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Sharing Groundwater: A Robust Framework and Implementation Roadmap for Sustainable Groundwater Management in California

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Review
This working paper was reviewed by multiple experts inside and outside the Nicholas Institute for Environmental Policy Solutions. However, it has not undergone a formal review process as it is intended to present preliminary analysis, stimulate discussion, and inform debate on emerging issues. It may eventually be published in another form and its content revised.

SUMMARY

This working paper offers a framework and roadmap for development of a robust groundwater-sharing system consistent with California's Sustainable Groundwater Management Act, which requires communities in priority areas to prepare groundwater sustainability plans.

The proposed system draws on global experience. Robustness is its signature feature. Opportunities are maximized by a suite of robust local governance, allocation, and administrative arrangements. Additionally, the proposed system incentivizes innovation, stimulates investment, and facilitates low-cost adjustment to changes in groundwater demand.

Among the dynamic components underlying this sharing system is a share register that records ownership and transfers of ownership in a basin's available shares. These unit shares are fungible; each represents a proportional stake in access to the basin's groundwater resources. Volumetric allocations are made in proportion to the number of shares held during determined periods throughout the water year. These allocations are recorded in bank-like water accounts, affording account holders an efficient means to manage their resource but also ensuring that they cannot use more than is available. Unused water can be saved for later use. At the start of the transition to the new system, users are given an allocation buffer so that they have flexibility and time to adjust. Those who want to can make quick non-contestable trades at low cost.

OVERVIEW

California's Sustainable Groundwater Management Act (SGMA) calls on local agencies to find a way to avoid six undesirable results associated with groundwater use. This report seeks to help the 127 basin communities involved by offering a mockup of the groundwater plan that each of these communities is being encouraged to prepare. In essence, it is suggested that water-sharing systems be used to bring local groundwater use within sustainable limits.

The roadmap's core features draw on the global experience in water resource management. If implemented, it can be expected to bring about a considerable increase in wealth and community resilience. Communities that adopt the proposed system can expect to deliver SGMA outcomes at less cost and greater benefits and also to become wealthier and more resilient.

Robustness

The arrangements chosen are designed to make the strategies and mechanisms used to manage groundwater use in California as robust as possible.

Robust systems withstand the test of time. They endure and function well under pressure. Often, they have a sense of simplicity and elegance. They tend to be easy to describe. Typically, they build resilient, prosperous communities.

Under the proposed groundwater sharing regime, there are increased incentives and rewards for efficient water use and innovation, for those willing to adapt. The proposed transition pathway is clear. Water trading is encouraged.

Markets and Trading

Throughout California, there has been much interest in the potential of market-like processes to improve groundwater use. This report delivers a simple message. If markets have a useful role to play in water allocation, then, rather than focusing on building markets, it is better to first build the institutional arrangements that make low-cost trading possible. The next step is surrounding these arrangements with administrative structures and accounting systems that can be and are trusted. If the resultant system has integrity and can be banked on, then markets will emerge naturally.

The tests of the robustness and integrity of a good water management system are the frequency with which people trade opportunities to use and invest in water, the worth of the assets so created, and the rarity of legal arguments. Along the way, costs have to be kept low and everyone given the opportunity to search for better ways to use groundwater.

Sharing

In essence, SGMA identifies a need for local groundwater-dependent communities to find a new way to *share access* to groundwater and keep use within sustainable limits. If access has to be shared, then it makes conceptual sense to issue shares. The roadmap suggests that communities consider using shares to define each user's long-term and ongoing interest in a groundwater resource.

Shares, when issued, entitle their holder to a proportion of the total amount of water that may be taken from a defined water resource.

Robust sharing systems are characterized by a simple rule: If someone wants a larger share, then he or she has to find a way to persuade someone else to take a smaller share.

Value can be added and opportunities increased by guaranteeing the integrity of share registers and making shares mortgageable. To encourage investment, these shares are issued in perpetuity.

When shares can be mortgaged at low cost, the associated registers have integrity, and trusted administrative systems are put in place, banks become interested in financing much more investment than otherwise would be the case.

Allocations

Sharing is a long-term concept. Dynamism can be brought into the system by making annual allocations to shareholders in proportion to the number of shares they hold.

Administrative costs are kept low by giving each shareholder a water account. These accounts operate and look like a bank account. At the start of the water year, allocations are credited to a shareholder's account. Use, as it occurs, is debited. As with a bank account, shareholders can log into their accounts and transfer unused allocations to someone else.

As with money, water saving is encouraged. Every shareholder is given the opportunity to decide whether or not to use allocations, transfer them, or save them for use in a subsequent year. When unused allocations are carried forward to the next year, adjustment is made only for hydrological losses.

Managing Third-Party Impacts

The water sharing approach summarized above is sometimes known as an "unbundled" approach because core components of the allocation and use management systems are separated from one another.

In an unbundled system, the potentially adverse impacts of some forms of water use on third parties are managed using a separate instrument. To this end, groundwater users are allowed to take groundwater from a well if and only if they hold a valid groundwater use permit. The conditions set out in these permits include the arrangements necessary to prevent adverse third-party effects from occurring.

A typical groundwater use permit would authorize the taking of groundwater from a nominated well, stipulate how the volume taken will be estimated, nominate the water account from which this volume will be deducted, and nominate what penalties will apply if permit conditions are breached. When necessary, local draw-down effects are managed by setting a maximum daily pumping rate.

Maximum pumping rates can also be used to prevent seawater intrusion or the movement of contaminated plumes.

System-wide third-party effects are managed through decision-making rules set out in a groundwater sustainability plan. Often it is more efficient to divide a groundwater resource—often called a basin—into a number of management zones. Within a zone, the nature of each share is identical. A standard set of groundwater use permit conditions is prepared for each zone.

The Plan

System-wide third-party effects, such as unacceptable rates of drawdown, are managed at the system level by using processes set out in the system's sustainability plan. These arrangements include the processes to be followed when deciding how much groundwater should be periodically allocated to each shareholder, how fast such allocations can be reduced, and how the unused allocations are to be protected.

These same plans are used to determine annual allocations per share, the rules for varying these allocations, carryforward, and so forth.

The Roadmap

Developed in consultation with local water users and managers, the appendix contains a generic roadmap for the development of groundwater sharing systems in California whose detail requires modification to suit local circumstances.

The roadmap is drafted in a form that, with amendment to take account of local conditions and addition of other required general materials, could be submitted as a groundwater sustainability plan to be approved by the Department of Water Resources.

There are two main differences between the roadmap and current departmental guidelines for the preparation of plans. The first difference is the emphasis on the administrative and regulatory arrangements necessary to ensure successful implementation. The second is a much simpler approach to the collection and use of information.

Rather than putting early emphasis into estimation of sustainable yield and so on, the roadmap suggests that priority should be given to developing the administrative systems necessary to build confidence in and encourage acceptance of the new groundwater management system. Early consultation with the department is recommended. Meetings that we have had with departmental officials suggest that they would be pleased to receive a proposal from a groundwater sustainability agency willing to test using a groundwater sharing system consistent with the roadmap set out in the appendix.

Once approved by the department, the provisions in the plan would be binding on groundwater users and on the state. Opportunities to change the plan without due process and wide stakeholder engagement would be limited.

Relationship of Roadmap to Existing Water Rights

The roadmap does not seek to extinguish existing groundwater rights. Rather, it places a sharing system over existing groundwater rights. To continue to extract groundwater from a well once a plan such as this has been approved and comes into full effect, it would be necessary to have an existing right and to comply with the provisions of the sharing system.

Language

Discussions about options and the best way forward are likely to be easier if the terms used to describe the proposed "new" system are different from those used to describe the "current" system. To this end, it is suggested that all involved use terms like *shares* and *allocations* to describe the proposed "new system" and use established terms like *water rights* to describe elements of the current system.

Governance

As local trust and timely decision making is important, it is suggested that the groundwater sustainability agencies required under SGMA begin the process of developing a plan by forming a small independent board to ensure that the proposed groundwater sharing system and plan has integrity and is designed and implemented successfully.

To speed innovation and investment, it is suggested that the integrity and accuracy of the proposed share registers and water accounting systems be guaranteed as valid by the state. This is achieved by using a register rather than a paper trail to define ownership and making it clear that the only way to prove share ownership is to have one's name recorded in the register. Similarly, any mortgage or other financial interest not recorded in the register would not be deemed a valid interest.

Transition Arrangements

The roadmap contains a default share allocation mechanism and a suggested adjustment pathway. The default suggestion is that the initial share assignments and allocations be made so as to cause minimum disruption and offer greatest flexibility during the initial transition period. This is achieved by starting with a share distribution that approximates existing use and then transitioning to a "fairer" arrangement over a 10-year period. During the transition period, it is suggested that each community consider redistributing a proportion of each shareholding according to community perceptions of the fairest way to allocate shares.

At the start, it is suggested that shareholders be given buffer allocations to allow them flexibility and that it be possible to carry forward unused allocations from year to year. In essence, this means that each groundwater user has considerable opportunity to decide how best to make the adjustments necessitated by SGMA.

Finally and in light of the value of conjunctive use arrangements, it is suggested that consideration be given to the merits of setting aside a drought reserve for allocation to shareholders in the case of the emergence of a severe surface water shortage.

INTRODUCTION

In 2014, California's legislature passed a three-bill package that called on the California Department of Water Resources to categorize each of California's 515 alluvial groundwater basins into one of four priorities and to put in place arrangements for those basins identified as either high or medium priority to progressively mitigate and ultimately eliminate six undesirable results from occurring.[1] Known as the Sustainable Groundwater Management Act (SGMA),[2] it holds that depending on priority and possible status of critical overdraft, groundwater use in medium- and high-priority basins is to be brought into balance by either 2040 or 2042.[3]

The Department of Water Resources, pursuant to C.W.C. § 10722.4 and §10933, employed the ranking methodology of the recently completed CASGEM Program to establish the initial basin prioritizations. Ultimately, 127 of the state's basins were identified as being of medium or high priority.[4]

A subset of 21 groundwater basins has since been designated as critically overdrafted (Figure 1). The act requires that groundwater use in these 21 basins be brought under a groundwater sustainability plan or set of plans by January 31, 2020. All other high-priority and medium-priority basins must be managed under a groundwater sustainability plan by January 31, 2022.[5]

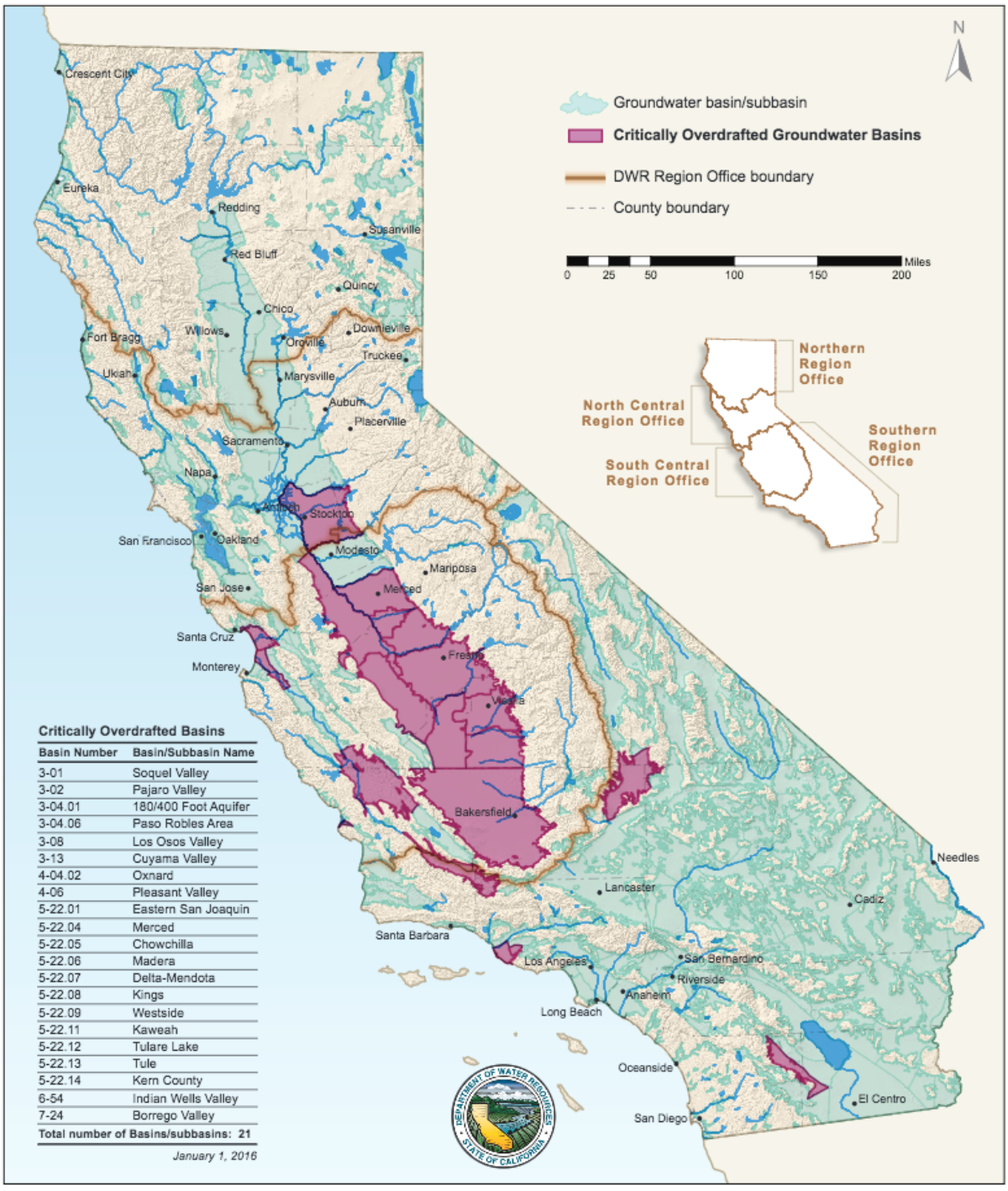
SGMA envisions that the required plans be developed by local groundwater sustainability agencies (GSAs). These agencies are a new form of administrative body in California, having only come into existence with the passage of SGMA.

Prior to SGMA, only a handful of basins were extensively managed under the auspices of a governing authority, most of which resulted from an adjudication or special act of the legislature. SGMA gives these authorities de facto standing as their basins' GSAs. In all other basins, eligible local agencies have until June 30, 2017, to notify the Department of Water Resources of their intent to form a GSA for part or all of a basin.

As of January 2017, 237 entries have been posted by various entities and, with some overlap, have given notice of their desire to form a GSA.[6] For basins where no one proposes to form a GSA or there is failure to produce a plan or coordinated group of plans for the entire basin, the responsibility for plan preparation ultimately passes to the State Water Resources Control Board.

[1] See http://www.water.ca.gov/groundwater/sgm/SGM_BasinPriority.cfm.
[2] Sustainable Groundwater Management Act (2014). See http://groundwater.ca.gov/docs/2014%20Sustainable%20Groundwater%20Management%20Legislation%20with%202015%20amends%201-15-2016.pdf.
[3] See https://www.opr.ca.gov/docs/2014_Sustainable_Groundwater_Management_Legislation_092914.pdf.
[4] CASGEM's prioritization scheme takes into account major groundwater factors such as the number of total and public supply wells, irrigated acreage, historic impacts of groundwater use, and the basin's reliance on groundwater as a primary water source. See http://www.water.ca.gov/groundwater/casgem/pdfs/CASGEM_Basin_Prioritization_Brochure.pdf.
[5] See http://www.water.ca.gov/groundwater/sgm/cod.cfm.
[6] See http://www.water.ca.gov/groundwater/sgm/gsa_table.cfm.

Figure 1. Critically overdrafted groundwater basins in California, 2016



Source: http://www.water.ca.gov/groundwater/sgm/pdfs/GW_basinsCriticalOverdraft_CA.pdf.

A Blueprint

Building on ideas contained in *A Blueprint for Development of Robust Water Allocation Systems in the Western United States*,[7] this report offers an implementation roadmap for consideration by those involved in forming these agencies. The report's focus is on the architecture of the systems that each

[7] See Nicholas Institute, *Unbundling Water Rights: A Blueprint for Development of Robust Water Allocation Systems in the Western United States*, by M.D. Young, P. Culp, D. Deane, M. Doyle, C. Esau, T. Profeta, S. Routson, and D. Sunding, Nicholas Institute Report 15-01 (2015), https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_r_15-01.pdf.

GSA needs to put in place and takes readers through a search. This search is for the best way to transition toward the development of robust groundwater management arrangements.

Alternative Approaches

SGMA offers each local community of groundwater users the opportunity to design its own management system.[8] This report suggests that, rather than doing the minimum necessary to comply with SGMA, California groundwater users will be better off if they use this opportunity to transition toward a state-of-the-art water entitlement, allocation, and management system.

Australia started a similar journey in the mid-1990s and now, some 25 years later, has a state-of-the-art water entitlement and allocation system that is serving water users, local communities, and the environment well. Along the way, Australia made many expensive mistakes and learned many lessons.[9] The central idea underpinning this report is that with attention to detail and avoidance of the mistakes Australia made, it is possible for California groundwater users to see SGMA as an opportunity rather than a threat.

Robustness

SGMA opens up a new opportunity for California groundwater users. In the past and when faced with a water shortage, governments have typically mandated a reduction in water use, banned certain practices, and begun curtailing rights or deliveries. In other parts of the world, moratoriums have been placed on new development and, in some groundwater systems, on the deepening of wells. These solutions are blunt. In recognition of the folly of taking a blunt approach, SGMA has given local communities an option to find their own solutions and implement them.

Robust institutional arrangements demonstrate an ability to function gracefully during periods of extreme stress and enable those dependent on them to recover gracefully. With careful attention to detail, their designers try to make them bulletproof. Typically, they are easy to describe. They carry a connotation of elegance and simplicity in structure. They are trusted and expected to work well in the worst water-supply conditions one can imagine.[10]

Vision

Adding Value

When water management arrangements are flawed and there is uncertainty about the future, the value of an irrigated farm tends to be much less than otherwise would be the case. The corollary to this observation is the well-known proposition that the better management systems are, the greater the value of the water-dependent businesses and the legal entitlements associated with them will be. Conceptually, SGMA has created an opportunity to improve the value of groundwater rights in California. To do this, those GSAs taking up this opportunity could put a robust water entitlement and allocation system in place. Robust systems are characterized by their capacity to perform well in the face of exceptional circumstances, such as a millennium drought, and the expectation that they can withstand the test of time.

Language

The language used in the previous paragraph, with its emphasis on the need for a new water entitlement and allocation system, is intentional. Early in the search for an improved way to manage Australia's water resources, those leading the search decided to adopt a new set of terms and avoid

[8] If a local community does not establish a GSA in a timely manner or fails to prepare a groundwater sustainability plan in the required time, the state is required to step in and impose a plan on the basin. See SGMA §10735 and §10736.

[9] See M.D. Young, "Environmental Effectiveness and Economic Efficiency of Water Use in Agriculture: The Experience of and Lessons from the Australian Water Reform Programme" (2010), www.oecd.org/water.

[10] See M.D. Young and J.C. McColl, "Robust Reform: The Case for a New Water Entitlement System for Australia," *Australian Journal of Agricultural and Resource Economics* 36(2)(2003): 225–34; M.D. Young and J.C. McColl, "Defining Tradable Water Entitlements and Allocations: A Robust System," *Canadian Water Resource Journal* 30(1)(2005): 65–72.

talking loosely about "water rights" and the need to improve them. The new set of terms enabled all to compare the new system with the old system using dialogues that encouraged constructive discussion. Assisted by an ever-deepening drought and the reality that the existing old system was dysfunctional, political consensus for the need to transition to a new system that respected existing water rights soon emerged.

Above all else, this report recommends the use of terms that enable discussion about differences between the current and proposed new regimes.

Six Building Blocks

The remainder of this report offers a framework and then sets out a roadmap for the implementation of a robust groundwater management system consistent with SGMA.

One of the aims of this report is to make it easier for groundwater sustainability agencies to understand the nature of the SGMA journey and what is required. The timelines proposed in the legislation are tight. We see two pathways forward. The first is to use the roadmap as a template that needs to be adapted to accommodate local considerations and current administrative arrangements. The second is to use the roadmap as a guiding checklist to assist in identifying factors that have to be considered.

In essence, the suggested groundwater sharing system has six building blocks:

(1) The **granting of shares** to individual users in delineated zones in a manner similar to the way shares are issued to people with an interest in a company.
(2) The annual announcement of the volume of **water allocations** to be credited to each shareholder's **water account** at the start of each season coupled with the debiting of allocations from each account as water is used.
(3) A requirement that any groundwater user hold a **permit** that allows groundwater to be extracted from a well only when the water account associated with the well is in positive balance.
(4) The preparation of clear **management plans**—a groundwater sustainability plan—that set up a regulatory and administrative framework for managing water use in a groundwater basin on a zone-by-zone basis.
(5) Appointment of independent **basin authorities** with the skills and knowledge to make the timely decisions necessary to ensure efficient and effective use of water at the local level.
(6) Administrative arrangements that allow the **speedy, low-cost trading of shares and allocations** without fear that the process will become entangled in expensive legal argument.

Legal Structure

As is the case with fishery share systems, tradable development rights, and carbon emissions trading schemes now used in California and elsewhere, it is recommended that these six building blocks be placed on top of existing groundwater rights as a regulatory overlay. That is, it is recommended that no attempt be made to extinguish or replace existing groundwater rights. Rather, it is suggested that the proposed sharing system sit alongside existing rights and entitlements.

Once the proposed sharing system is put in place, land owners will be required to both hold a water right and comply with a new set of groundwater sharing regulations developed by a GSA in consultation with local water users. To this end, the roadmap contains a clause that states any land owners who comply with an approved groundwater sustainability plan may do so without compromising their current rights.

When approved, provided it is written in a regulatory style, a plan would gain legal status similar to any other regulations made by the Department of Water Resources. The result is a suite of administrative arrangements that would be binding on all the basin's groundwater users and on the state.

Unbundling

Academics describe the sharing system suggested in this report as an "unbundled" system. In some legal circles, a property right is described as a bundle of sticks or features that can be pulled apart.

Unbundling is the name given to a regulatory structure where each stick is defined separately. The result is a structure that makes speedy adjustment possible as each feature can be dealt without compromise to issues that operate at different scales, in different locations, and in different time periods. The simple guideline is that there must be at least one instrument—or stick—for each objective or issue of concern. When unbundling, it is critical that each instrument be defined in a manner that has hydrological integrity. There must, for example, be no "paper water" left in the system.[11]

In addition to unbundling, which reduces transaction costs, the suggested regime seeks to add elements known to increase the value of each share and each allocation in a way that makes even minute savings and trades worthwhile. This is achieved primarily by

- Putting in place local, apolitical governance structures capable of making final allocation and trading decisions as quickly as circumstances change;
- Guaranteeing the integrity of share registers and water accounts;
- Making it easy to mortgage shares and use shares as collateral to enable new forms of investment;
- Making it possible to transfer allocations from one water account to another at very low cost and without any risk that a third party may attempt to undo such a transfer;
- Encouraging and effectively permitting people to save water and carry unused groundwater forward from one year to the next;
- Significantly reducing the risk that groundwater use will end up in the courts and require investment in expensive litigation processes; and
- Allowing aquifers to be used as a reservoir for the storage of both surface and groundwater.

