

## NATURAL RESOURCES

# Easier Said than Done

## *Will evolving groundwater rules in the West support markets?*

BY ANDREW B. AYRES

In America's western states, groundwater—water stored in underground aquifers—is a key source of supply for cities, farms, and other users. Groundwater often accounts for 50% or more of annual water supply in states such as Arizona, California, New Mexico, and Texas. Much of this is used for agricultural irrigation, but it is common for municipal and industrial users to rely heavily on groundwater for their supplies. In arid and drought-prone regions, intermittent wet periods result in aquifer recharge that supports increased extraction during dry times. Without this natural storage, modern life in the American West would not be feasible.

Despite this importance, groundwater often is not governed by precise allocation rules. Claims to the subterranean resource are seldom quantified, extraction typically is not measured, and it generally is not quite clear who owns what. In many cases, aquifer depletion has resulted. Beyond overdrafting a common resource, pumping groundwater can impose additional meaningful external costs on others, such as by causing land to subside (or sink), which reduces storage space and can damage infrastructure, or compromising water quality by drawing seawater into the aquifer in coastal regions. For example, subsidence in California's San Joaquin Valley has caused canal sections in some major water infrastructure projects to sink, reducing their conveyance capacity by 50% or more. It can also affect surface water users who divert water from rivers and lakes: when these sources are sufficiently interconnected with groundwater, pumping can reduce streamflow. Responsibility for addressing those effects is often not clear.

A changing climate will complicate matters. More variable snowpack that melts more quickly may lead to earlier, less manageable runoff, and ultimately less recharge unless efforts are made to capture flood flows. More persistent and intense droughts may likewise increase the demand for water stored underground. At the same time, the population of the West is growing and, along with it, new demands for reliable water access.

The consequences of prolonged overdraft, intensified by recent droughts, have stoked increased interest in improving and further

formalizing groundwater management in some western states. Although established management regimes surround Arizona's urbanized areas of Phoenix and Tucson, drawdown of groundwater in rural areas has intensified in recent years—alongside calls for more active management and state legislative efforts to give users the tools to implement it. Farther east in Texas, the “rule of capture” is still a dominant force, and strict production controls on groundwater extraction have historically been more the exception than the rule. Local efforts to control access and implement robust metering have increased in recent years but are still few. In California, users in a number of basins have succeeded in constituting comprehensive groundwater pumping rules, some defining quantified and tradable rights to pump. A 2014 California law, the Sustainable Groundwater Management Act (SGMA), may drive similar solutions in other overdrafted basins.

### NEW LEGISLATION FORESEES LOCAL SOLUTIONS IN CALIFORNIA

SGMA mandates the formation of local agencies that will address long-term basin overdraft. These Groundwater Sustainability Agencies (GSAs) must design institutions, plans, and implementation strategies through collaborative processes with local stakeholders. Successful implementation will involve balancing the basin over the long term so that total extractions do not exceed recharge. The law requires that pumpers avoid other harmful impacts (e.g., subsidence) that are “significant and unreasonable.” Defining what constitutes such an impact is a key task for the GSAs.

But this will not occur overnight. Although the initial Groundwater Sustainability Plans (GSPs) have been submitted for the state's critically overdrafted basins, the GSAs need not secure sustainable management until 2040. Many other basins in the state will be submitting their plans this coming year, with an attainment deadline of 2042. In the meantime, the GSPs will be reviewed by state agencies, who may reject the plans and ultimately intervene—but pumping will continue for now. Many GSAs are considering a gradual reduction in pumping, a “glide path” to sustainability.

Moreover, SGMA itself does not balance groundwater basins.



Local water users must negotiate, design, and implement solutions to increase recharge, reduce pumping, or bring about some combination of the two. Initial interest in expanding recharge to boost the reliable yield of an aquifer is high; this could proceed, for example, by capturing excess, unclaimed flood flows and directing them to specially designed infiltration basins. In the San Joaquin Valley, California's largest agricultural region and also home to most of its critically overdrafted basins, relatively few GSPs include quantified plans to reduce pumping. This, despite the fact that there is not sufficient water to make up deficits through increased recharge alone. Many difficult decisions about how to balance demands with available supplies have yet to be made.

This balancing will deliver important long-term benefits. Many pumpers, especially municipal water systems, have an interest in seeing water tables stabilized to promote long-term reliability. Other harmful effects of pumping—whether subsidence, seawater intrusion, or cross-well interference—should also diminish. But sustainability will not come without costs: cutting back on groundwater pumping means going without, and water scarcity will increase in the near term. Ensuring that these reductions do not result in high-value uses (such as municipal supply, orchards, or vine crops) going without while lower-value uses continue is important for regional economies and an area where California's surface water market can help.

