Lessons from the Land of Oz for the American Southwest: Australia's Responses to Its Millennium Drought

A Study Tour Report

TreePeople

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TreePeople's mission is to inspire, engage and support people to take personal responsibility for the urban environment, making it safe, healthy, fun and sustainable and to share the process as a model for the world.

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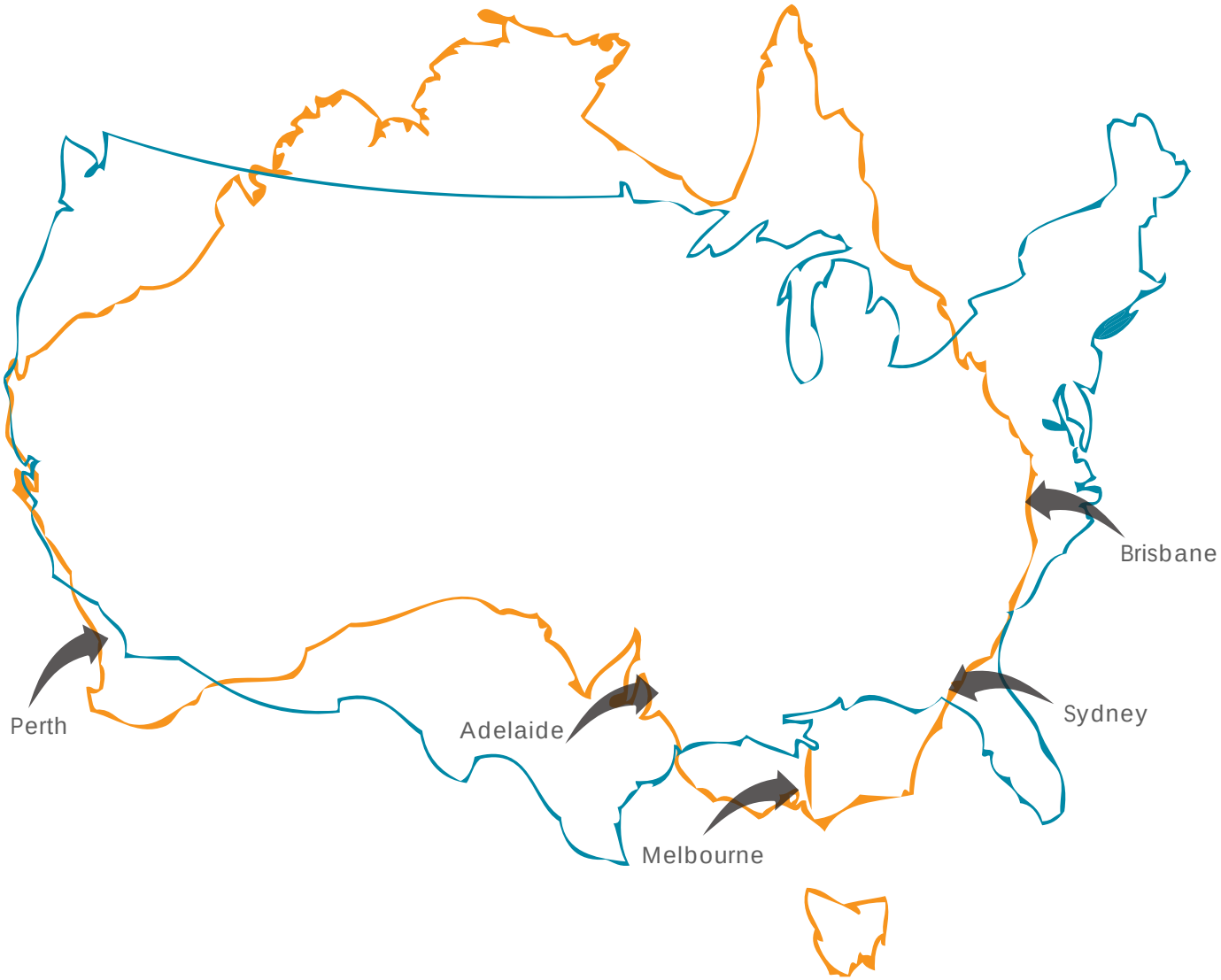
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EXECUTIVE SUMMARY

In 2012, TreePeople, a Los Angeles-based environmental nonprofit organization, embarked upon an information and best practices exchange program between government, research and community organizations in Australia and Southern California. The program is aimed at sharing innovations, best practices and experience related to community, business and government agency engagement in urban rainwater capture and water conservation practices. A particular focus is on identifying successes, challenges and lessons learned from Australia's devastating "Millennium Drought" as a way to help prepare Southern California to quickly develop and implement a sustainable approach to meeting water needs in the face of its looming long-term water crisis.

Research is a major element of this ongoing program. TreePeople staff took two research trips to Australia in 2012 and met with water management and planning entities in Australia's five largest cities. This study tour report highlights data that were collected on innovations and experiences related to urban water conservation, rainwater harvesting and other drought responses. Study tour findings are shared, including both success and challenges that water managers encountered as a result of policy, program and investment actions. Among the themes that emerged were:

- The drought fostered a vibrant culture of residents taking responsibility as water managers, which was demonstrated strongly through rainwater harvesting.
- The drought produced astonishing, lasting successes in urban water conservation programs that continue long after the end of the drought.
- Dwindling water supplies pushed disparate entities to manage in an integrated fashion, in turn producing the conditions necessary for ambitious plans and opportunities for collaboration, innovation and project co-funding.
- Indoor plumbing of rainwater harvesting systems can improve their return on investment.
- It can be difficult to future-proof and ensure the long-term viability of projects and programs unless a holistic approach is taken in which multiple benefits are incorporated into design and implementation.
- In drier climates, conventional infrastructure and traditional attitudes toward landscape aesthetics support high water use.
- Sustainable landscape transformation is best addressed before drought hits.

Many American water leaders have visited or studied Australia with the intention of scaling up that country's solutions. TreePeople shares that objective and has taken a methodical approach to first analyze and evaluate, and then organize and deploy specific strategies to taking those lessons to scale.

The data shared within the report provide a foundation for an exchange that TreePeople will continue to facilitate between water management sectors in the United State and Australia, offering applicable lessons to Southern California and much of the American Southwest as our region enters a new era of climate and water uncertainty.

BACKGROUND

ABOUT TREEPEOPLE

TreePeople's mission is to inspire, engage and support people to take personal responsibility for the urban environment, making it healthy, fun, safe and sustainable – and to share the process as a model for the world.

Since its founding in 1973, TreePeople has trained and supported Los Angeles and Southern California residents to plant more than 2 million trees along local streets, business districts, on school campuses, and at local, state and national parks and forests. We have educated nearly 2 million students. TreePeople's most significant contribution to the field of forestry has been creation of the Citizen Forester model, where individual residents are trained to plant and maintain urban forests where they live, learn, work and play.

TreePeople has served as a model for more than 50 other organizations nationwide and has been featured in national publications, documentaries and other broadcast media. Honors include the UN Environment Programme's Global 500 Roll of Honour and being named the 440th Point of Light.

For more than a decade TreePeople has been a recognized leader in integrated urban watershed management in the L.A. region. Our focus is on managing rainwater by incorporating green, nature-based infrastructure into urban areas. We are demonstrating that this approach yields numerous environmental, social and economic benefits, while helping eliminate waste and duplication.

