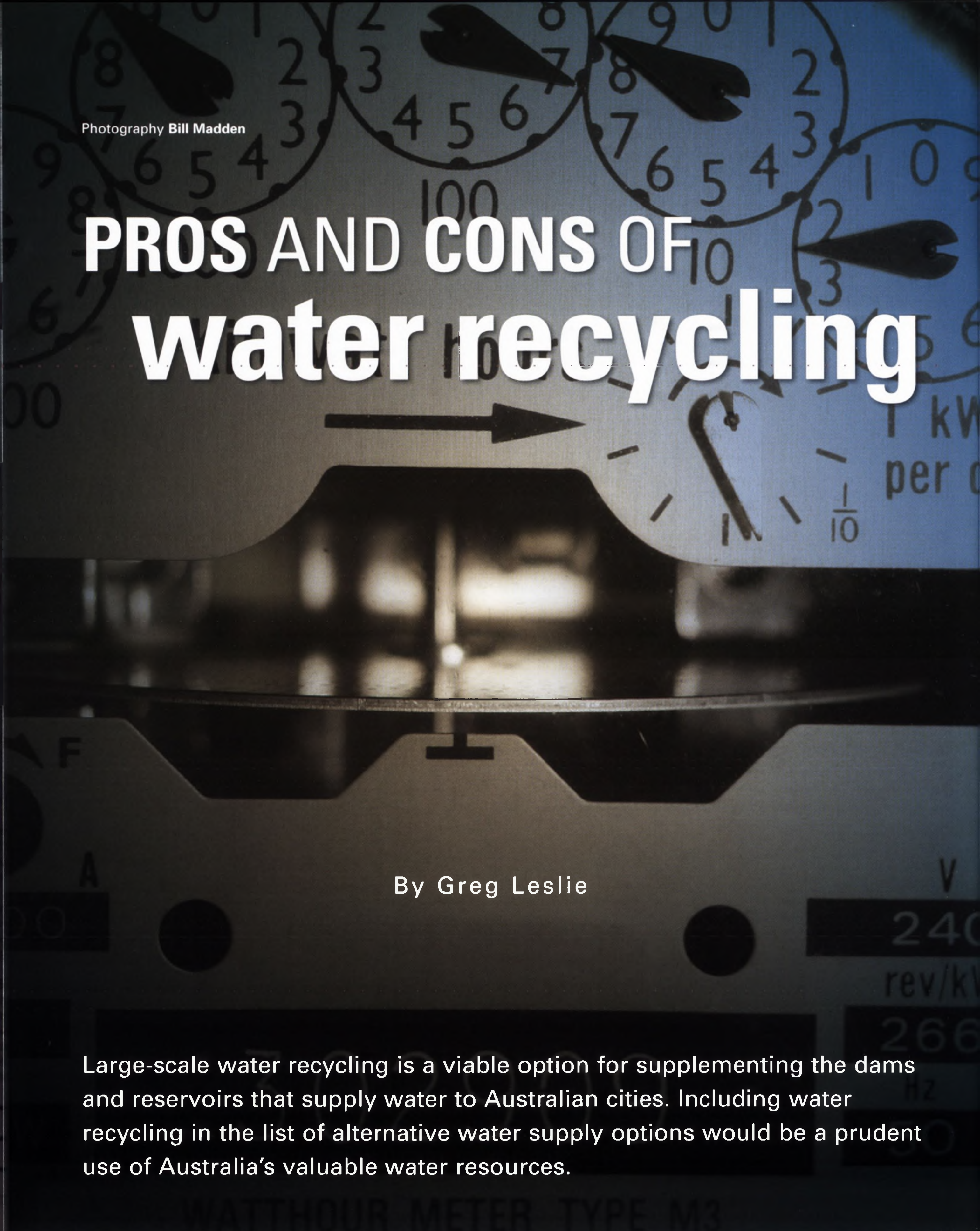

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PROS AND CONS OF water recycling

By Greg Leslie

Large-scale water recycling is a viable option for supplementing the dams and reservoirs that supply water to Australian cities. Including water recycling in the list of alternative water supply options would be a prudent use of Australia's valuable water resources.

