Groundwater

Hidden promise, hidden perils

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Introduction

Groundwater is a vital component of Australian water supplies. Towns, agriculture, pastoralists, mines, species and ecosystems all rely on it to varying degrees. Until relatively recently, groundwater was, at best, an afterthought in Australian water reforms. This chapter discusses:

- The significant promise that this hidden resource holds for increasing the availability and reliability of our water supplies – critical issues for the continued operation and expansion of water-intensive industry, agriculture and mining;
- The perils that its use may bring; and
- The trajectory of water policy and reform over the past three decades to now focus squarely on groundwater.

Finally, it outlines key challenges to groundwater regulation, policy and management that lie ahead. The core of these challenges is this: how can we best manage the potential perils of pumping groundwater, while making sure that we can benefit from its significant strategic promise?

Hidden promise

From the late 1800s, artesian bores supported settlers and pastoral development in Australia's arid zone. Groundwater development for irrigation started in earnest after World War II.[1] Unlike surface water development, which benefited from massive, public dam-building projects and substantial government subsidies for irrigation, individuals invested in and built groundwater infrastructure on their private land to serve more diverse end uses.[2] Compared to surface water, the politics of groundwater management retains a greater emphasis on independent, local, autonomous action,[3] and historically has had a lesser emphasis on management in the broader public interest. As groundwater use grows and its impacts are felt more keenly, this is changing rapidly.

Between 1985 and 1997, groundwater use in Australia increased by around 90 per cent.[4] Demand for groundwater is still increasing.[5] Pastoral enterprises, mines, towns, and sometimes agriculture in much of arid and semi-arid Australia rely solely or mostly on groundwater.

A number of physical and regulatory factors drive increasing groundwater use. Sometimes, particularly in arid areas, groundwater is the only available water source. Even where surface water sources are available, groundwater can offer significant advantages over surface water. Groundwater use does not involve the economic and environmental costs of building and maintaining a dam and extensive water distribution infrastructure, although, in non-artesian systems, it does involve ongoing pumping costs. Most importantly, it is a reliable, on-demand supply, which provides a buffer against surface water variability. Accordingly, groundwater use increases significantly during droughts. In some circumstances, groundwater is produced in large quantities as a by-product of another activity, as in coal seam gas extraction. Regulation can also inadvertently drive increasing groundwater use. Most notoriously, large increases in groundwater use in the Murray-Darling Basin followed the imposition of a cap on river diversions in 1997.

As overall water scarcity increases, groundwater also has an important role to play in modern "conjunctive water management" strategies. These strategies seek to recognise and take advantage of the different attributes of groundwater and surface water to achieve both environmental and socio-economic objectives, for example, strategically using groundwater in place of surface water to protect low river flows, or during drought, to provide supplementary water supplies.

Hidden perils

Historical focus on salinity

Historically, groundwater issues entered the policy domain on the back of rising saline water tables. Increasing salinity can render water unusable by economically productive consumptive uses and ecosystems alike. Rising saline groundwater can result from excess irrigation water seeping through fields or unlined canals, adding to naturally saline groundwater. Clearing land for grazing or dryland agriculture can also cause this effect by reducing the take-up of groundwater by vegetation.

Over the past three decades, salinity concerns have driven substantial policy development and the creation of a wave of local and regional natural resources institutions. During the 1980s, broad-based community concern about salinity in Victoria and Western Australia was a key factor in the creation of Landcare – the now widespread and celebrated movement of community groups for managing natural resources.[6] In 2001, ministers across the Murray-Darling Basin states adopted a Basin Salinity Management Strategy, which established valley-specific salinity targets, and began constructing a network of engineering works to intercept saline groundwater before it entered into and caused environmental and economic damage to rivers. In parallel, the National Action Plan for Salinity and Water Quality (2000–2008) provided for regional water quality targets, regional natural resource management plans, capacity-building and public communication programs, and regulatory reforms.[7]

However, at the end of the first decade of the 21st century, concern about groundwater salinity had decreased noticeably: there were fewer reports of spreading land salinisation, shallow saline water tables appeared to be falling, and national-level support for salinity management had largely ceased.[8] More recently, comparatively muted interest in groundwater salinity surrounds the need to consider the salinity impacts of environmental watering.[9] Though it is unclear whether the threat of salinity truly has passed, law and policy reforms relating to groundwater now focus overwhelmingly on allocating groundwater and preventing and reducing overuse.