Today, TreePeople is among the longest established environmental organizations in California. We are supported by 12,000 members, 11,000 volunteers and sustained by a staff of 50 educators, foresters and program administrators. TreePeople has recently completed a 10-year vision to help the Los Angeles region achieve a tipping point toward climate resilience and sustainable water supplies.

ABOUT THE PROJECT

TreePeople sought and received grant funding to build an information and best practices exchange program between government, research and community organizations in Australia and Southern California. The project goal is to share innovations, best practices and experience related to community, business and government agency engagement in urban rainwater capture and water conservation practices. The program is particularly focused on identifying successes, challenges and lessons learned from program and policy responses to Australia's recent and devastating "Millennium Drought."

A major component of this ongoing program is research. TreePeople staff took two research trips to Australia in 2012 and met with entities in Australia's five most populous cities and state capitals:

- Sydney, New South Wales
- Melbourne, Victoria
- Brisbane, Queensland
- Adelaide, South Australia
- Perth, Western Australia

Data were collected on innovations and experiences related to urban water conservation, rainwater harvesting and other drought responses, providing applicable lessons to Southern California and much of the American Southwest as our region enters a new era of climate and water uncertainty.

WHY AUSTRALIA

In searching for viable solutions to climate change impacts on Southern California's water supply – especially the forecast for intensifying droughts – TreePeople identified Australia as an ideal case study on drought-response strategies, including the use of urban rainwater harvesting.

Australia and the United States share several cultural, physical and climatic similarities. Both countries enjoy a high standard of living with comparable lifestyles, and have a mutually attractive, trend-setting relationship that suggests a socially viable technology transfer. Both have semi-arid Mediterranean climates on their west-facing coasts, complemented by more humid climates on their east coasts. The landmass of Australia is roughly the same as that of the contiguous United States (the map on page 1 shows an actual comparison), though Australia is much more sparsely populated. A notable difference between the two countries is that Australia has a total population of 22 million (roughly the population of Southern California), while the U.S. has a population of more than 300 million. Most Australians live on the continent's southeastern coast, leaving vast swaths to the country's largely uninhabited outback.

Australia is a land of extremes, a large and remote continent where some of the world's most unusual species evolved – among them the kangaroo, platypus and echidna. It has arid deserts that receive less than 5 inches (100 mm) of rain annually, and tropical coastlines that may see 10 feet (3,200 mm) of monsoonal rain in the same year.

The variation in climatic conditions throughout Australia was evident in the five cities we visited. The populous cities of the southeast coast each receive moderate rainfall on average, with precipitation generally spread throughout the year. Sydney (which has a temperate climate) and Brisbane (which has a humid sub-tropical climate) each average about 45 inches (1,150 mm) of rain per year. Melbourne's moderate oceanic climate brings an average of 25 inches (600 mm) of rain annually. Perth and Adelaide are both in Mediterranean climates – similar to Southern California's – characterized by hot, dry summers and cool, wet winters. Historically, annual rainfall has brought an average of 32 inches (800 mm) and 17 inches (400 mm) respectively. Los Angeles receives a yearly average rainfall total of 15 inches, though there is great variation from year to year.

In recent decades, Australia has experienced wild climatic shifts that may be indicative of early climate change impacts. For example, we learned that in the last decade Adelaide has experienced unprecedented shifts in the form of heavy summertime storms (including 100-year storms). This is uncharacteristic of Mediterranean climates and may indicate that the region is shifting into another climate type. Water managers are observing the region's long-term weather trends to determine how Adelaide's climate shifts are likely to impact water management infrastructure.

The continent has experienced several devastatingly dry episodes since the nineteenth century. The most recent – called the "Millennium Drought" – started in 1997 and continued through 2010, and brought the country's longest period of rainfall deficit on record. The Millennium Drought was so severe and long-lasting that it became the foremost national issue for most Australians. It created a profound need for solutions and produced a political atmosphere supportive of deep investment and rapid innovation. Much of the research TreePeople conducted for this project focused on responses to this drought.

The Millennium Drought came to an abrupt end just as Australians began to wonder whether rain would ever return. One of the strongest La Niña events on record hit in 2010 and 2011, bringing widespread rainfall and flooding across Australia and swinging the continent wildly from "famine" to "flood." Brisbane was among the hardest-hit areas. Many of Queensland's rivers broke their banks in December 2010 and January 2011, flooding much of the state, prompting mass evacuations, killing several dozen people and causing more than AU$2 billion in damage.

Another wild swing in climate came in late 2012 and early 2013, as a severe summer heat wave hit much of the country. More than two-thirds of Australia experienced temperatures above 107°F (42°C) in the first part of January 2013, causing wildfires in five of the six continental states and breaking heat records throughout the country.

It is within this context of drought and extreme climate resilience that TreePeople sought to learn about Australia's experiences and derive applicable lessons for the American Southwest.

PROJECT ACTIVITIES

Ozwater '12, May 2012

Ozwater is Australia's leading international water conference and trade exhibition hosted annually by the Australian Water Association. The event hosts hundreds of speakers and exhibitors and draws thousands of attendees. Ozwater 2012 was held May 8-10 in Sydney.

TreePeople staff Rebecca Drayse (Director, Natural Urban Systems Group) and Edith de Guzman (Research & Analysis Manager, Natural Urban Systems Group) attended more than 40 presentations on topics ranging from quantifying the costs of urban water restrictions to engaging communities in water management. The breadth of presentation topics and the variety of speakers representing multiple disciplines provided a comprehensive context within which to learn about Australian water management. The conference served as an ideal starting point for building the information and best practices exchange program. The trip was also an opportunity to hold select meetings and tour demonstration sites following the conference.

Study Tour, August - September 2012

In August and September 2012, Rebecca Drayse and Edith de Guzman returned to Australia with Andy Lipkis (TreePeople Founder and President) and Peter Massey (Director of Grants). The group undertook a three-week study tour and participated in nearly 40 meetings, presentations and tours in Australia's five largest cities – Sydney, Melbourne, Brisbane, Perth and Adelaide. The group sought to learn the full dynamics of the country's response to the Millennium Drought, meeting with representatives of local, state and federal government officials, research institutions, utilities, engineering firms and nongovernmental organizations. The trip coincided with a workshop on rainwater-harvesting research, hosted by the Urban Water Security Research Alliance in Brisbane, which brought together dozens of rainwater harvesting experts from throughout Australia. The TreePeople team met with a wide array of water management experts over the course of the study tour. The research conducted during this trip informs the majority of what is shared in this report.

Questions considered during the study tour included:

- How were drought-response approaches selected?
- What lessons were learned as a result of major investments in rainwater harvesting, conservation, desalination and other projects and programs?
- What role did community behavior change programs play?
- Which responses are viable for implementation in California and the Southwestern United States?

A BRIEF AUSSIE-AMERICAN GLOSSARY

Australian	American
Catchment	Watershed
Tank	Rain-harvesting cistern
Reticulated	Networked
Mains water	Municipal water
Bore water	Well water
Water Sensitive Urban Design	Low Impact Development

Rainwater refers to rainfall that has not come in contact with ground surfaces such as streets and parking lots, and includes rain that is captured from roofs and other aboveground surfaces. *Stormwater* is rainfall that has come in contact with ground surfaces.

Rainwater harvesting is the practice of capturing and storing rainwater for later use. *Stormwater management* is the practice of handling wet-weather runoff to mitigate flooding and water quality degradation while managing for waterway improvement and, where appropriate, groundwater replenishment

SUCCESSES AND EXEMPLARY APPROACHES

POLICY AND PLANNING

Integrated planning creates opportunities for collaboration, innovation and cost-sharing, and produces the conditions necessary for setting and accomplishing ambitious sustainable goals.

