the drought occurred before all management activities had been fully tested. The next drought will provide a more complete measure of the effectiveness of these tools.

TABLE 6

Evaluation of Victorian environmental water allocation and planning

Tools	Benefits	Risks/ Uncertainties
Water entitlement framework	▪ Provides environment with clear rights to water which was not questioned during the Millennium Drought	▪ Environment does not have a higher legal standing than other users
Seasonal allocations against water shares	▪ Ensures that over-allocation of water does not occur in any year, reducing the risk of qualifications to the environment	▪ Conservative approach to allocations reduces water available early in the season when the environment requires it the most
Carry-over	▪ Allows environment to save up water for large events, without having to purchase water on the market or needing large infrequently used entitlements ▪ Allows individual to manage their own risks, reducing the risk of the environment's rights being qualified in dry years	▪ Water that is carried over is subject to spill rules, therefore it may not be accessible for large environmental events ▪ Community concerns that the large amounts of environmental water increases the risk of a spill
Water markets	▪ Provides environmental water holders with opportunity to optimize its portfolio in any given year ▪ Provides funding for environmental research or small works to optimize environmental outcomes	▪ Pressure from the community to fund environmental watering through the sale of environmental water could result in reduced environmental outcomes ▪ Large environmental water holders have the potential to significantly impact market prices through their decisions ▪ Potential pressure on environmental water holders to sell water to irrigators rather than use for environmental purposes
Planned environmental water	▪ Provides a "set it and forget" approach to providing flows that are required annually ▪ Delivery fees are not imposed on this water as it is seen as a core part of maintaining the river for all users ▪ Community largely supportive of planned environmental water during average conditions	▪ Reduced flexibility can result in flows causing environmental damage ▪ Potential for rights to be qualified
Held environmental water	▪ Provides environment with fully flexible water to meet its objectives ▪ Equal rights as other users, therefore community does not question the environment's rights to water	▪ Increasing pressure for the environment to water sites for social benefits ▪ Long-term storage and delivery costs associated with entitlement
Qualification of rights	▪ Environment receives compensation for rights that have been qualified	▪ Planned environmental water is typically the first rights to be qualified ▪ May be used politically to satisfy a user group.
Environmental water planning framework	▪ Links directly with water resource planning allowing the environment to have a voice in any re-balancing of water. ▪ Links watering activities with complementary works which focus investment ▪ Is based on best available scientific information and experimentation ▪ Community is accepting of the framework	▪ If scientific information is incomplete some actions undertaken may not meet their objectives ▪ If rebalancing the community may accept/demand less environmental outcomes, putting species at risk
Environmental flow studies	▪ Provide scientifically defendable information on the ecological and geomorphological requirements of rivers and wetlands. ▪ Guide environmental water managers in undertaking environmental watering activities	▪ If flow studies are used without considering current environmental conditions or new information, flow delivered may not achieve desired objective
Prioritization of environmental water	▪ Provides robust rationale for environmental watering to the community ▪ Can be used across catchments to make decisions	▪ Risk that managers/community will want to hardwire the relationship between prioritization and the subsequent management response, reducing flexibility

Tools	Benefits	Risks/ Uncertainties
Seasonally adaptive approach	▪ Provides a clear direction for environmental watering activities under different climate scenarios ▪ Allows environmental managers to identify important drought refuges ▪ Requires scientist to provide pragmatic advice on the water requirements of waterways, in particular during drought periods ▪ Reflects similar decision making process used by irrigators in the use of their water, therefore can relate to watering actions being undertaken	▪ Scientific community is often unwilling to provide advice on sub-optimal flow rates because of the concern that they may become the recommend average flows
Annual environmental water planning	▪ Ensures waterway managers are responsible for environmental water planning in their area ▪ Integrates water corporation planning with environmental water planning ▪ Provides a transparent and repeatable approach to environmental water planning ▪ Involves local community in the environmental planning process, creating advocates for environmental water management	▪ Risk that multiple environmental water holders will come up with different watering actions for the same area, creating confusion and possible environmental damage
Scenario planning	▪ Provides certainty to environmental water holders on how their water will be used ▪ Allows waterway managers to be very responsive to changing river conditions, maximizing environmental outcomes ▪ Identifies any issues and risks that may occur due to watering so they can be addressed beforehand	▪ Can lead to risk-averse management decisions and reduce potential environmental outcomes
Environmental works and measures	▪ Allows for environmental watering in areas which would not receive water under most conditions ▪ Maximizes environmental outcomes using significantly less water ▪ Strong community support for these often large infrastructure works	▪ High cost of building, operating and maintaining works
Complementary use of agricultural/urban (consumptive) water	▪ Allows environmental outcomes to be met without using large volumes of environmental water ▪ Little concern from community as long as their rights are not impacted	▪ Possible that system losses may be transferred to the environment ▪ Community concern of prolonged flooding risk ▪ Potential litigation for water users
Monitoring of water planning activities	▪ Conceptual models provide cost effective way to test key hypothesis to improve environmental watering ▪ Engages the community in environmental watering activities ▪ Event monitoring enables waterway managers to quickly update their planning and delivery to improve outcomes	▪ Validations of conceptual models can be costly and difficult to implement if there is no clear rationale for the monitoring ▪ Large broad scale monitoring programs are unlikely to capture the effect of environmental watering programs due to the natural range of variability

