Executive Summary

Objectives of this document

Climate change and a growing population, and increasing urbanisation, add to the stresses on Australia's water resources. To meet Australia's urban water requirements we need to both continue to conserve water and to diversify our sources of supply. Desalination of seawater, water recycling, increased use of groundwater, and stormwater and rainwater harvesting are being used in different Australian urban centres to augment water supply.

However to date managed aquifer recharge (MAR) has not been considered on an equal footing or as part of these more established alternatives for diversifying water sources for urban areas.

This document aims to provide information about the use of MAR primarily for cities but also in regional communities and rural areas. The document is intended to enable decision makers, water utilities and the broader community to consider MAR projects, where appropriate, as part of the water supply portfolio, taking account of costs, security, quality of supply and environmental and social benefits and constraints.

This document also provides an introduction for regulators or potential proponents of MAR projects to the new national guidelines for managing health and environmental risks associated with MAR projects.

Recent Australian MAR experience has highlighted a number of gaps and problems with existing policies and frameworks for water management. These appear to have the potential to unnecessarily constrain investment in urban or peri-urban MAR projects. These issues are discussed briefly and some suggestions are made for dealing with them.

Current status and potential for MAR

In Australia in 2008, MAR contributed 45GL/yr to irrigation supplies and 7GL/yr to urban water supplies across Qld, SA, WA and NT. These include 3ML/yr of stormwater recharge recovered for drinking supplies, and up to 700 ML/yr of reclaimed water recharge to augment horticultural irrigation supplies.

Where urban aquifers have been mapped in Perth, Adelaide and Melbourne, there are known prospects for managing the storage of 200 GL/yr urban supplies. Recharged water may be sourced from rainwater, stormwater, reclaimed water, mains water or other aquifers. Opportunities in other cities and in regional areas await assessment.

Substantial opportunities for MAR are expected, but not yet assessed, in rural catchments where water has not been over-allocated, particularly in coastal catchments with unconfined aquifers.

Costs

The average levelised cost of eight urban stormwater aquifer storage and recovery projects of between 75 and 2000 ML/yr was found to be $1.12/kL. This is less than current prices of mains water in capital cities. Approximately $0.84/kL of the above cost was attributed to project costs subsequent to the capture of stormwater. Projects between 15 and 75 ML/yr do not benefit as much from economies of scale with the levelised cost of the smallest project being $3.00/kL.

For agricultural recharge projects where infiltration basins can recharge unconfined aquifers at high rates the levelised cost of recharge and recovery is more than an order of magnitude less, *eg.* in the Burdekin Delta, Queensland, the cost is $0.07/kL. This project has proven to be economic for irrigation of sugar cane and has been operated continuously for 30 years.

Comparisons with alternative urban supplies show levelised costs of stormwater aquifer storage and recovery (ASR) are 30 to 46 per cent of the costs of seawater desalination and ASR consumes three per cent of the energy.

Comparative unit costs for urban water storages show that aquifer storage costs are one to four per cent of tank storages and they occupy less than 0.5 per cent of the land surface area. Injection well systems have a similar cost to lined earthen dam impoundments but occupy less than 0.2 per cent of the land surface area.

Public acceptance

In Australia, as in the United States over 40 years, there is evidence that public acceptance of water recycling via aquifer recharge for drinking water supplies is strong, in marked contrast with water recycling without natural storage and treatment.

Diverse objectives of MAR projects

MAR projects, particularly in urban areas, can have objectives additional to water supply. These objectives vary from site to site. MAR schemes can provide multiple economic, social and environmental benefits and often it is the combination of these benefits which provides the basis for investing in MAR. For example stormwater MAR in Salisbury commenced only because of the need for flood mitigation, coastal water quality improvement and due to the amenity value of public water features and green space reflected in real estate prices.

In rural and urban areas MAR has been used successfully to reduce salinity of groundwater and protect crops where irrigation water was salinising, and it can be used to protect coastal aquifers from saline intrusion.

Urban opportunities - water security

If 200GL of the Water Services Association of Australia projected 800GL shortfall in water in Australian cities by 2030 were met from stormwater ASR the cost savings in comparison with seawater desalination would be $400million per year in addition to significant environmental benefits.

Seawater desalination, water treatment and water recycling plants are most efficient when operated at a constant rate. Aquifer storage may be used effectively in combination with these sources to reduce costs of meeting seasonal peak demands.

Less than three per cent of urban stormwater runoff is currently harvested for use in Australian cities. In capital cities with annual rainfall in excess of 800mm, the volume of urban runoff exceeds the amount of water delivered by water mains. Water storage is the main impediment and MAR provides a solution to this where suitable aquifers are present.

