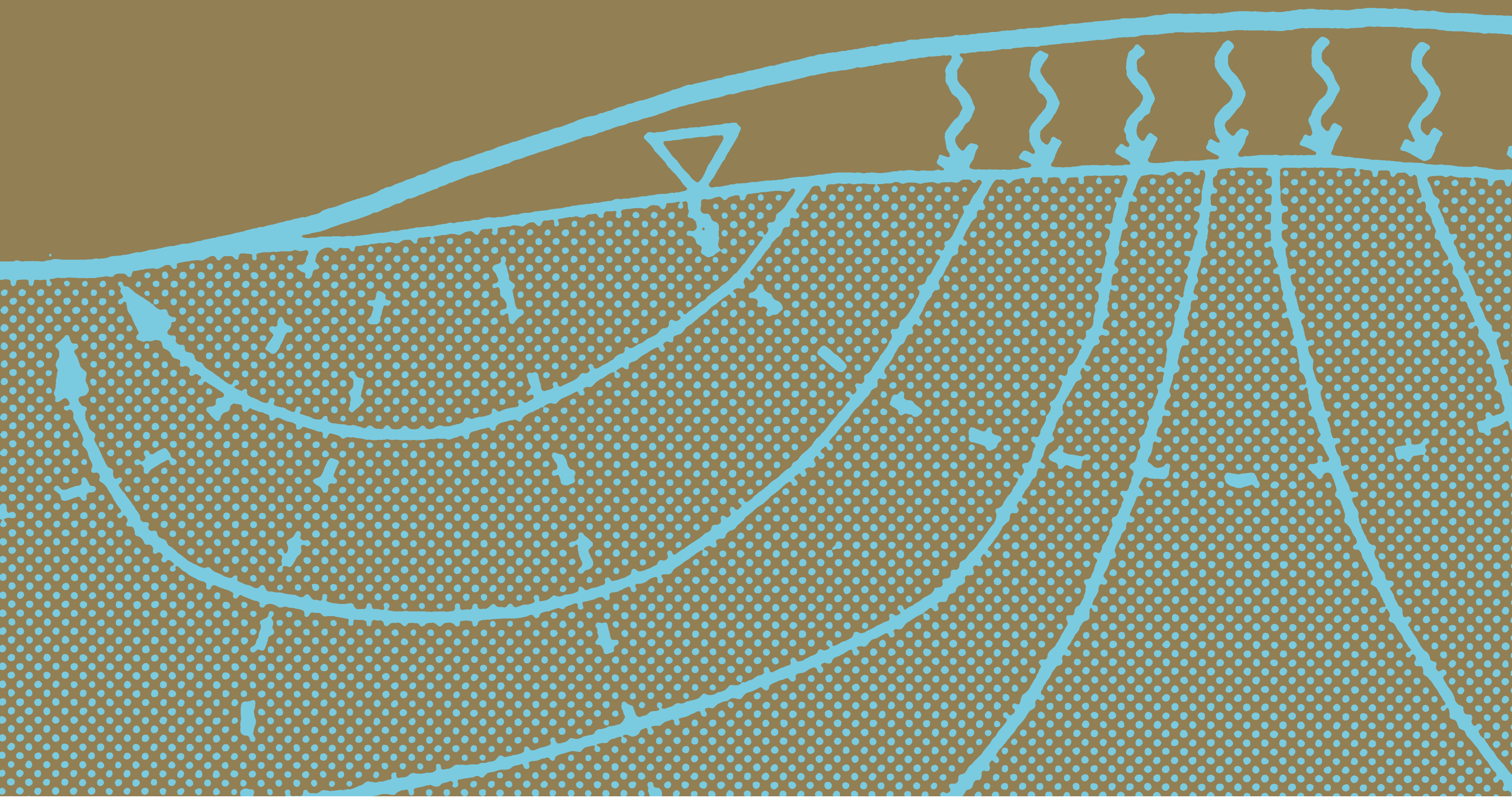
MARCH 2018

Navigating Groundwater-Surface Water Interactions under the Sustainable Groundwater Management Act