The Roadmap

The appendix contains a generic roadmap for consideration by groundwater sustainability agencies and the local groundwater users they represent. Written in plain English, the roadmap seeks to map out the flavor of a groundwater sustainability plan based on the proposed sharing system, which could be submitted by a groundwater sustainability agency to the Department of Water Resources for approval. Some have described it as a template; others see it as a guide. Both assessments are correct.

The next part of this report describes some of the rationale behind each section of the roadmap. This is followed by two hypothetical discussions of what might happen in a typified coastal basin and a typified Central Valley basin, were they to implement a plan based off the roadmap. Some broader state-wide considerations and opportunities are raised in the last section.

Those who have not already done so are advised to at least glance at the roadmap before reading further. One of our aims in preparing this report is to make it easier for local communities to understand what is required under SGMA and think through what would otherwise seem like a daunting agenda. We hope that by doing this, ultimately, SGMA will be seen as a process that has added value rather than reduced opportunity.

[11] "Paper water" is water that cannot be found anywhere other than on paper. For a discussion on the theory of unbundling see M.D. Young, "Designing Water Abstraction Regimes for an Ever-Changing and Ever-Varying Future," *Agricultural Water Management* 145(2014):32–38. doi:10.1016/j.agwat.2013.12.002.

Groundwater Sustainability Plans

In most basins, local authorities are in the process of forming their groundwater sustainability agencies (GSAs). The roadmap is designed to help those involved in forming a GSA see what a final version of the plan they are required to prepare might look like. Its focus is on administrative structures, outcomes, decision-making processes, regulatory processes, and day-to-day operations. There is a big difference between appointing an agency and trusting those appointed to work out what to do and going to a community with a clear, detailed vision. A community that goes to its members with a plan to establish a GSA with a view to implementing a robust groundwater-sharing system might find it much easier to garner support—especially because of SGMA's demanding timeline.

The roadmap attempts to build on the guidelines that the Department of Water Resources has been discussing with local communities and the general vision espoused by SGMA, namely, that "sustainable groundwater management is best achieved locally through the development, implementation, and updating of plans and programs based on the best available science."[12] A set of regulations, decision-making rules, and administrative processes are presented as options for consideration. All are designed to build trust and confidence. If local communities and the department can sign off on this framework, much of the detail can be left to locally employed people.

The roadmap adds governance and administrative considerations to the array of best management practices that were identified and drafted by the Department of Water Resources.[13]

SGMA identifies a need to avoid six "significant and unreasonable" undesirable results: (1) depletion of groundwater levels, (2) reduction of groundwater storage, (3) land subsidence, (4) potentially adverse impacts on surface water use, (5) seawater intrusion, and (6) degradation of water quality.[14]

The roadmap has been prepared in a manner that can put in place a suite of processes that will enable the avoidance of these undesired results within the required timeframe. If a plan commits to a set of regulatory arrangements that can reasonably be expected to deliver the outcomes required by SGMA and progress is confirmed in an annual report, then much more of the detail can be left to local people.

Departmental agreement to ratify plans similar to the roadmap can be expected to produce the outcomes required by SGMA at much less cost than many of the detailed reporting requirements under consideration. In particular, there may be no need to prepare and submit lots of detailed information about aquifer form and function and the state of local knowledge about each aquifer where the plan is designed to adapt to address deficits in the basin's water balance based on representative monitoring and groundwater levels.[15]

The proposed water sharing and allocation system couples incentives for water conservation and rewards innovation with arrangements that make trading possible. In particular, the structure of the proposed water-accounting system makes possible low-cost trading of water allocations and shares.

The proposed planning system also puts in place a suite of administrative and consultation arrangements that protect local groundwater users from sudden changes in the amount of groundwater they may access. If a community, a court, or the state wishes to stop something from occurring, it must amend the basin plan, which can be done only through due process. Decisions made in a manner consistent with an approved plan cannot be undone.

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[12] C.W.C. §113.

[13] See http://www.water.ca.gov/groundwater/sgm/bmps.cfm.

[14] See SGMA §10721(x).

[15] Of particular mention is the leeway offered by the Department of Water Resources in its GSP Emergency Regulations §354.28(d) and §354.36 to monitor basins, assess minimum thresholds, and evaluate sustainability indicators using representative monitoring and groundwater elevations as a reasonable proxy. See http://www.water.ca.gov/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf.

THE PLAN

Framework

This report suggests that each groundwater sustainability agency put in place a new set of regulations that enable the management of groundwater use on a day-to-day basis by an independent, skills-based authority.

As well as setting up the necessary governance and administrative arrangements, these plans should also set up the rules for determining how much total water can be extracted from an aquifer, how access and use of this water is to be managed, and how the required transition to balanced use is to be achieved.

As can be seen from the length of the roadmap in the appendix, these plans need not be long.

Plan Objectives

To gain acceptance at the community level, a groundwater sustainability plan needs to encourage economically efficient water use and investment, incentivize conservation, facilitate continuous adjustment, make it possible for new uses and new businesses to emerge, make best use of local information, and ensure equitable access.

It is therefore suggested that the six undesirable results be grouped under a single sustainability objective and matched with other objectives designed to ensure that groundwater use and conservation maximize opportunities to contribute to local and regional development. That is, the planning approach suggested is one that takes local social and economic considerations into account.

As a basis for discussion, the roadmap suggests a generic set of six objectives:

- Avoid the six undesirable results and minimize the risk they might cause to occur.
- Encourage economically efficient groundwater use and investment.
- Encourage water users and investors to search for ways to conserve water.
- Facilitate continuous adjustment as water supply and demand conditions change.
- Provide fair and equitable access to water for domestic purposes.
- Maintain local control of groundwater management.

SGMA sets one further constraint. Depending on the status of the basin, groundwater use has to be brought into balance by either 2040 or 2042. The roadmap suggests that this requirement be referred to as the plan's **sustainability goal**. That is, the plan should pursue its primary goal but do so with careful attention to objectives of importance to local communities.

Keeping It Simple and Affordable

Rather than spending large amounts of money in an attempt to build complex hydrological models and climatic predictions, the roadmap suggests an iterative approach that can be implemented rapidly and adapted as knowledge about each aquifer improves, inflows occur, and groundwater use practices change.

In the early stage of plan implementation, a simple set of allocation rules may be all that is needed to bring about a transition to a feasible regulatory structure.

Instead of putting a massive amount of money into the development of models that seek to estimate a conclusive, frozen value for "sustainable yield," it is suggested that the journey toward achieving the sustainability goal be made using decision-making rules determined by the average depth to groundwater monitored at carefully chosen sites. The question of how many sites or wells to monitor is a local matter.

If average depth to groundwater at these sites declines, the allocation made to shareholders in the zone where water levels are declining must be reduced.[16] The roadmap makes it clear that no one can be guaranteed access to a perpetually static volume of water. Water supply involves risk, and those risks have to be managed.

In many cases, refinement of estimates of sustainable yield and other factors can be left until after the basic structures and processes are in place. In practice, the commitment is to transition to a set of allocation arrangements that, by 2040 or 2042, can be expected to keep the mean depth to groundwater within a predefined band.

Avoiding Massive Disruption

The proposed water supply allocation pathway is designed to give all existing groundwater users time to adjust.

When the sharing system first comes into full operation, the roadmap suggests that each water user be given an allocation equivalent to the maximum amount they used in the previous five years and a start-up buffer that can be carried forward from year to year with adjustment for losses. In addition, for the first two years, the plan requires that allocations per share per year not be reduced by more than 1.5% per annum.

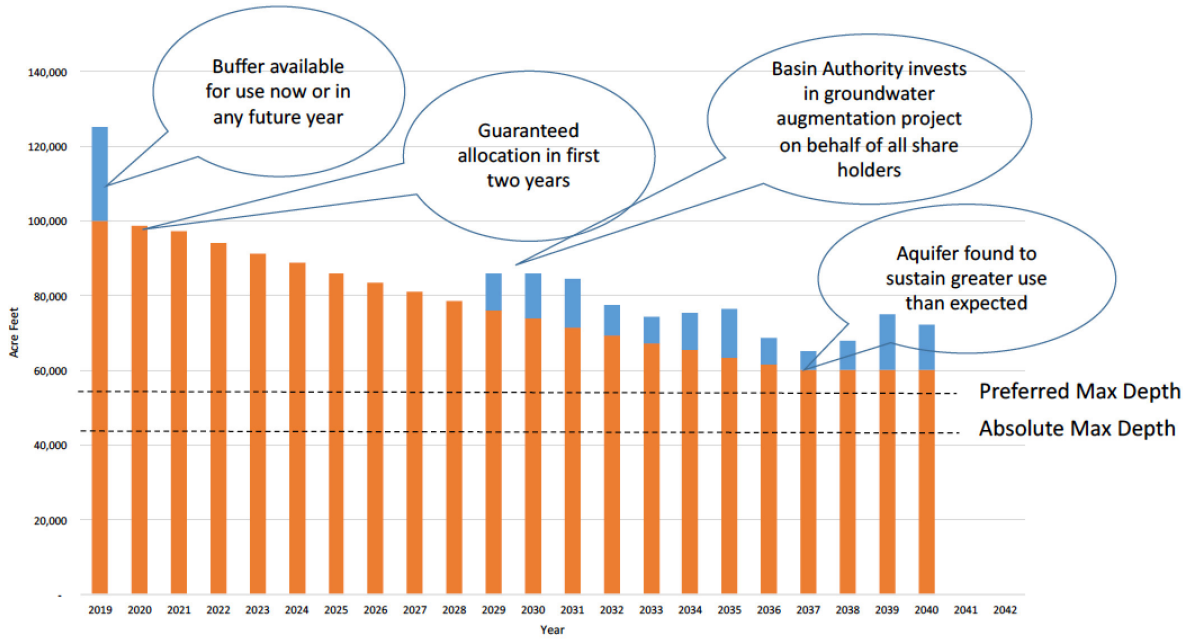
As the plan is implemented, it is suggested that the practice of setting an upper limit on reductions continue so that all groundwater users can plan with confidence. In practice, the result is an "allocation band" that constrains basin authority decisions. How tight or narrow to make this band is a matter for community consideration and consultation.

Figure 2 shows a mock-up of the total annual volume of allocations made in a hypothetical area where the current take is in the vicinity of 100,000 acre-feet. At the time the plan was put in place, it was expected that use would need to be reduced to 55,000 acre-feet. Along the way, however, it was realized that use only needed to be reduced to 60,000 acre-feet (the modelers had it wrong). All users start with a buffer so that no water users start with access to less than they have been using. That is, groundwater users are given time to understand how the new system will "really" work, to plan, and to start to adjust. In practice, this means that allocations per share are higher in early years and less in later years. But with a buffer, water users are free to choose when they use the water they can expect to receive over the full transitional period.

In 2029, an agency-funded groundwater augmentation project gets underway and, as a result, there is an increase in the volume of allocations made per share.

[16] At least three or four wells need to be monitored per management zone at the same time every year. See section "Aquifers and Management Zones" on page 21 for more detailed discussion of management zones. See footnote 15 for a fuller explanation of permitted basin monitoring via proxy.

Figure 2. Key features of suggested arrangements for the supply of groundwater as arrangements are put in place to bring use within sustainable limits



Drought Preparedness through Adjustment, Carryforward, and Transfers

The sharing system in the roadmap has been prepared in a manner that encourages all water users to plan for dramatic changes in supply and demand conditions. In particular, with adjustment for hydrological losses, groundwater account holders are given the opportunity to carry forward unused groundwater from one year to the next. They are also granted the opportunity to speedily trade groundwater allocations with one another and use the value of any shares they hold to finance installation and development of water-saving technologies.

In short, each plan should be seen as one of the region's key instruments for managing drought. In light of this, the roadmap suggests that it should not be possible to suspend a plan by reason of the fact that a drought has caused the declaration of a state of emergency.

When one looks carefully at the individual implications of an adjustment strategy, such as the one suggested in Figure 2, the presence of an initial start-up buffer coupled with a guaranteed opportunity to carry forward unused allocations means that each groundwater user is given considerable flexibility.

Pursuing the Sustainability Goal

Each GSA is required to achieve its sustainability goal by 2040 or 2042. The roadmap does this by requiring the basin authority to control the rate by which groundwater users are assigned permission to extract water. To assist them in doing this, the roadmap requires that for each zone the basin authority set (1) an average maximum depth that acknowledges that groundwater stocks can be used as a buffer and should be expected to go up and down and (2) a preferred maximum depth to force all to recognize that it is time to carefully review and reconsider how much water should be allocated.

These limits are designed to trigger community discussion about how much water to allocate to each shareholder and how previous decisions constrain future decisions. SGMA requires that by 2040 or 2042, the average depth to groundwater is expected to have stopped declining. The disparity between these depths will likely vary from basin to basin and depend on the allocation rules put in place by the basin authority. These rules will likely be based on the authority's adherence to SGMA's sustainability goals, responsibility to overlying stakeholders, and stewarding of the basin for accessing shareholders.

In recognition that communities need to achieve the sustainability goal and avoid undesirable results, the roadmap also proposes an absolute maximum depth. The purpose of this absolute maximum is to make it clear that ultimately groundwater use has to be brought within sustainable limits.

When the absolute limit is reached, the basin authority is required to declare that the annual allocation to be made to each shareholder will be zero. When it makes such a declaration, however, access would still be allowed to unused allocations that have been carried forward and domestic water users would still be allowed to take enough water to meet essential household needs.

Governance

When deciding whom to appoint to make decisions about water use, there are two basic approaches. Individuals are appointed either because of their perceived ability to represent the organization that nominates them or because of the skill and expertise that they would bring to the table.

Representative governance systems have a high degree of accountability. Members are often sent to meetings with "instructions" to pursue outcomes preferred by their organizations or constituents. When members fail to achieve these particular outcomes, they might be dismissed through votes of no confidence or elections. The alternative approach is more skills based in style. This latter approach focuses on the benefits of ensuring that the decision-making body has the necessary skills to make timely, well-informed decisions and resolves issues in a manner that ensures closure so that stakeholders dependent on the decision can act with subsequent confidence. In systems that operate under skills-based appointment, much care is taken to avoid appointing individuals seen to hold conflicts of interest as this might undermine general trust in the body. Those appointed are expected to make apolitical decisions in the best interests of all.

Recognizing the merits of both approaches, the roadmap suggests that California groundwater users will be served best by an approach that combines the advantages of representativeness with skills-based decision-making structures.

It is suggested that those local organizations electing to establish a groundwater sustainability agency initially form the general vision and overall framework of the plan. It is then recommended that these agencies establish themselves as a permanent committee whose prime role is to appoint people to a five-member skills-based basin authority responsible for preparing a final plan and putting in place the necessary arrangements to enable cost-effective implementation. Accountability within this structure is multifaceted. Member-agencies of the GSA are accountable to their constituents and members of the authority accountable to the GSA as a whole but not to any subgroup of groundwater users.

A capacity to make timely, final decisions is particularly important—as is a sense of trust. If, for example, California experiences something similar to Australia's decade-long Millennium Drought, where surface water supplies fail, then one would expect a basin authority to be able to act quickly. A small, expertise-based basin authority can be expected to make decisions in a manner that enables groundwater users to respond rapidly and, in particular, to modify their personal water use and even land-use decisions in days.

The cost of administration is also an issue. The smaller the authority, the less it should cost to run.[17]

Basin Authorities

As a general rule, the members of a small, expertise-based authority should be expected to defend any decision the authority takes. If a member is seen publicly to disagree with a decision made, they can be expected to resign. Above all else, it is critical that all members of an authority are seen to be working as a coherent team, each benefiting and learning from each other's expertise.

[17] Some communities might like to include fiscal prudence in the list of objectives they seek to pursue.

It is well known in the corporate world that the quality of decision-making starts to decline when the number of people involved in making a decision increases beyond between five and seven members.[18] It is also well known that life for a chief executive officer is easier if the task is to implement the board's decisions.

In recognition of all these considerations, the roadmap suggests that the agencies initially forming the groundwater sustainability agency consider the best way to appoint people to their basin authority and review their performance (Figure 3).

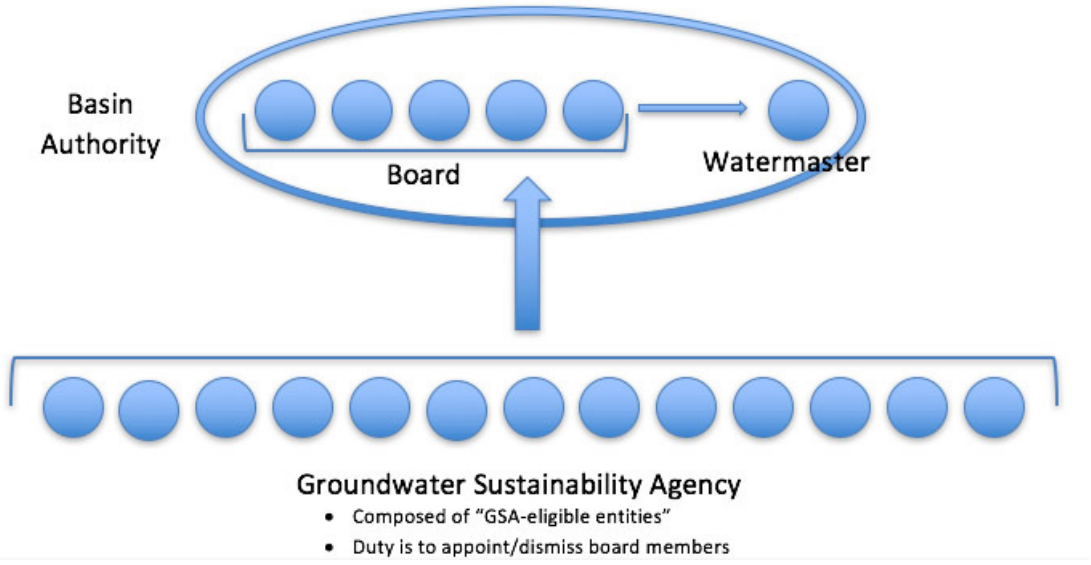
The roadmap suggests that if a substantial majority of members of the GSA or the Department of Water Resources are dissatisfied with the performance of one or more members of the authority, it be possible to dismiss them and, in extreme circumstances, appoint an administrator to take over until new members can be appointed. As it is likely that some shareholders will not be associated with any of the agencies on the GSA, it is also suggested that it be possible for a substantial majority of shareholders to dismiss members of the authority by a vote of more than 60% of all basin shareholders or of the shareholders representing more than 70% of the shares in the basin.

So that the system can be expected to continue to function while members are being replaced, it is suggested that the authority be responsible for appointing its watermaster, whose task, under the direction of the elected members, would be to build the systems necessary to give effect to a plan similar to that described in the roadmap.

The roadmap suggests that basin authorities consist of

- A chair with strong leadership and communication skills
- Four independent members whose collective expertise would enable them to resolve all the legal, financial management, communication, impact assessment, hydrological, and environmental issues likely to come before them
- A watermaster.

Figure 3. Conceptual structure of GSA governance



[18] Using empirical data from a survey of over 2,700 U.K. companies, for example, Guest concludes, "Our results are somewhat inconclusive on the precise identification of an optimal board size since this differs by performance measure, although we can reasonably conclude that it is less than ten members." See P. Guest, "The Impact of Board Size on Firm Performance: Evidence from the UK," *European Journal of Finance* 15(4)(2009): 385–404. The quotation appears on page 23 of the version available at https://dspace.lib.cranfield.ac.uk/bitstream/1826/4169/4/The_impact_of_board_size_on_firm_performance.pdf.

To ensure continuity of knowledge, it is suggested that members initially be appointed for one, two, three, four, or five years. Reappointment would be possible. Appointed by the basin authority, the watermaster would be an ex officio member and not have a vote. The watermaster's main responsibility would be to ensure that the authority's plan is implemented in its entirety.

Avoiding Conflicts of Interest and Insider Trading

From time to time, there will be a need for the basin authority to make decisions that have market consequences. In addition, it is important for members of the authority to be able to make balanced decisions and not feel any obligation to represent the viewpoint of a subset of water users. To this end, it is suggested, as a draft for consideration, that members of the authority should not have a direct interest in using more than five acre-feet of water per year in the basin they are involved in governing and should not hold more than 1% of the shares in any of the basin's zones.[19]

By limiting the size of any basin authority member's direct interest, there is little opportunity for them to be involved in insider trading. Insider trading is possible if any other person can gain preferential access to, for example, the size of an annual allocation decision. If this is not possible, then it may be necessary to suspend trading while decisions that could result in insider trading are made. Insider trading risks are reduced further by widely publicizing the fact that the authority is about to make such a decision.

The roadmap suggests that the basin authority be allowed to meet in private when considering issues that might change the value of shares or allocations. If this option is taken, then one would expect the basin authority subsequently to announce its decision in a manner that enables all shareholders and other water users to profit equally from the announcement.[20]

If, for example, the authority is considering making a top-up allocation to ease pressure on surface water supplies, then it would be important for all shareholders and all water users to be able to discover this fact at the same time.

Prior to making such a decision, one would expect an authority to engage with all stakeholders and encourage them to contribute to the decision-making process.

Reviews and Plan Amendments

The proposed authority's main task would be to prepare a plan and, once it has been approved, ensure its successful implementation.

As unexpected changes in water supply and demand conditions will occur, there is also a provision for the basin authority to review and amend a plan when conditions justify an unscheduled review. The roadmap also suggests a review of the plan immediately before full implementation and every five years thereafter.

Public Participation and Engagement

In water resource management, especially in regions where there is access to both surface and groundwater, it is important to be able to revise operating rules as quickly as supply and demand conditions change. This is possible only within the constraints established in the plan. To prevent decisions from undermining shareholder confidence, any changes to the plan may only be made after the basin authority has given all stakeholders an opportunity to comment on the proposed change and to suggest other changes.

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[19] These numbers should be regarded as indicative of what is needed to ensure there is no significant conflict of interest. These arrangements would, for example, not preclude a GSA from appointing a person with substantial holdings in another basin.

[20] That is, to the extent possible, the basin authority should not be subject to the provisions of the Brown Act. If this proves impossible, then the authority would need to advise all that it is about to make a decision that could affect market values and, if necessary, suspend trading while the decision is made.

Specifically, the roadmap requires that plan amendment deliberations begin with extensive local engagement and be followed with the release of a draft amendment before any formal proposal for change is submitted to the Department of Water Resources.

Ratifying an Amendment

In the interests of expediency, the roadmap suggests that a plan allow amendment to any of its annexes without requiring such an amendment to be ratified by the Department of Water Resources.