There is potential to move some surface water to areas that

currently rely on extensive groundwater pumping, whether only during drought or on a more regular basis. The San Joaquin Valley is home to many surface water haves and have-nots, and gains from some trades are likely large. Previous work by my organization, the Public Policy Institute of California, has shown that expanded surface water trading could reduce the cost of SGMA compliance in the valley by perhaps 60% by smoothing out differences in the value of water use if and when high-value uses are forced to reduce groundwater pumping.

Nonetheless, transfers of surface water entitlements—whether short-term leases or permanent trades—face several hurdles. State and federal reviews can take time and hinder trading. Not all parties can trade surface water if there is no conveyance to move water from seller to buyer. Finally, local agricultural irrigation districts and some county governments may adopt rules that discourage trading in order to keep water local; today, some districts only allow water users to move water to their own lands outside the district, and counties have restricted some water sales in the past in order to protect groundwater from overdraft. Whether such county restrictions will be amended now that groundwater is under GSA management is uncertain.

Moving surface water to smooth out new imbalances created by groundwater cutbacks may play an important role in reducing the costs of groundwater management. However, there is also a need for an organized system for cutting back on groundwater

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use. (Doubly so if various impediments render reallocating surface water difficult.) Formally accounting for groundwater pumping can allow markets to develop that would further reduce the costs of reaching sustainability. Despite California's lack of statewide management until recently, it is home to successful groundwater markets in basins where individual rights to pump have been adjudicated and quantified. These cases can deliver some lessons for basin planners in California and elsewhere.

### **GROUNDWATER TRADING CAN DELIVER LARGE BENEFITS**

Court processes to adjudicate groundwater claims in California have primarily been motivated by local resource users interested in halting overdraft and clarifying their entitlements vis-à-vis one another. These processes began in the early 20th century and today 27 different areas have adjudicated groundwater rights. In more than 20 of those, rights are defined volumetrically. While trading is allowed in most of them, only a handful see regular market activity. One of those is the Mojave basin, the subject of a recent study by myself and Kyle Meng and Andrew Plantinga of the University of California, Santa Barbara.

The Mojave groundwater aquifer is located in southern California, just north of the growing urban areas in the Los Angeles basin. In the early 1990s, local groundwater users began a process to settle and quantify groundwater claims. These quantified pumping rights became tradable, laying the foundation for a functioning groundwater market administered by a third-party watermaster. Pumpers received initial allocations that entitled them to pump quantities in line with their historical use, and these have been progressively ramped down over time. Since the new system was adopted, annual trading has regularly exceeded 20,000 acre-feet of water and hovered between 20% and 30% of total annual pumping in any given year. Water users trade both annual pumping allowances and permanent rights to pump.

To understand the benefits of the new trading system and who received them, we began by analyzing land values of parcels overlying the aquifer. Estimating the benefits of environmental markets like these has proved difficult in the past because restrictions tend to be adopted when the resource is already in a degraded state. As a result, comparing areas with environmental markets to those in other areas can be misleading. In the Mojave, the area covered by the adjudication (in which rights to pump are quantified) does not encompass the entire basin, enabling a comparison of parcels just inside the boundary (subject to restrictions, but with tradable rights) with those just outside (without restriction, but no tradable rights). These fringe parcels are otherwise similar, aside from not being included in the new management regime. In our analysis, the value of a parcel includes the bundled value of land as well as water resources.

We found that having a market greatly increases the value of groundwater use. In total, we estimate over \$500 million in benefits. The bulk of these benefits, over \$400 million, accrues as

increases in the value of groundwater rights held on land parcels within the adjudicated area. Land values are much higher just within the adjudicated area than in our comparison (control) group along the fringe. In part, this arises because of the ability to transfer water to high-value uses in urban settings. Urban areas within the Mojave, growing rapidly in the decades preceding and since the adjudication, were proponents of the management transition that has stabilized water tables and improved long-term supply reliability. Indeed, the rest of our estimated benefits accrue to customers of urban water utilities that were able to acquire water to expand their supply portfolios.

Our estimate reflects the value of being able to reallocate water to higher-value uses—which is of critical importance for reducing the costs of cutting back groundwater use to achieve sustainability. It does not include the benefit of reduced pumping costs because of the stabilized groundwater table. In addition, some other environmental improvements followed: the adjudication process established groundwater level thresholds designed to maintain flows in the Mojave River, and both state agencies and other nonprofit organizations have acquired pumping rights for other environmental purposes.

Following the lead of adjudicated basins like the Mojave, users in some groundwater basins subject to SGMA have started the process of formally measuring groundwater use and setting up market institutions. Near Ventura, the Fox Canyon Groundwater Management Agency has developed a pilot groundwater market that will help users minimize the costs of reducing pumping in a basin where continued overdraft could exacerbate costly seawater intrusion problems. The Rosedale–Rio Bravo Water Storage District has developed a trading platform for pumping allocations, one of the first in the San Joaquin Valley. And in the Borrego Valley in southeastern California, pressure under SGMA to close a sustainability deficit totaling approximately 75% of annual pumping prompted adjudication proceedings that recently quantified tradable pumping allocations; with such steep anticipated reductions, the ability to trade between low- and high-value uses may prove especially valuable.

