Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s

In this exhibition, we invite visitors to consider the historical relationship of "water crises" of various kinds to the development of urban water systems, through the experience of the driest inhabited continent on earth, Australia. We have chosen a range of different departures from water-related business as usual—from shortage to flood, pollution to drainage—in the five mainland Australian state capitals from the late nineteenth century to the present. The part of this exhibition devoted to each city focuses thematically on just one or two kinds of crisis, while the timeline covers a wider range of events in each place.

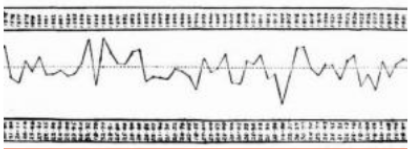
Introduction

Adelaide

Brisbane

Melbourne

Perth



Timeline

Sydney

Further Reading

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About the Exhibition

This exhibition arose from an Australian Research Council (ARC) funded research project on "Water and the Making of Urban Australia: A History Since 1900" (DP180100807). The project aims to produce the first integrated and comparative historical study of the provision, use, and cultures of water in Australia's five largest cities from 1900 to the present, leading to new understandings of the historical drivers of today's urban water systems and how these systems have historically impacted on human and ecological welfare. Such historical knowledge is critical at a time when the water systems of Australia's largest cities are under growing pressure from environmental change and population growth. The research project seeks to contribute to the creation of more resilient and sustainable water systems by enabling us to learn from the past and by contributing to national and international conversations on urban water beyond technical solutions. The authors are grateful for the support of the ARC and the Rachel Carson Center for Environment and Society, and in particular Jonatan Palmblad at the RCC, who coordinated the exhibition. We also thank the many institutions and individuals who provided images and reproduction permissions.

Introduction

In 2015 the World Economic Forum declared water crises to be the biggest risk facing the planet. Since then, the combination of rapidly growing urban populations, insufficient or inappropriate infrastructure, and climate change has seen urban centers become increasingly vulnerable to water supply disruptions widely understood as "crises." São Paulo, La Paz, and Cape Town are presented as cautionary tales to political and urban leaders in the expectation that this will lead to improved water planning and governance. Beyond these conspicuous examples, histories of urban water show that adverse events are commonly important drivers of change in water management—but patterns of crisis and response do not always produce good long-term outcomes.

In this exhibition, we invite visitors to consider the historical relationship of "water crises" of various kinds to the development of urban water systems, through the experience of the driest inhabited continent on earth, Australia. We have chosen a range of different departures from water-related business as usual—from shortage to flood, pollution to drainage—in the five mainland Australian state capitals from the late nineteenth century to the present. The part of this exhibition devoted to each city focuses thematically on just one or two kinds of crisis, while the timeline covers a wider range of events in each place.

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Map by Nathan Etherington.

Residents and water managers in each of these cities have had to adapt to different environmental conditions and constraints. Their climates vary considerably: subtropical Brisbane and Sydney are well-watered in most years; temperate Melbourne has a modest but evenly-distributed rainfall; Perth and Adelaide experience the wet winters and dry summers typical of Mediterranean climates. The eastern cities in particular are vulnerable to the effects of the El Niño Southern Oscillation, which brings regular periods of savage drought, usually followed by a deluge of rain.

The amount of rain falling over each city and its catchment has varied over time, with the annual averages in each case lower—sometimes markedly—since 1975 than in the decades prior. Rainfall also varies—again, sometimes greatly—across each metropolitan area: for example, from 1961–90 an average of 1302 mm fell on Observatory Hill in central Sydney each year, but only 864 mm fell in average on Blacktown, a suburb of western Sydney.

Geography, too, is influential. Melbourne extends inland from the shores of an enclosed bay; Perth stretches

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along a sandy coastal plain dotted with wetlands and bounded by an escarpment; Sydney is oriented around its harbor as well as beaches and inland river systems; rivers also run through Perth, Melbourne, Adelaide, and Brisbane. Varying relationships between rainfall and surface water in the five cities give rise to different opportunities for water source development and waterborne waste disposal, as well as different water crises.

Brisbane is flooded by the second and third highest recorded floods within a fortnight. Unknown photographer, 1893.

Courtesy of the State Library of Queensland. Image 84890. Click here to view source.

How a "crisis" is framed and understood matters: we need to ask how dominant understandings of adverse events emerge in particular contexts, and what responses and actors they summon. In Australia, when water supplies for a city have run low this has not been portrayed as a crisis of overconsumption, or of exceeding environmental constraints, but of insufficient supply and inadequate infrastructure. Almost invariably the immediate response has been to restrict water use in order to share remaining supplies, with the ultimate solution seen to lie in expanding capacity to extract or make more potable water—via dams, rivers, groundwater, or desalination. In the case of flooding, the crisis has not generally been discussed as one of poor urban planning creating flood vulnerability in particular areas, but rather as inadequate provision for floodwater control. Framing the problem in this way has summoned river engineers and dam builders, rather than more informed town planners and local governments. In the case of sewerage pollution on Sydney beaches, the problem was not seen as inappropriate waste of a resource or underinvestment in treatment but as poorly located disposal. This is

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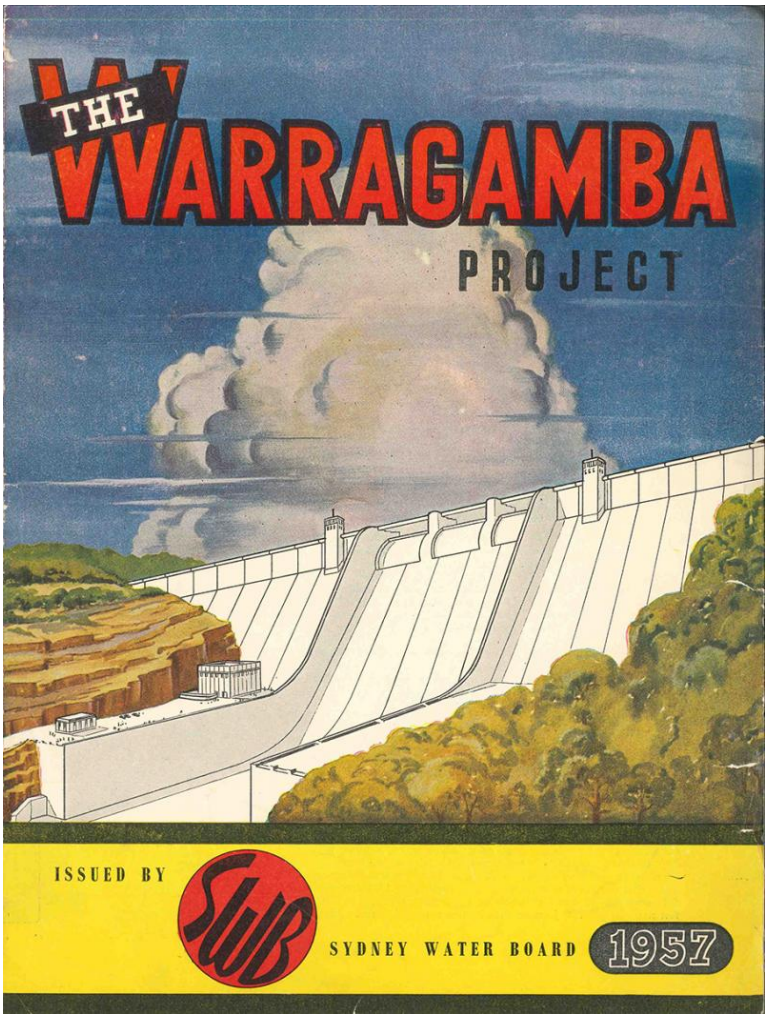
not to say that the proposed solutions have not served the urban population well—at least in the short term they have worked to provide sufficient water, prevent flooding, and ameliorate disease and pollution. However, they have often also served to postpone vulnerability, rather than offering truly sustainable solutions.



Artist's impression of the Warragamba Dam published with Sydney Water Board promotional material in 1957. Unknown illustrator, 1957.

Courtesy of the State Library of New South Wales.

The nature of responses has also been shaped by contemporary everyday politics. For example, for much of the twentieth century, heroic infrastructure was not only a means to address a specific water problem, but also a symbol of technological progress and environmental control, which drew admiring audiences (and voters) as well as expanding water supplies and in some cases providing capacity for flood mitigation. Historically, the most

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heroic infrastructure has been the large dams that ring every major city. More recently, desalination plants have taken on this mantle.

In Australia, primary responsibility for urban water supply and sanitation has lain with colonial and (after Federation of the colonies in 1901) state government. Administrative frameworks for the state management of water supply, sewerage and drainage have evolved in changing political and economic contexts, for example with the gradual rise and fall of engineer-led water Departments or Boards and the more recent transfer of services to water companies using publicly built infrastructure.

From the late nineteenth century, the construction and commissioning of centralized systems of water, sanitation, and drainage established an expectation among both water managers and urban residents that such services were the responsibility of a public authority. There were some exceptions—for example in what a reporter called Melbourne's "heartbreak streets"—where suburban expansion outstripped government capacity for service provision. Here residents of postwar suburbs worked together to develop drained streets, and sanitation was often accomplished on-site with septic tanks; it took many years for government provision to catch up. In general, as the cities grew and the less costly opportunities for water supply and sanitation were exploited, water utilities have had to work hard to return some of the responsibility for water to system users, for example in encouraging water-conserving practices and the installation of water tanks and water-efficient appliances.

Children ride bicycles near the open drains of Bulli Street, Moorabbin, ca. the 1960s. Unknown photographer, n.d.

In Perth there was an early, unsuccessful experiment with private provision of the city's water supply, which was mired in conflicts of interest and underinvestment; the government bought the system in 1896. All the urban water utilities were thereafter operated by government agencies for the public good. As water is foundational to human life and well-being politicians have not been bold enough to privatize urban water utilities outright, though the rise of neoliberalism has led to the corporatization of water in Melbourne (1992), Sydney (1994), Perth (1996) and Adelaide (2002).

Corporatization is essentially a soft form of neoliberal management, in which agencies are fully owned and operated by the state, but have a separate financial and legal status. This means that managers are expected to account for expenses and revenues as if the utility were an independent company, ostensibly separating political decision-making from the pursuit of economic efficiency. In some cases, management has been contracted out to private corporations. Citing reduced political interference and greater transparency and accountability, this institutional structure pushes questions of sustainability and long-term environmental impact to the margins, despite increasingly widespread public concern over environmental issues.

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Many of the wetlands fed by the Gnangara groundwater mound are now in a state of ecological emergency. Photograph by Department of Water and Environmental Regulation, WA, 2010.

Problems with sewage treatment in Adelaide and the contamination of Sydney's drinking water have been linked to cost-reduction programs at both utilities. Running water utilities as businesses can create perverse incentives, as the model generally relies on income from production and distribution of water, rather than its conservation. Water services managed for profit, as in the case of Sydney's desalination plant, do not necessarily align with

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public or environmental needs. However, calls from the business sector for further privatization of Australian urban water services are ongoing, despite misgivings from many other quarters .

Water crises in the Australian past have mainly been associated with periods of rapid population growth, extreme weather events, or both. As we now proceed further into a period of global climate breakdown, the challenges to urban water systems will increase. History shows that many responses to past water crises have been reliant on construction of heroic infrastructure, which often provided opportunities for political gain, and which empowered engineers rather than citizens. This focus on engineering rather than social and cultural solutions has often deferred rather than solved problems. As the case studies here reveal, short-term solutions to water crises can come with a long-term cost. Past decisions to increase supply capacity and construct infrastructure can also limit future solutions. Urban sprawl; the loss of natural wet-lands and aquifers; and reliance on a single source of supply have long-term environmental consequences, as well as raising the cost of future responses. While the water-sensitive urban design movement is providing Australian water utilities with new strategies to meet the challenges of the future , questions remain around how to build a shared sense of responsibility for water security, and how to reconcile the demands of present profitability and future sustainability in urban water systems.

Websites linked in this text:

- https://www.icij.org/investigations/waterbarons/big-pong-down-under/
- https://www.infrastructureinvestor.com/australia-land-privatisation-true-water/
- https://watersensitivecities.org.au/
- http://www.environmentandsociety.org/exhibitions/drought-mud-filth-and-flood/about-exhibition

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Adelaide: Restricted Development

Map by Nathan Etherington.

Adelaide is located between the sea to the west and a low range of hills and desert to the north and east. It has a Mediterranean climate of light winter rains and hot dry summers that average 27–29°C (maximum 46.1°C). The city receives an average annual rainfall of 550 mm per year. Water scarcity has been an issue ever since it was founded by British settlers in 1836. In late summer, after several weeks of high temperatures and little rain, dust storms (and, in many years, bush fires) frequently visit the fringes of the city.

Planned around a central business district, ringed by open parkland and surrounded by suburban lands, Adelaide's location was determined by a freshwater stream, called Karrawirra Parri by the local Kaurna people and the River Torrens by settlers. The river was, in fact, a string of water holes that drained into swampy reed beds near the coast and ceased flowing each summer.

Despite the lack of a substantial and continuous source of fresh water, the population grew steadily, regularly putting efforts to improve water supply infrastructure to the test. The first reservoir was not properly completed until 1862—a small affair drawing water from the original string of water holes about 15 kilometers upstream from the city.

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The need for a reliable supply saw five more reservoirs built by 1903, serving a population of around 200,000 people. But even these reservoirs were relatively shallow and struggled to guarantee the water supply in periods of drought.

For the past 150 years the story of Adelaide's water supply has been one of periodic inadequacy, either in quantity or quality. In recurrent periods of drought, compulsory restrictions on demand have been imposed to conserve supply and "manage" shortfalls. "Waterproofing Adelaide," the name of a 2005 government-commissioned report, has been a constant but elusive goal for the citizens of the city for almost 200 years.

River Torrens, looking east. Unknown photographer, ca. 1860.

Photo courtesy of the State Library of South Australia, B-2780. Accessed on 13 March 2019. Click here to view source.

1927–29; 1930–31, and 1934: Water Restrictions and Inadequate Storage

There had been significant droughts and periods of restricted water consumption before the 1920s. In 1914–15, for example, the price of water was increased sharply and the use of any reservoir water for gardens was prohibited. Officers from the Water Supply Department issued special warnings to racing, lawn bowls, tennis, and golf clubs to restrict their water use. But the restrictions from 1927 to 1929 and again in the early 1930s raised the level of alarm, with concerns of epidemic disease should the shortage prove catastrophic.

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The city's then-largest reservoir, Millbrook, virtually ran dry in the autumn of 1929 and Adelaideans were shocked that its level had reached the "lowest witnessed since catchment was constructed." A township that included a Methodist church and post office, which had been sacrificed to make way for the reservoir, began to reappear as the water receded. Information about the amount of water available in storage and the amount consumed was regularly published in the papers.

Old Millbrook Bridge, usually underwater, exposed by drought. Unknown photographer, c. 1930–34.

Photo courtesy of the State Library of South Australia, B 6477.
Accessed on 13 March 2019. Click here to view source.

At this time not every house had a water meter, and the authorities increased their efforts to increase the number of metered premises. In addition to restrictions on water use, the low water pressure meant that in some suburbs water was barely supplied. Firemen complained of the difficulties caused by low water pressure. By 1931 the Engineer for Water Supply declared Adelaide was "sitting on a volcano" and must "impound new water" by constructing a new reservoir to safeguard the city. By 1938, the state's largest reservoir, Mount Bold, was complete. Located southeast of the city it holds enough water to supply the entire state for only 79 days if used in isolation.

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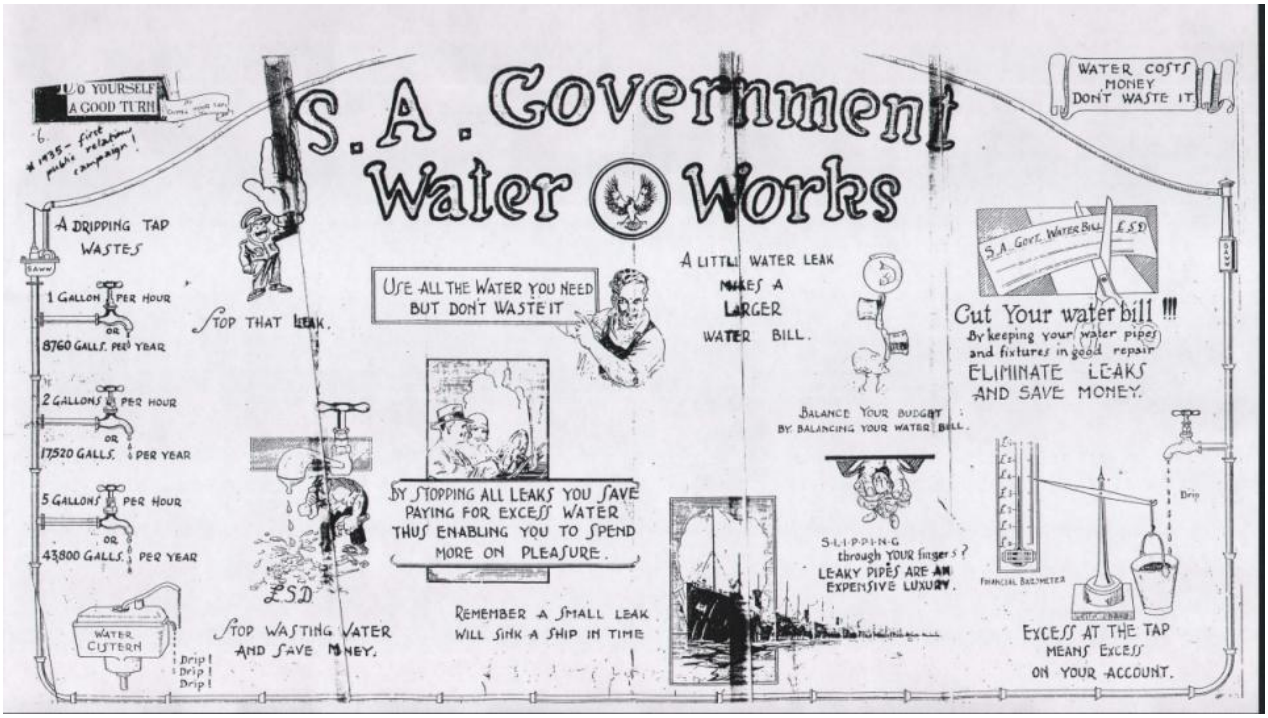

In 1935, South Australia's Water Works Department began its first public water conservation campaign. Unknown illustrator, 1935.

1947–1955: False Hopes of a Permanent Solution

Water shortages loomed large again in the late 1940s and early 1950s, with zoning of water restrictions used to spread the burden. Hand watering of gardens only was permitted, and newspaper editorials bemoaned user selfishness and the lack of foresight of previous governments. Reports suggested a number of buildings burnt down "owing to lack of water." During one shortage the news reported that a local mother was forced to wash her baby in water from the ice-chest drip-tray.

The long-held dream of accessing water from the River Murray (approximately 60 kilometers from the city) was now both urgent and also feasible. The plan was to pump the river's water into the city's shallow water storages to provide enough water for the growing population. The Engineer-in-Chief assured citizens that once the pipeline was completed, Adelaide would never again endure a water shortage.

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Mild steel concrete-lined pipe leaving E&WS yard in Kent Town as work on Mannum-Adelaide pipeline begins, 1951. Unknown photographer, 1951.

In 1955 the River Murray water began to supplement Adelaide's supply, ending five years of summer water restrictions across the city. Water carried by the pipeline did alleviate water shortages for several decades, although it didn't ensure all suburbs received good water pressure. The quality of Adelaide's "hard" water was notorious (it was common folklore that the only two cities in the world where cruising passenger ships refused to take on water were Aden in the Middle East and Adelaide).

Water scarcity did see local innovations, the most famous perhaps being the commercial production of a dual

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flush toilet. This invention, installed in new homes from 1981, aimed to reduce the wasteful use of potable water. In the early 1990s, full cost-recovery pricing, as part of a nationwide push toward water market reform, also reduced the growth in demand. Nonetheless, the perception that Adelaide's supply was underpinned by the Murray remained. This ensured that long-established attitudes towards European-style gardens, and later household swimming pools, were not seriously questioned. Backyard rainwater tanks, although still in evidence in older homes, were regarded as relics of a drier age.

2003–2011: Permanent Restrictions and a New Technological Solution

Australia's Millennium Drought began in 1996 and lasted over a decade. The nationwide drought threatened the sustainability of the whole Murray-Darling river system, and with it the future of dependent rural and urban communities. Adelaide's water supply, "underpinned" by the river since 1955, was no longer guaranteed.

In July 2003, water restrictions were imposed for the first time since the 1950s. Initially the restrictions covered the timing, duration, method, and frequency of watering gardens and grounds. Cars were to be washed only by bucketed water. Filling swimming pools was restricted. These "Level 2" restrictions became "Permanent Water Conservation Measures" in October of that year.

In January 2007 more restrictions, again limiting the time, frequency and methods of watering were imposed. Restrictions were increased eight more times until finally being revoked towards the end of 2010. The 2003 restrictions, however, were made permanent and are now known as "Water Wise Measures."

In addition to restricting water use, rebate schemes were offered for the installation of rainwater tanks, greywater systems, and water-saving plumbing fittings. In 2006 the building regulations were amended to mandate supplementary water supplies in all new dwellings. By 2007 over 40 percent of dwellings in Adelaide had a rainwater tank, more than double any other Australian capital.

The Millennium Drought's impact was felt across the nation. Competition for River Murray water increased inter-state tensions, especially when in October 2007 the *Adelaide Advertiser* reported that "emergency plans had been prepared to supply Adelaideans with bottled spring water for drinking." While this never eventuated, when the drought broke in 2010 Adelaide residents had lost their complacency regarding the city's water supply. The drought's legacies include a desalination plant capable of delivering 50 percent of Adelaide's water annually, permanent water saving measures, regulations encouraging household water tanks, infrastructure projects to capture stormwater, and an ongoing public interest in the management of the Murray-Darling Basin.

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The Millennium Drought prompted South Australia to secure alternative water supplies. Adelaide's Desalination Plant was commissioned in 2011. Photograph by SA Water, 2011.

The lack of an adequate water supply has been a constraint to Adelaide's development since its inception. Local infrastructure developments, responding to political and engineering imperatives and with little or no consideration of environmental equilibrium, regularly failed to keep up with demand. Seeking supply solutions from further afield merely deferred the environmental problems for several decades. The city remains vulnerable, affected not only by local climate and weather patterns, but by water consumption decisions beyond its jurisdiction. While recent efforts to diversify water sources and reduce demand may add a level of temporary resilience to Adelaide's water supply, history suggests there will be more challenges in the future.

Websites linked in image captions:

- https://collections.slsa.sa.gov.au/resource/B+2780
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Brisbane: Dams and the Subtropical Challenge

Map by Nathan Etherington

Brisbane (Meanjin) is the only capital city in Australia built on a floodplain, and the only large metropolitan area to experience major flooding. Its subtropical climate is characterized by summer rain and comparatively dry winters. Brisbane, with an average rainfall of 1149 mm, is the third wettest capital city after Darwin and Sydney.

Established as a British penal settlement in 1824, on land appropriated from the Aboriginal Turrbal and Jagera peoples without treaty or compensation, the infant city suffered a major flood in 1841, with the high water level at 8.43 meters, inundating most of the built-up area. Despite this lesson, the new town embraced the river, filling

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its floodplain with homes and businesses. With each successive decade of urban growth, the flood hazard grew and the potential damage bill expanded. While engineering structures mitigated the floods, nature would prove that they could not be prevented: Brisbane continued to experience major flooding.

The 1893 Flood

In 1892–93 Queensland experienced severe drought in the western districts. Relief came with an especially wet season in 1893, from what is now understood to have been a forceful La Niña event. Over 1,025 mm fell in February alone, causing three floods in the Brisbane River (Maiwar), two of which were over eight meters high.

These floods claimed 35 lives out of a population of 100,000. An estimated 350 hectares in South Brisbane and 130 hectares in North Brisbane were submerged. The Indooroopilly and Victoria bridges were destroyed, leaving the city without a cross-river bridge for two years. Water subsumed almost two-thirds of the Brisbane business district, reaching 4.8 meters deep in places, lapping verandah tops. In South Brisbane, only the roofs of buildings could be seen, peeking out of miles of unbroken water. February's *Town and Country Journal* reported that Stanley Street, South Brisbane's main thoroughfare had become "one long stretch of ruin and desolation."

Brisbane is flooded by the second and third highest recorded floods within a fortnight. Unknown photographer, 1893.

Courtesy of the State Library of Queensland. Image 84890. Click here to view source.

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The river's floodwaters ignored class distinction, with the *Maryborough Chronicle* reporting that "cottage, bungalow, and mansion" vanished equally under the floodwaters. Railway lines and roads were destroyed and the port closed. As fears rose about the threatened water supply, Brisbane was left without gas and electric light. The floods created enormous social problems, including homelessness, destitution, hunger and unemployment.

Flood descriptions portray a sensory overload. Newspapers recounted the noise —the roar of the floodwaters, the crash of debris and "heart-rending screams." Journalists recorded the devastation and suffering vividly. Smell overwhelmingly dominated settler recollections, with typical accounts referring to the "terrific" stench of the receding flood and the "foul-smelling mud." The miasma of floodwaters and mud in Queensland's February sub-tropical heat, full of dead animals, debris, and raw sewage, would no doubt have been memorable.

