Water Resources

3.2 Water Resources

Key Findings

- Serious rainfall deficiencies over the past 11 years have reduced inflows to storages 30–60% below long-term averages. Water scarcity has been statewide in extent, exacerbated by high temperatures, and has worsened over time, with flow in the Murray and Melbourne storages reaching record lows in 2006.
- The harvesting of water from rivers and aquifers, altered flow regimes, loss of habitat connectivity and water pollution are key pressures on the environment arising from the State's water management. Drought and climate change compound these pressures.
- With climate change, streamflow may decrease by up to 50% across much of Victoria by 2070 compared to long-term average streamflow, further increasing competition for water resources.
- Victoria is heavily reliant on surface water (84% of water harvested), despite the increasing use of groundwater (13%) and recycled water (3%). The total volume of water harvested in 2006–07 was 4,094,030 ML.
- In the past four years, over 75% of the total flow was harvested for consumptive use from a quarter of Victoria's river basins. These were also the basins experiencing the greatest reductions in flow.
- In August 2008, groundwater levels in half of the most highly developed or potentially stressed groundwater management units (Water Supply Protection Areas) were at their lowest on record.
- Approximately one-quarter of water harvested in Victoria was lost or unaccounted in 2005-06, which equates to about three times the water consumed in metropolitan Melbourne. The Victorian Government is making significant investments to reduce unaccounted water in rural water supply systems.
- Irrigated agriculture is the largest single sector of water consumption and accounts for about 74% of surface water consumed in Victoria. Allocations have been markedly reduced due to water scarcity in the past few years.
- Melbourne accounts for about 10% of total water harvested for consumption. *Per capita* water consumption has decreased by 34% in 2006-07 compared to the average of the 1990s.
- A six-fold increase in the consumption of recycled wastewater in Victoria has occurred over the past decade. In 2006-07, 95,500 ML or about 1/4 of the total wastewater produced across Victoria was recycled.
- A water conservation ethos has emerged in response to water scarcity, which in combination with restrictions, and a range of demand management measures, has resulted in significant decreases in residential and non-residential water consumption, both in Melbourne and regional Victoria.
- The Victorian Allocation Framework is fundamental to the management of water resources in Victoria. The principle of protecting private rights to water is central to the allocation framework.
- Significant improvements in the way water is managed for the environment have occurred in the past decade, including the recognition of the environment's right to water in the allocation framework, commitments to improve flow regimes; better water accounting and scientific understanding.
- During times of low streamflow, the current allocation system reduces environmental flows more than it reduces water for consumptive uses.
- The urgency for government action has been accelerated by the reality of irretrievable ecological damage caused by past and current management practices, prolonged water scarcity leading to reduced security of supply and climate change projections.
- Providing and protecting adequate flow regimes and water levels in rivers and aquifers remains a central issue. Adequate flow regimes and environmental water reserves are yet to be agreed for many rivers and aquifers across Victoria. These are being developed through Regional Sustainable Water Strategies and other government programs.
- Rivers are mostly connected to groundwater, yet they are currently managed separately. An integrated management approach is being trialled through the *Upper Ovens Stream Flow Management Plan*.
- The Victorian Government and water corporations have implemented demand management strategies and commenced major infrastructure programs, such as the desalination plant for Melbourne and pipelines to connect water supply systems, in response to current and projected risks to the security of urban water supply.
- The implementation of a diverse range of water use efficiency and conservation strategies, and decentralised water systems, should continue in conjunction with major source augmentation projects to minimise the cost and environmental impact of improved urban water supply security.
- Urban water resources planning now accounts for the possibility that the historically low streamflows recorded over the last three years may continue into the future.
- Victoria is recognised for its leadership in water resources management, which is rapidly increasing in sophistication and accountability, but to date this has not been enough to secure the health of inland waters.
- The sharing of water between competing consumptive and environmental uses ultimately involves social and therefore political choices. Traditionally the environment has been the loser. Difficult decisions will need to be made in future, as water availability declines, and pressures on natural resources, and the need to maintain healthy and productive ecosystems, increases.

This section should be read in conjunction with Part 4.3 Inland Waters, which reports on the current condition of rivers, wetland and aquifers.

Objectives

- Maintain and improve the environmental condition of rivers, lakes, wetlands, estuaries and aquifers
- Improve efficiency of water use
- Manage the total water cycle to maintain and build resilience in human settlements and environmental systems

Description

Streamflow in Australia is highly variable. In response, human settlements have transformed inland waters into a complex and extensive system for harvesting, transporting and controlling the movement of water[1], with the highest levels of per-capita storage in the world[2]. Australia's intensity of water use is amongst the highest in the OECD on a per capita basis[3].

For much of the twentieth century, management of Victoria's inland waters was closely allied with a drive for development, which was seen as unquestionably desirable. Accordingly, government investment in water supply and infrastructure augmentations has distorted prices, encouraged excessive and inefficient consumption and largely ignored associated environmental impacts[4]. Today the river systems are environmentally degraded.

A prolonged drought has focused attention on the management and use of water in Victoria. In recent years, the State has struggled to meet demand for water. The view that climate change has played a hand in reducing water availability has heightened concerns and helped to spur government action. Since the 1980s, governments have gradually recognised that past use of water resources has left a legacy of environmental damage and that improving water resource management is critical to achieving sustainability[5]. However, the implementation of reforms has been inadequate, especially in relation to over-allocation of water for irrigated agriculture and the impacts of incremental water resource development[6].

Although often perceived as a common good to be shared by all, entitlements to water use have strong property rights attached[7]. Property rights provide the certainty and security required for investment in primary industries. Historically, the flow regimes required to maintain river systems were not recognised; where adequate flows were not provided, rivers suffered. The allocation framework now recognises the environment's legal right to water, although it can be qualified by ministerial discretion. Higher levels of harvesting from the environment have been limited through caps, and the role of markets in the allocation of water for agriculture has been encouraged[8].

Further adjustments to consumption and property rights to water are now needed to ensure that the health of Victoria's rivers improves. In doing so, care is required to minimise undesirable social and economic consequences. Resistance to change is reinforced by the nature of water infrastructure, which is long-lasting and reliable but also inflexible and expensive to replace.

Improved distribution efficiency and water use efficiency is essential to economic prosperity and to accommodate population growth. This requires improved management of supply and demand in the context of the total water cycle. Managing the total water cycle means considering all its parts, natural and constructed, surface and sub-surface, and recognising them as an integrated system[9]. It means recognising that water has many users on its journey through the catchment, and is able to support several uses simultaneously. Diversifying source options and reusing water as many times as possible through a mix of centralised and decentralised approaches are important aspects of improved urban water supply. On the demand side, promotion of conservation measures and water use efficiency must continue.

Water resources planning has in the past assumed that rainfall and runoff fluctuates within an unchanging envelope of variability[10]. In the face of water scarcity and climate change, however, long term historical averages can no longer be used to plan for the future, and new approaches to assessing resource availability are developing.

The Victorian Government, Commonwealth Government and water authorities have responded to the crisis by committing approximately $7.05 billion over the next decade to major water supply infrastructure projects in Victoria. Victoria has established a 15 year *Statewide Water Resource Review* and *Sustainable Water Strategies* to enable long term, large scale decisions on water use, and share available water between competing users.

Providing inland waters with adequate flow regimes is essential to the maintenance of environmental values and the ecological processes on which humans depend. This is not well accepted even today. Living well within our environment requires a greater appreciation of the periods of drought and flooding that support inland waters, a thorough rethinking of how our social and economic systems interact within these cycles, and a recognition that ultimately there is no way to live independent from them.

This section examines the availability and consumption of water in Victoria and the pressures that consumption places on the environment. Key management responses to these pressures are outlined. The impacts of these pressures, and the condition of inland waters, are discussed in 4.3 Inland Waters.

Water Resources

Surface water resources—rivers, streams, lakes and dams—are the most abundant fresh water resources in Victoria, followed by groundwater and recycled water (see Figure WR1). Vast marine water resources are also accessible along Victoria's coast.

These resources are interconnected in the water cycle (see Figure WR2). Approximately 15% of rainfall becomes surface runoff and streamflow, and only one per cent is stored as groundwater[11].

Surface water and groundwater are connected. In unmodified rivers, almost all of the flow in the dry season is provided by groundwater discharge. In southern Australia, about half of the total flow in perennial rivers is due to baseflow, of which groundwater is a major component[12]. Seepage from surface waters also supports groundwater levels. In this chapter these resources are presented separately to illustrate available stocks. Water resources in this section are presented in terms of long term average availability and variability, but also in the context of the current drought and projected changes in water availability under climate change.

This section presents the availability of rainfall, surface water and groundwater. Recycled water is discussed in Water harvesting, Urban water harvesting. Available water is shared between competing users through the allocation framework (see Box WR1).

Figure WR1. Relative abundance of water resources in Victoria, 2006-07
Source: Victorian Government (2008)

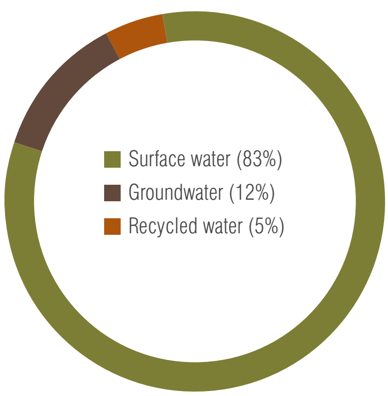
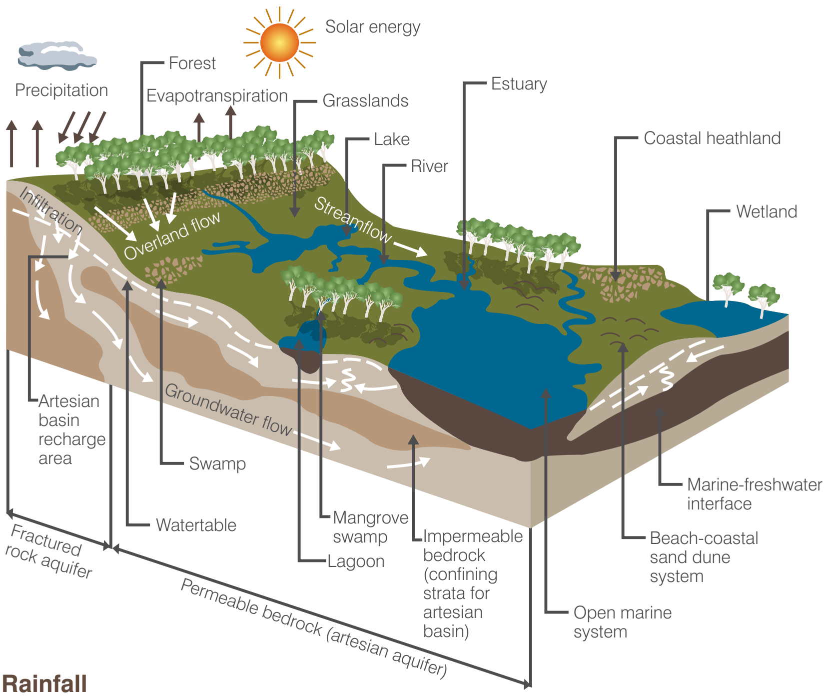


Figure WR2. The water cycle
Source: in Evans, R. (2007) The Impact of Groundwater Use on Australia's Rivers



Rainfall

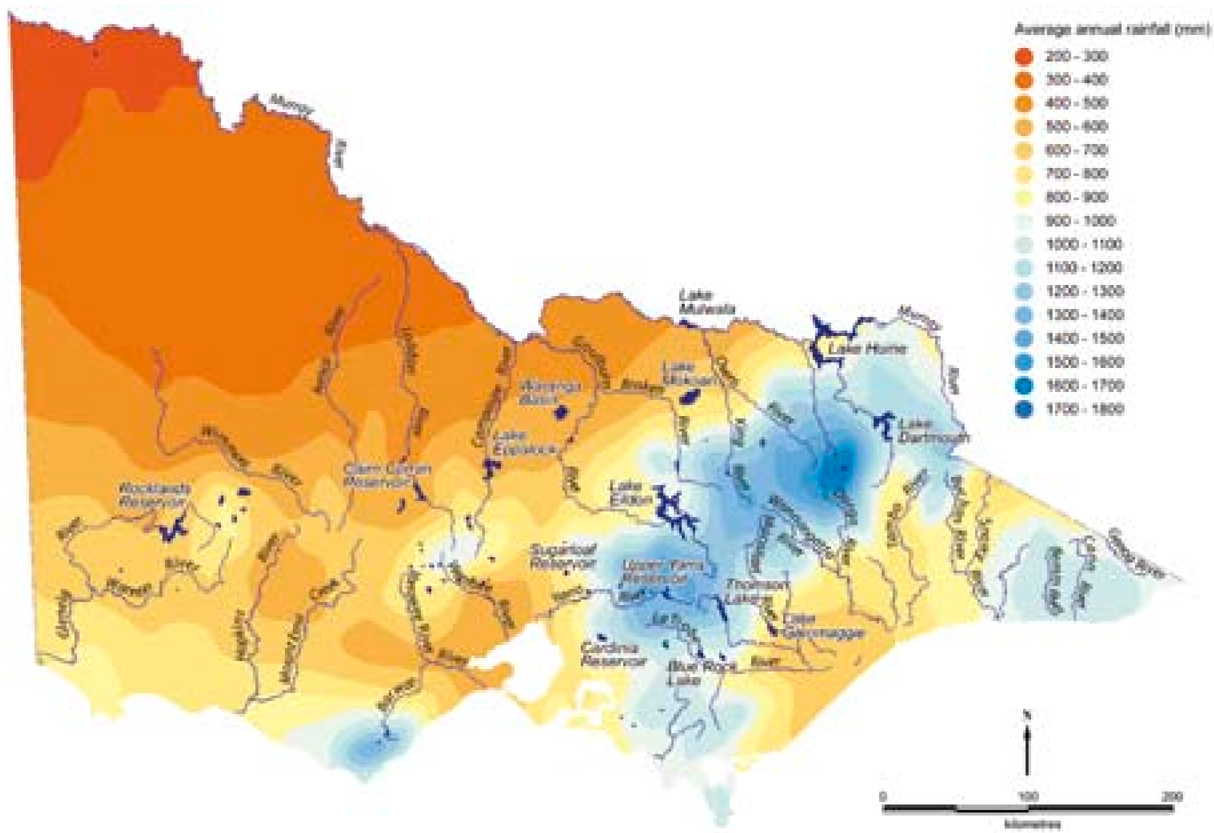
Victoria's water resources are shaped by its climate, particularly rainfall patterns. The average annual rainfall in Victoria from 1961 to 1990 was less than 300mm in the North West but higher in the mountainous regions, with the alpine areas receiving up to 1,800 mm (see Figure WR3)[13]. Rainfall is more reliable south of the Great Dividing Range[14]. Rainfall is generally heaviest in winter and lowest in summer, although in East Gippsland seasonal variations are not as pronounced[15].

Over the past 11 years, the majority of Victoria has experienced serious rainfall deficiencies, with large areas including the Port Phillip, Westernport and Wimmera regions experiencing lowest levels on record (see 4.1 Atmosphere, Climate Change). Over south-eastern Australia, 61% of the rainfall decline has occurred due to much drier autumns[16]. Autumn rainfall in Victoria has decreased by 40% between 1950 and 2006, compared to the long-term seasonal average[17]. It is highly likely that these rainfall deficits are linked to global warming[18].

The past 11 years has also been unusually warm with temperatures 0.5-1°C above the long-term average (see 4.1 Atmosphere, Climate Change), which has increased the impact of evaporation on water storages and soil moisture. Analysis of data from 1950 to 2006 show that a rise of 1°C in the Murray Darling Basin leads to an approximate 15% reduction in the annual climatological inflow, even if rainfall does not change[19].

Victoria has had only one year in the past 11 with annual rainfall above the long-term average. This succession of dry years has made it impossible for soil moisture to recover, leading to reduced streamflows and increasing impacts on hydrological and agricultural systems.

Figure WR3. Major rivers and storages in Victoria, with rainfall contours, 1961–1990
Source: Bureau of Meteorology, Department of Sustainability and Environment[20]



Surface Water

Current levels of consumption and modification of the flow regimes of surface waters for consumptive uses have degraded the condition of inland waters and are, in many cases, unsustainable[21] (see Pressures on the environment). There are very few opportunities to divert more water from rivers[22].

Streamflow in Victoria is highly variable, with most basins receiving only a fraction of their average flow in most years. The generally dry conditions are punctuated by wet years with flows well in excess of the average, which replenish storages and river systems.

Over the past 11 years, the scarcity of surface water in Victoria has reached levels without historical precedent (see Figures WR4-6). Victoria is largely dependent on surface water, and the impact of water shortages has been increased by their statewide extent, high temperatures and the deepening scarcity of water over time. In 2006, both the River Murray and Melbourne's reservoirs experienced their lowest inflows on record (see Figures WR5 and WR6)[23], and in 2006-07, the State's inflows were 26% of their long term average[24]. Fifteen of Victoria's 29 river basins recorded inflows below 20% of the long term average in 2006-07, including the Murray at 16%, and only the Snowy and East Gippsland Basins recorded inflows greater than 50% of the average[25]. For the Loddon and Wimmera basins, the average flow for the 10 years to 2006 has been only 33% and 17%, respectively, of the long-term average.

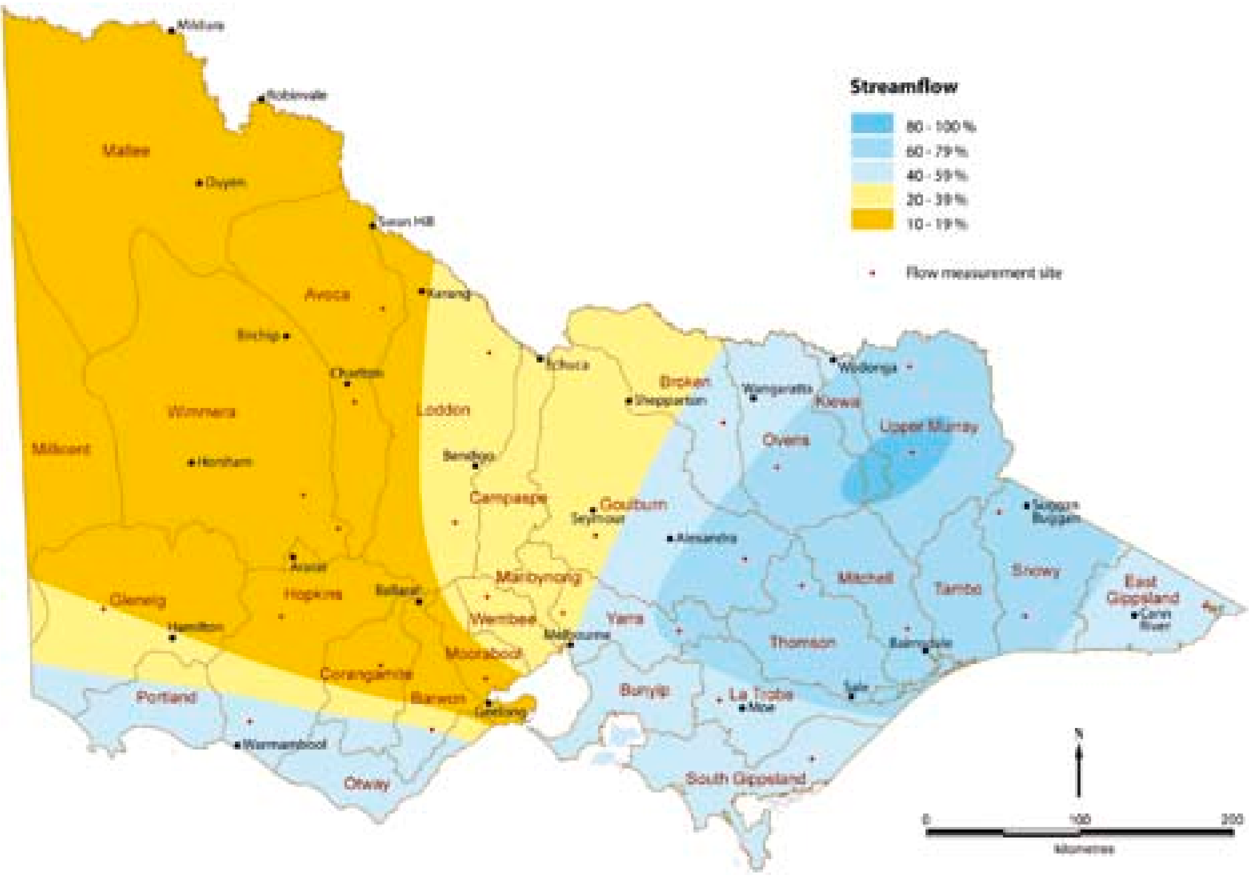
The availability and reliability of surface water resources varies across Victoria. Surface water is more readily available in the eastern half of Victoria, which generates up to 80% of the State's streamflow[26]. Rivers with the most constant flow tend to have their headwaters in the mountainous, high-rainfall areas of Victoria, such as the Otway Ranges and the State's north east, whereas rivers with highly variable flow are more common in low-rainfall regions. Many basins including the Wimmera/Avon, Broken, Loddon and Campaspe do not receive more than about 30% of their annual average streamflow in 50% of years[27]. Basins in Victoria with the most reliable streamflow such as the Upper Murray, Bunyip and Latrobe Basins do not receive more than about 70% of their annual average flow, in about 50% of years[28].