For amendments to the body of the plan, rather than setting up a culture of top-down approval, the roadmaps structure suggests that it be the role of the department to ratify (rather than approve) amendments to the plan so that the amendments gain the same regulatory status as the original plan.[21] That is, the roadmap is designed to maximize a sense of local autonomy. To this end, the proposed final sign-off process forces the department to approve proposed changes to the plan in a timely manner. This is achieved via the following procedure:

(1) Basin authority announcement of a decision to consider amending the plan.
(2) A call for comments and submissions followed by a thorough public engagement process.
(3) Preparation and exhibition of the proposed amendment as a draft.
(4) Formal consideration of any comments received on the draft.
(5) A final decision on the nature of the amendment it wishes the department to ratify.
(6) Consistent with SGMA, submission of the final amendment to the department for ratification so that the amendment becomes binding under California law.
(7) A legal arrangement that ensures automatic ratification unless the department returns it to the basin authority for further consideration within 30 days.
(8) Should the department return the amendment to the basin authority for further consideration and amendment, a final step that requires the department to either ratify the newly considered version of the amendment within 30 days or arrange for an administrator to take over the functions of the basin authority.
(9) Failure of the department to respond or appoint an administrator within 30 days results in the automatic approval of the amendment.

To be specific, when the Department of Water Resources first approves a plan consistent with the roadmap, it is proposed that the department agrees to respond to any requests to amend a plan in a timely manner and to waive its legislated entitlement to take up to two years to respond.

Aquifers and Management Zones

Early on in the development of a water sharing plan, each basin authority will need to determine how many management zones and aquifers it will need to recognize.[22] As a guiding rule, each aquifer should be defined and managed separately. That is, if there is an unconfined aquifer and a confined aquifer, the boundaries to each should be defined separately and shares issued in each.

A second issue is the size of each zone. As a guiding rule, each subbasin should be as large as possible so that opportunities to trade allocations are maximized. For this to occur, the size of each zone should be such that the 1:1 trading of allocations is possible. That is, there is a tradeoff to be made between connectivity and size. Quite large zones can be established when aquifers are continuous. In fractured aquifers, every trade may need to be subject to careful assessment. The

[21] If the prime function of the department is to ratify that a decision has been made in the best interests of all, then there is a strong expectation that the basin authority will have already made the "right" decision. When something is submitted for "approval," there is a sense that further negotiation can occur. The department approves the plan the first time it is submitted. Thereafter, amendments are ratified.

[22] In the roadmap, the term *management zone* is used in preference to the Department of Water Resources–defined "management area" (GSP Emergency Regulations §351(r)) due to the dynamic ability of such a term to be applied to both two-dimensional (e.g., surface area) and three-dimensional space (e.g., aquifers).

roadmap contains a suggested set of rules for modifying zone boundaries, transferring shares and allocations from one basin to another, and extending a basin to cover a larger area.[23]

Water Sharing

In most California groundwater basins, groundwater use has been relatively unrestricted.[24] Until SGMA, most aspiring groundwater users needed only to apply for permission to drill a well, certify that drilling the well would not contaminate the underlying aquifer, obtain the relevant permit, drill the well, install the necessary equipment, and start pumping. Land parcel owners were then free to take as much water from the area under their land as they liked.

In the early stages of groundwater development in California, open, unfettered access caused few problems. Both formal and informal practices of conjunctive use also permitted many aquifers to be heavily drawn on in some years while naturally recharged in others. But improved pumping and irrigation technology and increased demand have begun to produce an array of results that have been identified by SGMA as "undesirable."

Simple restrictions on groundwater pumping could be used to prevent undesirable results but, if implemented, would come at a very high cost. An order requiring every groundwater user to apply for less than two acre-feet per acre, for example, could be used to reduce groundwater use but would make the production of many crops impossible unless they were produced by drawing on a mixture of surface and groundwater sources.

Rather than taking this extremely restrictive approach, the roadmap suggests that both groundwater users and local communities will be better off if limits on overall basin groundwater use are coupled with opportunities for people to profit from saving water and searching for ways to use it more efficiently. This is achieved primarily by putting in place a groundwater sharing system that involves:

- Issuing shares to land parcel owners;[25]
- Making volumetric allocations in proportion to the number of shares held;
- Putting in place simple yet trusted systems for share registering, water accounting, and water use monitoring; and
- Requiring all groundwater users to hold a permit requiring them to comply with specific conditions, including a requirement to extract water only when their groundwater account is in positive balance.

The separated nature of this regulatory structure—called an unbundled system in academic circles—allows opportunity for the development of low-cost administrative structures and rapid response to changing conditions.

One of the key design aspects is an increase in the degree of fungibility of each component.[26] In particular, each share is identical and, hence, there is no opportunity for a third party to intervene with a view to stopping the transfer of a share from one person to another. The same applies to volumetric allocations. Within any zone, each allocation is identical and the transfer of allocations from one

[23] When in doubt, the pragmatic advice is to start small and increase the size of a zone or combine it with an adjoining zone at a later stage.

[24] Notable exceptions prior to SGMA include adjudicated basins and basins managed by special districts enacted by the California legislature.

[25] In cases involving municipal purveyors, industrial users, etc., who have a long-standing arrangement entitling access to a well located on land owned by someone else, it may be more appropriate to issue shares either directly to the user or, alternatively, to the landholder on the condition that they be transferred immediately to the user at no charge.

[26] Fungibility is the degree to which all items in a market are tradable. U.S. dollar notes are very fungible. Provided they are not counterfeit, they are nearly the same and mutually exchangeable on a one-to-one basis. Every one of them is worth one dollar. In contrast, a surface water right issued in 1896 for the use of 3,000 acre-feet at the place where two rivers meet is unique in virtually all its characteristics. In essence, most surface water rights in California are about as infungible as they can get.

account to another done at a one-to-one ratio. Consideration and management of potentially adverse effects on third parties is achieved by placing conditions on groundwater use permits. For this reason, we focus the next section of this report on groundwater use permits.

Groundwater Use Permits

From the perspective of a land parcel owner, the proposed regulatory system would require the owner of any land parcel to ensure that any person taking water from that parcel do so only in a manner consistent with the conditions set out in a groundwater use permit attached to the land parcel. That is, land parcel owners are the only legal entity that can hold such a permit, and they are responsible for ensuring compliance with it.

Under a plan similar to the roadmap, each groundwater use permit would contain a link to a water account from which the watermaster would deduct water allocations as water is extracted from a well and require that the extraction of groundwater only be permitted when the water account has a positive balance. Groundwater use permits would be issued only to legal entities recorded in a county's assessor's parcel number database and always be associated with a specific assessor's parcel number. It would be the responsibility of the owner of the land parcel to ensure that any tenant complies with the permit's conditions.

Groundwater use permits can also be used to control adverse local effects and third-party considerations. If, for example, the proximity of one well to another necessitated controls on the pumping rate due to the adverse effects resulting from a wide cone of depression, the permit might set a limit on the amount of water that may be extracted per day, week, or month so as to prevent the emergence of an unreasonable cone of depression.

This same regulatory mechanism can be used to limit extraction from land parcels close to the sea where, if too much water is taken, seawater can intrude into an aquifer. It can also be used to prevent pumping near plumes in a manner that causes the plume to migrate.

In essence, groundwater use permits have two primary functions. The first requires its holder to keep the water account associated with it in nonnegative balance. The second enables the regulation and prevention of adverse local effects. In recognition of this latter function, the roadmap suggests that watermasters take great care when issuing groundwater use permits and only do so when they are confident that they have taken all adjoining landholder concerns fully into account.

Water Accounts

With the exception of domestic and de minimis groundwater users, the roadmap requires all groundwater users to hold a water account and keep it in nonnegative balance. One month before the commencement of each water year, the basin authority would announce the total volume of water to be made available to shareholders and when these allocations will be credited to each account. As soon as these allocations are credited to a water account, each shareholder is free to use it, transfer their water to another account, or save it for a "nonrainy" day. As water is extracted from a well, the estimated net volume extracted would be deducted from the relevant water account. Table 1 describes how this process of using, saving, and transferring allocations might look for a hypothetical shareholder.

Table 1. Mock-up of a water account held by a parcel holder in ABC Basin[a]

Date	Action or event	Debit	Credit	Balance
1 Oct 2019	Opening balance			0.00
1 Oct 2019	Start-up buffer		+83.33	+83.33
1 Oct 2019	Share allocation 10,000 shares at one acre-inch per share		+833.33	+916.66
15 Oct 2019	Net use—estimated using satellite imagery and land parcel area	-10		+906.66
30 Oct 2019	Net use—estimated using satellite imagery and land parcel area	-15		+891.66
5 Oct 2019	Within-zone allocation transfer to M.D. and S.M. Jones	-50		+841.66
20 Nov 2019	Metered use taken for industrial water use purposes on land parcel (six acre-feet with 50% return following treatment in septic system)	-3		+838.66
25 Nov 2019	Purchase from D. Smith (Zone 2) 30 acre-feet at 0.8 per acre-foot		+24	+862.66
28 Dec 2019	Transfer to J.J. Esau	-70		+792.66
30 Mar 2020	Aquifer recharge using water sourced from the state water project		+100	+892.66
~				~
~				~
~				~
30 Sept 2020	Closing balance at the closure of the 2019/20 water year			+892.66
End of year	Amount to be carried forward to the next water year with 10% adjustment for losses	-89.3		+803.36

[a] ABC Basin Water Account 2019/20 Water Year commencing October 1, 2019.
J.D. and C.E. Wilson linked to Groundwater Use Permit # ZZ123456 in Zone 1.

As mentioned above, with adjustment for losses, any unused groundwater allocation can be carried forward from one water year to the next.[27] As with a bank account, access to each water account would be restricted to the watermaster and people authorized by the account holder. The watermaster could, however, release aggregated data so that all users could quickly determine how much groundwater was left in each zone. As a bare minimum, everyone should be able to discover how much groundwater is still available for use.

When it comes to allocation trading, account holders would need to decide whether or not to allow a broker to access their accounts and, if so, under what terms and conditions.

Accounting for Return Flows

When setting up any water accounting system, a choice needs to be made between the use of a "gross" or a "net" water accounting system.[28] Both systems are equally robust but differ in administrative

[27] Losses include flows from one zone to another, to a surface water resource, and to the sea. Losses can also occur as a result of evapotranspiration when groundwater levels are close to a land surface.
[28] Sometimes "gross" and "net" accounting systems are described, respectively, as the difference between the amount of water "withdrawn" from an aquifer and the amount that is "consumed." The amount consumed is the amount that is

costs. To a considerable extent, the choice comes down to the decision as to whether or not to meter water use or rely on satellite technology to estimate use. Provided surface water use is metered, recent advances in the analysis of satellite images make both approaches feasible. But as satellites cannot see into buildings and through glasshouses, some metering will always be necessary.

When a gross accounting approach is adopted, a meter is typically used to estimate the volume of water extracted from a well and this amount deducted from the relevant water account without adjustment for return flows. Instead, every year, the basin authority estimates the average amount of water that is returned to the aquifer and, as average water use efficiency increases, reduces allocations per year.

As a result, when a gross accounting system is used, each shareholder has an incentive to be among the first to increase water use efficiency. Those who do so gain a volumetric advantage until the others catch up. Whilst this approach is simple to administer, one of its downsides is that it can cause overinvestment in water-efficient technology at the regional level—especially when the mix of ground and surface water supplies is variable. When variability is high, a regional economy will be better off if some water users rely on opportunistic production systems that require little investment and, when supplies are short, can be shut down at little cost.

When a net accounting approach is adopted, water users are charged only for the net amount of water they consume. To do this, it is necessary to estimate net use on each and every land parcel. In recent years, there have been considerable advances in remote sensing technology, and it is now possible to use this technology to estimate the net amount of water used on each land parcel. If surface water use is metered, then, conceptually, it is possible to rely on this technology to estimate the net amount of groundwater used on a parcel-by-parcel basis.

Before consideration of administrative costs, arguably, net accounting systems are more equitable. It also needs to be recognized that in some groundwater systems there can be a considerable delay before returning water becomes once again available for use.[29] The use of remote sensing technology also means that there is no need to install meters on each well, decide who should own them, and, if smart meters are not used, work out how frequently to read them, and so on. Careful assessment of all the options and of community preference is critical.

Aquifer Recharge

In many parts of California there has been considerable investment in developing efficient ways to recharge an aquifer. In essence, there are two types of recharge projects: those designed to benefit all shareholders and those designed to benefit an individual water user. Either way, a permit needs to be issued and a means to estimate the amount of water being returned to the aquifer established.

As recharge occurs, the volume of water returned is credited to the appropriate water account. From then on, it is up to the account holder to determine how the water is used. In the case of an irrigation district, for example, this water might be passed on to all the businesses that purchase water from the district. Where an individual decides to recharge an aquifer, all the benefit would pass directly to that individual.

It is important for all augmentation projects to be treated in the same manner. If, for example, a basin authority commissioned a groundwater recharge project for the benefit of all shareholders, it would still have to establish a project water account. Once water was in that account, the authority could then decide to transfer the resultant allocations through to shareholders.

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withdrawn less that which returns via seepage back to the aquifer. When the irrigations system being used is very efficient, gross and net use is similar.

[29] Sometimes it is better to be approximately right than comprehensively wrong. In many cases, it is better to be approximately right than expensively precise.

Recharging an aquifer as a means of groundwater banking is also encouraged by the roadmap. The banking entity might be a local irrigator or a large municipal water purveyor in need of additional reservoir capacity. Should the recharge project be approved, the entity would be issued a permit and given a water account for the specific project.

Trading Allocations

When allocations are made, every shareholder has to decide whether or not to use them, sell them to someone else, or carry them forward for use in a subsequent year.

As with a bank account, the roadmap envisages that users be given access to their own accounts and be able to check that use is being correctly debited and, if they wish, execute a transfer.

Integral to a robust groundwater management system is the ability for individual users to manage their allocations, whether they decide to manage by using, saving, or transferring that allocation. When a plan first comes into full effect, all users will need to decide how much of their buffer allocation to keep and how much to use. They will also need to decide whether or not to adopt more efficient water using technologies or, for example, change the crops they grow. As shareholders and permit holders will have groundwater accounts created in their names, the costs of transferring allocations from one account to another should be minimal. As with bank accounts, the water accounts would be set up so that every account can be accessed and managed over the internet.

When it comes to transfers, there are two options. One is for account holders to manage the transfers themselves. The other is to either transfer allocations to a broker or authorize a broker to access the account. While it may be tempting for a basin authority to offer to set up a brokering service, Australian experience suggests it may be wiser to leave water brokering to independent brokers. As a general rule, it is wiser for the keeper of the accounting system not to be involved in helping to negotiate prices.[30]

Within-zone allocation trading can occur at a one-to-one exchange rate and, in continuous aquifers, can be both unfettered and instantaneous. In fractured aquifers and those with a slow connection, there can be need for a time delay while water moves from one location to another. When water is traded between zones, however, full account needs to be taken of the impacts that transfer of water from one zone to another can have on the interests of other water users. In particular, as well as setting exchange rates, the basin authority may need to change its allocation rules as trades occur. If one person trades 10 acre-feet from one zone to another, then the impact of the trade on water levels in the zone is probably trivial. If 50 people all decide to transfer 100 acre-feet to an adjoining zone, then local groundwater levels might temporarily rise,[31] and a way needs to be be found to shepherd the water from one zone to another without compromising the allocation rules set out in a plan. If allowance was not made for this fact, those who remain could argue for an increased allocation. In light of this, the roadmap allows the basin authority to suspend interzone trading so that, for example, it can manage a sudden rush to transfer large amounts of water from zone to zone and adjust exchange rates so that the hydrological impacts and potential impacts of transferring large volumes of water from one aquifer to another can be managed.

To retain investment confidence and a stable market, the roadmap proposes that the basin authority may neither reverse the transfer of an allocation from one zone to another nor retroactively modify an exchange rate. The roadmap envisages that the volume of interzone trades be tracked and that an automatic exchange rate review be triggered whenever the volume of trades exceeds a nominated

[30] Even if a watermaster does not look into anyone's account, the fact that he or she can do so means that sooner or later someone will accuse that individual of attempting to manipulate a transaction using information not available to others.

[31] In this scenario, initially there may be an increase in the groundwater level in the zone that is transferring water use opportunities to another zone. As the total amount of water being used in the basin remains the same, the basin as a whole remains in balance. The most appropriate groundwater level to maintain in each zone may change.

amount. Annex 3 in the roadmap sets up rules for the transfer of allocations from one zone to another.[32]

Interbasin Transfers

A related issue is the question of whether or not to allow the transfer of groundwater allocations out of a basin using a pipe or other conveyance system. As a general observation, the most common position taken by communities is that transferring across jurisdictional boundaries but within the same region is reasonably acceptable. Similarly, people living in a basin rarely object to piping water into "their" basin. Many people, however, oppose the piping of "their" water to a distant basin. It needs to be recognized, however, that if someone from a different basin is willing to pay more for access to water than its value to businesses and households in the local basin, then it may be better for the local district to accept the resultant payment and allow the money received to be reinvested in other, more profitable, ventures.

There is, however, an additional consideration. Some people are of the view that the piping of water out of a basin should not be allowed to occur until the sustainability goal has been reached. As noted above, this may not be in the best interests of the community as it forgoes an economic opportunity.

The roadmap takes the view that matters like the piping of water out of a district are more efficiently and effectively resolved by the local authorities responsible for approving the construction of the pipeline and not a basin authority. Basin authorities, however, would be responsible for negotiating the rules necessary to manage the subsurface conveyance of water from one basin to another. To this end, the roadmap provides both for interzone transfer agreements and the realignment of zone boundaries. The ultimate role of the authority is to ensure that any water extracted from a well is properly accounted for and, as it is so taken, deducted from the appropriate water account. Other than ensuring that use does not harm an aquifer, it is not the authority's role to determine how and where this water is used.

Enforcement

In practice, the water-accounting and groundwater-use-permitting systems are among the most critical parts of any water sharing system. If the systems put in place are not rigorous and have no integrity, the entire regulatory system must be expected to fail.

Every water user must be made to understand that the uncorrected overuse of a water account is as serious as stealing from one's neighbor. To this end, the roadmap makes a clear distinction between unintentional and intentional overuse.

Unintentional overuse can occur by accident. Whenever this happens, every water user is given an opportunity to return the account to a nonnegative balance within 30 days. To encourage communication, as soon as an account goes into negative balance, the owner of that account would immediately receive an advisory warning. The account holder would then have 30 days to either organize for the transfer of unused water allocations from another account or opt to have his or her groundwater permit suspended until the commencement of the following year and have an amount equal to the deficit debited from the water account.

The cost of opting to borrow from next year is likely to be double the cost of purchasing unused water allocations from someone else. This arrangement is designed to provide a strong incentive for water users to keep their water accounts in a nonnegative balance. As peer pressure plays an important role in securing compliance, the watermaster would in such circumstances be required to notify all other

[32] As allocations cannot have any third-party interest recorded against them, there is no need for a basin authority to prevent any trade executed by the account holder. As with bank accounts, there is a need for procedures to both make it difficult for anyone to break into an account and, if this occurs, take appropriate action. In the case of groundwater, the risks of this are much less as trades can only be conducted among known account holders. The beneficiary of a fraudulent transfer can easily be identified.

shareholders that the user's account is in serious deficit. If an account holder fails to make good or fails to elect to borrow from next year's water account, the roadmap assumes that the holder is seeking intentionally to challenge the integrity of the sharing system and should be treated accordingly. Intentional overusers, it is suggested, should

- Have their groundwater use permits suspended immediately
- Have an amount equal to double the overuse debited from their water account
- Consistent with SGMA, be liable for a fine of up to $500 per acre-foot
- Consistent with SGMA, be liable for a fine of $1,000 plus $100 per day that the violation occurs after 30 days of the initial notification.[33]

Regular or ongoing attempts to overdraw an account or any attempt to run an account seriously into deficit would be defined as intentional overuse and, in addition to the above penalties, could result in the cancelation of a groundwater use permit.

In addition, it is suggested that all other shareholders and permit holders in the zone be notified that the overuser's water account has been suspended and is at risk of cancelation. If overuse continues, the watermaster should be required to cancel the permit.

Domestic Uses

The arrangements set out in the roadmap give preferential treatment to domestic groundwater users who source their water from their own private wells. The reasons for this preferential treatment are twofold. First, access to the water necessary for household and domestic purposes is considered by the state of California to be a fundamental human right.[34] Second, the costs of metering groundwater use on domestic wells in many locations is likely to be greater than its benefits and could run into politically difficult enforcement challenges.

Sometimes it is better to be approximately right rather than expensively correct. In practice, it is likely to be more cost effective to require counties and cities to offset the impact of estimated domestic groundwater well use on an aquifer than to issue shares to and meter each domestic well.

The roadmap suggests that domestic households be allowed to extract up to two acre-feet of water per annum. Then, to ensure that domestic groundwater use does not adversely affect the interests of each shareholder, the watermaster is required to establish a groundwater account for each region where domestic groundwater use is occurring to offset for that use and require the relevant county or city to keep that account in nonnegative balance. Among other things, this gives these agencies a strong incentive to encourage households to connect to a main water supply.

In practice, one would expect these agencies to make land subdivision approvals subject to the supply of sufficient shares to enable the offset of the approval on a city's or county's financial budget.

In recognition of the importance of continuing to provide domestic access to water during periods of extreme stress, the roadmap also provides that when zero allocations per shareholder are being made, domestic groundwater users will be restricted to 0.5 acre-feet per household. This arrangement also extends to any household that draws its water from a well primarily used for irrigation purposes, permitting it a minimum allocation of 0.5 acre-feet.

Finally, as a city or county would only have to account for actual use, every time it succeeds in convincing a household to source its water from a municipal water purveyor it would be able to transfer the shares necessary to do this to the relevant purveyor.

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[33] See SGMA §10732(a).

[34] See http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB685.

Other De Minimis Uses

In most California groundwater districts the nondomestic forms of de minimis water use are few. Of these, one of the most common uses is the pumping of water for livestock using a windmill or a solar pump. The roadmap suggests that, subject to a volumetric restriction of one acre-foot per annum, nondomestic de minimis use be allowed to continue and be ignored until a basin authority considers that the cost of accounting for them is less than the benefit to all others of doing so. Where they are significant, the most cost-effective solution probably involves a means to collectively assess the effects of this form of water use at the farm or district level and charge all a flat fee for the cost of offsetting their collective impact on an aquifer.

Shares

The last part of the trio of suggested permit, allocation, and sharing arrangements is the role that shares play in deciding how opportunities to access groundwater are distributed. Any share allocation process normally begins with the "closure" of access to the aquifer in question. In the roadmap, this is achieved by determining that once shares have been issued, the only way anyone can increase the number of shares they hold is to find someone prepared to transfer shares to them.[35]

Following the model used by corporations, each share is numbered and is not divisible. To enable the efficient management of these shares, the roadmap suggests that either one or 10 shares be issued per acre-inch of current use.[36] Once the initial share allocation has been made, further shares may be issued only if a way can be found to jurisdictionally increase the size of the aquifer when, for example, its boundary is changed.

