Cities Taking Action

Melbourne: responding to a changing climate

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ABOUT MELBOURNE

Melbourne is the capital of the state of Victoria, in south-east Australia. With a population of 4 million (Colebatch & Lahey 2009), it is Australia's second most populous city. In 2009, Melbourne was named the world's 'third most liveable city' by the Economist Intelligence Unit.

Melbourne is located on a large natural bay (Port Phillip Bay), with the city centre positioned at the northern-most point of the bay, at the estuary of the Yarra River (Figures 1 and 2). With a planned city centre and low-density sprawl in much of the metropolitan area, Melbourne is typical of many Australian capital cities. It is part of the Port Phillip and Westernport region which covers an area of approximately 13,000 km^2. The region includes bay and ocean environments with eight National Parks, six State Parks, eight Marine Protected Areas and a wide range of parks and conservation reserves, all of which support many rare and diverse flora and fauna species (DSE 2008).

Melbourne is one of few cities in the world that sources its drinking water from protected catchments. More than 157,000 hectares, consisting largely of pristine mountain forest, have been closed to the public since 1890, resulting in some of the cleanest drinking water in the world. As a result, the water requires minimal quality treatment. Melbourne's water supply system is also largely gravity fed and uses little energy in supplying water to the city.

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Water storage and supply for Melbourne is managed by Melbourne Water, which is owned by the Victorian Government. Melbourne Water also treats most of Melbourne's sewage in the Eastern and Western Treatment Plants and provides recycled water to customers for a range of uses including irrigation, industrial processes and open space irrigation. Rivers, creeks and major drainage systems are also managed by Melbourne Water. The three Melbourne retail water companies (City West Water, Yarra Valley Water and South East Water) operate the water distribution and sewerage systems for the metropolitan area.

Melbourne's 38 councils (including Melbourne City Council) are responsible for implementing water-related urban planning provisions and have a role in flood protection by managing local drains (for catchments under 60 hectares). Councils are also responsible for managing stormwater pollution and community education around the protection of waterways. As large water users (particularly for open spaces), councils play a significant role in conserving water resources.

CLIMATE PROJECTIONS FOR MELBOURNE

Melbourne's climate is historically variable, with both average annual temperature and rainfall fluctuating

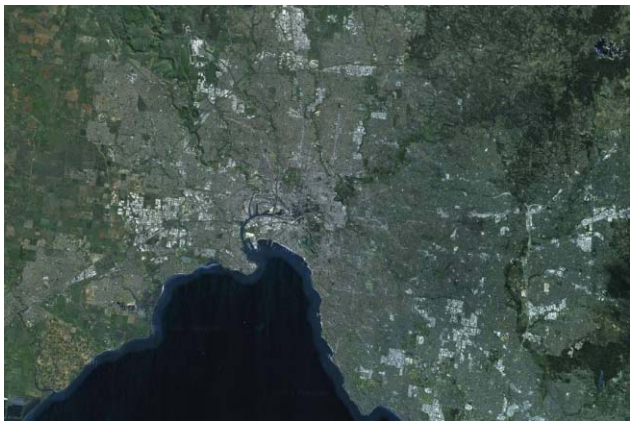

Figure 1 | Satellite picture of Melbourne. *Source*: Google Earth.

considerably across the region. Annual rainfall averaged across the region is 864 mm, but is less than 600 mm to the west of Melbourne and more than 1,400 mm in the Dandenong Ranges east of the city. Generally, rainfall is greatest in winter and spring. On average, there are 135 days each year when at least 1 mm of rain falls. Average annual temperatures, equally, vary between 10 and 16°C across the region. Largely as a result of the urban heat island effect, Melbourne's city centre has historically been the warmest on average (DSE 2008).

The decade ending 2009 was the warmest on record in Australia. Each preceding decade since the 1940s was warmer than the previous one, suggesting a gradual warming of Australia's climate (Australian Government–Bureau of Meteorology 2010).

Climate change projections for Melbourne show the following trends:

- **Hotter**–greatest increases in temperature are expected in summer;
- **Drier**–greatest decreases in rainfall are expected in spring;
- **Fewer rainy days** but increasing rainfall intensity during storm events.

By 2030, average annual temperatures will be around 0.8°C warmer. Summer temperatures are expected to increase by 0.9°C, while winter is likely to be 0.7°C warmer. Reductions in the total average annual rainfall of around 4% are expected, with the greatest percentage reduction occurring in spring (7%).