The availability of water varies significantly from season to season. Across the State, streamflow is lowest in late summer and autumn, with about 60% of annual average streamflow between July and October[29].

One of the iconic rivers in eastern Victoria is the Snowy River. After the construction of the Snowy Mountains Hydro-electric Scheme in NSW in 1967, only one per cent of its total flow downstream of the scheme remained (see Water Harvesting).[i] This report discusses the Victorian component of the Snowy River's flow, while acknowledging that it is severely reduced. The River Murray, the biggest river in Victoria, has its flows reduced and regulated by diversions within its catchment upstream of Victoria, but nevertheless it still provides large volumes of fresh water to Victoria's dry Mallee.

The quality of surface waters is important for both consumption and the maintenance of environmental condition.

Figure WR4. Reduction in streamflow, July 1997 to June 2007, compared to the long term average
Source: DSE (2008)[32]



i The Victorian, NSW and Commonwealth Governments have committed to return 21% of annual natural flow by 2012, but at present the provision of flows is behind schedule (see Management Responses).

Water quality reflects the extent to which the catchment is modified, and how it is managed. Drinking water must be of high quality; to ensure this, potable water supply catchments are managed more strictly than others. There are 134 declared water supply catchments across Victoria[30].

A feature of Melbourne's water supply is its declared catchments. These uninhabited, forested regions above the Upper Yarra, Maroondah and O'Shannassy reservoirs supply high-quality drinking water requiring little treatment. By 2050, an estimated 30GL a year yield could be derived from these catchments by preventing clear-felling[31]. Factors such as salinity, turbidity, nutrient or pathogen levels affect the range of uses for which water is suitable, and the cost of water treatment.

Recommendation

WR1 The Victorian Government should assess the merit of removing logging from Melbourne's water supply catchments, to maximise catchment yield and water quality.

Figure WR5 River Murray inflows from 1891 to 2007
Source: Victorian Government (2007)[33]

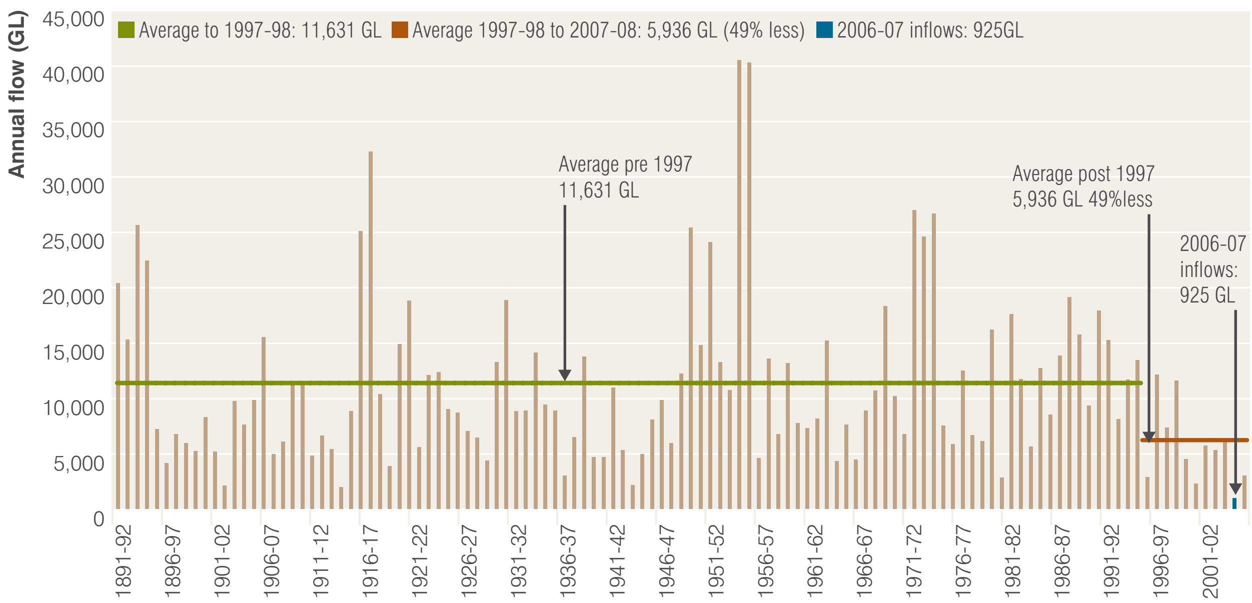
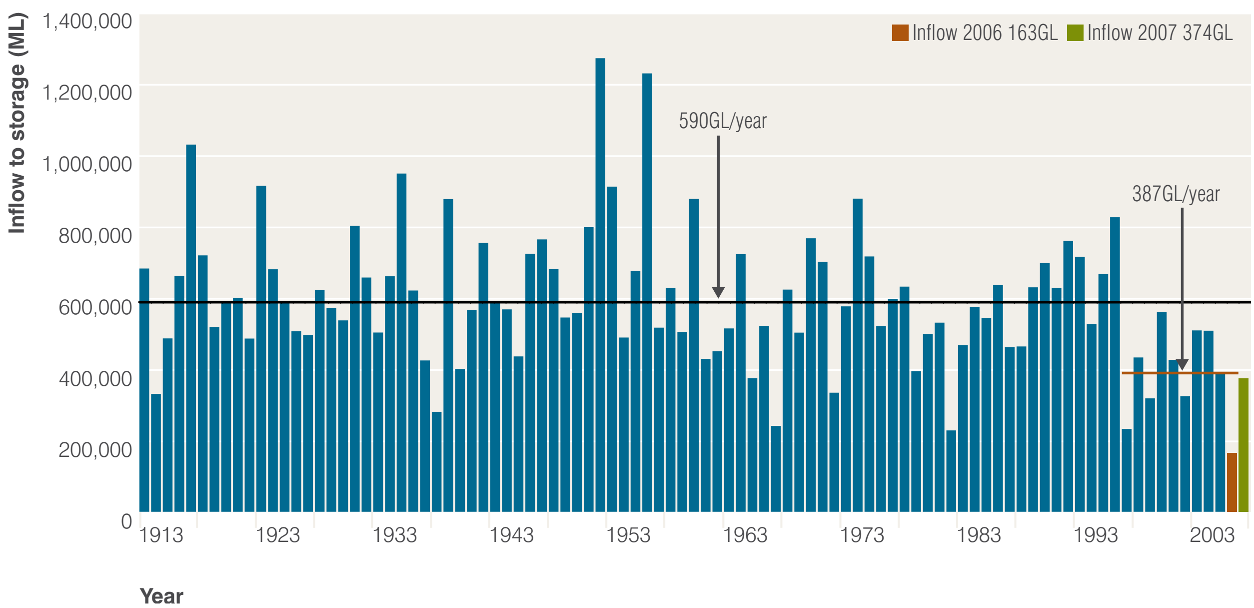


Figure WR6 Inflows to Main Harvesting Reservoirs supplying Melbourne, 1913–2007 (Thomson, Upper Yarra, O'Shannassy and Moroodah Reservoirs)
Source: Melbourne Water[34]



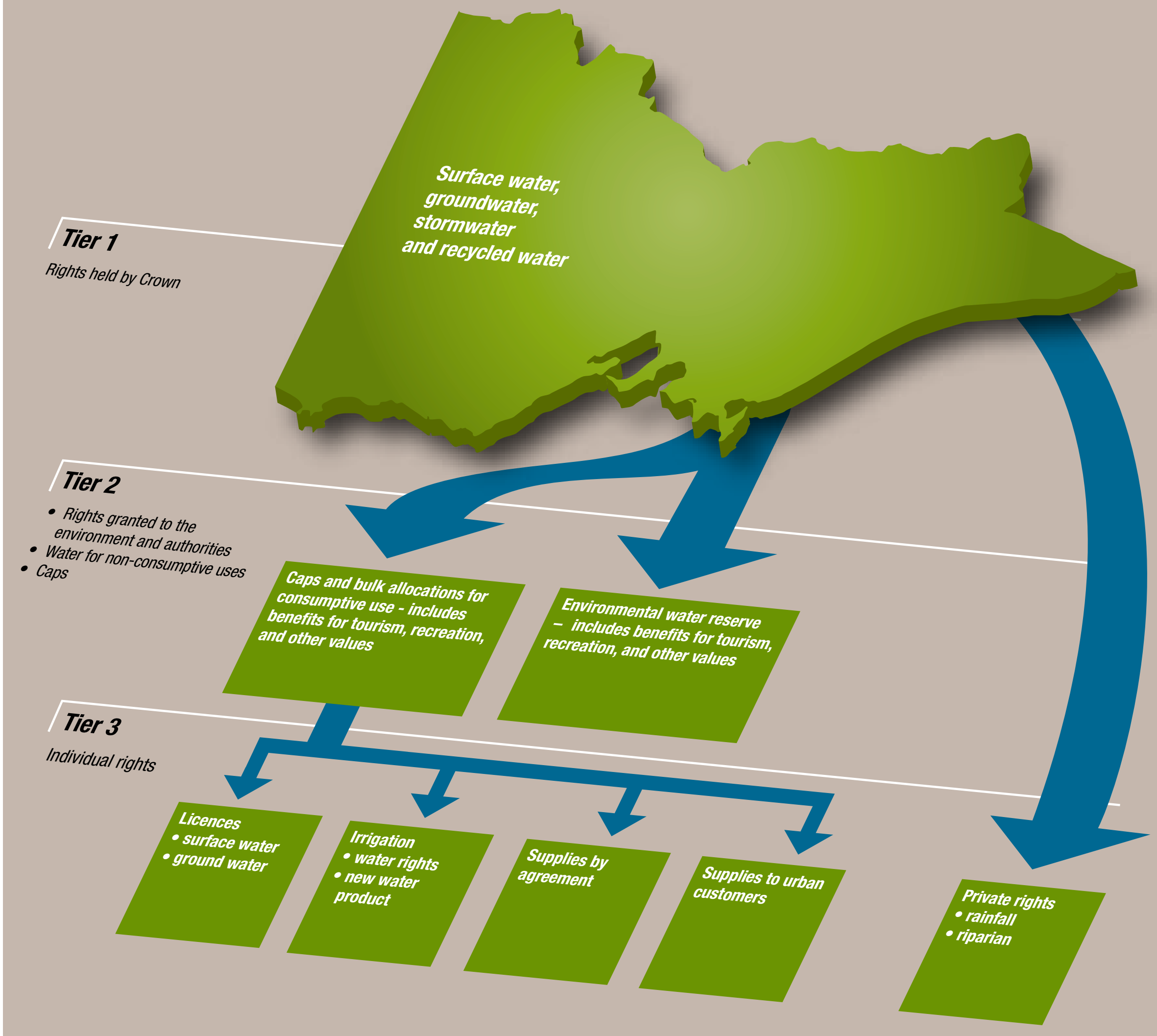
Box WR1 Allocation Framework

Water availability varies greatly over time, is often difficult to define in terms of its extent, is vital for ecological health, regional economies and communities, and is a basic requirement for human life[35]. Any framework for allocating water has to work within these constraints to share a "consumptive pool" of water between competing users.

Central to the Victorian allocation system, is the principle of protecting private rights to water[36]. The State, under the Water Act 1989, retains the overall right to the use, flow and control of all surface water and groundwater on behalf of all Victorians (see Figure WR7)[37]. The environment has a right to water, known as the environmental water reserve, which was created in 2005 through the *Our Water Our Future* reform of the allocation framework. Entitlements, which specify the maximum amount of water taken and used under specific conditions, are issued to individuals and organisations[38]. Four different types of entitlements are issued: bulk entitlements; environmental entitlements; water shares; and water licences[39]. Water shares for irrigation were simplified by *Our Water Our Future* into two kinds of shares: high reliability and low reliability shares[40]. Environmental entitlements allow water to be legally set aside for environmental use. Other provisions allow for water to be taken for domestic and stock purposes without an entitlement[41].

Entitlements have ongoing or indefinite tenure. A significant change to the allocation system, also introduced in *Our Water Our Future* is the 15 year Statewide Water Resource Review. This review is undertaken to determine whether the resource base has suffered a decline, if it has fallen disproportionately on the environment or water users; and if river health is declining for flow related reasons[42]. Through this process the government may, as a last resort, adjust entitlements.

Figure WR7 Victoria's Water Allocation Framework.[43]



Other important elements of the allocation framework are caps, allocations and a market based trading system. Caps are limits on the amount of water extracted from either a surface water or groundwater geographic area. Allocations are the amount of water that can be used under an entitlement, each year[44]. Allocations do not always equal the entitlement volume, as allocations are reduced according to water availability in dry years. Historically, access to 100% of the entitlement volume plus a share of an additional, lower reliability consumptive pool (low reliability shares) has generally been available[45]. When an entitlement holder has used his/her allocation, no further water is available except through trading on the water market. Further conditions on the extraction and use of both surface and groundwater are placed through conditions on entitlements and licences; surface water management plans, groundwater management plans, water supply protection area plans and local diversion rules.

Bulk entitlements held by urban water corporations govern the rules through which water is taken for towns. The bulk entitlements generally prescribe a cap, extraction rate and obligation to pass flows below dams and weirs. Urban water corporations can participate in the market.

Over-allocation

Too much water is now being taken out of many of Victoria's rivers, wetlands and aquifers[46]. The excessive extraction of water is commonly referred to as over-allocation, but a distinction is made between over-allocation and over-use. Over-allocation is the situation where more entitlements have been issued in a system than can be sustained. Despite the serious damage to river health and broad acceptance of the reality of over-allocation particularly in the Murray Darling Basin, showing it analytically is difficult. There is no national standardised, agreed method of showing over-allocation, or calculating sustainable yield[47]. Over-use is when the volume of water taken from the system exceeds the allocation. This can occur, for example, due to high allocations, or the disproportionate reduction in water available for the environment during times of low streamflow.

The impact of extraction of surface waters is considered in terms of its impact on the flow regime, which is the sequence of flow events that vary in timing, size and duration, and the role of the flow regime in supporting different ecological functions (see Part 4.3 Inland Waters). The sequence may be quite variable on an annual basis but often shows predictable patterns over inter-annual and longer term periods. The harvesting of water for consumption is only one pressure on flow regimes. Other significant changes to flow regimes are caused by the infrastructure used to control the flow of water, such as dams; and the timing of water releases for hydro-electricity generation and use of rivers to convey irrigation and urban water supplies. Drought compounds the impact of these pressures. The condition of a flow regime is not determined through the amount of water harvested, but by a comparison of the observed state to an estimated natural state for the different components of the flow regime (see Part 4.3 Inland Waters, Flow regimes).

Caps on surface and ground water extraction across Victoria were established under *Our Water Our Future*, in addition to those already in place in the Murray-Darling Basin. Where over-allocation was deemed to have occurred, caps were based on existing entitlements and levels of development, rather than an assessment of the seasonal flow requirements of rivers or aquifers[48]. In catchments where development levels were low, caps were established on the basis of protecting environmental values. This allows for water resource development whilst protecting environmental values. Caps are fundamental elements of the allocation framework, as they prevent further water resource development in over-allocated or fully allocated systems, protecting the rights of existing water users and the environment. These caps do not address current levels of over-allocation, or the impacts of altered flow regimes.

Where over-allocation has occurred, water must be recovered to augment the flow regime. The next 15 year water resource review will occur in 2019, but this is too late. Currently, initiatives are focused on investing in distribution savings; enabling donations and investment in reconfiguring irrigation systems (see Part 4.3: Inland Waters, IW1 Flow regimes). Decisions relating to the need and methods of water recovery are made through the Regional Sustainable Water strategies, and generally protect existing entitlements from any impacts. A number of improvements to flow regimes have been made throughout Victoria, but these have been largely masked by the current drought and qualifications to environmental flows. Investment in water infrastructure and water recovery by the Victorian Government, as well as other states and the Commonwealth, needs to be coordinated to the highest level, to avoid policies and projects with conflicting outcomes. A greater range of options for improving flow regimes needs to be considered, as to date the seasonal flow requirements of many rivers in Victoria have not been met.

Recommendation

WR2 Investment in water infrastructure and water recovery by the Victorian Government, as well as other states and the Commonwealth, needs to be coordinated to the highest level, to avoid policies and projects with conflicting outcomes.

Water Storages

Major Storages

Recognition of the potential impact of drought on consumptive uses in Australia has led to the highest levels of per-capita storage in the world[49]. Throughout Victoria, major storages have been developed to reduce natural fluctuations in river flow and provide a continuous and reliable water supply to consumers. The total volume of storages for Melbourne's water supply is 1,773 GL and major regional storages have a volume of 9,767 GL[50]. Dams and weirs constructed across rivers and streams also allow for regulation of the flow downstream. In some cases, weir pools and ponds have been established and maintained purely for ornamental purposes.

Dams and weirs are the most common alteration to the flow regime of streams and a major cause of pressures to river systems[51] (see Pressures on the Environment). New on-stream storages are not supported under current government policy as they do not create new water; the amount of surface water that can be extracted is already capped; the best sites for storages are already used; they damage river health; and the increasing inter-connection of water supply systems reduces the need to build more storages locally[52]. Only two large rivers in Victoria – the Mitchell and the Ovens – are relatively intact through the entire system and they contribute significantly to the health of the Gippsland Lakes and River Murray, respectively.

In five basins the total storage capacity is greater than the total annual average flow in that basin (see Figure WR8). The three largest storages in Victoria are the Dartmouth Reservoir (3,906 GL) and Hume Dam (3,038 GL) in the Upper Murray Basin, and Lake Eildon (3,390 GL) in the Goulburn Basin (see Figure WR3, WR8). Under the Murray-Darling Basin Agreement, the Dartmouth and Hume storage capacity is shared with NSW, and minimum flows for South Australia are specified[53]. Melbourne's largest water storage is the Thomson reservoir (1,123 GL), which was constructed in 1983.

Average inflows to storages over the last 10 years have generally been 30–60% below the long-term average[54]. As a result of extended periods of low flow, storages in the Wimmera/Glenelg, Maribyrnong, Campaspe and Werribee basins were less than 10% full at the end of 2006–07 (see Figure WR9). Melbourne's water storages have declined steadily since 1997, triggering water restrictions and major investment in water supply infrastructure (see Water harvesting, Melbourne water grid).

Evaporation can result in huge losses from storages. In 2006–07, approximately 308 GL of water evaporated from major storages across Victoria[57]. The impact of evaporation increases for shallow dams, particularly in arid regions. Lake Victoria and the Menindee Lakes in NSW, which supply water to Victoria, lost about 210 GL to evaporation in 2007, but lost over 700 GL to evaporation in 2001 when water levels were higher[58]. A storage considered to have unacceptably high rates of evaporation is Lake Mokoan, which is currently being decommissioned. Created in 1971 to serve the Murray and Goulburn irrigation areas, the lake loses five times as much water through evaporation as the city of Shepparton consumes in a year[59]. Water authorities are increasingly managing storages to reduce evaporation[60], but more could be done throughout the Basin and the rest of Victoria to account for and then limit the amount of water lost to evaporation.