Following the drought, the state government of Victoria appointed the Ministerial Advisory Council (MAC) to provide independent advice on urban water management. In 2011, the MAC responded with a roadmap recommending key priorities to improve Melbourne's water management to bring about benefits including healthier urban waterways, greener open spaces, reduced urban heat-island effect, future water security, and decreased reliance on rural water.

The MAC produced the *Living Melbourne, Living Victoria Implementation Plan*. The plan calls for three strategies:

- Overhaul the water planning framework to better respond to broader community and environmental needs and more effectively integrate with urban planning
- Transform the way water resources and the water system are managed
- Establish the Office of Living Victoria (OLV) to drive reforms by coordinating urban and water planning.

The plan has been adopted and strategy implementation is fully underway. The value of the OLV is reflected in how well-resourced it is – AU$50 million in its first year alone. The plan is being praised as a successful approach in integrated planning and management that is advancing Victoria's sustainable agenda and providing a model for other cities.

Another examples is from Queensland, which was hard-hit by the drought. Most of the state's population lives in Brisbane, Gold Coast and surrounding areas in the southeastern part of the state, yet an organized regional response to the drought was not reached until the drought was full-fledged and dams were at about one-third of capacity (rainfall ultimately sunk to 4 percent of average and dam storage diminished to 10 percent of capacity). At the beginning of the drought, the region's water supply management was highly siloed, with 10 major agencies and 25 distinct water utilities overseeing water management and distribution.

The SEQ Water Grid was formed in 2008 with a three-pronged drought response:

- Create an infrastructure network connecting these agencies and manage water in a "grid"
- Institute aggressive demand management
- Consolidate agencies by function into a vertical supply chain.

The Grid was designed to combine supplies so that agencies with an oversupply could be connected to areas with insufficient supply. SEQ Water Grid succeeded in securing water supply for the region while avoiding severe water restrictions for ratepayers. In January 2013, SEQ Water Grid was absorbed into

Seqwater. Seqwater is the state entity now responsible for ensuring a safe, secure and reliable water supply for South East Queensland, as well as managing watershed health and providing recreational facilities for the community.

Managing risks on a case-by-case basis rather than prescribing overarching regulatory targets fosters freedom to innovate and experiment.

Australian regulatory agencies, by and large, manage for public health and environmental risk, allowing projects to be designed around risk-management, and on a case-by-case basis. This in contrast with an approach where regulatory targets are set for all projects that fall under the same category – the type of regulation by which many American cities are governed by.

- The approach of treating water only to the standard necessary for its intended end-use is often referred to as *fit for purpose* and is widely practiced throughout Australia. Under this approach, rainwater that is plumbed indoors for flushing toilets and other non-potable uses does not have to be treated to drinking-water standards. Currently, public health regulations for plumbing rainwater indoors do not exist for Los Angeles County, and the practice is virtually unheard of in California. The vast majority of indoor non-potable end-uses are served with water treated to drinking standards.

- In Australia, purple pipes are commonly used for any non-potable end-use. Visible tags or stickers indicate that the water is not suitable for drinking, along with what the source of water is (e.g., "rainwater"). In California, regulators and proponents of developing a diversified local supply portfolio that includes graywater and rainwater have been gridlocked in arguments over how to designate pipes delivering water from different sources. As the discussion over this topic continues today, regulators often express a preference for a pipe of a different color for each alternative supply. Advocates of efficiently using multiple water supplies point out that regulating multiple colors of pipes would complicate matters for installers, who would be required to source pipe colors that may not be widely available on the market.

- Managed Aquifer Recharge (MAR) is the process of adding a water source (such as stormwater or recycled water) to aquifers under controlled conditions for withdrawal at a later date. It is also used as a barrier to prevent saltwater or other contaminants from entering the aquifer. This method has been tested in Adelaide, South Australia since the 1990s under the National Water Quality Management Strategy (NWQMS). The NWQMS operates as a set of guidelines rather than law, allowing water managers to experiment with new approaches. In some applications, water is injected directly into the aquifer without having to be treated to drinking-quality standards. The approach assigns an ecological use to water that may be too brackish for irrigation or indoor use, but which can be used for other purposes. The state health department monitors risks on a case-by-case basis to ensure no adverse impacts are created for communities.

Performance-based development regulations are an effective way to achieve water and greenhouse gas reductions.

Rather than mandate specific development restrictions for achieving sustainable targets, Australia offers examples of flexible performance-based regulations focused on reaching resource reduction goals. This approach allows developers and homeowners to choose the most suitable path for compliance. Benchmarks can be set at various scales (ranging from household-specific to the citywide), and compliance points are awarded for water conservation, rainwater harvesting and energy reduction technologies.

- The Building Sustainability Index (BASIX), adopted in 2004, is New South Wales' state-level legislation governing new residential development and significant redevelopment. BASIX is widely cited throughout Australia as a model approach to sustainable development in urban areas. BASIX is incorporated into the entire development process, from design to completion. Prior to receiving a building permit, the homeowner or developer is prompted to use an online assessment tool that determines anticipated water and energy demands of the proposed development, as well as how it is likely to perform against existing dwellings of the same type. Once all sections are passed, a BASIX certificate is generated (a fee applies). The certificate is then submitted along with the development application for approval before construction can begin. If the project is approved, the BASIX certificate is again submitted along with the application for an occupancy certificate, and the certifying authority is then required to issue a BASIX completion certificate.

CONSERVATION AND BEHAVIOR CHANGE

The drought fostered a vibrant culture of residents taking responsibility as water managers, which was demonstrated strongly through rainwater harvesting.

The drought inspired deep public engagement in both conservation and rainwater harvesting. Daily newspapers began publishing dam level updates alongside weather forecasts, and water education programs were pervasive at the local, state and national level. Australians became acutely aware of the water crisis and their individual part in building their country's resilience to drought.

- The drought resulted in one third of Australian households owning rainwater tanks. The highest levels of ownership are in South Australia and Queensland. At 45 percent of households, Adelaide has the highest rate of rainwater tank ownership in the country (due largely to historically poor mains water quality).

- Prior to the drought, 5 percent of Brisbane's households had rainwater tanks. Incentive programs added about 250,000 tanks to the city, and now one-quarter of households have tanks.

A large rainwater tank greets visitors at the Commonwealth Scientific and Industrial Research Organization campus near Adelaide.

Water conservation program results far exceeded expectations in terms of water conserved and lasting changes in behavior.

Encouraging results from conservation programs indicate that lower water demand levels were maintained even after the drought was declared over and restrictions were lifted. The drought inspired innovation at the agency and consumer level, and led to investments in widget-based retrofits (e.g., ultra low-flow toilets, shower timers, rainwater harvesting tanks), most of which are still in place. Investments were also made in educating ratepayers, leading to behavior that has fundamentally changed.

- In Brisbane, water use in 2005 was 80 gallons (300 liters) per person/day. During the drought the demand decreased to 32 gal (120 L). It has since risen slightly, but is still very low at 42 gal (160 L). About half of the demand reduction can be attributed to structural changes that are "hardwired" into water usage – such as water-efficient toilets. The lasting behavioral change is what most surprised water managers.

- Melbourne experienced similar success. Water demand in the 1990s was 122 gal (423 L) per person per day. Today it is 61 gal (230 L).
- In the City of Los Angeles, per capita water demand is 150 gal (570 L) per day.