The central businesses of Brisbane lay under water during the 1893 floods. Photograph by Paul Poulsen, 1893.

Courtesy of State Library of Queensland. Click here to view source.

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The 1893 floods accelerated a program of engineering interventions that included dredging the river, truncating bends, building training walls, and ultimately the decision to build Somerset Dam in the early 1930s, even though its completion took another twenty-five years.

The Australia Day Floods, January 1974

In the La Niña year of 1974 Queensland received an estimated 900,000 million tons of rain in January. As Brisbane prepared for its annual Australia Day public holiday on 26 January, a large monsoonal trough, associated with Cyclone Wanda, hovered above the 13,500 km^2 Brisbane River catchment.

Floods inundated central Brisbane in 1974. Unknown photographer, 1974.

A slow moving rain depression dumped huge amounts of rain, flooding local creeks and the Bremer River tributary upstream in Ipswich. Brisbane experienced three separate intense rain events, with record rain of 600 mm falling over three days. On 26 January Brisbane received 314 mm of rain, only the second recorded time the average monthly rainfall was exceeded in 24 hours and the city's wettest day in 87 years. The capital braced itself for riverine floods. On 29 January the river peaked at 5.45 meters in Brisbane city, the largest floods since 1893 (8.35 m and 8.09 m).

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Spectators watched in awe as the turbulent river raced at 22–25 km per hour towards Moreton Bay. The *Courier-Mail* and *Sunday Mail* offered graphic descriptions: "houses were swept into raging floodwaters," "ripped off their stumps, steel walls of factories were torn open, and luxury craft were smashed to matchwood." The river—now more than three kilometers across at its widest, having swelled into its floodplain—submerged or destroyed everything in its path. Upstream, land lay inundated up to nine meters, leaving buildings submerged to roof height for up to three days.

Men rescue beer from a flooded brewery in Brisbane during the 1974 floods. Unknown photographer, 1974.

Floodwaters cut across highways and railway lines and closed the airport. Only one bridge over the river remained open, streets became canals, and Brisbane became largely isolated. Flooded suburbs were left without gas, and electricity supplies were thwarted, with suburban substations and the main power station inundated. Forty kilometers upstream in Ipswich, coal production ceased, with stored supplies left rain-soaked.

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Raw sewage from the submerged Ipswich sewerage plant and domestic outhouses poured into the river. Debris, chemical contaminants, dead fowl, horses, and cattle floated in the floodwaters, increasing the public's risk of gastroenteritis and tetanus. As the flood waters receded, they left behind layers of disease-carrying sludge, and the rancid smell of mud and effluent permeated the air.

The floods claimed 14 lives in Brisbane and affected 13,000 homes in 30 suburbs that were left submerged, inundated, or damaged, in a city of 712,500 people with 217,847 dwellings. People wept openly in the streets as they returned to the shells of their homes to find their possessions ruined, or their homes damaged beyond repair. With agricultural land rendered unproductive and food left rotting in the Brisbane Markets, the community faced food shortages. Numerous industries, shops, and businesses struggled to resume work, threatening the viability of businesses and the livelihoods of their employees. The cost of damage was estimated at a crippling AUD $178 million.

Many people dealing with flood damage struggled to comprehend why they had been flooded, despite living on a floodplain. To their mind, Somerset Dam had failed to withhold the floods. But relief was seemingly at hand, as the Bjelke-Petersen state government had implemented plans for a second dual-purpose, flood migration and water supply dam, Wivenhoe, which was completed in 1984. This dam, residents hoped, would finally floodproof Brisbane.

2011 Flood: It Happens Again

After almost a decade of drought, water levels in Southeast Queensland's dams had plummeted to frighteningly low levels. In late 2010 Australia entered the strongest La Niña period since 1974. By 5 January 2011, record-beating rainfall had flooded more than 78 per cent of Queensland, 1 million square kilometers (an area greater than France and Germany combined). Worse was to come between 10 and 12 January, as 1000mm fell in the Brisbane River catchment within 48 hours. Townships were almost obliterated by floodwaters on 10 January and the floods took 16 human lives. The floodwaters raced towards Brisbane, reaching heights of 4.46 m at the Port Office Gauge.

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Floodwaters and debris inundated suburban homes in the 2011 Brisbane flood. Photograph by John Doody, 2011.

John Doody, Brisbane, Australia, 2011.

Accessed via State Library of Queensland on 14 March 2019. Click here to view source.

Brisbane's central business district became an archipelago, with 22 streets and hundreds of buildings inundated. Businesses closed for five days, unsettling the local economy. In all, 14,100 Brisbane properties were affected across 94 suburbs, with 1,203 houses flooded: moreover, 1,879 businesses were partly and 557 completely inundated. As floodwaters receded, Brisbane again lay buried in mud, dead animals, decaying vegetation, and sewage, which created a foul-smelling miasma that permeated nostrils, clothing, and memory.

State Premier Anna Bligh later acknowledged that "it felt that all our knowledge, our science, our preparation, and experience might be useless in the face of Mother Nature's new and incomprehensible behavior." Yet floods were not "new." Since British colonization Brisbane had experienced four large floods (in 1841, twice in 1893, and in 1974).

The completion of Somerset Dam in 1959 and Wivenhoe Dam in 1984 had deluded many into thinking that Brisbane had been flood-proofed. While the dams reduced the flood height by 2 m, decades of building on the floodplain had greatly increased the flood damage, a bill that reached 3 billion Australian dollars. The flawed dependency on flood mitigation dams made the floods seem "incomprehensible," rather than a naturally occuring event.

Websites linked in image captions:

- http://rosettadel.slq.qld.gov.au/delivery/DeliveryManagerServlet?change_lng=en&dps_pid=IE287796
- http://rosettadel.slq.qld.gov.au/delivery/DeliveryManagerServlet?change_lng=en&dps_pid=IE288348
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- http://hdl.handle.net/10462/deriv/244027

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Melbourne: DIY Infrastructure

Map by Nathan Etherington.

Post-World War II Melbourne offers a case study of the causes and consequences of enabling the development of suburbs with low standards of water infrastructure in response to rapid population growth. Service provision by different levels of government lagged behind population growth; as a result, private citizens drew on stocks of "social capital"—the norms, networks, and trust that facilitate cooperation between and within groups—to participate in collaborative problem-solving at a local level.

Melbourne before 1945

Established by Tasmanian squatters in 1835 on land illegally acquired from the Indigenous Wurundjeri population, what is now Melbourne was laid out at a freshwater site on a bank of the Yarra River, around 16 km upstream from its outlet at Hobson's Bay.est, the soil is heavier, the land generally flat.

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While the Yarra itself is only 233 km in length, its catchment south of the Great Dividing Range extends to over 5000 km^2, with large floodplains and billabongs (oxbow lakes) along its course holding water after heavy rain and snowmelt. At Melbourne the river reaches an area of flat, swampy ground that is naturally prone to flooding. Gentle hills and river valleys extend to the east and southeast, with a mix of elevated sites and marshy ground extending south along Port Phillip Bay. To the north and west, the soil is heavier, the land generally flat.

Heavy rainfall in April 1901 causes the Yarra to flood its banks. Photograph by Mark James Daniel, 1901.

Image courtesy of the State Library of Victoria.
Click here to view source.

While the town center was laid out in a formal grid by surveyor Robert Hoddle after the settlement was officially recognized in 1836, Melbourne's physical development was driven from the outset by speculators who valued profit over aesthetics.

As the entry port to the Victorian goldfields, Melbourne was the fastest growing city in the world in the early 1850s, with a population that reached 125,000 by 1861. Gold-rush Melbourne was a chaotic boomtown, but safe water was available from 1857. It was drawn from the Yan Yean reservoir, the most ambitious water supply scheme attempted anywhere in the world at the time.

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As Mark Twain observed in 1897, "Melbourne spreads around over an immense area of ground." Like Adelaide and Perth and cities in the western United States and Canada, Melbourne grew by building detached cottages and bungalows close to dispersed docks, factories, and public transport routes to the city center. A preference for single-family houses in a suburban setting was expressed by all classes.

The population of "Marvellous Melbourne" had reached 473,000 by 1891, after growing by 205,000 people in a single decade. Only 15 percent of the metropolitan population lived in the City of Melbourne, with the rest scattered across 19 independent local government areas.

The Watts River Scheme was completed and the water turned on by the Earl of Hopetoun (the Governor), on 18 February 1891. Unknown photographer, 1891.

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The development of new suburbs depended on the expansion of the publicly owned railway network. In 1891, the colonial government created a statutory authority, the Melbourne and Metropolitan Board of Works (MMBW) to build an underground sewerage system and maintain the water supply. Road construction and drainage was the responsibility of local councils.

When the boom collapsed, Melbourne had enough subdivided land served by railways and tramways to provide new home sites for another half century. The city grew by 460,000 people between 1922 and 1947, with suburban expansion following the existing public transport network. Shopping strips developed at railway stations and tram stops. Beyond easy walking distance, ample subdivided lots remained unoccupied and unpaved roads meandered into farmland.

The average population density of the built-up area declined, as the dominant housing style, the Californian Bungalow, sat across broader lots with space for garages. The extra distance between houses increased per capita infrastructure costs, and the MMBW struggled to keep pace with water and sewerage connections.

Postwar Suburban Pioneers

A small boy negotiates a slippery track as he returns home after collecting two pints of milk at the nearest dairy, after milkmen refused to deliver to residents in Birdwood Street, South Oakleigh in Melbourne, Victoria, due to the deplorable state of the roadway. Unknown photographer, 7 June 1949.

Photo courtesy of News Limited.

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Like other Australian cities, at the end of World War II Melbourne faced a backlog of demand for housing due to deferred consumption and investment. At the 1947 census there were only 877 dwellings for every 1,000 Australian households.

During the postwar economic boom, household expenditure was sustained by almost continuous full employment. With increased aspirations and purchasing power, more Australians bought more houses, cars, and consumer durables. Despite rising construction costs, shortages of qualified building tradespeople, and restricted production of building materials, the city absorbed over one million new inhabitants by 1971, many of them migrants from Europe.

Two-thirds of Melbourne's population growth between 1947 and 1966 took place in new "greenfield" suburbs. Austere building styles, reduced dimensions of houses, and Commonwealth government subsidies made homeownership feasible for working-class households.

Families continued to aspire to suburban living, and responded to the gap between the cost of buying an established house and their own budget constraints by self-building. Self-building households could either do all of the construction, using family labor and/or that of friends and neighbors; act as site manager, coordinating the various subcontractors in the construction process; or hire a builder and reduce costs by providing "sweat equity" in the form of unskilled labor. Cheap building materials, such as concrete roof tiles, plasterboard, fibro, plywood, compressed fiber board, and metal-framed windows further reduced costs. Throughout the 1950s, around one-third of new Australian houses were owner-built.

Heartbreak Streets and Community Responses

On the suburban frontier, houses, cars, and domestic appliances attested to rising postwar living standards. Amidst this private affluence, outside the houses public squalor prevailed.

Mrs. J. Asbury gives her daughter Barbara a lift across the flooded drain outside her home in Cuthbert Street, Reservoir in Melbourne, Victoria. Photograph by Len Drummond, 1953.

Photo courtesy of News Limited.

Land prices were low because vacant lots were abundant due to previous subdivision activity. Few services beyond electricity and piped water were provided. The common lot size of quarter of an acre (approximately 1,000 km^2) provided room for garages and makeshift bungalows, in which families could live while the main house was being built.

Sewerage provision lagged in the face of high costs and shortages of labor and capital, but lots were large enough to permit the use of septic tanks and pan (pail) toilets. While these solved the immediate problem of disposal, seepage from the septic tanks polluted local waterways.

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Local governments generally did not grade roads, let alone metal or pave them, and footpaths, gutters, and stormwater drains were not usually provided.

In the winter of 1955, Melbourne's *Sun* newspaper ran a series of reports on the state of the "heartbreak streets"—hundreds of miles of unmade roads in new suburbs. A reporter found that "young couples who have built their homes on the city's fringes step out of their front gates into mud," providing further insights with photos and interviews:

> Life, the ordinary housewifely shopping outing, which is a pleasure to most women, becomes drudgery. Back home from the shops means ... not a cup of tea, but half-an-hour of scraping and washing off mud [from] her pram before she can take it into her house.

In Sunshine where the roads were unmade and there was no running water, Mrs Anita Steigler and her son Ernst along with the family dog set out for home with a bucket of water. Mrs Steigler uses three of these for the family bath. Also pictured is Mrs Urmgard Stanik, who has to carry water home. Unknown photographer, 26 July 1953.

Photo courtesy of News Limited.

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In response, citizen groups, drawing on stocks of social capital, held working bees to improve road surfaces, build footpaths and nature strips (grass verges), and form drains. Women took leading roles in this work, and were active in lobbying local councils and state governments to improve conditions.

In one suburb, groups of housewives built their own roads, wheeling barrows and laying bricks, with their husbands doing the heavier work on the weekends. Volunteers established churches and sports clubs, built community halls, and raised money to support local schools.

While collaborative problem-solving made the "heartbreak suburbs" habitable in the short term, the legacy of poor water infrastructure provision endured for years. The number of Melbourne houses without sewerage stood at 173,000 by 1973, an increase of 56,000 over ten years. To address the problem, the MMBW built the Eastern Treatment Plant, located in the main corridor of suburban growth, which opened in 1975.

Victorian Government planning regulations now required sewerage connection in all new suburbs, and gave local councils the power to compel households to connect if sewerage was available. This stopped any further increase in the number of houses without sewerage, but the MMBW lacked the financial resources to reduce the backlog by building new mains in the outer suburbs.

Unidentified new housing estate in a suburb of Melbourne. Unknown photographer, ca. the 1950s.

Photo courtesy of the Melbourne and Metropolitan Board of Works Collection, H2016.285/17, Pictures Collection, State Library Victoria. Accessed via State Library Victoria on 13 March 2019. Click here to view source.

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Soon after coming to power in 1972, the Federal Labor Government established a national sewerage program, grants from which allowed the MMBW to reduce the number of unsewered properties to 88,000 by 1979. After over two decades in which new communities worked to overcome the problems arising from inadequate water infrastructure, the state had resumed responsibility through a mix of regulation and increased funding.

Children ride bicycles near the open drains of Bulli Street, Moorabbin, ca. the 1960s. Unknown photographer, n.d.

Websites linked in image captions:

- http://handle.slv.vic.gov.au/10381/22992
- http://handle.slv.vic.gov.au/10381/399481

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Perth: Water Beneath the City

Map by Nathan Etherington.

Perth is the only capital city in Australia to rely heavily on groundwater for its water supplies. Founded in 1829 as a British colony on the west coast of the continent, the settlement at Perth grew to sprawl across the Nyoongar lands of the Swan Coastal Plain. The early years were difficult for colonists who arrived unprepared for the long, dry, and hot summers of the site's Mediterranean climate. For most of the nineteenth century, the people of Perth relied on natural springs and household wells for their water supplies. Their proximity to cesspits meant that drinking water was often contaminated and diseases spread easily. The association of nearby wetlands with disease, as well as demands for fertile land and flood management, prompted a series of drainage programs that

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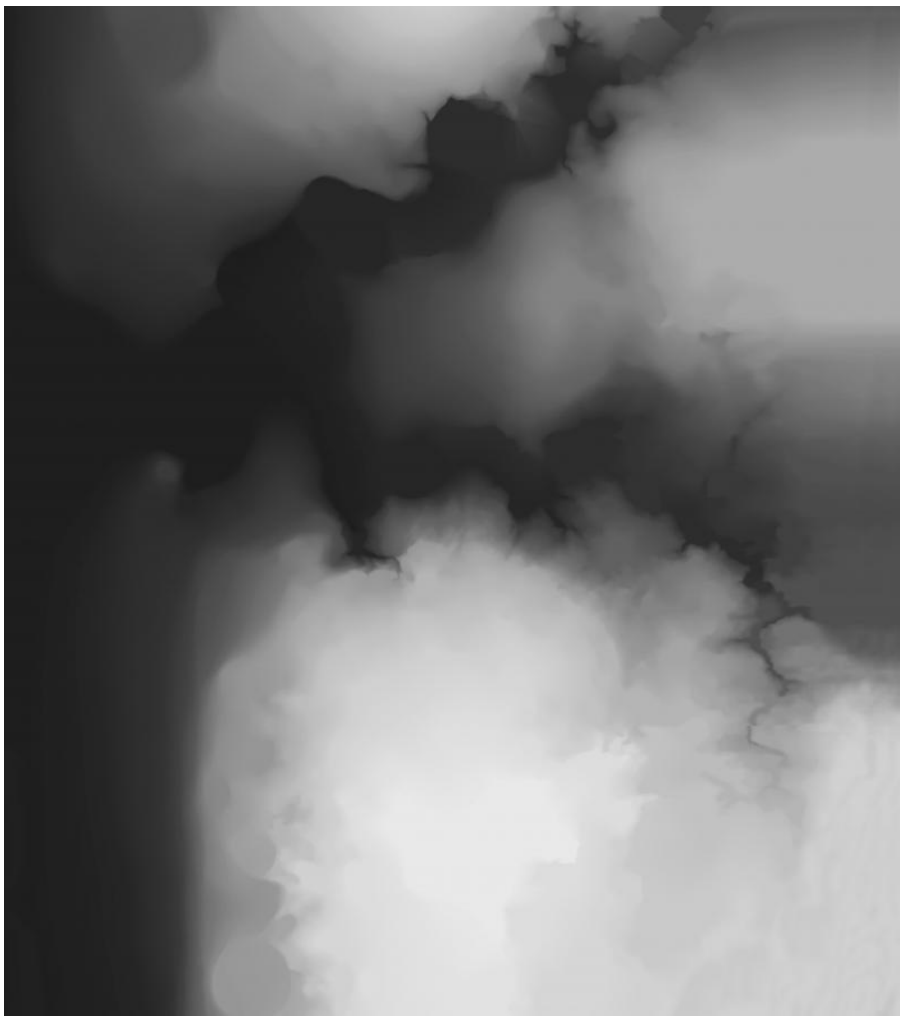
transformed the hydrology of the Swan Coastal Plain.

For thousands of years, Nyoongar had followed the chain of wetlands along the coast, caring for their country while collecting food and other resources. These wetlands were fed from the aquifers of a vast groundwater system that lies beneath Perth's sandy soils. Near the surface are large reservoirs of water, the Gnangara Mound to the north of the Swan River, and the Jandakot Mound in the south. Beneath these are deeper aquifers: the Leederville Aquifer, and lower still, the Yarragadee Aquifer, which lies beneath the entire Swan Coastal Plain and holds almost 2,000 times as much water as Sydney Harbour. The vast reserves of the Yarragadee are thought to be up to 40,000 years old.



The form of the Swan River can be seen in this relief map of the superficial groundwater mounds beneath Perth. The lighter tones represent the higher groundwater elevations beneath the city surface. Image by Daniel Jan Martin, 2018.

Until the 1920s, water from artesian bores and the Victoria Reservoir in the Darling Range east of the city supplemented household supplies, but growing demand, inadequate supplies, poor water quality, and mounting

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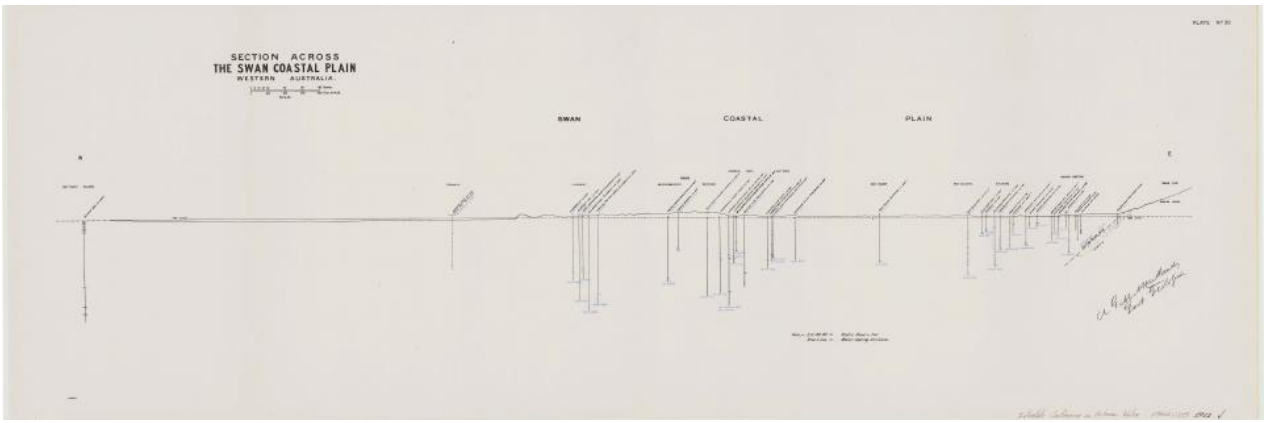
public protest forced the government to dam additional streams in the Darling Ranges for urban water supplies. Over time, however, these dams proved inadequate in periods of drought and high water demand, prompting measures to curb water consumption. In the 1970s, water authorities also began to supplement dam water with groundwater drawn from the unconfined underground reserves beneath the suburbs.

From the 1970s, the onset of a regional drying trend increased the city's reliance on these aquifers. Today, nearly half of the city's potable water is drawn from aquifers, with the rest supplied mostly by desalination. This reliance has brought its own problems, as slowly unfolding subterranean crises have developed over time, hidden from view until they finally take a toll on the people and ecologies at the surface.



Early sectional surveys show an emerging awareness of the extents of groundwater beneath Perth. This mapping of groundwater depth and volume was produced by government geologist A. Gibb Maitland in 1912.

Graphic by A. Gibb, 1912. Section across the Swan Coastal Plain, Western Australia / A. Gibb Maitland, Govt Geologist.
Plate no. 39 in "Report of the Interstate Conference on Artesian Water, Sydney, 1912." Published: Govt. Printer, Sydney, 1913.
National Library of Australia MAP G8971.C315 1912

Chart of Swan River from a survey / by Captn. James Stirling, R.N., 1827 National Library of Australia MAP T 1209.

1970 Digging Deep

By the mid-1970s, Perth's dams could no longer sustain the escalating demands of a population growing in size and prosperity. A decade earlier, international efforts to improve hydrological knowledge had encouraged Australian endeavors to undertake the long-awaited measurement of the continent's water resources. In Western Australia, explorations of the Swan Coastal Plain around Perth revealed extensive stocks of water below the ground. Decades after the decision to obtain water from the streams of the Darling Ranges, the water authorities now believed that these groundwater reserves could be cheaply utilized to supply the suburbs.

With the first bore sunk in 1971, these aquifers soon provided about 10 percent of Perth's water supply and experts predicted the city's reliance on this source would grow. When harsh water restrictions and higher water prices were introduced later in the decade, many households responded by installing private bores or wells in their backyards. The only cost was sinking the well and keeping it maintained. By installing these private supplies, these households essentially gained access to virtually unlimited water for garden use, and, as a result, bore ownership in Perth trebled between 1976 and 1982.

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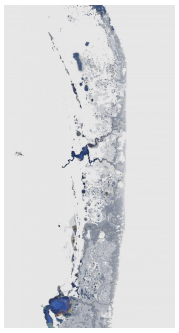
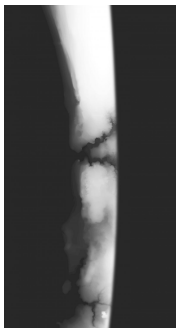
Perth's Urban Area, 2018.



Perth's Wetlands, 1827.



Perth's Groundwater Mounds.

These mappings of the Swan Coastal Plain show (i) Perth's current urban area, (ii) the historic extents of the rivers, streams and wetlands which once covered the Perth region, and (iii) a visualization of the superficial groundwater mounds beneath the city (in this relief map, lighter tones represent the higher groundwater elevations). Images by Daniel Jan Martin, 2018.

Water authorities welcomed this boom in bore ownership: as half the average household consumption of water was being used in the garden, bores alleviated pressure to build more costly water infrastructure for the city. But, as not one of these bores was licensed, metered, or monitored, water use skyrocketed. One 1985 report estimated that a household with a domestic bore consumed over seven times the amount of water of a household dependent on public supplies.

By the end of the 1970s, then, both scheme water supplies and private supplies in Perth were being drawn from the subterranean treasure trove of groundwater beneath the suburbs.

Meanwhile, in the 1960s ecologists estimated that over half of the wetlands of the Swan Coastal Plain had been lost already, and predicted that the public and private abstraction of large amounts of groundwater would endanger those that remained. They expected the draw on groundwater would threaten sensitive communities of flora and fauna, including migratory waterbirds. These concerns were realized in 1991 when large tracts of groundwater-dependent banksia woodland perished, prompting the water authorities to curb their pumping.

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Black swans and other waterbirds on Lake Gwelup. Perth's wetlands are expressions of the groundwater below and continue to support the city's significant biodiversity. Photograph by Daniel Jan Martin, 2018.

2001 Driest Winter on Record

As the drought of 2000–2001 took its toll on the city's dams, groundwater again filled the gap, contributing over half of Perth's water supplies. Water from the Gnangara Mound was pumped into Mundaring Weir to supply residents of the inland mining center of Kalgoorlie, six hundred kilometers away. The state government also offered households a financial incentive to install their own backyard bore, with information on the suburbs best-suited for private water supplies available from the 1997 *Perth Groundwater Atlas*. In 2009, about one in four Perth households had their own bore; their use was unlimited until 2007, when it was restricted to 3 days a week during the summer months. Market gardeners also faced new restrictions on the expansion of their properties from 2007, and found it necessary to sink deeper bores to reach the declining water table.

