A Review of Groundwater Sustainability Plans in the San Joaquin Valley

Public comments submitted to the California Department of Water Resources
May 14, 2020

Ellen Hanak, Jelena Jezdimirovic, Alvar Escriva-Bou, and Andrew Ayres[1]

PPIC Water Policy Center
500 Washington St., Suite 600
San Francisco CA 94111

1. Introduction

The San Joaquin Valley—California's largest farming region—has the largest groundwater overdraft in the state. This makes the valley ground zero for implementing the Sustainable Groundwater Management Act (SGMA). PPIC has done extensive work on what SGMA means for this region, including analyzing promising solutions to bring basins into balance.

We recently reviewed the 36 new groundwater sustainability plans (GSPs) in the region's 11 critically overdrafted basins. Our goal is to help build shared understanding of how well these plans tackle several core objectives: assessing the extent of groundwater overdraft; developing a realistic portfolio of projects and management actions to close this gap by 2040; and effectively addressing undesirable results of overdraft, with a focus on dry drinking water wells and land subsidence.

Here we provide some highlights from this analysis, and some suggestions for DWR's own review of these plans, as well as several priority actions the state can take to support effective SGMA implementation. At the end, we provide links to a series of short articles that provide further details, along with related data sets. To provide some context, we begin with a brief summary of key findings from our earlier research.

We appreciate the opportunity to share these observations, and would be happy to follow up as needed.

2. Background: Key findings from PPIC's earlier research

In *Water and the Future of the San Joaquin Valley*, we estimated that the region's annual groundwater overdraft for the 1988-2017 period was nearly 2 million acre-feet (maf), or 11% of net water use. As the region's main water user (nearly 90% of net water use), the agriculture sector will need to lead on adaptation efforts. About a quarter of the deficit could be met by augmenting water supplies at a cost farmers can afford—mainly by expanding groundwater recharge efforts. The balance will likely need to be met by managing demand—i.e., using less groundwater.

How the region implements these strategies has major implications for the regional economy. In particular, flexible demand management is key to minimizing negative impacts on the economy. We estimate that water trading can significantly lower the costs of managing demand—by enabling water to go to the most productive farmlands. Figure 1 presents several economic measures of SMGA impacts, including changes in crop revenues as well as GDP and jobs generated on farms and in related food and beverage processing. Local trading of both

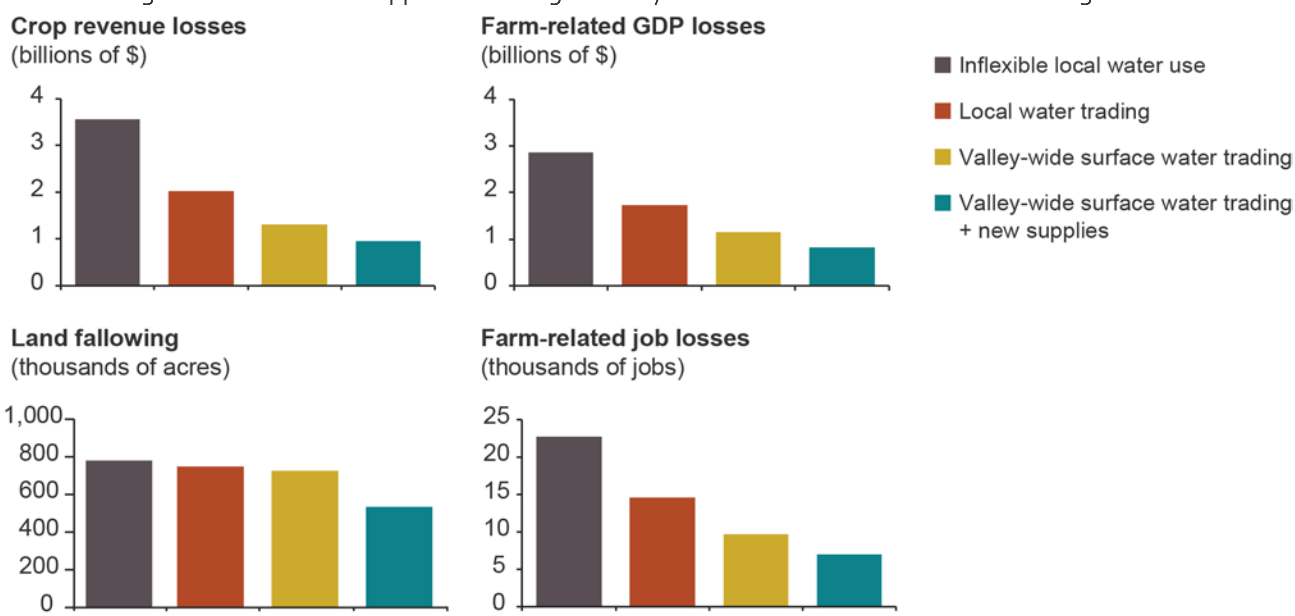
[1] Author contact information: hanak@ppic.org; jezdimirovic@ppic.org; escriva@ppic.org; ayres@ppic.org

groundwater and surface water within basins can reduce the costs of adjustment by about 40 percent, and expanding surface water trading across basins within the region can reduce costs by about 60 percent. A portfolio of water trading plus investments in cost-effective new supplies can bring costs down to less than one-third the level they would be with no new supplies and inflexible water management. Augmenting supplies can also reduce the amount of land fallowing required to end overdraft from roughly 750,000 to 535,000 acres.

Successful implementation of this mixed portfolio will require substantial coordination among parties both within and across basins—both to develop water trading and recharge agreements and to expand shared infrastructure needed to support these actions, such as regional water conveyance. Although SGMA has brought many parties together for groundwater sustainability planning, institutional fragmentation will pose challenges to developing the level of coordination required.

FIGURE 1

Water trading and cost-effective supplies would significantly reduce the economic burden of ending overdraft



SOURCE: Updated by the authors using data and methods described in Technical Appendix C of *Water and the Future of the San Joaquin Valley* (Medellín-Azuara, Escriva-Bou, and Jezdimirovic, 2019).

NOTES: Estimates of regional farm-related GDP and job losses include crops and several downstream sectors that depend on crops as inputs, including dairy, beef, and food and beverage processing. For crops, beef, and dairy, these estimates include direct farm employees and contract labor.