The impact of climate change is likely to be felt most through extreme weather events. By 2030, the number of hot days (over 30°C) will increase from 30 to 34 (and to 49 under a higher emissions growth scenario by 2070). Bushfire risk is also expected to increase. The number of 'extreme' fire danger days is expected to increase by between 12 and 38% by 2020, and by between 20 and 135% by 2050.

By 2070 the region can expect to be:

- 1.3°C warmer with 6% less rain under a lower greenhouse gas emission growth scenario; or
- 2.6°C warmer with 11% less rain under a higher greenhouse gas emission growth scenario.

Runoff into the Yarra, Maribyrnong, Werribee and Bunyip Rivers is likely to decrease by up to (Australian Government–Bureau of Meteorology 2010, which was based on climate modelling used for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change).

IMPLICATIONS FOR MELBOURNE'S WATER RESOURCES

To account for the highly variable rainfall, Melbourne is served by a system of ten reservoirs with a total capacity well in excess of annual water demand. This provides a buffer between demand and supply in particularly dry

Figure 2 | Melbourne city centre and Yarra River. *Source*: Melbourne Water.

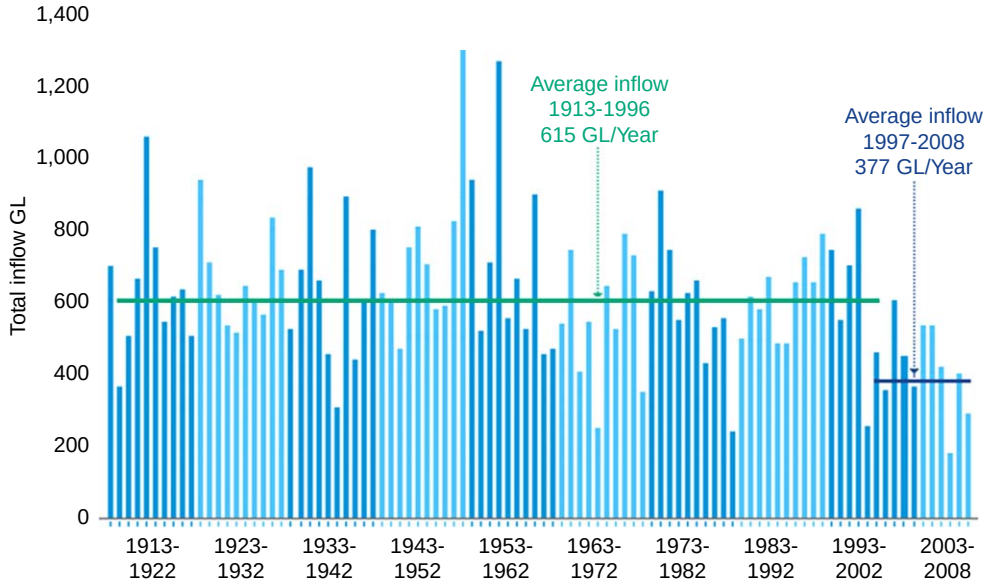

Figure 3 | Annual Inflows into Melbourne's Four Major Reservoirs. *Source*: Melbourne Water.

periods and makes use of flood events when they occur. Nonetheless, the current system relies entirely on rainfall runoff and an assumption that the stored reserves will be sufficient to maintain supply during droughts which have historically lasted for one to two years.

Recent experience is testing some of these assumptions. Already in the last decade (1998 to 2007), average annual temperatures in the region were 0.4°C warmer than the 30 year (1961 to 1990) average. In the same period, a marked decline in the region's rainfall took place (Australian Government – Bureau of Meteorology 2010). While average inflows to Melbourne's reservoirs between 1913 and 1996 were 615 Gl a year, inflows between 1997 and 2008 averaged 377 Gl (Figure 3), a decrease of 39%.

The South Eastern Australian Climate Initiative, a three year, A$7.5 million research programme involving government and industry, confirmed in 2009 that the decline in rainfall is due to rising levels of greenhouse gas emissions, rather than natural variability (Fyfe 2009).

Melbourne's water resources are therefore already under stress. Related current challenges include:

- **Bushfires:** Melbourne's pristine forest catchments face bushfire threats in most years. The 2009 'Black Saturday' bushfires, which killed 173 and injured 414, damaged about 30% of the catchments (Figure 4). Immediate impact on the quality of water supplied to Melbourne was successfully managed, but decreases to water yield are expected for at least 80 – 100 years as the forest regenerates.
- **Drought**: Melbourne and the surrounding areas have been in drought since 1997. From over 90% in early 1997, storage levels have dropped significantly to just over 30% as of June 2010.
- **Environmental flows:** Victoria's waterways experience continued pressures associated with low flows and dry conditions. Changes in the distribution of native fauna such as the platypus are beginning to be shown by monitoring data. Demands for water by consumers,

Figure 4 | Wallaby Creek catchment (a) before and (b) after Black Saturday. *Source*: Melbourne Water.