Alida Cantor
Dave Owen
Thomas Harter
Nell Green Nylen
Michael Kiparsky

BerkeleyLaw
UNIVERSITY OF CALIFORNIA
Center for Law, Energy & the Environment

UC WATER
Security and Sustainability Research Initiative

Cantor, Alida, Dave Owen, Thomas Harter, Nell Green Nylen, and Michael Kiparsky.
2018. Navigating Groundwater-Surface Water Interactions under the Sustainable
Groundwater Management Act. Center for Law, Energy & the Environment,
UC Berkeley School of Law, Berkeley, CA. 50 pp.
Available at: https://doi.org/10.15779/J23P87 or law.berkeley.edu/gw-sw

Wheeler Water Institute
Center for Law, Energy & the Environment
University of California, Berkeley, School of Law
390 Simon Hall
Berkeley, CA 94720-7200

clee@law.berkeley.edu
clee.berkeley.edu
wheeler.berkeley.edu

UC Water Security and Sustainability Research Initiative
www.ucwater.org

MARCH 2018

Navigating Groundwater-Surface Water Interactions under the Sustainable Groundwater Management Act

Alida Cantor, Dave Owen, Thomas Harter, Nell Green Nylen, and Michael Kiparsky

Wheeler Water Institute
Center for Law, Energy & the Environment
UC Berkeley School of Law

BerkeleyLaw
UNIVERSITY OF CALIFORNIA
Center for Law, Energy & the Environment

UC WATER
Security and Sustainability Research Initiative

About the report and the workshop series

This report draws from a two-part workshop series held at UC Berkeley School of Law in June and July of 2017. The two day-long workshops brought together approximately twenty recognized thought leaders in hydrogeology, law, and policy, including key academics, practitioners, and decision makers. Participants were asked to discuss a range of legal and technical dimensions of groundwater-surface water interactions and water rights under the Sustainable Groundwater Management Act (SGMA). Topics included examples of conflicts between groundwater and surface water users and how conflicts have historically been resolved; how SGMA alters or should alter legal relationships between groundwater and surface water users; the tools needed to identify and address potential conflicts between groundwater and surface water uses; and the potential interactions between SGMA and other laws governing water use and environmental protection. Participants discussed these issues both in general terms and through the lens of specific case studies.

The authors synthesized content from the workshops and conducted additional legal analysis and technical and legal literature review to develop the policy-focused themes reflected in this report. This report strives to provide guidance for practitioners, including groundwater managers and state agency staff.

Contents

Figures, tables, and sidebars

Executive Summary

California's Sustainable Groundwater Management Act (SGMA), passed in 2014, recognizes and addresses connections between surface water and groundwater. The statute is California's first statewide law to explicitly reflect the fact that surface water and groundwater are frequently interconnected and that groundwater management can impact groundwater-dependent ecosystems, surface water flows, and the beneficial uses of those flows. As such, SGMA partially remedies the historically problematic practice of treating groundwater and surface water as legally distinct resources.

SGMA requires groundwater sustainability agencies (GSAs) to manage groundwater to avoid six undesirable results, including significant and unreasonable adverse impacts on beneficial uses of surface water. While this aspect of SGMA is clearly important, significant uncertainties exist regarding how GSAs will actually define and achieve this goal.

Addressing SGMA's requirements for groundwater-surface water interactions will be difficult. Defining the issues at stake in any given basin, let alone successfully balancing the range of uncertainties and potentially conflicting interests, will pose challenges for many GSAs. No clear, pre-defined formula exists to guide GSAs in determining what significant and unreasonable depletions of interconnected surface water will be, or whether planned actions will sufficiently avoid them. Yet they are required to do so. Many GSAs will face pressure to aggressively address impacts on surface water in their basin. Many will face equal or greater pressure not to draw the line. Nevertheless, it will fall to the GSAs to make a determination, and to defend it in their groundwater sustainability plans (GSPs). Therefore, GSAs will likely take on some level of risk—of successful political opposition to their GSP, of succesful legal challenges to their GSP, of their GSP performing ineffectively, or of all of these outcomes. Given the aggressive timeline inherent to SGMA, addressing this risk early will be crucial for preserving management options.

Challenges and risk are not the whole story, however. The process of addressing groundwater-surface water interactions also offers GSAs an opportunity to help communities and other stakeholders resolve, or avoid, difficult conflicts, and to do so in lasting ways. While California law has only recently begun to seriously address conflicts between surface and groundwater uses, those conflicts have been occurring for decades, and in some places for over a century. SGMA, in other words, did not create conflict between groundwater pumping and beneficial uses of surface water; instead it created an opportunity—as well as an obligation—to respond to those challenges. Embracing that opportunity will not be easy, but GSAs that take SGMA as an opportunity to resolve longstanding issues can do lasting good.