Socio-economic consequences of overusing groundwater

Depending on the nature of the aquifer, overusing groundwater lowers groundwater levels or decreases groundwater pressure. This can cause a variety of adverse impacts on human communities, species and ecosystems. It can increase the costs of pumping groundwater, since more energy is needed to lift water as the depth to water increases. More seriously, nearby poor quality groundwater or seawater can intrude into otherwise fresh aquifers, which can render a water supply unusable. The land surface can subside, permanently reducing aquifer storage space and damaging overlying infrastructure. The reliability of water entitlements to rivers that are connected to aquifers can decrease, since pumping from these aquifers "pulls in" and depletes the connected rivers. This can be economically inefficient, since the value of affected surface water entitlements can exceed the value of the pumped groundwater.[10] In the Murray-Darling Basin, Australia's most important agricultural region, a quarter of the volume of groundwater currently extracted will eventually be sourced from streams, though this impact will take some time to manifest.[11]

Groundwater overuse is a particularly thorny issue in the context of aquifers that were recharged during different geologic periods and climates, and are no longer actively recharged, for example, the Great Artesian Basin and the Murray Group Limestone aquifer that straddles the Victoria-South Australia border. In such areas, groundwater extraction permanently depletes, or “mines”, the resource. This “fossil” groundwater supports around $25 billion (one-third) of Australian mineral exports,[12] as well as many homesteads, towns, mines, and pastoral enterprises in this arid zone. The key management issue is setting an acceptable rate of aquifer depletion, which involves considering the appropriate planning horizon, the direct and indirect costs and benefits of depletion to present and future generations, strategies for coping with post-depletion water scarcity, the protection of any ecosystems and cultural values that depend on the resource, public participation requirements, and appropriate monitoring strategies.[13]

Ecological consequences of overusing groundwater

Overusing groundwater can also affect species and ecosystems that depend either entirely, or in part, on groundwater (groundwater-dependent ecosystems, or GDEs). Some GDEs depend on groundwater coming to the surface, like species and ecosystems associated with springs, wetlands, and rivers. Groundwater pumping can reduce or completely dry up river flows,[14] effectively reversing some of the gains that have been made in buying back water for the environment, or threatening otherwise protected environmental flows. Other GDEs depend on groundwater being available below the ground surface: riparian and floodplain vegetation relies on groundwater being available within the root zone; microbes, invertebrates, and even subterranean fish live in aquifers themselves; and estuarine, coastal and marine species and ecosystems, like seagrass beds, may rely on submarine groundwater discharges.[15] An even wider range of species and ecosystems rely *indirectly* on groundwater, as in food webs that rely on groundwater-dependent terrestrial vegetation.[16] Some GDEs are iconic – take river red gums along the Murray, desert mound springs in the Great Artesian Basin, and the Coorong lake system – while cave-dwelling invertebrates and other aquifer fauna are largely unknown to the public, and sometimes even to science.

Law and policy processes for protecting water for GDEs generally are more recent than those for surface water systems. Protecting GDEs is likely to be equally, if not even more controversial than protecting in-stream flows, given the economic implications of limiting groundwater pumping to protect them, and the lower public awareness, and scientific uncertainty, surrounding the water needs of GDEs.

In general, we know comparatively little about the water requirements and tolerance of water stress of GDEs. Large-scale projects to measure aquatic ecological health, like the Sustainable Rivers Audit (established 2004, and ongoing) have not so far considered GDEs in any significant way. A comprehensive inventory and map of GDEs around Australia was released in September 2012, going some way to addressing this gap.[17]

Law and policy tools for dealing with groundwater overuse

A range of state-level policy and legal tools has been used to deal with groundwater overuse, including pumping limits (particularly during peak groundwater demand periods), water conservation measures, and artificial water supplementation for affected GDEs.[18] Most famously (or infamously, depending on your point of view), the Achieving Sustainable Groundwater Entitlements Program reduced entitlements in six inland NSW groundwater basins to address overuse, following an initial Namoi Groundwater Structural Adjustment program, which focused on the Namoi River catchment. Reductions were related to historical levels of extraction, and the state and federal governments provided $125 million in financial assistance to affected entitlements holders, who also bore some costs. A community development fund helped communities adjust to reduced groundwater availability.[19] Reducing use as early as possible helps to rein in the costs, and political risks, of bringing back overused systems.[20] It also avoids the development of economic dependence on a resource that is unsustainable.

In 2007, the Federal Government passed the Water Act—the most significant regulatory effort to prevent and reduce water overuse in Australia's history. The Water Act provides for a legally binding Basin Plan, which is required to limit the use of groundwater and surface water in the Murray-Darling Basin to an "environmentally sustainable" level of extraction. It will cap groundwater use in the Murray-Darling Basin for the first time. Legally, ecological considerations are critical to establishing these limits – many would say paramount, though some consumptive water users challenge that interpretation of the Water Act. As a matter of policy, the Commonwealth and state governments will fund infrastructure measures or buy water entitlements from water users, rather than compulsorily acquiring water entitlements, where the Basin Plan requires reductions to current extraction levels.

