# Marketing the Sustainable Groundwater Management Act: Applying Economics to Solve California's Groundwater Problems

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In 2014 California adopted the Sustainable Groundwater Management Act (SGMA), which represents California's first statewide groundwater management planning program. SGMA calls for local agencies to develop groundwater sustainability plans within the next five to seven years and then achieve sustainable levels of groundwater extraction by approximately 2040–2045. Given the current levels of overdraft in many California groundwater basins, substantial reduction in groundwater extractions will be necessary to meet the mandates of SGMA.

This paper proposes that California agencies may be able to avoid many of the disputes associated with substantial curtailments in groundwater extraction through the use of groundwater markets. Specifically, the paper will begin with the path-breaking work of Nobel laureate Elinor Ostrom, whose work on understanding groundwater basin management as a specific example of "common pool" resources was based on her analysis of groundwater basins in Southern California. Ostrom's work provides the theoretical basis through which local agencies can minimize the disruption caused by the reduced groundwater extraction mandated by SGMA.

After discussing the theory of groundwater markets, the paper will discuss existing groundwater markets in the United States and Australia. Groundwater pumpers in areas as diverse as Nebraska, Texas, and the Murray-Darling Basin all have implemented market-based systems in recent years to allocate extractions to uses deemed most valuable. Transfer payments under these market regimes have enabled some pumpers to achieve a "soft landing" and exit the market. We propose that the California Department of Water Resources develop one or more model regimes that could be used as local agencies seek to implement SGMA. The paper will conclude with general observations regarding the intersection of market mechanisms and regulatory requirements in the management of natural resources.

To understand the potential ways in which groundwater markets can assist California water agencies in implementing SGMA, it is important to understand the key components of the new legislation.

First, before determining how to manage a groundwater basin, there must be agreement on what constitutes a groundwater basin. In the normal situation, defining a groundwater basin by means of the major fault zones and differentials in water levels across those fault zones is relatively straightforward. In many cases, though, especially in California's Central Valley, a groundwater basin may extend for tens, if not hundreds of miles. SGMA, relying on work performed by the California Department of Water Resources, adopts basin boundaries that are primarily based on hydrogeographic factors but that also divide basins based on political boundaries. Thus, adjacent portions of a single groundwater basin may—for purposes of SGMA—be managed differently because they lie in different counties. Such potential externalities to management plans developed under SGMA present one of the largest challenges to the successful implementation of the act, but also one of the areas wherein markets may be most useful.

Second, after determining the boundaries of a groundwater basin, there must be a determination of which agency or agencies will actually perform the management. Under SGMA, any local public agency with authority to manage water can declare itself to be a "groundwater sustainability agency" or "GSA" and so will be eligible to participate in the management of a basin that it overlies. When—as is typically the case—there are multiple GSAs overlying a single basin, SGMA assumes that those agencies will be able to develop some *modus vivendi* that will enable them to manage the basin, perhaps a joint powers authority or similar collective management approach. If not, a basin with multiple GSAs could devolve into a series of individual management plans, each tied to a particular GSA, that collectively are intended to meet the sustainability target in SGMA. As with the basin boundaries question, if there are multiple GSAs in a basin, there may be an opportunity for a groundwater market to assist the agencies in moving toward a beneficial outcome.

Third, the centerpiece of the SGMA (as its name implies) is a mandate that groundwater basins be managed in a manner that is "sustainable" over the long run. This mandate for sustainability is largely the same as the previous legal standard that basins be managed in a manner that was consistent with the "safe yield" of the basin. The innovation in SGMA is that the GSA(s) overlying a groundwater basin are required to develop and adopt a plan that is intended to achieve a sustainable level of groundwater extraction (a groundwater sustainability plan or GSP) by either 2020 or 2022. The GSP, once adopted, must then actually achieve sustainability within twenty years. The GSP can achieve sustainability by reducing extractions, importing water from outside the basin, or finding ways to increase the native water supplies in the basin

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(e.g., developing new surface storage to serve the basin). Once again, a market mechanism could be of great utility in helping to coordinate efforts of different groundwater basins to achieve a sustainable level of extractions.

## *Common Pool Resources*

The economic theory that supports the use of markets as an integral part of groundwater management was originally developed by Nobel laureate Elinor Ostrom. While in graduate school at UCLA, she studied the disputes over the use (and overuse) of groundwater in Southern California during the 1950s. From that work, she developed a theory of what she described as "common pool resources" (i.e., those resources that are sufficiently large so as to make it very costly to exclude others from use of the resource). In this respect, common pool resources resemble "public goods" such as national defense. The key difference between common pool resources and public goods, however, is what Ostrom calls "subtractability." One person's use of national defense or the weather forecast, for instance, does not detract from another person's use. Hence, national defense or a weather forecast is a public good. By contrast, even though there are few barriers to entry in a groundwater basin, one pumper's use of water directly reduces the quantity of water that another pumper can extract (e.g., by lowering the static groundwater level). Thus, common pool resources are those for which there is, as Garret Hardin famously put it, a "tragedy of the commons."