When boundaries are realigned, an appropriate number of shares are moved from one zone to another without change to any other shares. Administratively, this is much cheaper than defining each share as a proportional entitlement. When expressed as a proportional entitlement, every time a boundary is altered every share has to be canceled and reissued.

Share Transfers

From a share-trading perspective, the larger the area of each zone, the greater the number of shares and, hence, the greater the opportunities to trade shares. The roadmap suggests that, while the trade of shares between zones should not be allowed, it will be possible for any shareholder to organize what is known as a "tagged" trade.

A tagged trade involves the purchase of shares in one zone with the intent of always extracting the water allocated to these shares in another zone. When this is done, the purchaser requests that a permanent entry be made in the water accounting system that requires all allocations made to them in one zone to be transferred, as soon as they are allocated, to a water account in the other zone at whatever the exchange rate is. In practice, tagged trading is less risky for the basin as a whole than the permanent interzone trading of shares as the practice assigns all the long-term exchange-rate risk to the purchaser. No long-term risk is borne by third parties. Permission to enter into a tagged trade should be made in a manner that is binding on the basin authority. Once approved, the only way the basin authority could stop it from continuing in perpetuity would be to set the between-zone exchange rate to zero.

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[35] There are exceptions. Additional shares can be issued when the area of a basin is increased. When the total volume of available groundwater available is increased a new share issue could be made. In Australia's Great Artesian Basin, for example, the government decided to cap a significant number of artesian wells. As a result, there was a considerable reduction in water losses, and the government decided to offset some of the costs of capping the wells by auctioning off some additional water rights.

[36] The issuing of unit shares, rather than shares defined as a proportion, makes it much cheaper to realign zone boundaries. Once the total number of shares has been determined, each share effectively entitles its holder to a proportion of all allocations made; whenever there is a boundary change every share has to be reissued. If shares are defined as a unit then when shares are moved from one zone to another, for example, only those shares involved in the adjustment process need to be canceled in one zone and reissued in the other.

Share Registers

Finally, as one of the objectives of the proposed sharing regime is to decrease risk, the roadmap proposes that the share register be structured in a manner similar to a Torrens title land registration system.[37] Rare in the United States, these registers are established by a government and make it clear that the only way a person can own a share is to have their name recorded in the register. There is no argument. If your name is not there, you are not the owner. In practice, this means that any person wishing to purchase a share can do so only by contracting to change the share register. Costs are low, and no title insurance is necessary.

When shares are traded from one interest to another, the application must indicate the nature of the required change in the water account to which the share is linked.

Mortgages

As an incentive to increase investment, the roadmap also suggests that it be possible to register an interest in one or more shares and then require that transfers occur only in a manner that has been approved by the registered interest. A number of water and fishery share systems in Australia and New Zealand allow for the low-cost registration of interests in shares, and this has proved to be effective in catalyzing investment and innovation in these sharing systems. The most common type of financial interest is a mortgage secured against the value of a share portfolio. Banks tend to like this form of security, as a mortgage over a share is much easier and quicker to liquidate than a mortgage over a land parcel.

Changes in Land and Share Values

Note that during the process of setting up a water sharing system there can be a significant shift in the value of irrigated land. Under the traditional system, a farm may be worth US$1 million. In a sharing system, that value might be divided with the shares worth perhaps US$200,000 and the land parcel US$800,000.

Global experience would, however, suggest that separation of land ownership arrangements from water rights could result in a significant increase in the value of a water right. As a result, during the transition to a groundwater sharing system, careful communication with the banking sector and those responsible for local rating systems is necessary. During the transition, the roadmap proposes that any interests recorded against a land parcel be transferred to the shares issued to each parcel owner so that there is minimum disruption to existing financial arrangements.

During the transition process, local cities and counties may need to review the implications of a decision to issue shares that might cause a reduction in land values.

Issuing Shares

Arguably, when introducing a groundwater sharing system, the most difficult issue to resolve is the question of who to issue shares to and how many shares to issue to each person. In essence, the challenge is to find the fairest way to cut the "cake" in a manner that recognizes existing laws, notions of equity and fairness, and the value of current production systems. When it comes to equity considerations, there is a need for fairness in process and fairness in outcome.

With regard to fairness in process, it is important that all people are given the opportunity to contribute and that their views are heard and seen to be heard. With regard to outcome, it is important to consider immediate and longer-term outcomes. Also, it is important to understand that what seems like a minor variation in an allocation formula may transfer many thousands of dollars from one group

[37] See M.D. Young and J.C. McColl, "Robust Separation: A Search for a Generic Framework to Simplify Registration and Trading of Interests in Natural Resources," report for CSIRO Land and Water (2002), http://www.myoung.net.au/water/publications/Robust_Separation.pdf.

of individuals to another. No matter how well-designed the process is, it must be expected that influential stakeholders may try to manipulate the process to gain advantage. As experience with the issuing of shares in U.S. fisheries has shown, for example, this means there is a need for careful attention to consultation and negotiation processes.[38]

The available experience tends to make two points. First, any share allocation process needs to be implemented in stages. Steps that can be handled with administrative efficiency should be separated from those steps that, without careful attention to process, can be expected to cause controversy. Noncontroversial steps include, for example, informing people that shares will be issued only to the people whose names are listed on the county's land parcel register. The message is simple: "Any person who thinks that the register is incorrect should act immediately to correct it."

Second, most sharing systems start with a significant degree of "grandfathering." That is, the initial allocation needs to be closely correlated with existing patterns of water. Attempts to start with a radical reallocation of opportunities usually fail. During the early stages of introduction, avoid allocating shares in a manner that imposes costs on existing groundwater users. In particular, avoid forcing existing users to suddenly have to buy water allocations from people who in the past have never used water.

Steps

In an attempt to separate the controversial from the noncontroversial, the roadmap suggests a six-step process:

(1) **Determine eligibility**. Determining who is eligible to be included in the share allocation process.
(2) **Design the allocation database**. Determining the full range of data to be collected and considered during the share allocation process.
(3) **Assemble and validate the database**. Collecting the necessary data and validating its content.
(4) **Develop and finalize the formula.** With due process and engagement, determining the most appropriate formula or formulas to be used to determine how many shares each eligible entity should receive in a manner that is seen to be fair and then choosing the most appropriate formula to use.
(5) **Build the share register**. Combining the data in the database with the selected allocation formula to build the register and then inviting all who think they should have received shares to check the accuracy of this register and, if they find any error or omission, request that it be corrected.
(6) **Confirm the accuracy of the share register**. A final step that makes it impossible for any further changes to be made to the register because of an error or an omission.

Once a decision on eligibility is taken, all but the fourth step—selection of the allocation formula—are processes that need to be run and, in competent hands, should not prove controversial.

With regard to eligibility to receive shares, the roadmap suggests that eligibility should be restricted to those entities whose names are recorded in a land parcel register. Only the land parcel owner—whether an individual landowner, the municipal water purveyor, or the federal government—would be issued shares. That is, no tenant or lessee would be entitled to receive shares.

[38] There is considerable experience in the allocation of shares in fisheries—including a number of U.S. fisheries. An excellent summary of this experience by Wendy E. Morrison and Tara L. Scott can be found at http://www.nmfs.noaa.gov/sfa./management/allocation/morrison_scott_allocation_report.pdf.

The roadmap also suggests that shares sufficient to offset the impacts of domestic water use be issued to the cities and counties that, under the plan, are required to offset the impacts of this form of their groundwater use on other shareholders.

Sharing Formulas

With regard to the formula to be chosen, the roadmap puts forward a suggested default option for the allocation of shares that has been developed in consultation with a significant number of stakeholders.

From the perspective of land suitable for irrigation, there are two differing perspectives. The first is that allocations should be made on the basis of recent use adjusted for capacity to improve efficiency so that the sharing-system rollout does not adversely impact existing water users. The second is that allocations should be made in proportion to land area as this is what many consider the current right to be. Pragmatically speaking, think of the first perspective as an *existing use* perspective and the second perspective as an *area* perspective.

Default Sharing Formula

To assist all to understand at least one of the options and the processes that need to be followed, the roadmap contains a default formula for consideration by forming GSAs. The default suggests that, initially, the formula be skewed in favor of existing uses but be rolled out in a manner that is coupled to a process that progressively reallocates shares in proportion to land area. That is, at the start, all existing users are grandfathered in to the system in a manner that causes minimum disruption. A percentage of each shareholding is then reallocated in proportion to land area so that ultimately a proportion of all the shares are issued in proportion to land area. Under this arrangement, any land parcel owner who has yet to begin using groundwater is given an increasing opportunity to do so.

With regard to the detail necessary to determine the best way to estimate existing use, fishery share and Australian water reform experience suggest it is possible to rely on best practice water use recommendations made by an independent authority, on historical use data, preferably adjusted for the efficiency of water-using technology, or both.

In the case of the latter approach, if one irrigator is growing oranges using overhead sprinklers and another irrigator is using a much more efficient drip irrigation system, then it can be argued that the drip irrigator is entitled to more shares for having already upgraded to the use of state-of-the-art technology. This irrigator has less room to move and, arguably, has already made a contribution to the resolution of the basin's problems.

The roadmap's suggestion is that shares be allocated in proportion to the estimated maximum annual amount that would have been used in the last five years using best management practices. There are, however, many variants of this arrangement. Other equally valid approaches take the mean of the last five or so years or allow the year of lowest consumption to be dropped from the data used to determine share entitlements.

An issue of greater importance is the question of who decides on the formula to be used and what processes should be used in the lead-up to the final decision. Pragmatically, the process chosen needs to be seen as equitable and brought to closure as quickly as possible. Once all the information is in and the consequences understood, a decision needs to be made. Procrastination is unlikely to lead to a better outcome and more likely to create a sense of distrust.

In the interest of getting an efficient and politically acceptable decision, fishery sharing experience suggests that if a basin authority comes to the view that the formula choice might compromise its capacity to retain community support, it should use an independent panel to run the processes necessary to select the most appropriate share allocation formula. As drafted, the roadmap allows the basin authority to leave determination of the most appropriate share allocation formula to use to an independent panel.

A Warning

When it comes to community discussions about the question of which version of a formula to support, it is surprisingly hard for each water user to work out which version of the formula is best for them. Unless one lies at the extreme of the distribution, it is necessary to know the size and status of every entity under consideration.

When many water users are involved in a share allocation process, and they all have different histories of water use, typically one needs a computer to sort through the options and assess distributional effects. It is easy for a groundwater user to argue vigorously for one version of the many formulas under consideration and, at a later date, discover that it would have been better to argue for a different version.

Community, Environmental, and Other Special Projects

In addition to all the above features, the roadmap opens up an opportunity for a city, county, or other entity to organize to sponsor a community project. A city might, for example, decide to undertake to supply and be accountable for all the water used to maintain a football field or a privately owned park. For completeness and as it may make implementation of the entire plan administratively easier, the roadmap opens up the opportunity for cities and counties to engage in such projects.

Funding

The last issue raised in the roadmap is the question of funding. One would expect the watermaster and all authority members to be paid and have all operating and accommodation costs and other expenses reimbursed. To this end, the roadmap suggests that costs be recovered via an array of charges including charges per share, per unit of water extracted, or for every water account held. In addition, it is suggested that the basin authority charge on a cost-of-service basis.

Given the pioneering nature of the work entailed in setting up a sharing system, there may be a strong case for financial assistance from the government.[39] If there is broad interest in the pursuit of sharing systems consistent with the roadmap, then it would be preferable for the state government to fund and coordinate development of the necessary share registers, water accounting, and use monitoring systems. Primary responsibility for the ongoing funding of a GSA and any basin authority established and so on depends on the nature of the agreement among the parties that establish the GSA. SGMA authorizes a GSA to levy a broad range of fees to accomplish this.[40]

Conclusions

The above description of the roadmap has been written for the purpose of providing an overview of the design of robust water sharing arrangements. The overall structure of the suggested framework focuses on development of local knowledge and quick response capacity by all, including the state government. Unbundling and the separate management of shares (investment), volumetric allocations (production), and environmental impacts (use approvals) make it possible to manage issues at scale. For the first time, communities will be able to resolve the issues associated with each asset without disrupting other features that are essential to community functioning and vitality.

The shares system would allow for a robust drought management regime to be put in place. If implemented along the lines suggested, for the first time ever, all California groundwater users are granted the opportunity to carry unused water forward from year to year. Low-cost allocation trading becomes possible.

A mortgageable asset is also created. Share registers are guaranteed and can be expected to catalyze significant investment and innovation. A pragmatic, long-term adjustment strategy is put in place.

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[39] See http://www.waterboards.ca.gov/water_issues/programs/grants_loans/gw_funding/ and http://www.water.ca.gov/irwm/grants/sgwp/.

[40] See SGMA, Chapter 8 "Financial Authority."

TWO ILLUSTRATIVE CASE STUDIES

During development of the roadmap, we worked closely with people involved in the development of groundwater sustainability agencies in the San Luis Obispo Valley Basin, Tule Subbasin, and Kern County Subbasin. Initially, we had planned to use real data and present modeled scenarios of what a transition to a water sharing system would mean for these communities. As we progressed this work and spent time with them, however, it became clear that if we did this we would violate our own guidelines for the development of local plans.

Instead, we offer two hypothetical cases studies—one for the California coast and one for the Central Valley. Each case study reveals how different elements of the suggested sharing system can be used by potential GSAs to resolve the challenges faced by each type of groundwater-using community.

Coastal Basin Hypothetical

Overview

Attributes common to coastal basins in California include

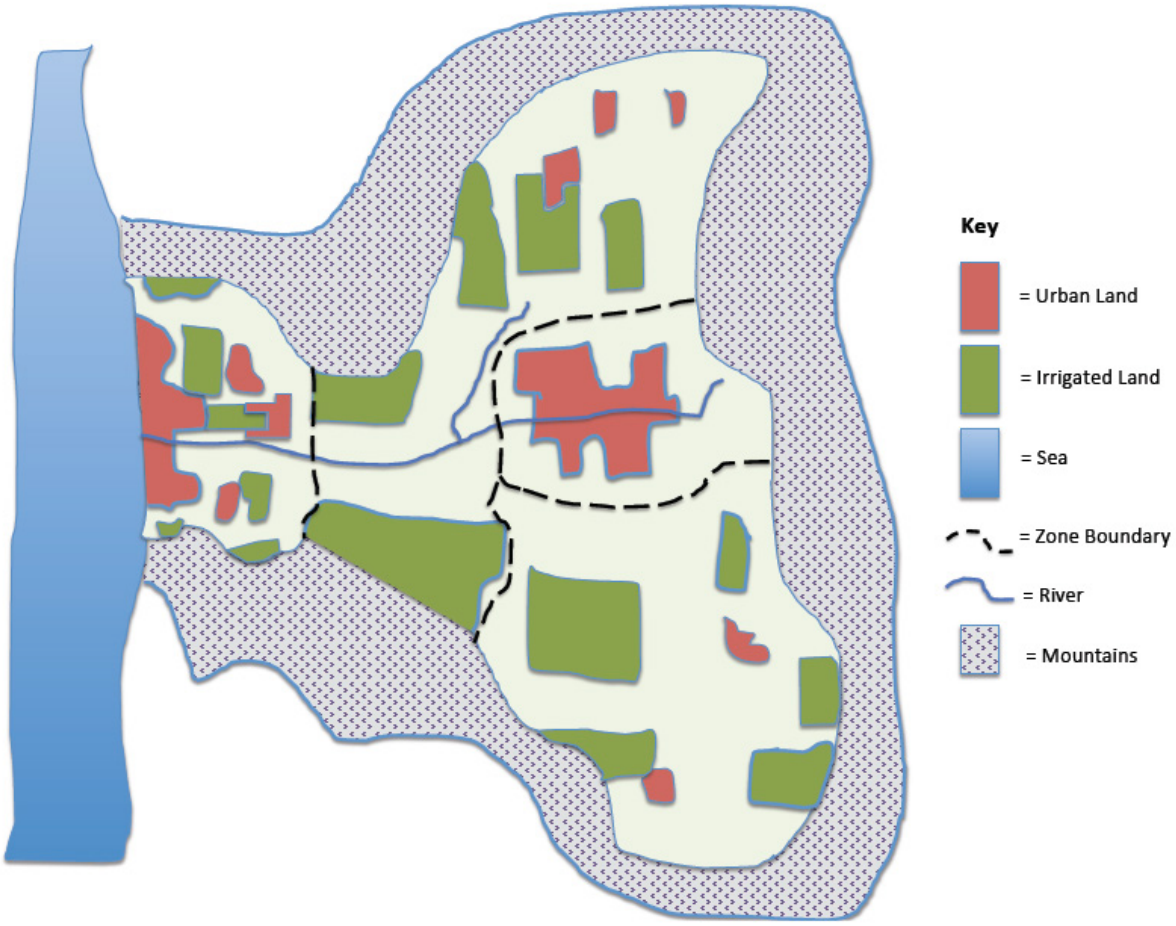
- A coastal aquifer buffering against or succumbing to saline water intrusion from the sea;
- Mixed land uses, including dense areas of urbanization, commercial development, and agricultural plots benefiting from the coastal climate;
- Surface water systems of minimal annual or ephemeral flows;
- Significant surface water imports to meet urban and industrial needs; and
- Heavy reliance on groundwater and coastal showers to meet agricultural needs.

Figure 4 presents a mock-up of a hypothetical coastal basin with a relatively simple hydrology. All groundwater flows toward the center of the basin and then, if not pumped, from the center to the sea via a coastal subbasin.

Adjacent to the sea, some high-value irrigated vineyards remain in close proximity to a growing city renowned for its beach and restaurants. Inland, there is another much larger city with a thriving community reputed for its strong connection with the wine industry. A few small towns are located throughout the basin.

Most of the basin's land is used for dryland agricultural purposes and rural living. Nearly all of the "good" irrigation land has been irrigated for many years. Given current prices and current technology, there is little further land suitable for irrigated agriculture. This is why it remains in dryland agriculture. It is common for people to live on a rural block of between one and five acres in size.

Figure 4. Simplified mockup of a typical West Coast groundwater basin



In this hypothetical coastal basin, there are three subbasins—namely, a northern subbasin, a southern subbasin, and a coastal subbasin—and a small ephemeral river that flows through the center of the basin and intermittently reaches the sea. To achieve its long-term sustainability goal, groundwater use has to be reduced by 30% from around 300,000 acre-feet to around 200,000 acre-feet. Saline water intrusion is threatening the viability of the vineyards near the sea. With the exception of land within the two cities, all land zoning is under the jurisdiction of the local county's board of supervisors.

There is an inland city and a coastal city. The inland city has a municipal water purveyor that sources 60% of its water from several wells close to the city and 40% from a dam located in the nearby hills. (During long dry periods, more is taken from the groundwater source.) It treats sewage and returns it to the aquifer via the river (very little reaches the sea). The near-urban area contains 60 households that rely on "their" domestic wells.

The coastal city sources all of its water supply from a nearby dam and is surrounded by 40 households that rely on a domestic well. Inside the city and one mile from the sea a contaminated plume of water has been found drifting slowly toward the sea.

Beyond the boundaries of each city, there are 470 "domestic" land parcels. Typically, each "domestic" land parcel is between one and five acres in area.

Using its data and the above knowledge, the Department of Water Resources identified the basin as a medium-priority basin that is not in a critical state in 2016. The target date for attaining the long-term sustainability goal is 2042.

Governance

After careful assessment of the options and several community meetings, a group of seven local organizations including the county, the two cities, and several farm organizations agreed to establish a working group to work out how to form a groundwater sustainability agency (GSA). The county agreed to support this working group, recognizing that ultimately the county itself would at least be partially responsible for the basin's administration. Luck was on everyone's side. Members of the working group got on well and enjoyed meeting on a regular basis.

After several meetings, it was decided that the county and the inland city should enter into a joint powers agreement, bring their common powers to the GSA, and enter into a memorandum of understanding with the five other organizations involved. The coastal city, which was not involved in groundwater use, decided not to be involved in the joint powers agreement. Following the passage of these agreements, the GSA was officially formed and notice posted to the Department of Water Resources.

After 90 days and no opposition from other GSA-eligible agencies, the GSA became the exclusive GSA for the basin. The GSA also gained an in-principle support from the Department of Water Resources for them to appoint a basin authority and prepare an administrative plan consistent with this report's roadmap. Encouraged by enthusiastic county supervisors and the inland city mayor, it was decided to go for the first-mover advantage that would be obtained by moving ahead of the 126 other California groundwater basins involved in the SGMA process.

Each organization was allowed to appoint two persons to the GSA on the understanding that their main responsibilities would be to appoint a chair and four other people to a basin authority and then monitor its development.

An appropriate chair and four other members with appropriate skills were soon found. The chair was a well-recognized communicator and respected leader. Everyone was pleased that this person accepted the position. After considerable discussion, it was decided to appoint a wine grower from a neighboring basin to the authority. Other members included a water lawyer with policy experience, a consulting hydrologist, and a local economist. By May 2017, a watermaster who had worked in local government had been appointed, and the task of developing and implementing the plan began.

As soon as the chair of the basin authority was appointed, she met with the working group, thanked them for their hard work, and invited them, on behalf of the authority, to form the basis of the authority's stakeholder reference panel. In retrospect, it became obvious that this decision saved the basin authority a lot of time and angst as the members of the working group held much of the information to which they needed access.

Funding

During the search for authority members and the watermaster, a proposal was submitted to the Department of Water Resources and the California State Water Board to secure the funds necessary to cover 50% of the cost of setting up and running the basin authority for its first two years. The proposal was approved and funds were disbursed from the Proposition 1A Department of Water Resources Sustainable Groundwater Planning Grant Program. The other 50% of funding came from the county in the form of office space and administrative support. All staff, it was proposed, would be employed through the county. The county also agreed to provide financial management services.

Monitoring and Accounting for Groundwater Use

Collectively, the basin authority, in consultation with their stakeholder reference panel, identified two early challenges. First, they had to decide whether or not to monitor extractions using meters or rely on the new remote satellite sensing techniques that had yet to be proven. As the basin is often covered by fog, it was decided to go with the use of smart meters. They also decided to adopt a gross accounting system in the hope that this would keep administrative costs low. Arguing that it would be

better if everyone had the same meter, it was decided also that all meters would be owned by the basin authority and the cost of installing and reading them be recovered through an annual charge on groundwater use permit holders. As a result of this decision, a number of land parcel owners immediately decided to decommission wells they were no longer using. At the same time, a letter was sent to all land parcel owners informing them whether or not the county records indicated that a well permit applied to their land.

Issuing Shares

The second issue related to the collection of the data needed to determine eligibility to receive shares and allocate them. Work on assembling the database needed to enable the issuing of shares, however, was delayed until the basin authority had finalized the rest of the plan. This, the basin authority concluded, was important as meters could not be installed on wells until the plan had been approved by the Department of Water Resources.[41]

Work on the steps involved in allocating shares started late in 2017. The first step in this process involved developing a way to align well completion reports and permits with land parcels. This proved to be a nontrivial exercise, as it was common for the water from a well to be used on several land parcels. A consultant was appointed to develop an efficient solution to this challenge and assemble the necessary data.