In the mid-1990s, Perth's water managers had identified a regional drying trend since the 1970s, which had reduced the amount of streamflow into the city's dams by nearly 50 per cent. It did not take long for the burden of greater consumption in a drying climate to take its toll on the already strained underground reserves and the

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wetlands that depend on them. Faced with the challenge of ecological triage, authorities pumped water into some areas, such as the Yanchep caves and Lake Jandabup, in the hope that this might revive them.

Perth's Southern Seawater Desalination Plant converts seawater from the Indian Ocean to drinking water, to meet more than half of Perth's scheme water demand. Photograph by Nearmap Australia Pty Ltd, 2019.

Ongoing questions about Perth's water security in a drying climate dominated the 2005 election, and a year later a seawater desalination plant was completed at Kwinana to supplement the city's water supplies. A second was finished in 2011.

2014 Saving the Aquifers?

In late 2012, the first reports of a worrying trend began to emerge: years of low rainfall, water abstraction, and thirsty pine plantations had combined to produce a sinking effect in Perth suburbs. These findings confirmed conservationists' long-held suspicions that environmental authorities had inadequately policed the water abstraction of market gardeners and the Water Corporation.

Since 2014, the state government has invested in a groundwater replenishment scheme, which involves "recharging" the Gnangara Mound with treated wastewater. Perth residents have been more willing to stomach this process than their Queensland counterparts in Toowoomba, who rejected a similar proposal in 2006. Not only a less energy-intensive mode of water supply than desalination, recycling wastewater in Western Australia's capital presents an alternative to the abiding dream of piping water from the state's northwest. Satisfied with the first phase of the replenishment program, in 2017 the government began to pump recycled wastewater into the older Leederville and Yarragadee aquifers that lie beneath the Gnangara Mound.

Only time will tell if this approach will save the aquifers, while sustaining the water cultures of the people of Perth.

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The original virtual exhibition features an interactive photo gallery. View the photos on the following pages.

Orange stains caused by the iron-rich groundwater are commonplace across Perth. These enduring traces of Perth people's reliance on bores for irrigation are here documented in a photo essay by Loren Holmes.

Photograph by Loren Holmes, 2018.

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Sydney: Dam Water, Filth to the Ocean

Map by Nathan Etherington.

Although Sydney is a young city by world standards, rapid growth in the late nineteenth century saw its population rise to 500,000 by 1900, about the same size as Melbourne's. These two cities were then among the twenty biggest in the world. Sydney has two characteristics not shared by any other Australian mainland capital: a huge deep harbor that could take a large volume of stormwater runoff and sewage, and forested catchments with valleys ideal for building dams. These natural features were exploited by the city's water managers from an early stage as these sought to provide the city with plentiful water and cheap sanitation. Trying to manage demand, with few exceptions, has so far only been a response to acute crises.

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Building Dams and Ocean Outfall Sewers

Sydney experimented with a sewage farm at Botany Bay in the 1880s, with tested effluent channeled into the Cooks River. However, rapid development in the eastern suburbs, based around the tramway system, saw an ocean outlet built in Bondi Beach, opening in 1889. The sewage farm was not expanded in step with the increasing volume of effluent from the southern suburbs, so closed in 1916. With the growth of population in the northern suburbs, fueled by the opening of the Harbour Bridge in 1932, another huge ocean outfall sewer, this time near Manly Beach, opened in 1933. For some decades sewage disposal was shielded from the public, as the ocean installations were embedded in sandstone cliffs, beyond public view. As more and more suburbs were sewered, the health risk created by night soil collection abated, although some suburban subdivisions from the 1950s were not sewered until the mid-1970s.

View of the pumping station and vent at the sewage farm in Botany. Unknown photographer, ca. 1900.

Botany Sewerage Farm, 1900? (City of Sydney Archives); 067261.
Accessed via the Dictionary of Sydney on 8 April 2019. Click here to view source.

From the 1880s most of the city's water supply came from relatively pristine river systems, especially the Nepean River, and water was pumped to large reservoirs for distribution to built-up areas. Beyond that many households had to rely on tank water. The great drought of 1901–2 required concerted action, not only to secure a safer water supply but a more guaranteed one. Dams were built to the south and west of the city center, with water

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pumped to reservoirs and water towers. Sydney's hilly topography made it easy to choose sites for reinforced concrete water towers. Before the building of apartment blocks from the 1960s, these were a prominent feature in the urban landscape.

Temporary pipeline constructed to carry water to Sydney during the 1880s drought. Unknown photographer, ca. 1890.

Courtesy of Sydney Water / WaterNSW6 Historical Research Archive.

Five medium-size gravity dams were built between 1902 and 1941, their walls created out of local sandstone. The average rainfall across the five dams, 1.25 meters, meant that they rarely fell below 50 percent of their storage capacity. However, a drought in the mid-1930s rattled the government-owned Water Board and it embarked on an emergency scheme on the Warragamba River, proposing a huge dam that would flood an entire valley. So vast was the project that the potential storage capacity of the new dam, Australia's largest, was almost four times the capacity of the previous five dams. However, the rainfall in the vast catchment to the west of the city was considerably less than that of the existing catchments, at just 0.81 of a meter.

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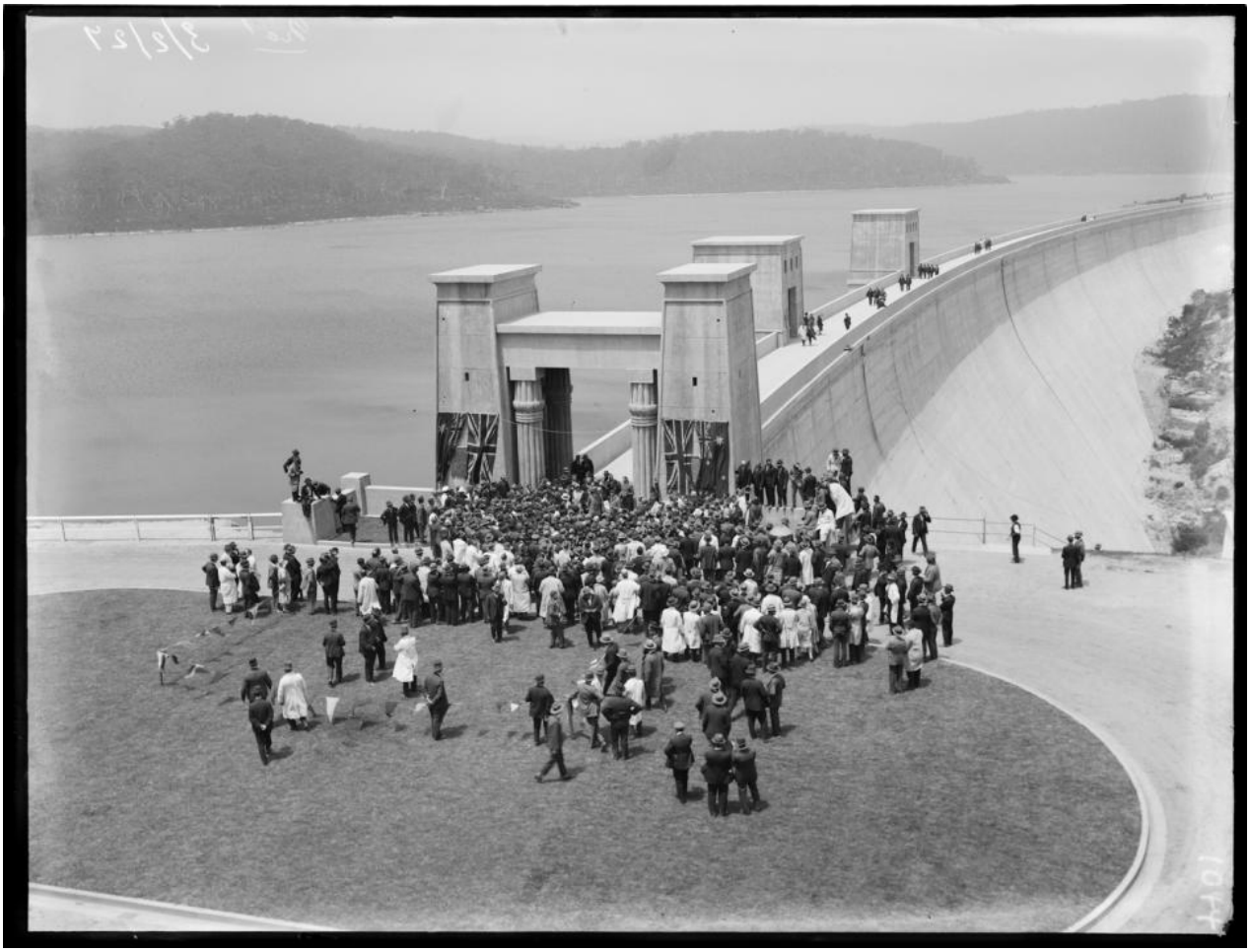

The official opening of the Cordeaux Dam in 1927 by Sir Dudley de Chair. Unknown photographer, 1927.

Courtesy of Mitchell Library, State Library of New South Wales, FL387028.
Box 76 No. 1044. Cordeaux Dam - Official opening Cordeaux Dam, Sir Dudley de Chair, 1927.

Warragamba Dam, which took its name from two Indigenous words, *warra* and *gamber*, meaning "water running over rocks," had been the traditional home of the Gundungurra clans. But, as with other clans, many died from European-introduced illnesses. After their lands were appropriated by colonizing farmers in the last decades of the nineteenth century, the remaining members of the clan were moved to the La Perouse settlement, not far from the Botany sewage farm.

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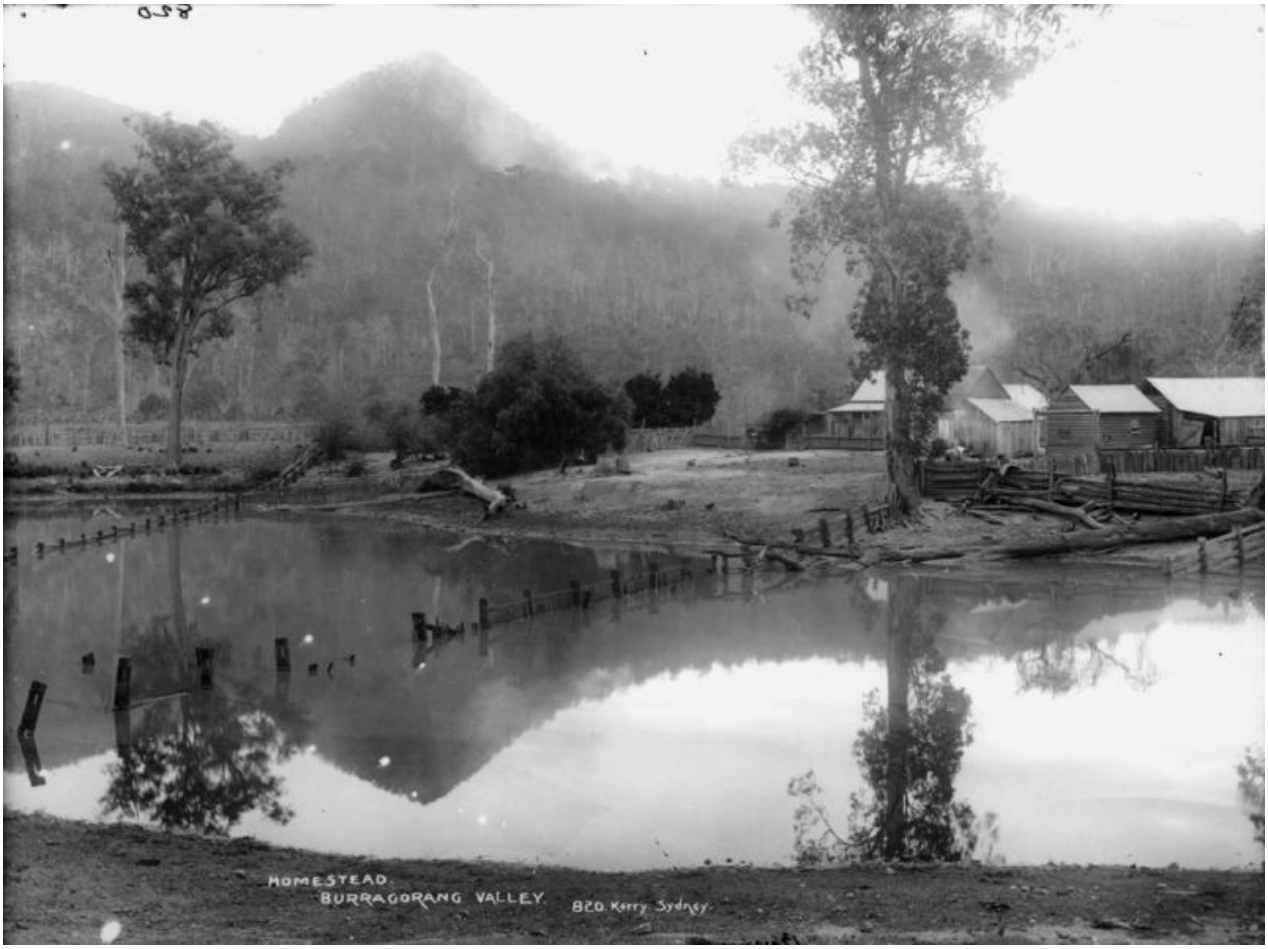
When the dam opened in 1960, the official government booklet observed:

> The building of the Warragamba Dam resulted in the flooding of the Burragorang Valley, drowning what was once the secluded haunt of aborigines and, later, a fertile farming district and popular holiday resort. The settlers have gone: the farms, guesthouses and the little schools and churches have been demolished; and water many feet deep covers the ground where they once stood. These things were inevitable in the cause of progress.



Photograph depicting the Burragorang Valley around the turn of the twentieth century. The valley would be flooded with the construction of the Warragamba Dam. Unknown photographer, ca. 1900.

Courtesy of Powerhouse Museum, Tyrrell Photographic Collection. Gift of Australian Consolidated Press under the Taxation Incentives for the Arts Scheme, 1985.

Accessed via Flickr on 29 May 2019. Click here to view source.

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The dam, with a surface area of 75 square kilometers, could, according to the government, be relied on to supply the growing metropolis on "even the hottest of summer days." A vast public display facility enabled children on school excursions and family groups on weekend picnics to admire the dam wall. Such grand public works were promoted as vital to the city's future.

So Sydney looked set to cope with increased population and a commensurate increase in water use by both industry and residents. From the 1980s, residents and businesses faced higher charges for excessive water use. Those charges and occasional water restrictions in summer kept demand in check.

The next major crisis came not from supply, but from pollution. By the early 1980s the ocean outfall sewers were polluting two of Sydney and Australia's most famous beaches, Bondi and Manly. The smell and the cloudy water could no longer be ignored. Few things bother Australian surfers more than dirty water and a polluted beach. Long extensions were built for the ocean outfall sewer pipes, and more elaborate systems were put in place to treat sewage before release into the ocean. It is much harder to treat stormwater runoff into Sydney Harbour and the ocean because there are hundreds of outlets, not just a handful of sewage treatment plants that can be easily monitored. So, as with cities around the world, an ongoing campaign to convince property owners not to place dangerous chemicals in public drains has had some success in raising consciousness about our collective responsibility to make sure that only rainwater ends up in stormwater drains. Some industries, including paint and gas manufacturers, had to be fined before they would embrace corporate responsibility.

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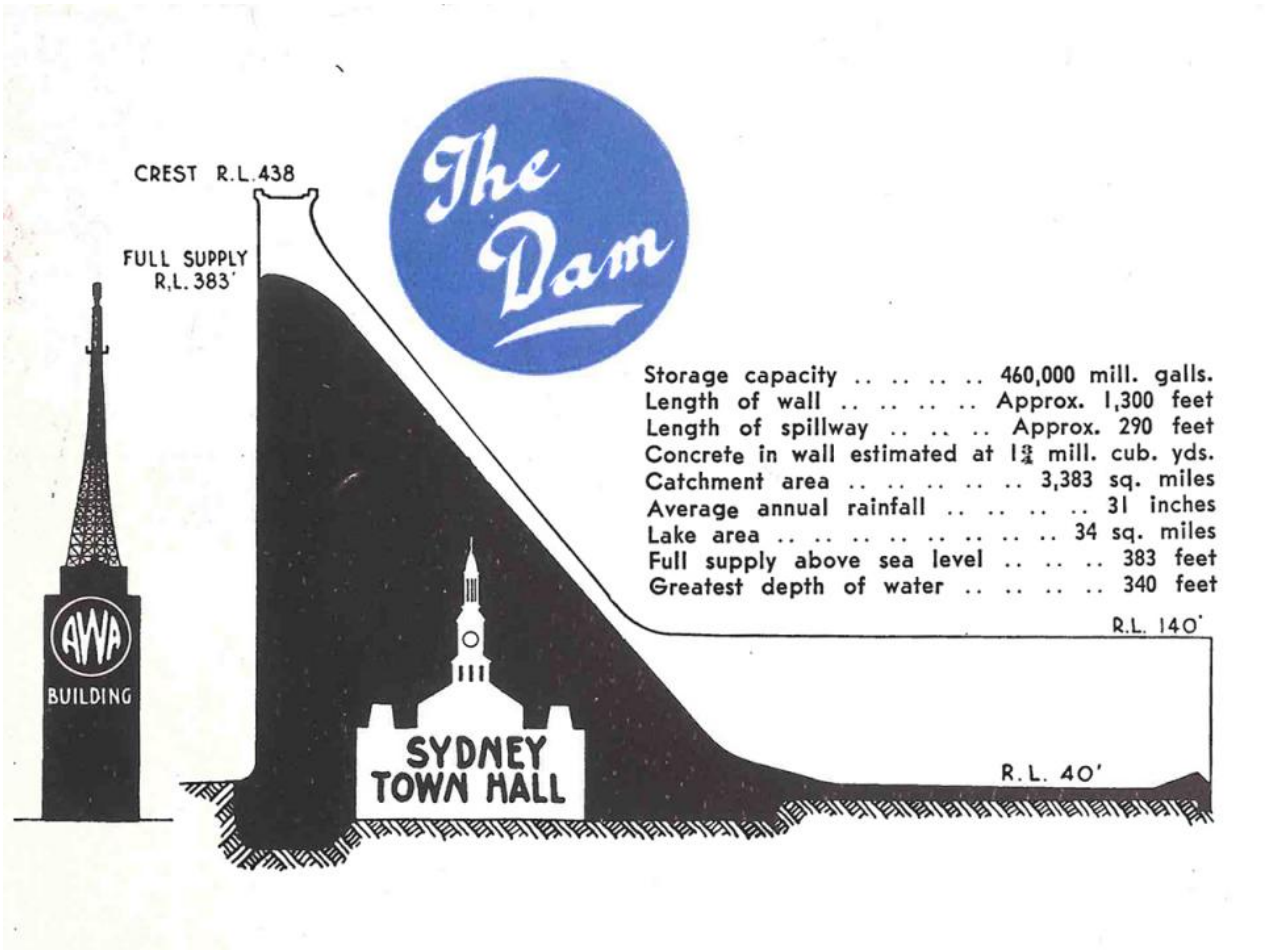

Diagram depicting the scale of the Warragamba Dam in relation to Sydney Town Hall and the AWA Building. Unknown illustrator, 1950.

Courtesy of Mitchell Library, State Library of New South Wales.

Dam Water, Manufactured Water

A severe drought from 2005 caught the state government off guard, especially when the level of the Warragamba Dam fell to 32.5 percent in February 2007, the middle of summer, when many households water their gardens frequently. Severe water restrictions succeeded in driving per capita consumption down from 300 liters per person per day to 230 liters—a poor effort compared to Brisbane, where in an even more severe crisis consumption was reduced down to 112 liters per person per day. Brisbane does have a higher rainfall than Sydney, and a higher proportion of houses with water tanks, mostly used for garden purposes. Sydney not only introduced mandatory water tanks for new dwellings, but has also maintained that requirement, abandoned in

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all other capital cities save Adelaide.

In a knee-jerk reaction the State Government, following the example of Perth (which has half Sydney's average annual rainfall) and Brisbane, worked with a private consortium to build a saltwater desalination plant at Kurnell, abutting the Pacific Ocean, just near Sydney's main airport. At an original capital cost of two billion dollars, it could theoretically produce up to 15 percent of Sydney's annual demand for water. But in the year it opened, 2010, Sydney's rainfall reverted to a more usual pattern; Warragamba Dam was not only full but overflowing by March 2012. The mothballed plant, now bizarrely half owned by the Ontario Teachers' Pension Fund, has become a giant white elephant, costing the government twenty million dollars per annum even when it is not operating, because of the contract it has with the private owners.

The Sydney desalination plant was constructed between 2007 and 2010. Photograph by Sydney Water, ca. 2009.

The experience of the great urban drought in Australia earlier this century shows that householders, with restraint, can drastically reduce their annual daily water consumption. However privately and publicly owned water authorities want residents and businesses to be profligate with water when the dams are over two thirds full, because their income is based on encouraging use. In Sydney, when dam levels fall below 60 percent, the

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government requests the desalination plant to be activated, not least in order to justify the excessive expenditure on the plant in the first place. Even more embarrassing for the government is the high annual transfer of funds to the private owners of the plant, whose only interest is profit. The Ontario Teachers' Pension Fund continues to hope for another great urban drought.

Websites linked in image captions:

- https://dictionaryofsydney.org/media/4627
- https://flic.kr/p/4ARGKw

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.
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Further Reading

Adelaide

A discussion of Adelaide's location and dependence on water is in Michael Williams' "The Making of Adelaide," in John W. McCarty and Boris Schedvin's (eds.) *Australian Capital Cities*. (Sydney: Sydney University Press, 1978, 112–43). Derek Whitlock's *Adelaide From Colony to Jubilee: A Sense of Difference* (Adelaide: Savvas Publishing, 1985) provides an easily accessible overview of Adelaide up until the 1980s. The more recently published *A History of South Australia* by Paul Sendziuk and Robert Foster (Cambridge: Cambridge University Press, 2018) brings the history up to date, albeit with a slightly wider focus. The definitive work on water in the city of Adelaide is Chris Daniels' edited collection *Adelaide: Water of a City* (Adelaide: Wakefield Press, 2010). Marianne Hammerton's *Water South Australia: A History of the Engineering and Water Supply Department* (Adelaide: Wakefield Press, 1986) provides insight into the formation and achievement of this key institution. A more technical paper modeling the impact of drought and the loss of River Murray water supplies is Holger R. Maier et al., "Impact of Drought on Adelaide's Water Supply System: Past, Present, and Future," in Kurt Schwabe et al. (eds.) *Drought in Arid and Semi-Arid Regions: A Multi-Disciplinary and Cross-Country Perspective* (Dordrecht: Springer, 2013, 41–62). How to balance a city's water supplies against the competing demands within the rural sector, with a specific case study of Adelaide, is discussed by Brian Richter et al. in "Tapped Out: How Can Cities Secure their Water Future?" *Water Policy* 15 (2013), 335–63. Current information on water supplies in Adelaide is available on the SA Water website https://www.sawater.com.au .

Brisbane

For an overview of Brisbane's urban water supply, see Gordon Greenwood and John Laverty, *Brisbane 1859–1959* (Brisbane: Oswald L. Ziegler, 1959) and John Cole, *Shaping a City: Greater Brisbane 1925–1985* (Brisbane: William Brooks Queensland, 1984). For more recent urban history see Peter Spearritt, "The Water Crisis in Southeast Queensland" in *Troubled Waters: Confronting the Water Crisis in Australia's Cities*, edited by Patrick Troy (Canberra: Australian National University, 2008, 19–36). For accounts of Brisbane floods, see Margaret Cook, "Damming the 'Flood Evil' on the Brisbane River," *History Australia* 13, no. 4 (2016), 540–56, and "The Australia Day Floods, January 1974," Environment & Society Portal, *Arcadia* (Spring 2017), no. 15, https://doi.org/10.5282/rcc/7871 .

Melbourne

For an overview of Melbourne's history in the past century, see Seamus O'Hanlon, *City Life: The New Urban Australia* (Sydney: NewSouth, 2018). The evolution of urban housing styles is discussed in Robin Boyd, *Australia's Home: Why Australians Built the Way They Did* (Melbourne: Penguin, 1978). Tony Dingle and Carolyn Rasmussen's book *Vital Connections: Melbourne and its Board of Works 1891–1991* (Melbourne: McPhee Gribble, 1991) is an excellent institutional history. On the postwar economic boom and development of

new suburbs, see Rodney Maddock, "The Long Boom 1940–1970," in Rodney Maddock and Ian McLean (eds.), *The Australian Economy in the Long Run* (Cambridge: Cambridge University Press, 1987, 79–105); Tony Dingle, "People and Places in Post-War Melbourne," in Graeme Davison et al. (eds.), *The Cream Brick Frontier: Histories of Australian Suburbia* (Monash Publications in History No. 19, Monash University, 1995, 27–40); Tony Dingle, "Necessity the Mother of Invention, or Do-It-Yourself," in Patrick Troy (ed.), *A History of European Housing in Australia* (Cambridge: Cambridge University Press, 2000, 57–76); Lionel Frost, "Town and Country in the Menzies Years," in J. R. Nethercote (ed.), *Menzies: The Shaping of Modern Australia* (Brisbane: Menzies Research Centre/Connor Court, 2016, 231–55). For a contemporary account of conditions in postwar suburbs, see Barry McCrea, "Heartbreak Streets," *Sun* (Melbourne), 15 August 1955, 9–13.