Population growth, coupled with less predictable yield from dams and reservoirs, has accelerated the need to develop new sources of drinking water for Australian cities. Developing new water sources requires careful planning in order to ensure that future generations have access to the most basic necessity: safe, reliable, drinking water. There is no quick fix and all options should be on the table. It is lamentable that government policy in NSW and Victoria has ruled out water recycling as an option for maintaining dam levels. Water recycling treats wastewater as a resource, to be valued and reused, and can build on existing community investment in water and wastewater infrastructure. While not a panacea, experience shows that water recycling produces high-quality water that can safely be added to dams and has less impact on the environment than other options, such as desalination and long-distance water transfers.

WATER AND WASTEWATER SERVICES IN URBAN AUSTRALIA

The opportunities for, and obstacles to, large-scale recycling should be considered in the context of how water and wastewater services have been managed in Australia's cities. With the exception of Adelaide, which draws its drinking water from the Murray river, water supplies in the mainland capital cities are sourced from dams and other surface impoundments. Located some distance from the metropolitan areas, the dams capture and buffer the annual fluctuations in surface water run-off from the catchments. Water stored behind the dams is delivered by transfer pumps or by gravity and treated at water treatment plants (WTPs) prior to distribution to homes and businesses connected to the potable water mains. Drinking water used in the home and by industry is discharged to the sanitary sewers, which flow to sewage treatment plants (STPs) where the wastewater is treated and discharged into the environment.

Australian water authorities are recognised as world leaders at managing the assets used to deliver water and wastewater services. By judiciously locating dams and reservoirs on different river systems and, in some cases, installing pipelines that allow water transfers between catchments, water authorities have constructed a supply network with a yield that is several times the annual demand of the population. In the case of Sydney, the location of the dams and reservoirs were identified in the 1860s and 1870s, and the system was planned to cater for growth and development through to the end of the 20th century. Similarly, by controlling access to the areas behind the dams and segregating the collection and discharge of waste water from rivers that flow into the dams, the authorities have maintained the quality of drinking water.

By creating a system that captures surface run-off in wet years to meet demand in dry years, water authorities have done an excellent job in providing a safe and reliable supply of water to Australian cities.

Not surprisingly, water authorities in Australian capital cities have been less than enthusiastic about recycling wastewater. Until as recently as 2003, both Sydney and Melbourne recycled less than 3% of wastewater discharged

While no panacea, water recycling produces high-quality water and is better for the environment.

from sewage treatment plants.[1] In the last four years, although the percentage of recycled water used for industrial and irrigation purposes has increased, there is resistance to the use of recycled water to supplement dam levels on the grounds that prohibiting wastewater discharge into drinking water catchments is necessary to protect public health, regardless of the recycled water's quality. However, it might be time to rethink this position, with dam levels falling to as low as 20% of capacity after several years of below-average rainfall.

WASTEWATER AS A RESOURCE

Water authorities in other parts of the world view recycling as a viable practice that maximises both water resources and the investment made by the community in water and wastewater infrastructure. In short, wastewater is a resource that should be managed and used in a range of applications, which includes maintaining flows into dams and groundwater

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> Water should be judged by its quality, rather than its history.

basins that are used to supply drinking water. Public health is managed by the judicious use of treatment technology and is based on the tenet that 'water should be judged by its quality rather than its history'.[2]

Urban communities in Belgium, the Netherlands, Namibia,[3] Singapore[4] and the US view wastewater as a resource that is to be carefully managed. These communities have developed schemes that intentionally collect and treat municipal wastewater to a quality that can safely be returned to the aquifers, reservoirs and dams. The amount of wastewater that is returned to a particular reservoir or aquifer varies from less than 2% to more than 90%, depending on the jurisdiction of the project and the season. Schemes operating in California and Virginia have close to 30 years of continuous operating experience and deploy a range of water treatment processes to treat wastewater to a quality that exceeds that of the original drinking water system. On the west coast of the US, the Los Angeles County Sanitation Districts began diverting treated wastewater into a series of percolation basins that recharge the local groundwater aquifers, which are accessed as part of the drinking water supply, in the mid-1960s.[5] In the late 1970s, the Occoquan Sewage Authority in Virginia decommissioned and diverted wastewater flows from 11 sewage treatment plants in the Occoquan catchment to a centralised treatment plant that discharges into the Occoquan reservoir, which supplies the northern suburbs of the District of Columbia with drinking water.[6] However, it was experience gained in Orange County, California – particularly the use of membrane processes to treat wastewater – that underpinned the development of recycling projects in other parts of the US, Singapore and Europe.