Figure WR8 Long-term average annual streamflows and total storage capacities (Victorian components only)
Source: Victorian Government (2007)[55]

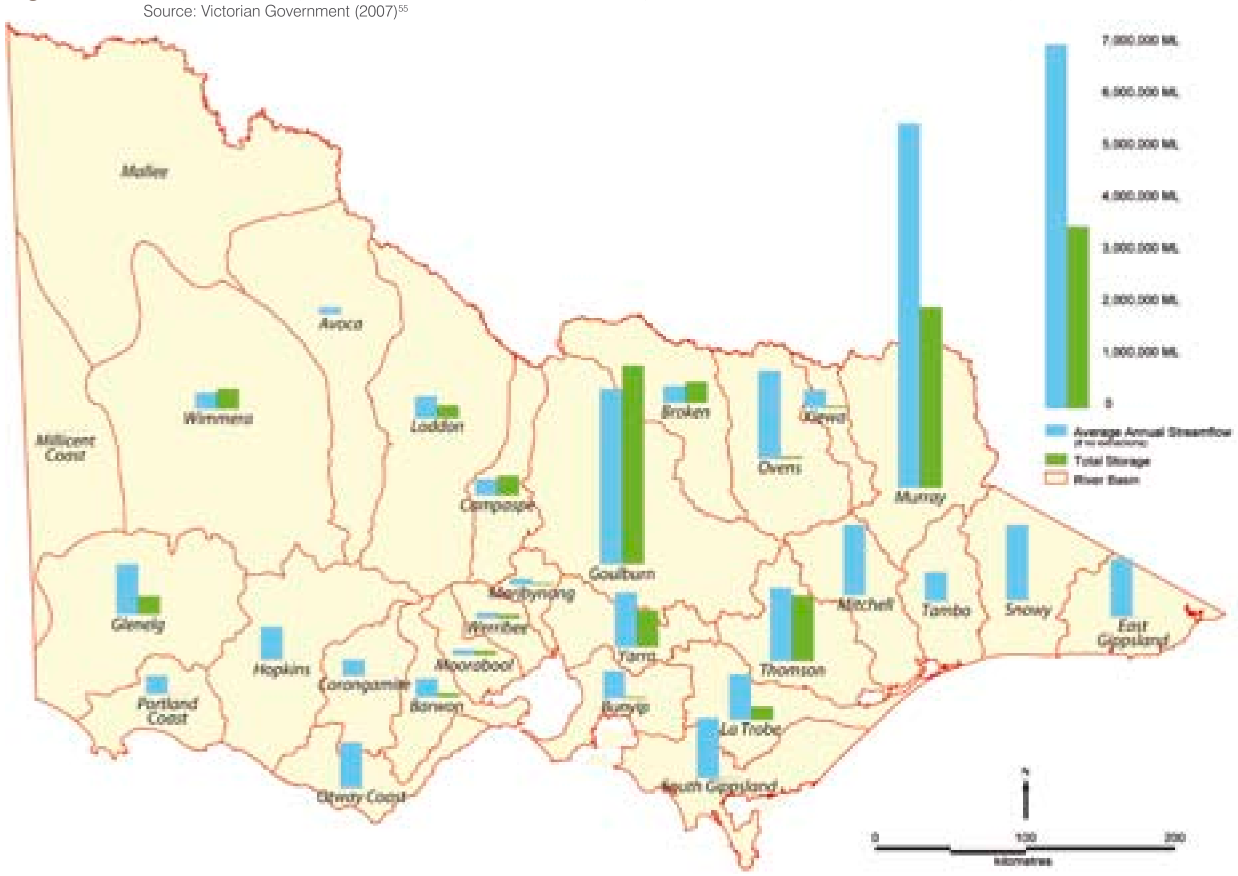
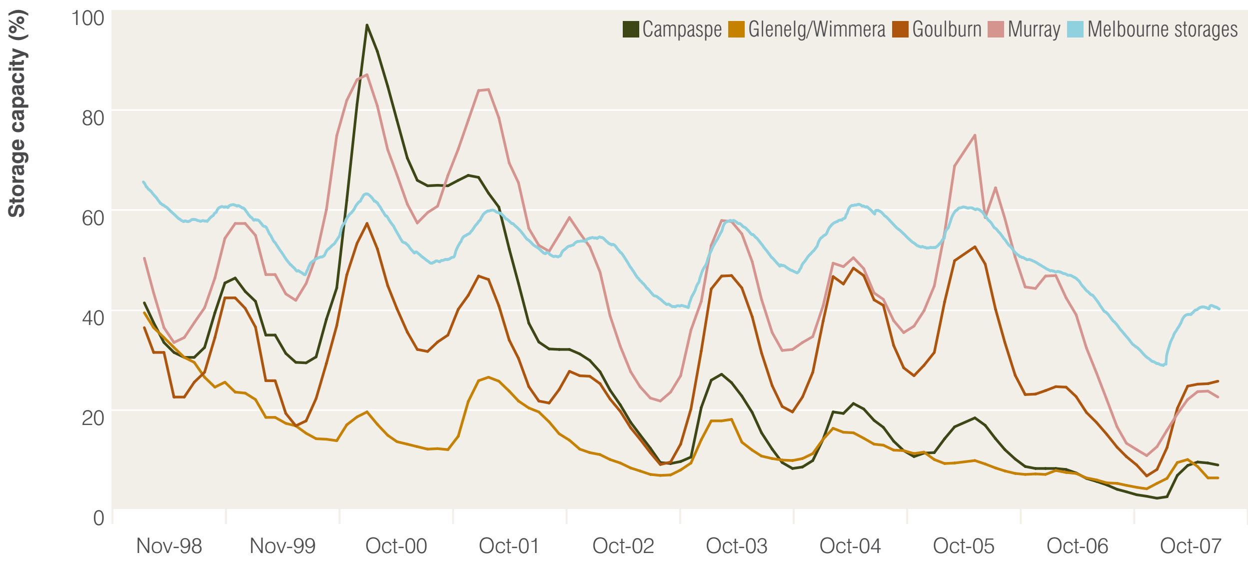


Figure WR9 Decreasing storage levels in selected basins and Melbourne's storages over the past decade
Source: Victorian Government, Melbourne Water[56]



Farm Dams

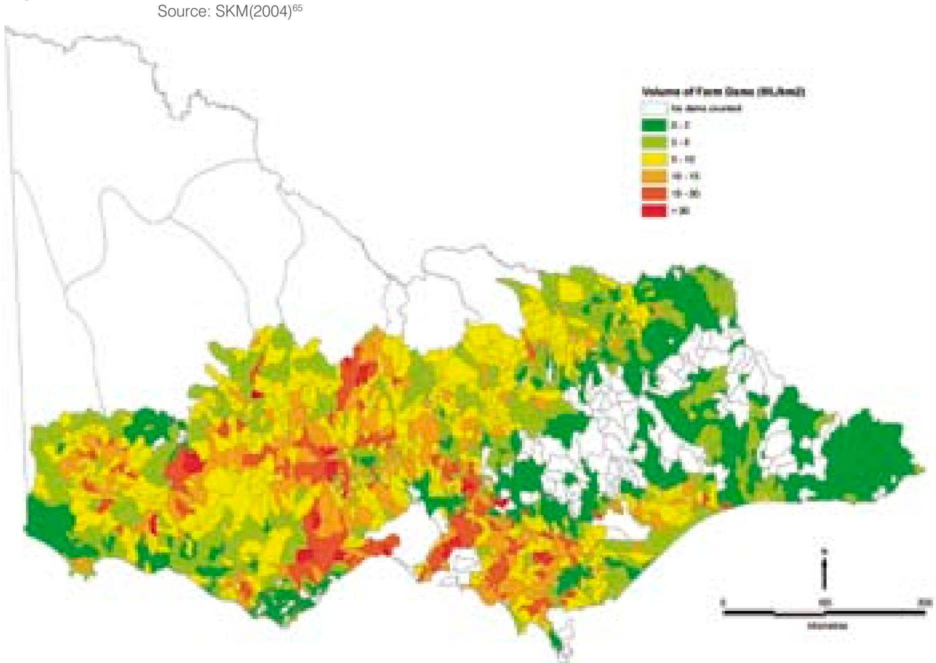
The number of farm dams has increased from 300,000 in 1988 to 355,000 in 2004–05, with an estimated capacity of 523 GL[61]. The current reduction in streamflow has increased the need for landowners to store water locally for stock and domestic water supply. On an individual basis this is justifiable, but the cumulative impact across a catchment can be substantial. By intercepting runoff, farm dams increase evaporation and reduce streamflow, and thereby affect flow regimes (see 4.3: Inland Waters, Altered flow regimes). For each megalitre of farm dam storage, average annual runoff is reduced by an estimated 0.84 ML[62]. Due to the shallow nature of farm dams, evaporation rates are high relative to major storages. In 2006–07, evaporation from farm dams in Victoria was about 226 GL[63]. This is equivalent to 73% of the evaporation from major storages, but from only about 5% of the capacity of major storages. In 2006–07, about 37% of inflows in the Hopkins Basin were captured by farm dams, almost half of which was lost to evaporation[64].

The concentration of farm dams is highest in the areas fringing Melbourne, particularly in the Moorabool, Barwon and Lake Corangamite areas (see Figure WR10). In the Moorabool catchment, farm dams are estimated to capture 18% of mean annual flow[66]. There is currently a moratorium on new allocations, and since 2002 licences were required for all new farm dams for commercial and irrigation use, but these measures will not prevent growth in farm dams for stock and domestic purposes[67]. The number of farm dams in the Yarra Valley and Mornington Peninsula also increased before 2002, to allow irrigation as vineyards expanded[68]. There is a need for a clear policy on domestic and stock and aesthetic farm dams to manage their cumulative impact on streamflow, particularly in peri-urban areas.

Recommendation

WR3 The Victorian Government should review policy on farm dams to control their cumulative impact on streamflow, particularly in peri-urban areas.

Figure WR10. Farm dam storage capacity, represented as storage density (ML/km^2)
Source: SKM(2004)[65]



Groundwater

As surface water availability has declined, the use of groundwater to complement surface water sources has increased. About 60 Victorian towns use groundwater for at least some of their drinking supply[69], and in many regional areas, groundwater is the sole source of water[70].

Groundwater is simply underground water, stored in gaps or pore spaces between rocks, sand and gravel. Due to the different depths of aquifers, and varying speed with which the water moves through the ground, groundwater can have vastly different degrees of interaction with other elements of the water cycle. Some groundwater may not have any interaction with surface waters for thousands of years (eg in the Mallee), whereas other groundwater is functionally part of the river running immediately above it. The upper Ovens Basin, for example, is well known for the strong connection between surface water and groundwater.

Victoria's useable groundwater resource is relatively small and is about 10% of surface water sources[71]. The volume of groundwater able to be allocated in a discrete groundwater management area is known as a Permissible Consumptive Volume (PCV). PCVs have been declared for 57 groundwater management and water supply protection areas (see below).

In Victoria's south-west, groundwater is an important source of drinking water[72], with good quality water available. Groundwater salinity causes problems in the river basins which drain to the River Murray[73]. In the Shepparton Irrigation Region, for example, increased groundwater recharge has created a surficial aquifer (< 25m depth), whose depth to the surface needs to be closely managed to ensure it does not destroy land productivity.

Groundwater levels and their implications for land salinisation are discussed in Part 4.2 Land and Biodiversity, LB6 Salinity. Groundwater is also extracted in this region from underlying aquifers, such as the Katunga and Campaspe Deep Lead, which are at depths greater than 25m. Shallow groundwater in the Mallee and Wimmera regions is particularly saline, and there is only limited potential for economic use[74].

Managing groundwater

Aquifers must be managed to prevent over-extraction. In practice, this means some aquifers are managed according to extraction rates and water levels, as well as aquifer volume[75]. The use of groundwater for consumption is affected by water quality, aquifer depth, and the amount that can be extracted[76]. For management purposes, groundwater is divided into groundwater management units (GMUs). Groundwater management areas (GMAs) are individual aquifers, or groups of inter-related aquifers, where groundwater resources of a suitable quality for irrigation, commercial or domestic or stock use may be available[77]. When a GMA resource is stressed or under threat, the rural water corporation usually declares it a Water Supply Protection Area (WSPA). The area outside of GMAs and WSPAs is known as 'unincorporated area', where there is usually limited groundwater available. There are currently 40 GMAs in Victoria, 24 WSPAs, and three Unincorporated Areas (one per rural water corporation area) (see Figure WR11). In total 24 WSPAs have been declared, comprising 36% of all GMUs.

In the past, groundwater has not received the same degree of attention as surface water, because surface water was plentiful and cheaper to access, and groundwater is unseen, often poorly understood and relatively expensive to access. At a national level[78], implementation of groundwater policy has been slow and incomplete. Australia still has no agreed method for assessing the sustainable use of groundwater, almost a decade after it became COAG policy[79]. Significant work is required to improve the regulation of groundwater use at the national level. Whilst in Victoria surface water and groundwater are managed under similar though not yet integrated regimes, better scientific understanding of environmental requirements, as well as greater rigour of licensing and metering are still required for groundwater use to become as well regulated as surface water use.

Groundwater's involvement in the water cycle is complex and it must be assessed on a case by case basis, but this knowledge is required to improve water resource management. The practice of managing surface and groundwater as a single inter-connected system needs to be implemented in those parts of Victoria where connections are identified. This approach is currently being trialled through the development of the *Upper Ovens Stream Flow Management Plan*.

Recommendation

WR4 The practice of managing surface and groundwater as a single inter-connected system needs to be implemented over Victoria. The scientific rigour of groundwater management and implementation of Council of Australian Government Policy commitments should be improved as part of achieving this objective.

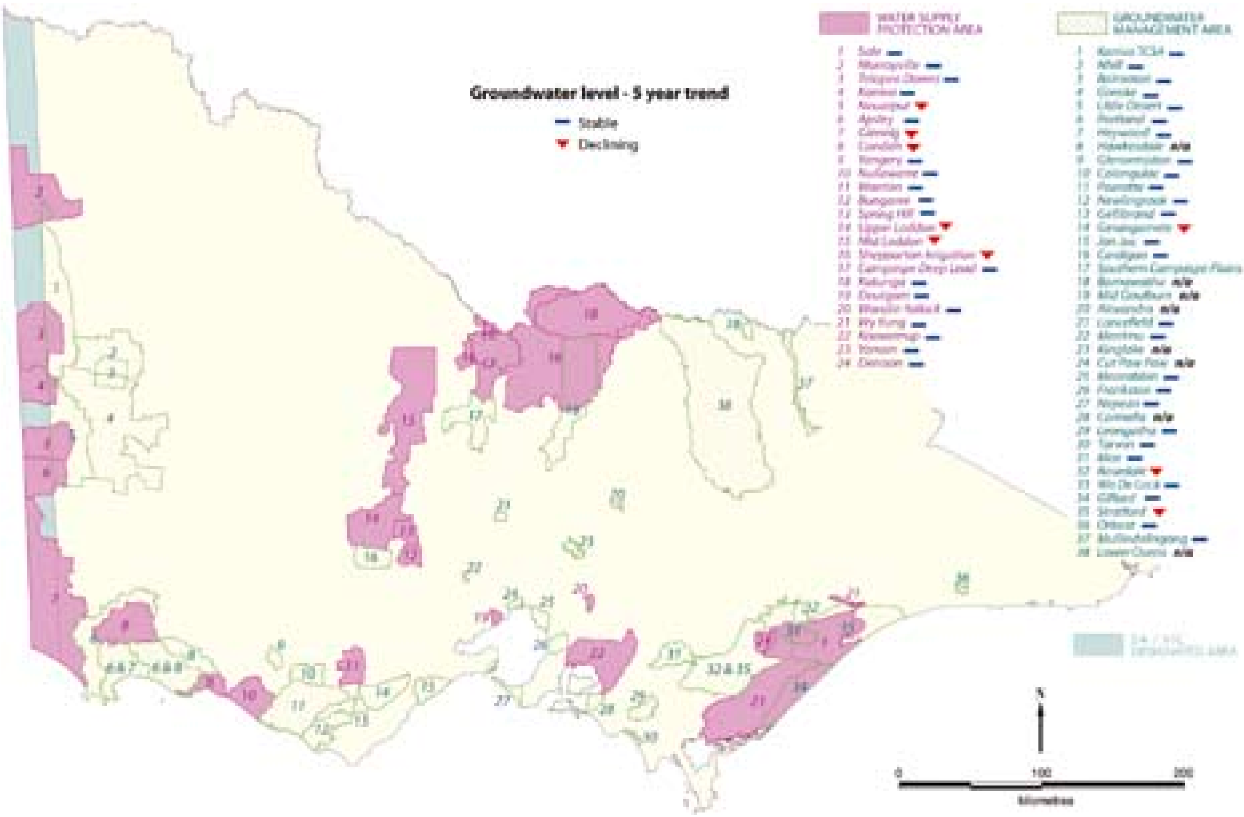
New industries or initiatives such as coal seam gas extraction and geo-thermal power also seek access to groundwater, particularly as the availability of surface water is limited. Other potential uses of aquifers include managed aquifer recharge where water, such as recycled water or stormwater is stored for later extraction, and carbon sequestration, which is the long-term/permanent storage of carbon dioxide in the pore spaces of aquifers.

Issues associated with these developing technologies are somewhat different to traditional consumptive uses, and may include appropriately licensing the extraction from deep aquifers; risks and opportunities created by emerging technologies; and competing priorities of reduced greenhouse emissions and aquifer protection. Developing policy which addresses the needs of emerging energy technologies, whilst protecting environmental assets, may create a more positive investment environment. A laissez faire stance will only create uncertainty.

Figure WR11 Groundwater management units, and long term trends in groundwater level

Source: DSE (2004)[80]

NOTE: This figure includes surface water WSPAs and the SA/VIC border zone which is not a Victorian WSPA



Trends in groundwater levels

Long term trends, over the five years to 2006-07, show regional groundwater levels across Victoria were generally stable, with some areas declining due to reduced recharge or extraction (see Figure WR11)[81]. Six WSPAs and 3 GMAs were identified as having declining trends over the five years to 2006-07[82].

Groundwater levels and trends for August 2008 show more widespread decreasing trends, due to the continuing lack of recharge and increased consumptive pressure[83]. Levels are categorised as declining in 11 of the 24 WSPAs (Apsley, Campaspe Deep Lead, Condah, Glenelg, Mid-Loddon, Neuarpur, Sale, Shepparton Irrigation Region, Springhill, Upper Loddon and Yarram). Water levels in the rest are categorised as stable, however all are below the long term average. In August 2008, water levels were the lowest on record for 12 WSPAs.

Offshore oil and gas production have also caused long term reductions in groundwater levels in the Gippsland Basin, which is represented by the Yarram WSPA (for more information see Part 3.1: Energy). At the local scale, changes to groundwater levels may vary from these trends, which represent the regional situation.

Harvesting Water

Harvesting of surface water normally occurs through either active diversions (pumping) or passive collection of runoff (farm dams, rainwater tanks) and streamflow (dams). Active diversion of water only affects the flow regime when the pumps are operating; dams affect the flow regime any time they are not full, regardless of the level of inflows or extraction. Groundwater is harvested by pumping from bores.

Harvesting of marine water has historically been pursued only by coastal heavy industries. Land-based marine aquaculture is a non-consumptive user of marine water. Decreasing availability of fresh water and advances in desalination technology have rendered the harvesting of seawater or saline groundwater increasingly cost-effective for urban uses, although desalination remains an energy-intensive solution, and not without its own site-specific environmental impacts.

Major schemes

As Victoria's water supply network has developed, water systems have become more interconnected to provide greater flexibility and security of supply. This is particularly true of the Melbourne region and the Goulburn-Murray Irrigation District. In regional areas, urban water systems tend to be small and stand-alone rather than interconnected. There is also a greater reliance in these areas on non-reticulated sources of water such as rainwater tanks and groundwater bores. Rural and urban water systems are largely separate, but measures to secure water for critical human needs, and the drive to broaden water markets, have lessened this distinction.

The irrigated areas have extensive drainage networks to remove excess water and mitigate the effects of salinity. In 2005–06, an estimated 376,000ha of Victoria's irrigation districts was serviced by surface drainage, 76,000ha by sub-surface drains, and a further 241,000ha required surface drainage[84]. Land and Water Management Plans and Whole Farm Plans are being used as the basis for effective implementation of drains and groundwater pumping (see Management Responses).

The ecological health of natural waterways and wetlands, and the harvesting and conveyance of water for irrigation, are inextricably linked. Unfortunately the extensive modification of river systems and over-consumption of water, combined with the effects of salinity have resulted in extensive and in some cases irreversible ecological damage[85] (see Pressures on the environment and Part 4.3: Inland Waters).