The ecological promise of the Basin Plan may take some time, and further iterations, to be fully realised. Surprisingly, given preceding scientific work on levels of groundwater overuse, a proposed version of the Basin Plan undergoing consultation at the time of writing requires reductions from baseline levels of groundwater extraction in very few areas – and allows for significant increases in groundwater use, compared to an earlier policy statement.[21] The proposed plan also takes a narrow view of GDEs, focusing on groundwater-dependent surface water systems, chiefly rivers, and uses a high threshold for recognising connectivity between groundwater and rivers.

Development of groundwater policy

Through much of the development of major water policy initiatives in Australia, groundwater policy has been either absent, or a mere echo of surface water issues; indeed, until the 1990s, assessments of water use largely ignored groundwater.[22] Onlookers might conclude that policy-makers sometimes simply inserted the words "and groundwater" throughout an existing policy document for surface water, without considering its special attributes and dependencies. Historically, developments in surface water policy also largely ignored the potential for adverse flow-on effects of those policies on groundwater, as in the increase in groundwater extractions that followed the 1997 Murray-Darling Basin surface water cap. Since groundwater often moves slowly, a time lag separates the time at which groundwater pumping occurs and the time at which connected river systems are depleted, such that we are yet to see much of the impact of this increased groundwater pumping.

Groundwater policy development began in earnest in 1996. The seminal microeconomic reforms of the 1994 Council of Australian Governments' (COAG) National Water Reform Framework were driven by surface water.[23] They aimed to increase the efficiency, economic viability, and sustainability of the water industry by dangling the carrot of central tax revenue at states that met reform goals. The reforms did not mention groundwater, though reference to groundwater was later deemed "implicit".[24]

In 1996, the National Water Reform Framework was amended to explicitly mention groundwater reforms relating to trading, pricing, and institutional arrangements, among other things.

A National Framework for Improved Groundwater Management in Australia was also released in 1996 as a more comprehensive guide to states and territories on reforms in groundwater management. Among other things, it encouraged them to:

- Define the concept of sustainable groundwater yield, in the context of principles of ecologically sustainable development, and develop groundwater management plans to facilitate intra-aquifer trading and reduce groundwater use to the level of the sustainable yield;
- Integrate surface water and groundwater management, especially relating to pricing, allocations and trading;
- Employ groundwater user charges to recover direct management costs, such as the costs of licensing; and indirect costs, such as the costs of formulating policy, where this was "realistic"; and make transparent any subsidies where recovering indirect costs was unrealistic; and
- Increase public awareness of the value and vulnerability of groundwater.

The Groundwater Framework spurred states to begin groundwater management planning processes,[25] but many of its other recommendations remain largely unaddressed.[26]

Between 2004 and 2006, the Federal Government and all state and territory governments signed the National Water Initiative (NWI), reinvigorating coordinated national water reforms. Broadly, the NWI seeks to improve water governance, and the efficiency, productivity, and environmental sustainability of water use. Among other things, it focuses on achieving transparent and statute-based water planning, nationally compatible water access entitlements, integrated management of surface water and groundwater, resolution of water over-allocation and over-use, effective water accounting, and open water markets.[27] The National Water Commission was established in 2004 to oversee the reforms.

The 2007 Water Act, discussed above, gave regulatory teeth to elements of the NWI, at least in the Murray-Darling Basin. Contrary to common views, parts of the Water Act also apply outside the Murray-Darling Basin. The Act grants substantial powers to the Bureau of Meteorology in relation to collecting and disseminating information about groundwater around the nation, much of which had been buried in paper files at state and local water agencies. Though less sensational than reining in water use in the Murray-Darling Basin, the creation of an easily accessible repository of groundwater information provides vital support to agencies and businesses for understanding and managing groundwater resources.

Recognising the historical lack of attention to groundwater management, the Federal Government also invested $82 million in a Groundwater Action Plan (2007–2012), which funded investigations into aquifers, groundwater quantity, quality, and GDEs; a National Centre for Groundwater Research and Training; and a knowledge and capacity-building program, which produces principles, guidelines, and good practice examples relating to groundwater.

The past three decades have seen groundwater policy and regulation progress at an astounding pace. Licences to pump groundwater have been introduced, then quantified, then, in some places, made tradeable. The term GDE is now a well-established part of our water lexicon. However, groundwater regulation and policy still have a way to go, and key challenges remain to be addressed.