A long history of rainwater harvesting (RWH) produced demand for incentivizing the practice and generated much data on costs, benefits, challenges and opportunities for optimizing RWH systems

Most Australian cities have a culture of rainwater harvesting (RWH), partly because many urban residents are still connected to their outback roots where RWH was for a very long time (and in many cases still is) the only water supply. The drought reawakened interest in RWH and increased demand for the practice within most urban areas, both for potable and non-potable uses. Water managers found that the concept of RWH was very popular with ratepayers. The public was receptive and in fact demanded incentives for RWH tanks and equipment, which effectively gave agencies a mandate to invest in RWH programs.

A notable exception to the remarkable popularity of RWH in Australia is Perth, where groundwater recharge through infiltration is more commonplace, and the vast majority of parcels have "soak wells" (see Practical Implications below). Perth's soils are sandy, and groundwater is of sufficiently good quality to be used for irrigation (and is not strictly adjudicated like it is in much of Southern California) – resulting in more than a third of households having wells on their properties that they use in order to extract "bore water" for irrigation purposes. Even still, about 10 percent of households in Perth have rainwater tanks.

Many studies on RWH in Australia were undertaken in recent years, researching topics including cost-effectiveness, the rainwater harvesting-energy nexus, health risks and behavioral impacts on water demand. A sampling of those studies and their key findings is included at the end of this report.

PRACTICAL IMPLICATIONS

Indoor plumbing of rainwater harvesting systems can improve their return on investment.

A faucet in the public restroom in Melbourne Water's brand-new building is served by captured rainwater.

Some Australian cities require rainwater tanks be piped indoors for uses such as toilet flushing, laundry and filling water heaters. This ensures year-round use of rainwater by shifting use from irrigation (a high-volume, weather-dependent application) to relatively low-volume applications that take place irrespective of the weather. This is particularly relevant in regions where the precipitation regime varies greatly by season – as is the case in Southern California. In these climates, rainwater can only be harvested predictably during the few wet months of the year, when the landscape is fed by rain and does not need supplemental irrigation. Once the drier months return, the harvested rainwater is quickly used up, leaving tanks empty until the next rain.

- Households in Queensland were found to reduce demand by 10,500-13,000 gal per year (40,000-50,000 L per year) per home when they used rainwater tanks for outdoor irrigation. When indoor use was added by connecting the tank to the home, savings increased to 24,000 gal/year (90,000 L/year).

- South Australia's state government recognizes the benefits of plumbing RWH systems into the home. Residents in Adelaide and other parts of the state continue to enjoy access to state government incentives for installing such systems, even after the drought.

"Soak wells" are a simple and inexpensive rainwater infiltration practice that can be appropriate in areas with high-permeability soils.

A simple groundwater-recharge best management practice called a *soak well* can be found on the majority of residential properties in Perth, Western Australia – where native soils are sandy. Similar to a drywell, a soak well is comprised of a hole (approximately 3 feet wide and deep) filled with a hollow plastic, PVC or concrete cylindrical unit. The hole is then back-filled with sand and/or gravel and may be topped with a concrete paver for added structural stability. Soak wells are generally used to infiltrate runoff from roof downspouts.

Soak wells are buried underground and take no aboveground space, making this practice appropriate for parcels with limited outdoor space. In Perth, inexpensive do-it-yourself kits are sold at local hardware stores. Soak wells are often used in conjunction with shallow groundwater pumping for irrigation at the parcel scale in Perth. Due to strict adjudication of groundwater-pumping rights in much of Southern California, it is unlikely that soak wells could be used for the purpose of supplying irrigation at the parcel level without a significant change in policy. Soak wells are nevertheless an example of an uncomplicated and economical infiltration practice that could work well in high-permeability soils in the Southwest United States, particularly in areas of groundwater overdraft.

At the local Bunnings hardware store in Perth, soak well kits and rainwater-harvesting tanks are available off-the-shelf.

Urban lakes and wetlands can be used to capture street runoff, improve water quality and serve as an irrigation supply source – all while providing recreational opportunities.

Melbourne's Royal Botanic Gardens Working Wetlands Project is designed to rehabilitate lakes suffering from diminishing water volumes and declining quality. Stormwater runoff is diverted from surrounding streets into the wetlands, treated through floating islands, circulated through a series of lakes and finally stored in large tanks. Once stored, the treated water is available for irrigation. This approach allows urban runoff to be viewed as a resource, creating a steady demand for non-potable water.

The City of Los Angeles has designed similar projects, including its Proposition O-funded rehabilitation projects at Echo Park Lake and Machado Lake. The Melbourne project differs notably in the inclusion of storage tanks as an additional component that extends the project's function beyond water quality management and into water supply provision. This example may provide a viable model for restoring urban water bodies while addressing runoff, water quality and localizing supply.

CHALLENGES AND CAUTIONS

POLICY AND PLANNING

It can be difficult to future-proof and ensure the long-term viability of projects and programs unless a holistic approach is taken in which multiple benefits are incorporated into design and implementation.

With the abrupt end to the drought, desalination plants built in Sydney and Melbourne in response to the drought became redundant. Desalinated water is energy-intensive and therefore significantly more expensive to produce than traditional sources. In 2010, dam levels throughout Southeast Australia rose with the return of heavy rains, restoring the water supply that most Australians have historically depended on – and thus removing demand for desalinated water. Plants in Sydney and Melbourne went idle, except as necessary to maintain their condition as operational. The plants required major investments and had been funded largely through utility fees. Melbourne's Wonthaggi desalination plant had a capital cost of more than AU$3 billion and will cost Melbournians eight times that amount over the next 28 years. Regardless of their level of use, the costs for building, maintaining and operating the plants must be footed by ratepayers whose cost per unit of water has risen sharply in recent years.

The issue of paying for major long-term investments like desalination plants is exacerbated, somewhat paradoxically, by the success of conservation programs and the subsequent decline in water sales. Revenue losses present a challenge for water agencies that need to recover costs of expensive new assets. A common reaction in Australia's post-drought era has been to cut conservation program staff and incentives. Sydney Water, which had a conservation division of some 50 staff during the drought, was downsized to five following the drought. (This topic was beyond the scope of TreePeople's study tour. However, the Alliance of Water Efficiency, an international nonprofit organization dedicated to the efficient and sustainable use of water, held a summit titled "Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting" in August 2012. More information and a white paper are available on the Alliance's website at www.allianceforwaterefficiency.org).

Another area of water management that could benefit from a more holistic approach is the often-disconnected manner in which water quality and water supply targets are achieved. The types of water quality protection mandated under the federal Clean Water Act in the United States are essentially lacking in Australia, where water supply has been a more important motivator for water management than has water quality. A more

robust water quality management approach represents a potential economic driver for Australian cities seeking to invest in Water Sensitive Urban Design (WSUD) practices and can help ensure continued funding for WSUD. Conversely, in the American Southwest, urban watershed management has mainly been driven by water quality, and less so by water supply. Both countries could benefit from using strategies that incorporate multiple benefits including improved water supply and quality and enhanced ecological functions and amenities.

Political priorities change with the weather.

The severity of the drought called for swift and novel responses and investments in water-saving programs and projects. The dismal water supply forecast led to high levels of support for many government agencies to try new approaches. The public responded with a willingness for lifestyle adjustment and behavior change.

With the return of rain, political priorities shifted to the economy and many innovative water supply programs were dismantled. An additional challenge to maintaining sustainable water planning on the political agenda is that Australia's political pendulum swings wildly between progressive and conservative governments. In American politics, these shifts are felt most strongly at the federal level, but in Australia, they are palpable at the local and state level as well. Typically, investment decisions in natural resource management are closely aligned with each party's agenda, and there is often a desire by a new administration to not be associated with the previous administration, sometimes prompting old programs to be removed.