Goulburn-Murray Irrigation District

In terms of water delivered, the Goulburn-Murray Irrigation District is the largest water supply system in Victoria. Goulburn-Murray Water, which manages this system, harvests about 3,000 GL a year[86] *and* accounts for 90% of water entitlements used for irrigation in Victoria[87]. The irrigation district extends from Yarrawonga and Shepparton in the east to Boort and Swan Hill in the west[88], and encompasses the basins of the Murray, Kiewa, Ovens, Broken, Goulburn, Campaspe and Loddon Rivers[89]. There are numerous major storages in the region, including the Hume, Eildon and Dartmouth. Both natural waterways and hundreds of kilometres of open channels are used to interconnect the storages and provide water to irrigators. Water generally moves in a westerly direction, with the Murray River providing the main means of moving water from major storages in the Snowy Mountains towards irrigation areas in the Mallee, some 600 km to the west[90]. Irrigation systems in northern Victoria are being extensively modernised (see Management Responses).

Melbourne Water Grid

The Melbourne Water Grid, which supplies water to the Greater Melbourne region, serves the bulk of Victoria's population and, in economic terms, is the largest of Victoria's water supply systems (see Figure WR12)[91]. Water is harvested mainly from the Thomson and Yarra basins, with smaller amounts available in the Bunyip and Goulburn basins[92]. Generally, water flows from elevated storages north and east of Melbourne to the west.

Despite significant demand reductions after years of education campaigns and demand management policies, the low storage levels experienced in 2006–07 (see Water Storages) prompted the State Government to substantially increase the Melbourne region's water supply capacity within five years[93]. The chief augmentations, which will supply about 60% of the 2006-07 annual demand, are a seawater desalination plant at Wonthaggi to supply up to 150 GL a year[94], a connection from the Goulburn River to Sugarloaf reservoir (the Sugarloaf pipeline), which will supply up to 75 GL a year[95], and the Tarago Reservoir reconnection, which will supply up to 15GL a year[96] (see Management Responses).

Figure WR12 Melbourne's water supply system
Source: Melbourne Water Corporation

Interconnection of water supply systems to form the Victorian "Water Grid" is a further, dramatic transformation of the way in which water moves around Victoria. The Grid will increase the resilience of individual systems, enable better use of existing storages, and has potential to increase water use efficiency through an expanded water trading market. Aside from desalinated water, however, it will still be affected by statewide reductions in water availability under climate change. In addition to the Sugarloaf pipeline, and the recently completed Goldfields Superpipe which connected Ballarat and Bendigo to the Goulburn Murray, the Government has also committed to pipelines connecting Hamilton to the Grampians, and Geelong to Melbourne.

By harvesting water from ever-more-distant catchments, the Melbourne region continues to increase pressure on the natural environment. The impact of Melbourne's water consumption currently extends eastward as far as the Gippsland Lakes and, with the construction of the Sugarloaf pipeline, north to the Murray River, which is already over-allocated. Given the poor current condition of the Goulburn River, only independently verified water savings should be supplied to Melbourne. Research should now be applied to improving water use efficiency and reducing the cost of alternative sources of water. This may include indirect potable use of recycled water, or innovative decentralised supply solutions (see Box WR2).

Recommendations

WR5 The Victorian Government should engage with the community to get a better understanding of values, aspirations and fears related to urban water supply, including drinking purified recycled water supplied through indirect potable re-use.

WR6 The Victorian Government should support research to develop technologies which improve the cost-effectiveness and viability of alternative sources of water such as solar desalination and indirect potable use of recycled water.

Box WR2 Port Augusta Solar Desalination plant

Australia's first solar-powered desalination plant is to be built at Point Paterson near Port Augusta in South Australia[97]. The $370 million project will combine solar power production, desalination and commercial salt production in a single industrial complex. Benefits of the project include the reduction of greenhouse emissions, a reduced dependence on the River Murray for drinking water, and a commercial use for the brine, which eliminates the need for offshore disposal. The solar field will be laid out over an area of two kilometres square, with each solar mirror standing three metres tall. The first stage of the project will produce 5.5 GL of water a year, expandable to 45 GL a year, sufficient for the needs of 250,000 people. It will also produce 200 MW of electricity: 50 MW solar thermal and 150 MW combined cycle gas turbine.

This system is being implemented in a very different context to the desalination plant in Melbourne. It is, however, a good example of an alternative water supply concept that is sensitive to energy requirements being implemented as part of a total system, to maximise broader benefits for local consumer and industries.

Separate wastewater and urban drainage systems transport wastewater and drainage in generally westerly and southerly directions across Melbourne. The separation of drinking water from contamination by wastewater and drainage in the late nineteenth century led to major improvements in public health by removing the threats of cholera, typhoid and dysentery[98]. The continued safe provision of drinking water and disposal of wastewater remains an abiding achievement of Victoria's water industry, and is central to public health. The two main wastewater treatment plants in the region are the Western and Eastern Treatment Plants, at Werribee and Carrum Downs respectively. Treated wastewater is either recycled or discharged into Port Phillip Bay (from the Western Treatment Plant) or Bass Strait (Eastern Treatment Plant). There are also 17 other wastewater treatment plants[99] which treat about 10% of the region's wastewater, and provide a valuable source of recycled water to local areas. Drainage systems are directed towards natural waterways which, in the Melbourne region, generally discharge to Port Phillip Bay.

Macalister Irrigation District

The Macalister irrigation district in the Thomson River basin is the second largest irrigation district in Victoria, and stretches from Lake Glenmaggie east to Sale[100]. The main storage in this area is Glenmaggie Weir on the Macalister River. The Macalister River joins the Thomson River further downstream, which flows to the Gippsland Lakes.

Wimmera-Mallee Stock and Domestic Supply system

This system, thought to be the largest of its kind in the world[101], consists of over 16,000 km of open channels that supply water for 10,000 rural customers and 40 towns between the Grampians and the Murray River[102]. Water is generally drawn from storages in the Grampians, but the system is also connected in the north to the Waranga Western Main Channel, which is one of the main arteries of the Goulburn-Murray Irrigation District[103]. Due to evaporation and seepage in the earthen channels, the Wimmera-Mallee system is the least-efficient major water distribution system in Victoria. Before piping of channels began in the early 1990s in the northern Mallee, 85% of the water harvested was lost through seepage and evaporation. A total of 120,000 ML left storages in the Grampians each year, but only 17,000 ML was ultimately consumed[104]. The channel system is progressively being replaced with a network of pipes (see Management Responses, Improving efficiency of water distribution systems).

Hydro-electricity and power generation

Water is used for both hydro-electricity (a non-consumptive use) and power generation in the Latrobe Valley (a consumptive use). The Snowy Hydro-electric Scheme, located in NSW, has a significant effect on rivers in Victoria. The scheme collects water from the Snowy River and diverts it through tunnels in the mountains to dams. After electricity generation, the water flows into the Murrumbidgee and Murray Rivers, boosting their flow by an average of 1000 GL a year[105], but leaving only about one per cent of the original flow in the Snowy River[106]. Hydro-electricity generation occurs at 23 locations throughout Victoria[107], as well as a number of mini-hydro plants, and generated 12% of Victoria's renewable primary energy in 2005–06 (see Part 3.1: Energy). Power generation in the Latrobe Valley (Latrobe Basin) consumes approximately 100 GL a year, primarily for plant cooling. Alternatives to using high-quality water for cooling exist and should be investigated (see Part 3.1: Energy).

Recommendation

WR7 The Victorian Government should continue to work on or implement programs, in consultation with industry, to reduce potable water use in electricity generation.

Urban Water Harvesting

The historical separation of the sources of drinking water from wastewater and drainage streams has helped to entrench the practice of meeting growing demand by drawing more water from distant rivers and disposing of the additional waste expediently. However, concerns have been expressed for some years that the infrastructure costs, water quality and environmental impacts associated with this practice have reached an unsustainable level[108].

Since the 1990s, an approach known as *water sensitive urban design* (WSUD), which accounts for the sustainable use of water and environmental protection, has gradually emerged. WSUD seeks to incorporate all aspects of the urban water cycle, including water supply, stormwater runoff, waterway health, wastewater treatment and recycling, into urban planning and design[109]. WSUD is yet to become a mainstream approach to the provision of water services, because it requires radical changes in technology, the capacity for organisations to institute these changes, and new organisational systems and policy and regulatory frameworks[110]. However, Melbourne has made significant progress towards institutionalising urban stormwater quality management, which is an important aspect of WSUD[111]. Understanding gained from the integration of stormwater quality management can be progressively expanded to include other aspects of the water cycle, including the development of alternative water sources and building resilience to climate change[112].

Melbourne generates substantially more wastewater and stormwater than the total volume of water it consumes, but at present 22% of wastewater is recycled[113], and only 0.2%[114] of rainwater and stormwater is harvested (see below). Hence, there are opportunities to develop alternative sources of water in both centralised (such as large-scale recycling) and decentralised forms (e.g. opportunistic stormwater harvesting, household rainwater tanks).

Compelling reasons for considering a total water cycle approach were demonstrated by a review of water supply options for the Armstrong Creek urban growth area, which is located about 10km south of Geelong's CBD, and will ultimately accommodate 22,000 dwellings plus commercial and recreational areas. Options ranging from the provision of desalinated water from Melbourne (a business as usual scenario), rainwater tanks and wastewater re-use were evaluated. The greatest overall benefits, including the best net present value, a 75% reduction in mains water use compared to the business as usual scenario, a 63% reduction in wastewater discharges, and the greatest reduction in greenhouse emissions were provided by an option that combined rain water tanks, water efficient appliances and gardens, and decentralised wastewater re-use[115]. Geelong City Council has endorsed investigation of this option as part of its sustainable growth strategy for Armstrong Creek.

The largest application of a total water cycle approach to the provision of water services in Australia is in the suburbs of Pimpama and Coomera, 40km south of Brisbane. This area, at the northern end of the Gold Coast, is expected to increase in population from 15,000 to around 120,000 by 2056. The Pimpama Coomera WaterFuture Master Plan, approved by the Gold Coast City Council in 2005, mandates third pipes for all new homes to receive Class A+ recycled water for non-drinking purposes and mandatory rainwater tanks. It is anticipated this approach will reduce demand for mains water to the home by 84%[116].

Community values and aspirations play an important role in urban water management practices[117]. The State Government has an important role in both providing leadership and engaging with the community to better understand values, aspirations and fears related to urban water supply, including indirect potable re-use. Experiences of other urban centres deploying these technologies should be monitored and used to inform Victorians of the benefits and costs of these approaches.

Recommendation

WR8 The Victorian Government should continue to pursue decentralised supply options to minimise economic and environmental impacts associated with improving urban water security.

Recycled water

Recycled water can be harvested from a number of sources but is characterised by post-consumer recovery and re-use prior to the entry of water back to the environment. Recycling wastewater has the potential to reduce the impact of wastewater discharges to the environment, reduce water harvesting from the natural environment, and potentially increase environmental flows. The potential for savings are also increased, as more is done with the water harvested from the natural environment. The volume of wastewater that a community produces is relatively stable, so recycling provides a reliable source of water. Guided by long-term goals to improve social and environmental conditions, recycling can increase the resilience of the water systems on which communities depend.

There has been a six-fold increase in the consumption of recycled wastewater in Victoria over the past decade. In 2006-07, 95,500 ML or about 1/4 of wastewater produced was recycled[118]. From 1996 to 1999, an average of 16,900 ML, or 5% of the wastewater produced, was recycled[119]. Reasons for the increase have included reduced water availability from other sources and greater investment in recycled water infrastructure. The volume of wastewater generated has also increased over this time, from 367,000ML in 1996-99[120] to 469,000ML in 2004-05[121], but reduced water consumption and wet weather events reduced the volume produced in 2006-07 to 413,279ML[122]. Consumption of recycled wastewater is proportionally larger in regional areas due to the smaller volumes produced and proximity to fit-for-purpose uses. In 2006–07, 31% of treated wastewater in regional areas was recycled, with four regional water authorities recycling 80% or more of their total wastewater[123]. A high proportion of water from the small decentralised plants in the Melbourne region is also recycled.

Wastewater can be recycled at a range of scales, from lot scale through to centralised schemes that supply large volumes of water to residential, industrial and agricultural consumers. As wastewater is conventionally collected in a central location and treated either for recycling or disposal to the environment, most wastewater is currently recycled at a system-wide scale, and consumed by the bigger water users. Common uses are for turf farms, some industrial processes, irrigated agriculture and recreational lands such as parks and golf courses[127]. A number of large recycling initiatives are currently underway in Victoria include the mandating of third pipe systems for up to 43,000 households and the upgrade of the Eastern Treatment Plant to produce 100 GL of reliable, high-quality water a year (see Management responses, Increasing the use of recycled water).

Minimising risks to end users and public health remains a central concern. The successful recycling of wastewater requires confidence and trust between the providers and consumers of recycled water services. Wastewater contains pollutants that may require several stages of treatment to achieve a given standard, but this increases costs. Each recycling option needs to undergo a sustainability assessment which includes the energy used, disposal of the waste streams produced and impact of the use of the recycled water. In some recycling options the project cost may be prohibitive, outweighing potential benefits.

Recycled water is now being considered as a means to increase environmental flows and to allow further harvesting of drinking water. This approach is currently planned for Lake Wendouree in Ballarat. The addition of large volumes of recycled water to natural waterways, even when treated to a high standard, needs to be considered carefully because it may cause changes in ecology due to the temperature or chemical composition of the treated water. Guidelines are being prepared to assist the development and evaluation of these scenarios.

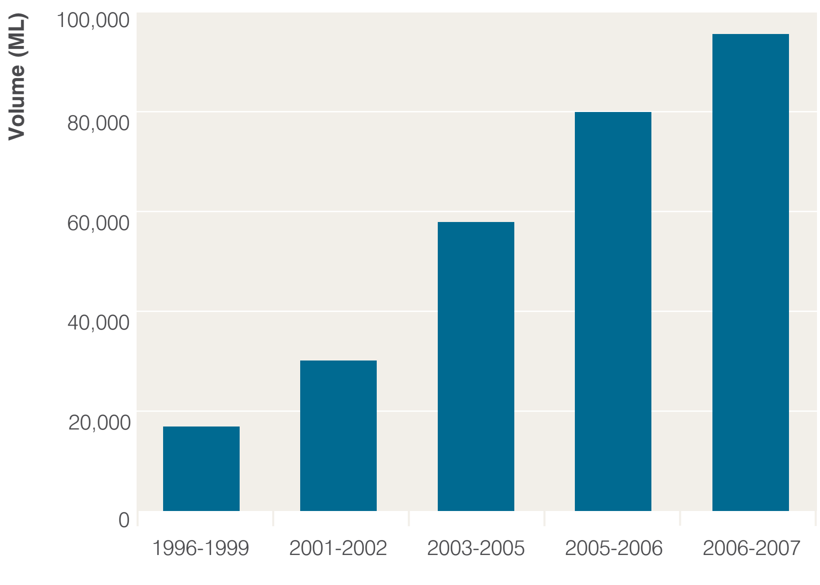
Stormwater and drainage

Drainage systems have been constructed to prevent flooding or waterlogging. The draining of wetlands and channelisation of streams to increase their flood abatement capacity has extensively damaged inland waters throughout Victoria (see Part 4.3: Inland Waters, IW2 In-stream and wetland habitat).

Drainage systems typically funnel rain falling on roofs and roads to a nearby waterway[128]. While some urban waterways benefit from the additional flow, in general this approach to stormwater management puts pressure on freshwater environments (see Part 4.3: Inland Waters, IW1 Altered flow regimes).

New techniques are being implemented to capture and recycle stormwater in urban areas for non-drinking purposes, to reduce mains supplied water consumption and the environmental impact on receiving water bodies[129]. Two recent developments that have institutionalised these practices are the *Stormwater Quality Offset Strategy*, implemented by Melbourne Water in 2005, and the revision of *Clause 56* of the Victorian Planning Provisions in October 2006[130]. A current focus of the stormwater industry is to ensure the effective implementation of the mandated practices across the entire Melbourne region[131].

Figure WR13 Volume of wastewater recycled in Victoria[124,125,126]



Water consumption

Rainwater

For some houses, rainwater is the only source of water. In urban areas, where reticulated water is available, rainwater tanks provide an alternative, decentralised water source. Rainwater tanks provide urban water users with one of the few water supply options which are under their control, and results in an increased awareness of the water cycle. Cost-effectiveness varies greatly according to rainfall and usage patterns, ease of plumbing, roof area and tank size[132]. Using rainwater for toilet flushing and washing maximises year round use, but rainwater tanks have been installed for a variety of other reasons, such as avoiding restrictions on outdoor watering.

For new housing developments, rainwater tanks are potentially cost-effective as part of an integrated approach to providing water services, and should therefore be considered along with other water source options[133]. Rainwater tanks improve the resilience of urban water supply systems to droughts[134]. The cost-efficiency of rainwater tanks improves where the installation of major water supply infrastructure can be deferred[135] and stormwater volumes can be reduced, deferring upgrades to drainage infrastructure and reducing investment in water quality improvement works.

For the supply of existing households, rainwater tanks are cost-competitive with large scale source options such as desalination[136] only in certain situations, such as those described above.

Rainfall patterns vary considerably over Melbourne's large metropolitan area and household water consumption varies dramatically over the course of a week, so evaluation of the benefits and costs of rainwater tanks requires modelling at appropriate temporal and spatial scales.

Grey water re-use

Grey water is non-toilet household wastewater[137]. As water restrictions have reduced or in some cases prevented the watering of gardens with drinking water, the use of grey water for these purposes has become more popular. Grey water constitutes over half the water consumed for residential purposes but, depending on its origin, may contain toxic chemicals or pathogens that pose a significant risk to human health. Guidelines such as those published by the Victorian Environment Protection Authority have been developed to minimise these risks[138].

Victoria's water consumption increased over the last century, peaking in the 1990s (see Figures WR14 and WR15). Since then, and particularly in the last few years, consumption has dropped in line with decreasing water availability. Yet, the State's population and economy have continued to grow.

In 2006-07, the total volume of surface, ground and recycled water harvested for consumption in Victoria declined to 4,094,030 ML from 5,383,400 ML in 2005-06[139]. This 25% decline in water harvested reflects the very low surface water inflows recorded in 2006-07. Victoria continues to remain heavily reliant on surface water sources, although groundwater and recycled water are increasingly important.

Irrigated agriculture accounted for just under three-quarters of surface water consumed in Victoria, with the second-largest sector being urban and commercial consumption (see Figure WR16)[141]. The volume of water harvested for irrigation declined by 16% to 2,559,830 ML in 2006-07 compared to 2005-06, and by 40% compared to 2003-04, which was still considered a dry year[142]. The decreasing availability of water for irrigation in northern Victoria in recent years is reflected in Figure WR14. Water harvesting across Victoria is concentrated in the Goulburn, Murray, Yarra, Thomson and Latrobe basins (see Figure WR17).

Figure WR14 Historic volumes of water harvested for consumption in the Goulburn-Murray Irrigation District
Source: Goulburn-Murray Water

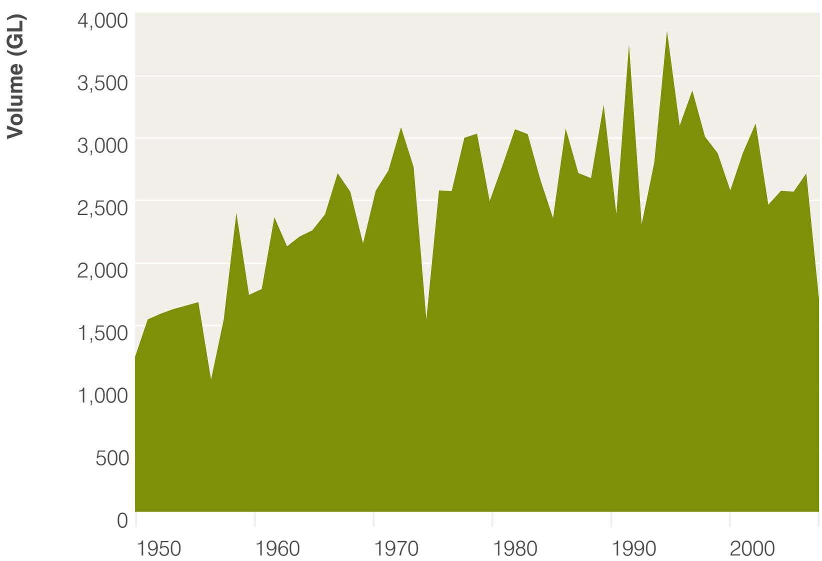
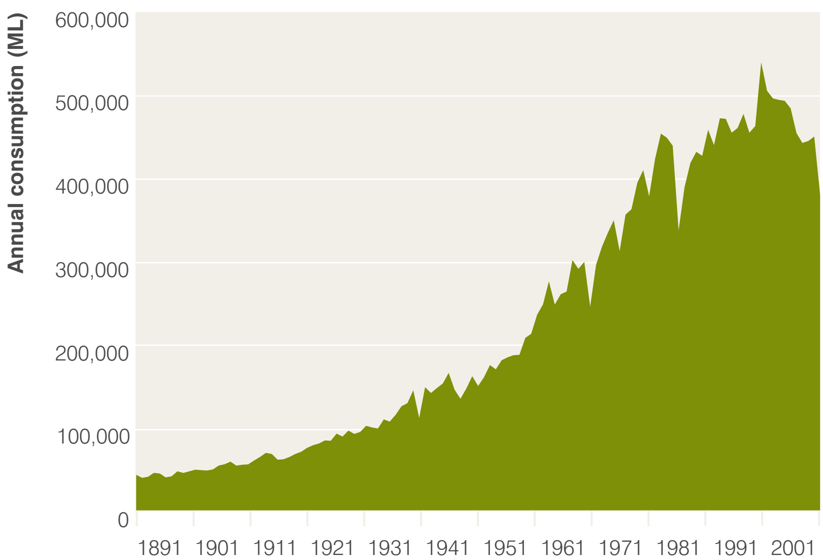


Figure WR15 Historic water consumption in Melbourne, showing impacts of water restrictions
Source: Melbourne Water[140]



Heavy industry, and in particular coal fired power generation, is an important consumer of water in the Latrobe Basin (see Part 3.1: Energy). The volume of water harvested for heavy industry and power generation decreased slightly in 2006-07 to 119,480 ML, although there was a slight increase in water harvested for power generation[143].