Coastal Zone Shares

With regard to the coastal subbasin, the coastal city had not and was not aspiring to take any groundwater as it was too salty. The coastal city did, however, decide to account for the effects of the 40 known domestic wells in its subbasin. The rest was relatively simple; the only other groundwater users were 12 vineyards and seven wineries located on each property. Pragmatically, it was decided that each vineyard would be allocated 0.8 acre-feet per irrigated acre. To make the conversion process as simple as possible, it was decided that share entitlements would be described in the same number of units as acre-feet on the understanding, of course, that shares simply represented a proportional unit of interest in the basin's water resource. Table 2 shows assessed share entitlements.

Table 1. Assessed share entitlements

Entitlement Recipient	Share Entitlements
Coastal city for domestic well offsetting of 42 wells by an estimated 1.2 acre-feet per well	50.4
Vineyard land parcel owners, 700 irrigated acres at 0.8 acre-feet per acre	560
Wineries that in the most productive year over the last five years had produced 15,000 cases at an estimated 0.5 acre-feet per 100 cases	75
Total	1,144.6

The basin authority decided that shares would be issued at a rate of 10 shares per acre-inch of share entitlement, which resulted in a proposal to issue $1{,}144.6 \times 12 \times 10 = 137{,}352$ shares.

As this announcement was made, two domestic well users who owned five acres of land each realized that the city might pressure them to either shift to the city's municipal supply or limit their total water use to two acre-feet per annum. Wanting to use more than this amount, they requested and were granted the opportunity to be issued shares in the same way as vineyard operators were to receive shares. One of them received 2.2 share entitlements and the other 3.2 share entitlements. (Two years

[41] The right to enter a land parcel and install a meter was attached to the Groundwater Use Permit and these could not be issued before the Plan was approved.

later both wondered whether or not they had made a mistake. They had forgotten to take account of the cost of having to hold a standard groundwater use permit and metering their use.)

Inland City Zone

Share allocation in the inland city zone was straightforward. Maximum groundwater use by the city's municipal water supplier in the last five years was 28,800 acre-feet, so the city accepted the offer of 28,800 × 12 = 345,000 shares. To this, the city was assigned a further 1,008 shares in light of its obligation to offset the effects of 60 domestic wells at an estimated 1.4 acre-feet per well. The higher rate of conversion for inland city wells compared with coastal domestic wells that the inland climate is drier and warmer.

Early on in the plan's development, the city fought hard to have the area it drew water from as a separated zone. This arrangement was included in the plan, but as they proceeded it became clear that this meant they alone would need to live within the limits of "their" zone.

Northern and Southern Zones

Having found the preparation of an "interim" plan relatively easy and the issuing of shares in the coastal zone noncontroversial, the basin authority began to address share allocation in the north and the south. They had hoped to proceed along the same lines, issuing shares to irrigating farmers using a standard allocation per irrigated acre and issuing sufficient shares to the county to enable them to offset the effects of domestic wells located outside the inland city.

As they had done in the coastal zone, it was decided to estimate water use on irrigated land using a set of independent estimates of water use available from a local university. For the purpose of deciding each person's conversion entitlement, it was decided to use the following recommendations:

- Irrigated alfalfa — 2.9 acre-feet per acre
- Citrus — 1.5 acre-feet per acre
- Deciduous fruit trees — 2.1 acre-feet per acre
- Vegetable production with three crops per year — 1.6 acre-feet per acre
- Grapes — 0.8 acre-feet per acre

Two unanticipated issues quickly arose. First, a number of irrigated land parcel owners had recently changed land use. Some had swapped from more to less water-intensive crops and others from less to more water-intensive crops. Second, there were large areas of nonirrigated land that parcel owners felt had irrigation potential. These landowners were arguing that they should be granted their "fair" share.

With regard to the first issue, there were several cases where land that had been used to grow irrigated alfalfa at a rate of 2.8 acre-feet per acre had been converted into vegetable production that only used 1.6 acre-feet per acre. The affected land parcel owners in both cases were furious as they were leasing their land to tenants and had swapped tenants because they could get more rent from a vegetable farmer than from an alfalfa grower. If they had known that this decision would reduce the number of shares they received, they said, they would never have agreed to do this. Eventually, it was decided that shares would be issued in proportion to assessed water use on current (not past) land use.

The other question, that of whether or not to issue shares to nonirrigating landowners, proved to be a difficult discussion. Early on, it was recognized that if there was to be no increase in total groundwater use, then every share issued to a nongroundwater user would disrupt an existing business. Community discussions identified support for the initial proposition that share allocations, at least in the short term, should not disrupt current use. Many nonusers, however, were arguing that they should be entitled to some shares. As a result, they began to lobby for the annual reallocation of 1% of all shares to landowners in proportion to area.

The issue was resolved when the community came to the view that nearly all the land suitable for irrigation was already being irrigated and that it would be unreasonable to assign shares to these land

parcel owners as they would never be able to use this water on "their" land. Their right, if it existed at all, was a paper right and not one that could ever be exercised. There were, however, a few land parcel owners who did have some land that could be developed for irrigation.

Discussions about how many shares should be issued to nondomestic non-irrigated land had another effect. As people explored this issue, it was suggested that a percentage of each shareholding could be taken from each shareholder and that these shares, instead of being reallocated in proportion to land area, could be auctioned. If this was done, a vibrant share market would be established, and the resultant revenue could be used to offset the fixed cost of running the basin authority. What could be fairer, it was said, than requiring everyone to contribute 1% of the value of their shares to the costs of running the basin authority? The idea nearly got off the ground but was killed off by the inland city, which wanted to maintain monopoly control of "its" zone. It was fearful that someone might outbid it at the auction and that it would lose its monopoly status. Ultimately, it was decided to fund the basin authority using charges similar to those set out in Annex 4 to the roadmap.

Outcomes

In retrospect, the decision to go for first-mover advantage worked. The basin secured a major role in advising other groundwater basins on ways to set up sharing systems. Several consulting businesses were established, and the region became a recognized world leader in groundwater management.

An unexpected spin-off was a rapid shift in groundwater use along the coast. Several of the vineyards there had been noticing that their yields and the quality of their fruit was in decline. Salinity levels were getting too high to grow grapes. The opportunity to set up tagged trades was discussed with them, and several grape growers decided to put such a deal together. Each was successful in locking in a commitment to allow them to always trade their water allocations inland. With these approvals locked away, they were able to move much of their production inland and allow the most saline parts of their land to be converted into resorts whose water would be supplied by the local municipality. This shift halved local groundwater demand and solved the coastal city's seawater intrusion problem.

Transition to the sharing system also made it easier to manage the plume near the coast. In 2025, when this plume was discovered, all groundwater pumping near it had to be stopped. The basin authority used its powers to do this but kept making allocations to all shareholders in the zone. Those adversely affected by the plume discovery found that selling some of their allocations to others in the basin could offset the financial impact, significantly reducing the cost of managing the plume.

During the transition, its impact on a water sharing system had two other implications. Local banks noticed that share values tended to rise, and they started to lend money using the value of these shares as security. Bank support for a transition to a sharing system quickly moved statewide. Banks had discovered that shares were easy to value and, if a borrower got into financial difficulty, much easier than land to liquidate. Many irrigators sold shares to finance improvements in water use efficiency.

The rising value of shares relative to irrigated land, however, did challenge the county commissioners, who feared that the transition to shares might erode their capacity to tax land values. For a while they considered introducing a mechanism that would enable them to define basin water shares as a form of property that could be taxed. As a result of the growth and regional development that occurred, however, they decided not to try to tax basin shares.

Population growth in the inland city raised another issue. As the inland city expanded, the city's municipal water purveyor started to source water from outside "its" zone. Accustomed to being a monopoly shareholder in the city's zone, it approached the basin authority with a view to revising the boundary. The result of starting these discussions was the reverse of what the purveyor had expected. The basin authority, now confident of its capacity to manage the basin, offered a counterproposal. It said that the city's monopoly control of a sub-subbasin was inappropriate. It was time to roll the city's zone back into the southern zone. In 2028, all the inland city's shares were converted into southern zone shares.

On several occasions, public discussions focused on the fate of the stream that flowed through the inland city. These issues were never resolved and credit never sought for the contribution that the inland city's treated effluent made to the basin, but there was discussion about the case for setting a policy threshold that would require the average maximum depth to groundwater to rise over time.

Central Valley Basin Hypothetical

Overview

Figure 5 shows the location of groundwater basins in central California that have been classified as critically overdrafted. Nearly all Central Valley basins south of the delta fall into this category.

Figure 5. Location of critically overdrafted basins in Central California

Source: http://www.water.ca.gov/groundwater/sgm/pdfs/GW_basinsCriticalOverdraft_SCentralRegion.pdf.

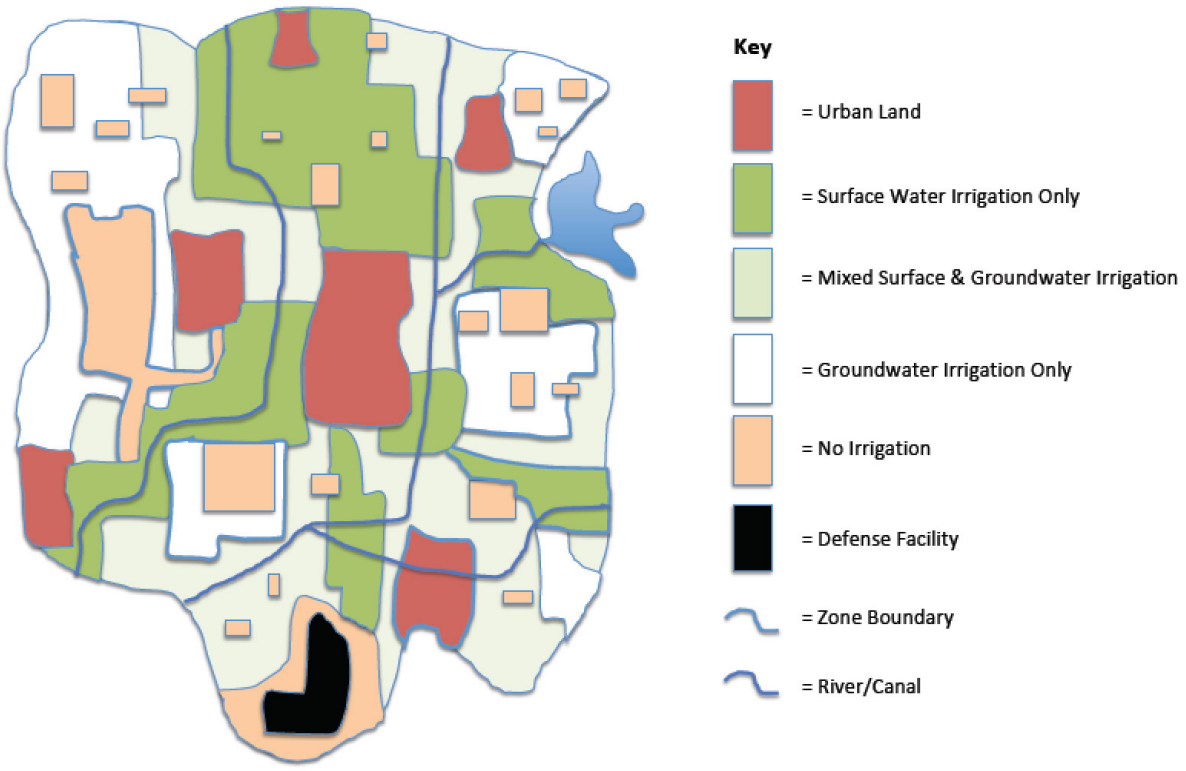
Attributes common to basins in California's Central Valley include

- Relatively large irrigation communities and cities;
- Access to both surface and groundwater, with a strong dependence on access to groundwater during drought;
- A wide variety of permanent and annual crop types;
- Large belts of near-continuous irrigation; and
- Significant overdraft that, in some areas, has led to land subsidence.

As with the coastal case study, the discussion below is hypothetical and bears no resemblance to any single basin. Our aim is to reveal the full range of challenges faced in the Central Valley and, through this, show how various features of the roadmap enable the resolution of these challenges. In our hypothetical basin (Figure 6), there are five broad land categories: (1) land never irrigated, (2) land irrigated only from a groundwater well, (3) land irrigated by a mix of surface and groundwater, (4) land that relies solely on water from a surface water supply, and (5) urban land.

There are several large cities and many small towns in the basin. One of the larger cities sources water both from groundwater and surface water. The surface water arrives from the Sierra Nevada Mountains to the east by way of the Central Valley Project.

Figure 6. Simplified mock-up of a typical Central Valley groundwater basin



In this hypothetical Central Valley basin, there are two aquifers, a confined aquifer and an unconfined aquifer. At present, the confined aquifer is used only for domestic water supply and is not being overdrafted. To achieve the long-term sustainability goal, groundwater use has to be reduced by 40% from 500,000 acre-feet to around 300,000 acre-feet. The main canal that brings water into the basin is lined, but several of the lateral ditches are not, and losses from these ditches play an important role in topping up the unconfined aquifer. Surface irrigation water is supplied to the basin through three separate irrigation districts that source their water from the Central Valley project.

A wide variety of crops are grown in the district, including alfalfa, almonds, cherries, corn, cotton, grapes, kiwi, olives, oranges, pistachios, plums, prunes, tangerines, walnuts, and wheat. In addition to

these crops, there are three large feedlot dairies and a power station that uses water for cooling. All but two vineyards have their own wineries. There is a cotton gin and 23 packing sheds.

Outside the urban area, there are 1,500 land parcels under irrigation and 200 other (nonirrigated) land parcels.

In the southern corner of the basin, the U.S. Air Force has a large defense facility that has been drawing around 1,800 acre-feet per year from the basin and that has no connection to a surface water supply.

(1) There is a small Native American community living in one part of the basin on its own land.
(2) Since 2000 and as the water table has dropped, 300 domestic groundwater users have seen their wells go dry.
(3) The three irrigation districts have been operating a water bank for the past 20 years and have six major customers who store excess surface water in the basin for later withdrawal during times of drought.

Governance and Funding

The development of governance arrangements for the basin were more complex for the Central Valley basin than they were for the coastal basin. The number of stakeholders involved was much larger, and considerable effort was put into dealing with the challenges presented by a mixture of surface and groundwater supplies, as well as the complexities of adjacent interbasin connections. Just when it looked like progress was being made, several prominent academics argued that the scale was all wrong and that it was incumbent on the counties to set up a single GSA responsible for preparing a plan for the entire San Joaquin Valley. Easily said—but, in practice, much harder to do.

Ultimately, it was decided that decisions had to be made and that it was best to start at the subbasin scale, encouraging each subbasin to follow a similar planning process and, once groundwater use was under control, find a way to bring each subbasin into an integrated planning system. “It would be foolhardy to try to do everything at once,” they said. “Each basin first has to build a system that enables the volume of groundwater each person uses to be recorded and overall use to be regulated.” The academics’ recommendation was rejected.

“Construction of a fully integrated system can wait,” it was said. “It would be crazy to attempt to do everything at once. Let’s not put the cart before the horse.”

A Basin Plan

In our hypothetical basin, the three cities, three irrigation districts, two grower organizations, the Native American community, the defense facility, and the corporation that owned the power station came together to form a GSA. As with the coastal basin, the legal structure involved the county and the groundwater-using cities entering into a joint powers agreement that would enable this entity to agree to work with the other organizations via a memorandum of understanding. The main thing that all organizations wanted was a say in who was appointed to the basin authority. They did not want any financial or legal liability.

A basin authority and a watermaster were appointed, and they quickly began work. Before starting on the plan, they soon realized that consultants should be appointed to assist the authority to work out how many zones to establish, what exchange rates to set, and how their allocation decisions might be affected by those made in other basins. As several nearby GSAs were seeking answers to the same questions, a firm was retained to provide advice to them all on a cost-sharing basis. These same GSAs also all agreed to appoint a single company to supply all the computing systems needed to build their share allocation databases and to share registers, water accounting systems, and reporting systems.

Initially, it had been hoped that the Department of Water Resources would provide the computing systems needed to establish register and water accounts, but as discussions progressed, it became clear

that the state was not yet ready to do this. “Let many flowers bloom,” the department said. They wanted local basin authorities to test alternative systems. The department did, however, agree to specify a protocol that, if followed, would enable the state to guarantee the integrity of share registers and water accounts. In practice, this had the same effect. A subsequent court case found that by approving the plan the state also guaranteed the integrity of share registers.

With the basin zone boundary and exchange rate issues resolved, a final plan was prepared and quickly approved by the department. This included an arrangement that required the department to ratify plan amendments within 30 days. When agreeing to this arrangement, the department stated that it was “very keen to give the proposed local basin authority every opportunity to succeed.”

While all this was happening, a lunch among the chairs of the boards of supervisors for Kern, Kings, Tulare, and Fresno Counties produced a suggestion that it would be better for the valley if all GSAs adopted a common share allocation formula. To this end, they would try to persuade their basin authorities to appoint an independent share allocation panel to recommend the most appropriate share allocation method to adopt.

The decision to manage the effects of one basin’s plan on all other basins worked out. There had always been a healthy sense of cooperation among the valley’s irrigation districts. As one of the county supervisors said, “People exchange information because it makes sense to do so. They don’t when they are ordered to do so. There is no need for top-down direction on issues like this. In fact, it would be counterproductive.”

Issuing Shares in the Confined Aquifer

To date, use of the confined aquifer underlying the basin had been restricted to domestic, commercial, and industrial purposes. Many were of the view that more use of this aquifer could be possible.

In recognition of these considerations and the fact that it was thought that this confined aquifer was made up largely of fossil water and knowledge about it was limited, it was decided to declare this aquifer a separate groundwater resource. Sixty percent of the shares were issued to existing users and 40% to the county for sale whenever the county thought it appropriate to do so.

Issuing Shares in the Unconfined Aquifer

The report from the independent share allocation panel was well received. The panel recommended use of a formula that, to an outsider, looked similar to the one used in the coastal basin. In essence, it recommended recognition of (a) existing users, and (b) an underlying groundwater right correlated with land area that many considered to have been established in the law.

As with the coastal basin, it was recommended that each groundwater user be given a start-up 10% allocation buffer and that, at least for the first two years, rollout of the new system should cause minimum disruption.

Differing from the coast, however, the panel recommended the collection of actual data on water use for each of the previous seven years including five before SGMA had been adopted by the legislature. This was possible as a number of the irrigation districts had been experimenting with the use of satellite imagery to estimate water use and had found it to be reliable. It was possible to use satellite imagery coupled with data held by each water district to reconstruct a historical record.

On a land-parcel-by-land parcel basis, the total amount of water used for each of the previous seven years was entered into a database and the amount of surface water that each district had supplied to that parcel subtracted. The resulting database reported on groundwater use by land parcel. Share entitlements, it was recommended, should include an arrangement based on the average proportion of ground and surface water use. At the same time, the nature of the crop and the efficiency of water use on each parcel were recorded. Data on water use efficiency and crop type proved to be important. Permanent crop irrigators with state-of-the-art drip irrigation systems argued that they deserved a

greater share allocation than those with older flood and spray irrigation systems who could make savings when they upgraded.

In addition, a way had to be found to accommodate the concerns of several irrigators who had decided to transition from growing alfalfa to growing less water-intensive almonds. Their conversion from alfalfa to almonds involved leaving land fallow for a year while a new drip irrigation system was installed and then planting trees less than a few feet tall. These small almond trees would use very little water but, when they fully grown, would use nearly as much water as alfalfa.

With all these discussions going on, the basin authority was pleased that they had left resolution of all these challenges to an independent panel. Engagement on this issue needed to be managed carefully. Highly skilled professional advice was needed.

Early in the process, the panel was made very aware that they would need to be careful when deciding how many shares to allocate to new irrigators. One of these new irrigators had purchased a large area of undeveloped land in 2014 and, in 2015, had begun converting one square mile of this land into an almond plantation. Groundwater use in the last year according to the owner was 0.3 acre-feet per acre. When the trees were in full production, however, he was planning to use 3.5 acre-feet per acre per year. The panel needed to decide if investments like this deserved nothing because the transition began after SGMA was passed or if investments like this should be recognized.

The formula recommended by the panel proposed that, initially, each groundwater user be granted shares in proportion to an independent estimate of best irrigation practice for each crop type in the hottest of the last seven years and a 10% start-up buffer allocation too.

To fairly account for differences in the age of permanent plantations, each water user would have his or her start-up buffer adjusted so that no permanent plantation owner would experience a windfall gain or loss. Owners of young permanent plantations would see their initial allocations per share increase as their trees grew. Owners of old, inefficient plantations would receive an additional top-up allocation in proportion to the maximum amount of water they used in the last seven years. These share allocation adjustments, it was recommended, should be phased out after five years.

The final part of the formula added a process that would reallocate a small proportion of each shareholding in proportion to parcel area. This final part of the formula, it was argued, recognized the underlying right but did it in a manner that did not force a sudden change. It was recommended that this reallocation mechanism only apply to the owners of irrigable land greater than five acres in area. That is, the owners on nonirrigable hills, for instance, would be excluded. After much discussion, it was concluded that 1.1% of each shareholding be reallocated in proportion to parcel area for each of the first ten years of full implementation. Most dryland landowners and those who had only been using surface water thought that this should have been around 2%.

In addition to this transition arrangement, the panel recommended that a volume of groundwater be set aside in a special reserve that could be issued on the basis of land area if a severe drought emerged during the transition period. This, the panel reasoned, would be equitable, as some landholders only use groundwater in times of extreme water shortage, and this had not happened in recent years. Until the transition had been completed, these land holders could be disadvantaged unfairly.

When presenting its final report, the panel warned all that everyone should be very careful before jumping to conclusions. To work out, selfishly, which variant of the formula was best for oneself, one either needed a computer or a mind that could keep track of 1,700 histories of water use and knew how efficient each user was and what crops each person was growing. After careful consideration, the panel's recommendations were accepted and the plan amended so that the watermaster could build the register and give everyone involved a water account.

As the watermaster started to roll out the share register, it became apparent that there were still a few unregistered wells and some people still trying to increase their entitlements by sinking new wells. As the number of unregistered wells was few, and each appeared to have been sunk a long time ago, a quasiamnesty was declared and completion permits issued for these wells. Those still trying to increase their share entitlements by pumping were told that the basin authority's decision on the formula was final.

Share allocations made to municipal water users in the basin, wineries, feed lots, dairies, fruit packing sheds, the cotton gin, and the power station proved to be noncontroversial, and in essence, shares were issued to each of them in proportion to the maximum volume extracted over the previous five years. The U.S. defense base, as it was in the bottom corner of the basin, was split off as a separate zone. Several of the people involved in the process commented that it was pleasing to see the federal government subject to the same groundwater use regulations as everyone else.