The research presented here examines some of the legal and institutional questions that will inevitably arise as GSAs seek to address groundwater-surface water interactions under SGMA. The core goal of this report is to help parties identify and address these questions, and ultimately to let GSAs and stakeholders manage groundwater-surface water interactions proactively and effectively.

KEY QUESTIONS FOR SGMA IMPLEMENTATION

While SGMA brings groundwater-surface water interactions into fresh focus, many open issues remain. This report focuses on several key unanswered questions:

1. How will surface water law and groundwater law interact under SGMA?

2. What constitutes a significant and unreasonable adverse impact on beneficial uses and users of interconnected surface water?

3. Which entities are responsible for addressing what aspects of the interactions between surface water and groundwater?

4. What might a process for effectively resolving groundwater-surface water issues and conflicts look like?

5. What legal and technical aspects of groundwater-surface water interactions under SGMA are unknown or uncertain, to what degree, and how and why might this uncertainty matter?

To begin to address these questions, UC Water and the Wheeler Water Institute convened two workshops at UC Berkeley School of Law in June and July 2017. These workshops brought together recognized thought leaders in hydrogeology, law, and policy, including key academics, practitioners, and decision makers. These discussions and additional research by the authors are the basis for this report.

We intend for this report to provide general guidance for SGMA's implementers and interested stakeholders, although definitive answers do not exist for every issue we raise. Addressing groundwater-surface water interactions in California is largely uncharted territory. Significant physical, legal, and technical uncertainties will need to be resolved over time. Further, the diversity and uniqueness of groundwater and surface water basins around the state suggest that one-size-fits-all solutions will rarely exist, and that on some issues, each GSA will need to chart its own course. And yet, SGMA's timeline dictates that GSAs and others need to make decisions and develop sustainability plans within the next few years. To assist these efforts, we examine the risks and benefits associated with different approaches for addressing groundwater-surface water interactions as part of SGMA implementation.

CONSIDERATIONS REGARDING GROUNDWATER-SURFACE WATER INTERACTIONS UNDER SGMA

Several overarching considerations emerged from our research. Below, we distill these considerations into a set of pointers to help GSAs and others structure their thinking about groundwater-surface water interactions.

1. **GSAs must strive to understand how groundwater management affects surface water and its uses.** This point is obvious but also important: SGMA tasks GSAs with avoiding depletions of interconnected surface water caused by groundwater extractions if those depletions have significant and unreasonable adverse impacts on beneficial uses of the surface water. Beneficial uses include consumptive and non-consumptive human uses and environmental uses (including by groundwater-dependent ecosystems). What it means to address groundwater-surface water interactions is less clear and will hinge on how GSAs define what is "significant and unreasonable"—a definition that must be backed up with evidence in the development of a GSP. But regardless of GSAs' decisions about which effects are significant and unreasonable, meeting SGMA's requirements will require GSAs to develop a working knowledge of the hydrogeology that controls the interconnections between surface water and groundwater within their basins. The nature and depth of understanding that will be required in any given basin will vary, as will the tools and methods needed. GSAs are not solely responsible for managing water supplies, but the basic task of developing this understanding is no longer optional.

2. **GSAs will need to consider how groundwater rights, surface water rights, environmental laws and regulations, and other relevant legal principles interact.** Understanding the ways groundwater management intersects with groundwater and surface water law is challenging,

particularly because many legal questions remain unresolved. But by taking on this task, GSAs can reduce the risk of legal challenge to their GSPs. To do so, they will need to develop an understanding of appropriative and riparian surface water rights, relevant environmental laws and regulations, and instream flow requirements within the basin. Table 1 summarizes some potential interactions between SGMA and specific areas of law and regulation relevant to groundwater-surface water interactions.

3. **GSAs must decide what is significant and unreasonable, and these local decisions will intersect with other laws.** Beyond just understanding how groundwater-surface water interactions intersect with other state and federal laws, GSAs also will need to make decisions that affect these intersections. Most importantly, GSAs must decide what counts as a significant and unreasonable impact upon beneficial uses of surface water. Those decisions will both affect and be affected by other legal requirements.