In 2005–06 approximately 1,338 GL, or 26% of water harvested, was not accounted for (see Water consumption, Unaccounted water).

Despite decreasing water availability, the relative proportions of surface water consumed by the major sectors appears consistent with previous decades, although the relative proportion of water harvested for irrigaion is gradually decreasing.

Domestic and stock water consumption occurs throughout the State and is a relatively small use of water. Some domestic and stock consumption remains unaccounted for, as private individuals have the right to take water without a licence from a farm dam, groundwater bore, or a river abutting private property for domestic or stock use[145].

Water quality is a crucial aspect of water supply. For drinking water, the most important aspect is microbiological water quality, which is indicated by the bacterium *Escherichia coli (E.coli)*[146]. During 2006-07, over 98% of Victoria's population received drinking water that met E. coli requirements as specified by Department of Human Services[147]. In some areas of western Victoria, desalination has been used to treat lower-quality groundwater required to supplement drinking water supplies.

Historical records of groundwater and surface water harvesting and consumption are patchy and inconsistent on a statewide basis, even for the 1990s. Poor data make it difficult to gauge trends on a statewide basis, reducing the accuracy of planning decisions. Water accounting has been greatly improved through the production of the Victorian Water Account, and metering is currently being improved through government programs.

Figure WR16 Total water resources harvested, source and consumer class across Victoria in 2006-07
Source: Victorian Government (2008)[144]

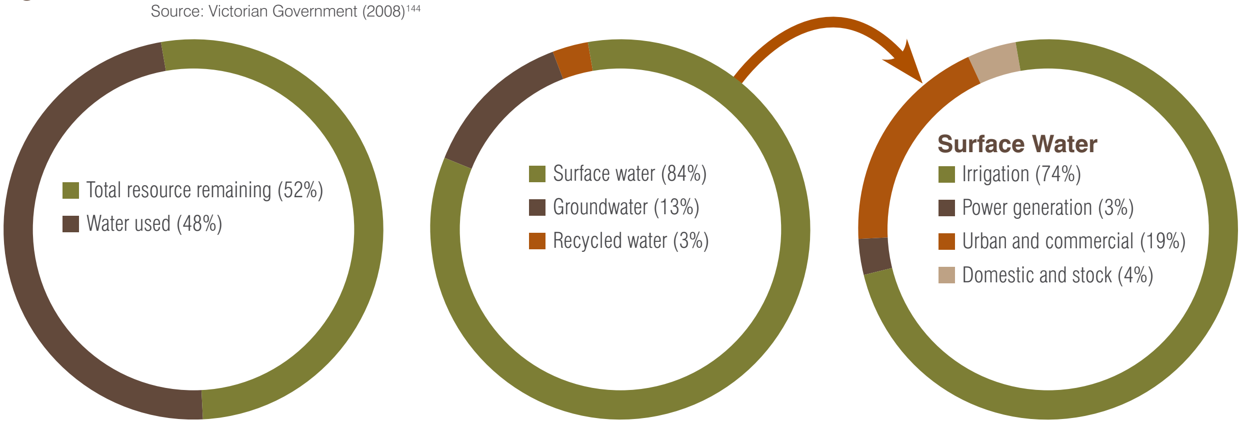
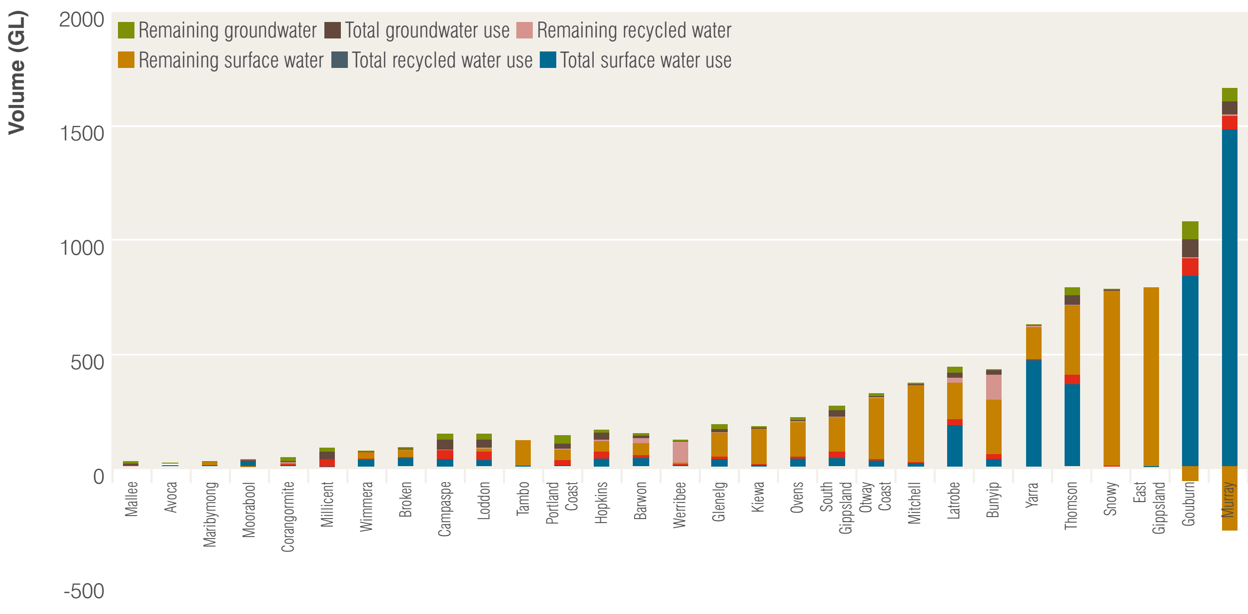


Figure WR17 Total surface water extraction and wastewater recycling across Victoria in 2006–07[ii]
Source: Victorian Government (2008) 148



ii For groundwater, the total water resource is the total entitlement limit. As groundwater management units are different to surface water basins, groundwater resources and consumption were apportioned based on the percentage of the total surface area of the individual groundwater management units within the basin.

Irrigated agriculture

In addition to the major irrigation districts of the Goulburn-Murray and Macalister regions, irrigation also occurs in the Werribee, Maribyrnong and Bunyip basins and around Mildura (see Figure WR18). Over the past decade, the area of land irrigated has consistently been in excess of 600,000ha (see Part 4.2: Land and Biodiversity, (Indicator LB14). The area of irrigated horticulture in the Lower Murray region increased by 42% between 1997 and 2006[149]. In 2007, however, the area irrigated suddenly decreased to about 400,000ha, or 1.9% of Victoria's total area, due to the scarcity of water for irrigation. Irrigation may also be decreasing in some salt affected areas, around Pyramid-Boort and Shepparton[150].

Approximately two-thirds of the water used in irrigation is applied to pastures, which occupy some two-thirds of irrigated land in Victoria[151]. The bulk of the pasture, and in excess of 50% of the water used for irrigation, is for dairying[152]. Other significant uses include livestock, pasture and grains, grapes and fruit (see Figure WR19)[153].

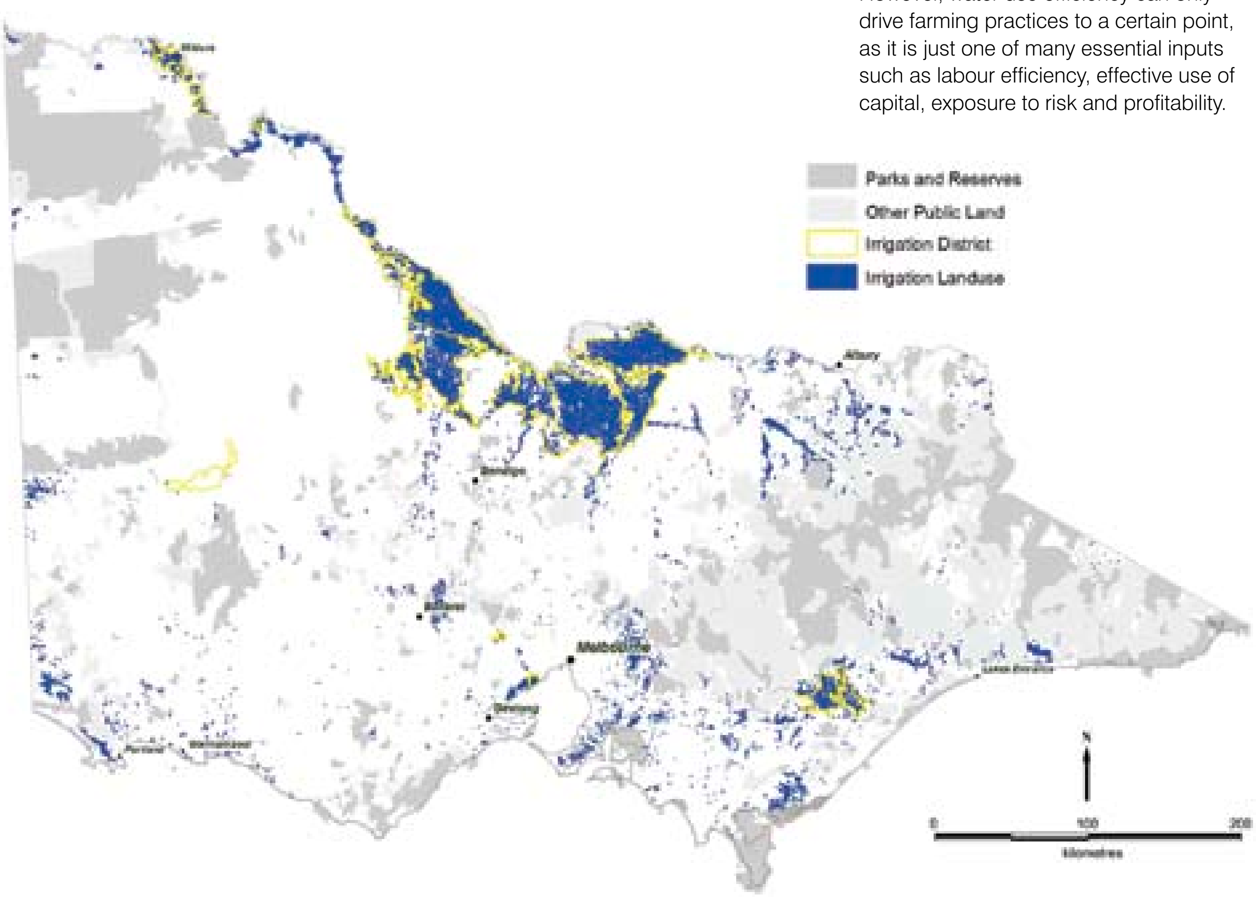
Decreasing availability of water in the past decade has reduced consumption. In 2006–07, 1,703GL was extracted for consumption in the Goulburn-Murray Irrigation District, less than half of the highest volume of 3,852 GL in 1994–95, and allocations have declined over the past decade (see Figure WR20). Water shortages leading to very low or zero allocations have also been experienced in the Campaspe, Wimmera, Werribee, Bacchus Marsh, and Maribyrnong irrigation districts over the past few years. Werribee irrigators have increasingly been forced to rely on recycled water from the Western Treatment Plant (See Management Responses).

Water consumption in irrigated agriculture is strongly influenced by the allocation framework (see Box WR1) and its availability on the water market. Trading on the water market is generally limited to the irrigation industry. However, Commonwealth government agencies have recently entered water markets to meet environmental commitments by buying water from willing sellers in the irrigation industry. Victorian water authorities (e.g. Coliban Water) have also entered the water market to improve urban water security.

Major changes to the allocation framework have occurred recently, including the permanent trading of water rights and unbundling of water and land entitlements[154]. Evidence suggests that trading of water to higher value uses is occurring (see Part 4.2: Land and Biodiversity)[155]. The unbundling of water entitlements (separating the ownership of water from the ownership of land) has created a need for greater transparency in the ownership of water entitlements, such as that which exists with land titles.

Environmental impacts, particularly due to salinity and nutrients, have also affected irrigation practices and patterns of water consumption. In the 1980s it was recognised that salinity could destroy the productivity of important agricultural regions such as the Shepparton Irrigation District[156]. As a result, more emphasis was placed on improved water use efficiency and better drainage systems, which have led to demonstrated improvements in on-farm water use efficiency (see Management Responses, Improving irrigation efficiency, whole farm planning in the Shepparton area. For more information on salinity see Part 4.2: Land and Biodiversity). Irrigation practices in the Macalister Irrigation District have been influenced by declining water quality in the Gippsland Lakes, which suffer from ongoing cyanobacterial blooms (see Part 4.3: Inland Waters, IW4 Water quality). However, water use efficiency can only drive farming practices to a certain point, as it is just one of many essential inputs such as labour efficiency, effective use of capital, exposure to risk and profitability.

Figure WR18 Irrigation landuse in Victoria
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



Upgrades to distribution infrastructure and the management of regional environmental impacts require additional government and private investment, as infrastructure access fees only recover costs for system operation. Long-term economic and environmental viability were not considered when irrigation systems were installed, so it is not surprising that irrigators would struggle to maintain and upgrade these systems without assistance[157]. Furthermore, as the loss of natural capital is not accounted for and its cost passed on to the consumer, it is difficult for irrigators to recover these costs.

Financial and political drivers for irrigation remain strong. Across Victoria, the irrigation sector generates $9 billion in annual production[158]. This equates to about 4% of gross state product (GSP)[iii], but its contribution to export income is significant. Food and fibre exports, of which dairy and meat contribute 50%, account for about 35% of Victoria's export income[159]. The State Government currently has a target for increasing agricultural production to $12 billion of food and fibre exports by 2010[160], a substantial increase on the $7.2 billion exported in 2006[161]. This target should be carefully considered in terms of current knowledge regarding water availability, river health implications, external economic factors and the potential to achieve higher levels of irrigated production through improved water use efficiency.

There are large established communities, particularly in northern Victoria, that depend on irrigation. Irrigation generates economic and community activity that is three to five times higher than would be supported from rain-fed production alone[162]. There is a need to rationalise and then make the best use of existing infrastructure, and strongly encourage innovation and adaptation towards long-term environmental, social and economic viability.

Recommendations

WR9 The Victorian Government should make information on the ownership of water entitlements publicly accessible.

WR10 The Victorian Government should carefully consider its food and fibre export target of $12 billion in light of external economic factors, current knowledge regarding current and future water availability, river health implications, and potential to achieve higher levels of irrigated production through improved water use efficiency.

Figure WR19 Average annual water use and economic value of major irrigation industries of northern region
Source: DSE (2008)

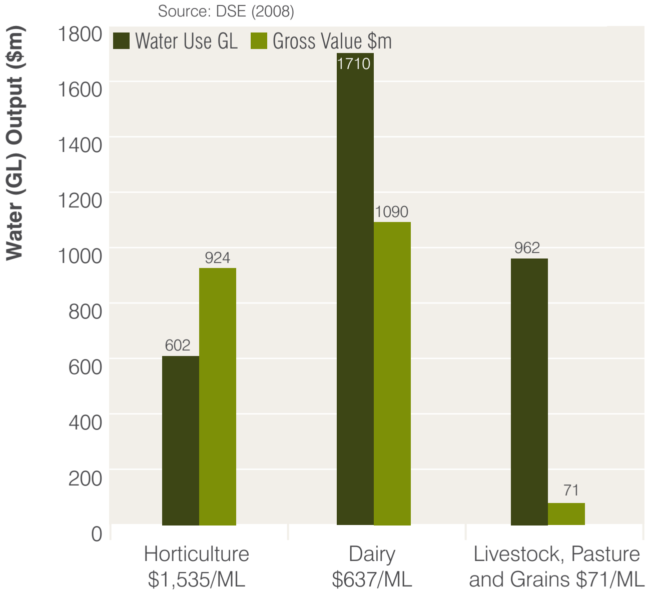
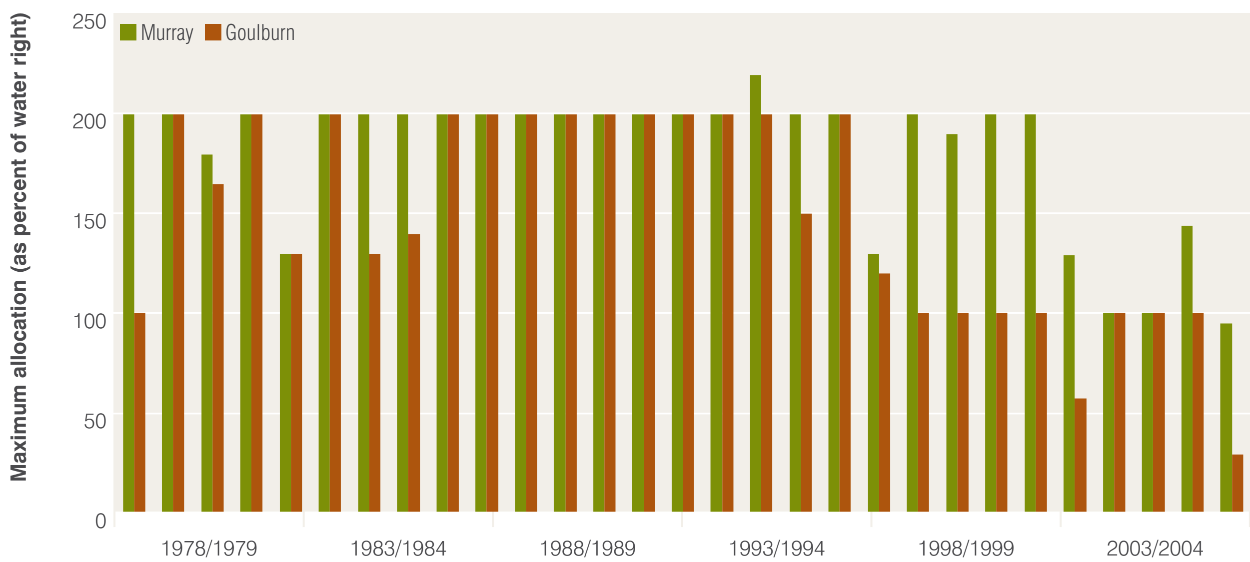


Figure WR20 Maximum allocations in the Goulburn Murray Region
Source: Goulburn Murray water



iii Based on 2006–07 GSP of $247,440m

Residential and non-residential consumption

Residential consumption and non-residential consumption, which includes businesses, commercial and industrial consumers, as well as power generation, accounted for 22% of water harvested for consumption in 2006-07. Of this amount, about 55% was consumed in the Melbourne region, with 26% of water consumed in regional Victoria and the remaining 19% in the Latrobe Valley[163].

Melbourne's water consumption has increased steadily over the twentieth century to a maximum of 538,387 ML in 1997, punctuated by occasional decreases caused by water restrictions. In 2006-07, the total volume harvested for consumption in Melbourne was 412,555 ML, about 10% of the total surface, ground and recycled water harvested for consumption in Victoria, a decrease of 24% over the past 11 years[164].