Key groundwater regulation, policy and management issues

Few would dispute that groundwater policy has lagged behind policy for surface water. As a result, significant opportunities arise to extend advances in the surface water policy sphere to groundwater. Other groundwater policy issues arise because of the special attributes of groundwater, chiefly the greater degree of uncertainty about the resource that comes about because of its hidden nature, and the time lags that separate pumping and its effects. The latter can make imposing restrictions on pumping politically difficult, since the benefits of restrictions generally are felt in future election cycles.

Preventing and reducing impacts on third parties and the environment

A major concern of modern reforms to groundwater regulation and policy has been preventing impacts on third parties – other groundwater users, users of water in connected rivers, and GDEs. Much work remains to be done on this front. Many groundwater-using activities – mining, oil and gas activities, forestry plantations, and stock and domestic bores – are often not subject to regular licensing requirements under state laws. When unaccounted for in water plans and entitlement regimes, these types of uses represent a substantial risk to the integrity of water entitlements and environmental conditions, since their effects are not managed together with those of other uses. Integrating these activities into water planning regimes is crucial for avoiding this risk. Related to this, managing connected groundwater and surface water in an integrated way aims to ensure that groundwater pumping does not inadvertently affect the reliability of third parties' entitlements to connected surface waters – still more a policy aspiration than practice in Australia. If left unchecked, this lower reliability will mean greater uncertainty in water investments.

To better protect GDEs, water entitlement and planning frameworks should more systematically consider and provide water for them. Policy must also safeguard politically hard-won, and often expensive environmental flows by strategically buying back groundwater entitlements, where groundwater pumping will deplete streamflows within the water planning horizon.

Recent history demonstrates that preventing and reducing groundwater overuse to protect third parties or the environment is both politically difficult and also expensive. Policy support for groundwater offsets would help on both fronts, by allowing further economic development dependent on groundwater, where it is cost effective to undertake measures to ensure that pumping has no net impact. Offsets would enable new groundwater pumping in fully allocated basins, conditional on offsetting the pumping impacts to connected streams (for example, by buying and retiring a surface water entitlement), or offsetting anticipated local drawdown in groundwater levels (for example, by paying for others to conserve water). Formal groundwater offset schemes could also be used to facilitate groundwater trading that would otherwise cause adverse effects on third parties or the environment. Experience of offset schemes in the United States suggests they can be useful, but may require complex rules to ensure no net impact. [28]

Finally, groundwater policy should better translate heightened concerns about Indigenous water interests into clearly specified objectives and quantified water requirements for economic development or sustaining culturally important and groundwater-dependent river flows, wetlands, springs, and ecosystems (some notable examples of which are found in Western Australia and the Northern Territory).[29]

Improving flexibility for water users

A further category of groundwater policy opportunities relates to making groundwater entitlements and use more flexible. Policy could significantly enhance business flexibility by enabling entitlement holders to "carry over" unused groundwater allocations from one year to the next, subject to a maximum limit – a practice that is presently only permitted in a small number of states in relation to groundwater, but is common in relation to surface water. Carrying over allocations allows water users to "save" their allocation for future dry periods, evening out variability in water availability.

Expanding groundwater trading (that is, trading of the right to take groundwater from one location to another) would also improve business flexibility and allow new groundwater-dependent economic activity where levels of groundwater use reach extraction limits. Groundwater trading is presently only significant in New South Wales, Western Australia and South Australia. Various factors hamper groundwater trade, including unclear principles for approving trades, which leads to uncertainty for aspiring traders; areas in which groundwater extraction does not require a license, which dampens demand for trade; sometimes low levels of metering of groundwater use, which also reduces demand for trade, since bore owners can extract more than the authorised volume of their entitlement, rather than purchasing additional water; and cumbersome technical assessment requirements.[30]

Groundwater trading and carry-over provisions are complicated by "sleeper" and "dozer" licences – entitlements to access groundwater that are not used, or only partially used. Such licences pose a risk because activating them can exacerbate overuse.

Whereas carry-over rules allow individual entitlement holders to store their water for future dry periods, managed aquifer recharge projects allow for additional centralised, underground storage to even out water supply variability. Managed aquifer recharge is currently rare in Australia, but could be facilitated by defining property rights to unconventional source waters (like stormwater and urban wastewater) and access rights to aquifer storage space, developing rules for accounting for storing and recovering water, and rules for preventing impacts on third parties and the environment.[31]

More active groundwater management

Recent groundwater policy in Australia exhibits laudable regulatory rigor, for example, in limiting extraction guided by environmental requirements, rather than outdated concepts of "safe yield", which are common in other jurisdictions.[32] However, in adopting a focus on controlling extraction, policy-makers have tended to overlook groundwater management approaches that rely on infrastructure or more active management. At least two notable opportunities arise in connection with a more active management approach: managed aquifer recharge, described above, and conjunctive water management strategies.