The successful management of common pool resources, according to Ostrom, share a number of characteristics: (1) clearly defined boundaries, both in area and in participants; (2) rules that are tailored to the local circumstances; (3) local governance; (4) active monitoring for compliance with adopted rules; (5) graduated sanctions for violations of those rules; (6) conflict resolution mechanism within the institution; and (7) support for local institutions by external governments. Although it is too soon to tell whether every GSP will include these characteristics, many—if not most—of these concepts are integral portions of SGMA.

As noted above, the questions relating to defining the basin to be managed and the agencies that will participate in management directly respond to Ostrom's first criterion. A GSP, if properly developed, will be a set of rules that involve local governance, rules tailored to local circumstances, and active monitoring for compliance, thereby complying with several more of Ostrom's criteria. The Chair of the California State Water Resources Control Board, Felicia Marcus, has stated on many occasions that the State of California wants to support local agencies in implementing SGMA and not interfere with their ability to craft local solutions to local problems. In this way, yet another of Ostrom's criteria is met. Chair Marcus notes, however, that if agencies fail to implement SGMA properly, the act provides for graduated sanctions, up to and including the imposition of a groundwater plan by the State of California. Thus, yet another of Ostrom's criteria is included in the design of SGMA. Indeed, the only one of Ostrom's criteria for the successful management of a common pool resource that is not required by SGMA is a conflict resolution process within the GSA/GSP. Prudence indicates that such conflict resolution processes (short of litigation) should be included, but they are not required by the law.

One of the path-breaking elements of Ostrom's work was her ability to move beyond the dichotomy of managing resources either by means of the private market or governmental "command and control." She wrote in *Governing the Commons*,

> Institutions are rarely either private or public—"the market" or "the state." Many successful CPR [common pool resource] institutions are rich mixtures of "private-like" and "public-like" institutions defying classification in a sterile dichotomy. By "successful," I mean institutions that enable individuals to achieve productive outcomes in situations where temptations to free-ride and shirk are ever present. A competitive market—the epitome of private institutions—is itself a public good. . . . No market can last for long without underlying public institutions to support it. In field settings, public and private institutions frequently are intermeshed and depend on one another, rather than existing in isolated worlds.

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Part of her evidence for this approach is the history she describes in *Governing the Commons* of the Raymond Basin and the Central and West Basins in Southern California. In both cases, litigation led to the development of institutions that had all of the criteria that she describes as being necessary for the successful management of common pool resources. She then notes (at pages 114 and 136) that in both cases, after the establishment of these institutions, localized markets for water developed, which then served to reallocate water based on local needs.

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We believe that Ostrom's analysis of Southern California groundwater basins is a "back to the future" look at the way in which SGMA can be implemented successfully. As noted above, SGMA includes almost all of these key elements that Ostrom identifies as being needed to manage a common pool resource successfully. Ostrom's observation that, with the development of these types of institutions, markets naturally developed within each of the basins, leads us to conclude that

incorporating markets within those institutions from the start will ease the implementation of SGMA and help groundwater pumpers in overdrafted basins find the proverbial "soft landing." Moreover, well-functioning markets within groundwater basins can also help address the externalities between basins or between GSAs, as noted above.

### *Real-Life Experience with Groundwater Markets*

There are numerous examples of successful groundwater markets in the United States and beyond. In this section we review a few of these markets, with an eye toward illustrating how particular design features address common problems in implementing groundwater markets. It is important to note that these markets are intended to operate within a specified groundwater basin; developing a market for the transfer of groundwater between different groundwater basins is an entirely different discussion.

Because groundwater is a common property resource, pumping can lead to impacts on other groundwater users. Changing the location of pumping, as in a market-based exchange, may change the distribution and magnitude of pumping externalities.

Accurate monitoring and measurement of groundwater use is a precondition for the establishment of a market. Well metering and reporting are mandatory in a growing number of groundwater management areas around the world. Users in adjudicated groundwater basins in California are typically required to meter and report their water usage to the basin watermaster. Similarly, in much of the states of Kansas and Nebraska, irrigation wells must be metered and pumping reported annually, while groundwater management districts in other states such as Texas are increasingly requiring meter installation. Metering is also found elsewhere in the world, including in Australia and New Zealand, as well as in some river basins in China. SGMA provides GSAs with a number of tools that can accomplish the monitoring of groundwater extractions, ranging from actual metering of individual wells to monitoring of groundwater levels through monitoring wells or remote sensing. GSAs will—and should—make different decisions based on the conditions of each groundwater basin that are consistent with good management practices.