Melbourne's *per capita* consumption increased from the post-war period to a historical maximum of 500 L/person/day in 1981[165]. Over the past decade, however, per capita consumption has decreased by 34% from 423L/person/day during the 1990s[166] to 277L/person/day in 2007[167]. This is the lowest level of per capita consumption since 1934[168], and Melbourne now consumes less water per household than any other Australian capital city[169].

Sixty percent of Melbourne's water is used for residential consumption[170], while non-residential uses account for about 30% (see Figure WR21). The remainder (10%) is unaccounted-for (see Water consumption, Unaccounted water). These proportions appear to have remained reasonably consistent since at least the late 1980s[171].

Residential consumption

In 2006-07, the average household in Victoria consumed 493L/day[173]. Throughout the State, annual consumption per household in 2006-07 ranged from 189L/day for Westernport Water's region, which has a large seasonal population, to 1361 L/day in Lower Murray Water's region in the northwest of the State[174]. The most likely cause of high levels of water consumption is higher levels of outdoor water use and seasonal factors such as the use of evaporative air conditioning and swimming pools.

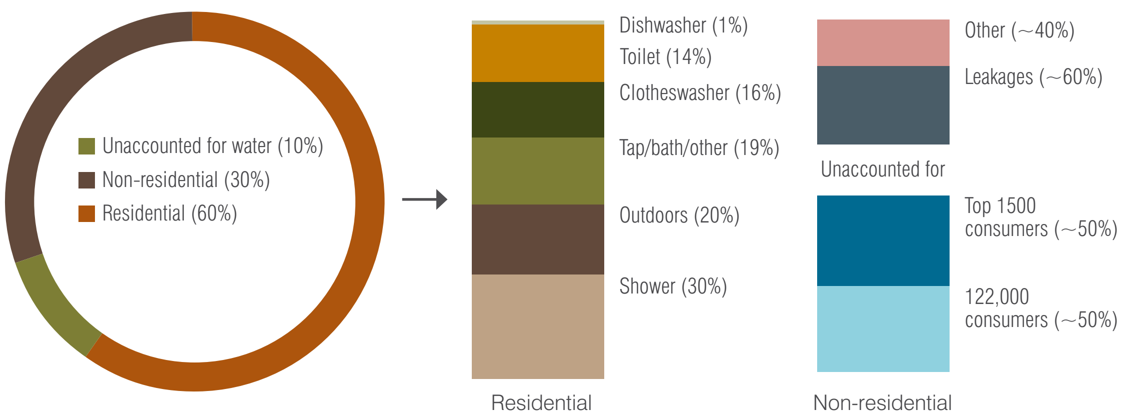
The largest single component of Melbourne's residential water use in 2004 was showers (30%), followed by outdoor use (20%)[175] (see Figure WR21). Since then, consumption has further decreased, with restrictions on outdoor water use likely to increase the relative proportion of indoor water use.

Since the 1980s, demand management has helped to reduce water consumption. Successful early demand management measures included the introduction of dual-flush toilet systems and user-pays pricing[176]. Notwithstanding differences in methodology, clear changes in consumption patterns are evident between the study above and estimated consumption patterns in 1981, when garden watering accounted for 40% of the 500L/day per capita consumption, and toilet flushing was the second largest component at 20%[177]. In recent years, water restrictions, behavioural changes and water use efficiency measures such as water–efficient showerheads have been key factors contributing to decreases in per capita consumption[178] (see Management Responses, Reducing residential and non-residential consumption).

Many towns have been subject to stringent but effective water restrictions since 2002. Urban water restrictions were in place in 436 Victorian towns at 31 July 2007, with 31 towns on Stage 1, 52 on Stage 2, 44 on Stage 3, 18 on Stage 3a and 291 on Stage 4 restrictions[179]. Coliban Water, which supplies the central region from Bendigo northwards, delivered 30% less water in 2005–06 compared to 2001-02[180]. In Bendigo, water consumption in the summer decreased by more than 50% over this period.

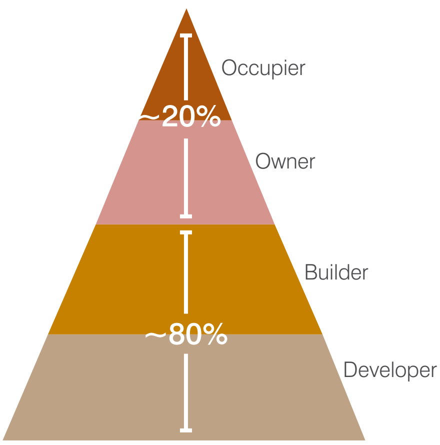
Underlying short-term trends is a steady growth in population, from 1.2 million at the start of the twentieth century to 5.2 million in 2007[181]. The significant falls in consumption achieved by water restrictions show that, to some extent, it can be decoupled from population growth. Further decreases remain possible. Installation of water-efficient devices throughout the house and garden can result in water savings of up to 45%[182]. Furthermore, the State Government has envisaged that, by 2055, an average house will use 70% less water than in 2006[183]. Residential consumers also often overlook the water required to produce goods, such as food, the fibre in clothes, manufactured goods and power production, which are considered simply as part of the manufacturing process (see Part 3.3: Materials).

Figure WR21 Indicative summary of residential and non-residential consumption in Melbourne
Source: Victorian Government (2007[172]), Melbourne Water (2006)



Water consumption and the potential for water savings is also determined through the whole cycle of land-use planning, building, owning and furnishing a house. Of the total gains in water use efficiency possible, up to 80% can be made or lost in decisions taken by the developer and builder (see Figure WR22). These findings highlight the importance of incorporating water use efficiency into planning procedures (e.g. Clause 56) incorporating water savings features into household design (e.g. Five Star Building standard – see Part 3.1 Energy), and mandating water efficient appliances. Water use efficiency of existing buildings, both residential and non-residential, also needs to be addressed in the context of social equity. The importance of behavioural change in driving water conservation highlights the continued need for increased "water literacy" as called for by the Victorian Women's Trust (2007)[184].

Figure WR22 The magnitude of possible water savings reduces through the decision cycle
Source: PMSEIC (2007)



Recommendations

WR11 The Victorian Government should advocate for the establishment of a set of national, mandatory minimum standards for water use efficiency in new appliances, homes, commercial and government premises and subdivision design.

WR12 The Victorian Government should increase the water efficiency performance thresholds expected from the 5 star building standard, which may include the mandatory installation of rainwater tanks where third pipe systems are not available, and include stormwater quality objectives.

WR13 The Victorian Government should support increased water use efficiency within current commercial building standards.

WR14 The Victorian Government should introduce measures to significantly improve the energy efficiency of existing buildings, for example by requiring: compulsory disclosure of water efficiency at point of sale or lease; and ensuring minimum standards for water use at point of sale or lease.

WR15 The Victorian Government should maintain efforts to improve water literacy in the community.

WR16 The Victorian Government, in partnership with local government, should develop programs to overcome recognised barriers to demand management.

Non-residential consumption

About half of the water consumed for non-residential purposes in Melbourne is used by 1,500 companies[185]. About a third of these are manufacturing businesses, with other big users including hospitals, parks and golf courses, universities and hotels[186]. The remaining 50% of non-residential consumption is consumed by 122,000 businesses[187]. From 2002 to 2007, the largest 200 non-residential consumers have been encouraged to save water through the Pathways to Sustainability program. The outcome has been a 17% reduction in water used by these consumers[188]. This program has now been expanded into the WaterMAP program, which is mandatory for non-residential consumers which use more than 10ML of potable water a year (see Management responses).

Unaccounted water

In 2005–06, 26% of water extracted for consumption in Victoria was unaccounted, which is equivalent to almost three times the water consumption of Melbourne. The State Government has committed in the order of $2.8 billion to rectify this situation (see Management Responses, Improving the efficiency of water distribution systems). The highest levels of unaccounted water are found in rural channel distribution systems, which supply water for irrigation, domestic and stock, and town consumption. The causes are shown in Figure WR23.

On average over 800,000 ML of water is unaccounted on an annual basis in the Goulburn-Murray Irrigation District[189]. Under ongoing drought conditions, such as those experienced in the past 10 years, models of the irrigation system show unaccounted water on average exceeding 700GL a year. Irrigation systems in Victoria are now being extensively modernised (see Management Responses).

Losses to leakage and seepage are dependent on the length of time irrigation channels are kept full, as well as the volume of water supplied. Due to the current, severe water shortage the operation of distribution systems has been modified in order to reduce these losses (eg in the Goulburn Murray irrigation district)[190], although this causes inconvenience to individual irrigators. The overall reduction in water supplied, however, compared to the total losses in the system, resulted in an overall reduction in the efficiency of irrigation systems throughout Victoria from 72% in 2005-06 to 65% in 2006-07[191].

Metering error, deliberate or inadvertent, is an important component of unaccounted water in irrigation systems, as some metering systems tend to underestimate the actual volume of water delivered. This water remains in the system and is used for irrigation. While installing more accurate meters will effectively reduce the water delivered to irrigators, infrastructure upgrade projects contain measures that may offset the impact of these reductions[192]. Standards for the design and installation of water meters are being developed through the National Water Initiative[193].

Between 1% and 20% of irrigation water used in the southern part of the Murray-Darling Basin returns to waterways through drains and groundwater flow[194]. These are substantial volumes that play a significant role in the local water cycle. While reducing unaccounted water is an important means of improving the management of water resources, the implementation strategy must be appropriate to the local situation and ensure there is no overall loss in benefits received by the environment. To understand the full extent of water consumption and return flows, the accuracy of water balance calculations should be improved by undertaking work to remove gaps in knowledge or data.

Recommendation

WR17 The Victorian Government should ensure return flows captured by water recovery projects are accounted for and the implications of removing them understood, so there is no overall loss in benefits received by the environment.

Figure WR23 Components of unaccounted water in irrigation distribution systems
Source: Adapted from Harding, S. and Viney, B

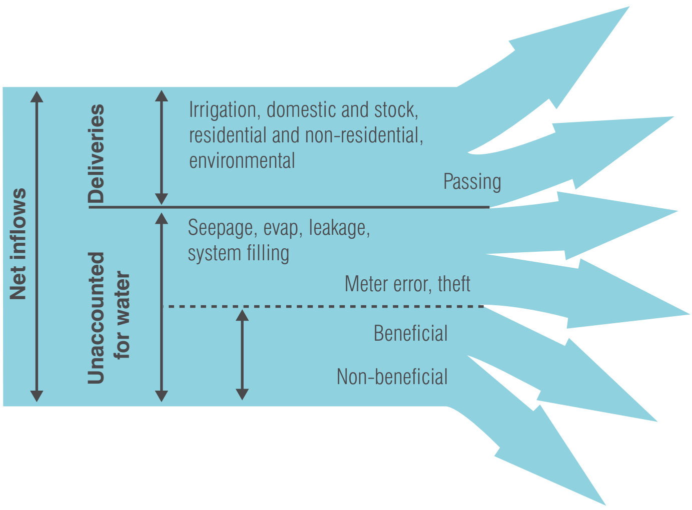
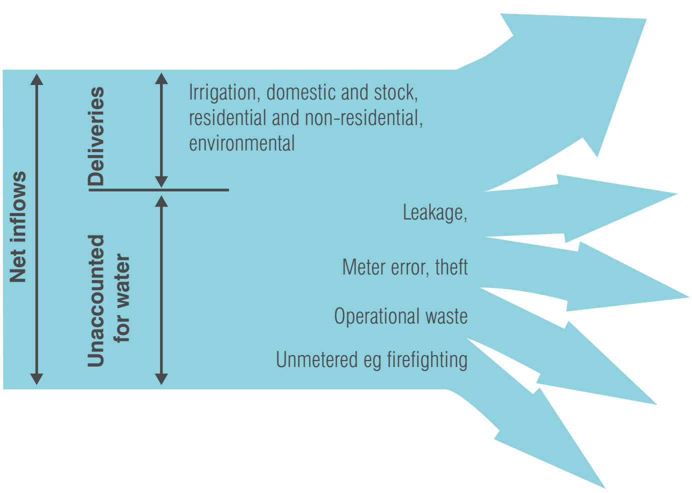


Figure WR24 Components of unaccounted water in urban distribution systems



The least-efficient major water distribution system in Victoria is in the Wimmera-Mallee (previously discussed in Water harvesting; also see Management Responses, Improving the efficiency of water distribution systems). In other distribution systems managed by regional water authorities, unaccounted water was as high as 349 L/connected property/day in Coliban Water's region, which includes the city of Bendigo[195], in 2005–06. Most of this water was lost in an ageing open channel network that supplies rural customers[196]. In 2006-07, unaccounted water reduced to only 52L/connected property/day[197]. This dramatic change is thought to be due to limited rural allocations through a piped system as a result of water scarcity, and improved pressure management.

Central Highlands Water, which supplies the area in and around Ballarat, also reported a high level of unaccounted water of 139 L/connected property/day during 2005–06, which also reduced significantly to 87.8L/connected property/day in 2006-07198,[199].

In 2005–06 an average of 10% of water supplied to residential and non-residential consumers was unaccounted across the State[200]. Unaccounted water across Melbourne ranged from 56 to 82.2L/connected property/day in 2006-07[201]. Typical causes of unaccounted water in urban systems are shown in Figure WR24.

Pressures on the environment

Patterns of water use in Victoria are unquestionably placing heavy pressure on the resource and therefore the environment. To this end, Commonwealth and State governments are heavily engaged in the policy consequences.

Climate change

As stressed a number of times in this report, current projections indicate that Victoria's future climate is likely to be warmer and, for most of the State, drier than during the second half of the twentieth century[202] (see Part 4.1: Atmosphere, Climate Change). The reduction in water availability will jeopardise the condition of terrestrial and aquatic ecosystems and further increase competition for water resources.

With lower rainfall and higher temperatures, streamflow, soil moisture and recharge of groundwater are likely to decline. By 2070, streamflow may decrease by up to 50% across much of the State compared to long term averages (see Part 4.3: Inland Waters, Impacts of climate change on inland waters). Changes in streamflow by 2030 may vary from 25% to 40% decreases in river systems in west and north-western Victoria to no change or slight increases in East Gippsland (see Figure WR25)[203]. More detailed predictions of changes to water availability were provided for the Murray Darling Basin by the Sustainable Yields Project (see Part 4.3: Inland Waters, Impacts of climate change on inland waters). Predictions of changes to runoff across northern Victoria for the 'best guess' 2030 scenario varied from reductions of 11% to 18%, with a range from a 47% decrease to a 1% increase, compared to long term averages.

The current decrease in streamflows experienced in many rivers, particularly in western and central Victoria, has generally been greater than in the 'high' climate change scenario for 2030[204]. During years of low streamflow, environmental flows are disproportionately affected compared to the water available for consumption and are likely to decrease by more than the projected reduction in overall availability (see Pressures on the environment, Altered water regimes). An estimated 25% reduction in inflow to the Goulburn River by 2055, for example, would reduce water remaining for environmental flows by 40% compared to the long term average[205]. Climate change will exacerbate other pressures that cumulatively reduce water availability (Part 4.3: Inland Waters, Impacts of climate change on inland waters).

Water resources are expected to be affected by more frequent extreme events. Droughts, which have always been part of Victoria's climate, are predicted to increase, with 20% more drought months by 2030 and up to 40% more by 2070 (see Part 4.1: Atmosphere, Climate Change). The number of hot days experienced each year is also likely to rise. These impacts are likely to further emphasise the importance of water source options that reduce the current reliance on centralised surface water sources. Projections of extreme heavy rainfall indicate that these will be more common than increases in mean rainfall, which will mostly decrease. Implications for inland waters are discussed further in (see 4.1: Atmosphere, Climate Change). Climate change also needs to be incorporated into planning for water-dependent industries such as agriculture. In Australia, there is no coordinated and well resourced research program to establish the ecological, hydrological, social and economic impacts of long term droughts[206]. This knowledge gap should be addressed.

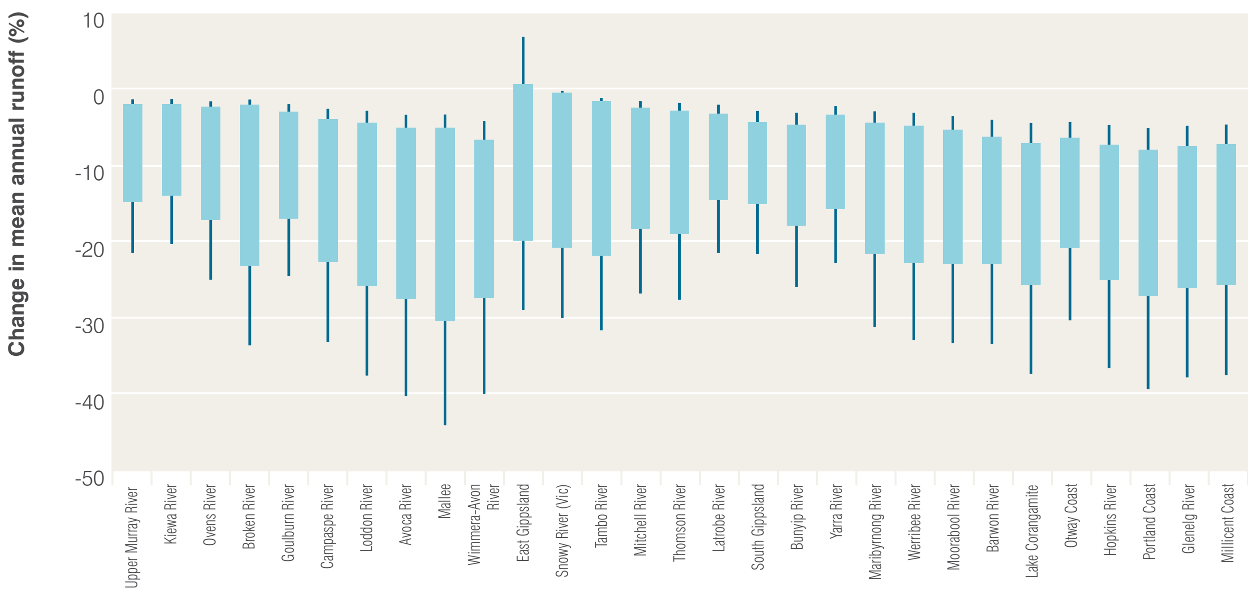
As climate change will have a significant effect on water resources, addressing climate change also addresses a root cause of future water shortages. In responding to the need to secure water supplies in the short term through projects such as the desalination plant and the Sugarloaf pipeline, it is important that the Victorian Government limits its contribution to the long-term impacts of climate change by minimising greenhouse emissions.

Recommendation

WR18 Research should be directed towards gaining a better, integrated understanding of the ecological, hydrological, social and economic impacts of long term droughts.

Figure WR25 Predicted range of change in annual runoff for river basins in Victoria in 2030 compared to current means

Source: Jones and Durack (2005)207, in Victorian Government (2007a).
NOTE: The thin vertical lines indicate the range of change from 10 climate models with a range of global warming of 0.54 – 1.24°C, while the central box shows the range of change for a median (0.85°C) global warming scenario.



Surface water harvested for consumptive use

Water consumption reduces water available to support ecosystem function. While the percentage of water remaining in the basin is an indicator of the pressure that consumption exerts in each basin, it is not useful as an indicator of the condition of flow regimes (see Part 4.3: Inland waters, Indicator IW1). In a quarter of Victoria's river basins, over 75% of the total annual flow was harvested in the past four years (2003–04 to 2006–07) (see Figure WR25). Basins that are particularly affected include the Goulburn, Moorabool, Loddon, Campaspe and Wimmera. The proportion of water harvested was much lower in a number of other basins, with 11 basins (39%) having 25% or less of their total flow extracted.

Water consumption has also had a profound effect on lakes and wetlands. Lake Hindmarsh, Victoria's largest freshwater lake, would naturally be full 65% of the time but due to extraction of water from the Wimmera River this has reduced to 15% of the time[208]. It is anticipated that by 2030, Lake Hindmarsh will only be full 4% of the time[209]. Lake Albacutya, which receives overflow from Lake Hindmarsh, would naturally be full 24% of the time but this has reduced to just 2%. Lake Connewarre and Reedy Lake have also been adversely affected by over-allocation of the Moorabool River for consumption[210].