Perth

For an overview of Perth's history in the past century, see Tom Stannage, *The People of Perth: A Social History of Western Australia's Capital City* (Perth: Perth City Council, 1979), and Jenny Gregory, *City of Light: A History of Perth since the 1950s* (Perth: City of Perth, 2003). For an Aboriginal perspective on Perth's wetlands, see Reverend Sealin Garlett and Corina Abraham, "The Significance of the Beeliar Wetlands for Aboriginal People," in Andrea Gaynor, Peter Newman, and Philip Jennings (eds.), *Never Again: Reflections on Environmental Responsibility After Roe 8* (Crawley: UWA Publishing, 2017, 43–9). The history of Perth's gardening preferences is discussed extensively in Andrea Gaynor, *Harvest of the Suburbs: An Environmental History of Growing Food in Australian Cities* (Crawley: UWA Press, 2006). On Perth's water history, including the development of groundwater resources and the impacts of climate change, see Ruth A. Morgan, *Running Out? Water in Western Australia* (Crawley: UWA Publishing, 2015). For a historical study of Perth's groundwater resources, see Bill Bunbury, *Till the Stream Runs Dry: A History of Hydrography in Western Australia* (Perth: Department of Water, 2010). The best areas for installing a household bore can be found online in the Perth Groundwater Map .

Sydney

For an overview of Sydney's development in the twentieth century, see Peter Spearritt's *Sydney's Century: A History* (Sydney: UNSW Press, 2000). The definitive account of the Sydney system is W. V. Aird, *The Water Supply, Sewerage and Drainage of Sydney* (Metropolitan Water Sewerage and Drainage Board, 1961). See also Dan Coward, *Out of Sight: Sydney's Environmental History, 1851–1981* (Canberra: ANU, 1988). On water crises in the 1980s and 1990s, see Christopher Sheil, *Water's Fall: Running the Risks with Economic Rationalism* (London, Pluto Press, 2000). For insights into the Indigenous history of the valley inundated by Warragamba Dam, see Jim Smith, *The Aboriginal People of the Burrogorang Valley* (Lawson: Blue Mountains Research Trust, 2016).

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About the authors:

Andrea Gaynor
Andrea Gaynor is Associate Professor of History at the University of Western Australia. An environmental historian, she seeks to use the contextualizing and narrative power of history to address contemporary problems. She is co-editor, with Nick Rose, of *Reclaiming the Urban Commons: The Past, Present and Future of Food Growing in Australian Towns and Cities* (UWAP 2018) . At UWA, she is Chair of the History Discipline Group and Director of the Centre for Western Australian History; she also convenes the Australian and New Zealand Environmental History Network and endeavors to inform policy as a member of The Beeliar Group: Professors for Environmental Responsibility.

Margaret Cook
Dr Margaret Cook is an environmental historian, cultural heritage consultant, a Post-Thesis Fellow at the University of Queensland, and an Honorary Research Fellow at La Trobe University. Her PhD, completed in 2018, explored the history of floods in the Brisbane River and her findings have been published in national and international journals and in a forthcoming book, *A River with a City Problem*, with University of Queensland Press. Her current research deals with the colonial settlement of central Queensland for the production of cotton in the 1920s, particularly gender, climate and water.
https://orcid.org/0000-0002-3354-0658

Lionel Frost
Born and raised in Melbourne, Lionel Frost is an associate professor in the Department of Economics, Monash Business School at Monash University. He is current President of the Economic History Society of Australia and New Zealand, and has published extensively on urban and economic history in Australia and North America. Recent publications include "The Economic History of the Pacific," in J. R. McNeill and K. Pomeranz (eds), *The Cambridge World History Volume VII: Production, Destruction, and Competition, 1750–Present* (2015).

Jenny Gregory
Jenny Gregory AM, is Emeritus Professor of History at The University of Western Australia, after a career at UWA that included time as Head of the School of Humanities, Chair of History and Director of UWA Press. Author of numerous publications in the fields of urban history, planning and heritage, her current research projects include responses to water famines and past governance of water and sanitation in Australian cities. Currently President of the History Council of WA, she has received a number of awards for her contribution to her profession and the community.

Ruth Morgan
Ruth Morgan is a Senior Research Fellow in the History Program at Monash University. She has published widely on the climate and water histories of Australia and the British Empire, including her award-winning book, *Running Out? Water in Western Australia* (2015) . Her current project, on environmental exchanges between British India and the Australian colonies, has been generously supported by the Australian Research Council and the Alexander von Humboldt Foundation. She is also a Lead Author in Working Group II of the Intergovernmental Panel on Climate Change's Assessment Report 6.

Martin Shanahan
Martin Shanahan is Professor of Economic and Business History at the University of South Australia and visiting Professor at the University of Goteborg (Sweden). He has written extensively on wealth inequality, business cartels, water markets, and climate change from the perspective of economic and business history. He is currently involved in a number of projects, including work (with Lionel Frost) that examines the impact on health and living standards of variations in access to water in two Australian cities.

Peter Spearritt
Peter Spearritt began his scholarly life as an urban historian and continues to be fascinated by how cities function and the impact they have on their environment. His *Sydney's Century: A History* (2000) traces the growth of Australia's largest city over the twentieth century, while *Where History Happened* (2018) examines urban and rural sites, from Cooktown in North Queensland to New Norcia, the Benedictine Abbey north of Perth. He is a critic of quick-fix solutions to urban water shortages, especially the building of desalination plants, when household water tanks and lowering household use of water would suffice in most instances.

Susan Avey
Dr Susan Avey is an architect and urban historian. Her research interests include individual agency in the historical development of urban environments, discovering everyday lived experiences of cities through historical data as well as the potential of drawing as a historical research tool. Recently Susan has worked in the School of Art, Architecture and Design at the University of South Australia and the International School of Hotel Management as a lecturer, studio educator, and academic researcher. She is currently engaged as a researcher in the School of Commerce at UniSA.

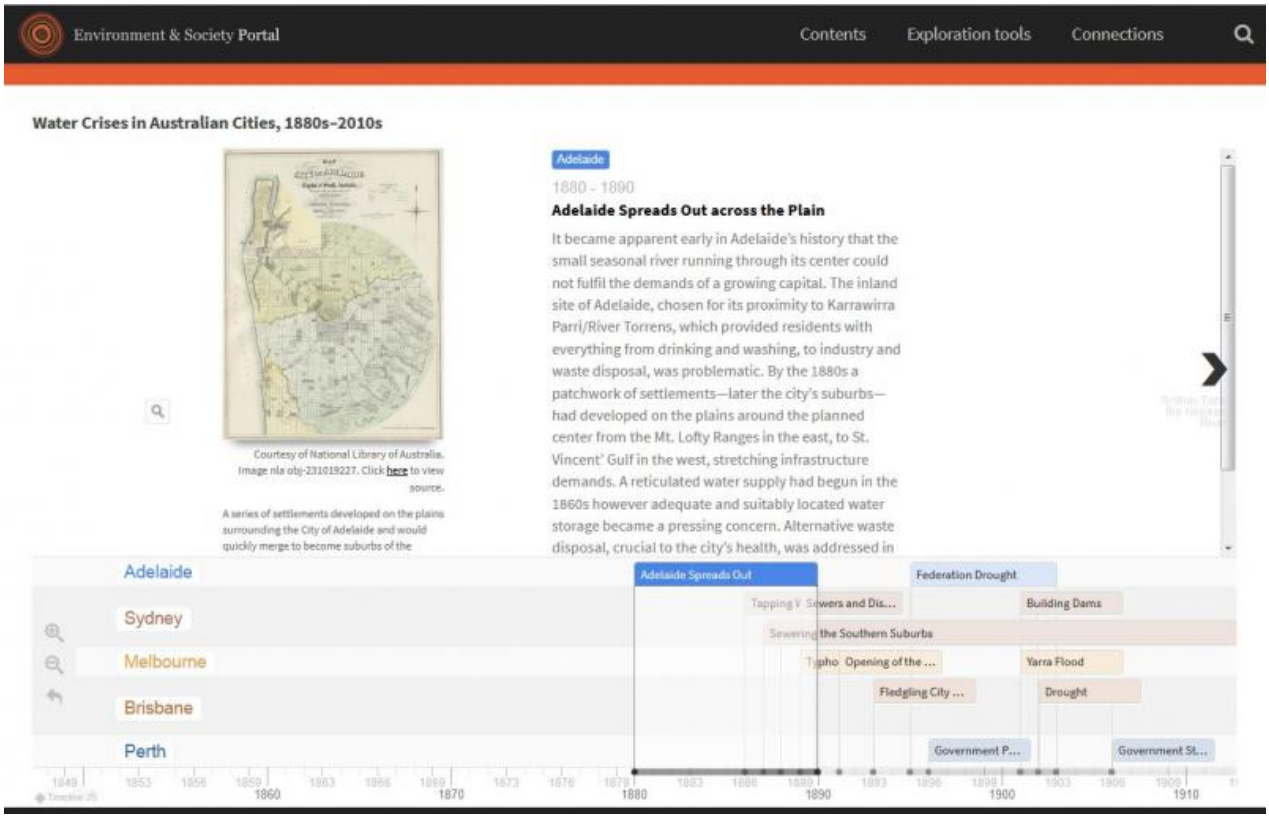
Nathan Etherington
Nathan Etherington is a doctoral candidate at the University of Sydney and a registered architect. He has degrees in architecture and arts from Harvard and the University of Sydney and his research is located at the intersection of architecture, landscape, and urban environments. Nathan is the founder and principal of NEA, an architecture practice based in Sydney. His current research interests explore the construction of urban landscapes through engineering and infrastructure.

Elizabeth Gralton
Elizabeth Gralton has a PhD in nineteenth-century French history from the University of Western Australia. Her research focused on contemporary reactions to and portrayals of the Paris Universal Exhibitions. She has taught in the areas of nineteenth-century Europe, early-modern France, urban history and art history. She is now based in Melbourne, working as a research consultant and studying cultural materials conservation.

Daniel Martin
Daniel Jan Martin is a designer, urbanist, and researcher based in the School of Design at The University of Western Australia. He studies urban ecology and hydrology in relationship to architecture and urbanism. His work has focussed on mapping, environmental communication, and education. Since 2016, Daniel has worked within the Cooperative Research Centre for Water Sensitive Cities where his current research is exploring strategies for coordinating infill housing with ecological repair.

Australian Cities Timeline: Water Crises in Australian Cities, 1880s–2010s

The original virtual exhibition features an interactive timeline on water crisis in Australian cities from 1888 to 2010. Visitors can browse the timeline chronologically or by one of the five cities showcased in the exhibition. Read an offline version of the timeline on the following pages or visit the online version here (http://www.environmentandsociety.org/exhibitions/drought-mud-filth-and-flood/timeline/timeline-australian-cities).



Screenshot of the Timeline for *Water Crises in Australian Cities, 1880-2010s*

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Chapter: Australian Cities Timeline
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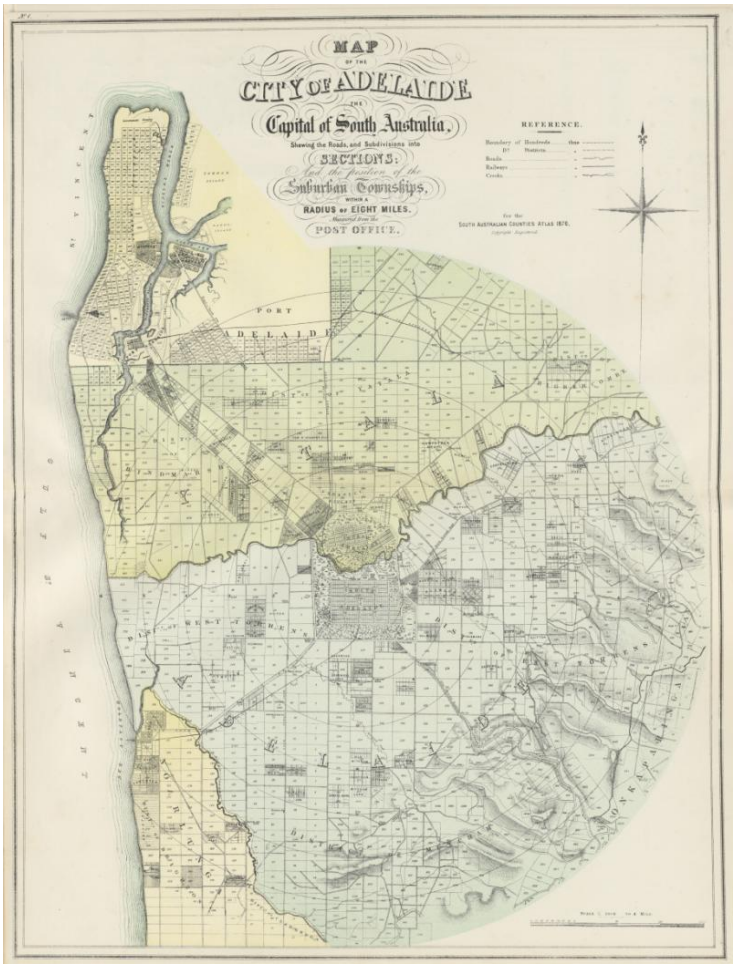
Adelaide spreads out across the plain

Timeline: Adelaide

1880 - 1890

It became apparent early in Adelaide's history that the small seasonal river running through its center could not fulfil the demands of a growing capital. The inland site of Adelaide, chosen for its proximity to Karrawirra Parri/River Torrens, which provided residents with everything from drinking and washing, to industry and waste disposal, was problematic. By the 1880s a patchwork of settlements—later the city's suburbs—had developed on the plains around the planned center from the Mt. Lofty Ranges in the east to St. Vincent Gulf in the west, stretching infrastructure demands. A reticulated water supply had begun in the 1860s, however, adequate and suitably located water storage became a pressing concern. Alternative waste disposal, crucial to the city's health, was addressed in 1882 when Adelaide became the first colonial capital in Australia to have a fully operational waterborne sewerage system.



A series of settlements developed on the plains surrounding the City of Adelaide and would quickly merge to become suburbs of the metropolitan area. Map by E. S. Wigg & Son, 1876.

Courtesy of National Library of Australia. Image nla obj-231019227. Click here to view source.

Websites linked in image captions:

- https://trove.nla.gov.au/version/43359625

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Sydney taps the Nepean River

Timeline: Sydney

1886 - 1888

Sydney's population growth and physical expansion necessitated more reliable sources of water. While a project was underway to supply the city from the Upper Nepean River, an extended dry spell forced the construction of a temporary solution known as the Hudson Brothers' Temporary Scheme. On the verge of a water famine, the New South Wales government approved the erection of temporary pipes and flumes to bridge gaps in the system between the Upper Nepean and the city and deliver water to the Botany swamps.

Temporary pipeline constructed to carry water to Sydney during the 1880s drought. Unknown photographer, ca. 1890.

Courtesy of Sydney Water / Water NSW Historical Research Archive

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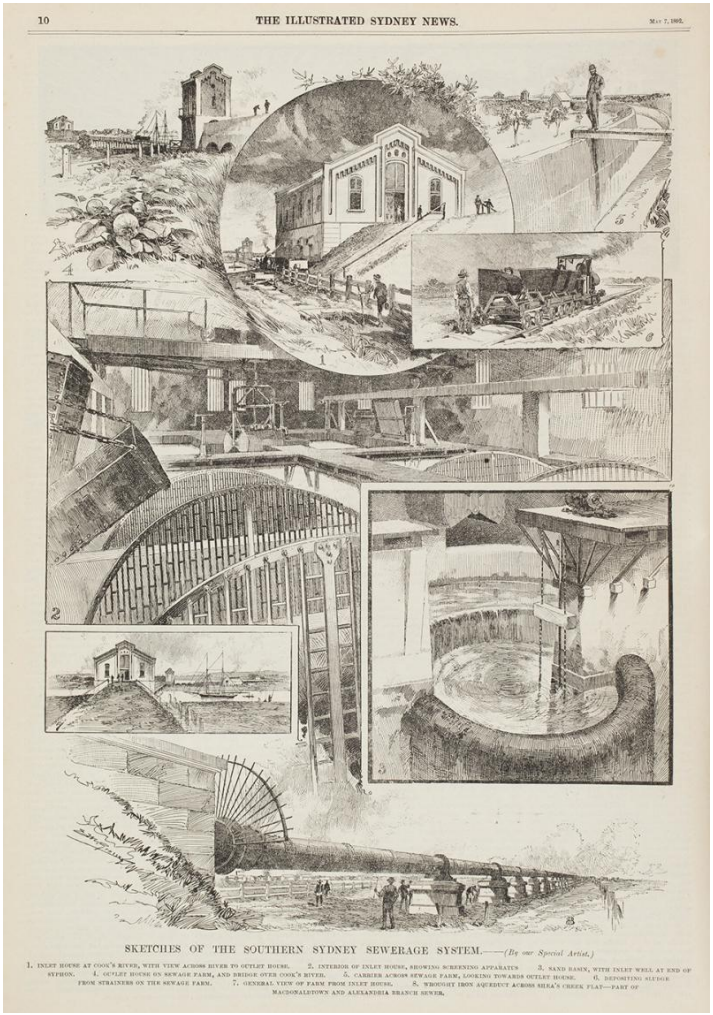
Sewering the southern suburbs

Timeline: Sydney

1887 - 1916

Sydney's southern suburbs were sewered in the 1880s, but rather than discharging at an ocean outfall, the waste was collected at a sewage farm near Botany Bay. The farm operated until 1916 when, because of its inability to cope with the increasing volume of sewage, it was abandoned in favor of an ocean outfall constructed at Long Bay.



Snapshots of the sewerage system serving Sydney's southern suburbs including the sewage farm and screening plant. Unknown illustrator, 1892.

Courtesy of the State Library of New South Wales.

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Dumping sewage in the harbor and ocean

Timeline: Sydney

1889

The City of Sydney was progressively sewered from the 1850s with the system discharging into the harbor. By the 1880s, the condition of the harbor was dire and increasing concerns about the relationship of human waste to disease prompted the construction of an intercepting sewer that discharged via an ocean outfall at Ben Buckler in Bondi.

Photograph of Bondi Beach at the end of the nineteenth century. Unknown photographer, 1895–1908.

Courtesy of Mitchell Library, State Library of New South Wales. Click here to view source.

Websites linked in image captions:

- https://search.sl.nsw.gov.au/primo-explore/fulldisplay?docid=ADLIB110366906&context=L&vid=SLNSW&search_scope=MOH&tab=default_tab&lang=en_US

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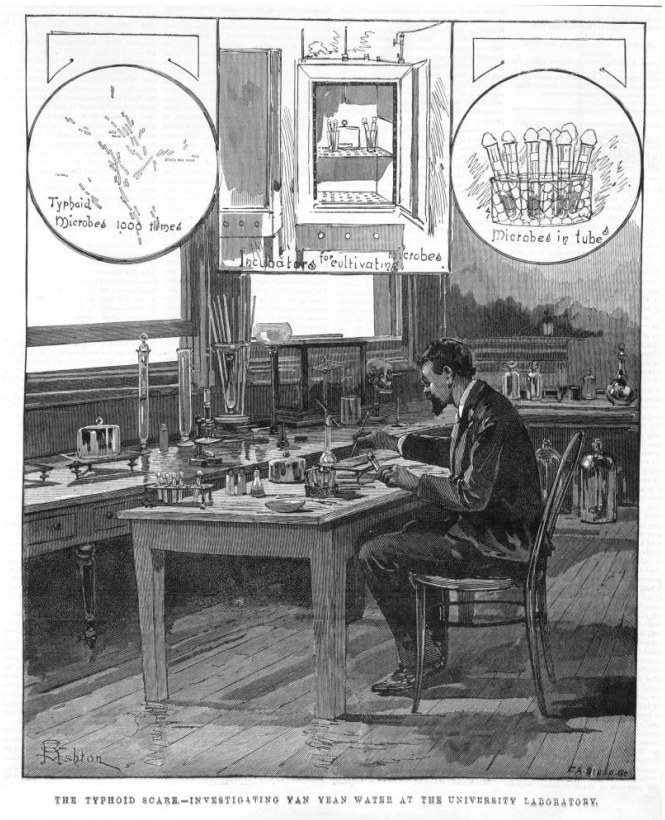
Typhoid epidemic and creation of the Melbourne and Metropolitan Board of Works

Timeline: Melbourne

1889 - 1890

In the rapidly expanding Melbourne of the 1880s, typhoid was a major cause of death. In 1889—Melbourne's worst typhoid year—there were 560 reported deaths from the disease. Growing understanding of the germ theory of disease transmission caused public authorities to accept the need for new technologies of water supply and sewage disposal. The 1889 Royal Commission into the sanitary condition of Melbourne recommended a "deep drainage system" to combat waterborne diseases such as typhoid. The Melbourne and Metropolitan Board of Works (MMBW) was formed in 1891—the first time that water supply and related infrastructure had come under the control of a single organization. Engineer-in-chief William Thwaites designed a sewerage system that included a pumping station at Spotswood and a sewage treatment farm at Werribee. The system, in conjunction with increased public awareness of hygienic practices, led to reduced transmission of waterborne disease.



THE TYPHOID SCARE.—INVESTIGATING YAN YEAN WATER AT THE UNIVERSITY LABORATORY.

This wood engraving published in *The Illustrated Australian News and Musical Times* shows a scientist investigating microbes from Melbourne's water supply. Illustration by George Rossi Ashton and F. A. Sleap, 1889.

Image courtesy of the State Library of Victoria. Click here to view source.

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Completion of the Maroondah Scheme

Timeline: Melbourne

18 February 1891

By the 1870s, it was clear that the Yan Yean water supply system—opened in 1857—was no longer sufficient to supply the metropolitan area. A flurry of works took place throughout the 1880s to improve the supply. The Maroondah Scheme (originally called the Watts River Scheme), completed in 1891, diverted water from the Watts and Graceburn Rivers and channeled it via the Maroondah Aqueduct to the Junction Basin in Preston. The Maroondah Aqueduct consisted of 41 kilometers of open cement channel, 11 tunnels, 15 kilometers of inverted siphons, and a pipe bridge over Plenty River.

The Watts River Scheme was completed and the water turned on by the Earl of Hopetoun (the Governor), on 18 February 1891. Unknown photographer, 1891.

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Brisbane inundated by second and third highest recorded floods

Timeline: Brisbane

1893

In 1893, two floods inundated Brisbane within a fortnight. Reaching record heights of 8.35 m and 8.09 m, these were the second and third highest recorded floods. Debate began on the most economical and effective ways to manage floods, most of which looked to engineering solutions.

Brisbane is flooded by the second and third highest recorded floods within a fortnight. Unknown photographer, 1893.

Courtesy of the State Library of Queensland. Image 84890. Click here to view source.

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Federation Drought and Adelaide's increasing water needs

Timeline: Adelaide

1895 - 1903

The turn of the century saw a prolonged period of below-average rainfall across much of Australia. Water storage facilities were being planned and developed to address Adelaide's growing water needs. By the end of the Federation drought, the city was being supplied by three significant reservoirs: Barossa, Hope Valley, and Happy Valley—to the north, east, and south of the city. Water from the Karrawirra Parri/River Torrens was captured upstream, northeast of Adelaide, and the now dammed water-course through the city could be beautified.

Karrawirra Parri/River Torrens, looking east. City and hills in the background, cart tracks in the foreground. Unknown photographer, ca. 1900.

Courtesy of State Library of South Australia. Image B-26486. Click here to view source.

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A shaky start to Perth's centralized water supply

Timeline: Perth

1896

In the 1880s, much of Perth's drinking water came from polluted wells. The City of Perth could not afford a water supply, so it negotiated with a private company to build a reservoir in the hills and a pipeline to Perth. Victoria Reservoir was opened in 1891, but the water company was both unprofitable and unable to address conflicts of interest around the pollution of the water catchment. After gold was discovered in the interior of Western Australia in 1892, the population of Perth boomed and the undercapitalized waterworks failed to keep up with demand. In 1896, as the water shortage escalated, the government bought the waterworks, installing a new board of management that increased the size of the pipeline from Victoria Reservoir and sunk bores in the city to supplement the hills' water with groundwater.

Water flows from an artesian bore on Loftus Street in West Perth. Unknown photographer, ca. the 1890s.

Courtesy of Water Corporation of WA. Source: Su-Jane Hunt. *Water: The Abiding Challenge*. Perth: Metropolitan Water Board, 1980.