Currently all urban MAR is for immediate economic benefit, including by local government. No government or water utility has yet undertaken MAR to develop strategic reserves for drought and emergency supplies, even though this may be the cheapest form of augmenting urban water supplies.

Recharging aquifers from mains water at times when reservoirs are approaching spill, subject to environmental flow considerations, is among the cheapest ways to build high quality drought and emergency supplies.

The highest valued use of aquifer storage and recovery (ASR) or aquifer storage, transfer and recovery (ASTR) would be to expand drinking water supplies by recovering stored water at drinking water quality and putting it into water mains. This would make use of the mains to transfer water entitlements from water rechargers to water users and thereby effectively expand the headworks reservoir capacity by water that has been banked in aquifers.

MAR potentially could provide opportunities to develop competition in otherwise monopoly water markets and could therefore benefit communities overlying aquifers.

The number, diversity and scale of MAR projects is growing in Australia and many other countries, particularly in urban areas, due to water shortages, fewer available dam sites, low costs compared with alternatives where conditions are favourable, and associated benefits of MAR.

Urban opportunities - water quality

New Australian guidelines address the risks to human health and the environment, and will bring national uniformity and reduce uncertainties in approval processes for new MAR water supply projects using all sources of water (including recycled water).

Water quality improvements during aquifer storage of recycled waters are being documented at demonstration sites and operational projects in Australia and overseas. The growing body of knowledge allows more confident reliance on aquifer treatment processes allowed for within the Australian Guidelines for MAR.

Urban stormwater stored in an aquifer for a year has been proven to meet all drinking water quality requirements and has been bottled as drinking water. Further research is needed to build confidence in the robustness and resilience of preventive measures to ensure that drinking water quality can be met reliably on an ongoing basis.

Recycled water, if stored in an aquifer for a period before recovery as drinking water, provides an additional level of public health protection beyond direct reuse.

In urban areas confined aquifers provide better protection for waters recharged via wells to supplement drinking water supplies. However, unconfined aquifers may generally be used for non-potable uses to substitute for mains water supplies and, in some cases, provide adequate protection for recovery as drinking water.

Governance

MAR is at the cutting edge of integrated water management, presenting opportunities for conjunctive management of surface water and groundwater resources and producing fit-for-purpose water supplies.

MAR can help to sustain groundwater supplies and dependent ecosystems in heavily used aquifers or as an adaptation to climate change if environmental flows and downstream entitlements can be assured.

However, where groundwater levels have been in decline, MAR alone may be insufficient to restore groundwater equilibrium. Appropriate resource management, to prevent excessive use of groundwater may also be needed, and this applies to rural and urban areas. In urban areas new governance methods may be required involving collective management, for example through groundwater users associations, due to large numbers of well owners. Costs imposed by restricting groundwater use may be compared with costs of MAR to determine optimal strategies in relation to changes in climate, land use and the value of various uses of water.

MAR should be avoided in over-allocated surface water catchments as its use would otherwise further deplete environmental flows and availability of water to meet downstream water entitlements. A possible exception is where it could be clearly demonstrated that MAR would increase environmental flows by reducing diversions and evaporation losses from off-stream surface storages.

Issues and solutions

Several actions are identified that could facilitate effective use of MAR.

Awareness

There is a need for awareness of the diverse range of potential uses of MAR. This document helps address that by describing the diversity of MAR, and its costs and effectiveness as a supply option.

The current lack of localised knowledge of MAR opportunities is being addressed by the production by NWC of maps of the suitability of aquifers for MAR for several cities. State natural resources management agencies could consider preparing MAR opportunity maps for water-scarce areas where there is a source of water available for recharge.

Approval processes

The time taken for the entitlements and approvals process for new MAR projects could be substantially reduced from the current range (six to 22 months). New National Water Quality Management Strategy Guidelines for MAR are expected to assist. Benefits can also be expected where jurisdictions look to address fragmentation in various aspects of urban water management and devise simpler interfaces and approval processes for proponents.

Entitlements

For investment to occur in MAR projects a level of certainty is required. In 2008 most jurisdictions in Australia had no system of entitlements *for* urban stormwater, reclaimed water nor *for the* allocati*on of* available aquifer storage capacity. Rights to recover stored water and rights to transfer entitlement to water are also immature. *Adoption of NWI consistent principles, regulatory and legal frameworks will facilitate investment in MAR.*

Integrated planning

MAR, because of its diverse benefits, is relatively disadvantaged by narrow sectoral evaluations with respect to alternative supplies. Recognition of the entire complex of costs and benefits in integrated urban water management is in any case a superior approach to water system planning and management. Mechanisms and institutions are needed to address coastal water quality, flood mitigation, urban amenity, land value, carbon offsets and water supply. Local demonstrations may assist States identify and value these associated costs and benefits in selecting city water supply projects, and aid in the development of appropriate planning and assessment processes. A water bank, an institution to optimise investment to meet projected future water allocations and associated criteria, could be part of the solution and assist in creating strategic reserves.