3. How realistic are the plans' assessments of groundwater overdraft?

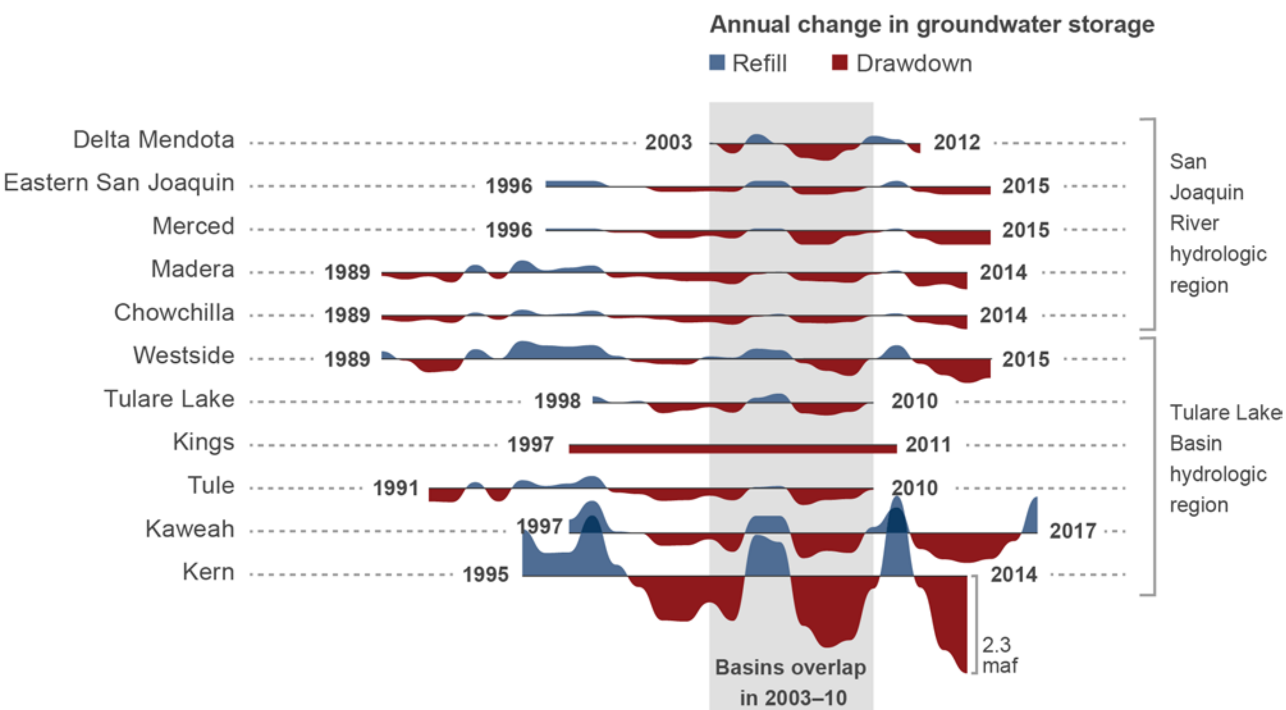
The regulations require groundwater sustainability plans to include three types of water budgets—historical, current, and projected—but allow substantial flexibility on the specifics. Historical budgets only need to include 10 continuous years of data, including the most recent years available for that basin. Current budgets need to show present-day conditions, and projected budgets need to look ahead 50 years and consider anticipated changes in population, climate, and other factors that could affect water supplies and demands. The plans can then choose which budget to emphasize for addressing overdraft.

Timeframes used to estimate overdraft vary widely across basins

In basins with multiple GSPs, the plans must use a common timeframe and a common overall budget. But there's no requirement for consistency across neighboring basins. Figure 2 shows the budget timeframes that the valley's plans use for their preferred estimates of overdraft. These timeframes vary widely. Basins in the wetter northern part of the valley (the San Joaquin River hydrologic region) are more likely to include the recent drought than are the basins in the drier, more groundwater-dependent southern valley (the Tulare Lake Basin hydrologic region). Budgets with more wet years will look more favorable than budgets with more dry years.

FIGURE 2

Timeframes used to estimate overdraft vary across basins



SOURCE: Jezdimirovic et al. (PPIC Blog, March 11, 2020). Author estimates based on groundwater sustainability plans submitted to the Department of Water Resources. For details, see data set: PPIC San Joaquin Valley GSP Water Budgets.

NOTES: Maf is million acre-feet. The figure shows timeframes used for estimating preferred water budgets. In the Kings basin we report average overdraft for each year, since estimates of annual change in storage were not available. In the Merced basin the preferred water budget used a shorter timeframe (2006–15) than the period shown here.

Plans acknowledge significant overdraft…

As Figure 3 shows, the plans report a considerable amount of overdraft—around 1.4 maf per year. But since they cover different timeframes, it's misleading to simply add up the totals reported. To compare apples to apples, we looked at the eight years that are included in all of the budgets: 2003–10. This short period is instructive, because it includes both wet and dry years. The plans estimate around 1.7 maf of annual overdraft in these years—fairly close to our valley-wide estimate of 1.9 maf for the same period. Overall, the plans are telling a story that is broadly consistent with the regional water balance in this period. This comparison also reduces the wet-year bias in many of the Tulare Lake Basin budgets.