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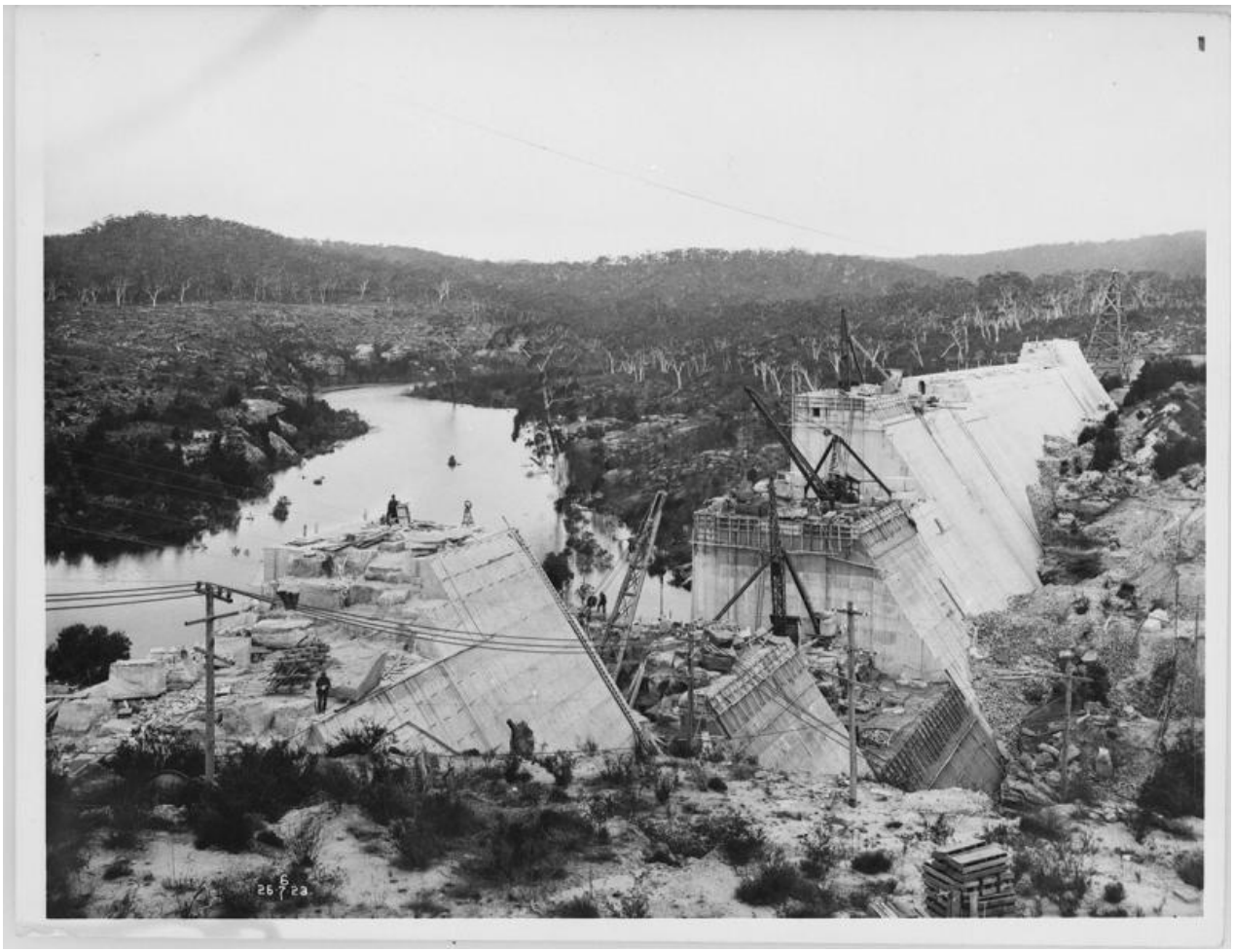
Building dams, damming rivers

Timeline: Sydney

1901 - 1902

A serious drought in 1901–1902 brought Sydney to the edge of water famine and triggered a Royal Commission investigation into the city's water supply. The commission recommended a series of dams in the Upper Nepean catchment beginning with the Cataract River and followed by the Cordeaux, Avon, and Nepean dams.



Cataract Dam under construction. Unknown photographer, 1906.

Courtesy of Sydney Water / WaterNSW Historical Research Archive.

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Yarra floods

Timeline: Melbourne

1901

Melbourne's location made the city vulnerable to flooding. After severe flooding in 1891, the Yarra Floods Board recommended that the river be widened and deepened between Prince's Bridge and the South Yarra railway bridge. In 1901, the Yarra catchment received a volume of rainfall greater than in 1891, but Melbourne did not experience the same high levels of flooding. The inspector-general of public works attributed the reduced flood levels to the river modifications. *The Argus* reported that "Everything goes to show that had not the works recommended by the Yarra Floods Board, after the flood of 1891, been at least partly carried out Melbourne would have been visited by the biggest flood known in the history of the state."

Heavy rainfall in April 1901 causes the Yarra to flood its banks. Photograph by Mark James Daniel, 1901.

Image courtesy of the State Library of Victoria.
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Southeast Queensland gripped by the Federation Drought

Timeline: Brisbane

1902 - 1906

In 1902—at the height of the drought— the Brisbane River, the city's main water supply, threatened to run dry. In 1906, the state meteorologist, Clement Wragge, had six Stiger Vortex guns fired into clouds at Charleville (western Queensland) to stimulate rain and break the drought. The experiment failed. Floods slipped from public consciousness as engineering investigations turned towards plans for a water supply dam.

Meteorologist Clement Wragge resorts to firing into clouds to trigger rain during the Federation Drought, 1906. Cartoon by Hal Eyre, 1906.

Courtesy of State Library of Queensland. Image 69461. Click here to view source.

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Fear of disease forces government action

Timeline: Perth

1906

With rapid population increase, a limited piped water supply, polluted wells, and the discharge of sewage via open drains into the Swan River, typhoid reappeared in Perth on a large scale in 1905. A typhoid epidemic had gripped the city in 1895–97 and memories were vivid. In 1906, the government began construction of a sewerage treatment works that included percolating filter beds on Burswood Island in the Swan River, close to central Perth. Treated waste flowed directly into the river. Work then began on constructing a network of sewerage pipes to the treatment plant, with 103 kilometers laid in Perth by 1913. Though the treatment plant resolved the typhoid crisis, its pollution of the river was untenable.

Burswood Island filter beds in the Swan River, part of the Claisebrook and Burswood Sewerage Treatment Works. Photograph by E. G. Rome, 1907.

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Timeline: Water Crises in Australian Cities, 1880s–2010s

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Another drought and the introduction of water restrictions

Timeline: Adelaide

1914

1914–15 was a period of severe drought, particularly in the lower Murray-Darling Basin region. In Adelaide, restrictions on the use of reticulated water supplies were introduced, a management practice that would continue intermittently until the present. Low water levels in the Murray River foreshadowed future water supply crises.

Children picnic near Berri, Murray Riverbed almost dry during the severe drought of 1914. Unknown photographer, 1914.

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Melbourne floods of 1916 and 1918

Timeline: Melbourne

1916

On 25 September 1916, *The Age* reported, "rarely in the history of Victoria has there been such a continuous downpour of rain as that which started on Thursday night." The Maribyrnong River was the first to flood, inundating the Colonial Ammunition Company in Footscray. The track at Flemington Racecourse was submerged. The Yarra also rose significantly, causing considerable damage to low-lying properties and gardens. Two years later, these areas flooded again, with hundreds of acres of cultivated land under water. Residents near the Moonee Ponds Creek were evacuated from their houses in boats.

The Maribyrnong River floods in 1916, inundating areas of Footscray and Flemington. Unknown photographer, 1916.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.

Timeline: Water Crises in Australian Cities, 1880s–2010s

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More water storage commissioned

Timeline: Adelaide

1918

Millbrook Reservoir was constructed between 1914 and 1918. With a capacity of 16,500 megaliters, the reservoir completely engulfed the small town of Millbrook. Its location in the Mt. Lofty Ranges in the upper reaches of the Karrawirra Parri/River Torrens provided gravity-fed water to the eastern suburbs of Adelaide.

Millbrook Reservoir was constructed between 1914 and 1918 and provided gravity-fed water to the eastern suburbs of Adelaide. Unknown photographer, ca. 1923.

Courtesy of the State Library of South Australia. Image PRG 280/1/37/421.
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Websites linked in image captions:

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Inter-war growth challenges Adelaide's water supply

Timeline: Adelaide

1920

The state's first Government Town Planner, Charles Reade, saw South Australia's Town Planning and Development Act legislated in 1920. This legislation had the potential to give structure to, and control over, rapid urban and suburban development in Adelaide. The struggle faced by the state's Waterworks and Drainage Commission continued, however, as it built new water supply infrastructure while coping with the demands of an increasing population and low, unpredictable rainfall. The city's sewerage system also required expansion and upgrading and plans to move the sewage farm away from developing areas were considered.

Inter-war growth saw new suburbs in Adelaide, including Colonel Light Gardens. Population growth and development challenged water supplies and infrastructure. Unknown photographer, 1925.

Courtesy of State Library of South Australia. Image B 2440. Click here to view source.

Websites linked in image captions:

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Protest over water famine forces the government to improve supply

Timeline: Perth

1920 - 1924

After World War I, veterans returned hoping for “homes fit for heroes” promised by government repatriation schemes. Assisted by immigration and natural increase, the population again surged. Building boomed in “bridal suburbs” and the infrastructure supplying water could not keep up. Perth was soon in the grip of a water famine. Those with rainwater tanks were lucky. Those connected to a piped water supply had their water cut off or pressure reduced. Water for drinking, cooking, and washing was limited and garden sprinklers were banned. Many families relied on water carted by horse. Artesian bores supplemented the meager water supply. In 1924, mounting protest forced the government to announce the Hills Water Supply Scheme, in which two pipehead diversion dams and then two major reservoirs were to be constructed on rivers and streams in the hills east of the city.

Metropolitan Water Supply, Sewerage, and Drainage Department.

Official Opening

of

First Section of New Hills Water Scheme for the Metropolitan Area

First Supply from New Hills Scheme.
In November, 1925, water from Churchman's Brook was diverted into the 16-inch main as shown above. Sixteen-inch main is laid from Churchman's Brook reservoir site to junction of 30-inch Main at Canning River.

By THE HON. ALEX. McCALLUM, M.L.A., Minister for Water Supply, Sewerage, and Drainage.

MONDAY, 7th DECEMBER, 1925.

Program for the official opening of the new Hills Water Scheme, 1925.

Courtesy of the John Curtin Prime Ministerial Library. Records of Alex McCallum. Programme for the official opening of the new Hills Water Scheme by The Hon. Alex McCallum, 7 December 1925. JPCML00821/5.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. “Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s.” Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Building more ocean outfall sewers

Timeline: Sydney

1926

The city's continued expansion to the north and west early in the twentieth century began to overload the sewerage system that had drained to treatment works at Willoughby Bay. Complaints from nearby neighborhoods prompted the construction of a third ocean outfall at Blue Fish Point, North Head, completed in 1926.

Construction of the Northern Suburbs Outfall Sewer. Photograph by Arthur Ernest Foster, 1929.

Courtesy of Mitchell Library, State Library of New South Wales, FL387116.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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New sewerage treatment works moves pollution from city and river to suburbs and ocean

Timeline: Perth

1926

The Burswood Island filter beds, constructed in the Swan River to treat the city's sewage, failed. People complained about the smell and raw sewage floating in the river, and nutrients discharged into the river led to extensive algal blooms. In spite of concerns over ocean pollution, in 1926 the government built the Subiaco Sewerage Treatment Works with an ocean outfall; the Burswood filter beds were closed in 1937. The sewage network grew and by 1939, Perth was 73% sewered. Most of the effluent from Subiaco went out to sea, though some was used to irrigate the grounds of a nearby mental hospital. Odor from the treatment plant prevented residential development in the area, which was instead used for waste disposal and institutional purposes.

Cleaning algae from the Swan River during controversy over the role of the Burswood Filter Beds in river pollution during the 1920s and 30s. Unknown photographer, n.d.

Courtesy of Water Corporation of WA.
Source: Su-Jane Hunt. *Water: The Abiding Challenge*. Perth: Metropolitan Water Board, 1980.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Reservoirs become low and Depression hampers development

Timeline: Adelaide

1927 - 1930

Water restrictions were enforced in Adelaide again after the drought of 1927–28, and an increased demand from population growth saw storage facilities, including Millbrook Reservoir, at alarmingly low levels. Struggling to keep up with demand, the Engineering & Water Supply Department (E&WS), as the authority was now known, began work on Mt. Bold Reservoir southeast of the city. The relocation of Adelaide's sewage farm was delayed but the facility continued to provide employment during the Depression.

Drought and growth saw water-storage levels drop during Depression years. Millbrook Reservoir was alarmingly low and water restrictions were enforced in many urban areas. Unknown photographer, 1930.

Courtesy of State Library of South Australia. Image B 5754. Click here to view source.

Websites linked in image captions:

- https://collections.slsa.sa.gov.au/resource/B+5754

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Postwar suburban boom leads to construction of more dams and sewerage headaches

Timeline: Melbourne

1927

Melbourne grew rapidly after World War I. Large block sizes led to low population density and high water needs. As the population spread, the Melbourne and Metropolitan Board of Works (MMWB) built more dams in the Upper Yarra catchment zone, including the Maroondah, O'Shannassy, and Silvan reservoirs. The Maroondah Reservoir was completed in 1927, submerging the Watts River Weir. Water continued to be supplied to Melbourne via the existing Maroondah Aqueduct. The O'Shannassy Reservoir was completed in 1928, and the Silvan in 1932. These three projects more than doubled the metropolitan water supply. In the outer suburbs, however, sewage disposal remained a problem for the MMBW. By 1930, around 19,000 Melbourne properties had water but no sewerage.

The construction of the Maroondah Dam, completed in 1927, was part of the Melbourne Metropolitan Board of Works' response to a growing population after the Second World War. Unknown photographer, ca. 1920s.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Accessing still more sources of emergency water

Timeline: Sydney

1934 - 1942

Water supply came to public attention again in the 1934–42 drought. Despite the construction of several dams in the early decades of the century, supply could not keep up with the city's suburban expansion. As an emergency measure, a temporary weir was constructed above the proposed site of the Warragamba Dam to supply additional water to the Prospect Reservoir.

Photograph of the Warragamba emergency overshot weir constructed as a temporary measure during the 1934–42 drought. Unknown photographer, ca. 1940.

Courtesy of Sydney Water / WaterNSW Historical Research Archive.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Yarra floods again

Timeline: Melbourne

1934

In early December 1934, the Yarra flooded again after 140 millimeters of rain fell on Melbourne over a period of 48 hours. The flood turned the Yarra into "a series of vast lakes connected by swirling rapids," stretching more than 65 km from Melbourne along the Yarra Valley. Bridges were swept away and homes were flooded and destroyed, leaving thousands homeless. One person drowned in the Yarra. From 1937 onwards, Victorian Government grants financed local councils to complete drainage works. Banks along the Maribyrnong and Yarra were sloped back, stabilized, and beached with bluestone to prevent erosion. Later, as trees were planted, the riverscapes became less flood-prone.

Heavy rainfall in December 1934 caused flooding and damage to property along the Yarra Valley, including the Kodak factory in Abbotsford. Unknown photographer, 1934.

Museums Victoria
Courtesy of Kodak (Australasia) Pty Ltd
https://collections.museumvictoria.com.au/items/1460487 .

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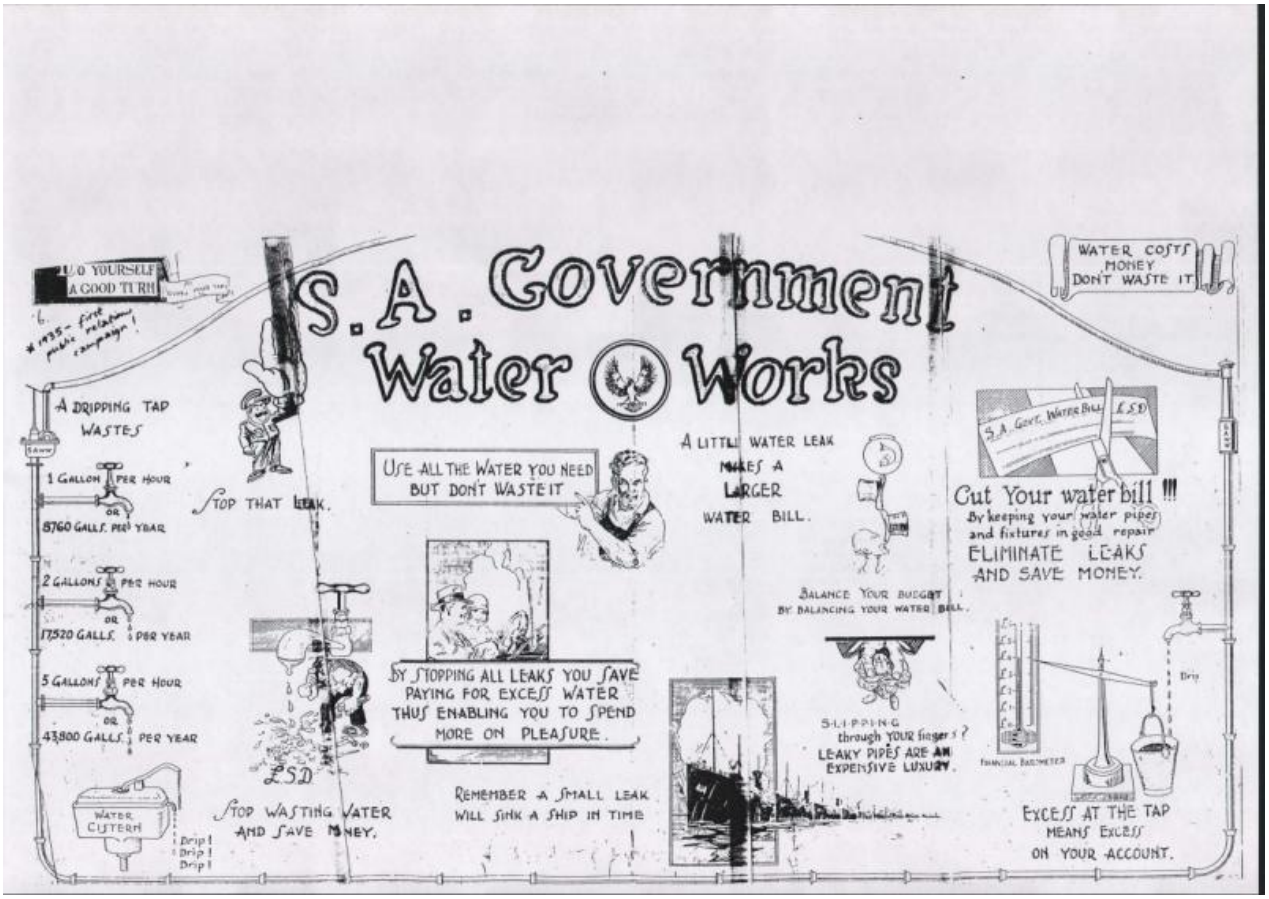
Residents encouraged to conserve water

Timeline: Adelaide

1935 - 1938

The cycle of development, population growth, demand, and drought continued and in 1935, South Australia's Water Works Department encouraged water conservation as an everyday necessity. In 1938, South Australia's largest reservoir, Mt. Bold, was complete with a capacity of 46,545 megaliters. Major infrastructure developments were barely keeping up with demand for water and it was clear that alternative solutions were required.



In 1935, South Australia's Water Works Department began its first public water conservation campaign. Unknown illustrator, 1935.

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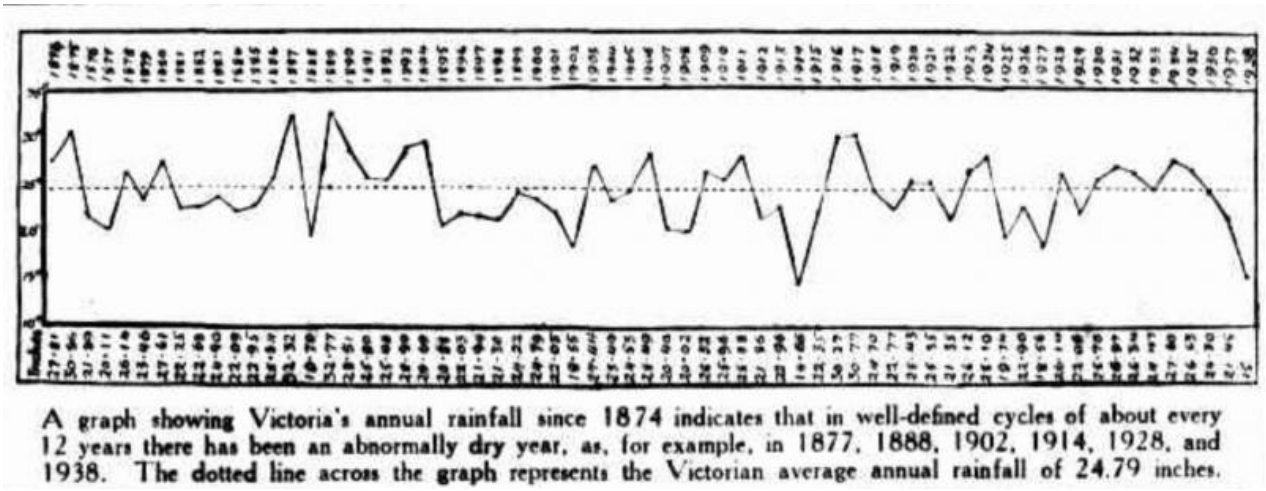
Drought and water restrictions

Timeline: Melbourne

1937 - 1938

By May 1938, a long period of dry weather was affecting Melbourne's parks and gardens. A diminished intake in catchment areas and increased water consumption meant that Melbourne reservoir levels started falling earlier than usual. Watering restrictions were implemented, and households were given advice about saving water. The Melbourne and Metropolitan Board of Works (MMBW) announced that offenders would be fined and could have their water supplies cut off. The drought sparked discussions about the construction of new storage solutions to prevent future water shortages. Bushfires in catchment areas also caused anxiety, as rainfall evaporated in burnt areas instead of feeding streams.



A graph showing Victoria's annual rainfall since 1874 indicates that in well-defined cycles of about every 12 years there has been an abnormally dry year, as, for example, in 1877, 1888, 1902, 1914, 1928, and 1938. The dotted line across the graph represents the Victorian average annual rainfall of 24.79 inches.

This graph, published in the *Argus* during the drought of 1938, shows Victoria's annual rainfall since 1874. Unknown illustrator, ca. 1938.

Image courtesy of Trove, National Library of Australia.
Click here to view source.

Websites linked in image captions:

- https://trove.nla.gov.au/newspaper/article/12080694.

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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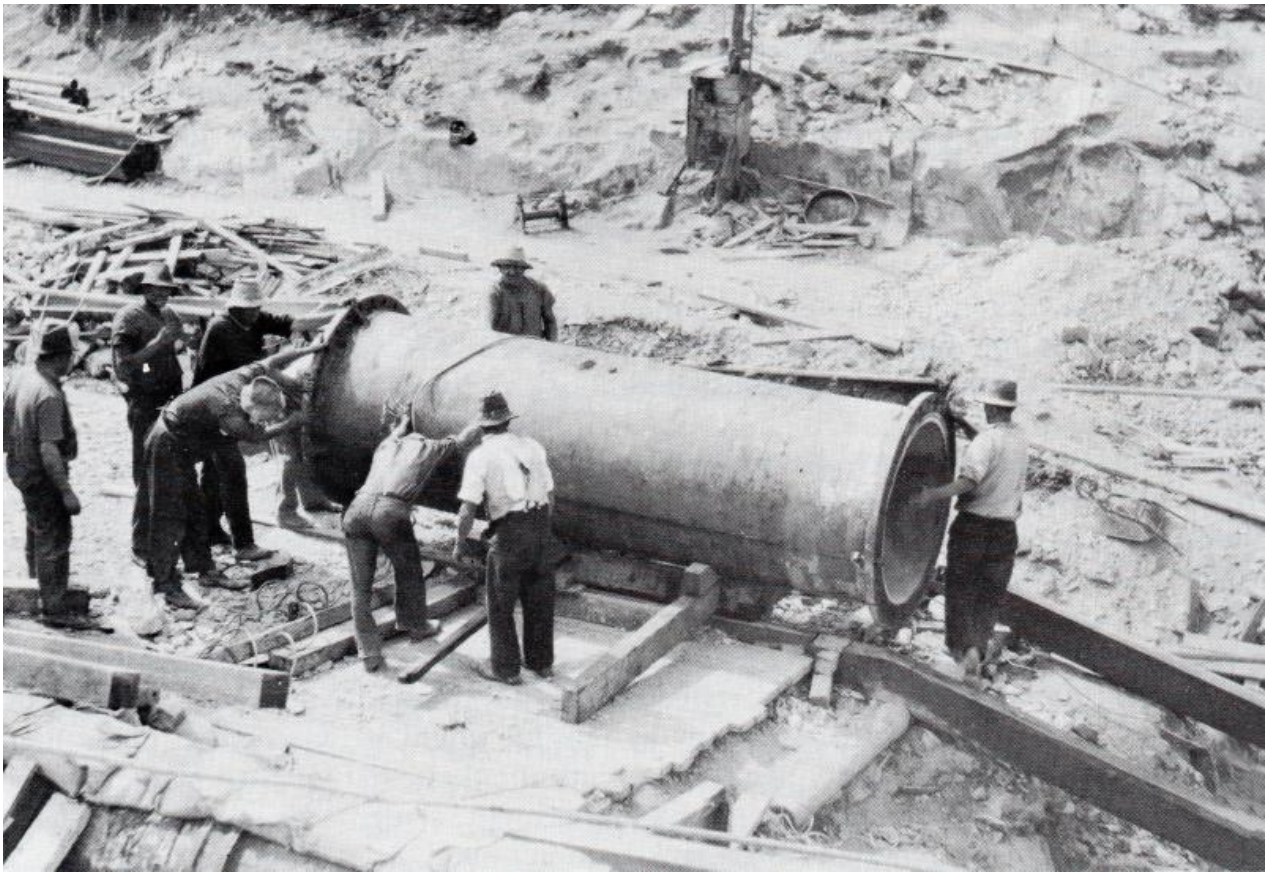
Government completes a major dam

Timeline: Perth

1940

The completion of Canning Dam in 1940 marked the culmination of the Hills Water Supply Scheme. Built largely by sustenance labor during the Depression, it was heralded as "the most ambitious water storage scheme in the history of the state." Perth people could no longer complain, as they did in 1923, that the supply of water "is so muddy and thick that it would...seriously injure a person's stomach." Many believed that Perth's water supply had finally achieved maturity after five decades of ad hoc development. The dam was considered an engineering achievement. One of the largest concrete dams in the world in its day, it had been built using innovative construction techniques. It provided work for 300 unemployed men, but conditions were hard, grinding and dangerous, resulting in three deaths and many accidents.