Conjunctive water management strategically takes advantage of the different attributes of groundwater and surface water. For example, accessing and alternating between surface water and groundwater can increase water security and business flexibility, and engineering technologies can use aquifer storage space to maintain or enhance in-stream flows.[33] National policy documents tend to emphasise only one half of conjunctive management, namely the potential adverse impacts that pumping groundwater can have on surface water.[34] They should focus greater attention on the potential benefits and costs of strategies for actively coordinating access to groundwater and surface water (whether or not the sources are connected), to increase supply reliability, manage water quality challenges, or reduce environmental impacts.

Such strategies can pose complex policy questions, particularly in relation to preventing inadvertent third party impacts. By contrast, the potential for conjunctive water management strategies to achieve those aims has been a key focus of water policy in some areas of the United States.[35]

Dealing with uncertainty

A key issue confronting groundwater managers is how to deal with and communicate uncertainty in relation to groundwater resources. Uncertainty attaches to many aspects of groundwater conditions and management, for example: how porous aquifers are; how far they extend; how they are connected to each other and to surface waters; how GDEs respond to pumping; and even how much groundwater is used, in the absence of comprehensive metering. As a consequence, uncertainty often surrounds assessments of pumping impacts.

Policy work should explore how groundwater management can best deal with these uncertainties, for example, what the precautionary principle means in this context; whether groundwater should be assumed to be connected to surface water, unless proven otherwise;[36] whether increased groundwater extraction should be assumed to be unsustainable, unless proven otherwise,[37] or be restricted to only a percentage of the calculated sustainable yield;[38] and how to structure operating rules to respond to unanticipated changes to the state of an aquifer.[39]

Groundwater information should be collected more strategically, to reduce uncertainties about groundwater resources and fill unmet management needs, particularly those that relate to relatively recent policy objectives. Clear areas for improvement are information about ecological outcomes related to groundwater flows, levels, and pressures; groundwater use (for example, using more comprehensive metering); levels of compliance with groundwater entitlements; and groundwater-surface water connections.

Collecting groundwater information tends to be much more expensive than collecting information about surface water. Water pricing reforms are therefore intimately related to ensuring good information and management. Generally speaking, water pricing does not presently allow for recovering management costs, which threatens the sustainability of water management efforts. User charges will be particularly important to ensuring adequate groundwater information, given financial constraints at the state government level, especially in the non-mining states.

Managing groundwater in the climate change context

As is the case for surface water, climate change looms as a key source of uncertainty and policy challenge for groundwater management. Climate change may alter a great many factors that can impact groundwater systems, for example, rainfall volumes and intensity, plant water use, and evaporation; feedback effects between variables make the situation even more complex.[40] Australian studies suggest that impacts are unlikely to be uniform across the country.[41] Groundwater demand is also likely to change as surface water systems become less reliable. The response of GDEs to climate change is even more uncertain,[42] as are the policy implications of providing adequate groundwater to sustain them in climatically changing conditions. A key issue in this context will be how to allocate climate change-induced risks among human and ecological water users, for example, by adjusting entitlements to account for changed water availability, and potentially changed environmental water requirements.

While some jurisdictions have already adopted policy to deal with the challenges above, they are in the minority. Even fewer jurisdictions actively implement the policies that do exist. Many of these issues are the subject of long-running groundwater policy aspirations, which remain largely unaddressed. This is the case, for example, for reducing overuse, regulating groundwater-using activities that presently fall outside water planning frameworks, introducing groundwater user charges, and protecting GDEs. Improving communication about the importance of groundwater, placing greater emphasis on its significant promise, and increasing its benefits through improving flexibility for groundwater users and managing groundwater more actively may help to address these challenges.

Conclusion

Australian groundwater policy development and regulation have developed before the appearance of many of the worst impacts that have occurred with groundwater overuse in other places – the stranded fish that die in the western US rivers that are pumped dry before they reach the sea; the steadily increasing groundwater pumping costs, gaping earth fissures, and damaged water canals in basins in which groundwater levels have dropped literally hundreds of feet; or the contamination of near-shore groundwater supplies with saltwater.[43] Further developing groundwater regulation, policy and management to address the outstanding challenges outlined in this chapter will help to prevent these perils from becoming our groundwater reality.

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