Following the end of the drought, the trend was toward returning to pre-drought policies. Queensland Development Code MP 4.2 required new houses in Brisbane to supply 18,500 gal (70,000 L) per year from a source other than mains water. The default was a 1,300 gal (5,000 L) RWH tank used for toilet flushing, clothes washing and outdoor irrigation. With the arrival of a new conservative government, this requirement was removed from the building code in 2012. The move was appealed by rainwater harvesting advocates, who commissioned the report *Effectiveness of rainwater harvesting for management of the urban water cycle in South East Queensland* (key findings are summarized at the end of this document). The Queensland state government reinstated the requirement in February 2013.

CONSERVATION AND BEHAVIOR CHANGE

The public perception is that a good tank is a full tank.

Rainwater tank owners in Australia often resist the idea of partially or completely emptying tanks – whether for personal use or to provide flood protection at the neighborhood scale (where tanks would be emptied in advance of a storm in order to increase capture capacity and decrease flood risk downstream). For these tank owners, the perceived value of personal water supply outweighs the value of benefits to the greater good. In Melbourne, some tank owners use their tank water minimally because they want stored water to be available for emergencies or in case drought conditions return.

An approach that may be applicable is to institutionalize a practice demonstrated at the TreePeople Center for Community Forestry at Coldwater Canyon Park in Los Angeles. Our 216,000-gallon (880,000 L) cistern is sized to capture enough rainwater in an average-rainfall year to supply the necessary water for park irrigation. In this system, if stored rainwater is depleted and the normal rainy season has passed, sufficient mains water is added to the cistern to meet minimal irrigation needs while leaving capacity for storing additional rainwater capture.

In drier climates, conventional infrastructure and traditional attitudes toward landscape aesthetics support higher water use.

Arid and semi-arid climates not only receive less rainfall but also have higher water demands than wetter climates, due largely to the fact that land is drier and requires more irrigation to maintain traditionally acceptable outdoor landscapes. In Melbourne, which receives an average of 25 inches (600 mm) of rain annually and has moderate rainfall throughout the year, 40 percent of households have irrigation systems. In Perth, which has a Mediterranean climate with hot, dry summers, that number more than doubles to 95 percent of households. This physical infrastructure of irrigation systems, coupled with cultural norms that still give preference to water-intensive landscapes, support higher water use in drier climates. Without programs aimed at attitude and behavior change and living within the region's means, drier climates will continue to use more supplemental water than their wetter counterparts.

PRACTICAL IMPLICATIONS

Sustainable landscape transformation is best addressed before drought hits.

Landscape transformation was not a major focus of conservation programs during the Millennium Drought, largely because outdoor watering was tightly restricted or entirely prohibited in the hardest-hit cities anyway. Neighborhood vigilance about water use reached a point where neighbors were keeping a watchful eye on each other for any evidence of outdoor water use, especially if their neighbors' gardens were faring well when others' were not. The demand for graywater and harvested rainwater grew, and homeowners using alternative sources of water posted signs on their properties stating that no mains water was in use outdoors. Water for irrigation was virtually regulated out of the water demand picture, so from a water supply standpoint, agencies found little benefit in offering incentives for replacing thirsty landscapes with more drought-resistant ones.

Rapid, widespread implementation without regulation resulted in variable effectiveness of rainwater harvesting systems.

The rapid rise in the popularity of rainwater harvesting provided an opportunity for eager vendors to flood the market. Thousands of rainwater-harvesting system installers appeared quickly; invariably some were more experienced and professional than others. Designing an effective system economically requires practical expertise calculating average yield and demand, properly sizing the tank and pump, applying treatment or filtration as needed, ensuring the exclusion of mosquitos and wildlife, and planning for overflow. The issue has improved as installers have consolidated and professional organizations have formed with the close of the drought, but some homeowners were nevertheless left with a negative experience of rainwater harvesting when their systems performed poorly.

Another factor was that until the drought began, most cities in Australia had limited experience with RWH in the urban context. Little was known about how to design urban RWH systems to compete economically with conventional water sources and to avoid adverse impacts on energy use. An example of evolving industry knowledge is that inappropriate sizing of pumps emerged as a problem. The Institute for Sustainable Futures (ISF) at the University of Technology Sydney found that energy use was oftentimes four to five times higher in early RWH systems compared to that of municipal water. The principal issue was found to be that small pumps would frequently turn on and off automatically. The energy required to turn a pump on several times a day was found to be higher than that required to keep a larger pump running steadily. ISF found that in some cases, the more water-efficient the system, the less energy-efficient it was. More research has been conducted since, and technical guidelines to address this problem now exist. However, there is no organized retrofit program for existing systems, so any improvements to present systems are ad hoc.

The unexpected success of conservation programs and the enduring behavior changes they fostered were themes commonly shared in Sydney, Melbourne, Brisbane, Adelaide and Perth. Other common themes were the overall personal responsibility water-management ethic adopted by Australians throughout the country, the rapid increase in the popularity of rainwater harvesting, and the innovation and collaboration that integrated resource management inspired.

Distinct themes driven by each region's unique cultural, political, environmental and climatic characteristics also emerged, and include the following.

Sydney

- Through its Building Sustainability Index (BASIX), New South Wales provides some of the best mandates (and previously provided some of the best incentives) for rainwater harvesting, Water Sensitive Urban Design, water use efficiency and energy efficiency.

- Sydney continues to serve as a laboratory for sustainable urban resource management approaches. The momentum is driven largely by a vision outlined in the *Sustainable Sydney 2030* plan, which is comprised of master plans for Decentralized Water, Decentralized Energy Generation, and Advanced Waste Treatment and Collection. Local government, universities and progressive developers in Sydney continue to test innovative approaches to water and energy efficiency and climate resilience.

Melbourne

- Melbourne and its neighboring cities embrace the public's ability to contribute toward Victoria's drought resilience. Effective public education succeeded in drastic water conservation during the drought and strict water restrictions were avoided. Melbournians have continued to practice water conservation. Yarra Valley Water redesigned its water bill to a new "Smart Water Bill" – an informative, easy-to-read bill that indicates how that household is faring compared to both traditional and water-efficient households. The bill also contains water-efficiency tips and rebates and has been effective in reinforcing changed behaviors.

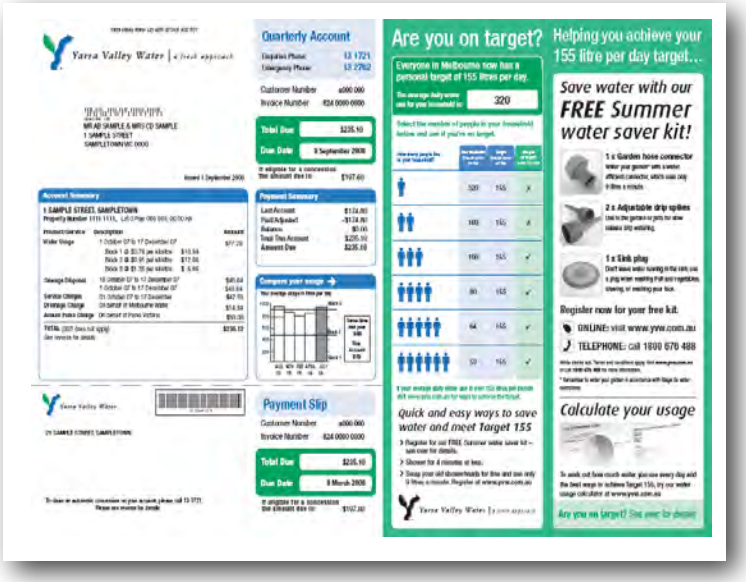

Image credit: Yarra Valley Water

Yarra Valley Water's redesigned bill shows ratepayers how their household's water use compares with regional goals.