Current levels of water consumption increase the pressure exerted by low streamflow on the biota of inland waters, despite their adaptation to high variability. The basins experiencing the greatest reduction in streamflow over this time also recorded the highest percentage of water harvested (see Figure WR26). In 2004–05, the share of water for the environment in the Upper Murray Basin reduced to 21% from the average of 56% of total flow, resulting in a 76% reduction in water available to the environment. In the Campaspe Basin in the same year the share of water for the environment fell from 46% on average to 8%, a 94% decrease in water available to the environment[211].

Rivers in the central region have also been affected in a similar manner, for example the Environmental Water Reserve (EWR) in the Moorabool River is 72% of the total resource under long term average conditions, but over the past four years there has only been an average of 19% of the total resource left in the basin (see Table WR1).

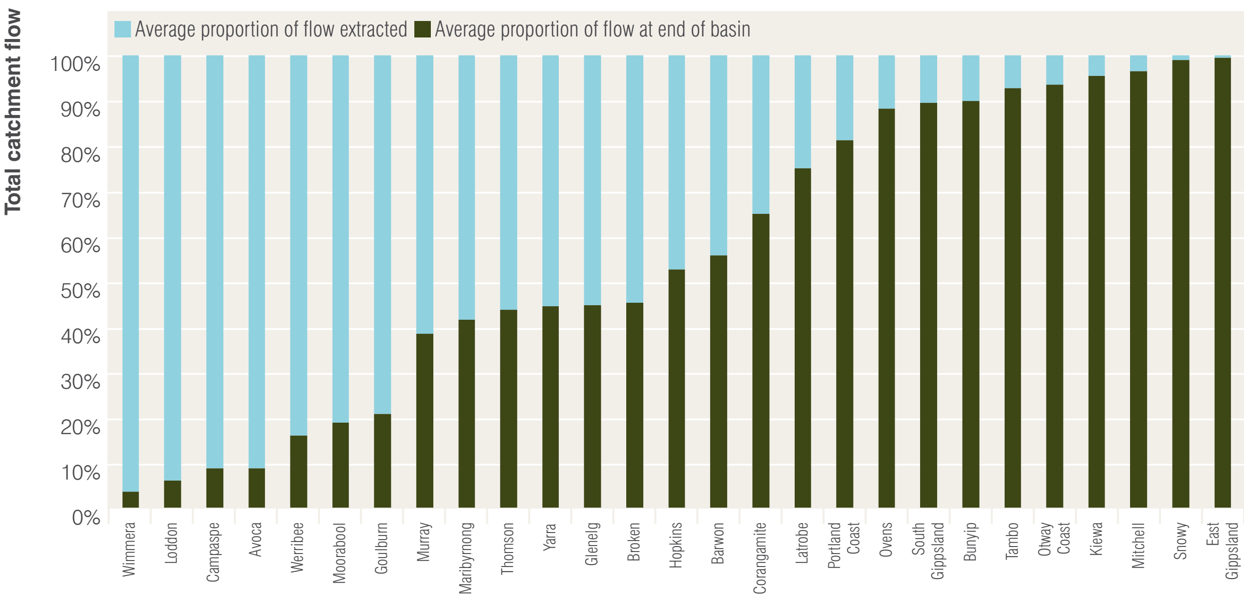
This shows how the current system for allocating water for consumption can disproportionately reduce water left to support ecosystem function. This system should be reviewed in light of current impacts of water allocation on flow regimes, and predicted changes in water availability.

Table WR1 EWR under long term average flows compared to average proportion of the total water resource remaining in basin (2003-04 to 2006-07)[216,217]
Source: DSE

River	Total EWR as per CRSWS[1,2] (% of total resource)	Average water remaining at end of basin (average 2003-04 to 2006-07)[3] (% of total resource)
Yarra	57%	45%
Werribee	64%	16%
Maribyrnong	87%	42%
Moorabool	62%	19%

1. These estimates are based on the full use of entitlements and long term average flows.
2. The total EWR includes additions to the EWR agreed as part of the Central Region Sustainable Water Strategy (CRSWS).

Figure WR26 The percentage of water remaining at the bottom of river basins, 2003–04 to 2006–07
Source: Victorian Government (2008) [212,213,214,215 iv]



iv The figure shows only the Victorian component of Upper Murray basin streamflow and Victoria's contribution to the environment's share of total flow. For more information on the calculation method, refer to the State Water Report, 2005-06.

Modification of flow regimes

The modification of flow regimes is one of the most significant pressures on Victoria's inland waters. In over half the river basins in Victoria, less than 20% of rivers have flow regimes in good condition (see Part 4.3: Inland Waters, IW1 Altered flow regimes).

Water resource management alters flow regimes through infrastructure such as dams, weirs and levees; harvesting water for consumption; using rivers to convey irrigation and urban water supplies; and water releases for hydro-electricity generation. Drought compounds the impact of these pressures.

Flow regimes are generally in worst condition below major storages and water diversion points. These are widespread across Victoria, with 19 out of 29 of river basins having at least one major on-stream storage. Storages often result in large decreases in flow immediately downstream—for example, 95% immediately downstream of the Upper Yarra Dam[218]. Implications of modified flow regimes include reductions in biodiversity and the degradation of water quality, in-stream habitat and riparian vegetation (see Part 4.3: Inland Waters, IW1 Altered flow regimes, Implications).

Impact on groundwater dependent ecosystems

Where aquifers are connected to surface waters, harvesting of water from groundwater bores, as well as the excessive extraction of surface water, can lower groundwater levels, leading to a range of environmental impacts. Some aquifers are confined and essentially separate from surface waters, thus the impact of extraction is limited to the depletion of that resource. In systems where groundwater and surface water are connected, the relationship between groundwater extraction and a reduced water table may not be 1:1 due to other factors such as evapo-transpiration.

River systems dependent on groundwater during summer, and terrestrial vegetation and wetlands dependent on groundwater, have been identified in all 30 groundwater management areas in Victoria so far assessed for groundwater-dependent ecosystems[219]. This assessment will be completed in July 2009. Offshore oil and gas production have also reduced groundwater levels in the Gippsland Basin (see Part 3.1: Energy).

Because groundwater and surface water have traditionally been managed separately, the potential reduction in streamflow due to the harvesting of groundwater has not been accounted for. Estimates for the Murray-Darling Basin suggest that about 500 GL a year has been counted twice as both surface and groundwater[220]. These accounting problems may be difficult to recognise because there is a time lag which may be decades or longer, between groundwater pumping and reduced streamflow[221]. This situation highlights the importance of water accounting and managing the total water cycle.

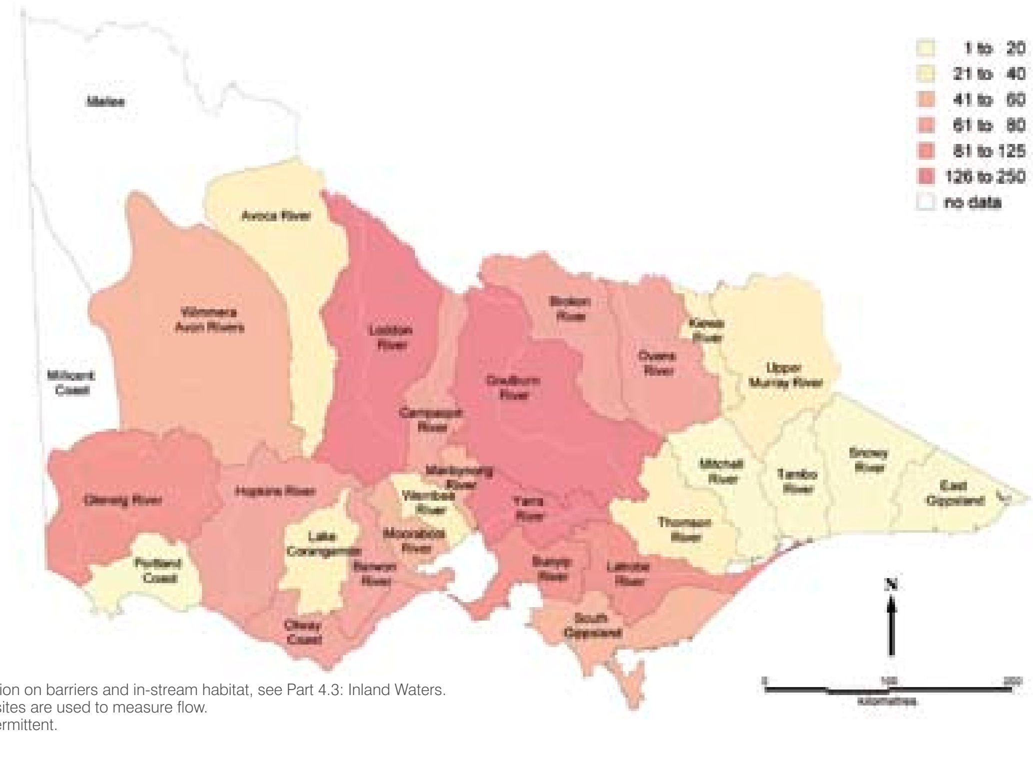
On the other hand, land use changes for agriculture have generally increased recharge to groundwater[222] (see Part 4.2: Land and Biodiversity). Additional groundwater recharge from irrigation has amplified this change, resulting in shallow watertables, waterlogging and increasing salinity in approximately 140,000 ha of land in the irrigation districts of northern Victoria[223]. Walker and Salt (2006) provide an account of the problems caused by high watertables in this region[224]. Improvements in the management of drainage systems and groundwater in irrigation districts, and rainfall deficits over the past 11 years, have started to mitigate environmental impacts.

Loss of habitat connectivity

Dams and weirs are the most common physical barriers[v] that interrupt the connectivity of river ecosystems.

There are over 1,000 farm dams and weirs on named waterways in Victoria, and a further 707 stream-gauging sites[vi], which also interrupt connectivity (see Figure WR27)[225]. The basins with the highest number of barriers related to water resource management are the Latrobe, Bunyip, Yarra, Goulburn and Loddon basins, which each have 100 or more such barriers. Many more dams and weirs occur on ephemeral[vii] streams throughout the State. Implications of barriers include the exclusion of migratory fish, and decreases in macro-invertebrate populations (for more information see Part 4.3: Inland Waters, IW2 In-stream and wetland habitat).

Figure WR27 Number of dams, weirs and stream-gauging stations that sever habitat connectivity, by basin
Source: Victorian Government (1999)



v For more information on barriers and in-stream habitat, see Part 4.3: Inland Waters.
vi Stream gauging sites are used to measure flow.
vii Temporary or intermittent.

Water Pollution

Cold water pollution

Water released from dams, including water released by hydro-electricity generators, may be significantly colder than the surface water, particularly during summer[226]. Across Victoria, 49 dams have been identified where this occurs, although it is most pronounced at the Hume, Eildon, Thomson and Dartmouth dams. The lower water temperatures prevent large native fish species from breeding[227] (see Part 4.3: Inland Waters, IW5 Aquatic fauna).

Increasing salinity

Irrigation drainage can contain elevated salinity which reduces water quality. This is a major problem in the northern irrigation districts. High levels of salinity destroy both ecological and economic values of land and water. More information on salinity is provided in Part 4.2: Land and Biodiversity, Salinity; and Part 4.3: Inland Waters, IW4 Water quality.

Nutrients, toxicants and pathogens

Wastewater discharges and spills and stormwater and drainage discharges are the main sources of nutrients, toxicants and pathogens arising from the use of water resources. The water quality status of nitrogen and phosphorus are discussed in more detail in Part 4.3: Inland Waters, Water quality.

The Western Treatment Plant at Werribee has historically been the largest single source of nutrients to Port Phillip Bay228 but improvements to treatment processes and reduced discharge volumes have reduced nitrogen loads by almost 60% since 2001[229]. As a primary threat to the health of Port Phillip Bay is nitrogen loading[230], it still remains sensitive to the discharge from the Western Treatment Plant. Ironically, the treatment lagoons at the Western Treatment Plant are part of a site of international significance that is protected under the Ramsar Convention[231].

The Eastern Treatment Plant at Carrum Downs discharges treated wastewater into Bass Strait at Boags Rocks. Ammonia levels and volumes of freshwater are having a detrimental impact on the marine environment in the immediate vicinity of the outfall, but no significant accumulation of contaminants has been observed in marine fauna[232]. Pollutant loads from the Eastern Treatment Plant will be considerably reduced by current projects to improve and recycle wastewater (see Management responses, Increasing the use of recycled water).

Nutrient concentrations in irrigation drainage are usually much higher than the ANZECC (1999) *Guidelines for Fresh and Marine Water Quality*[233].

Urban stormwater is the most significant source of pollution for Melbourne's rivers, creeks and wetlands[234]. Contaminants include nutrients, toxicants such as metals and hydrocarbons, pathogens and litter. Although these pollutants are generated in the catchment, the drainage system amplifies the environmental impact by directly transporting the pollutants to receiving waters, in particular Port Phillip Bay.

Photo: Jane Tovey

Management Responses

Major national and state policy initiatives and actions to improve water management have been implemented in the past decade, but recognition of the true extent of ecological damage caused by past management practices, prolonged water scarcity and the threat of climate change have increased the urgency for Government action.

Competing demands have placed increasing pressure on Victoria's limited water resources. In 2004, only 21% of Victoria's rivers were in good or excellent condition, and in the north of the State many tens of thousand of hectares of River Red Gum forests and wetlands are facing irretrievable damage (see Part 4.3 Inland Waters). Management responses to these issues are inextricably linked to agriculture and urban growth, with regional communities likely to be most directly affected.

This section reports on management responses in terms of three central objectives:

1) Maintaining and improving the condition of rivers, lakes, wetlands, estuaries and aquifers
2) Improving the efficiency of water use
3) Managing the total water cycle[viii] to maintain and build resilience in human settlements and environmental systems.

The National Water Initiative commits governments across Australia to achieving a nationally compatible market, regulatory and planning based system for managing water resources[235]. In Victoria, the principal vehicles for this integration have been the policy documents *Our Water Our Future* (2004); the *Victorian River Health Strategy* (2002); the Central Region Sustainable Water Strategy (2006) and *Our Water Our Future: The Next Stage of the Government's Water Plan* (2007). Specific strategies and plans support these documents at a range of scales, from regional down to sub-catchment (see Figure WR28).

The three remaining *Regional Sustainable Water Strategies* were due to be completed by 2008. The *Northern Region Sustainable Water Strategy Discussion Paper* was released in January 2008, and the *Eastern* and *Western Region Sustainable Water Strategies* will commence shortly.

viii In the urban context, this is represented by Water Sensitive Urban Design (WSUD)

Many organisations and individuals in Victoria are striving to improve their use of water, and this section describes only some representative responses, which focus on pressures relating to water consumption and flow regimes. Responses to other issues relating to inland waters, including climate change, are also reported in Part 4.3 Inland Waters. Not all of the reported responses are aimed at reducing pressure on the environment but their impact varies only by degree, as all water consumption occurs within the water cycle. All 'new' sources of water, including desalination, recycling, rainwater tanks and system inter-connections, will generally be more energy intensive than the older gravity fed supplies of water from elevated storages. Energy requirements and greenhouse emissions are also important considerations for water systems. Many of these responses are recent and are still being implemented.

Recommendations

WR19 The Victorian Government should finalise *Sustainable Water Strategies* for the Eastern and Western regions as soon as possible.

WR20 The Victorian Government should provide regular, consolidated reports on progress against the actions and outcomes within *Our Water Our Future and Regional Sustainable Water Strategies,* including compliance with environmental flow obligations.

Response Name

Improving the efficiency of water distribution systems

Responsible Authority

Victorian Government, Water authorities

Response Type

Infrastructure modernisation/asset management

The efficiency of distribution systems can be improved by addressing the causes of unaccounted water (see Figures WR23 and WR24). In urban systems, leak detection is an ongoing component of asset management. In rural systems, a range of projects is being implemented to improve outdated or ageing infrastructure (see figure WR29). Major projects include:

- The Wimmera Mallee pipeline, which will recover an estimated 103,000 ML annually, of which 77,400 ML will be returned to rivers and wetlands[236].
- The decommissioning of Lake Mokoan, which will recover an estimated 46,000 ML a year for environmental flows in the Broken River and Murray Rivers[237].
- The Northern Victoria Irrigation Renewal Project, which will comprehensively modernise irrigation areas in the Murray-Goulburn region. An initial $1 billion stage is expected to deliver up to 225,000 ML annually. Full implementation of this project, at an estimated cost of $2 billion, is expected to recover approximately 425,000 ML[238]. The savings from the Northern Victoria Irrigation Renewal Project will be shared between the irrigation systems, environmental water reserve and Melbourne consumers (via the Sugarloaf pipeline).
- The Shepparton Modernisation Project will recover an estimated 47,300 ML of unaccounted water which will be directed to the River Murray, and the Goulburn River.
- The Central Goulburn 1-4 channel automation project, which is expected to recover 18,000 ML of unaccounted water.
- Macalister channel automation project, which is expected to recover an average of 7,000ML of unaccounted water.

Some savings from the Central Goulburn and Shepparton modernisation projects will be used to help meet the 75,000 ML commitment to Melbourne in 2010-11.

In 2006–07, unaccounted water in Melbourne's distribution systems equated to a loss of 3.0 to 5.1 KL/km main/day[239]. City West Water used specialised equipment to detect subtle leaks and located 15 leaks within six kilometres of pipe, resulting in savings of 250 ML a year[240]. In 2006-07 South East Water surveyed more than 3,160 km of pipe, identifying and repairing some 421 leaks to save over 336 ML a year.[241] Coliban Water has outlined measures in its Water Plan to reduce leaks in its urban systems by 1,400 ML a year, and in its rural systems by 4,000 ML a year[242].

Modernising irrigation water infrastructure will allow more efficient use of available water. However, the rivers in the irrigation areas are already degraded, and less water is expected to be available in the future. The challenge for current and future governments is to maintain and improve the condition of the rivers in these areas despite increased competition for water and a need to maintain income from agricultural exports.