4. **Collaboration is important**. GSAs have significant authorities, but also must coordinate with others. Their purview for achieving sustainability is closely tied to the mandates of other local, state, and federal entities, as well as to consideration of the interests of a broad range of stakeholders, some of whom SGMA explicitly identifies. This is true of many aspects of SGMA, but coordination is particularly important for this particular undesirable result. Addressing surface water depletion means considering a wide range of stakeholder interests. Governance issues, including resources, capacity, and complexity, will be important and potentially limiting factors in determining what GSAs can achieve. Consequently, collaboration, negotiation, division of responsibilities, and other forms of engagement between GSAs and other entities will be crucial in most or all basins. However, questions remain about roles and responsibilities. Those questions will create challenges for GSAs but also offer opportunities to craft creative institutional arrangements.

5. **GSAs will need to develop management plans and make decisions despite significant legal and technical uncertainties.** Uncertainties include future climate variability, future legal developments, and technical uncertainties regarding the hydrogeology and ecology of the groundwater-surface water system. Legal and technical uncertainties will sometimes intersect, but GSAs will need to act even when neither the science nor the law is clear. An iterative approach may be appropriate: GSAs and other agencies and institutions must, in some cases, make proactive decisions as defensibly as possible in the face of uncertainty, yet must also be prepared to adapt as uncertainties are reduced through technical studies, institutional developments, and changes in the legal landscape.

SGMA's recognition of the hydrogeological reality of interconnected surface water represents a crucial step for California towards fully integrated water management. But this recognition does not on its own solve all of the existing legal and management challenges. Rather, new challenges arise when trying to implement the law, and many of these challenges flow from the various legal doctrines that will need to be reconciled.

In this report, we offer structure for those navigating the legal, technical, and institutional challenges that relate to groundwater-surface water interactions and that are likely to arise during SGMA implementation. The report enumerates key considerations developing innovative, place-based solutions that reflect SGMA's emphasis on local management. We highlight some of the roles and responsibilities of GSAs and others in addressing issues related to groundwater-surface water interactions. Our findings stress the importance of collaboration, not only among neighboring GSAs, but also with many other entities, in addressing the issues and challenges of managing groundwater-surface water interactions sustainably.

Table 1: Summary of key intersections between SGMA and other laws and regulations in the context of groundwater-surface water interactions

Area of law or regulation	*Key intersections between SGMA and other laws in the context of groundwater-surface water interactions*
Reasonable Use Doctrine	Groundwater use, like all water use in California, is subject to the reasonable use doctrine. But the practical implications of the doctrine are not entirely clear. Reasonable use is, by nature, a flexible and highly context-dependent concept that is based in part on value judgments.
Water rights	SGMA explicitly does not alter surface water or groundwater rights. However, the implications of bringing a groundwater basin's water budget into sustainable balance may bear directly on both. SGMA does not provide a formula for resolving conflicts between surface water and groundwater rights, but it does provide opportunity and a potential forum for doing so—if GSAs are ambitious.
Regulatory takings	Water rights in California are property rights, and surface or groundwater users may bring takings claims if they believe regulatory restrictions on use have effectively taken their property. However, inherent in those rights is susceptibility to reasonable regulation. GSAs can reduce the risk of takings liability by managing groundwater in a manner generally consistent with California water rights.
Public Trust Doctrine	If groundwater pumping within a GSA's jurisdiction draws water from aquifers that are tributary to surface waterways, the public trust doctrine is likely to be relevant.
Federal and State Endangered Species Acts (ESAs)	Endangered species laws apply to groundwater allocation decisions that may impact listed species. GSAs seeking to avoid consequences under the ESA should be aware of these species within the basin and explicitly address their needs when developing GSPs.
California Environmental Quality Act (CEQA)	The preparation and adoption of GSPs is specifically exempt from CEQA. However, implementation actions taken by a GSA under a GSP would remain subject to CEQA. Compliance with CEQA would include analyzing and mitigating potential negative impacts on interconnected surface waters.
Clean Water Act and Porter-Cologne Act	Although water quality is also addressed separately within SGMA, it is relevant to groundwater-surface water interactions, including through effects on streamflow volume and temperature.
Instream flow requirements	To avoid significant and unreasonable adverse impacts on surface water, minimize risk of litigation, and maximize their GSPs' defensibility, GSAs will need to be aware of instream flow requirements set by the State Water Resources Control Board and consider them when developing and implementing GSPs.