Domestic Groundwater Users

With a large, articulate, and well-organized group of domestic groundwater users in the basin it soon became clear that these users had to be fully involved in developing the plan and, in particular, in developing the arrangements that affected them directly. To this end, the authority decided to include three domestic water users on its stakeholder reference panel.

After much discussion, the cities involved convinced the basin authority that all domestic water use should be metered so that programs could be put in place to encourage conservation. There was much interest among several nongovernmental organizations on the effects that the entire sharing scheme might have on disadvantaged households.

Ultimately, these nongovernmental organizations concluded that all households, including those that rented a house, would benefit from the transition to a suite of arrangements that would bring an end to a decline in the depth of the water tables. Predictably, some domestic water users quickly began to focus on the work leading up to setting the absolute maximum depth to the water table that the draft plan proposed for each zone. The county also became interested in this number as it offered an important way to reduce the impacts of land subsidence on road maintenance costs.

Significantly, the issuing of shares to counties and cities enabled them to arrange for some domestic groundwater users to be connected to a municipal supply system at much less cost than deepening their wells. As this occurred, the county transferred the water shares being held on behalf of these domestic users to the local municipal water purveyor.

Outcomes

This Central Valley basin received international acclaim among professional facilitators. New consultation and negotiation practices were tried, and they worked. Early on, those responsible decided that it would be critical to build a sense of trust, fairness, and deep understanding of the process. This challenge was taken seriously. Some of the world's leading experts were brought in to assist with the process. There was broad acceptance of the outcome, especially among landowners who had not sunk a well but who had begun to receive shares from the reallocation process.

Three years after the sharing system was implemented, a review survey found that 90% wanted to stay with the new system and find ways to improve it.

As the new system was put in place, interest grew in the new arrangement that allowed the efficient banking of surface water. Very quickly, two of the irrigation companies applied for credit for leakage occurring from their unlined ditches. Rather than retaining this water, they transfered it to their irrigators on a pro rata basis. Each member of the basin was finding reasons to like the new system, which proved much more effective than the water banking system they had been running.

With much better information on the efficiency of water use on each parcel, a new team of irrigation technology advisors moved into the district. This generated considerable growth and optimism.

Unexpected support came from the banking sector. Impressed by the integrity of the new share registers and the competence of the local basin authority, they began to lend more money than they had been prepared to in previous years.

The banking industry also became interested in growing awareness of the ability of the new sharing system to grant landowners a permit to proceed with a new development without purchasing a water right. A mature market for both shares and allocations was established quite quickly. As a result, a few growers stopped worrying about water supply issues. Groundwater use was becoming the smart way to go as, unlike in the case of surface water, third-party court actions were rare.

Finally, with access to the surface water system and interest in storage, all the districts involved decided to move more quickly to resolve the overdraft problem at the valley level. This proved relatively easy as a number of basin authority members sat on several authorities, and a few were using the same watermaster. In 2030, serious discussion about the best way to form a locally controlled Central Valley groundwater basin authority began.

BROAD CONSIDERATIONS

Context

This working paper has focused on options for development of a generic roadmap for the sustainable management of California's groundwater resources at the local level. The roadmap presented here has been prepared primarily by those in the process of forming sustainable groundwater agencies, but a number of opportunities are available to the state of California to help expedite progress. These include helping to build trust in sharing systems, undertaking not to extinguish existing rights, and helping with the development of registers and accounting systems. Each of these statewide opportunities, however, need to be considered with care. Retention of SGMA's success is contingent on retention of a strong sense of local ownership.

Building Trust

The roadmap has been crafted so as to build a strong sense of local trust and respect. To this end, it is suggested that the role of the department be one of ratifying plans like the one attached to this report, not approving them, and that the state not be allowed to procrastinate. The suggested water accounting system in particular has been designed to enable individual water users to respond continuously to changing conditions. SGMA has a strong local emphasis. Once the department has approved the initial plan, it has suggested that amendments to plan annexes be left to a basin authority who has to, among other things, retain the support of both local shareholders and the organizations that form the GSA that appointed them.

Similarly, once an initial plan has been approved, it is suggested that the department signal that it expects local basin authorities to be both accountable and responsible for their decisions. It is therefore suggested as well that departmental approval of any proposed amendment plan to take the form of ratification necessary only to bring legal effect to the proposed amendments.

Protecting Existing Rights

A related issue is the question of what SGMA means for existing groundwater rights, which, in many areas, are unclear.

To increase confidence in the proposed water sharing arrangement, the roadmap contains a clause that, if approved, would certify that no existing water right may be extinguished or curtailed as a result of a decision to comply with this plan. State willingness to agree to an arrangement like this would do much to build confidence and trust. To this end, it may be possible for the state water board to issue a resolution to practice a policy of nonintervention in basins that are managed by the proposed sharing system with compliance upheld locally and effectively by the GSA.

Information Management

Ultimately, SGMA can be expected to bring significant long-term benefits to local communities, in light of which funding is available to assist local communities to collect the information necessary to put new systems in place. If adoption of the suggested water sharing approach is widespread, then around 100 basins will have to all establish new share registers, water accounting systems, permit registers, and client communication systems. Some of these may be most efficiently built at the local level; others will be most efficiently built once and then supplied to all.

In essence, there are two options. Either this can be left for each basin to resolve on its own or some of these steps can be managed centrally with a view to reducing costs and the emergence of systems that can be coordinated.

As a bare minimum, consideration needs to be given to the benefits of standardizing software so that the recording systems chosen enable the low-cost migration of data from one system to another—unless, of course, all basin agencies are required to use the same system. The state or counties could come together and run a competition inviting firms to offer to supply such a system by a certain date,

choose the preferred supplier or suppliers, and then contract for this system to be supplied to all GSAs that would like to use it.

Issuing Shares

When considering the nature of the registers to be built, it will be important to decide who is responsible for creating and issuing shares and allocations. Some people are of the view that, as the state created SGMA and issues water rights, it is the state that should guarantee the integrity of each share register. If the state is responsible, then market confidence would be greater if the integrity of the processes used are guaranteed by the state. For a guarantee to be given, legislation enabling basin authorities to issue shares on behalf of the state may be necessary. If the concepts suggested in this report are adopted, groundwater shares would become valuable assets worth billions of dollars at the state level.

The other view is that counties or basin authorities should assume full legal responsibility for creating share registers and the water accounting systems associated with them. If this latter path is taken, then international experience would suggest that shares will be of lesser value and confidence in the entire sharing system will be less.

Either way, there will be significant benefits to the development of a process that reduces the need for each basin authority or GSA to reinvent the wheel. Australian experience suggests that there is a strong case for standardization—especially in regions where there is surface or groundwater interconnectivity. In Australia, water share registers and most water accounting systems are computer-based and maintained by the state.[42]

Torrens Title–Like Registers

This report proposes that any register established under SGMA be built in a manner that is consistent with Torrens title land registration principles. Pure Torrens title land registration systems are not used in the United States. A few states do use Quasi-Torrens title systems—each administered by a court. These systems, however, run into problems because of the way land titles have been granted and recorded over the last few centuries. These historical problems can be avoided by starting from scratch.

In essence, a Torrens title registration system has two prime characteristics: the integrity of the register is guaranteed, and any interest not recorded on the register is invalid.

Under a Torrens title system, what you see is what you have. There is no need for any title searches and so on. There is no transaction risk.

In practice, this means that if you want to acquire a water share, for example, you contract to change the register and pay for the share as the name on the register is changed. This change will be made, however, only if all parties with a registered interest in a share agree to the change. In the case of a mortgage, for example, a bank could be expected to agree to a change only if all the money owed to it is returned to it at the time the change is made.

If California could legislate to enable the construction of Torrens title–like water registers, it would significantly reduce the cost of trading shares and, by making it possible to mortgage shares at low cost, both increase their value and, because banks would charge less, increase investment. The only loser from the development of such systems would be the legal profession, which would arguably have a lesser role to play in groundwater management. With time and if the necessary legislation is

[42] For more information on the general applicability of the Australian approach to water entitlement registers see M. Young, "Designing Water Abstraction Regimes for an Ever-Changing and Ever-Varying Future," *Agricultural Water Management* 145(2014): 32–38 and M. Young, "Unbundling Water Rights: A Blueprint for Development of Robust Water Allocation Systems in the Western United States," NI R 15-01 Durham, NC: Duke University (2015), http://nicholasinstitute.duke.edu/publications.

written with care, it would be possible for the state to start a process that enables the conversion of "old system water rights into new ones of guaranteed integrity at much less cost to all than the current adjudication methods used by the courts."[43]

Once the necessary legislation has been passed, the state could delegate responsibility for maintaining share registers to counties.

System-to-System Interaction

The last issue to raise is the question of how best to manage the effect that allocation decisions made in one basin have on other basins and the surface water systems associated with them. The roadmap's architecture does this by enabling water to be transferred from one basin to another, for shares to be moved from one basin to another, and for the boundary of any basin to be modified.

These arrangements, however, do not deal with the question of how, specifically and hydraulically, water flows from one "basin" to another. The structure of the road map is such, though, that adjacent basin authorities could come to an agreement that places limits on the extent of drawdown permitted.[44] If voluntary agreement cannot be reached, then there may be a case for the development of governance arrangements that enable water allocation decisions to be managed at the basin level.

Reforms of the magnitude envisaged by SGMA are, however, more like a journey involving many steps. This first step is to find a way to monitor groundwater use and bring it under control. Once this has been done in a manner that brings confidence and trust, the next steps should become easier. This report's roadmap is a first step.

[43] The Australian state of New South Wales has a process that enables conversion. The holder of an old system title can apply to have it converted into a new system title. To do this, people make an appropriate application that includes as much information as they can find about the land title they think they hold, and a provisional new title is issued by an appropriately trained officer. The state then conducts an appropriate search and, ultimately, the old title is formally extinguished and the provisional caution removed from the new system title.

[44] The Department of Water Resources has already laid the groundwork for such agreements in its GSP Emergency Regulations. Article 8 describes the two primary forms of interagency agreements, namely, "Interbasin Agreements" that recognize the benefit of cooperation for GSAs in hydrologically connected basins (§357.2) and "Coordination Agreements" that are necessary should multiple plans be developed to manage a single basin (§357.4). See http://www.water.ca.gov/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf.

APPENDIX: MOCKUP OF A GROUNDWATER SUSTAINABILITY PLAN FOR THE ABC BASIN

1. This groundwater sustainability plan was prepared by the **ABC Groundwater Sustainability Agency** in consultation with local water users, stakeholders, and community groups. The plan establishes a set of administrative and regulatory arrangements necessary to bring groundwater use and conservation of the **ABC groundwater resources within sustainable limits**.

2. This **ABC Basin Groundwater Sustainability Plan** is consistent with the provisions of the Sustainable Groundwater Management Act and regulations of the Department of Water Resources.

3. This plan seeks to bring use of the ABC groundwater resource within sustainable limits by 2040.[45] It does this primarily by starting the processes necessary to enable a suite of administrative arrangements and market-based regulations to be placed over existing and, as of yet, largely unregulated groundwater rights. The plan is structured in a manner that incentivizes the search for cost-effective ways to use groundwater and bring groundwater use within a sustainable range. Augmentation from surface water flows is encouraged.

4. It is anticipated that implementation of this plan will proceed in two phases. In the first phase, arrangements will be put in place to establish the regulatory and administrative systems and infrastructure necessary to bring this plan fully into effect. This will include establishing an independent authority whose members will appoint a watermaster and will be responsible for putting in place all the arrangements necessary to enable full implementation of this plan. Toward the end of this implementation phase, it is anticipated that this plan will be reviewed and, if necessary, amended so as to ensure that it can come into full regulatory effect as efficiently as possible.

5. This plan will come into full regulatory effect when the authority finalizes the proposed share allocation and makes a volumetric allocation to each share holding.

Vision Statement

Note: *Visions are best developed in close consultation with a wide range of stakeholders. Some GSAs may prefer to develop a mission statement, a charter, or both. At best, this section is illustrative of what might emerge from such a process.*

6. Water right holders, water users, and community residents in the ABC Groundwater Basin wish to ensure that groundwater use in its region (1) makes the greatest contribution possible to local, state, and national prosperity; (2) is kept within sustainable limits; and (3) has no undesirable results.[46]

7. This vision and its implied outcomes will be achieved by establishing a set of robust water sharing, allocation, and management arrangements that regulate access to groundwater.

8. It is understood that if one person wants access to a larger share of a water resource, then someone else must accept a smaller share. It is also understood that the systems put in place must impose an absolute limit on the amount of groundwater that may be consumed in any year and that, as climatic conditions change and knowledge about the aquifer improves, this absolute limit may need to be revised. These two realities need to be recognized and a system put in place to ensure that all groundwater is put to its best social, economic, and

[45] Some basins have until 2042 to achieve this requirement.

[46] A reference to national prosperity may be needed only when groundwater basins cross state borders or when surface water from another state might be used to recharge an aquifer.

environmental use. This will be achieved through the coupling of the existing water rights arrangements with a new regulatory framework. This framework is designed to encourage water users to continuously seek opportunities to improve the way water is used and invest in water-saving technologies as supply and demand changes.

9. This plan envisions a transition to a constellation of regulatory and administrative arrangements that reward stewardship, protect the ABC Groundwater Basin from undesirable results, and require fiscal prudence. The consultation and engagement processes used are intended to establish trust and confidence among groundwater users and other stakeholders. It is critical that all entities understand that knowledge about the ABC Basin will never be perfect and that water users need to have decisions affecting water supplies made in a timely manner.

Plan Framework

Note: *This section is written as a layperson's summary of what is planned and intended.*

10. To bring groundwater use in the ABC Basin within sustainable limits, groundwater users will be required to comply with the regulations established through this plan.

11. An independent, five-member basin authority will be appointed to work with a watermaster to establish a groundwater sharing system in the ABC Basin. The system will be set up during 2017 and come into full operation at the commencement of the 2018 water year.

12. A watermaster, under basin authority direction, will issue shares to all existing water right holders in a manner consistent with the final version of this plan.

13. Every shareholder will be given a groundwater account and, at the start of each water year, the basin authority will make a volumetric allocation to these accounts in proportion to the number of shares held.

14. Shareholders will be free to choose whether or not to use, save, or, by way of transfer, sell any allocations made to their water account. Adjusted only for hydrological losses, account holders will be allowed to carry forward unused water allocations from one water year to the next.

15. Share ownership will be defined by reference to the ABC Basin Share Register. Any claimed interest in an ABC Basin share shall be deemed to be invalid unless it is recorded in the ABC Basin Share Register.

16. To take water from a well, a landowner must hold a groundwater use permit, domestic groundwater use permit, or de minimis groundwater use permit. Each groundwater use permit will be linked to an ABC Basin Groundwater Account.

17. Groundwater recharge projects will be encouraged. Groundwater recharge projects will be assigned a groundwater account and allocations credited to these accounts as recharge occurs.

18. Location-specific conditions in groundwater use permits will manage undesirable local effects including seawater intrusion, cones of depression, migration of contaminant plumes, and land subsidence.

19. The integrity of the ABC Basin Share Register and water accounting system will be guaranteed by the state of California.

20. Allocations will be made to groundwater accounts on an annual basis according to rules established in an annual water allocation framework.

21. Unless exempted by holding a domestic groundwater or de minimis groundwater use permit, no legal entity will be allowed to take water from a well in the ABC Groundwater Basin unless (1) the landowner where the well is situated holds a groundwater use permit authorizing the taking of water from that well and (2) the water account associated with the relevant land parcel has a positive water allocation.

22. XYZ County and the city of EFG will be required to maintain a water account with a positive water allocation to offset the effects of their own groundwater use, domestic groundwater use community projects, and environmental projects on water supplies. If allocations per share are reduced to zero, then domestic and de minimis groundwater use will be constrained but not completely curtailed.

23. Landowners who unintentionally allow the balance of their water account to become negative have 30 days to make good. If they cannot do this, they may borrow from the next year's allocation with a two-for-one penalty. Intentional overuse will result in a three-for-one penalty and suspension of the relevant groundwater use permit until the relevant water account is returned to a nonnegative balance.

24. This plan is designed to enable water users to plan for droughts and, hence, they may not be suspended by the Department of Water Resources following the proclamation of a state emergency or local emergency because of the severity of drought conditions.

25. A mix of fees, charges, and grants will likely be used to fund implementation.

Purpose of Plan and Goals

Avoiding Undesirable Results

26. Consistent with the Sustainable Groundwater Management Act and resultant administrative decisions, the purpose of this groundwater sustainability plan is to incentivize investment in water-using activities and water use so as to avoid six undesirable results. These undesirable results or outcomes are

- Significant and unreasonable depletion of groundwater levels;
- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable land subsidence that substantially interferes with surface land uses;
- Extraction or use of groundwater that has significant and unreasonable adverse impacts on beneficial uses of surface water;
- Significant and unreasonable seawater intrusion; and
- Significant and unreasonable degradation of water quality, including the migration of contaminant plumes that impair groundwater supplies.

Sustainability Goal

27. The **sustainability goal** of this plan is to bring the **water budget** or net water withdrawals, inflows, and outflows of water into balance before 2040. This goal is to be achieved in a manner that recognizes the capacity of the basin to accommodate further drawdowns; the economic, social, and environmental consequences of transitioning to a balanced groundwater use system; consequences for surface water supplies; impacts on water quality; and changes in the demand and supply of water in the face of climatic variability.

28. The plan's sustainability objectives[47] are to

[47] Attention to undesirable results is required in legislation. The undesired seawater intrusion result could be deleted in basins not adjacent to the coast. Other goals are negotiable.

- Avoid the six undesirable results and minimize the risk that they might occur;
- Encourage economically efficient groundwater use and investment in the ABC Basin;
- Encourage water users and investors to search for ways to conserve water;
- Facilitate continuous adjustment as water supply and demand conditions change;
- Provide for opportunities for people to secure access to groundwater in a fair and equitable manner; and
- Maintain local control of groundwater management.

29. It is recognized that all people should have an opportunity to access sufficient water to meet essential household needs.

Zones

30. The regulations in this plan apply only to the groundwater resources located in the ABC Groundwater Basin as determined by the boundaries shown on the map in Annex 2.

31. To enable the effective management of this basin, the ABC Groundwater Basin shall be divided into management **zones** and **aquifers** as shown in **Annex 2,** with each zone and aquifer treated separately.[48]

ABC Groundwater Basin Authority

32. The **ABC Basin Groundwater Sustainability Agency** shall establish an independent, skills-based **ABC Basin Authority** to give effect to this plan.

33. The basin authority shall be responsible for ensuring that progress toward this plan's goals are measured and achieved in a timely manner.

34. The basin authority shall consult with the ABC Groundwater Sustainability Agency on a regular basis.

35. All decisions made by the basin authority shall be in accordance with the rules set out in this plan as constrained by the **annual allocation plan framework** in Annex 1.

36. Allocation decisions made in a manner consistent with this plan shall be final and cannot be overridden by the ABC Basin Groundwater Sustainability Agency.

37. Composition of the Basin Authority and Appointment of Members

38. The basin authority shall consist of a chair, four independent members, and a watermaster.

39. The basin authority shall appoint its watermaster, and this person shall be an employee of the organization. The watermaster shall be a nonvoting, ex officio member of the basin authority.

40. The chair and members of the basin authority are to be chosen so as to ensure that basin authority members, collectively, have expertise in

- Community leadership, engagement, and consultation,
- Policy administration,
- Water resources management,

[48] As a guiding principle, in the initial stages of this plan, more rather than fewer zones should be established. If a subsequent hydrological review finds that the amalgamation of two zones is feasible and the exchange rate for the transfer of water allocations from one zone to another is feasible, then the zones may be amalgamated and the shares in each zone converted into shares in the combined zone in a manner that does not diminish the value of any shareholding. The same logic applies to hydrologically distinct aquifers. If, for example, an unconfined aquifer is sitting on top of a confined aquifer, then shares would be allocated to each aquifer.

- Environmental management,
- Irrigated agriculture and associated water supply systems,
- Urban and industrial water supply and management,
- Hydrology,
- Water law, and
- Financial management.

41. When appointing the basin authority, the ABC Basin Groundwater Sustainability Agency shall call for applications from people interested in becoming a member of the basin authority. The agency or any person acting on behalf of the agency may approach potential candidates on a confidential basis.

42. Neither the chair nor any independent member of the basin authority may be appointed for more than five years. The basin authority chair and all independent members shall be eligible for reappointment.49 Initial appointment periods are to be staggered so as to establish continuity in knowledge at an early stage.

43. Basin authority members shall be paid and shall be entitled to have any expenses they reasonably incur reimbursed.

Quorum

44. The basin authority may not vote on any issue unless three voting members are present.

No Conflict of Interest Allowed

45. No member of the basin authority shall

- Be appointed as a representative of an interest group or an organization;
- Have a direct interest in using more than five acre-feet of water per year in the ABC Basin; or
- Hold more than 1% of the shares in any zone.

Equitable Decision-Making Processes

46. The basin authority shall consult widely with all shareholders, water users, and those people living in the basin.

47. In consultation with the ABC Groundwater Sustainability Agency, the basin authority shall appoint a community reference panel to assist it in its deliberations.

48. The basin authority shall make every effort to make and announce its decisions in a manner that gives all shareholders and all water users equal opportunity to profit from its decisions.

49. When meeting to determine or discuss how much groundwater to allocate to shareholders, to revise carryforward rules, to set exchange rates, or for any other matter likely to influence share and or allocation prices, the basin authority may meet behind closed doors.[50]

50. The basin authority shall keep minutes of its meetings and shall make the results of its deliberations available to the public in a timely manner.

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[49] A default suggestion would be to appoint the chair for five years and the other members for one, two, three, and four years. A nonbinding administrative understanding that the member only appointed for one year could expect to be reappointed for a subsequent five-year period could be communicated to candidates.

[50] If this arrangement is not possible, then an astute authority would notify all shareholders that they are about to make a decision that might affect share or allocation values. In extreme circumstances, and if the authority is unable to meet behind closed doors, it may be necessary to suspend share and allocation trading until the relevant decision has been made and announced.

51. If the basin authority chair is unable to be present at a meeting of the basin authority, then he or she may appoint any other member of the basin authority other than the watermaster to act as the basin authority's chair.[51]

Periodic Plan Reviews

52. The basin authority may commission a review of the plan at any point in time and for any reason.

53. In the six-month period before this plan comes into full effect, during the fourth year of the full operation of this plan and every five years thereafter, the basin authority shall commission an independent assessment of the effectiveness of this plan and the processes associated with it.

54. The terms of reference for the independent assessment shall require that the public be invited to suggest ways to improve the plan.

55. Within seven days of receiving the independent assessor's final report, the basin authority shall forward the assessment to the Department of Water Resources and the ABC Basin Groundwater Management Agency and make the assessment public.

56. Within 30 days of receiving the independent assessor's final report, the basin authority shall announce how it intends to respond to the assessment and, if appropriate, how it intends to involve stakeholders in a plan amendment process.