…but some basins are likely underestimating the problem

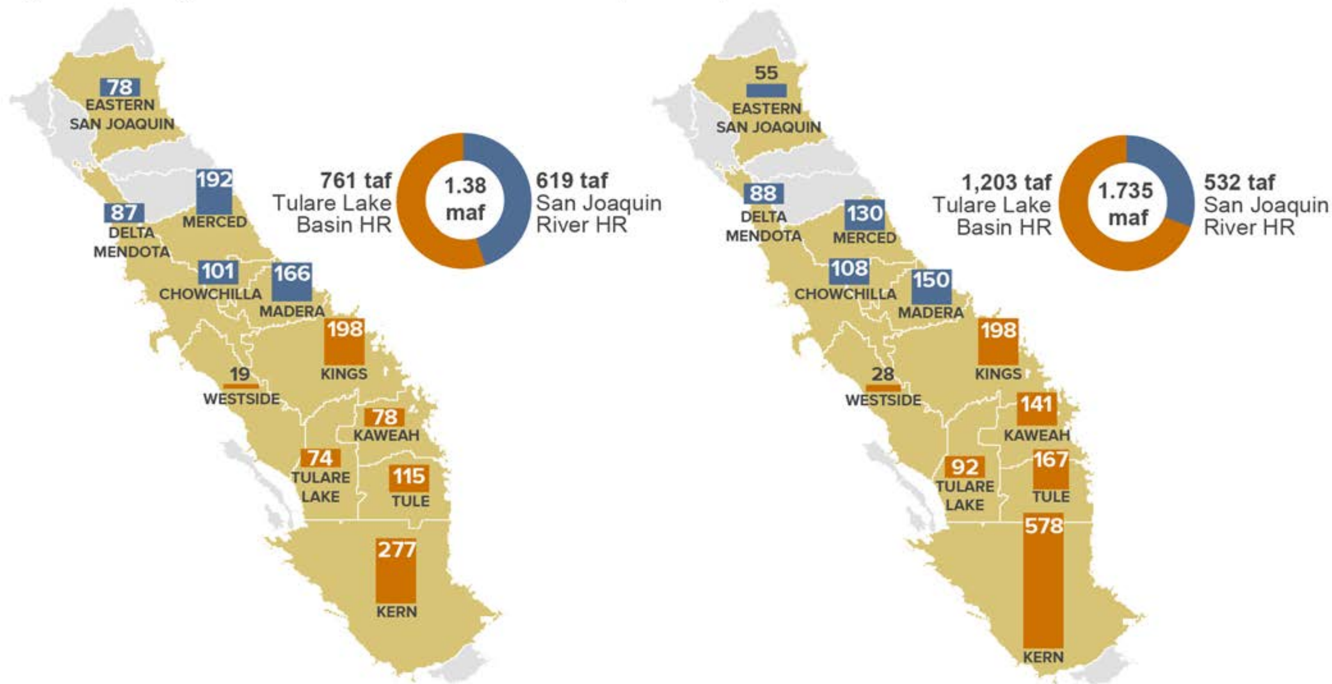
Even so, some basins—including those that do not cover the recent drought—are probably underestimating overdraft. And if the future is drier than the past, the overall challenge for the valley could be greater. We found, for instance, that the region-wide overdraft for 2003–17 (a period that included a record-breaking five-year drought) was 2.4 maf/year—a good deal higher than the 30-year average of 1.8 maf.

FIGURE 3

Plans acknowledge significant overdraft

A) Plans' preferred estimates of overdraft (years variable)

B) Overdraft recalculated from the plans (2003–10)



SOURCE: Jezdimirovic et al. (PPIC Blog, March 11, 2020). Author estimates based on groundwater sustainability plans submitted to the Department of Water Resources. For details, see data set: PPIC San Joaquin Valley GSP Water Budgets.

NOTES: HR is hydrologic region. Maf is million acre-feet, taf is thousand acre-feet. Most plans use historical or current budgets for their preferred estimate of overdraft. The Eastern San Joaquin basin uses a higher, projected number. In several basins with multiple plans (Delta Mendota, Tule, Kern) there are some discrepancies for the total preferred estimates of basin overdraft.

4. How realistic are the plans' proposals to end overdraft?

SGMA requires water users to bring their groundwater basins into long-term balance over the next two decades. Although there are no easy solutions, the math is simple: bringing these basins into balance will require expanding water supplies, reducing water demands, or a combination of these two approaches. Plans must present quantitative estimates of the anticipated yield from water supply projects and demand management actions needed to address overdraft.

Plans present solutions that would more than address the anticipated level of overdraft…

Most plans follow these SGMA requirements (exceptions include the Merced basin, where the plan does not estimate the yield of supply projects; and Tule, where several plans are vague on how they will fill the gap between projected supplies and overdraft). In aggregate, the plans present over 2.2 maf/year of supply and demand solutions—more than enough to address the level of overdraft they are anticipating.

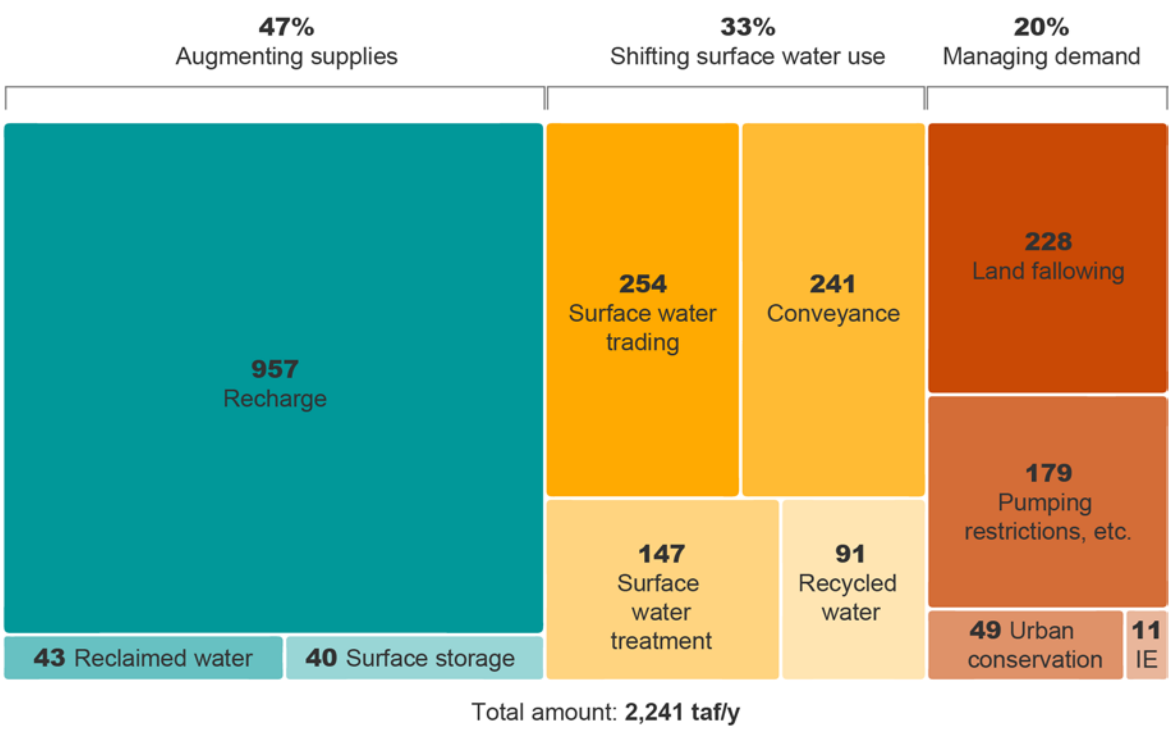
… but they emphasize solutions on the supply side, and relatively little on the demand side…