Figure 5 | Community raingarden. *Source*: Melbourne Water.

industry and business have resulted in reduced water allocations for the environment.

- **Population growth:** Recent population projections indicate that Melbourne's population is likely to reach 5 million before 2030 – faster than previously anticipated. Melbourne is also projected to overtake Sydney as Australia's largest city by 2037, owing to higher house building rates and projected numbers of immigrants (Dusevic 2010).

Other expected areas of risk to Melbourne's water resources were identified in a collaborative study between Melbourne Water and CSIRO in 2005 – one of the first studies worldwide to examine the implications of climate change on water, sewerage and drainage systems. The major risks identified included:

- Increased potential for corrosion and odours caused in the sewerage network as a result of increased sewage concentrations;
- Increased incidence of sewer overflows due to increased rainfall intensity during storms;
- Increased risk of pipe failure and collapse due to dry soil conditions;
- Increased salinity levels in recycled water due to rising seawater levels resulting in increased infiltration to sewerage network and at wastewater treatment plants;
- Increased flooding risk and property damage due to increased rainfall intensity during storms;
- Increased risk of damage to stormwater infrastructure and facilities (e.g. underground drains, levee banks, pump stations) due to higher peak flows;
- Potential for negative water quality impacts in Port Phillip Bay due to increased concentration of pollutants entering the bay and higher ambient bay water temperatures (Howe *et al.* 2005).

While the possibility of step changes in climate conditions was identified in the study, the reductions in streamflow since 1997 now exceed the severe climate change projection for streamflows for 2050. Extreme bushfires and heatwaves have further emphasised the uncertainty inherent in adapting Melbourne's water resource systems to a variable and changing climate.

RESPONDING TO A CHANGING CLIMATE

The water sector in Melbourne

The ongoing drought and the Howe *et al.* 2005 study highlighted that a reliance on centralised, rainfall-dependent water sources is no longer sufficient to ensure Melbourne's water security. There is an increasing focus

Figure 6 | Raingarden at the Federation Square car park. *Source*: Melbourne Water.

Figure 7 | Golf course using recycled water. *Source*: Melbourne Water.

on diversifying the water supply portfolio to build resilience to major shocks to the system – such as significant drops in reservoir runoff or major bushfires that destroy catchments.

At the strategic level, Melbourne Water is moving towards integrated city and water planning, recognising the integral role of water in sustainable cities, and increasingly considering decentralised solutions (see Figures 5 and 6). See for example Skinner (2010), which poses the theory that the introduction of water-sensitive urban design (WSUD) measures early in the planning of the built environment can result in a reduction in residential demand from centralised potable water supplies of over 20% or 70 Gl – or about a third of the projected 2050 Melbourne 'water deficit' (the extent to which average annual demand exceeds supply).

While WSUD has been a focus of Melbourne Water's work for years, the emphasis has largely been on improving stormwater runoff quality, reducing peak flows and protecting waterways. Increasingly, stormwater is being recognised as a resource with the potential for considerably reducing demand for potable water. There are currently over 70 stormwater harvesting projects in Melbourne, with a combined volume of approximately 2.7 Gl. These projects range from irrigation of open spaces (golf courses, sports fields and parks; see Figure 7) to use for toilet flushing in public buildings and truck wash-downs.

Recycled water is used as a resource for irrigation, open spaces and industrial processes. In 2008/09, 65,587 million litres of recycled water were supplied in metropolitan Melbourne. The retail water businesses are developing projects to deliver the government's potable substitution targets, such as dual pipe schemes in new residential developments, with Melbourne Water to provide much of the bulk recycled water supply.

The water sector and beyond: collaboration for sustainability and liveability

Beyond the water sector, Melbourne Water recognises that collaboration is the key to maintaining Melbourne's liveability and to creating sustainable cities of the future.