Workers rolling a cast-iron pipe into position in 1934 during the construction of the Canning Dam. Unknown photographer, 1934.

Courtesy of Water Corporation of WA.
Source: Layman, Lenore, and Tom Stannage, eds. *Celebrations in Western Australian History: Studies in WA History*. Nedlands (W.A.): Centre for Western Australian History, Dept. of History, University of Western Australia, 1989: 70–71.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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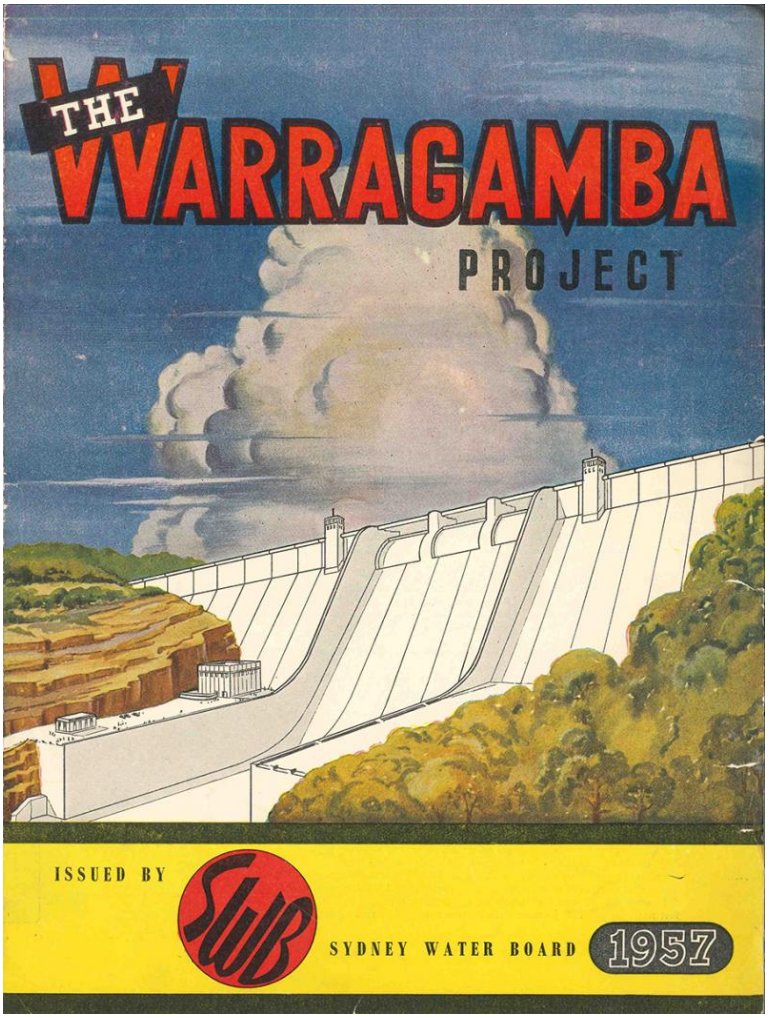
Constructing Warragamba Dam

Timeline: Sydney

1946 - 1960

Plans to construct a dam on the Warragamba River had been in process for several decades but by the 1940s, the desire for a solution to guarantee future water supply to the city spurred the start of construction on what was to become Australia's largest urban dam, a vast and reassuring concrete edifice.



Artist's impression of the Warragamba Dam published with Sydney Water Board promotional material in 1957. Unknown illustrator, 1957.

Courtesy of the State Library of New South Wales.

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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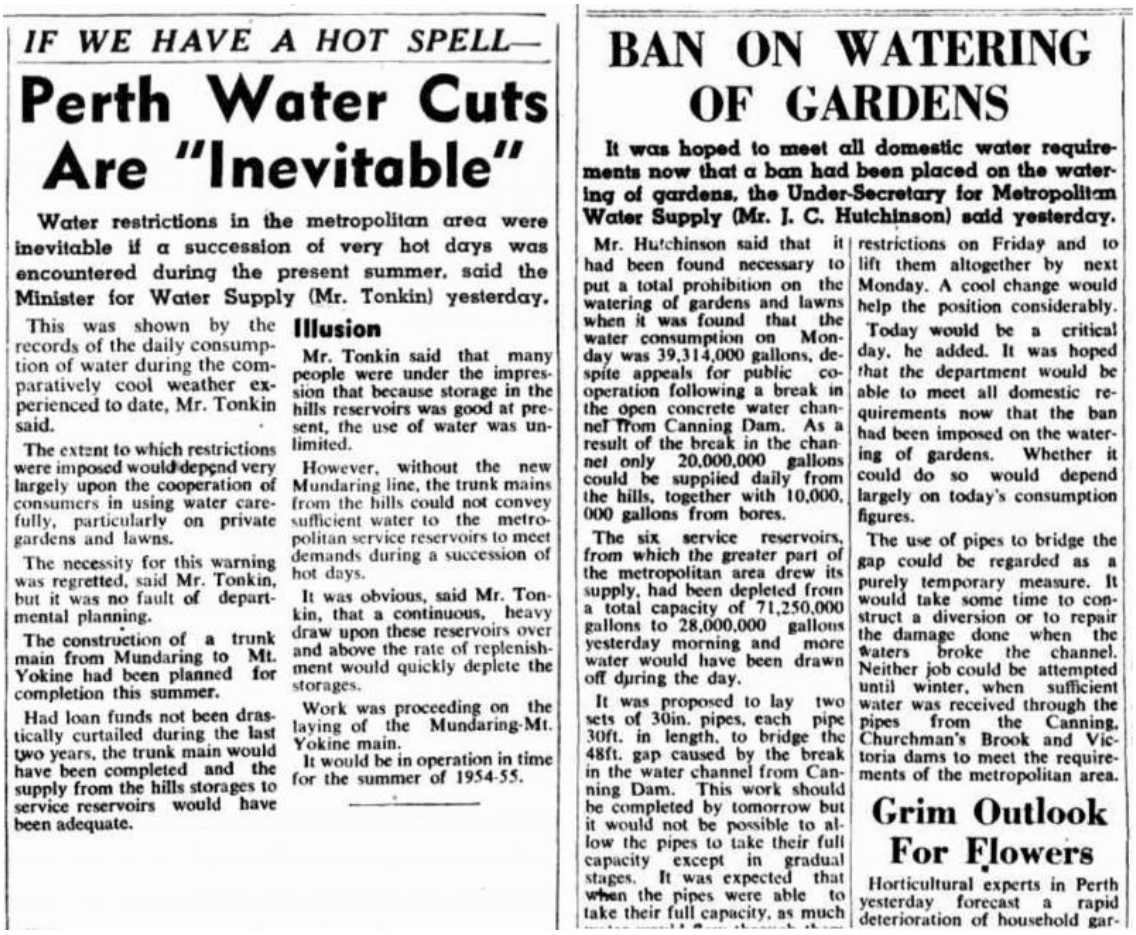
Authorities introduce restrictions on the watering of gardens

Timeline: Perth

1947 - 1951

Amid a developing culture of profligate suburban water use and postwar population growth, technical failures of dams and pumping stations led to drastic summer water restrictions in 1947, 1949, and 1950. These restrictions continued sporadically throughout the 1950s where hot summers followed drier winters. During this time, Perth households were going "bore mad," rapidly sinking private garden bores in response to these restrictions, a practice encouraged by the authorities. In response to the ongoing shortages and anticipated urban growth, in 1951, planning began for a dam on the Serpentine River, 50 kilometers southeast of Perth. Serpentine Dam was completed a decade later.



IF WE HAVE A HOT SPELL—

Perth Water Cuts Are "Inevitable"

Water restrictions in the metropolitan area were inevitable if a succession of very hot days was encountered during the present summer, said the Minister for Water Supply (Mr. Tonkin) yesterday.

This was shown by the records of the daily consumption of water during the comparatively cool weather experienced to date, Mr. Tonkin said.

The extent to which restrictions were imposed would depend very largely upon the cooperation of consumers in using water carefully, particularly on private gardens and lawns.

The necessity for this warning was regretted, said Mr. Tonkin, but it was no fault of departmental planning.

The construction of a trunk main from Mundaring to Mt. Yokine had been planned for completion this summer.

Had loan funds not been drastically curtailed during the last two years, the trunk main would have been completed and the supply from the hills storages to service reservoirs would have been adequate.

Illusion

Mr. Tonkin said that many people were under the impression that because storage in the hills reservoirs was good at present, the use of water was unlimited.

However, without the new Mundaring line, the trunk mains from the hills could not convey sufficient water to the metropolitan service reservoirs to meet demands during a succession of hot days.

It was obvious, said Mr. Tonkin, that a continuous, heavy draw upon these reservoirs over and above the rate of replenishment would quickly deplete the storages.

Work was proceeding on the laying of the Mundaring-Mt. Yokine main.

It would be in operation in time for the summer of 1954-55.

BAN ON WATERING OF GARDENS

It was hoped to meet all domestic water requirements now that a ban had been placed on the watering of gardens, the Under-Secretary for Metropolitan Water Supply (Mr. J. C. Hutchinson) said yesterday.

Mr. Hutchinson said that it had been found necessary to put a total prohibition on the watering of gardens and lawns when it was found that the water consumption on Monday was 39,314,000 gallons, despite appeals for public cooperation following a break in the open concrete water channel from Canning Dam. As a result of the break in the channel only 20,000,000 gallons could be supplied daily from the hills, together with 10,000,000 gallons from bores.

The six service reservoirs, from which the greater part of the metropolitan area drew its supply, had been depleted from a total capacity of 71,250,000 gallons to 28,000,000 gallons yesterday morning and more water would have been drawn off during the day.

It was proposed to lay two sets of 30in. pipes, each pipe 30ft. in length, to bridge the 48ft. gap caused by the break in the water channel from Canning Dam. This work should be completed by tomorrow but it would not be possible to allow the pipes to take their full capacity except in gradual stages. It was expected that when the pipes were able to take their full capacity, as much restrictions on Friday and to lift them altogether by next Monday. A cool change would help the position considerably.

Today would be a critical day, he added. It was hoped that the department would be able to meet all domestic requirements now that the ban had been imposed on the watering of gardens. Whether it could do so would depend largely on today's consumption figures.

The use of pipes to bridge the gap could be regarded as a purely temporary measure. It would take some time to construct a diversion or to repair the damage done when the waters broke the channel. Neither job could be attempted until winter, when sufficient water was received through the pipes from the Canning, Churchman's Brook and Victoria dams to meet the requirements of the metropolitan area.

Grim Outlook For Flowers

Horticultural experts in Perth yesterday forecast a rapid deterioration of household gar-

Snippets from front pages of *The West Australian* from the early 1950s, a time of frequent water restrictions. *The West Australian*, 17 December 1953 and 18 January 1950.

Courtesy of Trove, National Library of Australia.

Click here and here to view sources.

Websites linked in image captions:

- https://trove.nla.gov.au/newspaper/article/49606204
- http://nla.gov.au/nla.news-article47823775

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Adelaide searches for a new supply

Timeline: Adelaide

1948 - 1954

A post-war boom saw population and development stretch Adelaide's water supply beyond its limits. Water restrictions were a part of life from 1949 to 1954. Water pressure and quality were constant issues as the government sought a solution that could support growth and withstand periods of low rainfall. The answer lay in the Murray River, 60 kilometers away from the city, and work on a pipeline began in 1951.

Fires are a common occurrence in Adelaide's hill zone suburbs. In 1954, the water supply ran dry as people struggled to save their homes. Photograph by News and Mail, 1954.

Courtesy of State Library of South Australia. Image B 71598-10.
Click here to view source.

Websites linked in image captions:

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Mannum-Adelaide Pipeline is complete; new reliance on Murray River

Timeline: Adelaide

1955

In 1955, Adelaide's water supply began to be supplemented with water from the Murray River. The pipeline, which took five years to build, solved the city's immediate water problems. Once commissioned, however, the state became reliant on water from the Murray River, a remote and shared source. Adelaide and nearly 80 percent of the state's population were now linked to the river.

Mannum-Adelaide pipeline under construction. Completed in 1955, the pipeline connected Adelaide to Murray River. Unknown photographer, 1953.

Courtesy of State Library of South Australia. Image B 20276. Click here to view source.

Websites linked in image captions:

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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“Heartbreak streets” of the postwar boom

Timeline: Melbourne

1955

Melbourne faced a serious housing shortage after World War II, as residential building had ceased during the War and post-war immigration and the baby boom increased demand. Many households responded by building their own houses, and soon whole suburbs of owner-built houses appeared on the fringes of Melbourne. Many of these houses had only a rudimentary water supply—sometimes limited to a communal tap at the end of the street—and no sewerage. These desolate places were known as “heartbreak streets.” The MMBW could not keep up with the demand to connect houses to amenities, and by 1955 there were 52,140 properties without sewerage.

An unsewered area in Melbourne, where street channels were used to dispose of kitchen and laundry waste. Unknown photographer, 1955.

Originally published in *Metropolis: Quarterly Journal of the Melbourne and Metropolitan Board of Works* 1, no. 1 (August 1955).

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. “Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s.” Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.

Timeline: Water Crises in Australian Cities, 1880s–2010s

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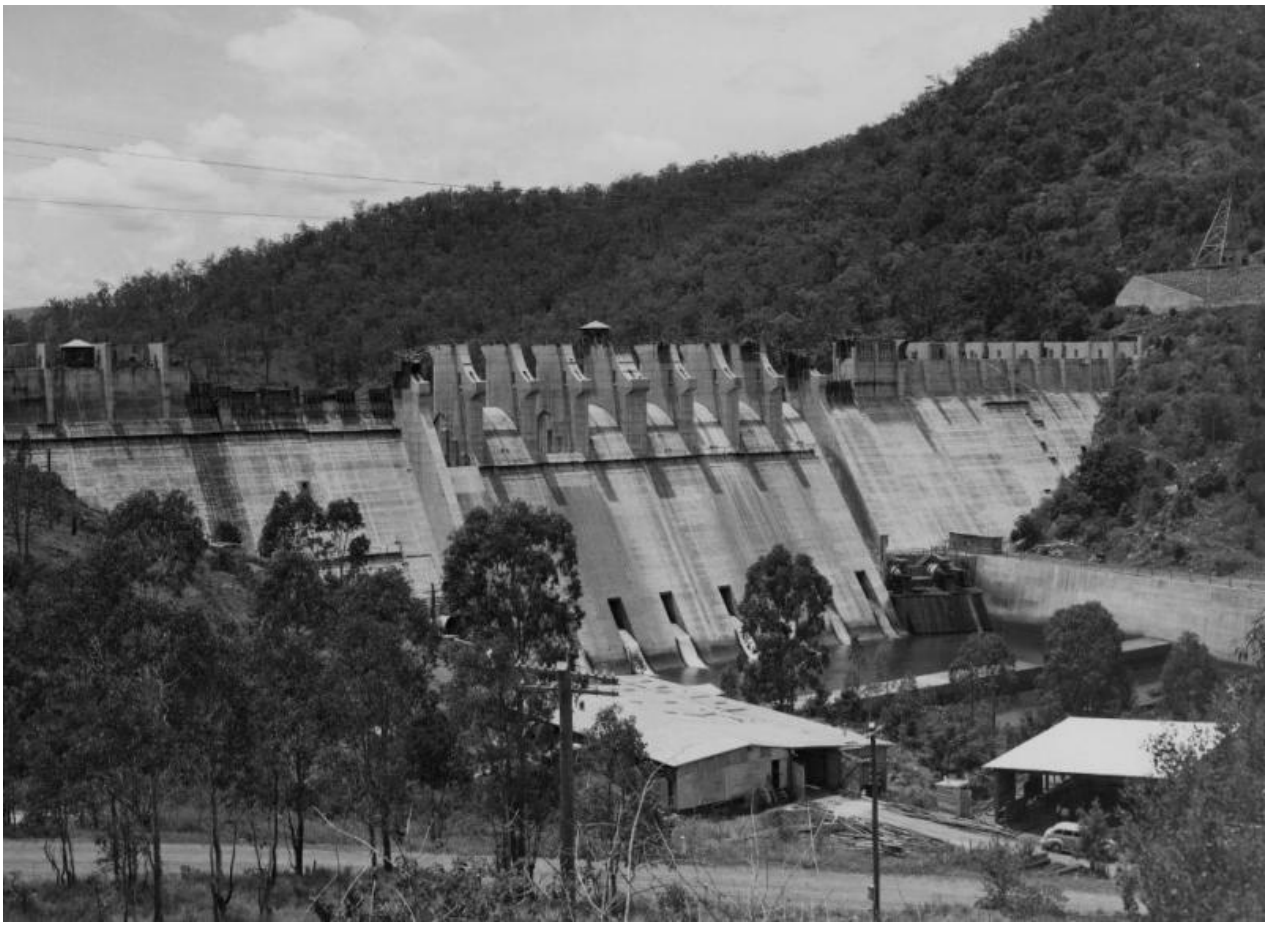
Dual-purpose Somerset Dam complete, mitigates flood and drought

Timeline: Brisbane

1959

Begun in 1935, but not completed until 1959, Somerset Dam was built to address the twin environmental problems of flood and drought. Built primarily as a water storage dam, with water levels kept below 40 percent of capacity to allow for retention of flood waters, the dual-purpose dam was the first of its type in the Southern Hemisphere.



Somerset Dam was the first dual-purpose water supply and flood mitigation built in the Southern Hemisphere. Unknown photographer, 1949.

Courtesy of *Sunday Truth* and State Library of Queensland. Image 150518.
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Websites linked in image captions:

- http://www.environmentandsociety.org/%20https%3A//hdl.handle.net/10462/deriv/109926%20

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Building sewerage in the suburbs

Timeline: Brisbane

1961 - 1967

In 1961, 60 percent of Brisbane's suburbs were unsewered, dependent on backyard outhouses and night-soil collectors. Much of the sewage emptied into creeks and the river system. Lord Mayor Clem Jones won the municipal election in 1961 with a promise to sewer the metropolis. By 1967, 60 percent of the city was sewered, leaving a much smaller proportion of houses dependent on septic systems than in Melbourne or Sydney. Consequently, Brisbane did not receive federal funding under the Whitlam Labor Government for sewerage, but was able to utilize it to build a sewerage and wastewater treatment plant at Luggage Point in 1973–74.

A rapid program of sewering the suburbs occurred in the 1960s and replaced the backyard outhouses. Photograph by Brisbane City Council, 1961.

Websites linked in image captions:

- https://library-brisbane.ent.sirsidynix.net.au/client/en_AU/search/asset/11245/0

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Droughtproofing Melbourne

Timeline: Melbourne

1966 - 1984

From the end of the Second World War until 1971, the population of Melbourne doubled. In an era that favored technocratic solutions to challenges of population growth and water shortage, new dams were seen as the ultimate solution. In 1966–67, Melbourne experienced its driest year on record. The Public Works Committee recommended damming and diverting the Thomson River and building a reservoir at Cardinia Creek. The Cardinia Reservoir was operational by 1973. The Thomson reservoir, completed in 1984, more than doubled Melbourne's water storage capacity. It was thought that Melbourne's water shortage issue had been permanently solved.

Following the drought of 1966–67, plans were made to drought-proof the city by damming the Thomson River. The Thomson Dam was completed in 1984. Photograph by Melbourne Water, 1981.

1981 Melbourne Water.
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Websites linked in image captions:

- https://www.flickr.com/photos/melbournewater/5028899543/in/album-72157632684258110/

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Timeline: Water Crises in Australian Cities, 1880s–2010s
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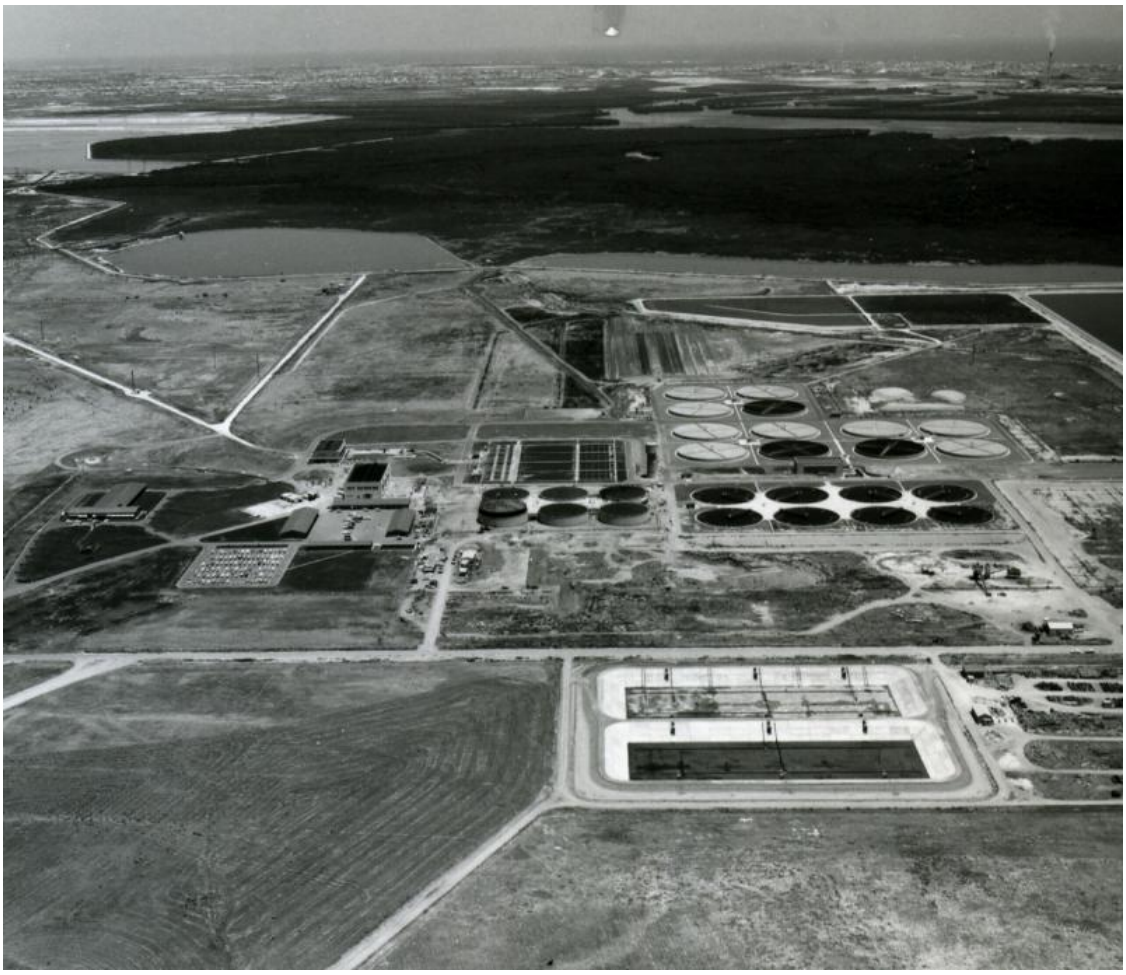
Bolivar Wastewater Treatment Plant opens

Timeline: Adelaide

1966

The Depression and the outbreak of the Second World War delayed plans to move the city's main sewage farm from Regency Park (originally Tam O'Shanter) located between the city and Port Adelaide to the northwest. Population increases and nearby development meant the facility could not expand to meet increased demand and made its location undesirable. After planning to relocate the facility in the 1920s, the E&WS Department eventually opened Bolivar several kilometers north of the city in 1966.



Bolivar Wastewater Treatment Plant became operational in 1966, moving sewage treatment away from residential development. Unknown photographer, 1968.