The plans assume that new supplies will fill more than three-quarters of the total overdraft gap in their jurisdictions, while demand management will save less than one-quarter. This is the inverse of our estimates, which considered both the costs and the amount of water that might be physically available from a wide range of sources. We found that it would be difficult to increase supplies by more than half a million acre-feet (See Chapter 2 in *Water and the Future of the San Joaquin Valley*).

…and the supply numbers do not add up

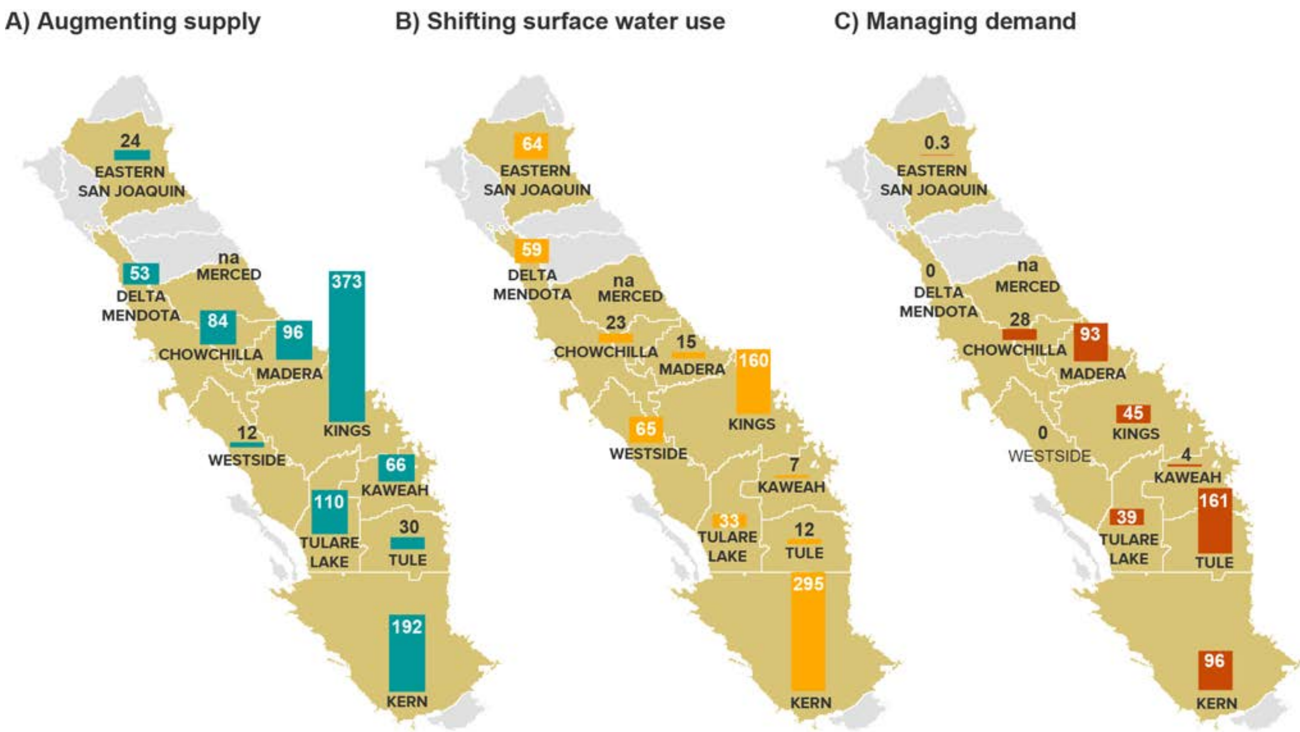
The supply solutions can be broken into two groups—projects that would augment overall supplies available in the region, and projects that would shift surface water supplies from one water user to another (Figure 4). Most basins look to both kinds of solutions (Figure 5). At the regional scale, neither category reflects a realistic assessment of the potential for these solutions to end overdraft.

FIGURE 4
Plans' overdraft reduction portfolios emphasize accessing new supplies



SOURCE: Author estimates based on groundwater sustainability plans submitted to the Department of Water Resources. For details, see the data set: PPIC San Joaquin Valley GSP Supply and Demand Projects.
NOTES: The amounts are shown in thousand acre-feet per year (taf/y). IE is irrigation efficiency. The pumping restrictions category also includes groundwater allocations, water metering, pricing incentives, and groundwater trading. Reclaimed water includes desalinated brackish groundwater and water produced by oil extraction.

FIGURE 5
Portfolio approaches vary across basins



SOURCE: Author estimates based on groundwater sustainability plans submitted to the Department of Water Resources. For details, see the data set: PPIC San Joaquin Valley GSP Supply and Demand Projects.

NOTES: The amounts are shown in thousand acre-feet per year (taf/y). Estimates of volume for projects were not available in Merced. For the Tule basin, the list of projects is downloaded from the Basin Setting appendix, which listed groundwater sustainability agency projects for inclusion in the projected water budget modelling. We assume that the full size of demand management for Pixley ID and Lower Tule River ID is the historical overdraft in those agencies, though this is not explicitly stated in the appendix.

The "augmenting supply" category includes nearly 1 maf of groundwater recharge, plus small amounts of surface storage and reclaimed brackish and oilfield water. The emphasis on recharging groundwater basins with unclaimed floodwater is consistent with our finding that recharge is the most promising new supply option. But the anticipated volumes do not appear realistic. Although this total might be physically available for recharge, there are serious capacity constraints to getting this water underground. A central challenge is moving very large volumes of water to storage sites quickly. Addressing this challenge is likely to require regional investments in conveyance, and greater efforts to coordinate the management of surface and groundwater storage infrastructure in order to expand their combined impact—actions not now anticipated by the plans. Even then, it is probably not feasible to capture all available water in very wet years. So water users will be competing for floodwater that can be feasibly captured—likely a much smaller volume.