In 1976, the Orange County Water District, south of Los Angeles, commissioned Water Factory 21, an advanced water treatment plant that treats municipal wastewater to drinking-water quality and injects the water into a coastal aquifer to prevent the movement of seawater into the local drinking water wells.[7] The completion of a planned expansion, scheduled for late 2007, will increase the capacity of WF21 by a factor of six and create a scheme that will provide as much as 15% of the annual volume used to recharge the drinking water aquifers accessed by a population of 2.5 million.[8]

The acceptance of recycling by water authorities in the arid south-west of the US is linked, in part, to the physical reality that wastewater is routinely discharged into rivers upstream of an inlet to a drinking-water treatment plant. However, the state statutes concerning water resources are just as important in creating an environment that supports recycling in arid parts of the US, particularly in California. That recycled water is considered a resource is consistent with the section of the California State Constitution dealing with the beneficial and reasonable use of water.[9] A unique feature of the State Constitution is the uniform prohibition on the wasteful use of water. Article X, section 2 of the Constitution contains the express proclamation that 'the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented'.[10] In the 1960s, the *Porter-Cologne Act*, Division Seven of the California Water Code, defined recycled water as 'water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would otherwise not occur and is therefore a valuable resource'.[11] The *Porter-Cologne Act* led to wastewater being treated as a valuable resource, which influenced the development of several iconic water recycling projects. Moreover, under the California's 'reasonable use' doctrine, it is possible that using potable water from the Colorado river or from northern California could be considered unreasonable given that recycled water was available and of appropriate quality.[12]

Water quality requirements and regulations for the controlled use of recycled water are contained in the California Code of Regulations under Chapter 4, Title 22, which covers the range of uses for recycled water from the irrigation of pastures and woodlots, the watering of public parks, application in cooling towers, and in the production of fruit and vegetables eaten raw, through to the use of water to recharge drinking water supplies. These regulations, like the recently adopted Australian National Guidelines for Recycled Water, define the features that must exist in all water recycling schemes to protect public health.[13]

WATER RECYCLING SCHEMES

Planning water recycling to restore levels in dams and groundwater basins is effectively no different to the situation that exists in many towns in Australia already, where wastewater is discharged into rivers upstream of drinking water treatment plants. An example of unplanned or incidental wastewater recycling may be found in the City of Richmond in NSW where, for more than 20 years, water has been safely sourced from the Hawkesbury river at a point that is approximately 20km downstream of the Penrith STP.

When planning recycling schemes, the conventional STP is upgraded using advanced water treatment (AWT) processes, and the water produced is transferred via a dedicated pipeline to the dam or aquifer. The dam or aquifer provides an environmental buffer that allows the recycled water to mix with water from other sources before treatment at a conventional drinking water treatment plant.

The AWT plant is usually located within the boundaries of an existing STP, and provides additional treatment, beyond the requirements of conventional sewage treatment, so that the recycled water quality is suitable for its intended use. Wastewater from the existing STP contains a suite of contaminants, including pathogenic micro-organisms, synthetic and naturally occurring organic chemicals, and residual nutrients such as nitrogen and phosphorous and dissolved salts.

Over the last 30 years, various water treatment processes have been used to reduce the concentration of these contaminants to levels that are appropriate for the re-introduction of the water into the dams or aquifers. In the 1970s, the AWT systems were very similar to conventional drinking water plants, so that wastewater would be subjected to similar treatment steps as the water flows into and out of the dam or reservoir. The objective of the treatment process was the inactivation of pathogens, to prevent contamination of water supplies and to further reduce the level of nutrients to prevent algal blooms and other symptoms of eutrophication in reservoirs.[14]

In California, reverse osmosis membranes – similar to those used in seawater desalination plants – were added to the AWT process so that a portion of the water was treated to reduce the concentration of dissolved salts, as a strategy for mitigating the impact of increased salinity on water distribution systems. By the late 1990s, reverse osmosis was used to treat all the water because it effectively removed many dissolved organic chemicals as well as salts and nutrients. Additional treatment, post-reverse osmosis, in the form of ultraviolet light in combination with hydrogen peroxide, removes trace organic chemicals that may pass through the membrane, and provides additional disinfection.[15] Consequently, advance water recycling plants currently have more in common with seawater desalination plants than with conventional drinking water plants.