- Water agencies are continuing to support programs that involve the public in water management. Melbourne Water's 10,000 Raingardens Program is a five-year program that started in 2008 and is funded through drainage fees collected by Melbourne Water and its partner agencies. As a result of the program and other efforts, more than a quarter Melbourne's residents now practice some form of sustainable stormwater management on their properties. The program does not heavily incentivize participation through rebates or free materials. Rather, participants' names are entered into raffles (such as for a $1,000 gift certificate for a home improvement store). Even with limited incentives, Melbourne Water has been successful in raising awareness and inspiring action related to the connection between water management on residential parcels and a resilient water supply for the Melbourne region. As this report goes to print, the program is drawing to a close and is expected to reach its goal.

Brisbane

- Southeast Queensland is home to several communal rainwater harvesting systems designed to test the potential energy efficiency, water distribution and public health benefits of managing rainwater at the neighborhood scale. Capo di Monte is a 46-home retirement community south of Brisbane where potable demand is met with RWH through a communal tank network. Wastewater is treated and stored onsite and is then used for non-potable uses. While energy demand is higher for this system than a traditional water supply, per capita water demand is significantly lower than in surrounding areas: 18.5 gal (70 L) per day compared with 32 gal (122 L) per day in Melbourne.

- Southeast Queensland's astonishing success in demand management continues to inspire water managers in other cities around the world. Per capita water demand was cut by about two-thirds during the drought and has remained low since. Water use in 2005 was 80 gal (300 L) per person/day. At the height of the drought it was reduced to 32 gal (120 L). In 2012 it was still low, at 42 gal (160 L).

Perth

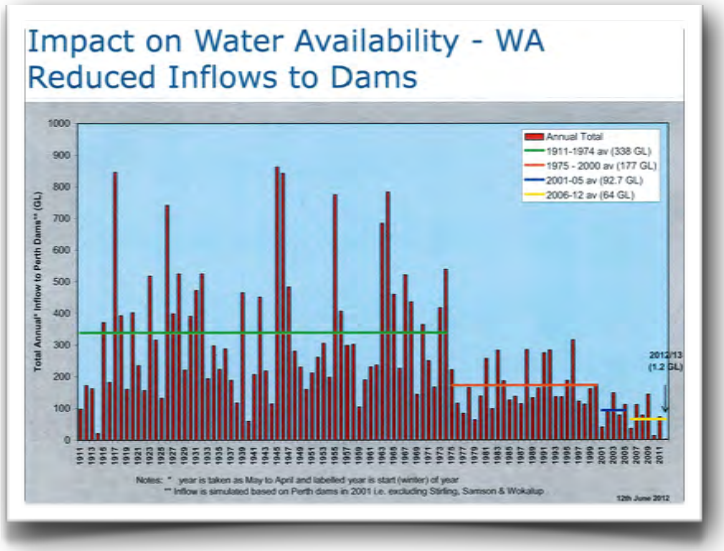

Image credit: Water Corporation

This graph is presented at many meetings about water management in Perth. The region's climate has been drying since the 1970s, resulting in a 75 percent reduction of flows to dams.

- In Perth, discussions about water forecasting do not include the word *drought* but rather center around adaptation to a *permanently drying climate*. As in much of Australia, the public discourse on climate change is mature and there is widespread acceptance that climate change is real and happening. Public education and engagement about water use focus on continued long-term adaptation, and water use strategies are not referred to as *restrictions* but rather *water efficiency measures*.
- Ninety-five percent of households manage their rainwater by infiltrating it through soak wells. Much of Perth overlies shallow aquifers that are not strictly adjudicated, allowing residents to use the aquifer as storage. A third of Perth's properties pump irrigation water directly from aquifers.

Adelaide

- Despite its Mediterranean climate and relatively low rainfall (17 inches in an average year) Adelaide and neighboring towns have the highest percent of tank ownership in Australia. Adelaide is at the mouth of the Murray-Darling River Basin, which drains much of Southeast Australia, including large portions of Queensland, New South Wales, Victoria, South Australia and all of the Australian Capital Territory. Water quality has long been of poor quality at the mouth of the basin, and many Adelaideans trust rainwater captured off their roofs more than they do river water or groundwater. Before the drought, 38 percent of homes harvested rainwater. The number increased to 45 percent during the drought. In Adelaide, many rainwater harvesters use rainwater for potable purposes including cooking, drinking and washing.

At Unity Park in the City of Salisbury, an Aquifer Storage and Recovery site is testing the infiltration effectiveness of six biofiiltration ponds filled with different media.

- Increasing water demand from development and agriculture in South Australia has produced a long-term downward trend in groundwater levels. Aquifer Storage and Recovery (ASR) is the process of infiltrating or injecting water into aquifers under controlled conditions for withdrawal at a later date. It can also be used as a barrier to prevent saltwater or contaminants from entering the aquifer, as is done in Southern California with recycled water. The cities of Adelaide and Salisbury have tested ASR since the early 1990s. The Commonwealth Scientific and Industrial Research Organization is leading several long-term ASR research studies to identify the most effective applications for using this approach to augment and improve local water supplies. Among the ASR methods being tested is Managed Aquifer Recharge (MAR), which uses stormwater or recycled water to replenish aquifers.

SELECT PROJECTS

Central Park Frasers, Sydney, New South Wales

The project is a large urban infill development currently under construction that will feature 11 mixed-use buildings and open space. The project is designed to help the city meet greenhouse-gas reduction and sustainable water management goals laid out in the *Sustainable Sydney 2030* plan.

- Features include a central thermal and tri-generation plant, where engines using natural gas produce thermal and electrical energy. Hot and cold water, the bi-products of energy generation, are captured to provide heating and cooling for air and water for delivery throughout the large development.

Darling Street/Darling Square Park, East Melbourne, Victoria

This City of Melbourne project provides treated stormwater to irrigate nearby parks and tree medians in surrounding streets.

- Street runoff is diverted into a gross pollutant trap and a sedimentation chamber before being conveyed into underground tanks. The collected water is then pumped into the vegetated street median for biofiltration treatment. Once treated, the water is stored in a holding tank where it becomes available for irrigation use. The water undergoes UV treatment before it is used for irrigation.

On Darling Street in Melbourne, stormwater runoff is conveyed to the street median for biofiltration, after which it is stored in an underground tank for irrigation of Darling Square Park across the street.

Capo di Monte, North Tamborine, Queensland

This project is a 46-home self-sufficient retirement development south of Brisbane that was built in a location with no reticulated water supply and no sewer collection.

- Rainwater is collected and treated for all household uses (including drinking) at the neighborhood scale using communal tanks. Wastewater is collected in large tanks and treated for reuse for toilet flushing and irrigation. Stormwater is managed to prevent any adverse impact on local waterways.

- Average annual household demand is 9,250 gal (35,000 L) for potable water and 13,750 gal (52,000 L) for non-potable water. Overall demand is an astonishingly low 18.5 gal (70 L) per person per day.

Rainwater and recycled water serve all potable and non-potable demand at Capo di Monte. Gutter downspouts direct roof runoff so it can be collected onsite.