The "shifting surface water use" category includes surface water trading, local conveyance projects to extend or expand surface water deliveries, water treatment projects to enable urban areas to shift from groundwater to surface water, and recycled wastewater projects that redirect water that was contributing to downstream supplies or groundwater recharge to other users. These projects would generally increase the supplies within an individual GSP's territory without changing the region's (or in some cases the basin's) water balance. Our analysis shows that shifting surface water use can be an important tool for reducing the costs of SGMA implementation. But plans need to account for these transfers on *both* sides of the equation, and there is little evidence that they considered the "minus" side—that is, subtracting water from the balances of the places that would be supplying it.

Few plans explore incentives for more flexible demand management

For the most part, the plans fall short on their analysis of demand management. Since reducing water use in this region largely means reducing the amount of irrigated cropland, there's been reluctance to seriously consider the demand side at this early stage of SGMA implementation. And most plans that acknowledge the need to manage demand do not yet consider flexible tools that could reduce the economic costs—for example, groundwater trading, fees tied to volumes pumped, and monetary incentives for land fallowing.

5. How well do plans address undesirable results?

GSPs must show how they are avoiding six undesirable results of excess groundwater pumping: lowered water levels, reduced water storage, seawater intrusion, degraded quality, land subsidence, and surface water depletion (which can affect both downstream surface water users and groundwater-dependent ecosystems). Groundwater sustainability agencies (GSAs) must set minimum thresholds to avoid effects that are "significant and unreasonable," which can vary with local conditions, or develop programs to mitigate these effects.

We reviewed how the plans address two important undesirable results within this region—the lowering of water levels, which has caused shallow drinking water wells to run dry; and land subsidence, which is damaging critical infrastructure. While plans in some basins are making strides in addressing these concerns, others still have major gaps.

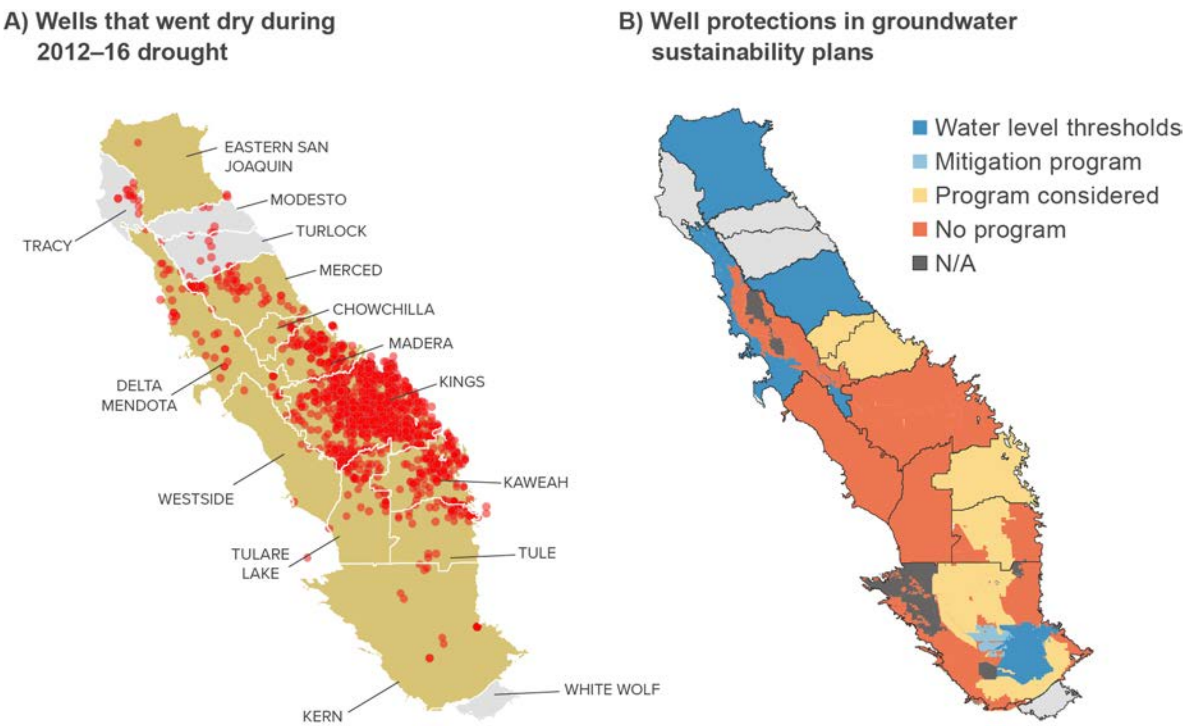
Many plans do not consider protections for domestic wells

In the San Joaquin Valley, groundwater is the primary source of drinking water. While groundwater levels in the valley have generally been declining for decades, the problem of overdraft—which can cause shallow wells to run dry—is particularly acute during droughts as surface water supplies for irrigating crops are limited. This especially affects domestic wells and small community wells, which tend to be shallower than those used for irrigation or large urban water systems. During the 2012–16 drought, 2,600 well-dependent households reported water shortages across the state; almost 80 percent of these were in the San Joaquin Valley. We estimate that the valley's total number of dry domestic wells was likely higher (Figure 6, panel A). Many small community wells also faced shortages.

In several basins, plans set water level thresholds to protect domestic wells from going dry (Figure 6, panel B). Some other plans acknowledge that their thresholds might cause some wells to go dry, and they already have a mitigation program in place or propose considering mitigation in the future. Plans in the remaining basins either do not discuss the potential impacts their thresholds have on domestic wells or do not consider these impacts to merit action. This includes the Kings Basin—home to a dense network of well-dependent communities—where three plans acknowledge that roughly 600 domestic wells may go dry, but do not consider this a significant and unreasonable impact of continued overdraft.