Acronyms

CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
EWH	Environmental Water Holder
IEC	Index of Estuary Condition
ISC	Index of Stream Condition
IWC	Index of Wetland Condition
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
RSWS	Regional Sustainable Water Strategy
RWMS	Regional Waterway Management Strategy
VEWH	Victorian Environmental Water Holder
VMFFE	Victorian Murray Flora and Fauna Entitlement

Glossary

Allocation	The specific volume of water apportioned to water entitlements in a given season, defined according to rules established in the relevant water plan.
Basin Plan	Guides governments, regional authorities, and communities to sustainably manage and use the waters of the Murray-Darling Basin. Came into effect in November 2012.
Bulk entitlement	The right to water held by water corporations as defined in the Water Act of 1989. The bulk entitlement defines the amount of water that a corporation is entitled to from a river or reservoir, and may include the rate at which it may be taken and the reliability of that entitlement.
Bulk entitlement conversion	The process by which unclear rights were documented and made legally binding akin to property rights.
Cap	Upper limits for the diversion of water from a waterway, catchment, or basin for use for non-environmental purposes (also known as sustainable diversion limits).
Carry-over	The rule which allows entitlement holders to store unneeded water from one year to the next.
Catchment	The area of land where the surface water converges to a single point. Also known as a watershed.
Consumptive water	Water use by irrigators, stock, and domestic users, and urban water authorities for non-environmental purposes. Sometimes referred to as the “consumptive pool.”
Delivery Share	An entitlement to have water delivered to land in an irrigation area. It gives access to a share of the available capacity in the channel or piped network that supplies water to the property. Delivery share is tied to the land and stays with the property if it is bought or sold. It also stays with the property if the water share is sold separately.
Drought refuge	A key location which is managed to provide emergency habitat for the survival of birds, animals, and fish during a drought to enable recovery of these populations after the drought.
Entitlement	A right to take, use, extract, or have water delivered that may be limited by conditions. The most common types of entitlements are water shares, delivery shares, water-use licenses, take-and-use licenses, water allowances, supplies by agreement, and works licenses.

Environmental flow studies	Studies designed to calculate the amount of water required to sustain aquatic ecosystems, with a minimum risk of degradation.
Environmental water holders	Managers of held environmental water.
Environmental waterway manager	In their role as waterway managers, Catchment Management Authorities and Melbourne Water act as caretakers of river health, responsible for regional and catchment planning and coordination, and waterway, floodplain, salinity, and water quality management.
Environmental watering	The use of held environmental water in rivers wetlands and floodplains.
Environmental Water Reserve	The aggregate of Victoria's managed environmental water, comprised of three integral components: planned environmental water (passing flows); held environmental water (environmental entitlements and acquired water); and unregulated flows and spills from storage facilities (above-cap water).
Environmental works and measures	Installation of weirs, levees, and pumps to transport water to important environmental waterways.
Event-based monitoring	Monitoring specifically during the period of environmental watering.
Held entitlement	Water share akin to a property right, which give the holder a share of the regulated capacity of a system.
High-reliability water share	Legally recognized, secure entitlement to a defined share of water. Water shares are classed by their reliability, which is defined by how often full seasonal allocations are expected to be available. Allocations are made to high-reliability water shares before low-reliability shares.
Low-reliability water share	A water share with a relatively low reliability of supply. Allocations are made to low-reliability water shares after high-reliability shares.
Millennium Drought	Lasting from 1996-2010, this was the most severe drought in Australia's historical record and led to sweeping changes in water management across Australia.
Murray-Darling Basin Authority	Authority charged with the operation, planning, and management of water resources and associated risks in the Murray-Darling Basin.
Permanent water market	The buying or selling of water shares.
Planned entitlement	A right to water denoted by a rule in a bulk entitlement—for example, a minimum passing flow or a cap of total extractions in a system.
Passing flow	Minimum flow rules set for a waterway. They can be as simple as a set flow rate requirement all year-round, or as a flow rate delivered at a point in a river based on the time of year, or as volume in storage.
Qualification of rights	During a declared water shortage, the water minister can alter the amount of water available to users and, if necessary, reduce the Environmental Water Reserve to enable urban and domestic water needs to be met.
Regional Sustainable Water Strategy	Victorian state government strategies for deciding on large-scale, long-term changes in water use and investment. The RSWS also provides a strategic and regional context to help address local issues.
Ramsar Convention	An international treaty signed in 1971 (also known as the Convention on Wetlands of International Importance). The broad aims are to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain.
Reliability	Water shares are classed according to their reliability, which is defined by the frequency with which full seasonal allocations are expected to be available. Most water shares are classified as either high-reliability or low-reliability water shares.
Sales water	Lower-reliability water offered to irrigators on a seasonal basis, in proportion to their base rights, after provision has been made to meet the base rights in the following year. This has now been converted into low reliability water shares
Seasonally adaptive approach	A decision-making tool used to identify a suite of management objectives set around different water resource scenarios, from drought to floods.
Stock and domestic rights	Right to take water, free of charge, for that person's domestic and stock use from a waterway or well to which that person has access.
Supplies to urban customers	Water delivered through urban water corporations' bulk entitlements, which allows for water to be delivered to urban customers without the need for individual rights.
Supply by agreement	An agreement between a water corporation and a person giving an entitlement to water for defined period. Usually covers less reliable water sources, like drainage water or areas where supply is not guaranteed.