Photo *Book111pg040image136* (*Bolivar 1968*) courtesy of SA Water Library.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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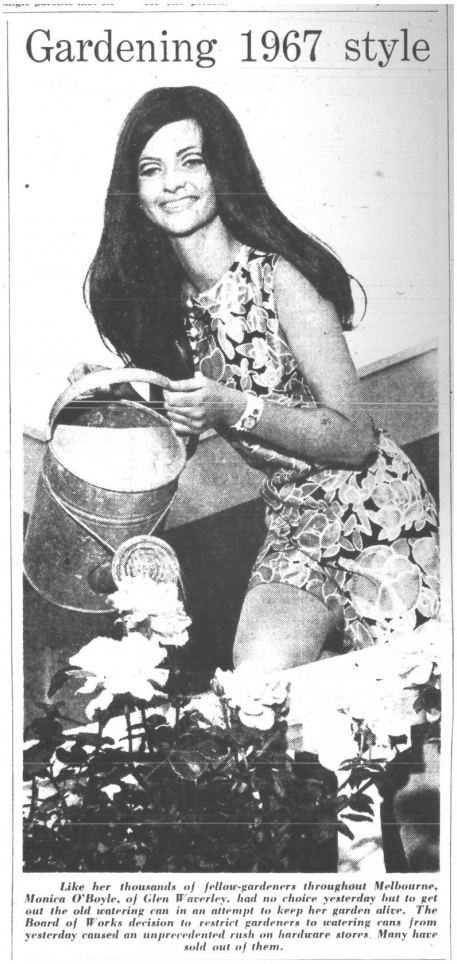
Drought and water restrictions

Timeline: Melbourne

1967

In 1967, Melbourne experienced its driest year on record. Only 380 millimeters of rain fell, less than 60 percent of the annual average. Restrictions were placed on the use of sprinklers and hoses for watering gardens (public and private), washing cars, and filling and cleaning private swimming pools. Only hand watering, using buckets, and watering cans was allowed. The Melbourne City Council tried sinking bores in Royal Park and the Fitzroy Gardens, but the water was too salty. Bores were sunk in private gardens, and orders for rainwater tanks rose.


Gardening 1967 style

Like her thousands of fellow-gardeners throughout Melbourne, Monica O'Boyle, of Glen Waverley, had no choice yesterday but to get out the old watering can in an attempt to keep her garden alive. The Board of Works decision to restrict gardeners to watering cans from yesterday caused an unprecedented rush on hardware stores. Many have sold out of them.

During the drought in 1967, Melbourne gardeners were restricted to using watering cans to keep their gardens alive. Unknown photographer, 1967.

Originally published in *The Age*, 2 December 1967.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Water supply holds through period of low rainfall and heat

Timeline: Adelaide

1967

From 1955 to 1968, two more reservoirs were commissioned to support suburban growth in Adelaide's north and southeast. Another pipeline, the Murray Bridge - Onkaparinga Pipeline was constructed connecting Adelaide's south to a supply of water from the Murray River. The year of 1968 saw heat waves, dust storms, and extremely low rainfall, however, the new water supplies meant that the city avoided water restrictions.

1967–68 was a period of very low rainfall, heat waves, and dust storms in Adelaide. Photograph by Sydney Oats, 1968.

Websites linked in image captions:

- https://collections.slsa.sa.gov.au/resource/B+71808

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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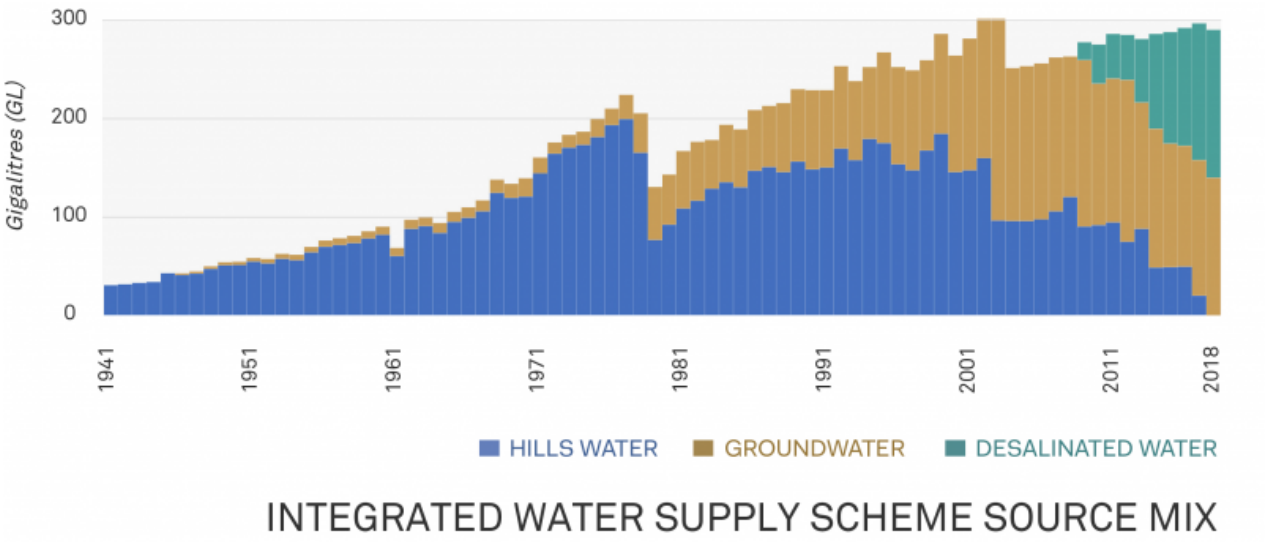
Tapping new supplies

Timeline: Perth

1970 - 1978

During the 1950s and 1960s, the population of Perth had soared thanks to the state's industrial expansion and mineral boom. Despite implementing water restrictions on suburban households, the water authority struggled to keep pace with the growth in demand and sought to develop new supplies. These measures included more dams, including North Dandalup (1971), South Dandalup (1973), and Wungong Dam (1978). Meanwhile, hydrological investigations had revealed extensive groundwater reserves underneath the suburbs that could be cheaply used for water supplies. The exploitation of the Gnangara Mound superficial aquifer commenced at Mirrabooka in 1970, followed by Gwelup (1974), Wanneroo (1976) and East Mirrabooka (1980); the Jandakot Mound was first tapped for the urban water supply in 1979. By the mid-1970s, groundwater provided about 10 percent of Perth's water supply and the city's reliance on this source was expected to grow. Since then, groundwater has become a vital source of water for Perth while dams have diminished in importance.



The mix of water supply sources in the Integrated Water Supply Scheme has changed substantially over time. Graph by Daniel Jan Martin, 2018.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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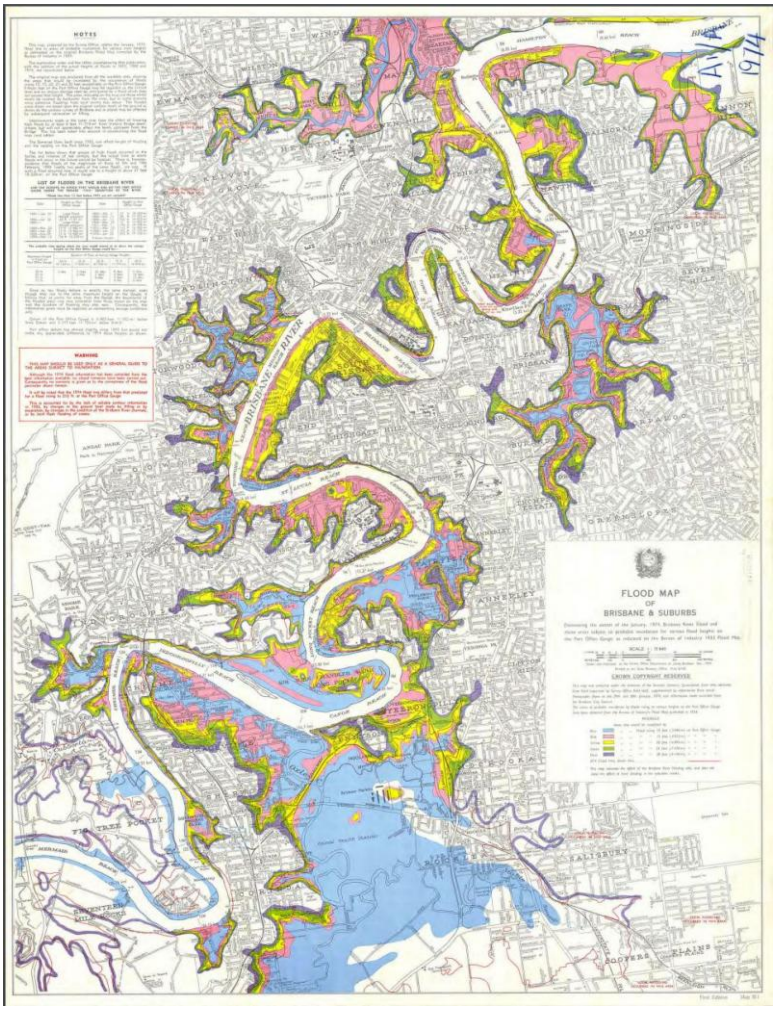
Brisbane suffers fourth-highest-recorded flood

Timeline: Brisbane

1974

Floods again devastated Brisbane, dispelling the myth that Somerset Dam would prevent flooding. This flood reached 5.45 meters but caused greater devastation than the 1893 floods because of industrial and residential development on the floodplain. The state government accelerated its plans to build a second, larger flood mitigation and water supply dam on the Brisbane River.



Flood map of Brisbane and Suburbs. Map by Brisbane City Council, 1974.

Courtesy of Brisbane City Council Archives, State of Queensland. Image BCC-CD21-002.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Schemes to import water

Timeline: Perth

1974

Although local water authorities turned to more conventional surface and groundwater supplies as the population boomed, they also explored the prospect of importing water from further afield. Among the ideas was piping water from the Fitzroy River in the state's northwest (at least 2,000 kilometers away). First proposed in 1974, the scheme was advocated again in the late 1980s, and still again in 2004. Despite the visionary appeal of conveying water to the state's capital, the economic and environmental costs of the project were simply too prohibitive. An even grander scheme arose in 1978 when water authorities entertained towing Antarctic icebergs to supply freshwater to Perth. Proponents continued to press for the exploitation of icebergs into the 1990s but were unable to convince the water authorities that the scheme was viable or necessary.

A commentary on the proposal to tow icebergs to supply freshwater to Perth by political cartoonist Noel Allan Langoulant, 1978.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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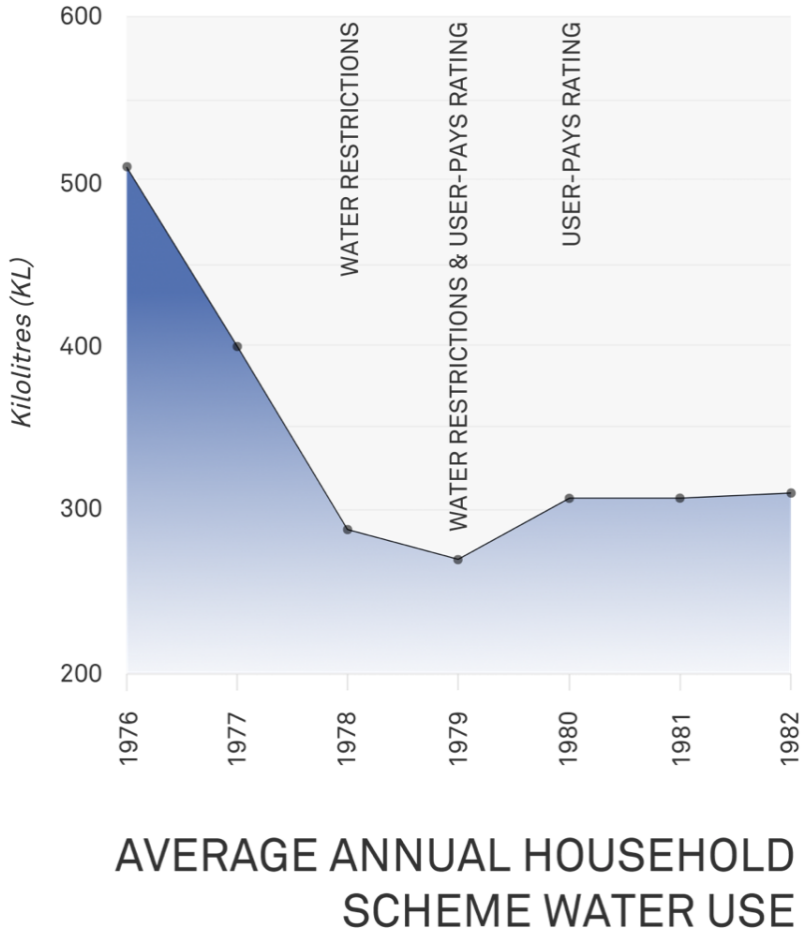
Curtailing demand with a user-pays water rating system

Timeline: Perth

1978

A series of dry summers in the 1970s led water authorities to introduce household water restrictions in mid-1977. These restrictions were eased in October 1978 to partial restrictions until May 1979. The political and financial cost of water restrictions, combined with the emerging influence of market principles on water resource management, led the state government to implement a user-pays water rating system in July 1978. Under this system, each household was charged a fixed fee and provided with an allowance of 150 kiloliters each year. Since each kiloliter used beyond this allowance was charged, this system rewarded consumers who used less water.



The introduction of user-pays preceded a dramatic reduction in water consumption. Graph by Daniel Jan Martin, 2018.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.

Timeline: Water Crises in Australian Cities, 1880s–2010s

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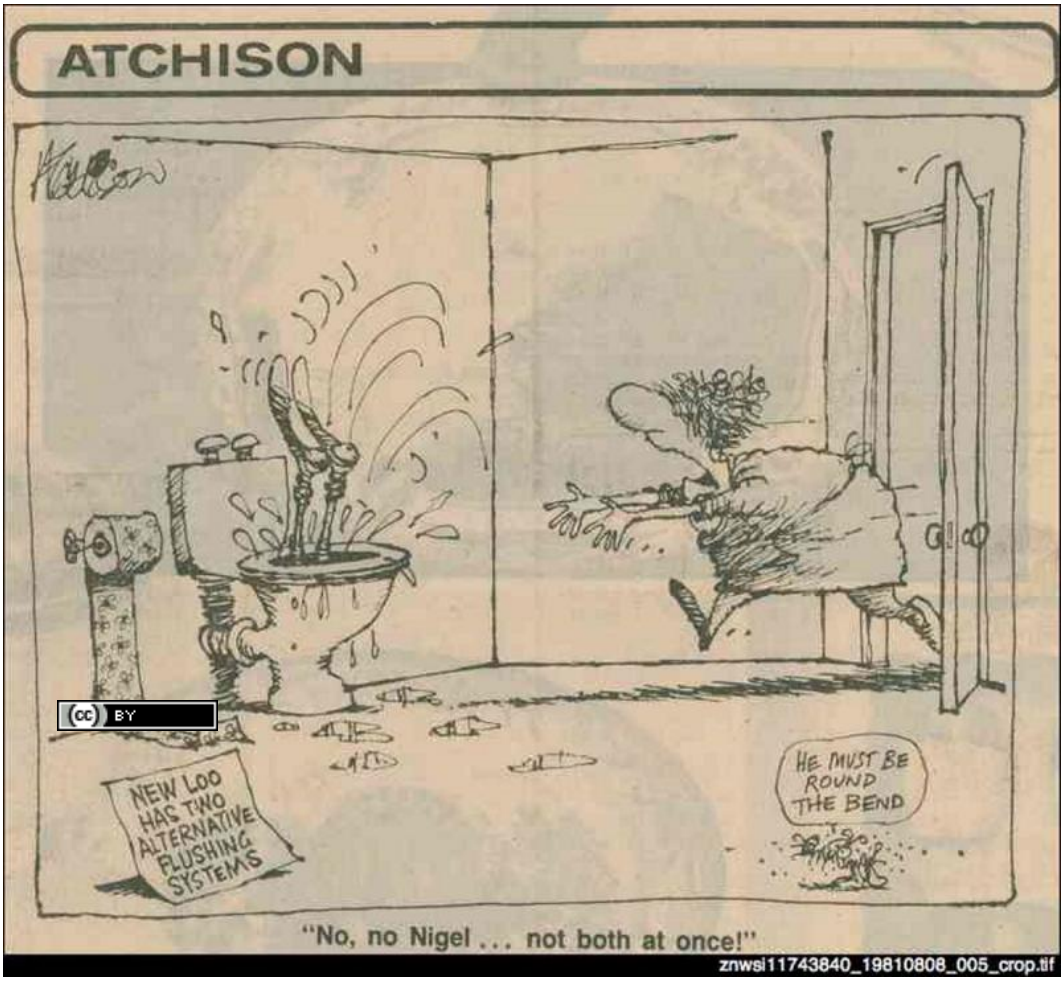
“Dual-flush” toilet cistern is approved for sale in South Australia

Timeline: Adelaide

1981

Designed in 1980 in Adelaide by sanitary manufacturer Caroma, the “dual-flush” cistern was approved for sale in South Australia to reduce household water use. Water conservation remained relevant as the cost of supplying water to the state grew.



“No, no Nigel ... not both at once!” Water-saving innovations remain important in South Australia. Cartoonist Atchison considers the new flushing system designed in 1980. Cartoon by Michael Atchison, 1981.

Websites linked in image captions:

- http://www.catalog.slsa.sa.gov.au/record=b1429864

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. “Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s.” Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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Wivenhoe Dam supplies water and mitigates flooding

Timeline: Brisbane

1984

Wivenhoe Dam was built in response to assessments that Brisbane's water supply dams would not meet demand by 1981. A second dual-purpose dam, it provided 1.15 million megaliters of water supply storage with an additional 1.45 million megaliters for flood storage. Completed in 1984, Wivenhoe Dam provided 90 percent of the region's water supply and managed the flow rate of 40 percent of the river system.

Wivenhoe Dam, completed in 1984, provided a second flood-mitigation and water-supply dam, and greatly augmented Brisbane's water supply. Photograph by John Perryn, 2011.

Websites linked in image captions:

- http://hdl.handle.net/10462/deriv/235016

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Brisbane City Council implements water meter installation program

Timeline: Brisbane

1989

In the 1930s, 80% of houses had water meters; by the 1980s, only 6% did. Reliance on Wivenhoe Dam for water supply enabled the City Council to cease installing water meters. Residential customers' water was unmetered, with no charge for excess usage. Recognizing the revenue potential of charging for water consumption, the Brisbane City Council reintroduced a water meter program in 1989. Between 1990 and 1995, 218,000 water meters were installed in new subdivisions. This did little to curtail water consumption as water remained cheap at less than $1 for 1000 liters, with daily per capita usage peaking at 700 liters in the 1990s.

In 1989, Brisbane City Council reintroduced a program of suburban water meters. Photograph by Brisbane City Council, 1989.

Websites linked in image captions:

- https://library-brisbane.ent.sirsidynix.net.au/client/en_AU/search/asset/2089/0

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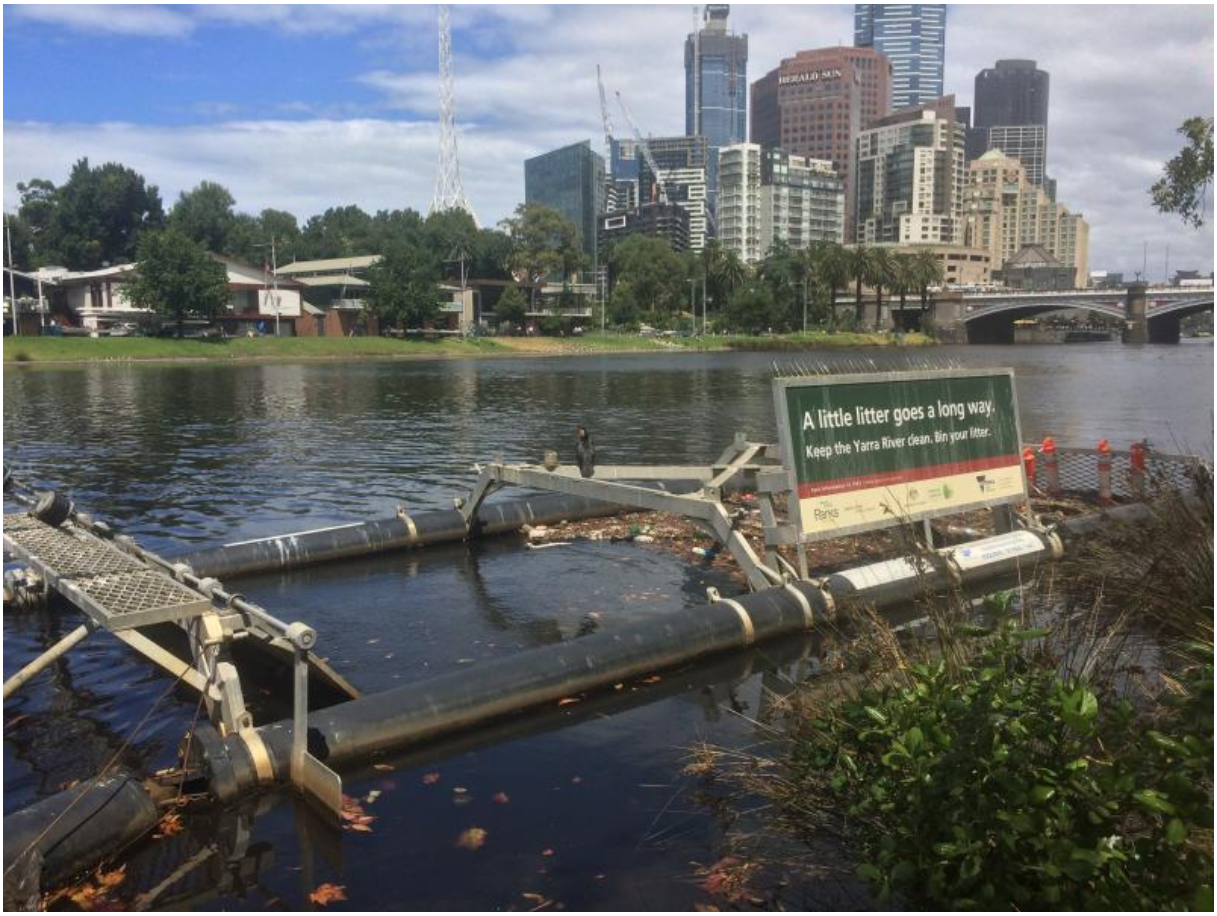
Concerns over the health of Port Phillip Bay

Timeline: Melbourne

1990

In the early 1990s, community concerns for the health of Melbourne's Port Phillip Bay resulted in the Port Phillip Bay Environmental Study, conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The four-year study investigated relationships between water quality and land activities such as industry, agriculture, and sewerage. The Port Phillip Bay catchment area is large and densely populated. Stormwater runoff from this area is, therefore, a substantial source of the pollution entering the bay. As the most visible form of pollution, the presence of litter is one of the key factors determining public perceptions of the health of waterways. From 1992, floating litter traps have been strategically placed in waterways to control litter entering Port Phillip Bay. Melbourne Water, Parks Victoria, and local councils manage these traps. Research in 1997 estimated that 230,000 cubic meters of litter were entering the waterways of greater Melbourne each year. The Parks Victoria Yarra River litter traps in the lower Yarra collect 1,500 cubic meters of litter and debris from the river annually.



Following concerns for the health of Port Phillip Bay in the early 1990s, litter traps were installed in waterways to prevent litter and debris from entering into the bay. Photograph by Elizabeth Gralton, 2019.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Timeline: Water Crises in Australian Cities, 1880s–2010s
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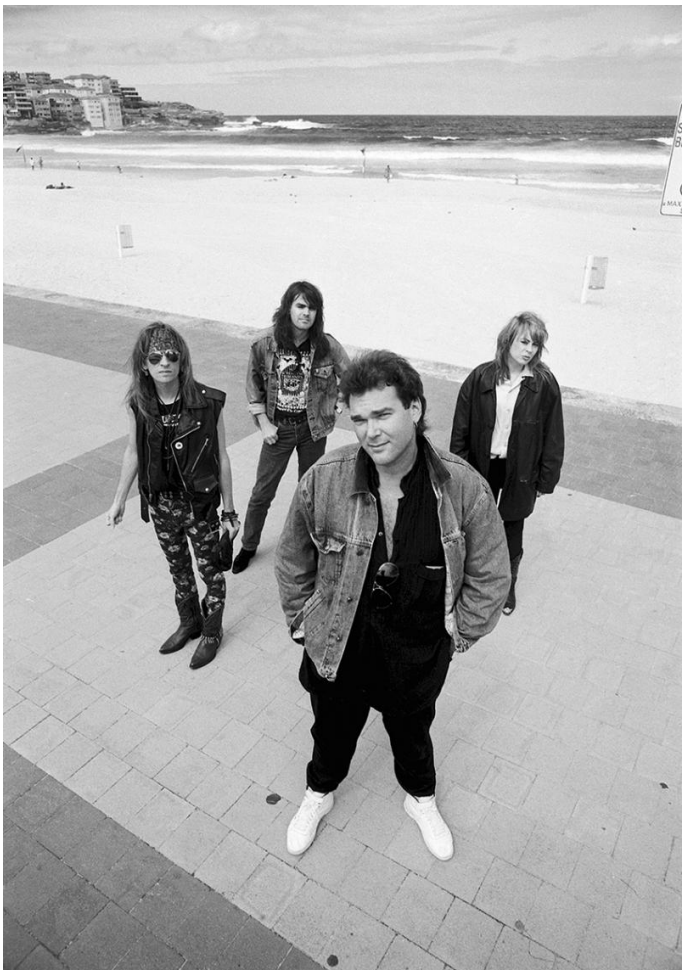
Getting rid of beach pollution

Timeline: Sydney

1990 - 1991

Following the construction of the sewage ocean outfalls in the late nineteenth and early twentieth centuries, beachgoers periodically voiced concerns about pollution. By the 1980s, the quality of the water at Manly and especially Bondi Beach had deteriorated to the point that public outrage culminated in the Turn Back the Tide protest concert at Bondi in 1989. The Water Board's response was to construct deep-water extensions to the outfalls discharging the city's sewage kilometers away from the coast.