I. Introduction

Until recently, California largely adhered to the "legal fiction"[1] that groundwater and surface water are separate resources. This fiction was at odds with physical reality, for surface water and groundwater are frequently connected. Consequently, groundwater management can impact flows in rivers and streams, and affect the beneficial uses and users of those flows. But those interconnections, though long accepted by scientists, were not integrated into California water law.

With the passage of the 2014 Sustainable Groundwater Management Act (SGMA),[2] that is beginning to change. SGMA requires California's new groundwater sustainability agencies (GSAs) to manage groundwater to avoid significant and unreasonable adverse impacts on beneficial uses of interconnected surface water.[3] Thus, understanding and managing the interactions between groundwater and surface water is an essential part of SGMA implementation.

However, significant uncertainties exist regarding how exactly GSAs will achieve this goal. Those uncertainties include unresolved legal questions, technical questions about the nature of groundwater-surface water interactions in particular basins, and institutional questions about who is responsible for developing and implementing solutions. Nevertheless, GSAs must deliver credible groundwater sustainability plans (GSPs) within a few short years, and those plans must address this element—and other elements—of sustainability.

This report's goal is to articulate and examine key legal and institutional questions about the interactions between groundwater and surface water in California under SGMA, and to propose considerations for GSAs and other relevant stakeholders as they work to develop answers for their basins. The report strives to help various parties, including GSAs, state regulators, water users, and the legal community, identify important SGMA-related legal and institutional considerations involving groundwater-surface water interactions. While GSAs must decide what is significant and unreasonable, these decisions will be made in the context of other state and federal laws, which raises risks that a local GSA's decisions could be challenged or undermined. This report aims to help GSAs minimize that risk.

A. REPORT FOCUS AND KEY QUESTIONS

The report focuses on the intersections between surface water law and the emerging SGMA regime. The report also focuses on questions about how potential conflicts involving intersections between surface water and groundwater might be resolved. While SGMA brings groundwater-surface water interactions into fresh focus, many key questions remain unanswered. The following questions are particularly important, and are the focus of the remainder of this report:

1. **How will surface water law and groundwater law interact under SGMA?** What tensions might arise between surface water rights and groundwater rights, and how might these tensions be navigated? How does environmental regulation of surface water uses intersect with groundwater management?

2. **What constitutes a significant and unreasonable adverse impact on beneficial uses and users of interconnected surface water?** When will impacts to surface water uses—including both human and environmental uses—necessitate a response by groundwater managers? How might a GSA, or a state regulator, approach this determination?

3. **Which entities are responsible for addressing the interactions between surface water and groundwater?** Which responsibilities legally fall to GSAs and which to other entities (e.g., individual groundwater users, individual surface water users, other government agencies)? Legal obligations aside, what roles might GSAs and other entities play in addressing potential or identified problems?

4. **What might a process for effectively resolving groundwater-surface water issues and conflicts look like?** How might potential conflicts involving the interaction between surface water and groundwater be resolved fairly and efficiently in the context of SGMA?

5. **What legal and technical aspects of groundwater-surface water interactions under SGMA are still unknown or uncertain, and to what degree?** How do legal uncertainties and technical uncertainties intersect with one another? How and why might uncertainty matter?

For many of these questions, definitive answers do not yet exist. Thus, this report is intended to provide general guidance for those involved in SGMA implementation. SGMA implementation, and in particular, legally addressing groundwater-surface water interactions, is largely uncharted territory for California. Significant physical, legal, and technical uncertainties will need to be resolved over time, so many of the questions raised in the report simply do not, or do not yet, have clear answers. Further, the diversity and uniqueness of groundwater and surface water basins in the state suggests that one-size-fits-all solutions will never exist, and that each GSA will need to chart its own course. And yet, SGMA's timeline dictates that GSAs and others need to make decisions and move forward with developing their plans to achieve sustainability.

In light of the tension between lack of clarity and the need to act quickly, we discuss each element in terms of existing knowledge, unanswered questions, and potential risks that might arise for parties as they seek to move forward in the face of uncertainty. This approach offers structure to decision makers and interested parties for near-term decisions, as well as clarifying why adapting to future developments will be essential in the long term.