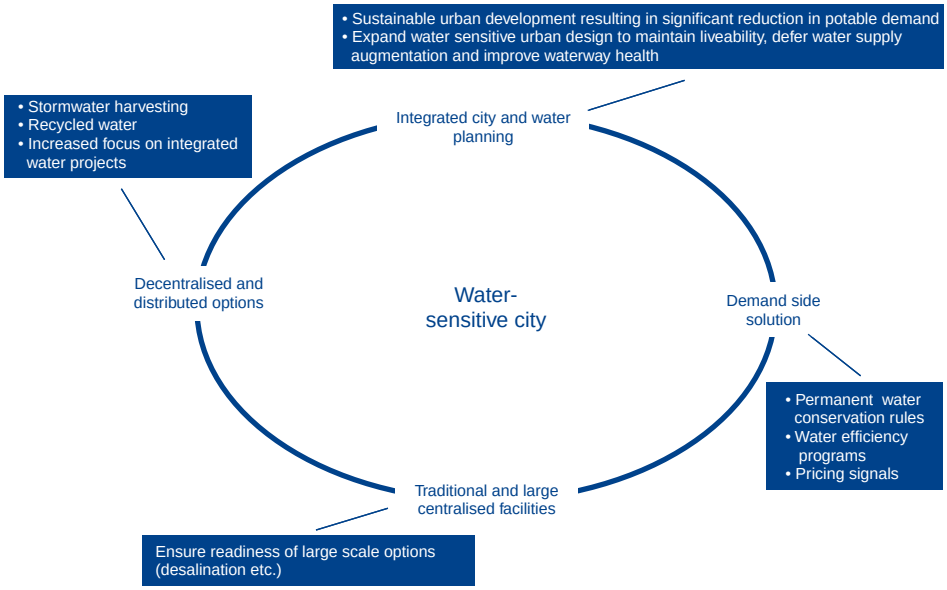

Figure 8 | Creating a More Water Sensitive City. *Source*: Melbourne Water.

Figure 9 | Council House 2 (CH2). *Source*: City of Melbourne.

This includes both local and international collaboration on projects as well as research and thought leadership initiatives, such as the 'Cities of the Future' workshop at the Australian Water Association's Ozwater 2010 conference (co-hosted with the Water Services Association of Australia).

At the local level, Melbourne Water and the retail water businesses are working together to develop and deliver a vision and supporting programme of sustainable water management for a better Melbourne (Figure 8). They are already collaborating with industry and local councils on integrated water strategy projects designed to take into account the entire urban water cycle. These projects aim to reduce the demand for potable water, reduce the volume of wastewater, improve stormwater runoff quality and reduce peak flows. They currently account for only a handful of examples, but their importance and visibility is growing considerably.

At a building level, multiple alternative water sources are already being utilised. The City of Melbourne's Council House 2–Australia's first new 6 star, Green Star-rated commercial office building (Figure 9)–is anticipated to reduce mains water consumption by more than half, compared with a standard equivalent building. In addition to water-efficient fixtures and on-site rainwater collection, blackwater and greywater treatment on site provides 72% of non-potable water.

Moving towards a more water-sensitive city is only one part of maintaining Melbourne's liveability. Other sectors–including the transport and urban planning sectors–have their own plans for achieving this objective. The water sector is looking to collaborate with these and other sectors–energy, education and health to name a few–to integrate planning towards a joint vision: creating a sustainable city of the future.

REFERENCES

Australian Government–Bureau of Meteorology 2010 *Annual Australian Climate Statement 2009* (www.bom.gov.au/announcements/media_releases/climate/change/20100105.shtml, accessed 16 November 2010).

Colebatch, T. & Lahey, K. 2009 Melbourne's population hits 4 million. *The Age*, 23 September 2009 (www.theage.com.au/national/melbournes-population-hits-4-million-20090922-g0j7.html, accessed 16 November 2010).

DSE (Department of Sustainability and Environment) 2008 *Climate Change in Port Phillip and Westernport* (www.climatechange.vic.gov.au, accessed 16 November 2010).

Dusevic, T. 2010 Melbourne on target to be our biggest city. *The Australian*, 27 April 2010 (www.theaustralian.com.au/news/nation/melbourne-on-target-to-be-our-biggest-city/story-e6frg6nf-1225858534865, accessed 16 November 2010).

Fyfe, M. 2009 It's not drought, it's climate change, say scientists. *The Age*, 30 August 2009 (www.theage.com.au/national/its-not-drought-its-climate-change-say-scientists-20090829-f3cd.html, accessed 16 November 2010).

Howe, C., Jones, R. N., Maheepala, S. & Rhodes, B. 2005 *Implications of Potential Climate Change for Melbourne's Water Resources*. Collaborative project, Melbourne Water and CSIRO Urban Water and Climate Impact Groups, Australia.

Skinner, R. 2010 Adaptation to climate change in Melbourne: Changing the fundamental planning assumptions, paper presented at the *Climate Change Impacts on Water Supply Forum*, Washington, DC, January 2010 (www.melbournewater.com.au/climatechangeadaptation, accessed 16 November 2010).