FIGURE 6

Many plans do not consider protections for domestic wells



SOURCES: Jezdimirovic et al. (PPIC Blog, May 14, 2020). 2012–16 dry domestic wells: author estimates based on well completion records and groundwater elevation data downloaded from the Department of Water Resources. Domestic well protections: author estimates based on groundwater sustainability plans submitted to the Department of Water Resources.

NOTES: Analysis of dry domestic wells includes wells built after 1981; excludes wells where groundwater elevation data not available. Roughly 2,300 domestic wells went dry in San Joaquin Valley, with 2/3 in Kings Basin. Mitigation programs exist at Kern Water Bank, Rosedale Rio Bravo, Pioneer Project. Areas marked N/A have few or no domestic wells. Basins in grey (Modesto, Turlock, Tracy, White Wolf) are not critically overdrafted and have not yet completed sustainability plans.

Plans allow significant subsidence to continue

Subsidence due to groundwater pumping has been occurring in the San Joaquin Valley for almost a century, but it accelerated during the 2012–16 drought. Subsidence has damaged some critical water conveyance arteries, including the Friant-Kern Canal (40% of capacity lost in some stretches), and the California Aqueduct (more than 20% of capacity lost). Bridges over these and other canals are sinking, a local dam can't hold water anymore, and stretches of the high-speed rail track have been designed to prevent damage from future subsidence.

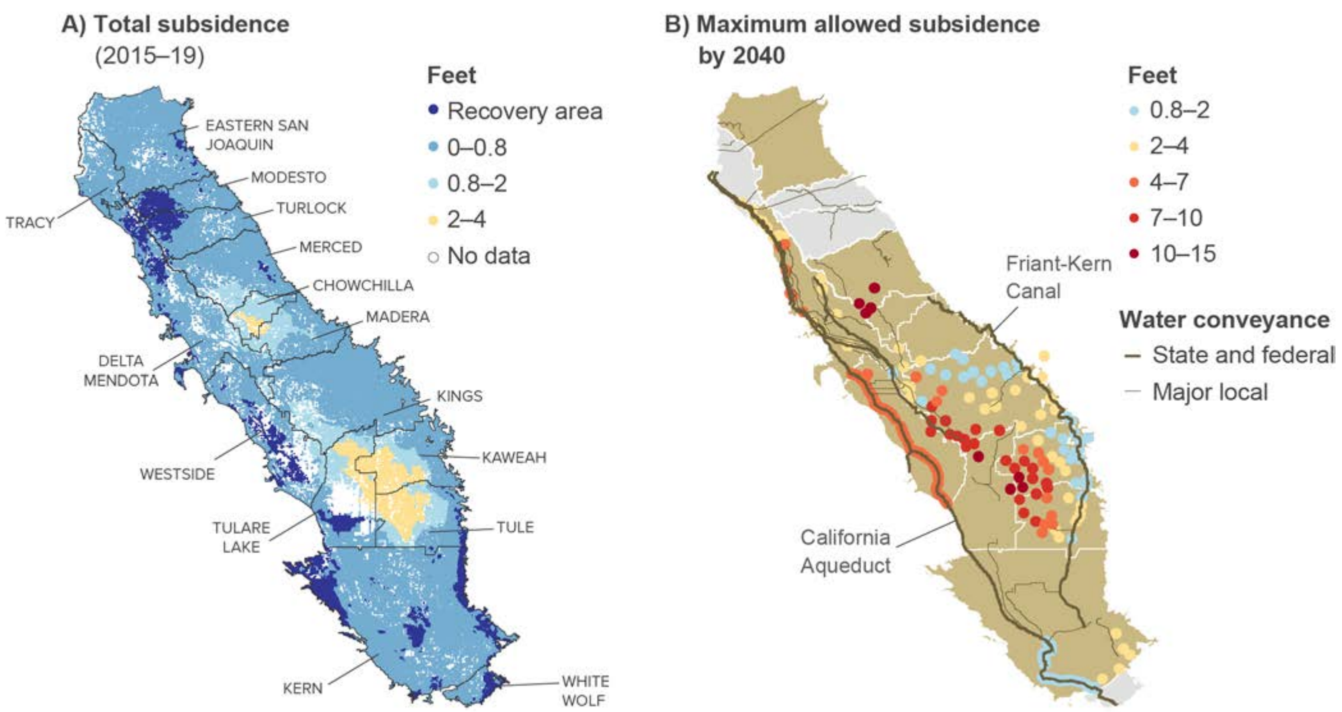
Subsidence can also permanently reduce the capacity of aquifers to store water. Valley aquifers may have lost as much as 3.25% of their capacity from soil compaction during the 2012–16 drought.

This infrastructure damage doesn't just affect the individual farms or water agencies that are pumping groundwater—it affects other parties, both locally and many miles away. Mitigating damage will cost many millions, if not billions, of dollars.

The plans vary widely in their approaches to addressing subsidence. In several areas where infrastructure has already been damaged, agencies are setting thresholds to avoid additional subsidence. For instance, in the Chowchilla basin and parts of Delta Mendota, goals include avoiding further damage to local conveyance infrastructure and to levees that provide flood protection. But most plans set thresholds that are not tied to specific past or future impacts. And many of these thresholds are quite high—allowing the rates of land subsidence observed during the recent drought. This raises the risk of future harm, even in areas that have not yet experienced damage.

Figure 7 shows subsidence rates over the past five years—which included both wet and dry years—alongside the cumulative amount of subsidence that the plans would allow over the next two decades. Recent subsidence rates are measured using satellite data, funded by the Department of Water Resources. Many plans are giving themselves a lot of leeway over the next 20 years, in some cases accepting 10–15 feet of additional subsidence. Even the lower thresholds in some sensitive areas might not end infrastructure problems and conflicts. For instance, the Friant Water Authority has warned that plans in the Tule basin will further reduce capacity in the Friant-Kern Canal, significantly affecting downstream water users. Similarly, the Department of Water Resources found that an additional 2.1 feet of subsidence in some sections of the California Aqueduct could further harm downstream water users. This is roughly one-third of the maximum amount allowed in the vicinity of the aqueduct by the Westside basin plan (6 feet).