B. WHO SHOULD READ THIS REPORT?

The information and analysis in this report may be relevant to a range of audiences, including:

Groundwater Sustainability Agencies. Understanding and addressing groundwater-surface water interactions is now an obligation for GSAs. For many GSAs, avoiding this particular undesirable result presents a challenge. This report addresses legal issues, constraints, and opportunities that GSAs might face, and discusses how GSAs might go about navigating the uncertainties involved.

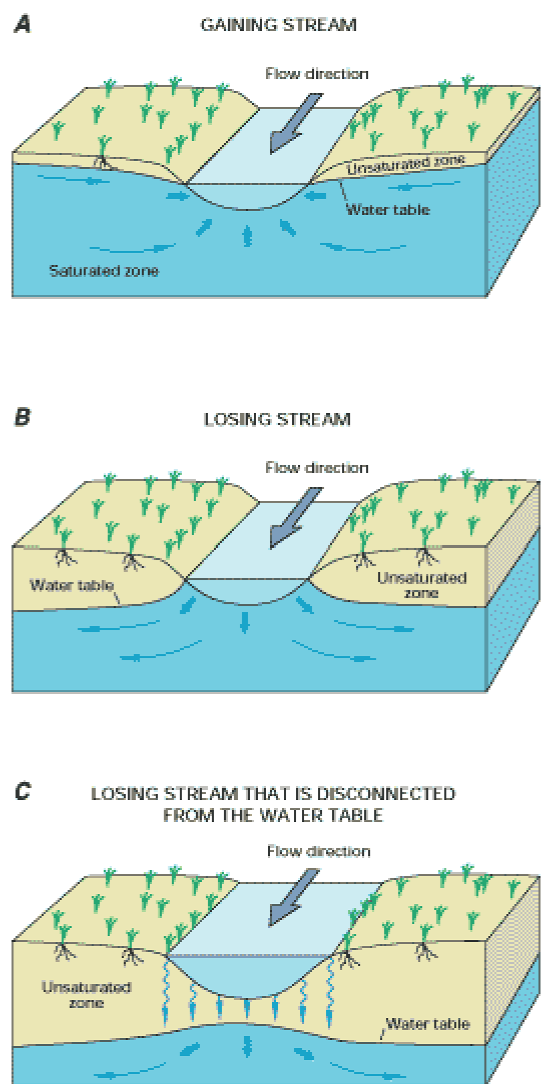
State and federal regulatory, water supply, and wildlife agencies. SGMA implementation raises questions about institutional responsibilities for addressing groundwater-surface water interactions. This report examines potential institutional roles and interactions between GSAs and other entities, including the California Department of Water Resources (DWR) and State Water Resources Control Board (SWRCB); state and federal water supply agencies including DWR and the United States Bureau of Reclamation (USBR); and state and federal wildlife agencies including the California Department of Fish and Wildlife (CDFW), the United States Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries), as well as the Bureau of Indian Affairs (BIA).

Other stakeholders involved in groundwater management. SGMA also affects other stakeholders with diverse interests, and the issues discussed in this report may be of interest to a number of other stakeholders including environmental groups, community groups, native American tribes, individuals and entities with surface or groundwater rights, technical consultants, and legal practitioners.

II. Understanding groundwater-surface water interactions

While this report focuses primarily on legal dimensions of groundwater-surface water interactions, one cannot understand those legal issues without some technical and scientific background. This section briefly explains the physical links between groundwater and surface water, the ecological consequences of those links, and the tools used to measure, characterize, and model the flows between groundwater and surface water.

Figure 1: Groundwater-surface water relationships: Gaining, losing, and disconnected streams. Source: USGS.[6]



A. LINKS BETWEEN GROUNDWATER AND SURFACE WATER

Groundwater and surface water are highly interconnected in many landscapes.[4] Streams, wetlands, and lakes can gain water from groundwater, lose water to groundwater, or do both at diffrent locations or at different times of the year (Figure 1).[5] The relationship between groundwater and surface water largely depends upon the elevation of the water table relative to the elevation of the stream surface. If the water table is higher than the surface water, groundwater flows into the stream or water body, and the surface water body is characterized as gaining. If the water table is lower than the stream surface, but still connected to the stream by a saturated zone, the stream or water body loses water to the water table, and the surface water body is characterized as losing. In some cases, when the water table has dropped far enough in elevation that the surface water and groundwater are separated by an unsaturated zone, a stream is characterized as disconnected.