Plan Amendment Process

Note: *As drafted, only the basin authority or an administrator can commence the plan amendment process. All other organizations, including the Department of Water Resources, can only recommend that the basin authority consider amending the plan.*

57. In the process of approving this plan, the Department of Water Resources authorizes the basin authority to amend any annexes to this plan and add additional annexes to this plan.[52]

58. If the basin authority considers that there may be a case for amending this plan, it shall inform all shareholders and holders of a basin groundwater use permit that the basin authority is considering amending the plan and why it proposes to do so and shall allow at least 30 days for submissions about the nature of the amendments under consideration. During this consultation period, any person may propose that the basin authority consider amending other features of this plan.

59. Having fully considered any submissions received, the basin authority shall then decide whether or not to propose amendments to the plan. If the basin authority proposes to amend this plan, then it shall prepare and publicize its proposed **amendments** and allow at least 45 days for all stakeholders to consider and respond in writing to its proposed amendments. This consultation period shall include a public meeting with the ABC Groundwater Sustainability Agency.

60. Following consideration of any submissions received and comments made by the ABC Groundwater Sustainability Agency, and at least 90 days after providing notice to a city or county subject to this plan, the basin authority shall publish its proposed amendments.

61. If the amendment is to one of the plan's annexes or adds an annex to the plan, this amendment shall be final when a notice to that effect is published on the basin authority's website and all

[51] The watermaster is protected from being placed in a position where he or she has to defend the authority's decisions. The watermaster's task is to implement decisions made by the basin authority. In effect, the watermaster is the CEO.
[52] Annexes, when added, do not have the power to override the substantive provisions and operating rules of the plan.

shareholders and every holder of a permit has been sent an email notifying them that the plan has been amended.

62. If the amendment is to the main body of this plan, then the basin authority shall submit a copy of its revised plan to the Department of Water Resources for ratification.

63. The Department of Water Resources shall then have 30 days to either ratify the amendments or recommend further amendments to the plan.

64. If the Department of Water Resources recommends that the basin authority consider making further amendments, the basin authority shall consider the need for further revision of the plan, make the changes it thinks appropriate, and then resubmit its revised amendments to the Department of Water Resources. The Department of Water Resources must then either ratify these revisions within 30 days or refer the basin to the State Water Resources Control Board with a recommendation that it appoint an administrator to take over the basin authority's functions.

65. At any stage during the above process, if the Department of Water Resources fails to respond within 30 days, the revised plan, as amended, shall be taken as ratified.

Water Sharing, Allocation, and Accounting System

Groundwater Use Permits

Note: *Groundwater use permits are similar to development or works approvals. They would, for example, require the maintenance of a positive volumetric balance in the water account associated with this permit and specify how the volume of allocations extracted from the well will be estimated. Where necessary, they could set a maximum daily or annual pumping rate so as to prevent unreasonable rates of draw down or seawater intrusion.*

66. During this plan's start-up period, every landowner with a well shall be issued a groundwater use permit authorizing the taking of water from that well. Where appropriate, a permit may authorize the taking of water from several wells colocated on the one land parcel.

67. Groundwater use permits may be issued only to the owner or owners of land parcels recorded in the ABC County Assessor Database. Each permit shall be associated with an assessor's parcel number or numbers as appropriate.

68. Any landowner who takes or extracts water from a groundwater source or permits another person to do so without a groundwater use permit or in a manner inconsistent with permit conditions shall be regarded as in breach of this plan and the Sustainable Groundwater Management Act. That is, it shall be the responsibility of the landowner to ensure that any tenants, sharefarmers, workers, subcontractors, and so on, comply with permit conditions.

69. For any part of the basin, such as an area where there is known to be plume, seawater intrusion, or any other local effect, the basin authority shall develop a policy for the management of the effect. This policy shall include a summary of the site-specific conditions to be included in relevant groundwater use permits and arrangements for monitoring the effectiveness of these conditions.

70. All groundwater use permits shall be consistent with

- This plan;
- Local permitting agency requirements;
- ABC County regulations;

- Department of Water Resources Bulletin 74-81 and 74-90 Water Well Standards;[53]
- State and federal regulations pertaining to water use and practices that might affect water quality; and
- Requirements that any water extracted from a well be put to a reasonable and beneficial use.

71. Groundwater use permits shall be issued by the watermaster and the master version of each permit kept in a publicly accessible electronic database. Each permit shall require that

- The current well and associated infrastructure be kept safe and meet the standards set out by the Department of Water Resources and the XYZ County Local Permitting Agency at the time the well was installed;
- The taking of water from the permitted well or wells occur only when there is a positive balance in the water account linked to that permit;
- Any groundwater extracted from a well be accounted for in a stipulated manner; and
- Permit conditions may be revised whenever either this plan is revised or a land-use or technical change requires modification of the methods used to estimate net water use.

72. To allow management of undesired local effects, a groundwater use permit may set a maximum annual, monthly, or daily limit on the amount of water extracted from the well or wells covered by that permit.

Domestic Groundwater Use Permits

73. Where the estimated annual volume of water taken from a well or collection of interlinked wells on a single land parcel is less than two acre-feet per annum and used only for **domestic household purposes**, the watermaster may issue a domestic groundwater use permit instead of a groundwater use permit and exempt the permit holder from annually accounting for the volume of water used.

74. All domestic groundwater use permits shall be consistent with

- This plan;
- Local permitting agency requirements;
- ABC County regulations;
- Department of Water Resources Bulletin 74-81 and 74-90 Water Well Standards; and
- State and federal regulations pertaining to water use and practices that might affect water quality.

75. To prevent increases in domestic household use from undermining the interests of other shareholders, every five years, the basin authority shall estimate the volume of water likely to be taken by these permit holders on an annual basis and require the relevant county and cities within each zone to maintain a water account with a balance sufficient to offset the estimated quarterly impact of domestic water users in each zone. The watermaster shall deduct this estimated amount from each domestic water use account, in arrears and on a quarterly basis.

De Minimis Water Use Permits

76. Where the estimated annual volume of water taken from a well or collection of interlinked wells on a single land parcel is less than one acre-foot per annum and the use is for a nondomestic purpose, the watermaster may issue a de minimis water use permit instead of a

[53] Historically, the state of California has authorized local permitting agencies (LPAs; usually the county, sometimes others) to maintain these standards and other requirements dictated by the LPAs. The standards can be viewed at http://www.water.ca.gov/groundwater/wells/standards.cfm.

groundwater use permit and exempt the permit holder from annually accounting for the volume of water used.

77. All de minimis groundwater use permits shall be consistent with

- This plan;
- Local permitting agency requirements;
- ABC County regulations;
- Department of Water Resources Bulletin 74-81 and 74-90 Water Well Standards; and
- State and federal regulations pertaining to water use and practices that might affect water quality.

78. Unless the authority finds to the contrary, it shall be assumed that the total volume of groundwater extracted for de minimis purposes is negligible and that the costs of bring these uses into the sharing system would be greater than the benefits to shareholders that could be expected to result from the inclusion of de minimis uses.

Community and Environmental Water Uses

79. Any council or city may establish a community or environmental water project, have the project associated with a water account, and have the estimated quarterly volume of water used by this project deducted from this account in a manner similar to that used to account for the effects of domestic water users.

Permit-Issuing Process

80. Before this plan comes into full effect, all land parcel owners with a well known to ABC County shall be issued a permit entitling them to take water from their wells in a manner consistent with this plan.

81. Applications for a new groundwater use permit shall be made to the watermaster and must be made before a well is constructed.

82. Applications shall include

- The APN of the parcel with which the well shall be linked;
- The GPS coordinates of the proposed well;
- The proposed maximum daily, monthly, and annual pumping rate of the well; and
- A commitment that will allow the volume of water taken from the well to be estimated.

83. All applications for a groundwater use permit must be lodged by or on behalf of the owners of the land parcel where a well is to be located. Whenever an application is received, the watermaster shall

- Publicly announce that the application has been received;
- Notify all adjacent land parcel owners of the nature of this application;
- Notify all the holders of all groundwater use permits likely to be affected by the application; and
- Give all interested third parties at least one month to object to the application.

84. If any objections to an application for a permit are received, the watermaster shall refer the matter to the basin authority for a decision as to whether or not to grant the permit and, if granted, the nature of the conditions to be attached to the permit.

85. If it deems appropriate, the basin authority or the watermaster acting on the basin authority's behalf may refer the application to a court for resolution.

86. Any permit shall expire two years after being issued if construction on a well has not been completed.

87. All groundwater use permits shall be publicly listed by the watermaster on the website of the basin authority.

88. Unless part of an arrangement is designed to incentivize improvements in groundwater quality, permits shall not be transferable.

Water Use Accounts

***Note**: As a general rule, there are three ways to account for the volume of water used: (1) assuming that for each type of land use, a relatively constant amount of water is used, (2) metering the gross volume of water taken, and (3) estimating the net amount used by linking satellite-derived estimates of evapotranspiration with land parcel data.*

89. Groundwater use in the ABC Basin shall be accounted for using net accounting practices.

90. Every groundwater use permit shall indicate how the volume of water that has been extracted from each well shall be turned into an estimate of the net amount of water that has been used.

91. If use is metered, then every five years the basin authority shall make a zonal estimate, by type of use, of the proportion of water that returns to the zone. The resultant proportion shall be known as a **return-flow coefficient.** As water is extracted from the well, the meter's estimate of the volume extracted from the well shall be multiplied by the relevant coefficient and then deducted from the groundwater account associated with the well.

92. If use is assessed using satellite imagery and land parcel data, then the estimated net amount of water used shall be deducted from the relevant water account. The determination of the watermaster as to the net volume of groundwater used during each accounting period shall be final.

Carryforward of Unused Allocations Allowed

93. With adjustment for losses, any unused groundwater allocations in an account shall be carried forward from one allocation period to the next.

94. The use of unused groundwater allocations carried forward from one water accounting period to the next will be allowed even when water allocations per share are zero.

95. Any unused groundwater that has been carried forward is to be accounted for and managed in exactly the same manner as any other allocations made to a water account.

96. The basin authority shall, on a regular basis, make it clear to all shareholders that it is the basin authority's responsibility to manage the groundwater resource and that water users are encouraged to plan for drought and sudden changes in water demand by carrying forward unused groundwater allocations from one water year to the next.

Transfer of Allocations among Zones and out of the Basin

97. The water accounting system used to track allocations shall permit the unfettered transfer of allocations within zones.

98. To facilitate the efficient aggregation of unused allocations and their transfer from one account to another, any legal entity may apply for and hold a zone-specific groundwater account that is not linked to any shares or any permit authorizing the extraction of water from a zone.

99. Annex 3 contains rules for the transfer of water allocations between zones and may allow the transfer of allocations from a zone being managed under this plan to a zone being managed under another plan.

100. Annex 3 may contain rules that restrict the piping or pumping of groundwater allocations from one basin to another but may not prevent any arrangement that was in place on the date that this plan was approved from continuing.

101. The question of whether or not to allow the pumping and piped conveyance of water from one basin to another is distinct from the transfer of water allocations between two hydraulically linked basins; it is not a matter that the basin authority should determine. The question should be resolved by those entities responsible for approving construction of any pipeline needed to facilitate the pumping of water from one location to another.

Groundwater Recharge and Augmentation

102. Any landowner may apply for a **groundwater recharge permit** that allows them to artificially add to the volume of groundwater in one or more of a basin's zones via managed infiltration or the direct injection of surface water.

103. A water purveyor may also apply for a groundwater recharge permit that gives the purveyor credit for surface water seepage from a ditch or channel into an aquifer.

104. Annex 3 shall contain a set of look-up tables to enable an objective estimate of the volume of water that has been added to an aquifer and, as a result, becomes available for use.

105. A groundwater recharge permit shall not be issued for any activity that is expected to return less than 50 acre-feet per annum.

106. Groundwater recharge permits that authorize recharge shall require the volume of all water returned to an aquifer to be estimated using an agreed-on methodology approved by the basin authority.

107. When and as recharge occurs, the watermaster shall credit the estimated volume to the water account associated with the permit and, thereafter, the resultant allocations shall be treated in exactly the same manner as all allocations.[54]

Significant Interception of Groundwater

Note: *In Australia and South Africa, water managers have found it necessary to control land-use practices that change the amount of water that can be pumped from an aquifer. In the southeast of South Australia, for example, a landowner who establishes a timber plantation over a shallow aquifer is required to account for the water extracted from the aquifer by these trees.*[55]

108. Examples of potentially significant forms of interception include the establishment of a timber plantation over a shallow aquifer and the capture of overland flows that otherwise would have infiltrated naturally into an aquifer.

109. Where appropriate and where a recent change in land-use practice is deemed by the basin authority to be intercepting significant amounts of water that otherwise would have been

[54] Certain agencies, such as an irrigation district, may be recharging the basin on behalf of their customers. In the first instance, the water allocations would be credited to the water account associated with the land where the recharge occurs. It would then be up to the owner of that account to determine how to distribute the resultant allocations. If the land is owned or leased to the irrigation district, it first would be credited to its water account. It would then be up to the district to determine how to distribute these allocations.

[55] For more information, see M.D. Young and J.C. McColl, "Double Trouble: The Importance of Accounting for and Defining Water Entitlements Consistent with Hydrological Realities," *Australian Journal of Agricultural and Resource Economics* 53(2008):19–35.

available to shareholders, the basin authority shall notify all relevant stakeholders that it may be necessary to amend this plan and bring certain forms of water interception into the accounting system used to prevent undesirable results.

110. The basin authority may require a land parcel owner to offset the impact of a significant form of groundwater interception. Offsetting is to be achieved either by (1) requiring the deduction of allocations from a water account equivalent to the estimated impact of the interception on other water users or (2) quarantining an appropriate number of shares from the annual allocation system so that, on average, the form of interception has no adverse effect on the expected number of allocations per share.

Penalties for Unintentional Overuse

111. If the balance of any water account becomes negative and the reason for this is unintentional, permit holders shall be given 30 days to either return the account to a positive balance or elect to cease pumping until the next year and have twice the deficit debited to the opening balance of their account for the following year.

112. If the holder of the account fails to elect to cease pumping or return the account to a nonnegative balance within 30 days, the watermaster shall

- Suspend the account holder's groundwater use permit;
- Debit three times the deficit from the account holder's opening balance for the following year;
- Notify all persons with a registered interest in the associated land parcel and all adjoining land parcel owners of the actions that have been taken; and
- If appropriate, arrange for the account holder to be penalized for breaching this plan.

113. A watermaster may lift the suspension when the account associated with it is returned to a nonnegative balance.

114. If a groundwater use permit remains suspended for more than two calendar years, the permit shall be canceled and the deficit written off as a loss to the basin as a whole.

Intentional Overuse

115. If a land parcel owner permits the water account to be overdrawn by more than 5% of the average volume of water applied to that parcel in the last five years or the basin authority judges the overuse to be intentional, the basin authority may either suspend a groundwater use permit for up to five years or cancel the permit.

Announcement and Issuance of Allocations

***Note**: It is important that all stakeholders, including those who have yet to secure shares or an allocation, are given equal opportunity to profit from the purchase and sale of water allocations and shares.*

116. Groundwater that is regulated under this plan shall be allocated by water year. Each water year shall commence on October 1 of one year and end on September 30 of the following year.

117. On the first working day after September 1 of each year at 10:00 a.m., the basin authority chair shall announce the volume of water to be assigned to each share so that the watermaster can credit this amount to the water accounts associated with each share at 9:00 a.m. on October 1.

118. The board may make additional allocations during a year in a manner that is consistent with the annual allocation framework set out in Annex 1.

119. Any or all unused annual allocations recorded in a water account may be transferred to any other water account in the same management area or with adjustment for losses and time delays from one region to another.

120. The watermaster shall keep the information contained in any nonnegative water account confidential. The watermaster may reveal the name of the owner or owners of any water account that is in a negative balance.

121. The watermaster shall regularly make aggregated information about the rate of water use in each region and the basin as a whole publicly available.

122. On the first day that this plan comes into full effect, the basin authority may (1) instruct the watermaster to make an additional buffer allocation to all shareholders in any manner that is consistent with this plan and (2) set aside a reserve amount of water to be allocated to the owners of land reliant on access to a surface water resource if a severe drought occurs during any of the first 10 years after this plan comes into full effect.

Share Register

123. The State Water Resources Control Board shall establish a share register for the ABC Groundwater Basin and establish efficient ways to allow negotiated changes to be made to this share register. This register shall be accessible by any member of the public over the Internet.

124. The State Water Resources Control Board shall guarantee and maintain the integrity of the share register.

125. Amendments to the ABC Basin Share Register may be made only by persons authorized by the State Water Resources Control Board to amend this register.

Recording Financial and Other Interests

126. When requested to do so, the watermaster shall record any financial, mortgage, or other interest over shares held in a common interest in the share register. When instructed by a court, the basin authority watermaster shall record an encumbrance over a shareholding. All legal entities with a registered interest in a land parcel shall be notified of the fact that shares in the ABC Basin will soon be issued and that this may affect the value of the land presently associated with these shares.

Share Transfer Process

127. When a shareholder, with the consent of all registered financial or other interests, applies for a change of ownership, the watermaster shall authorize that the change be made to the water register in the manner requested by the shareholder and approved by all registered and other interests in the share.

128. Appropriate identity checks will be used to minimize the risk of a fraudulent transfer. All parties named on an existing share and all registered interests must approve a transfer.

129. The watermaster may not refuse to transfer shares to a third party on the grounds that a groundwater use permit normally associated with a portfolio of shares has been suspended.

Restrictions on Share Transfers

***Note**: This section has been included in this roadmap because some people involved in its development considered that speculation should be prevented. International experience would suggest that the local benefits of allowing anyone to invest in shares, typically, are greater than the costs. The transfer of water out of district, however, is a different consideration and most efficiently managed via restrictions on the transfer of allocations out of a basin. In an unbundled sharing system, it is possible*

to allow money to come in but not allow water to flow out of the district. It is recommended that restrictions on share ownership not be included in any basin groundwater sustainability plan.

130. During the first 10 years of this plan, no more than 10% of the shares in each zone may be transferred to or held by a legal entity who does not own land in the ABC Basin or who was not a landowner in the XYZ Basin when this plan was approved.

Protection of Existing Water Rights

131. Any legal entity that accepts shares or a water use permit issued as a result of the adoption of this plan shall be defined as having fully met any reasonable and beneficial use conditions associated with any right to extract or use ABC Basin Groundwater on January 1, 2015, and all actions after this date that otherwise would have been necessary to retain that right.

Initial Share Allocation

Note: *The next clause is written with a view to stop people from pumping to obtain shares. There is no SGMA requirement for the suggested date. The data collected and assessed to be used for initial share allocations should come from a time period determined by the authority. A suggestion of five years into the past is used here, but this is certainly amendable.*

The question of who is eligible to initially receive shares is very important and should not be taken lightly. In this roadmap, all potential users are included in the process.[56]

132. Consistent with the Sustainable Groundwater Management Act, from January 1, 2015, access to the ABC Groundwater Basin shall be considered closed. That is, the basin authority may determine that shares will be issued in a manner that only takes into account the nature of groundwater use and associated investment made before January 1, 2015, or such other date as the basin authority determines.

133. Under this plan, the share allocation process shall involve six steps:

(1) **Determining eligibility**. Determining who is eligible to be included in the share allocation process.
(2) **Designing the allocation database**. Determining the full range of data to be collected and considered during the share allocation process.
(3) **Assembling and validating the database**. Collecting the necessary data and validating its content.
(4) **Developing and finalizing a formula.** With due process and engagement, determining the most appropriate formula or formulas to determine how many shares each eligible entity should receive in a manner that is seen to be fair and then choosing the most appropriate formula to use.
(5) **Building the share register**. Combining the data in the database with the selected allocation formula to build the register and then inviting all who think they should have received shares to check the accuracy of this register and, if they find any error or omission, request that it be corrected.
(6) **Confirming the accuracy of the share register**. This step makes it impossible for any further changes to be made to the register because of an error or an omission.

Step 1. Determining Eligibility to Receive a Share Allocation

134. Prior to the issue of shares to landowners in a zone, the watermaster, in consultation with the State Water Resources Control Board, the ABC County, and relevant cities shall (1) make efforts through public notices, newspaper advertisements, and community outreach to ensure

[56] There is considerable controversy around this provision. It is included here so that readers can see one way of dealing fairly with land parcel owners who have made post-SGMA investments. Readers are advised to read the narratives contained in the body of this report for a better understanding of the steps in the suggested process.

that all legal entities with an interest in the ABC Groundwater Basin are aware that a six-step share allocation process is about to commence, and (2) send a registered letter to all land parcel holders in the basin informing them that the basin authority has begun building the databases necessary to enable them to issue shares and groundwater use permits.

135. Shares may be issued only to the owners of land parcels, their assigns and successors, or both who are located within a zone identified in Annex 2 and associated with land that has an assessor's parcel number in the ABC County Land Register.

136. It shall be the responsibility of the owners of each land parcel to ensure that the ABC County Land Register is correct.

137. It shall be the responsibility of each land parcel owner to ensure that the ABC County well-permitting system includes a permit for any groundwater well in the ABC Basin.

Step 2. Designing the Database to Be Used for Share Allocation

138. The basin authority shall involve the water users from each zone and the local community associated with the zone in the processes used to determine the share allocation formula and make them aware of the fact that they are in the process of building the database to be used to allocate shares.

139. Within each zone and in addition to ownership and parcel area, the database shall classify land parcels as to whether or not they have a valid well permit and if, over the last five years, the land was used for one or more of the following purposes:

- Dryland production, recreation, or conservation uses;
- Municipal and industrial water provision;
- Irrigated agriculture that is reliant on surface water only, on surface and groundwater, and on groundwater only.

140. Industrial, commercial, recreational, amenity, or conservation activities reliant on their own water supply and considered in at least one year likely to have taken more than two acre-feet or less than two acre-feet.

141. Domestic household uses reliant on their own groundwater supply and in at least one year considered likely to have taken more than two acre-feet or less than two acre-feet.

142. De minimis uses, such as wells used to supply water to livestock, that are estimated to be taking less than one acre-foot per annum. The database may recognize more than one type of water use on the same land parcel. For example, a land parcel may be used for growing grapes and contain a winery that uses significant amounts of groundwater. Land use changes made after [date] shall not be recognized.

143. For **irrigated agriculture**, the database shall include

- The types of land use occurring on a parcel so that an independent estimate of the amount of water needed to efficiently produce a crop may be made;
- The value of any groundwater- and surface water–related fees paid to an agency over the last five years;
- The estimated proportion of the parcel that is irrigable;
- An independent estimate of the amount of groundwater required to efficiently and cost-effectively use the land for its nominated purpose;[57]

[57] A number of universities periodically publish independent estimates of the volume of water needed to grow a crop to maturity in different locations.

- The proportion of the required volume of water that is likely to have been sourced from the basin;
- Any independently verifiable data on the volume of water extracted from a ground or surface water source during each of the last five years;
- The average age of any permanent plantings on the land parcel; and
- Any other measurable factors identified during a community consultation process.