FIGURE 7
Plans allow significant subsidence to continue



SOURCES: Escriva-Bou et al. (PPIC Blog, May 14, 2020). 2015–19 subsidence: Tre Altamira InSAR Subsidence Data, downloaded from the Department of Water Resources. Subsidence allowed by 2040: author estimates based on groundwater sustainability plans submitted to the Department of Water Resources.

NOTES: Ft is feet. Recovery areas include those where land elevations have increased since 2015 (up to 0.3 feet). The dots in panel B are monitoring sites where GSPs will measure subsidence. This includes long stretches along the California Aqueduct in the Westside basin. The Chowchilla, Madera, and Eastern San Joaquin basins do not set explicit subsidence thresholds, instead using groundwater levels as an indicator. In addition to monitoring sites shown on the map, the Westside basin uses groundwater levels to track subsidence in some areas. Plans in the Kern basin have set some preliminary thresholds in sensitive areas, pending an ongoing comprehensive analysis. Basins shown in grey (Modesto, Turlock, Tracy, White Wolf) are not critically overdrafted and have not yet completed groundwater sustainability plans.

6. How do existing conditions affect potential SGMA solutions?

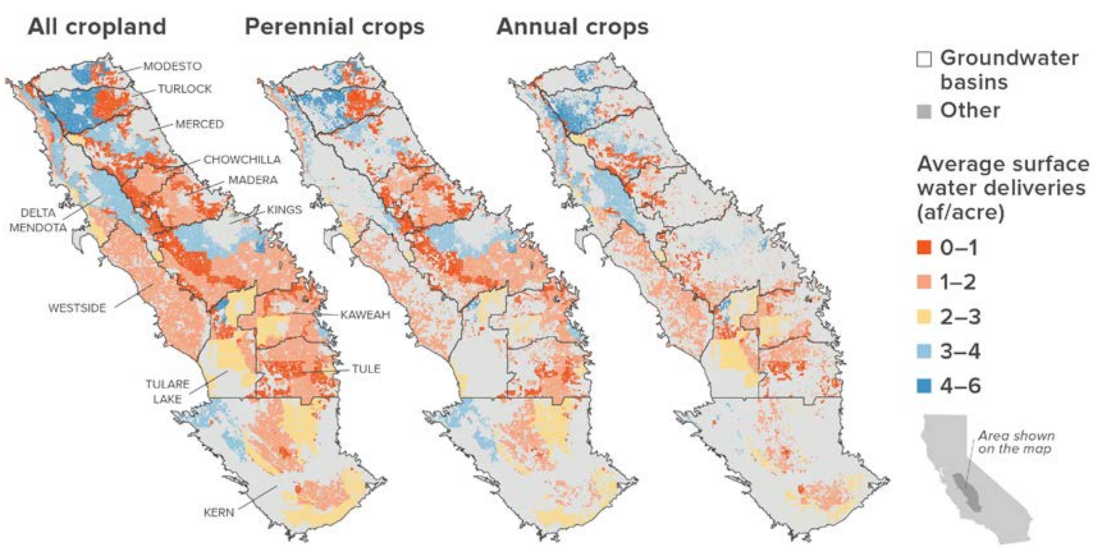
Water scarcity is not experienced equally across the San Joaquin Valley. Some areas receive abundant surface water to support cropland irrigation and drinking water supplies. Most others supplement their use with groundwater. Still others have no surface water access and depend entirely on groundwater. Water users in these groundwater-only areas are particularly vulnerable to pumping restrictions under SGMA.

In addition to water scarcity, in many parts of the valley groundwater quality continues to decline, affecting drinking water supplies and agricultural productivity. And the valley's riverine, wetland, and upland ecosystems are limited to small pockets of habitat. These variable conditions call for regional cooperation, to tackle water supply, quality, and environmental challenges jointly.

A major challenge is encouraging flexibility to lessen the regional economic burden of reducing groundwater use. Perennial crops now occupy nearly 60 percent of irrigated lands in the valley, and more than 20 percent of perennial acreage is on groundwater-only lands (Figure 8). The expansion of orchards has benefitted the regional economy, enabling valley agriculture to generate more GDP and jobs than would have occurred if farmers had not made this shift. But perennials are less flexible, because they need to be watered every year to maintain the investment. With groundwater cuts looming, areas with little or no surface water are on the front line of the effort to bring basins into balance. Inflexible approaches to managing this transition could result in unnecessarily large, undesirable reductions in high-value crop acreage, regional employment, and GDP. But scaling up flexible approaches requires GSAs to look beyond their boundaries, and beyond basin borders.

FIGURE 8

Surface water availability varies within and across basins



SOURCES: Jezdimirovic et al. (PPIC Blog, April 21, 2020). Surface water deliveries are estimated by the authors from various sources. For details see data set: PPIC San Joaquin Valley Surface Water Availability. Cropland is from the Department of Water Resources 2016 land use layer.

NOTES: Af/acre is acre-foot per irrigated acre. Although irrigation requirements vary somewhat by crop, irrigation method, and other factors, areas with less than 3 af/acre of surface water will generally need to use some groundwater to meet crop water needs. Other includes urban areas, managed wetlands, and other open space in all maps; in the perennial crops map, other also includes annual crops, and in the annual crops map it also includes perennials. Surface water deliveries are averaged for 2001–15.

This coordinated regional approach is also beneficial to manage land use transitions for lands that will be fallowed to balance groundwater basins. Effectively addressing water scarcity and the resulting land use changes in the valley offers opportunities to put lands coming out of production to good use—and gain “more pop per drop” from limited water resources. Multiple-benefit approaches to water and land management can enhance groundwater recharge and improve air and water quality. They can also promote healthier soils, new recreational opportunities, additional flood protection, improved habitat, and new revenue streams for private landowners engaging in conservation-oriented management.

The fragmentation of existing management entities poses a continuing challenge to the formulation of coordinated actions. Such coordinated action can yield large benefits. However, reaching agreement across numerous groups with different resource management rules and in some cases different objectives can be costly. For example, restrictions on moving water out of existing irrigation districts may be beneficial for local water users but harmful for the overall regional economy—and SGMA implementation. Finding ways to chart a promising path forward for source water regions could ease these discussions.