System operator	An authority responsible for the maintenance and operation of storage facilities and weirs. They provide water to bulk entitlement holders who then distribute to their customers or allocate it to the environment. Responsibilities are held by four water corporations across the state.
System operating water	Water required to cover system losses to enable the irrigation system to operate.
Take-and-use license	Either a fixed term or ongoing entitlement to take and use water from a waterway, catchment dam, spring, or aquifer.
Temporary water market	The buying or selling of a water allocation.
Unbundling	A major Victorian water entitlement reform where water provided to users was separated from land
Water corporation	Authorities charged with supplying water to towns and cities across Victoria for urban, industrial and commercial use. Water corporations administer the diversion of water from waterways and the extraction of groundwater
Water market	The temporary or permanent trading (buying or selling) of water
Water recovery	Generating water by undertaking works to reduce water losses in the system, which can be converted into held water or water on the market to meet water recovery targets.
Water shares	Akin to a property right, which gives the holder a water share from a particular system. Shares have varying reliabilities according to the particular catchment.
Water supply system	A body of water that is managed as a unit for the purposes of supplying water users.
Water use license	A license that authorizes the use of water for the purposes of irrigation on the land specified in that license.
Work license	A license that gives the right to construct, operate or modify water extraction works, like such as a pump.

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Appendix B: A Brief Summary of California and Victoria Water Law

Introduction

This appendix provides a brief introduction to the water rights systems in California and the Australian state of Victoria. We give an overview of the laws and regulations that guide water allocation and management in each state, with a concentration on water for environmental purposes

Although Australian and United States water law both evolved from the English law of riparian rights, the legal systems of the two nations have diverged in significant ways. Despite their many differences, however, two commonalities remain. First, in both countries, water rights are defined and administered principally by the states rather than the national government. Second, the laws of both systems seek to accommodate and balance the goals of providing water to serve the state's population and economy while also protecting the aquatic ecosystems that are the sources of these water supplies (Productivity Commission 2003; Hanak et al. 2011; Australia National Water Commission 2012).

California's Water Rights System

California water rights law is an amalgam of common law, statutory, and constitutional rules that have developed piecemeal—usually in response to a specific water management problem—from the mid-19th century to the present. This law began as a means of promoting the diversion and use of water to serve California's burgeoning economy and population, and has evolved to incorporate the concomitant goals of repairing and restoring the features of the state's environment that have suffered from water resources development. Indeed, the greatest challenge for California's water rights system is to respond to the often conflicting needs of facilitating the impoundment and diversion of water to provide reliable supplies while simultaneously protecting the aquatic ecosystems that are the sources of that water service (Hanak et al. 2011).

California has a complex and fragmented system of water rights that establishes a set of priorities to divert and use water and to allocate available supplies in times of shortage. The complexity arises from the panoply of rights to use water recognized in state and federal law. Intertwined with the riparian, overlying, and appropriative rights that comprise the vast majority of California's surface and groundwater rights are several other types of water rights that play a less significant role in state water resources administration. These include prescriptive rights, pueblo rights, and federal reserved rights (Littleworth & Garner 2007). Although these rights have had an important influence in some regions—especially in certain adjudicated southern California groundwater basins—for reasons of brevity we will simply note them here.