Urban green space is needed to allow stormwater harvesting and water treatment such as in wetlands. Provision of urban green space for MAR as part of water sensitive urban design allows a wider array of benefits than previously taken into account in urban planning. The symbiosis between land and water in urban areas through integrated planning processes will yield significant benefits for both sectors.

Investigations

The high cost of investigations and low level of knowledge of risk at the outset of MAR projects can be a deterrent especially to pioneering projects in new locations. As initially demonstrated in SA, some hydrogeological investigations supported by governments is warranted to assist with pioneering projects to facilitate private investment, considering the public good outcomes from such projects.

Inherent differences between sites mean that project-specific investigations will be required. However costs may be reduced if information gained in investigations and in monitoring at Australian and other MAR sites is recorded on publically accessible databases to facilitate knowledge exchange and synthesis.

To counter the high cost of monitoring, web-based real-time systems and well-designed reporting packages could be applied to meet different information requirements for operators, regulators and stakeholders.

Demonstrations

Increased familiarity with MAR within utilities and state agencies will lead to improved implementation and governance. This can be encouraged by establishing in each state at least one confined and one unconfined aquifer demonstration project and other pioneering projects, involving partnerships between state stakeholders. This would provide stakeholders experience with investigations, design, approvals, commissioning and operation, including testing water recovery for drinking water supplies. These sites also provide an excellent resource for research, training, evaluation, trialling of investigation methods, planning and governance arrangements and for raising awareness.

Pilot scale water treatment plants are also needed to allow inexpensive testing of treatment requirements for source-water, aquifer and end use combinations, particularly where drinking water is an end use.

Research

Increased diversity of MAR projects requires research and demonstration projects to help offset the risks for pioneering proponents where it is evident that project replication would have national value. Examples could include: use of aquifers for energy and water storage conjunctively, systems analysis of conjunctive management of surface and aquifer storages via MAR, and extending the types of aquifers used, water types and pre-treatment methods, recharge methods (eg. bank filtration), and applications (saline intrusion barriers, wetland protection, aquifer flushing).

The MAR Guidelines have little information on attenuation rates of some contaminants in aquifers needed for pre-commissioning risk assessments. Hence the NWC has initiated a project to produce first basic information and models, to be available on the web. Further information can be obtained from validation monitoring and research and be made publicly available in a useful form. Standardised methods are required for measuring in-situ attenuation rates in aquifers so that data are directly comparable.

Research is required to demonstrate sustainable achievement of drinking water quality for MAR sourced by urban stormwater and treated sewage effluent. Research is also warranted to establish bank filtration projects for towns whose run-of-river drinking supplies will be less reliable as a result of climate change. Effects of mixing of recovered water with other sources of water of drinking water quality and integrating infrastructure also warrant evaluation at demonstration sites.

Further research is needed to record and underpin improvements in MAR-related policies, management practices and institutional arrangements. Such research at the interface between integrated water management and urban planning would benefit from demonstration projects.

Further evaluation of community engagement processes and public support for establishment of MAR operations where water is recycled to produce drinking water supplies will be of great value. This will help ensure that local issues are addressed appropriately and thereby maintain or improve public confidence in the way this emerging technology is being implemented.

Training

With new technologies comes a need to develop new skills for effective utilisation. Establishing national short courses for MAR operators and regulators involving demonstration projects and current skilled operators would overcome the current lack of operator and regulator training. These would help to ensure risk management plans are designed and implemented effectively and entitlement issues are understood and addressed. A national accreditation program for operators would be a logical step in establishing ISO9000 quality management systems for drinking water supplies derived from MAR.

In-service training courses on hydrogeological investigation methods already address MAR, and MAR could also provide definitive applied case studies for use in university teaching of aquifer processes and measurement methods. Existing water quality management courses, particularly those involving augmentation of drinking water supplies with recycled water, could be expanded quite simply to address MAR.

Dissemination of information

Documentation of existing projects, such as a variety of demonstration projects, in a case study format, would simplify the task of project development and risk assessment for those encountering MAR for the first time. It is proposed that a national anthology of innovative projects be assembled and combined with reviews of projects at an international level.

Key information and data from investigations and monitoring, if recorded on nationally accessible databases, would facilitate knowledge exchange, synthesis and research. The Bureau of Meteorology water data system may be appropriate. Uses would depend on the level of information provided and could range from quantifying the annual water supply contribution of MAR to facilitating research. Public access to information from MAR sites would assist in reducing investigation costs at new sites and in ensuring all likely issues are addressed.