7. Implications for state action

The new GSPs are an important milestone in the implementation of SGMA, reflecting significant effort by many local parties to collectively address a complex set of issues. These first plans reflect large investments in the development of water budgets and a basic understanding of the lay of the land. Because SGMA allows basins to attain sustainability incrementally between now and 2040, GSAs may have some time to refine their plans for addressing overdraft through supply and demand projects and actions.

What is concerning about the work to date is that many plans have major gaps regarding undesirable results, which could once again accelerate if the state experiences another drought. Another area of concern is that the plans are too local to successfully manage the transition to groundwater sustainability in ways that are protective of the economy, society, and the environment. In many areas—planning for recharge, addressing infrastructure needs, sharing water, and more—local entities will need to collaborate both within and across basins. This is an area where the state could play an important role. DWR needs some formal mechanism to assess not only how well individual GSPs comply the law, but also how GSPs within a region fit together. This is essential in a region like the San Joaquin Valley, where the sub-basins are contiguous and interconnected. It will be equally important in the Sacramento Valley, where the first plans are due in 2022.

Here we offer some additional suggestions for DWR’s own review of these plans, as well as several priority actions the state can take to support effective SGMA implementation.

Analysis of overdraft:

DWR should promote more consistent approaches to the development and presentation of water budgets, both within and across basins, especially for the plan updates due in 2025:

- Require basins with multiple plans to explicitly show how the numbers add up and how their overdraft relates to the basin-wide total (an issue now in Tule and Delta Mendota).
- Require plans to provide annual water budget data (in Merced and Eastern San Joaquin, data were only provided by water year type, and in Kings annual data were not provided for the preferred model).
- Require plans to be more explicit about which of their required budgets—historical, current, or projected—they are using as a guide for management.

- Require plans to be more forward-looking in the development of budgets used to guide management. This includes considering events such as the 2012–16 drought, and how plans would respond to it.
- Encourage plans to standardize water budgets to ease cross-basin comparability. DWR's Draft Handbook for Water Budget Development (2020) is a useful resource for this purpose.

Supply and demand solutions:

DWR should promote more complete plan information, and assess the regional implications of proposed actions:

- Require plans that have not yet done so to be explicit about the expected yield of the projects and actions they are considering (an issue in Merced and Tule basins).
- Conduct a regional analysis of proposed supply projects, to understand where there are inconsistencies and overlap. The adding up problems that we identify on supply projects—with unrealistically high totals for new supplies, and inadequate consideration of the impacts on other users of shifting surface water to a plan area—reflect the fact that the plans are taking a local focus, without the benefit of a regional perspective.

DWR and other state agencies should also promote successful implementation of solutions:

- Establish a process to reduce conflict over access to water for recharge and ensure that it is allocated expeditiously to the most valuable uses. The State Water Board has recently improved the permitting process, but more needs to be done. An auction mechanism might be a preferable way to allocate these scarce supplies, rather than the traditional prior appropriation process.
- Promote and fund pilot projects to encourage agencies to take on new, untried efforts to manage demand, such as groundwater trading and stewardship of fallowed lands
- Promote and fund a regional assessment of cost-effective infrastructure solutions to support groundwater recharge and water trading. This matters greatly given that the most suitable areas for recharge, and the areas with greatest demand, are often not in the areas most closely connected to high-flow waters. It also matters for water trading that will support regional employment and income.

Addressing undesirable results:

We examined two of the six undesirable results, and found significant gaps. DWR should promote increased attention to undesirable results of groundwater overdraft:

- Require plans to provide more extensive analyses of undesirable results and more proactive responses.
- Require plans to more explicitly link their setting of thresholds to water budgets and planned projects and management actions. At present, the thresholds in some basins seem very lax relative to the stated objectives of augmenting supplies and managing demands to bring basins into balance.
- Continue supporting improved data collection for decision making (e.g., wells, subsidence).
- Support innovative mitigation solutions, which can sometimes be much less costly than setting stringent pumping restrictions.
- Where relevant, encourage discussion with stakeholders outside the plan area who have interest in addressing these undesirable results (e.g., those who depend on cross-basin infrastructure)
- Encourage joint consideration of drinking water supply and quality solutions where both problems exist. Where relevant, plans should link their efforts on drinking water supply mitigation to water quality solutions that the state is pursuing through other efforts.

We recognize that this is a challenging moment for local actors as well as the state, in light of pandemic-related restrictions on how people work, and economic impacts that are likely to affect budgets for some time to come. Yet it is important to maintain the momentum on SGMA implementation to safeguard California's future well-being. Wherever possible, the state should continue to lend strategic support to local efforts.

Additional resources

San Joaquin Valley GSP review articles on the PPIC blog

- "A Reality Check on Groundwater Overdraft in the San Joaquin Valley" (March 11, 2020)
- "What's the Plan to End Groundwater Overdraft in the San Joaquin Valley?" (April 6, 2020)
- "Water Availability for San Joaquin Valley Farms: A Balancing Act" (April 21, 2020)
- "Allocating Floodwaters to Replenish Groundwater Basins" (April 21, 2020)
- "Will Groundwater Sustainability Plans End the Problem of Dry Drinking Water Wells?" (May 14, 2020)
- "Sinking Lands, Damaged Infrastructure: Will Better Groundwater Management End Subsidence?" (May 14, 2020)

San Joaquin Valley data sets

- PPIC San Joaquin Valley GSP Water Budgets
- PPIC San Joaquin Valley GSP Supply and Demand Projects
- PPIC San Joaquin Valley Surface Water Availability
- PPIC San Joaquin Valley Water Balance 1988-2017

Other PPIC analysis on the San Joaquin Valley

Reports:

- *Water and the Future of the San Joaquin Valley* (February 2019)
- *Replenishing Groundwater in the San Joaquin Valley* (April 2018)
- *Water Stress and a Changing San Joaquin Valley* (March 2017)

Blog posts:

- "Got Surface Water? Groundwater-Only Lands in the San Joaquin Valley" (July 8, 2019)
- "Testimony: Water Supply and Quality Challenges in the San Joaquin Valley" (April 30, 2019)
- "A Winning Approach for Managing Groundwater in the San Joaquin Valley" (March 7, 2019)
- "Reducing Drought Risks in Rural Communities" (January 10, 2019)
- "How Much Water Is Available for Groundwater Recharge?" (June 14, 2018)