In contrast, the fragmentation results from three statutory exclusions from the regulatory system that was created by the Water Commission Act of 1913 and which is administered today by the State Water Resources Control Board (SWRCB). The Act, which is the foundation of the modern California Water Code, exempts riparian rights, existing appropriative rights, and all groundwater rights from the Board's permitting and licensing jurisdiction. (Gray et al. 2015)

Although surface water and groundwater are hydrologically interconnected in many regions of the state—and the extraction and use of one often affects the other—California law generally defines and regulates the two resources separately. There are a few location-specific exceptions. Underground water that flows in a defined subsurface channel is treated as surface water, and the extraction of this "non-percolating" groundwater is subject to the law of surface

water use. Some adjudicated groundwater basins integrate surface water and groundwater rights (Langridge et al. 2016). In addition, two recent judicial decisions have approved integrated regulation of hydrologically connected surface water diversions and groundwater pumping in the Russian River and Scott River watersheds pursuant to the reasonable use and public trust doctrines discussed below (Gray 2015). More generally, the Sustainable Groundwater Management Act of 2014 requires local water users to develop groundwater sustainability plans that address the relationship between groundwater pumping and surface water resources, and it authorizes Groundwater Sustainability Agencies created under the statute to engage in conjunctive management. The statute does not integrate surface water and groundwater rights, however (Gray et al. 2015; Kiparsky et al. 2016).

Because the legal issues raised in the main report focus on surface water rights, we will not include a detailed discussion of groundwater rights here.

The Riparian and Appropriative Rights Hierarchy

California law creates a hierarchy of surface water rights, with riparians at the top of the hierarchy and appropriators following in order of their priority of appropriation.

Riparian rights are based on ownership of land that is adjacent to a river or other water source. Riparians as a group have shared rights to divert water to supply reasonable and beneficial uses on their property. Riparian rights are not quantified, and the riparian right may expand or contract over time as the riparian's reasonable and beneficial uses change. Riparian rights may only be exercised to supply uses that are on the riparian land *and* within the watershed from which the water is diverted. Riparian rights also apply only to the natural flow of California's rivers—i.e., riparians have no rights to releases of stored water or to water that is imported from another river basin. As noted above, riparian rights are exempt from the SWRCB's permitting and licensing jurisdiction (Littleworth & Garner 2007).

Appropriative rights are based on the actual use of water, rather than land ownership. With few exceptions, appropriators may lawfully impound and divert water only if there is water available after the reasonable and beneficial riparian uses are fulfilled. If there is insufficient water to supply all appropriative rights, the available water is allocated among the appropriators on a "first-in-time, first-in-right" basis (Littleworth & Garner 2007). During the past two years of California's drought, the SWRCB issued "curtailment" letters to junior appropriators in several of the state's river systems to enforce the priority system (Gray et al. 2015). Appropriative rights are not limited by any place-of-use restrictions.

There are two categories of appropriative rights: pre-1914 rights that are exempt from the SWRCB's permitting and licensing jurisdiction; and post-1914 rights that based on permits and licenses issued by the board. (This refers to the date on which the Water Commission Act became effective.)

Pre-1914 appropriative rights are imprecisely quantified. They are based on the amount of water required to serve the appropriator's reasonable and beneficial uses plus any reasonable losses incurred during transport of the water from the point of diversion to the place of use. In contrast, permits and licenses grant a fixed quantity of water; they define the point of diversion, place of use, purpose of use, and lawful timing of the impoundment and diversion of water; and they usually include other terms and conditions to protect downstream water-right holders, water quality, and other instream uses (Littleworth & Garner 2007).

The lion's share of California's surface water is appropriated by public water agencies and delivered to their members and customers or to other water agencies pursuant to contract (Hanak et al. 2011). Cities and other municipal water purveyors may not claim riparian rights, and municipal water supply therefore is defined as an appropriative right (Littleworth & Garner 2007). Section 106 of the California Water Code grants municipal water supply a preferential legal status, however, declaring that domestic water supply is the highest use of water and that irrigation is the next

highest use (CWC § 106). The California Supreme Court has acknowledged that it has never resolved how these statutory priorities match up with the temporal priorities of the riparian/appropriative rights hierarchy (California Supreme Court 1983).

Although the Water Code defines water quality, fish and wildlife, and recreation as beneficial uses, California law does not authorize the appropriation of water for instream use (Littleworth & Garner 2007). As described below, however, section 1707 of the Water Code does allow riparians and appropriators to dedicate all or a portion of their existing rights to serve instream beneficial uses.

Reasonable and Beneficial Use

Article X, Section 2 of the California Constitution prohibits the waste of water and requires that all water rights be exercised reasonably to supply beneficial uses. This constitutional directive applies to all categories of surface water and groundwater rights, regardless of whether they are subject to the SWRCB's permitting and licensing jurisdiction (Hanak et al. 2011).

The California Supreme Court has emphasized that the determination of reasonable and beneficial use cannot be made simply by reference to an individual water right-holder's practices. Rather, the decision must take into account all competing demands for the water—both extractive and environmental—as well as broader hydrologic, ecologic, demographic, and economic considerations. The court also has held that reasonable use is a dynamic concept. A use that was reasonable when initiated may become unreasonable as demands on the resource increase, scientific understanding of the ecosystem evolves, new laws governing water use are enacted, and other conditions change (Gray 2015).