Environmental Technology Centre, Murdoch University, Perth, Western Australia

The ETC on the Murdoch University campus hosts more than 50 environmental technologies that form an integrated demonstration system. Technologies used and researched on the site include rainwater harvesting, sustainable wastewater treatment and climate-sensible buildings.

- Rainwater is treated and plumbed indoors for uses including drinking. When tanks are nearly empty, an automated system switches the source to mains water. A simple gauge is installed on each tank to indicate water level.

At Murdoch University's Environmental Technology Centre, rainwater-harvesting tanks store roof runoff for a variety of uses. An easy-to-read gauge shows the tank's level.

Greenfields Wetlands, Mawson Lakes, South Australia

The entrance to the Greenfields Wetlands leads to the Watershed Sustainability Centre. Nature trails include bird hides for viewing the abundant wildlife without disturbing it.

This project combines constructed wetlands, Aquifer Storage and Recovery (ASR), and environmental education in a facility that is open to the public. It is managed by the City of Salisbury.

- The 114-hectare space was formerly a livestock-holding area and began being converted into urban wetlands in the 1980s. The objectives of the project include flood protection and retention, enhancement of the landscape, improved water quality and ASR.

- Features include wetlands, a nature trail with boardwalks and bird hides (built through a welfare-to-work program), the Watershed Sustainability Centre and the Watershed Café. Onsite bores are used to inject water from the wetlands to groundwater at a depth of 330 ft (100 m). Extracted water is used for irrigation at 31 local schools.

Conclusion

The study tour was just the beginning of TreePeople's dialogue and exchange with Australia, and the benefits of spending time in the country were many. The in-depth nature of the trip allowed us to learn far more than traditional research and analysis of studies and plans would have provided. We were able to get behind the scenes of projects, programs and plans, and to go beyond the press packets and promotional materials to learn the daily challenges that water managers in Australia face.

We were fortunate to meet many dedicated and innovative professionals in the various water management sectors across Australia. Due to their generosity as hosts and willingness to frankly share both their successes and challenges, we gained a great appreciation of the similarity between many of the water issues Australia has faced and our current and future water challenges in Southern California and the Southwest U.S.

We have begun relationships with many institutions and individuals that TreePeople plans to foster to develop an ongoing exchange. We are finding opportunities to introduce Southern California water managers to some of their counterparts in Australia to facilitate relationship-building and information-sharing between the two countries. Currently in the works are a variety of presentations to share with targeted audiences about rainwater harvesting, conservation and community engagement in water management. We will use the information we have gathered and will continue to gather from Australia to help inform water supply, water quality and watershed plans throughout our region and are incorporating successful Australian strategies into TreePeople's 10-year vision to catalyze a regional shift toward sustainability. In turn, we will share our own region's experiences and lessons learned where they are relevant to the water sector in Australia.

As this study tour report goes to print, the next information-sharing phase of the exchange is in active planning and we look forward to providing our partners and interested audiences with updates on future activities.

OUR AUSTRALIAN HOSTS

We were fortunate to benefit from the generous hospitality and candor of many working on water and sustainability issues across Australia. Thank you to all of our Australian hosts.

John Adcock, Business Manager - *Trade and Investment Queensland, Queensland Government*

Andrew Allen, Strategic Water Engineer - *City of Manningham*

Don Begbie, Director - *Urban Water Security Research Alliance*

Edward Blakely, Honorary Professor in Urban Policy - *United States Studies Centre, University of Sydney*

The Honorable Jeffrey L. Bleich, Ambassador - *U.S. Mission Australia*

Amanda Chadwick - *Independent Pricing and Regulatory Tribunal of New South Wales*

Peter Coombes, Chief Scientist for Water - *Office of Living Victoria*

Bhakti Devi, Water Strategy Project Manager, Decentralised Water Master Plan - *City of Sydney*

David Hamlyn-Harris, Director and Principal Engineer, Water & Environment - *Bligh Tanner Consulting Engineers*

Bligh Tanner Consulting Engineers

Mark Pascoe, Chief Executive Officer - *International Water Centre*

Ralf Pfleiderer, Water Sensitive Urban Design Co-ordinator - *City of Melbourne*

Shelley Shepherd, Consultant - *New WAter Ways*

Dan Spiller, Director of Operations - *SEQ Water Grid*

Andrew R. Moore, Political & Economic Officer - *U. S. Consulate General Melbourne*

Michael Paramor, Chief Executive Officer - *Greening Australia*

Vaughan Pierce, Water Resource Manager - *MWH Global*

Sue Forester & Wayne Hendley, rainwater harvesters and proprietors of Spring Hill Garden Apartments, Brisbane

Jo and Graeme Gilbert, rainwater harvesters, Mt. Eliza, Victoria

Neal and Margaret Irving, recycled water users, Sydney area

Boeing Australia

Ian Thomas, President
Virginia Wheway, EHS Director
Candice Burns, Environmental Specialist - *Boeing Aerostructures Australia*

City of Salisbury

Milan Millison, Project Officer - Water Systems Unit and Wetlands Interpretive Officer
Bruce Naumann, Manager - *Salisbury Water*

Commonwealth Science and Industrial Research Organization (CSIRO)

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Peter Dillon, Stream Leader, Water Recycling and Diversified Supplies Urban Water Theme
Alan Gregory, Urban Water Theme Leader
Matthew Inman, Researcher, Ecosystem Sciences
Bradley Patterson, Principal Research Scientist, Environmental Process Engineering
Ashok Sharma, Principal Research Engineer, Sustainable Water Systems

Friends of Westgate Park

Tony Flude
Lecki Ord
Michael Ramsay

Government of South Australia, Department of Environment, Water and Natural Resources

Martin Allen, Principal Policy Officer
Julia Grant, Executive Director - Policy and Strategy
Steve Morton. Manager, Urban Policy and Economics - Policy and Urban Water

Institute for Sustainable Futures, University of Technology Sydney

Kumi Abeysuriya, Senior Research Consultant
Pierre Mukheibir, Research Director
Monique Retamal, Research Principal
Stuart White, Director

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Keysha Milenkovic, 10,000 Raingardens Program Manager
Bruce Rhodes, Manager, Water Resources - Strategic Planning
David Ryan, Catchments Manager, Waterways Group

Monash University

Phillip Johnstone, Director Science Policy Partnership, Centre for Water Sensitive Cities
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John Thwaites, Chair, Monash Sustainability Institute
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Murdoch University

David Goodfield, Environmental Technology Center
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SA Water

Rain Harvesting Group

Rain Harvesting Group

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Gareth Horton, Managing Director
John McInnes, Chief Operations Officer

SA Water, Government of South Australia

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Cameron Baldock, Business Sustainability Manager
Greg Ingleton, Principal EIA Advisor - Recycled Water
Steve Kotz, Long Term Planning Manager - Systems Planning
Karen Rouse, Principal Strategist Future Environment & Sustainability - Strategy Planning & Regulation
Kerry Rowlands, Manager Business Development

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Yarra Valley Water

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Anthony Brown, Project Manager
Cameron Fitzgerald, General Manager, Water Supply Demand Strategy for Melbourne
Kein Gan, Water Supply and Demand
Cara Machell, Customer Communications Specialist
Francis Pamminger, Manager, Research and Innovation
Glen Wilson, Sustainable Growth Planning

Photo credit: Yarra Valley Water

Yarra Valley Water

ADDITIONAL RESOURCES

We invite you to explore these resources, which include links to many of the programs discussed in the document.