ADVANTAGES OF WATER RECYCLING

Experience from other countries has shown that recycled water can be used to augment water levels in the existing surface and groundwater supplies. This form of water recycling provides a drought-proof supply that uses less energy than alternative water supply options, such as long-distance water transfers or desalination. More importantly, recycling treats water as a resource and builds on community investment in existing water and wastewater infrastructure.

REDUCING IMPACTS OF SALINITY THROUGH WATER RECYCLING

Reverse osmosis membranes are designed to remove salt from water. Consequently, current AWT processes that use reverse osmosis ensure that the quality of the recycled water contains less salt than inflows generated by surface run-off from the catchment. Populations served by water containing elevated levels of salinity typically experience deterioration of taps, hot water heaters, pipes and other fixtures of the water supply system. In southern California, it is estimated that damage to residential and industrial water systems due to high salinity in the water supplied from the Colorado river costs the community $300 million per year.[16] Recycled water produced using reverse osmosis contains less than 100 mg/L of dissolved salt which, when blended with water from the Colorado river containing between 700 and 900 mg/L, prevents the net accumulation of salts in the groundwater basins in Orange County. In Australia, the judicious use of high-quality recycled water could be a strategy in cities such as Adelaide, where water supplies are affected by salt levels in the Murray river.

DROUGHT-PROOFING WATER SUPPLIES

Recycling can supply a community with a new source of water that is independent of rainfall and which generally requires less energy than other water supply options, such as inter-catchment transfers or seawater desalination. On an annual average basis, recycling can supply most coastal cities with at least 25% of the total water demand. This is because the base flow through a sanitary sewer system, known as the average dry weather flow, is equivalent to approximately 60% of potable water demand. (The remaining 40% is used in applications outside the home and does not flow into the sanitary sewer.) The base flow through the sewers is independent of rainfall. Day after day, a continuous stream of wastewater is delivered to the sewage treatment plants and discharged through outfalls into rivers or the ocean. In cities such as Sydney, about 40% of the base flow is needed to ensure that deep ocean outfall does not become clogged as a result of the movement of sediments or the growth of barnacles and other marine biofilms. This leaves 60% of the base flow, or about 24%, for recycling back to the dams or the groundwater basis.

REDUCED IMPACT ON HABITATS AND LOWER GREENHOUSE EMISSIONS

The alternatives to recycling are to source water, provided it is available, from other catchments or to desalinate seawater. >>

> Building recycling into existing STPs takes advantage of existing infrastructure and investment.

The energy required to produce 1,000 litres of water in a water recycling scheme is three to five times less than that required by a seawater desalination scheme.

In many cases, the energy consumption and environmental impacts of recycling are significantly less than long-distance water transfers. For example, Sydney's water supplies are routinely supplemented by transfers from the Shoalhaven river, which requires that the water gains an elevation of 400m over a distance of 140km. However, water transfers, particularly in drought years, can starve riparian, wetland and other fluvial ecosystems. Moreover, water transfers are energy-intensive because water is an inherently heavy and incompressible solid that encounters high-friction losses when moved long distances.

For example, to transfer water from northern California to southern California requires 2.6 kWh of power for every ton (1,000 litres) of water (typical daily use of a family of four).[17] In addition, the diversion of water through the Sacramento-San Joaquin delta, east of San Francisco, has altered the natural flow of water, resulting in the movement of seawater into regions of the delta that adversely impact the habitat of 22 native species of fish and birds. In contrast, when the expansion of the original Water Factory 21 in southern California is completed in late 2007, the scheme will recycle 270,000 tons of water per day at less than 1.3 kWh. The energy saved by recycling water instead of transferring it from northern California will save an amount of energy equivalent to one million barrels of oil. Consequently, the Sierra Club, the Audubon Society, surfriders and other environmental groups have endorsed the Orange County water recycling initiative, because the project reduces greenhouse gas emissions and does not impact on fish and bird habitats.[18]