If the SWRCB or a court determines that a particular water use is wasteful or unreasonable, it has authority to order the water-right holder to alter its practices to comply with the mandates of Article X, Section 2. In addition, a finding of unreasonable use may cause the water right to lose its priority vis-à-vis junior water rights. The reasonable use doctrine thus introduces flexibility into what is otherwise a rigid water rights hierarchy. The reasonable use mandate also can promote efficient use and more efficient allocation of the state's developed water supplies (Gray 2015).

Water Trading

All surface water rights are transferable, although riparian rights generally cannot be transferred independent of the land to which they are appurtenant. Pre-1914 appropriators may transfer water without prior state approval, subject to the common law "no-injury" requirement. Post-1914 appropriators also may transfer water, but SWRCB approval is required if the transfer would require a change in the place of use, point of diversion, or purpose of use set forth in the permit or license. The board may not approve a change in water right if the change or transfer would harm other legal water users or unreasonably affect water quality, fish and wildlife, or other instream beneficial uses. Short-term transfers (one-year or less) are limited to the transferor's prior consumptive use and/or stored water; and they are exempt from environmental review under CEQA (Littleworth & Garner 2007).

Section 1707 of the Water Code authorizes any surface water-right holder to transfer water to another party (e.g., the California Department of Fish and Wildlife or an environmental trust) for the purpose of dedicating the water to instream beneficial use. These transfers may be permanent or time-limited. Section 1707 transfers are subject to review by the SWRCB. The board may not approve the petition unless it determines that the dedication of water to instream use will not increase the amount of water the transferor is entitled to use or unreasonably affect any legal water user. If the SWRCB approves the transfer, the instream water right carries the same priority as the water right on which it is based (CWC § 1707).

Instream water rights are a tiny component of California's water rights system (Szeptycki et al. 2015). The vast majority of the water that serves ecological functions is set apart from the water rights system as regulatory restrictions on water rights, rather than designated as an environmental water right (Gray et al. 2015).

Environmental Constraints on Water Rights

A variety of laws that protect water quality, fish and wildlife, recreation, wetlands, and other *in situ* beneficial uses also may limit the exercise of water rights. The most important of these laws are:

- *The California Porter-Cologne Act and the Federal Clean Water Act.* These statutes require the SWRCB and the nine Regional Water Quality Control Boards to publish water quality control plans for each of the state's principal river basins. The plans must identify the beneficial uses of these waters (e.g., municipal supply, irrigation, fish and wildlife, and recreation) and set forth water quality criteria to ensure the reasonable protection of the various uses. The plans must be revisited, and potentially revised, every three years (Hanak et al. 2011).

  To implement the water quality standards, the regional boards have authority to limit discharges of pollutants, and the SWRCB may place restrictions on the impoundment and diversion of water by permittees, licensees, and other water-right holders. Indeed, the water quality standards for the Bay-Delta have significantly constrained the diversion of water from the south Delta by the federal Central Valley Project (CVP) and the State Water Project (SWP) (Gray et al. 2013).

- *Section 5937 of the California Fish and Game Code.* This statute requires dam operators to release water to protect downstream fisheries. It has been the catalyst for several major environmental protection initiatives, including restoration of the Mono Lake ecosystem and the San Joaquin River Restoration Program. In both cases, compliance with the directives of section 5937 has required significant limitations on the impoundment and diversion of water (Gray 2012; Matthews 2007).

- *The Public Trust Doctrine.* All water rights must be exercised consistent with the public trust, an ancient doctrine that protects the public's rights in navigable waters, as well as their underlying submerged lands. The traditional public trust rights are navigation, commerce, and fishing. In a series of cases decided in the late-20th century, the California Supreme Court expanded the public trust to include recreational uses, and the preservation and protection of ecological services. In the Mono Lake case, the court held that the public trust is an integral part of the state's water rights system; and in that case and several others the SWRCB and the courts have applied the doctrine to limit the impoundment and diversion of water (California Supreme Court 1983).

  The public trust also imposes a continuing obligation on all water regulators and water managers to consider the public trust in their decision making and to protect the public trust to the extent feasible under the circumstances. Although the public trust only applies to navigable waters, the courts have ruled that the diversion of surface water from non-navigable tributaries and the pumping of hydrologically connected groundwater may violate the public trust if those diversions and extractions harm public trust uses in a navigable river, lake, or estuary (California Superior Court 2014).