### **REACHING AGREEMENT CAN BE DIFFICULT**

Despite the large gains in the Mojave, the process of crafting new institutions was not easy. Adjudication required two attempts: one in the 1960s failed, and the process was not formally restarted until the 1990s. The lawsuit initiating the adjudication in the 1990s kicked off over a decade of negotiation and litigation that took some parties to the state supreme court. Among all California groundwater adjudications, the average time from initial court filing to judgment has been eight years, with delays reflecting a mix of disputes over the basis of existing groundwater claims, measurement and allocation approaches, and other points of contention.

Even in the face of broad agreement that groundwater extraction is excessive—and that there would be benefits from

better controlling common-pool losses and allowing for low-cost market reallocation of groundwater—users often fail to reach agreement on the specific nature of the problem and the appropriate response. Negotiating any concessions or side payments necessary to formulate agreeable institutions is no easy task. Research that I co-authored with Eric Edwards of North Carolina State University and Gary Libecap of the University of California, Santa Barbara, provides broad insights into where breakdowns occur and which factors determine whether collective action to constrain pumping is successful.

Consider a case where coastal groundwater quality is threatened by intrusion of seawater into the aquifer as the water table declines. Pumpers closest to the coast stand to suffer the most from continued drawdown, and accordingly benefit the most from management. But addressing the problem may require including inland pumpers from the same aquifer in a new management regime that could constrain their pumping. In principle, negotiated payments from one group to another may resolve this tension, but in practice various barriers, measurement difficulties, and other costs of bargaining may impede this process. We looked to the history of groundwater management adoption in California to identify factors that may influence these costs and explain failure to adopt effective management solutions in cases where the need for, and benefits of, management are clear.

We compare basins that have adopted effective institutions in the past with otherwise similar basins where institutions are fragmented or missing. To design useful comparisons, we use an empirical model of management benefits to identify basins with similar potential benefits based on factors like the rate of water demand increases, the commonality of the aquifer (i.e., the extent to which one party's pumping might affect another), and others. Even when comparing basins with similar potential benefits, we found that failures of collective action are associated with the size of the basin and its user group, as well as variability in water use type and the spatial distribution of recharge within a basin. Overdraft and other common-pool groundwater problems persist where the number of negotiating parties is large, but importantly also where divergence between users in resource access conditions and water valuation is large. In many cases, these valuation differences arise between agricultural and urban users; in successful transitions, consensus often did not emerge until much farmland was urbanized and demands on the resource subsequently became more homogeneous.

The Mojave case demonstrates how certain allocation systems, coupled with a market, can bridge some of these gaps. Initial allocations to agricultural users and a sequential ramp-down of pumping allocations allowed agricultural users time to adapt, but it also ensured that they could monetize these new assets. As the ramp-down proceeded to constrain the supply of pumping entitlements, asset values rose and many farmers found themselves better off despite no longer having unrestricted access to

groundwater for irrigation purposes. SGMA implementation is bringing other questions to the fore. For example, how will GSAs handle dormant groundwater claimants: landowners who have not pumped in the past but nonetheless have a claim to the aquifer's resources and may demand an allocation. A recent adjudication in Antelope Valley resolved this question successfully through negotiated settlement, but the process took 15 years. Conflicting views of dormant claimants, long-time pumpers, and others with a mix of surface and groundwater entitlements will no doubt complicate the task faced by GSAs. In other western states, different legal foundations, resource and climatic conditions, and political considerations lead to similar but different sets of obstacles.

### TIME IS TICKING

Transitioning to more formal groundwater management regimes will prove instrumental for the continued prosperity of the West. Securing water supply for growing populations and growing economies in the face of a changing climate will require protecting and utilizing the storage space beneath our feet that allows municipalities, agricultural users, and ecosystems to weather droughts.

Stabilizing water tables can reduce pumping costs, ensure reliable future supply, and address other negative effects of groundwater pumping, but developing markets to help reallocate the resource as we do so will play a key role in reducing the costs of achieving sustainability. Developing markets can also provide a stronger foundation for resolving future disputes about resource use, as the rights and responsibilities of parties will be better understood and the costs of bargaining reduced.

Nonetheless, reaching agreement to further this transition can be difficult. With SGMA, as elsewhere in the West, ultimately the resolution will take time, and in the meantime pumping will continue. For how long and at what cost will depend on how effectively agencies and managers can address emerging obstacles to agreement. R

### READINGS

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