BUILDING ON EXISTING INFRASTRUCTURE

Perhaps the most important advantage of water recycling is that it builds on existing water and wastewater supply infrastructure. Unlike desalination, which for Australian cities is dependent on finding a suitable site and constructing new seawater intakes, treatment plants and pumping systems, water recycling plants are located at existing STPs. This is important, because the easements and environmental buffers are already in place and the operation of the recycling plant will not significantly increase the truck movements associated with existing STP, so operating the new recycling plant can be integrated with the routine operation of the STP, and the new infrastructure required is limited to the AWT system, storage for the water produced and the pump station. Integrating recycling into the routine management of wastewater acknowledges the value of the existing community investment in water and wastewater treatment plants, and treats the wastewater as a resource that can be returned to the environment to supplement natural flows in the catchment.

LIMITATIONS OF WATER RECYCLING

Water recycling is not a panacea for a city's water supply problems. Developing large-scale water recycling projects that supplement flows into existing storage reservoirs is complicated in Australian cities because of the distances between the dams and the wastewater treatment plants. For example, Sydney's Warragamba dam is more than 80km from the large coastal wastewater treatment plants. Consequently, construction of the transfer pipelines incur high capital costs and extended construction periods. Also, the quantity of water that can be recycled is limited, so water recycling should be seen as part of a suite of options that includes conservation measures, stormwater harvesting, and possibly desalination in order to diversify water supplies in Australian cities. ■

Notes: **1** J Radcliffe (2004) *A summary of the ATSE report on Water Recycling in Australia*, The Australian Academy of Technological Science and Engineering, p6. **2** I Law, 'Advanced reuse – From Windhoek to Singapore and beyond' (2003) 30(5) *Water* 31-6. **3** PE Odendaal, 'Recent Advances in Water Reuse Research in South Africa' (1991) 23(10-12) *Water Sci. Technol.* 2061-71. **4** H Seah, J Poon, G Leslie, and IB Law, 'Singapore's NEWater demonstration project – Another milestone in indirect potable reuse' (2003) 30(4) *Water* 74-7. **5** MH Nellor, RB Baird and JR Smyth (1984) *Health Effects Study Final Report, County Sanitation Districts of Los Angeles County, Whittier, CA.* **6** JM Montgomery, (1983) *Operation, Maintenance and Performance Evaluation of the Potomac Estuary Experimental Water Treatment Plant*, Montgomery (James M) Consulting Engineers Inc, Pasadena, CA, Alexandria VA, p168. **7** WR Mills, SM Bradford, M Rigby, and MP Wehner, 'Groundwater Recharge at the Orange County Water District' in T Asano (ed) *Wastewater Reclamation and Reuse* (1998) Vol 10, Technomic Publishing Company, Lancaster, PA, 1105-42. **8** J Daugherty, S Deshmukh, M Patel, and M Markus, 'Employing advanced oxidation for water reuse in Orange County' in *Watereuse Association, California Section Conference San Diego, CA* (2005). **9** California State Constitution, Article X, §2, 1928. **10** *Ibid.* **11** P McLaggan (1995) *Water Reclamation: A summary of California Laws and Regulations*, Argent & Schuster, Foresthill, CA, §3, pp5-6. **12** *Ibid.* **13** California Department of Health Services (2004) *Groundwater Recharge Draft Regulations*, Title 22 California Code of Regulations, Division 4 Environmental Health, Chapter 3. **14** Colorado River Basin Salinity Control Forum (2005) *Water Quality Review October 2005.* **15** Daugherty et al, above, note 8. **16** California Department of Health Services, above, note 14. **17** G Leslie, TM Dawes, TS Snow, WR Mills, and D Macintyre (1999) 'Meeting the demand for potable water in Orange County in the 21st century: The role of membrane processes' in *AWWA Membrane Technology Conference Americal Water Works Association, Long Beach, CA.* **18** Orange County Water District, *Groundwater Replenishment System List of Supporters*, www.gwrsystem.com.

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