- *The California and Federal Endangered Species Acts.* The state and federal endangered species acts prohibit the "taking" of endangered and threatened species unless authorized by an incidental take permit. The federal act also requires all federal agencies, as well as federal licensees, to consult with the US Fish and Wildlife Service (or the National Marine Fisheries Service for marine mammals and anadromous fish) to ensure that their actions do not jeopardize the continued existence of protected species or adversely modify "critical habitat" that is needed for their survival. The biological opinions that govern CVP and SWP operations have significantly

constrained water deliveries by the two projects, especially for users located south of the Delta. The endangered species acts also have limited the exercise of water rights in other basins, including the Klamath, Trinity, and Sacramento River watersheds (Hanak et al. 2011).

These regulatory standards are incorporated into California's water rights administration in a variety of ways, including triennial water quality planning, periodic endangered species act consultations, individual water rights decisions, and litigation. Some of the environmental laws—especially the water quality statutes and the public trust—require (or at least allow for) multi-criteria, integrated planning and decision making. Others are more directed to a single preventative or restorative goal. Implementation and enforcement of the endangered species acts, for example, has focused on specific threats to single species, rather than on the interactions among species in a dynamic ecosystem that is subject to many stressors (Hanak et al. 2013).

Moreover, some of the environmental standards are flexible, while others are more rigid and allow for little accommodation of competing interests. For example, water quality and flow criteria must be defined to provide "reasonable" protection to a broad variety of interests, including consumptive water demands and ecological needs. Limits on water diversions, flow bypass requirements, and other operational constraints may vary depending on hydrologic conditions (Gray et al. 2013). And the SWRCB has authority to issue "temporary urgency change orders" that relax water quality standards and diversion limitations on individual water-right holders during periods of acute water shortage (Gray et al. 2015).

In contrast, the prohibitions of the state and federal endangered species acts against the unauthorized "taking" of protected species, and the federal statute's mandate to avoid "jeopardy," are absolute. The agencies charged with their administration have no power to balance the competing interests in water supply and species protection or to issue *ad hoc* exemptions to encroach on vital instream flows to allow more water to be delivered to extractive uses. These statutes thus serve as a regulatory backstop for the protection of both endangered and threatened species and the aquatic ecosystems that comprise their essential habitat (Hanak et al. 2011).

Victoria's Water Entitlement System

Victoria's system of water rights (commonly called "entitlements") is set forth in the Water Act of 1989, which modernized the state's water laws and management policies. (Victoria DEPI 2016a) The Act authorizes the allocation of water through a three-tiered structure that begins with the declaration that "the Crown has the right to the use, flow and control of all water in a waterway and all groundwater." (Victoria Water Act § 7(1)) It empowers the Minister for Water to grant private rights to use that water, subject to the paramount rights of the Crown. The act also states that, in granting such rights, the minister must give regard "to the need to maintain the environmental water reserve in accordance with the environmental water reserve objective" (Victoria Water Act § 7(4)).

The rights granted by the minister form the second and third tiers of the Victorian water system. The second-tier rights are "bulk entitlements" and "environmental entitlements." The original 1989 statute only recognized bulk entitlements, but allowed bulk entitlements to be used for environmental purposes. The Water Resource Management Act of 2005 amended the law *inter alia* to create separate environmental entitlements.

- *Bulk entitlements* are granted to state-owned "water corporations" to supply water to urban and rural customers for domestic, irrigation, commercial, and industrial use. They provide the holder with the right to store and/or divert a volume of water directly from the river or to receive stored water from a project operated by another water corporation.
- Bulk entitlements allow the holder to specify the source and timing of water deliveries, subject to conditions that are designed to protect other entitlement holders (including environmental entitlements) on the same river system. As described below, bulk entitlements for stored water also require the holders to release "passing flows" from dams to support fish, wildlife, wetlands, and other environmental objectives. These are outlined in the Seasonal Watering Plan (Victoria DEPI 2016b).
- *Environmental entitlements* are held by the Victorian Environmental Water Holder (VEWH) for the purpose of providing water to rivers and wetlands for water quality, fish, and wildlife (Victorian EWH 2015a). These "enable active management of water to meet specific environmental needs such as fish spawning triggers or maintaining critical habitat during drought." These environmental objectives are outlined annually in the Seasonal Watering Plan (Victoria DEPI 2016c).
- Environmental entitlements also allow the environmental water holder to specify the source and timing of water deliveries and to control the released water as it flows downriver. Depending on the environmental objectives, the VEWH may protect the water from the point of release to the ocean, or it may use the water to meet instream flows for a designated segment of the river and then allow other users to divert the water below once it has fulfilled the instream objective. The VEWH also may divert the water itself, or allow a partner organization to divert the water, for wetlands watering or other non-riverine environmental use.

Although bulk entitlements and environmental entitlements are defined as specific volumes of water, the quantity that an entitlement holder may divert or receive from storage will vary each year depending on the total water available in the system.