Figure WR28. Victorian Water Plan types and relationships
Source: Hamstead, M., Baldwin, C., O'Keefe V. (2008)

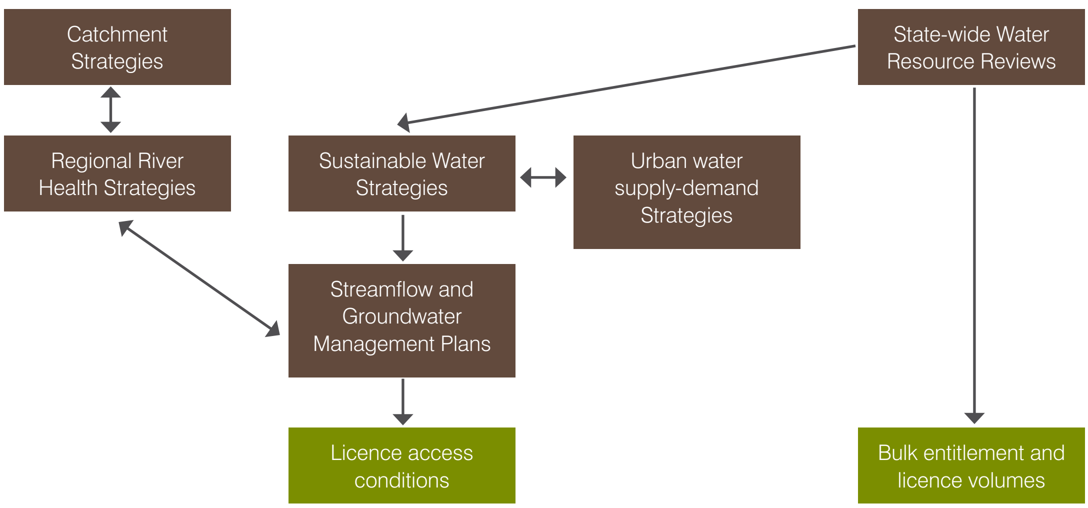
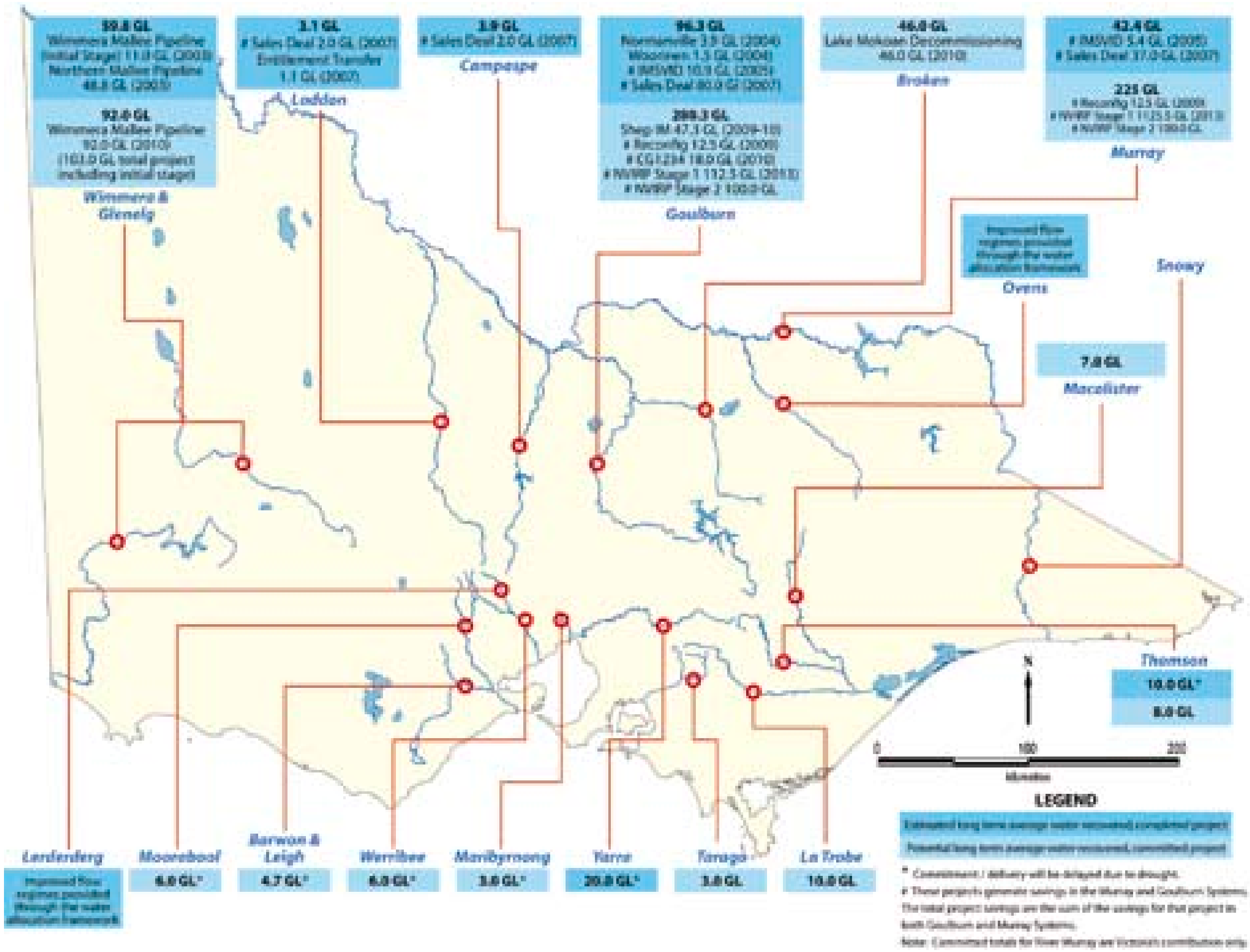


Figure WR29 Water recovery projects in rural distribution and irrigation systems
Data source DSE 2008
NOTES - This is total water recovered rather than water allocated for improved environmental flows. Long-term average volumes are based on conservative estimates of available water.



Improving irrigation efficiency

whole farm planning in the Shepparton Irrigation District

Responsible Authority

Goulburn Broken Catchment Management Authority

Response Type

Management plan

In 1990, the Shepparton Irrigation District established a Land and Water Management Plan to manage salinity. Water use efficiency was increased using Whole Farm Plans to improve farm layout.

By 2005, 200,000 ha of land in the area was operating under Whole Farm Plans[243]. This achievement was enabled by $10 million from the State Government, and up to $600 million invested by irrigators[244]. Better farm layout has resulted in savings totalling about 400,000 ML a year[245]. About 65% of farms have an irrigation water re-use system, accounting for 85% of irrigation water used in the area[246].

About 90% of dairy farms in the Central Goulburn irrigation area have reuse systems[247]. It is estimated that these improved farm drainage and water reuse systems have prevented 200,000 ML returning to rivers on an annual basis[248]. As a result annual pollutant loads being discharged to northern rivers have been reduced by about 750 tonnes of phosphorus, 400 tonnes of nitrogen and 450,000 tonnes of salt[249].

The statistics above demonstrate the communities' resourcefulness and capacity to work together[250]. Despite this effort, and the achievements of the broader landcare movement, both the ecology and the economy of the region remain under stress, and the way forward remains difficult. Water use efficiency is important to limiting environmental impacts and increasing economic viability during water shortages, but by itself will not lead to sustainability.

Response Name
Reducing residential and non-residential water consumption

Responsible Authority
Victorian Government, Water authorities, Industry groups

Response Type
Miscellaneous

Since 2002, the progressive imposition of water restrictions and other demand reduction strategies has been required to ensure continuity of water supply (see Table WR2). Statewide targets have been set to reduce *per capita* consumption by 30% in 2020, compared to average consumption in the 1990s[251]. This target was achieved in Melbourne in 2007, with *per capita* consumption 34% lower than this benchmark[252].

In the Melbourne region, water saved by conservation efforts since 2002 is now greater than six months of usage[253], highlighting the contribution of a conservation ethos to Melbourne's water supplies. As well as efforts by residential consumers, large non-residential consumers have demonstrated impressive water savings. Examples of water savings achieved through long-term process improvement include:

- Foster's Abbotsford brewery has nearly halved its water consumption over the past 15 years[254]
- Altona resin manufacturer Qenos has improved processes since 2002 to save 1200 ML a year, or over 30% of its water consumption[255].

In recent years the urgency of the situation has engaged public attention and water has been high on the public agenda. It is vital that system augmentations to Melbourne's and regional water supplies such as Bendigo and Ballarat do not weaken the strong water conservation ethos that has emerged. As water restrictions are eased, sophisticated and targeted behavioural change and communications programs are required to maintain and build community engagement with water conservation issues. Minimum water efficiency standards for buildings and appliances are required to facilitate further water conservation efforts.

Water conservation and water use efficiency are important but are only elements of a long-term transition to sustainability. As part of this transition, the consequences of water conservation, which may include social costs, future restrictions having less impact, and impacts on wastewater treatment systems also need to be considered.

Table WR2 Examples of demand reduction measures currently being employed by government and water authorities

Measure	Description
Water restrictions	Restrictions on certain uses. Under Stage 3a restrictions which were imposed on Melbourne in 2007, activities such as watering lawns and filling of new pools were prohibited[256]
Permanent water saving rules	Prescribes unacceptable uses of water, and outlines measures to save water in common activities such as cleaning paved areas[257]
Savewater.com alliance	Information for schools, community and industry[258]
Smart Water Fund	Since 2002, has provided over $2 million to over 150 water and biosolids recycling, and water conservation projects. Another $5M in funding is to be made available[259]
Education and behavioural change programs	Media campaigns, educational material such as informative water bills and the 'Shoestring Steps to Saving Water' brochure[260]
Water MAP (Water Management Action Plan)	The WaterMAP program seeks to improve the water use efficiency of non-residential consumers. The program is mandatory for non-residential consumers that use more than 10 ML of potable water a year, of which there are about 1500.
Stormwater and Urban Water Conservation Fund	Stormwater re-use and water conservation projects estimated to save 1,400 ML a year[261]
Environment and Resource Efficiency Plans	Plans that identify actions to reduce energy and water use and waste generation. From 1 January 2008, they apply to all commercial and industrial sites in Victoria using more than 100 TJ of energy and/or 120 ML of water in a financial year[262]
Watersmart Gardens and Homes rebate scheme	This scheme, funded by the Victorian Government, allows rebates to be claimed on water saving products like three-star water efficient showerheads, eligible dual flush toilets, garden products, rainwater tanks and systems for reusing household waste water[263].
WELS rating of water efficient appliances	WELS is the national Water Efficiency Labelling Scheme, which requires certain products to be registered and labelled with their water use efficiency under the national Water Efficiency Labelling and Standards Act 2005[264]. WELS was introduced on 1 July 2006.


Photo: Courtesy of DPI

Response Name
Increasing the use of recycled water

Responsible authority
Victorian Government, Water Authorities

Response Type
Water supply augmentation

In 2002 the Victorian Government set a target for 20% of Melbourne's treated wastewater to be recycled by 2010. Numerous water recycling projects are outlined in *Our Water Our Future* (2004) and the Central Region Sustainable Water Strategy (2006). In 2006–07, 22% of Melbourne's wastewater was recycled, so this target has been achieved ahead of schedule. Consumption of recycled wastewater is proportionally larger in regional areas due to the smaller volumes produced and proximity to fit-for-purpose uses.

Recycled water use in the Melbourne region currently focuses on the use of water from the Eastern and Western Treatment Plants for irrigation in the Cranbourne and Werribee Districts, respectively. The Werribee Irrigation District Recycled Water Scheme started operating in 2005, and was motivated by the urgent need to overcome drought conditions and to sustain future growth in production[265]. The Class A recycled water produced at the Western Treatment Plant is disinfected using UV radiation and chlorination and is safe for the irrigation of all food crops, but salt concentrations in trade waste received by Melbourne's Western Treatment Plant are not reduced in the treatment process. As a result the recycled water needs to be mixed with river water to reduce its salinity[266].

Despite the marginal quality of the water, it proved valuable over the past few years which were extremely dry. Under these conditions, surface water allocations were very low and salinity of river increased beyond that of the recycled water[267]. Due to the availability of recycled water the Werribee Irrigation District maintained about 70% to 80% of production. The 20,000 ML recycled over the past two years has also reduced nutrient loads to Port Phillip Bay by about 180 tonnes of nitrogen a year and 100 tonnes of phosphorus a year[268]. Desalination was recommended to help the recycled water meet fit-for-purpose objectives and thus improve its value to the irrigation industry,[269] but due to its cost it has yet to be implemented. The Western Irrigation Futures project, funded by Southern Rural Water and the Victorian Water Trust, is revisiting means by which water of a suitable salinity can be supplied.

Important recycling initiatives being implemented in the Melbourne region include the mandating of third pipe systems for up to 43,000 households and the upgrade of the Eastern Treatment Plant to produce 100 GL of reliable, high-quality water a year. In 2006, the Hunt Club Estate was the first residential development to receive recycled water, which is for non-drinking purposes. The estimated demand from this estate is 200 ML a year. With 43,000 services connected, an estimated 6,000 ML a year of recycled water will be required[270].

The Eastern Treatment Plant upgrade is expected to be completed in 2012, although uses of the recycled water have not been confirmed[271]. As well as minimising the environmental impact of wastewater discharge to Bass Strait, the upgrade will provide a large, reliable supply of water fit for a broad range of uses. The highest value use for which this water could be used is to augment Melbourne's water supply through indirect potable re-use, but the large supply augmentations in progress mean that this would not be required for many years.

Increased recycling at the Western Treatment Plant will consume up to 37,000 ML a year by 2010, and numerous, smaller, recycling projects are being established through funds such as the Stormwater and Urban Water Conservation Fund, which will save in the order of 600 ML a year[272].

A number of recycling schemes are also planned in regional Victoria, including:

- Bendigo Recycled Water Project[273], which will supply 4,300 ML a year from 2007–08
- Gippsland water factory[274], with an initial stage of 3,000 ML a year complete by 2008 and a full capacity of 13,000 ML a year
- Lake Wendouree recycling scheme, which will yield up to 800 ML a year by 2009[275]

For more information on recycling see Urban Water Harvesting, Recycled Water.

Response Name
A Desalination Plant for Melbourne

Responsible authority
Department of Sustainability and Environment

Response Type
Water supply augmentation

A feature of the *Our Water Our Future: The Next Stage of the Government's Water Plan* is construction of a seawater desalination plant to supply up to 150 billion litres of water a year to Melbourne, Geelong and South Gippsland and Westernport towns. Water will be delivered from 2011 via an 85-km pipeline which will connect the plant to Melbourne. The plant will be capable of providing around a third of Melbourne's current annual water needs. Environmental pressures include site works such as the pipeline and electricity transmission corridors and brine disposal. Desalination is energy-intensive and operating continuously, the desalination plant would consume up to 800 GWh a year, producing an estimated 1,117,950 tonnes of CO_2-e per annum.

The Government is commended for its commitment to fully offset the greenhouse gas emissions resulting from the construction and operation of the desalination plant through the purchase of accredited renewable energy credits. This commitment is in addition to the existing Victorian Renewable Energy Target (VRET) which will increase Victoria's level of renewable energy to 10% by 2016. The VRET scheme, however, is proposed to be absorbed within the national Mandatory Renewable Energy Target (MRET) which aims to supply 20% of Australia's energy by renewable energy by 2020. If this occurs, there is a risk that the renewable energy credits proposed may be simply absorbed into those achieved by the MRET scheme. The Government must ensure the desalination plant is powered by renewable energy which is in addition to an amalgamated VRET/MRET commitment and not that which would have occurred anyway.

The desalination plant will provide insurance for Melbourne's water security and is independent of rainfall, which will be particularly important as water scarcity increases with climate change. By reducing Melbourne's dependence on rivers and aquifers, there will be less pressure to compromise environmental flow regimes through qualifying EWRs in drought or worse, constructing new storages.

Water restrictions and other demand management measures have fostered a strong conservation ethos in Melbourne and markedly reduced consumption. Without ongoing commitment to demand management strategies, and institutionalising water efficiency measures through building codes and design standards, the large volume of additional water produced by the desalination plant carries the risk of undermining this ethos and a return to excessive water use by households and industry. The large volumes of water produced may reduce incentives to promote a greater mix of decentralised source options which may have lesser economic and environmental costs, and allow Melbourne's water supply system to be optimised at a finer scale.

Recommendations

WR21 The contract for the proposed desalination plant should allow the volume of water the plant supplies to be varied, so as not to provide disincentives to the implementation of beneficial water conservation and recycling projects, and to avoid paying for water that is not required.

WR22 The Victorian Government ensure that the proposed greenhouse gas offset purchase of renewable energy credits is additional and beyond the level proposed by either the VRET or MRET schemes.

Evaluation of management responses

The historic priorities for water resources management were to provide reliable sources of water for consumption and to protect the rights of consumptive users, but the focus has now broadened to protect the inland waters on which healthy communities and economies depend. Recognition of the reality of irretrievable ecological damage caused by past and current management practices, prolonged drought and climate change have increased the urgency for Government action. Providing and protecting adequate flow regimes for inland waters remains a central issue.

The current water crisis has been in the making for decades. Nationally, government and industry have been slow or reluctant in taking a lead in improving water use efficiency and constraining damage to inland waters[276].

In the past decade significant improvements in the way water is managed for the environment have occurred, including the adoption of a revised allocation framework which recognises the environment's right to water and caps the maximum volume of water that can be harvested from each basin; the designation of catchment management authorities as managers of the environmental water reserve; the adoption of the FLOWS methodology for assessing environmental flows; improved water accounting through the Victorian Water Accounts; and significant funding commitments to recover water through infrastructure upgrades, some of which will be allocated to the environment.

Sustained low levels of water availability have highlighted the need to improve water resource management, particularly in the context of climate change, but they also limit the impact of some responses. While acknowledging the constraints and challenges imposed by water scarcity, Government must continue striving to improve the management of water resources.

Difficult decisions will need to be made in future as water resources decline. An incremental approach to adapting to these changes may not lead to the best outcome. Given the centrality of the allocation framework to water resource management, it is vital that this system does not hinder the establishment of adequate flow regimes, nor further disadvantage environmental flows under a drying climate. A greater range of options for improving flow regimes needs to be considered, including adjustments to the allocation framework and entitlement buy-backs from willing sellers, to sufficiently meet the seasonal flow requirements of many rivers in Victoria.

Understanding of the impact of climate change on the water sector is developing rapidly, and is being assimilated into long term planning. The *Central Region Sustainable Water Strategy*, which was released in October 2006, was based on low streamflows recorded during the last decade continuing into the future. This was a significant departure from the conventionally conservative planning for water resources, which has in the past assumed that rainfall and runoff fluctuates within an unchanging envelope of variability[277], and used long planning horizons based on the expected lifetimes of major infrastructure such as dams and distribution pipelines. However, by June 2007, The *Next Stage of the Government's Water Plan* was released, which was based on the assumption that even lower streamflows recorded over the last three years may continue into the future. Water authorities throughout the State are now also basing their *Water Supply Demand* strategies on flow patterns from the past three years continuing into the future.

This is illustrative of how quickly the context in which water resource planning takes place is changing. The assumptions used in these strategies recognise the possibility that climate change may result in 'step changes' to streamflow.

Government, industry and community responses to water scarcity have emphasised the importance of water conservation and improved efficiency through a broad range of programs, ranging from the Northern Victoria Irrigation Renewal Project through to education campaigns. Large reductions in urban and industrial water use have been achieved and on-farm water use efficiency has improved. Water recycling has increased, providing a largely rainfall independent, alternative source of water for a range of beneficial uses and reducing polluting discharges to receiving waters. Government targets for increased recycling and reduced water consumption have been met well ahead of schedule.

The use of water resources can adapt to climate change, taking advantage of the creative combination of both new and old technologies. There may be less flexibility in managing the biodiversity values of inland waters, given their current condition. In this context, research and development to assist irrigated agriculture adapt and improve practices is essential. The Government's *Future Farming Strategy (2008)* allocated funding to projects including the development of more drought and salt resistant crops; developing tools to improve resource allocation and practice change methods[278]. Capacity building and support for irrigated agriculture is also provided by groups such as the Department of Primary Industries' Sustainable Irrigated Landscapes unit and the CRC for Irrigation Futures. Similarly, innovation and research should be applied to develop technologies which improve the cost-effectiveness and viability of alternative sources for urban water consumption.

The Victorian Government responded to Melbourne's water shortages and uncertainty over future inflows with commitments to build a desalination plant, the Sugarloaf pipeline and re-connect the Tarago reservoir which will augment supply capacity by about 60% of 2006-07 consumption; as well as providing for an additional 100GL a year of recycled water from the Eastern Treatment Plant.

The approach provides insurance that Melbourne will not run out of water, but the new sources of water for Melbourne, with the exception of reconnecting Tarago reservoir, will be more expensive and more energy intensive than existing sources. Developing new water sources inevitably causes environmental impacts. The cost and environmental impact of improved security of supply can however be minimised through a diversity of water use efficiency and conservation strategies, and the strategic use of decentralised water sources.

The large investment in supply augmentation should be matched by commensurate effort to improve the water use efficiency of new and existing, residential and non-residential water use. The opportunity should be taken to institutionalise, through improved building standards, regulations, appliance design standards and planning provisions, water efficiency and stormwater quality measures which have developed in recent years.

While the source augmentations may reduce the scope for decentralised water sources for established areas, decentralised systems may well be cost competitive, and have broader environmental benefits, in new developments or infrastructure upgrades. Water yield and quality should be given priority over logging in Melbourne's water supply catchments.

There are good reasons for acting swiftly to implement a broad range of supply augmentation and water use efficiency strategies: the water security of Melbourne and regional centres will be improved; innovation, niche markets and water conservation behaviour which have developed over recent years will be supported; community awareness of the importance of careful water use is now high; and it will be easier to accommodate burgeoning population growth and minimise the economic and environmental impacts associated with source augmentations.

Victoria has been recognised for its leadership in water resources policy and allocation, but to date this has not been enough. Inland waters do not necessarily benefit from water use efficiency *per se*, but from secure flow regimes to maintain their condition. At this stage, this remains a policy commitment rather than a measurable achievement.

For more information

Victorian Government management responses, publications, monthly water reports: http://www.dse.vic.gov.au/

Water resources, historical perspective: State of Victoria (1989) Water Victoria: A Resource Handbook. Department of Water Resources.

National Water Initiative policy and publications: http://www.nwc.gov.au/www/html/117-national-water-initiative.asp

Water corporation compliance and performance reporting:

http://www.esc.vic.gov.au/public/Water/Regulation+and+Compliance/Performance+Reports/Water+Performance+Reports/Performance+Reports.htm

Water allocation and policy, independent commentary:

http://www.myoung.net.au/water/

Murray Darling Basin information and publications: http://www.mdbc.gov.au/

Wentworth Group of Concerned Scientists: http://www.wentworthgroup.org/

Watermark Australia: http://www.watermarkaustralia.org.au/

Healthy Rivers Campaign: http://www.envict.org.au/inform.php?item=7

Photo: Jane Tovey