144. For **industrial and commercial water users**, such as a winery or a military base, the database shall include

- The value of any groundwater- and surface water–related fees paid to an agency over the last five years;
- If possible, a verifiable or independent estimate of the volume of groundwater used in each of the last five years;
- The quantity and value of products sold in any or all of the last five years as confirmed by an income or state sales tax return;
- The average amount of water likely to be used by an efficient water user for each type of product sold; and
- The water use efficiency of the equipment being used on the land.

145. For **municipal water supplies** provided by water corporations, mutual water companies, and small community water supply systems, the database shall include

- The volume of groundwater extracted from each zone in each of the last five years;
- The number of households and businesses supplied;
- An independent estimate of the average annual amount of water each household and business can reasonably be expected to use;
- The area of parks and gardens watered by groundwater and the amount these features can reasonably be expected to use in an average year.

146. For **domestic and de minimis groundwater uses**, the database shall include an estimate of the average annual amount of groundwater used by each parcel with accounting for the proportion that is likely to return, following use, back to the zone from which it is taken and an estimate of the proportion of water used within and outside the buildings located on the parcel.

Step 3. Assembling and Validating the Database to Be Used for Share Allocation Purposes

147. As soon as the database has been built, all parcel owners shall be informed of the information that has been associated with their land parcels and given at least one month to notify the watermaster of any amendments that they believe should be made to their entry or all similar entries.

148. The authority shall be the arbitrator of which requests for amendment to the database should be accepted.

Step 4. Determining the Formula to Be Used to Allocate Shares

149. It shall be the responsibility of the basin authority, in consultation with the ABC Groundwater Basin Agency and engagement with all stakeholders, to decide on the formula to be used to calculate the number of shares to be issued to eligible landowners.

150. The basin authority may appoint an **independent share allocation panel** to consult with relevant stakeholders and recommend the most appropriate share allocation formula or formulas to be used in each zone. If it is decided to appoint such a panel, its members shall

consist of a retired judge or experienced water lawyer, an economist, a sociologist, and an irrigator or experienced member of a mutual water company without any direct interest or connection to the basin.

151. As a basis for discussion, it is suggested that the formula chosen initially should cause minimal disruption to existing land-use arrangements and that discussions begin by recognizing that this plan

- Grants each shareholder an additional 20% allocation so that users have a buffer to assist them to transition into this basin groundwater sharing system;
- Limits the rate by which the basin authority may reduce water allocations per share;
- Allows the carryover of unused water from year to year and provides that these allocations may not be taken from a water account holder even if there is a severe drought; and
- Provides low-cost opportunities for water users to transfer allocations from one account to another.

152. Recognizing these considerations and the fact that protracted negotiations are expensive, unless the basin authority determines otherwise, the share allocation formula shall

- Estimate the maximum annual volume of groundwater used over the last five years in each zone that each eligible shareholder has used;
- Allocate shares in proportion to the estimated maximum amount of water that each shareholder has used in the last five years;
- Allocate shares so that each can be described initially as an entitlement to receive in the vicinity of one acre-inch of groundwater per annum;[58] and
- With the exception of shares held by a county or city, for each of the first 10 years of this plan, transfer 1% of each shareholder's shares to a pool for redistribution to land parcel owners with more than one acre of land not used for a domestic purpose.

Step 5. Establishing the Share Register

153. Under direction from the basin authority, the watermaster shall build the ABC Groundwater Basin Share Register in a manner consistent with this plan and the share allocation formula adopted by the authority.[59]

154. At the time when any shares are issued, any registered interest recorded on a land parcel shall be transferred to the shares initially associated with that land parcel.

155. Before January 1, 2019, where appropriate and with the basin authority's prior approval, the watermaster may amend any shareholding or issue additional shares so as to correct any errors or omissions found in the database.

Step 6. Confirming the Share Register's Accuracy

156. In the understanding that the data used to build the share register may contain errors or omissions, share allocations made in 2017 shall be provisional and confirmed as final on January 1, 2019.

[58] In some zones, it may be more appropriate to issue 10 shares per acre-foot so that it is unlikely that there will ever be a need to increase the number of shares on issues.

[59] An alternative arrangement is to split shares into two classes, a permanent and a transitionary shareholding, and then phase out allocations to transitionary shares over, say, a 10-year period.

Issuing Groundwater Use Permits and Associating Them with Water Accounts

157. The authority shall issue a groundwater use permit to the owner of every land parcel with a valid XYZ County well permit that is expected to continue to use water for nondomestic or non–de minimis purposes.

158. The authority shall issue a domestic groundwater use permit to the owner of every land parcel with a valid XYZ County well permit that is expected to continue to extract water only for domestic purposes.

159. The authority shall issue a de minimis groundwater use permit to the owner of every land parcel with a valid XYZ County well permit that is expected to continue to extract water only for de minimis purposes.

160. No one other than the owner(s) of a land parcel may apply for or be granted a groundwater use permit, a domestic groundwater use permit, or a de minimis water use permit.

161. Every groundwater use permit shall always be linked to a groundwater account and, at all times, this account kept in a nonnegative balance.

162. The master copy of all permits shall be kept by the watermaster in an electronic register that is publicly accessible and may be amended by the watermaster in any manner consistent with this plan.

Basin Boundary and Zone Boundary Modification

Modification of the Basin Area

163. When the basin authority wishes to bring a new area of land into the basin, it shall first amend this plan using the plan amendment processes set out in this plan.

164. When two adjoining basin authorities wish either to amalgamate part or all of a groundwater resource, this shall be achieved by announcing the intent to transfer zones from one plan to another, making appropriate amendments to each plan and then transferring the relevant shares from one basin to another.

165. When bringing land into a basin that is not inside a region under a plan similar to this one, the basin authority shall issue shares to all landowners in the region using the procedures and, to the extent possible, the formulas used to issue shares when this plan was first finalized.

166. When bringing new land into the basin or retiring land from a basin, the board shall do so in a manner that does not reduce the interests of any existing shareholder.

Zone Boundary Realignment

167. The basin authority may realign one or more zone boundaries by amending this plan. Whenever a zone boundary is realigned, the basin authority shall act in a manner that can be expected to preserve the interests of all shareholders.

168. During the process of zone realignment, all shareholders in the zone or zones that are to be reduced in size shall be offered the opportunity to surrender their shares on the understanding that they be offered shares in a larger zone. When this process occurs, the opportunity to convert shares shall be offered first to the owners of land in the area being moved from one zone to another.

169. When realigning zone boundaries brings new land into the basin, the board shall do so in a manner that does not reduce the interests of any existing shareholders.

170. When transferring shares from one zone to another as part of a boundary realignment process, the watermaster must give any registered interests recorded on those shares one month's notice that these shares are to be transferred from one zone to another as part of a boundary

realignment and then do so only in a manner that does not diminish the value of the registered interest.

171. Shares may not be transferred from one zone or basin to another unless the transfer is part of a boundary modification process.

No Confidence in the Basin Authority or One or More of Its Members

Note: *This section of the plan is drafted to ensure that, in the unlikely event that a majority of basin authority members are dismissed, the watermaster and all the processes relating to the making of water allocations and accounting for use continue to function.*

172. Basin authority members may be dismissed if their performance is found unsatisfactory by any one or more of

- The Department of Water Resources;
- A 60% majority of the members of the ABC Basin Groundwater Sustainability Agency;
- 60% of ABC Basin shareholders by number;
- Shareholders holding more than 70% of shares in the basin as defined by this Groundwater Sustainability Plan.

173. If, as a result of a dismissal, fewer than three appointed basin authority members remain, the State Water Resources Control Board shall appoint a **basin administrator** to take over all the basin authority's functions until the dismissed members can be replaced.

Appointment of a Basin Administrator

174. If the basin authority is replaced by an administrator, that person shall have all the responsibilities and regulatory powers of the basin authority including its power to appoint or dismiss the **ABC Basin Watermaster**.

175. The basin authority or a basin administrator are the only entities that can dismiss a watermaster.

176. When an administrator is appointed, that person shall work with the ABC Groundwater Basin Sustainability Agency to appoint a new basin authority with a view to ensuring that members of this basin authority can take over responsibility for the management of this plan within six months.

Suspension of Plan during Nondrought States of Emergency

177. When the governor of California proclaims a state of emergency or local emergency, the Department of Water Resources may approve suspension of this plan provided that the reason for the state of emergency is not a drought. In the case that a state of emergency is associated with a drought, this plan may not be suspended.

Fees and Charges

178. The basin authority shall recover the costs of the services it provides to the ABC Basin through a range of fees and charges.

179. Annex 4 contains a schedule of fees and charges to be collected by the basin authority.

Legal Status and Commencement

Summary of Engagement Process Used during Development of this Plan

180. A draft of this plan was circulated to people likely to receive shares under this plan on [date] and public meetings held to discuss it on [date] and [date].

ABC Groundwater Sustainability Agency Resolutions

181. On [date] the ABC Groundwater Sustainability Agency resolved that

(1) This ABC Groundwater Basin Plan offers the most appropriate way to achieve the objectives and sustainability goal set for this basin and puts in place all the administrative and regulatory arrangements necessary to ensure that the significant and unreasonable results identified in this plan can be avoided.
(2) The Department of Water Resources approves this groundwater sustainability plan for the ABC Groundwater Basin so that arrangements can be put in place to bring this plan into full effect.
(3) The Department of Water Resources confirms that this plan is sufficient to serve as the ABC Basin's Groundwater Sustainability Plan.

_____, Chair

_____, Member

_____, Member

_____, Member

_____, Member

_____, Member

_____ Date

Approval and Acceptance of Plan for the Management and Administration of the ABC Groundwater Basin

182. Pursuant to the powers granted to the Department of Water Resources via §10723.8, the arrangements set out in this plan shall come into effect on January 1, 2017, on the understanding that an ABC Basin Authority will be established and a watermaster appointed in a timely manner and that all efforts will be made to bring this groundwater sustainability plan into effect on the commencement of the water year starting on October 1, 2018.

_____
for California Department of Water Resources

_____ Date

Annex 1. ABC Basin Groundwater Annual Allocation Framework

183. The basin authority may make allocation decisions only in a manner consistent with this annex.

Relationship among Goals, Policy Instruments, and Management Actions

184. This plan establishes six objectives and one principal sustainability goal. One or more policy instruments and management actions are needed to enable the efficient attainment of each goal.

185. **The objectives** relating to the **undesirable results** of depletion, stock reduction, subsidence, and adverse effects on surface water will be achieved by

186. Setting maximum average, preferred maximum, and absolute maximum depths to groundwater;

- Determining the maximum net amount of groundwater that may be withdrawn from each zone and triggering actions that must occur when this maximum is reached;
- Every year determining the maximum amount of water in each zone that may be assigned to shareholders for use and making this amount available to shareholders from the commencement of each water year; and
- Putting in place a robust water-accounting and use-permitting system.

187. **The objectives** relating to the **undesirable results** of significant and unreasonable seawater intrusion and degradation of water quality and plume management, in addition to setting the maximum net amount of water that may be withdrawn, will be achieved by setting zone boundaries so as to enable the efficient control of undesirable results that are location specific and placing limits on the rate and volume of water that may be taken from locations where there is a significant risk of seawater intrusion or where a plume exists.

188. The objectives relating to social, economic, and community development shall be achieved by

- Unbundling the regulatory system so that efforts to make best use of water are incentivized and the costs of reallocation kept as low as possible;
- Establishing robust, publicly accessible share registers and making it possible to transfer shares at low cost;
- Enabling financiers and others with an interest in a share to record that interest in the register and prevent the transfer of the share until that interest is cleared;
- Establishing a robust water accounting system that maximizes opportunities to adjust quickly to changing water supply and demand conditions; and
- Setting exchange rates that permit the transfer of allocations between zones.

189. **The objectives relating to domestic water** use shall be achieved by

- Implementing administrative arrangements that prevent undesired outcomes, thereby reducing the likelihood that water use will have significant undesirable impacts on opportunities for households and disadvantaged communities to access and use water, and
- Allowing any household to take up to two acre-feet of groundwater per annum from the ABC Basin on the understanding that the impact of this use will be offset by an arrangement that requires ABC County to hold and maintain a water account from which the estimated volume of water used by domestic water users will be deducted on a quarterly basis.

190. The **sustainability goal** shall be achieved in each zone by

- Setting a maximum average depth to groundwater above which the basin authority should attempt to maintain the water table and not allow each zone to pass below;
- Setting a preferred average maximum depth to groundwater that should not be passed;
- Setting an absolute maximum depth to groundwater below which the depth will not be allowed to descend;
- Requiring the basin authority to reduce annual allocations per share by at least 10% per annum whenever the average depth drops below the maximum average depth to groundwater or the preferred average maximum depth to groundwater;
- Requiring the basin authority, when the average water level in a zone drops below the absolute maximum depth to groundwater, to set allocations per share to zero with the exception of (1) domestic users who in such circumstances shall be allowed to continue to take not more than 0.5 acre-feet per annum and (2) de minimis users located on irrigated land and not able to access surface water;
- Requiring the basin authority, when making decisions on the amount of water that may be allocated to shareholders in each zone, to take account of the volume of allocation trades that it has allowed to occur from one zone to another and, hence, the need to shepherd groundwater from one zone to another.

Monitoring and Reporting Progress toward Sustainability Goals

191. Every year, the basin authority shall monitor progress made toward each of the goals and release a report showing changes or otherwise. In particular, the basin authority shall establish at least four monitoring wells in each zone and shall provide an annual report on (1) the average depth to the water table in each zone, (2) the groundwater salinity in all zones adjacent to the coast, (3) the extent of land subsidence, and (4) the movement of any known plumes.

192. In recognition of the importance of pursuing social and economic goals as well as environmental goals, the basin authority shall include in its annual report a summary of

- The total economic value of the water in each zone as indicated by the number of zone shares on issue multiplied by the annual mean price of share transfers between independent entities;
- The nature and value of allocations in water accounts;
- The volume of allocations carried forward;
- The volume of water allocations and number of water use permit holders who at the end of the year had either elected to or been forced to borrow from next year's water allocation;
- The number of permits that were suspended at the end of the year or canceled during the year; and
- Its prediction of the rate by which allocations per year will need to be reduced to bring the use of groundwater in each zone to achieve this plan's sustainability goal.

193. The annual report shall be made public and submitted to the Department of Water Resources no later than the end of the first week of February of each year.

Interim Milestones

194. The basin authority shall set interim milestones so as to enable all water users to plan with confidence. To this end,

- Every five years, the basin authority shall set an upper limit to the amount by which it may reduce annual allocations per share;
- Each shareholder, in addition to the first year's allocation, shall be issued an initial buffer allocation equivalent to 20% of the first year's allocation;

- In the first year, the total amount of water allocated to all shareholders in each zone shall not be less than 98.5% of the volume of water estimated to have been used in the last water year before this plan came into full effect;
- In the second year, allocations per share shall not be reduced by more than 1.5% per annum;
- In subsequent years, whenever the average depth to groundwater declines, the basin authority shall be required to reduce allocations per share by at least 1.5%.

Annex 2. The ABC Groundwater Basin and Zones

195. The map below delineates the boundaries of the ABC Groundwater Basin under the jurisdiction of the ABC Groundwater Sustainability Agency and the zones to be used for groundwater management and water accounting purposes.

***Note**: Insert an appropriate map here.*

Annex 3. Accounting Arrangements for the Transfer of Water Allocations among Zones, Aquifer Recharge, and Aquifer Augmentation

Note: *This annex needs to be basin specific and in some cases project specific. It sets up the exchange rates to be used for the transfer of groundwater allocations from one zone to another and between connected basins. Where appropriate, the transfer of allocations from one zone to another may involve a time delay.*

Trading Allocations within a Zone

196. The basin authority shall only allow the transfer of water from one zone to another in a manner that neither disadvantages nor favors any other water users.

197. The trade of groundwater allocations within a zone in a confined aquifer is to be on a one-for-one basis. The trade of groundwater allocations within a fractured aquifer shall be on a case-by-case basis and in accordance with guidelines approved by the basin authority.

Trading Allocations between Zones

198. The basin authority must attempt to estimate the likely impacts that interzone trading can be expected to have on the depth to groundwater in each zone and set a limit on the maximum volume of water that may be transferred from one zone to another.

199. The conversion or exchange rate for the transfer of unused groundwater allocations and the maximum volume that may be transferred per year shall be published on the basin authority's website and be publicly accessible. The table used to define the exchange rates to be used shall take the form of the table set out below.

200. Transfers shall be made on a first come, first served priority basis. Multiyear approvals may be granted on the condition that the watermaster is authorized to and does make them on the first day of a water year.

201. To protect the interests of all shareholders and, in particular, to prevent a rush to take advantage of a sudden change in conditions, the basin authority may suspend interzone trading if, in its opinion, further transfer of allocations from one zone to another would have an adverse effect on the interests of other shareholders.

202. On the day that this plan comes fully into effect, the exchange rate for moving water allocations from one zone to another shall be as shown in Table A3.1.

Table A2.1. Sample exchange rate for moving water allocations

Source	Target			
	Zone 1	Zone 2	Zone 3	Zone 4
Zone 1	1	0.0	0.0	0.0
Zone 2	0.9	1	0.0	0.0
Zone 3	0.0	0.85	1	0.0
Zone 4	0.0	0.6	0	1

On the day that this plan comes fully into effect, during any water year the maximum volume of allocations that may be transferred from one zone to another shall be as shown in Table A3.2.

Table A3.2. Sample maximum volume of allocations

Source	Target			
	Zone 1	Zone 2	Zone 3	Zone 4
Zone 1	No limit	0.0	0.0	0.0
Zone 2	200	No limit	0.0	0.0
Zone 3	0.0	300	No limit	0.0
Zone 4	0.0	50	0.0	No limit

203. The basin authority may not retrospectively modify an exchange rate or revise the maximum volume of allocations that may be transferred from one zone to another in any water year.

Aquifer Recharge and Augmentation

204. The basin authority may, on a project-by-project basis, authorize the watermaster to periodically credit the recharge or augmentation of an aquifer at the rates shown in Table A3.3.

Table A3.3. Percentage of metered volume of water to be credited to relevant water account, by project

Project No.	Percentage of water
1	Y1%
2	Y2%
~	~
n	Yn%

Annex 4. Fees and Charges

205. The charges set out below may be modified by the basin authority on an annual basis.

206. No charges shall be set for the initial establishment of water accounts and the issuing of shares at the commencement of this groundwater sustainability plan.

Table A4.1. Share register charges

Action	$ per
Confirm the ownership of a share and the registered interests associated with it	Shareholding held in a common interest
Registration of a financial interest	Registration
Removal of a registered financial interest	Registration
Change in ownership in a shareholding with no registered financial interest and not involving the management of the transfer of money	Change in ownership
Change in ownership in part or all of a shareholding with a registered financial interest or confirmation of parties that they have received appropriate payments	Change in ownership
Registration of a lease for a limited period of time	Registration
Change in the water account associated with a shareholding	Change
Subdivision of a shareholding involving a financial interest	Subdivision
Change to the water account linked to one or more shares in the register	Change in water account

Table A4.2. Annual water resource management charges

Charge	$ per
Fixed annual water resource access	Share
Resource use monitoring	Well
Water use accounting and monitoring	Acre-feet allocated to each shareholding

Table A4.3. Water account charges

Action	$ per
Establishment of a water account	$0
Annual charge for maintenance of water account (all landholdings with a groundwater use permit must hold a water account)	Account
Manual transfer of water from one account to another	Transfer
Cancelation of a water account	$0

Table A4.4. Groundwater use permit charges

Action	$ per
Application for a permit	Application
Amendment of a permit requested by user	Amendment
Cancelation of a use approval	Cancelation
Amendment of use approval so as to retain consistency with this plan and related land- and water-use controls	Cancelation

ANNEX 5. Glossary of Terms

Note: *This glossary is an early working draft. More work is needed on its content.*

absolute maximum depth to groundwater: The threshold depth to groundwater at which all allocations to shareholders in a zone must cease.

allocation: A volume of water credited to a water account and made available for extraction, transfer to another water account, and carryforward to subsequent water years with adjustment for hydrological losses.

basin administrator: An individual appointed to take over the functions, powers, and responsibilities of the basin authority.

basin authority: A five-member body responsible for the scheduled achievement of the plan's objectives, implementation, and amendment.

basin share register: The only place where a person may go to find out who is the legal owner of each and every share in a zone and what fiduciary interests in a share exist.

de minimis groundwater use permit: A permit authorizing the registered owner of a land parcel to extract water from a well or a group of wells for livestock and other purposes at a rate of less than one acre-foot per year.

domestic groundwater use permit: A permit that authorizes the owner of a land parcel to extract and use groundwater from an approved well or group of wells for cooking, cleaning, hygiene, and reasonable outdoor watering purposes at a rate of less than two acre-feet per annum.

exchange rate: A conversion rate set by the basin authority to be used when transferring groundwater allocations from one zone to another.

groundwater recharge permit: A permit authorizing the artificial recharge of an aquifer and the crediting of the volume of water returned to a nominated water account.

groundwater use permit: A permit setting out the conditions that owners of land parcels must comply with when extracting or authorizing one of their nominees to extract water from a well or a group of wells colocated on the land parcel.

independent share allocation panel: An independent group of people appointed by the basin authority to manage the processes necessary for a basin authority to identify the most appropriate formula to use when allocating shares.

land parcel: A delineated area of land associated with an assessor's parcel number.

landholder: The named owner or owners of one or more land parcels.

maximum average depth to groundwater: An average depth to groundwater in a zone that the basin authority should seek to keep water levels above.

preferred maximum depth to groundwater: The depth to groundwater that, if reached, can trigger a significant reduction in allocations to each shareholder.

return-flow coefficient: The determined proportion of water applied to a land surface that returns to the basin area through infiltration in a specified zone.

share: A perpetual or ongoing entitlement to a share of all allocations made by a basin authority to a zone. Each share is numbered and is associated with a water account to which all allocations are made.

shareholder: The named owner of a share or group of shares in a basin share register. A shareholder is, by necessity, given a water account to which annual allocations of water per share are made.

sustainability goal: The objective of bringing the water budget or net withdrawals, inflows, and outflows of the basin into balance by a specified date.

Sustainable Groundwater Management Act: A three-bill package (AB 1739, SB 1319, and SB 1168) signed into California state law in 2014.

water use account: An account of guaranteed integrity that records the number of allocations that are held by the account owner and how any allocations credited to the account have been used, carried forward, or transferred to another account. Accounts may be linked to a shareholding or a groundwater use permit. They may also be held at arm's length from any shareholding or permit.

water year: A year-long period during which allocations made to water accounts at the beginning of that period maybe be used in full. When transitioning from one water year to the next, allocations remaining in water accounts from the previous year may be carried over into the next with adjustments for losses.

watermaster: A nonvoting, ex officio member of a basin authority who may be appointed or dismissed by the basin authority or administrator.

zone: A delineated part of a basin for which the basin authority shall announce the aggregate amount of water to allocate to shareholders in a management area and then, to the extent hydrologically possible, allow the 1:1 transfer of these allocations from one water account to another.

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