The third tier of the Victoria water rights system is comprised of individual rights to water use, the most important of which are "water shares." The Water Act required all existing water rights, with the exception of riparian rights for domestic use and stock watering, to be converted into water shares. Water shareholders must have a water-use license, which authorizes the application of water to individual parcels of land (Victoria DEPI 2016f).

A water share grants individual irrigators defined rights to receive water from one or more bulk entitlement holders. As with the entitlements themselves, although the water share sets forth a specific seasonal volume for each shareholder, the quantity that a shareholder actually receives will increase and decrease as a defined percentage of the total water available in the river system and in storage (Victoria DEPI 2016d).

There are two classes of water shares: high-reliability shares, which are generally used for irrigation of permanent crops, such as vineyards and orchards, and low-reliability shares, which provide water in wetter years. (*Id.*) Some urban water agencies have augmented their supplies by purchasing high-reliability water shares from irrigators.

Water shares are "unbundled"—they are not tied to land. As a result, water shares and seasonal allocations may be transferred to other consumptive users or to the environment. The Water Act of 1989 requires the Victorian government to maintain a registry of all water shares and transfers. Although a water shareholder may transfer all or part of its share or allocation, the shareholder has no power to change the source of the water. Thus, the transferee will receive its water from the same river system and reservoir as did the transferor (Victoria DEPI 2016e).

Water shares also may be used for environmental purposes. For example, the Commonwealth Environmental Water Holder (CEWH), which manages environmental water for the national government, and the Murray-Darling Basin Authority (MDBA), which coordinates land management and environmental watering throughout the entire basin, both hold water shares. Some of these water shares were acquired from consumptive users, others were made available from water savings and efficiency improvements funded by the Australian government (CEWC 2016; MDBA 2016). The CEWH and MDBA coordinate their environmental watering decisions with the VEWH.

Finally, in most water systems with significant storage, if an entitlement holder or shareholder does not use all of its available water in one season, it may bank that water for withdrawal during the following season. This type of carry-over "provides all water users—irrigators, urban water corporations, and environmental managers—with greater flexibility to manage their own water availability between seasons" (Victoria DEPI 2016g). Carry-over rights are subject to the availability of reservoir storage capacity, and the holder of the carry-over rights bears the risk that the stored water may be spilled (and thus lost) during times of high river flows.

The Environmental Water Reserve

Victoria maintains an Environmental Water Reserve, which is comprised of three integral components:

- *Planned environmental water (passing flows):* All bulk entitlements are subject to "passing flow" requirements—i.e., obligations to release stored water from the bulk entitlement—to ensure that there is sufficient water instream to protect water quality, fish and wildlife, and other ecological uses. A few environmental entitlements also are subject to passing flow requirements.
- *Held environmental water (environmental entitlements and acquired water shares):* The VEWH holds environmental entitlements that authorize it to use a volume of water held in storage to provide instream flows, wetlands watering, and other environmental uses consistent with the "seasonal watering plan." The VEWH, CEWH, and MDBA also have acquired water shares from consumptive users that they incorporate into their environmental watering programs (Victoria DEPI 2016g; Victorian EWH 2015b).
- *Unregulated flows and spills from storages:* These flows, usually created by heavy rainfall, supplement the environmental water made available through passing flows and management of the held environmental water (Victorian EWH 2013).

The VEWH incorporates the Environmental Water Reserve into the seasonal watering plan that it develops annually for each of Victoria's 10 catchment basins. This plan identifies the key environmental and biological objectives for environmental watering, specifies the quantities and flows needed to meet these objectives, defines environmental priorities, and describes the potential uses of the available environmental water under varying hydrologic conditions.

The VEWH adopts the seasonal watering plan following consultation with Victoria's other water managers, including the bulk entitlement holders, the CEWH and MDBA, the 10 catchment management authorities, and Melbourne Water. The VEWH also coordinates with the environmental water managers in New South Wales and South Australia (Victorian EWH 2015b).

The seasonal watering plan then guides the allocation and delivery of environmental water, as well as the releases from storage needed to fulfill the environmental watering objectives. Because rainfall varies each year, the plan identifies environmental objectives and allocations for four different hydrologic scenarios. In drought years, where there is little water allocated against the entitlements, the priority is to protect biological refuges and minimize ecological losses. In wet years, when full allocations occur, the objective is to enhance the environment (see main report, Figure 2).

Water Trading

The VEWH has an active water trading program. It has purchased water "to enhance environmental outcomes in systems where insufficient environmental water was available," and it has sold water that is surplus to anticipated ecological needs. The revenue from these sales may be used to purchase water to meet current shortfalls elsewhere in the basin, to acquire water at a later date to supply future environmental needs, and to fund improvements in environmental water management. "Water trading allows the VEWH to move water to the systems where it is most needed, and to smooth out some of the variability in water availability across systems and across years" (Victorian EWH 2015b).

As noted above, the CEWH and the MDBA also have acquired water shares that they use for environmental watering. They also trade those shares depending on hydrologic conditions and environmental watering needs.

