MAR in Australia

by Peter Dillon (18/6/2016)

Managed aquifer recharge currently makes only a small contribution to water resources development in Australia, estimated at ~400 Mm^3 (Table 1) that is 8% of approximately 5,000 Mm^3 national groundwater use (Harrington and Cook 2014). However through storage for use of associated groundwater and urban stormwater it is a very significant enabler of more environmentally benign expansion of iron ore mining, the coal seam gas industry and urban development. Scaling up of groundwater replenishment with recycled water for potable supplies has recently commenced due to significant cost savings with respect to seawater desalination.

When Perth was first settled by Europeans in 1829 roof runoff was drained into sumps and basins and infiltrated the sandy soil to reach the unconfined superficial aquifer. The scale of unmanaged recharge grew as the village grew into a city with paved roads and planning regulations mandated drainage sumps. With the establishment of Managed Aquifer Recharge Guidelines (2009), a WA Operational Policy for MAR (2011) and water sensitive urban guidelines developed by councils (eg South Perth 2012) this can now be regarded as MAR and is estimated at ~200 Mm^3/yr.

The first intentional recharge began in 1965 on the Burdekin Delta of central Queensland where surface infiltration of river water using sand dams, pits and channels augmented groundwater irrigation supplies to grow sugar cane in a coastal area and prevent saline intrusion. Two parallel recharge systems were run, the North and South Burdekin Water Boards were cooperatively managed by cane growers who opted to invest in building and maintaining recharge systems rather than face potential cuts in consumption otherwise imposed by government to protect the aquifer. In 2015 the Boards were amalgamated and the combined systems have continued with a mean annual recharge of ~40Mm^3 with year to year fluctuations depending on needs for direct use.

A national conference on Artificial Recharge (Volker 1980 ed.) in Townsville near the Burdekin Delta helped give exposure to the scheme and pioneering research on algal growth, clogging, groundwater modelling and design and operational performance of recharge structures. The conference helped catalyze formative MAR development elsewhere in Australia. Among these were, in South Australia, aquifer storage and recovery in the Bremer River irrigation area and recharge releases from a new reservoir in the Little Para River upstream of the northern Adelaide Plains (Dillon 1984). In north-west Western Australia, Opthalmia recharge dam and four basins were built at Newman, in south-east Queensland recharge weirs were built on the Callide and Lockyer Rivers, and in Victoria recharge basins were established near Geelong, to augment groundwater supplies to a growing urban area (Parsons et al 2012).

Ironically, recharge basins built downstream of the Ophthalmia Dam constructed in 1981 as part of a conjunctive storage scheme to support mining operations and the local community were not used because the dam was so effective in recharging the aquifer (~12Mm^3/yr) with detained water (WA Department of Water 2009). This was a great advantage in an area with annual evaporation of 3m/yr. Lack of awareness of the potential for MAR in Australia was a deterrent to progress, but where projects were established and successful they soon became replicated in their local area.

With a growing appreciation of the potential value of urban stormwater and reclaimed water in the 1990s as an outcome of the Commonwealth Clean Seas and Better Cities Programs, there was a need to also identify the water quality issues associated with MAR with these water sources. CSIRO worked with partner organizations including state departments, water utilities and local government to develop demonstration projects and to apply the principles of Australia's National Water Quality Management Strategy (NWQMS) to produce water quality guidelines for MAR that protected human health and the environment. Following review these were adopted by the Council of Australian Governments as 24th NWQMS document (NWQMS 2009). They are the first risk-based guidelines on MAR, account for all types of source waters, aquifers, recharge methods and end uses of water and allow for water quality changes, both improvements and deteriorations, in the aquifer between recharge and recovery. Subsequently some historical drainage wells have come under a revised management regime that accounted for water quality risks and are now considered as having transitioned from unmanaged to managed aquifer recharge.

Water entitlement issues associated with managed aquifer recharge were addressed in the National Water Initiative framework of entitlements, allocations and use conditions for each phase of harvest, recharge, recovery and use (Ward and Dillon 2011) that enabled fully articulated set of rights and responsibilities to mesh within existing groundwater and surface water management plans. Two states have adopted this framework within their water resources policies and other states are giving consideration.

Table 1: History of managed aquifer recharge in Australia (in $10^6 m^3$/year)

Decade	Total	Infiltration systems				Recharge wells			
		Rivers	Aquifers	Urban storm-water*	Recycled water	Rivers	Aquifers	Urban storm-water	Recycled water
1961-1970	79	10		69					
1971-1980	144	40		104	0	0			
1981-1990	185	53		130	0	2		0	0
1991-2000	213	53		156	0	2		2	0.2
2001-2010	257	53	3.5	182	0.6	0.1	0	17	0.2
2011-2015	410	53	3.5	208	1.8	0.1	113	29	1.5

* derived from estimates based on population, metropolitan area, impervious fraction, rainfall, runoff coefficient and proportion of runoff effectively recharged. Others values are based on measured data.