- Australia Water Association: https://www.awa.asn.au
- Alliance for Water Efficiency: http://allianceforwaterefficiency.org
- Bligh Tanner Consulting Engineers: http://www.blightanner.com.au
- City of Melbourne, Water Sensitive Urban Design: http://www.melbourne.vic.gov.au/Sustainability/SavingWater/Pages/Watersensitivedesign.aspx
- City of Salisbury, Wetlands and Water Programs: http://www.salisbury.sa.gov.au/Our_City/Environment/Wetlands_and_Water
- City of Sydney
    - Decentralised Water Strategy: http://greeninfrastructure.net.au/decentralised-water/
    - Sydney 2030: http://www.sydney2030.com.au/
- Commonwealth Scientific and Industrial Research Organization, Water Programs: csiro.au/Outcomes/Water
- Cooperative Research Centre for Water Sensitive Cities: http://watersensitivecities.org.au/
- Environmental Technology Centre, Murdoch University: www.etc.murdoch.edu.au/
- Friends of Westgate Park: http://www.westgatepark.org
- G'Day USA Australia Week: http://www.australia-week.com
- Government of South Australia, Department of Environment, Water and Natural Resources – *Water for Good* Stormwater Strategy: http://www.waterforgood.sa.gov.au/stormwater-wastewater/stormwater/stormwater-strategy/
- Greening Australia: http://www.greeningaustralia.org.au/
- Independent Pricing and Regulatory Tribunal: http://www.ipart.nsw.gov.au
- Institute for Sustainable Futures, University of Technology Sydney: http://www.isf.uts.edu.au
- International Water Centre: http://www.watercentre.org
- Living Melbourne, Living Victoria Implementation Plan: http://www.water.vic.gov.au/livingvictoria
- Melbourne Water
    - 10,000 Rain Gardens program: http://raingardens.melbournewater.com.au
    - Clearwater: http://www.clearwater.asn.au
- Monash University
    - Water for Liveability Centre: http://www.waterforliveability.org.au/
    - Sustainability Institute: http://monash.edu/research/sustainability-institute/
- National Water Commission: http://www.nwc.gov.au/
- New WAter Ways: http://www.newwaterways.org.au/
- Ozwater Conference: http://www.ozwater.org
- Rain Harvesting Group: http://rainharvesting.com.au
- SA Water: http://www.sawater.com.au
- SA Water Centre for Water Management and Reuse, University of South Australia: http://www.unisa.edu.au/Research/CWMR/
- SEQ Water Grid: http://seqwgm.qld.gov.au
- Sydney Water: http://www.sydneywater.com.au/
- Urban Water Security Research Alliance: http://www.urbanwateralliance.org.au
- U.S. Studies Centre, University of Sydney: http://ussc.edu.au
- Water Corporation: http://www.watercorporation.com.au/
- Yarra Valley Water: http://www.yvw.com.au

SELECT RAINWATER-HARVESTING STUDIES

The following is a sampling of Australian studies on rainwater harvesting that emerged as a result of renewed interest in the practice during the drought.

Dr. Peter Coombes, Urban Water Cycle Solutions, *Effectiveness of rainwater harvesting for management of the urban water cycle in South East Queensland*, 2012.

Key findings: Households complying with the Queensland Development Code (MP 4.2) requiring rainwater tanks to supply indoor and outdoor water have provided annual water savings of 11.3 to 21.2 gigaliters (gl) (9,160 to 17,187 acre-feet*) in the South East Queensland region, yielding an economic benefit to the Queensland government of $2,282 to $4,285 for each household with a rainwater tank. Continuing with the Queensland Development Code MP 4.2 will provide substantial economic benefits of $1,557 to $4,041 for each household with rainwater tanks and annual water savings of 57 to 107 gl (46,210 to 86,746 acre-feet) by 2056. The report recommends extending the strategy to include retrofitting existing buildings and determines that continuing the widespread rainwater-harvesting strategy would defer augmentation of regional supplies (through developing desalination plants and dams) by 12 years.

*An acre-foot is approximately 326,000 gallons. In Los Angeles, an acre-foot of water can meet the demand of two families of four for a year.

Matthew Ferguson for Sydney Water, *A 12-Month Rainwater Tank Water Savings and Energy Use Study for 52 Real Life Installations*, 2012.

Key findings: Fifty-two households in New South Wales that installed rainwater tanks to comply with Building Sustainability Index (BASIX) requirements were monitored. Mains water demand was reduced by an average of 21 percent per household. Connecting the tank to toilets and clothes washers was key to reducing demand. A number of measures were identified to optimize RWH systems, including connecting the tank to as much roof area as possible, properly sizing the tank, and reducing energy use by choosing the right size of pump and using pressurized tanks when possible.

Marsden Jacob Associates for the National Water Commission ,*The Cost-effectiveness of Rainwater Tanks in Urban Australia*, 2007.

Key findings: The cost efficiency of a tank is directly related to the whole of life cost and the yield that can be drawn from the tank over time. The yield of a rainwater tank is determined by both the volume and timing of runoff into the tank and the volume and timing of usage. The roof runoff is also influenced by the total volume and timing of rainfall. The timing of rainfall is based on the climate conditions. To determine the levels and variability of tank yield, Marsden Jacob developed a model to simulate rainwater tank water balances under different conditions (the Multi-factor Analysis Rainwater Tank, or MART, model). The model findings indicate that for systems used both indoors and outdoors, the "base case" will return a yield of 71 kilolitres (kl) (18,800 gal.) during an average year, and the collection area (such as roof size) has the single greatest impact on the total yield available from a rainwater tank. For outdoor-only systems, the yield falls to around 42 kl (11,000 gal.) per year for the base case scenario.

Yarra Valley Water, *Life cycle assessment and life cycle costing of water tanks as a supplement to mains water supply*, 2003.

Key findings: Three scenarios were modeled – Scenario 1 showed all water need being met with mains water; Scenario 2 was a 600-liter tank with no pump used for outdoor irrigation only; Scenario 3 was a pumped 2,250-liter tank used both for outdoor irrigation and for indoor toilet flushing. By simulating rainfall and household water use behavior, the proportion of total household water use from the tank was calculated to be 8.4 percent for the outdoor-only application and 29.6 percent for the indoor-outdoor one. In terms of environmental impacts, Scenario 1 had a lower energy impact while Scenarios 2 and 3 had better results for water use and nutrient emissions. Costs were incrementally higher for Scenarios 1, 2 and 3 respectively, and were 20 percent higher for Scenario 3 than Scenario 1.

Clockwise from top left:

A sign at the Lone Pine Koala Sanctuary near Brisbane tells visitors about the site's use of rainwater for irrigation and toilet flushing; Water Sensitive Urban Design as practiced on a street in Adelaide; tanks at the Capo di Monte development south of Brisbane store rainwater and recycled wastewater; wastewater is clean after treatment at Capo di Monte; elements of the onsite wastewater treatment plant at Sydney's Workplace 6 Building (home of Google's offices) are visible from the sidewalk; purple pipe at Mawson Lakes near Adelaide.

Clockwise from top left:

Urban wetland restoration at Westgate Park near Melbourne includes use of native plant species; a swan enjoys the lake at the restored park; Friends of Westgate Park lead a tour for TreePeople staff; a sign posted on a residence near Sydney indicates how the garden is watered; an interactive display at the South Bank Rainbank in Brisbane teaches visitors about stormwater treatment; like many residences in Australia, Spring Hill Apartments in Brisbane has multiple rainwater tanks which store water for irrigation.