Qualification of Rights

The Victoria Water Act allows the Minister of Water to "qualify" rights during periods of shortage to ensure that "critical water needs are met in extreme circumstances" (Victorian DEPI 2016h). Qualification represents a temporary change in water sharing arrangements within in a specific river basin. For example, the minister may alter bulk entitlements to deliver more water to urban users by disproportionately reducing irrigation supplies. The minister also has authority to reduce passing flows to make water available for essential human needs (Victoria DEPI n.d.).

When acting on proposals for qualification, the minister considers the proponent's claimed need for additional water, alternatives to qualification, the potential harm to instream and wetlands uses, and other third-party effects that may be caused by the reallocation of available supplies. Qualification orders are usually subject to specific terms and conditions. For example, during the Millennium Drought, the Minister granted a petition to qualify rights to reduce passing flows so that the stored water could be reallocated to critical human needs (principally indoor domestic supply). The qualification order required the proponent to manage "the impacts of the qualification on the environment including enhancing ecosystem resilience and recovery of ecosystems after the qualification expired" and to pay for these mitigation measures. (Victoria DEPI n.d.)

Mitigation is a common feature of the qualification process. In most cases, the required mitigation is for environmental protection and rehabilitation (Jensz 2016). In others, mitigation is designed to protect consumptive water uses that may be harmed when the qualification order alters the volume or timing of passing flows or releases from environmental entitlements. For example, in qualifying passing flows below a dam for the benefit of urban water supply, the Minister required the proponent "to develop and implement measures at its cost to ensure that a basic domestic and stock supply was maintained to affected rural landholders" located below the dam (Victoria DEPI n.d.).

Although passing flows and held environmental water are essential to the protection of fish and wildlife—including species listed for protection under Australia's Environment Protection and Biodiversity Conservation Act of 1999 (Australia 2015)—there is no legal prohibition on the qualification of these rights if the minister concludes, based on the criteria described above, that the water that otherwise would be delivered to support these species instead be allocated to vital domestic and economic uses. Critics of the Victoria Water Act have argued that the law should be amended to establish strict criteria to guide and limit the qualification of passing flows and environmental entitlements (Environment Victoria 2010).

Conclusion

As noted at the outset, California's and Victoria's legal systems share the common goal of accommodating and balancing the interests of assuring a reliable water supply for irrigation, urban, and other beneficial uses of water while also protecting fish and wildlife that rely upon freshwater flows. Yet, each state has chosen to pursue this goal in very different ways.

Victoria's laws allow for more flexible and responsive management of environmental water than does California's legal regime. Victoria better integrates environmental uses into its water rights system. Water for the protection *and* enhancement of fish, aquatic habitat, and wetlands has the same legal status as do water entitlements for municipal and irrigation uses. By contrast, with few and isolated exceptions, California defines the water that state and federal law allocates to environmental uses as a *limitation* on the exercise of water rights, rather than a water right itself.

Victoria also infuses its environmental watering program into all aspects of water planning and administration. This enables the state to define its environmental watering goals in a manner that accounts for seasonal and annual hydrologic variability, and to update both the goals and specific allocations of water to environmental uses as conditions change (Mount et al. 2016). In contrast, California (and federal) water regulators revise water quality standards and endangered species protections on a less regular basis, relying instead on temporary changes in water rights and modification of project operational standards to adjust allocations between environmental uses and water right-holders during periods of acute shortage (Gray et al. 2015).

Victoria's inclusion of environmental water in its system of water entitlements and shares also allows the VEWH and the other environmental water holders to manage that water flexibly as conditions warrant, including purchasing additional water over time and selling water when the full seasonal environmental allocation is not needed for instream and wetlands uses. In contrast, the lion's share of California's environmental water—which is set aside by state and federal regulations as minimum water quality and flow requirements—may not be traded. Only the small volumes held as instream water rights may be transferred.

Finally, Victoria law requires environmental allocations to be reduced in times of shortage commensurate with reductions in other high-reliability shares. This stands in marked contrast with California's system in which water rights—including instream water rights—are curtailed in reverse order of their priority. Thus, during times of shortage, if instream water rights are among the junior rights in a particular watershed, they are cut off completely to allow for full supplies to senior appropriators. More importantly, California's principal environmental water—that which is unavailable for diversion and use under the state and federal environmental laws—is not subject to curtailment because it is not held as a water right. Although these laws (in varying degrees) allow for planned or ad hoc adjustments in water quality and flow standards in response to variable hydrologic conditions, the alteration of environmental standards is not linked to the curtailment of water rights. Indeed, it is unusual for environmental regulatory standards to be relaxed significantly in times of drought as the fish that depend on these minimum volumetric and flow requirements are often under greater than normal stress due to the relative lack of water.

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