Uptake of MAR had been slow in Australia although following release of the MAR Guidelines there has been strong public acceptance and very rapid growth particularly in the resources industries and also by local government and water utilities as they identify opportunities for MAR to contribute to their portfolio of water management activities. Surprisingly there has been minimal effort in enhancing recharge in rural areas for agriculture since the foundational project that has operated effectively for 50 years. There are diverse drivers for MAR in Australia as revealed in the results of a national survey of 135 groundwater professionals in May-July 2015 (Fig 1). The dominant reasons given are to increase water security in drought, to meet growing demand for water and to mitigate decline in groundwater levels.

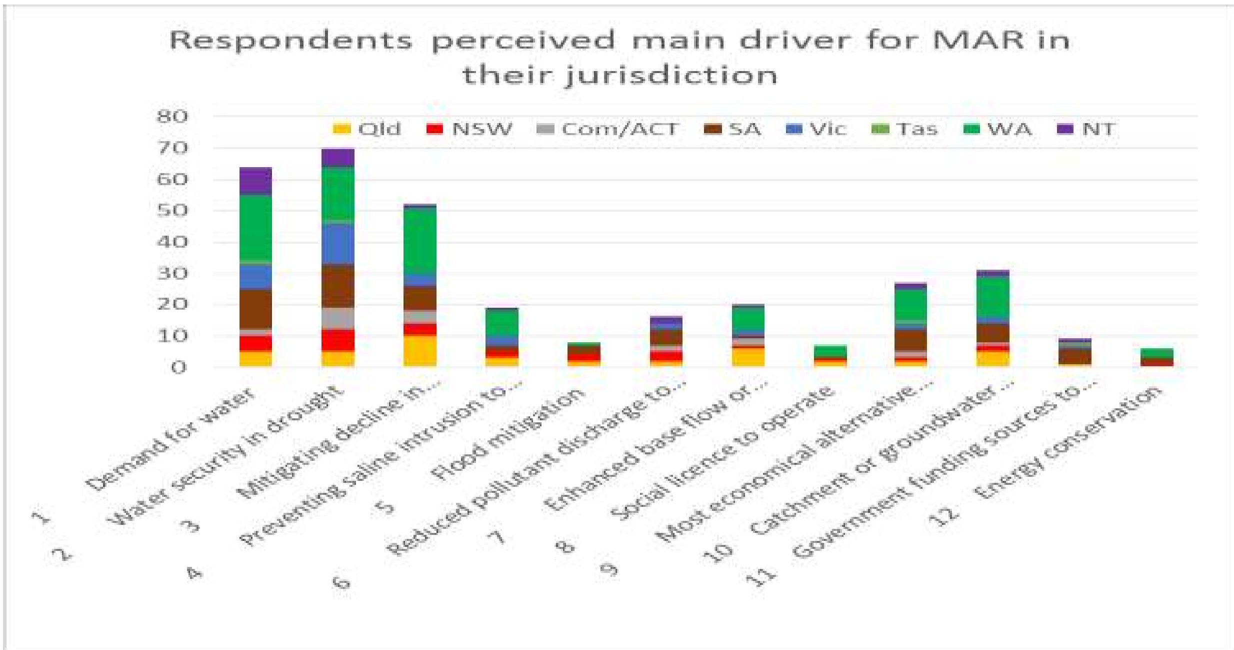

Figure 1. The main drivers for MAR perceived by 135 Australian respondents in a survey May-July 2015.

Two national symposia Volker (ed) (1980) and Sharma (ed) (1989) and International Symposium on MAR (ISAR4) (Dillon (ed) (2002) have been the dominant symposia in this field in Australia, and Australian authors have made significant contributions to ISMAR symposia since. Australian groundwater symposia conducted by IAH since 1994 have invariably included several papers on MAR and since 2000 this has also been reflected in OzWater and water recycling symposia conducted in Australia by IWA and AWA. At least twelve training courses and workshops have been run by NCGRT and its predecessor CGS since 1996 in various cities and encouragingly, two thirds of respondents to the survey claimed they had experience in MAR. There is now a MAR-Hub cluster of companies (http://marhub.net.au/) which collectively have experience in the full spectrum of MAR design and operation from hydrogeology to water treatment, systems integration, risk management, SCADA systems and wetland and water sensitive urban design. They are keen to apply their expertise internationally.

Research publications have largely focused on water quality in support of MAR guidelines and to lay the foundations for future updating of guidelines based on improved knowledge of the fate of pathogens and nanoparticles, and aquifer microbial ecology and fate of organic chemicals, natural organics and inorganics in relation to transitional thermal and geochemical conditions in aquifers and on development of robust field validation testing procedures. Clogging and its management also require improved predictive capabilities and development of comparative laboratory tests and field methods to optimize overall costs of operations and give greater assurance on preventative requirements.

Currently growth in MAR in Australia is soundly based and is expected to make a greater contribution than sea water desalination in the longer term due to lower costs. When the full benefits and costs of alternative water supplies are evaluated, it is expected that MAR will be increasingly adopted in Australia and could ultimately contribute 16% or more of national groundwater supplies.

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