Chrissie Amphlett from the Divinyls, Mark Medew and Warwick Fraser from the Screaming Tribesmen, and Mark Hunter from Dragon pose for the media prior to performing at the Turn Back the Tide concert to raise awareness of the high level of pollution in the water at Bondi. Photograph by Ben Rushton, 1989.

Sydney Morning Herald, 17 March 1989.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Private bores increase in response to water restrictions

Timeline: Perth

1994

Low dam storages after the dry winter of 1994 led the state government to impose the first water restrictions on Perth households since the late 1970s. These relatively moderate restrictions commenced in November and banned the daytime use of garden sprinklers. Their introduction was met with little protest, as a decade of conservation education had taken effect. Many households had also developed their own private groundwater supplies that alleviated their reliance on public supplies for outdoor purposes. These backyard bores were unlicensed, unmetered, and unregulated. By 2003, about a quarter of Perth households used bore water . Although these private supplies relieved demand on public water provision, their popularity has exacted an increasing toll on the city's groundwater reserves. The falling water table has allowed seawater to intrude into the groundwater system, putting this valuable resource at risk.

Many of the wetlands fed by the Gnangara groundwater mound are now in a state of ecological emergency. Photograph by Department of Water and Environmental Regulation, WA, 2010.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.
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Millennium Drought

Timeline: Melbourne

1996 - 2010

In 1996, Australia entered a period of unprecedented dry conditions known as the Millennium Drought. In Melbourne, water restrictions reduced consumption by 22 percent. In 2008, the Victorian government introduced Target 155, a program to encourage Melbourne citizens to limit domestic water usage to 155 liters per day. By the winter of 2009, the level of the Thomson Dam had dropped to 16 percent of total capacity. With new dams being off the policy agenda, the Victorian government approved the construction of Australia's largest desalination plant (costing more than all other Australian plants combined). After the Millennium Drought broke in 2010, the Thomson Dam returned close to full capacity. The Victorian Desalination Plant was completed in 2012, but did not deliver water to the system until 2017, as debate continued over the planning process and financial costs of the infrastructure.

Thomson Dam at low levels during the Millennium Drought. Photograph by Melbourne Water, 2008.

2008 Melbourne Water. Click here to view source.

Websites linked in image captions:

- https://www.flickr.com/photos/melbournewater/5028903801/in/album-72157624917339153/

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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Southeast Queensland endures its worst recorded drought

Timeline: Brisbane

2001 - 2008

As dam levels fell during the drought, water restrictions were introduced. In October 2005, sprinkler usage was limited. Hoses were banned in June 2006 and after November 2006, only limited hours of bucket watering were permitted under Level 4 restrictions. Greywater recycling was permitted in late 2006. As dams fell to 16.7 percent in 2007, water restrictions reached their most stringent with the aim of reducing per capita consumption to 140 liters per day. Residents of Southeast Queensland were issued with free timers to encourage short showers. Subsidies were offered for tanks and for the purchase of waterwise household appliances. Consumption per capita reached its lowest point of 112 liters per day in 2008, less than any other capital city in Australia.

During the Millenium Drought, the Queensland State Government introduced stringent water restrictions. Residents of Southeast Queensland were issued with free timers to encourage short showers. Photograph by Peter Spearritt, 2011.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society. doi.org/10.5282/rcc/8383.
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Perth's first sip of desalinated seawater

Timeline: Perth

2006

In the mid-1990s, local water managers identified a regional drying trend that had commenced in the 1970s and was affecting Perth's rainfall and water supplies. Following the dry conditions of 2001, the state government announced its intention to use seawater desalination technology to supply water to Perth. This plan was met with staunch opposition from environmentalists, rural politicians, and the news media. Alternative plans were mooted, such as tapping the South West Yarragadee aquifer and building a canal from the Kimberley in the state's northwest, before the government recommitted to building a desalination plant near the coast, south of Perth. In November 2006, the people of Perth were the first in Australia to sip desalinated seawater. Perth's second desalination plant was completed in 2011 and expanded in 2013.

Perth's Southern Seawater Desalination Plant converts seawater from the Indian Ocean to drinking water, to meet more than half of Perth's scheme water demand. Photograph by Nearmap Australia Pty Ltd, 2019.

Gaynor, Andrea, Margaret Cook, Lionel Frost, Jenny Gregory, Ruth Morgan, Martin Shanahan, Peter Spearritt, Susan Avey, Nathan Etherington, Elizabeth Gralton, and Daniel Martin. "Drought, Mud, Filth, and Flood: Water Crises in Australian Cities, 1880s–2010s." Environment & Society Portal, *Virtual Exhibitions* 2019, no. 3. Rachel Carson Center for Environment and Society.
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A "Water Grid" to manage SEQ water

Timeline: Brisbane

2006

In 2006, the state government introduced a $9 billion "Water Grid," linking all major SEQ dams, most notably Wivenhoe, Somerset, Enoggera, North Pine, and Hinze Dams. A network of 600 kilometers of bulk water pipelines linked Brisbane, Gold Coast, Logan, Ipswich, Redland, Sunshine Coast, and the Scenic Rim council areas, to allow a regional approach to water supply. Built by the state in response to the Millennium Drought, it connected with the Gold Coast Desalination Plant at Tugan and the Western Corridor Recycled Water Scheme. The system was created at vast cost in terms of both water mains and energy required to move water through the system, but by 2018 remained largely dormant.

In 2006, the state government introduced a $9 billion "water grid" linking major dams. Map by Seqwater, 2016.

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doi.org/10.5282/rcc/8383.
Timeline: Water Crises in Australian Cities, 1880s–2010s
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Making water: Desalination

Timeline: Sydney

2007

A severe drought early in the new millennium saw the level of the Warragamba Dam fall to 32.5 percent in 2007. Caught off guard, the state government outsourced a desalination plant on the Kurnell Penninsula, completed by 2010. Coinciding with a return to a more usual rainfall pattern for Sydney, the mothballed plant continues to cost the state a substantial amount of money annually due to a contract favorable to the private owners. A fall in dam levels to below 60% under the current drought conditions triggered the recommissioning of the plant in early 2019. Along with the supply of desalinated water, Level 1 restrictions on water usage were introduced in June 2019.

The Sydney desalination plant was constructed between 2007 and 2010. Photograph by Sydney Water, ca. 2009.

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Timeline: Water Crises in Australian Cities, 1880s–2010s

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Gold Coast Desalination Plant opens at Tugan

Timeline: Brisbane

2009

Built in response to the drought, and following the Perth Kwinana example, the Gold Coast Desalination Plant opened at Tugan in 2009 at a cost of AUD $1.2 billion. Designed to supply 125 megaliters of water per day, it was constructed as part of the "Water Grid." Used briefly to supplement drinking supplies in 2009–10, and during the 2011 and 2013 floods, in 2018 the plant remained in "hot standby" mode.

In 2006, the Queensland State Government introduced the "Water Grid," linking all major dams, and opened the Tugan Desalination Plant. Photograph by Seqwater, 2016.

Websites linked in image captions:

- https://www.seqwater.com.au/water-supply/water-treatment/desalination

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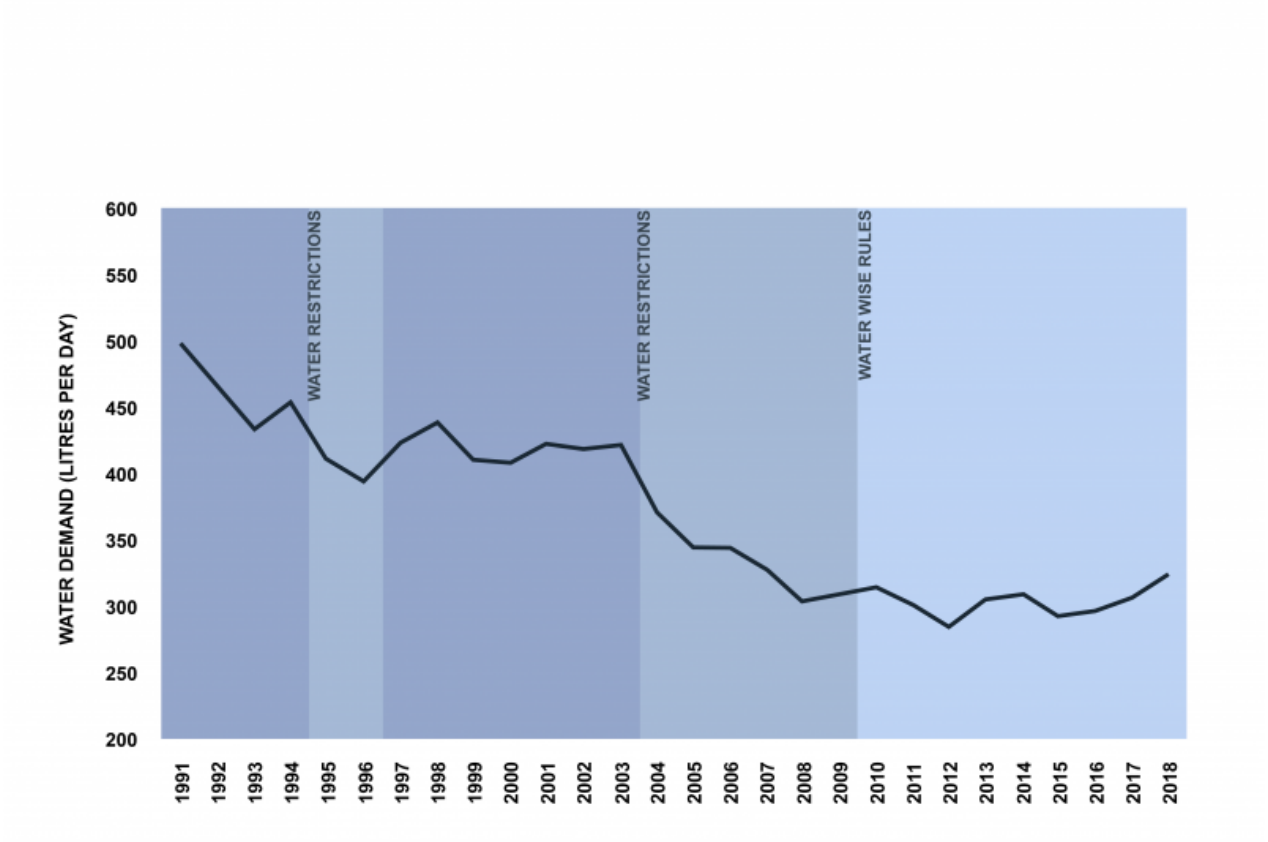
Water Wise Rules

Timeline: Sydney

2009

Severe drought conditions saw Sydney Water introduce long-term water conservation measures in 2009, including compulsory water tanks for new dwellings, and steeper charges for excessive water use. It encouraged schools, golf clubs, industry, and transport users to harvest more of their own water.



This graph shows the effect of water restrictions on consumption from the 1990s to the present. The "Water Wise Rules" introduced in 2009 are permanent guidelines on permissible water usage. Graph by Nathan Etherington, 2019.

Data from Sydney Water Conservation Report 2017–2018 .

Websites linked in image captions:

- https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq3/~edisp/dd_047419.pdf

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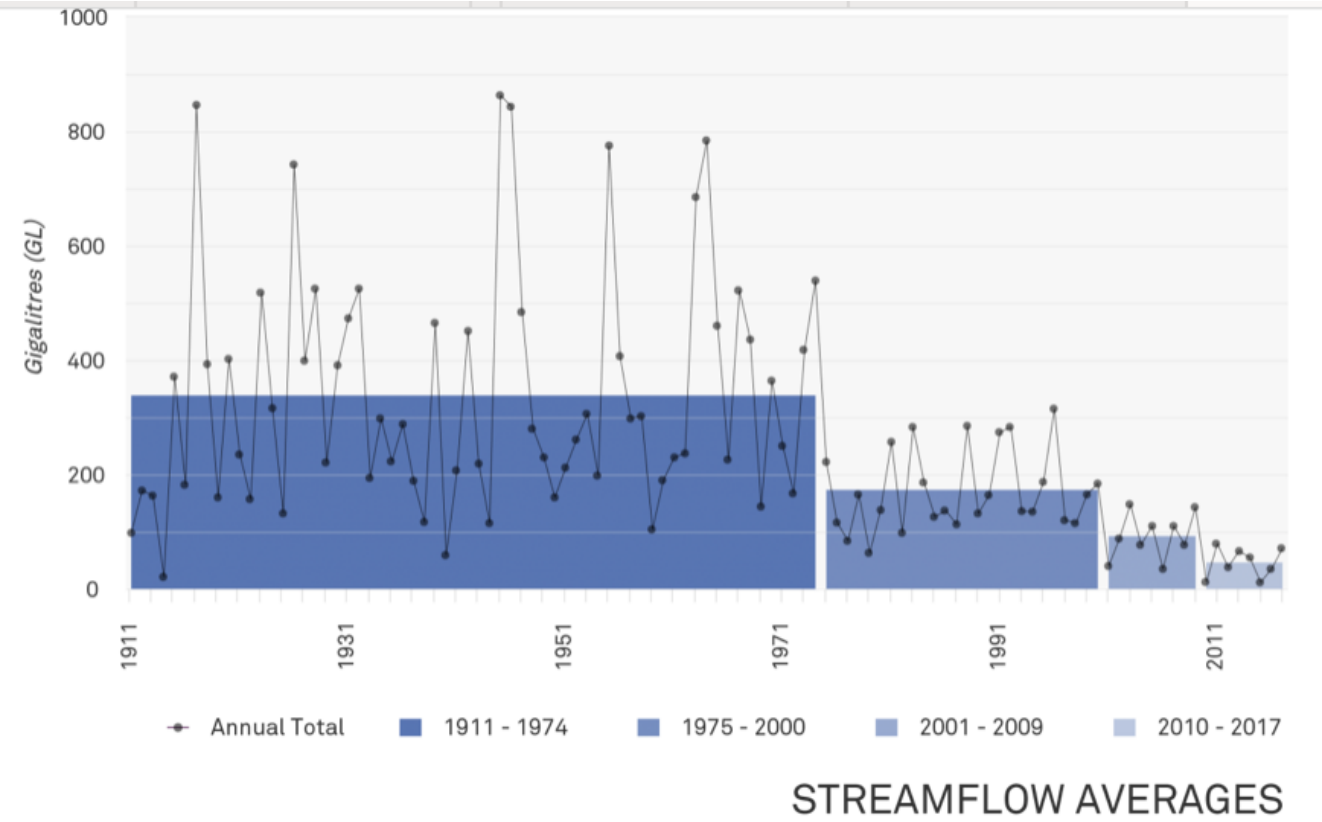
Driest year on record

Timeline: Perth

2010

In 2010, Perth recorded its driest year since records began. With little fanfare, the state government imposed total sprinkler bans during the winter months of June, July, and August, and restricted the use of private bores to three days per week—a policy that has continued. The combination of a drying climate and the city's increasing reliance on its groundwater reserves, meanwhile, took its toll. In 2011, the government commenced a trial to replenish the Gnangara Mound superficial aquifer with treated wastewater. Satisfied with the results, the water authorities decided to continue the replenishment program in 2017.



The graph of the declining streamflow averages into Perth's dams is a clear indication of a rapidly drying climate. Graph by Daniel Jan Martin, 2018.

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Brisbane experiences a 4.46-meter flood

Timeline: Brisbane

2011

Spring rain in 2010 broke records and filled the dams after years of drought. In 2011, a 4.46-meter flood swamped Brisbane, taking one life. In all, 14,100 properties were affected, with 1,203 houses and almost 2,500 business inundated. Sewerage treatment plants overflowed and pumping stations failed. At the peak of the flood, Wivenhoe Dam reached 197 percent of its normal water supply storage capacity, requiring controlled releases. A Commission of Inquiry investigated and dismissed allegations of culpability of the dam operators, but did see changes to the Wivenhoe and Somerset Dams' operating manuals.

Houses in Crutchley Street surrounded by flood waters in Fairfield, Queensland. Photograph by John Doody, 2011.

John Doody, Brisbane, Australia, 2011.
Click here to view source.

Used by permission.

Websites linked in image captions:

- http://hdl.handle.net/10462/deriv/244062

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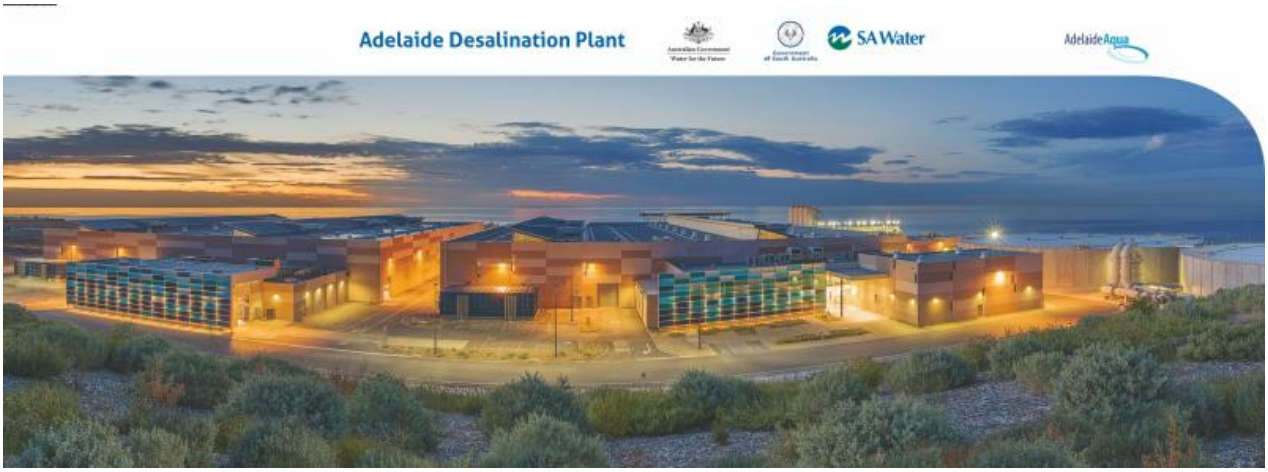
Drought dries up the river supply

Timeline: Adelaide

2011

From 1996–2010, one of the worst droughts on record saw the city of Adelaide in yet another period of insecure supply. Restrictions were put in place from 2003 until 2010, with some becoming ongoing water conservation measures. The supply of Murray River water for Adelaide was threatened as river levels and water quality dropped. A desalination plant built to safeguard the future of the city's water began production of potable water in 2011.



The Millennium Drought prompted South Australia to secure alternative water supplies. Adelaide's Desalination Plant was commissioned in 2011. Photograph by SA Water, 2015.

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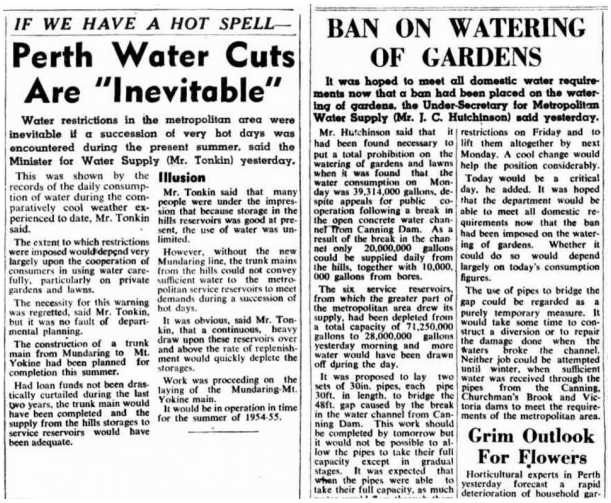
Map of Australia showing the location of the exhibition's five cities. Illustration by Nathan Etherington, 2019.



IF WE HAVE A HOT SPELL—

Perth Water Cuts Are "Inevitable"

Water restrictions in the metropolitan area were inevitable if a succession of very hot days was encountered during the present summer, said the Minister for Water Supply (Mr. Tonkin) yesterday.

This was shown by the records of the daily consumption of water during the comparatively cool weather experienced to date, Mr. Tonkin said.

The extent to which restrictions were imposed would depend very largely upon the cooperation of consumers in using water carefully, particularly on private gardens and lawns.

The necessity for this warning was regretted, said Mr. Tonkin, but it was no fault of departmental planning.

The construction of a trunk main from Mundaring to Mt. Yokine had been planned for completion this summer.

Had loan funds not been drastically curtailed during the last two years, the trunk main would have been completed and the supply from the hills storages to service reservoirs would have been adequate.

Illusion

Mr. Tonkin said that many people were under the impression that because storage in the hills reservoirs was good at present, the use of water was unlimited.

However, without the new Mundaring line, the trunk mains from the hills could not convey sufficient water to the metropolitan service reservoirs to meet demands during a succession of hot days.

It was obvious, said Mr. Tonkin, that a continuous, heavy draw upon these reservoirs over and above the rate of replenishment would quickly deplete the storages.

Work was proceeding on the laying of the Mundaring-Mt. Yokine main.

It would be in operation in time for the summer of 1954-55.

BAN ON WATERING OF GARDENS

It was hoped to meet all domestic water requirements now that a ban had been placed on the watering of gardens, the Under-Secretary for Metropolitan Water Supply (Mr. J. C. Hutchinson) said yesterday.

Mr. Hutchinson said that it had been found necessary to put a total prohibition on the watering of gardens and lawns when it was found that the water consumption on Monday was 39,314,000 gallons, despite appeals for public cooperation following a break in the open concrete water channel from Canning Dam. As a result of the break in the channel only 20,000,000 gallons could be supplied daily from the hills, together with 10,000,000 gallons from bores.

The six service reservoirs, from which the greater part of the metropolitan area drew its supply, had been depleted from a total capacity of 71,250,000 gallons to 28,000,000 gallons yesterday morning and more water would have been drawn off during the day.

It was proposed to lay two sets of 30in. pipes, each pipe 30ft. in length, to bridge the 48ft. gap caused by the break in the water channel from Canning Dam. This work should be completed by tomorrow but it would not be possible to allow the pipes to take their full capacity except in gradual stages. It was expected that when the pipes were able to take their full capacity, as much restrictions on Friday and to lift them altogether by next Monday. A cool change would help the position considerably.

Today would be a critical day, he added. It was hoped that the department would be able to meet all domestic requirements now that the ban had been imposed on the watering of gardens. Whether it could do so would depend largely on today's consumption figures.

The use of pipes to bridge the gap could be regarded as a purely temporary measure. It would take some time to construct a diversion or to repair the damage done when the waters broke the channel. Neither job could be attempted until winter, when sufficient water was received through the pipes from the Canning, Churchman's Brook and Victoria dams to meet the requirements of the metropolitan area.

Grim Outlook For Flowers

Horticultural experts in Perth yesterday forecast a rapid deterioration of household gar-

Snippets from front pages of *The West Australian* from the early 1950s, a time of frequent water restrictions. *The West Australian*, 17 December 1953 and 18 January 1950.

Courtesy of Trove, National Library of Australia.
Click here and here to view sources.

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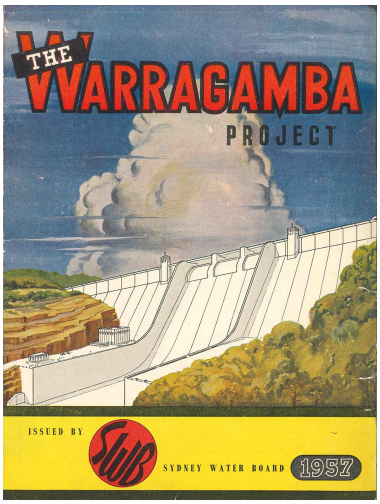


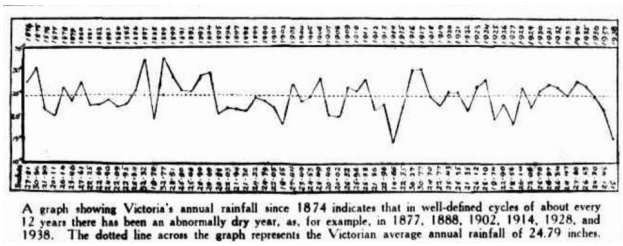
Artist's impression of the Warragamba Dam published with Sydney Water Board promotional material in 1957. Unknown illustrator, 1957.

Courtesy of the State Library of New South Wales.

Mrs. J. Asbury gives her daughter Barbara a lift across the flooded drain outside her home in Cuthbert Street, Reservoir in Melbourne, Victoria. Photograph by Len Drummond, 1953.

Photo courtesy of News Limited.

Perth's Southern Seawater Desalination Plant converts seawater from the Indian Ocean to drinking water, to meet more than half of Perth's scheme water demand. Photograph by Nearmap Australia Pty Ltd, 2019.



This graph, published in the *Argus* during the drought of 1938, shows Victoria's annual rainfall since 1874. Unknown illustrator, ca. 1938.

Image courtesy of Trove, National Library of Australia.
Click here to view source.

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Mannum-Adelaide pipeline under construction. Completed in 1955, the pipeline connected Adelaide to Murray River. Unknown photographer, 1953.

Courtesy of State Library of South Australia. Image B 20276. Click here to view source.

Brisbane is flooded by the second and third highest recorded floods within a fortnight. Unknown photographer, 1893.

Courtesy of the State Library of Queensland. Image 84890. Click here to view source.

Websites linked in image captions:

- https://trove.nla.gov.au/newspaper/article/49606204
- http://nla.gov.au/nla.news-article47823775
- https://collections.slsa.sa.gov.au/resource/B+20276
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