Establishing groundwater markets also requires enforcement of use limits when violations occur. When the submission of meter data is voluntary and there is no penalty for inaccurate reporting, there is little incentive to provide timely or accurate readings. Conversely, in some groundwater management districts, district employees do the meter reading, with fines for broken meters and severe penalties for violators. For example, in 2010, the Upper Republican Natural Resources District in Nebraska revoked the pumping rights, with a value in the millions of dollars, of several groundwater users who had bypassed their well-flow meters. In Australia, meters are similarly read by government employees, and there are large penalties for violators. Again, SGMA provides GSAs with a number of different tools to limit extractions in overdrafted basins to the limits established in a GSP (or mandated by a court). In some basins, remote telemetry may be the most useful way to ensure that extractions are consistent with the GSP; in others, a GSA will be entirely justified in relying on voluntary reporting. The key will be for the GSA, working with stakeholders, to determine what measure(s) work best for that basin in ensuring sustainable groundwater management.

A related issue is carryover of pumping permits between years. As water demand varies enormously based on climate, it is desirable to provide groundwater users with some flexibility of how permits are used across time. Groundwater management areas in both the United States and Australia allow carryover of unused allocations, though the amount that may be carried over is often limited. In all cases, though, carrying over unused annual allocations should only be done when that carryover reflects the hydraulic reality of the groundwater basin.

Because groundwater is a common property resource, pumping can lead to impacts on other groundwater users. Changing the location of pumping, as in a market-based exchange, may change the distribution and magnitude of pumping externalities; indeed, this is often the purpose of groundwater management. For example, groundwater-trading schemes in Nebraska use trading ratios that adjust for the difference in stream depletion between locations of buyers and sellers of groundwater rights. Consequently, when moving a unit of water to a location that induces more stream depletion than the original location, less than a unit of water may be transferred. The effect of trading ratios is to create location-specific market prices for groundwater.

Zonal trading schemes are also implemented to deal with concerns about the external effects of pumping. For example, trading in the Lower Lachlan and Murrumbidgee in the Murray-Darling Basin is subject to zonal restrictions where pumping rights may be transferred out of critical areas, but may not be transferred into critical areas. Similarly, in the Middle and Upper Republican Natural Resources Districts in Nebraska, trading is restricted to defined sub-areas so that the distance between the original point of groundwater pumping and the point to which water pumping is transferred is limited. For example, in the Upper Republican Natural Resources District, the pre- and post-trade points of extraction must fall within a 6-mile by 6-mile area.

If a GSA wishes to incorporate such differentials (trading ratios or zonal trading schemes) as part of a market (which has not, to the authors' knowledge been done in California), there will need to be careful analysis performed about the conditions giving rise to these trading differentials. For instance, even if there is more stream depletion associated with certain extractions, it may be beneficial to the groundwater basin (and not injurious to surface water users) to encourage such



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groundwater extractions in order to modify the overall basin groundwater contours. Similarly, it may be advantageous to encourage additional extractions in areas away from streams in order to better manage the groundwater basin. All of these decisions should only be made by the GSA after good technical analysis and extensive discussion with stakeholders. But, if such programs are implemented with local support and good technical understanding of the dynamics of a groundwater basin, we believe that they can help with the transition to sustainable groundwater management.

## *Conclusion*

The examples above show that carefully designed groundwater markets can (and do) function to adjust the use of water within a well-defined institutional regime, the type that the California Legislature intended to create in enacting SGMA. The law gives local agencies—the GSAs—the authority to monitor groundwater extraction and enforce pumping limits as may be needed to foster the development of groundwater markets. Other concerns specific to groundwater use such as pumping externalities and the ability to bank unused pumping credits can be addressed through thoughtful market design by local agencies and stakeholders.

We believe that GSAs can and should incorporate groundwater markets as part of their development of GSPs. Such markets, as discussed above, can reduce conflict between groundwater pumpers, reallocate water as between sectors during development periods, and otherwise improve the flexibility of a groundwater management system to adapt over time. All of these methods, including a groundwater market within a GSP should be considered by each GSA.

However, we also note that the development and implementation of groundwater markets in each of the areas described above took a number of years and involved some significant mistakes. Given the dire state of many of California's groundwater basins, we believe that the state does not have the luxury of "reinventing the wheel" of groundwater markets in a number of different groundwater basins at once. Instead, we believe that the California Department of Water Resources, possibly with the expert assistance of the University of California, should convene a working group of experienced groundwater managers to develop two or three "off the shelf" groundwater market packages that GSAs could customize to their own local situations. In this way, the experience of the Chino, Seaside, and Buena Vista Basins, which have developed small-scale groundwater markets within their boundaries, could readily be translated and disseminated to the many groundwater basins that will now be managed under SGMA. Moreover, because it is also likely that some of these groundwater basins will be the subject of future groundwater adjudications, the development of groundwater markets that could be employed by judges or special masters in the course of those adjudications would also benefit those groundwater basins.

In the end, Ostrom's work—as well as most economic theory—finds that common pool resources can be privatized, managed by the government, or managed in a more fluid and flexible manner through the combination of markets and governmental oversight. SGMA has opted for this last approach, and only time will tell whether Ostrom's optimism that groundwater could be successfully managed will prove to be true. We're betting that her analysis will prove to be correct in the end; after all, she did win a Nobel Prize in Economics.