Groundwater plays an important role in many ecosystems.[7] Groundwater-dependent ecosystems (GDEs) are comprised of springs and seeps, wetlands and associated vegetation, or stream flows from groundwater discharge (baseflow).[8] Groundwater pumping can impact these groundwater-dependent ecosystems; as groundwater is extracted, the water table drops, which can cause stream depletion via reduction in baseflow[9] and can impact groundwater-dependent ecosystems that receive less water as the water table lowers.[10]

It can be difficult to understand the precise nature of the connections between groundwater and surface water in a particular area because many groundwater basins have locally complex geology and ecology that complicates groundwater flow and groundwater-surface water dynamics. In the sedimentary basins currently subject to SGMA, groundwater-surface water interactions are shaped by stream geomorphology, subsurface structural discontinuities, and aquifer composition, including the distribution of bodies of sedimentary rock and flow characteristics throughout a given area.[11]

Impacts on streamflow and GDEs from groundwater pumping can be difficult to directly attribute to particular pumpers. One reason for this difficulty is that impacts are often time-delayed (by days, months, years, or even decades) and are complicated by temporal and spatial patterns of groundwater pumping, sometimes in conjunction with managed aquifer recharge.[12] Relationships between perched aquifer systems (those separated from underlying groundwater by a less permeable layer and an unsaturated zone) and regional pumping also are complex. While pumping of a regional aquifer may have an impact on surface waters at some point, stream reaches tied to perched aquifer systems are isolated from and not susceptible to groundwater pumping in the regional aquifer system below. Perched aquifer systems are also often important for GDEs, but may be difficult to manage from a regional perspective. Additionally, climate uncertainty and associated variability are likely to affect surface water availability, instream flows, and groundwater recharge,[13] presenting yet another set of complicating factors.

Groundwater-surface water dynamics, like groundwater flow, are complicated and rarely straightforward to understand and manage. Ecosystem dynamics can be complex, with many GDEs requiring different groundwater flow conditions at different times of year. Adequately understanding groundwater-surface water interactions may thus require substantial study.

B. TOOLS AND METHODS FOR UNDERSTANDING GROUNDWATER-SURFACE WATER INTERACTIONS

A range of tools and methods can be used to shed light on the complex relationships between groundwater and surface water.[14] There have been many technological advances in data collection, analysis, and modeling that contribute to a stronger knowledge of groundwater-surface water dynamics.[15] Table 2 summarizes a number of different tools and methods for monitoring and measuring stream-aquifer dynamics, ranging from simple to more complex methods, and summarizes some of the key factors that may be involved in deciding whether a tool is a good fit for use in a given basin.

These tools and methods have not been applied evenly across the state of California. For many basins throughout the state, significant uncertainty about groundwater-surface water interactions still exists.[16] Data collection, monitoring, and analysis remain limited in many areas. The uncertainty and limited availability of information regarding groundwater-surface water interactions present challenges for GSAs.

One challenge is related to maintaining GSA credibility with water users. Given limited information, groundwater users may not think that their pumping impacts surface water. For example, private pumpers five miles away from a river may not believe (or may refuse to believe) that their pumping could impact surface water. If these pumpers then dispute the basic factual premises for a GSA's management actions, and the GSA cannot respond with robust data, it will face credibility issues.

A second challenge is that GSAs will need to decide what amount of uncertainty is acceptable. As Table 2 outlines, there are a variety of tools and methods for measuring groundwater-surface water interactions. These tools vary widely in terms of cost and accuracy. There is also wide variance in the depth and accuracy of data and information that will be needed to understand a given basin, given that the precise nature of groundwater-surface water connections differs greatly within and between groundwater basins. Determinations about what constitutes an adequate conceptualization of groundwater-surface water interactions—and the costs of obtaining the information deemed adequate—are thus likely to vary widely. Data acquisition and analysis come with costs, and questions will arise regarding the acceptable balance of uncertainty and expense.

Table 2: Tools and methods for monitoring and measuring stream-aquifer dynamics

FIELD SAMPLING AND MEASUREMENT METHODS

TOOL / METHOD	DESCRIPTION	BENEFITS	COSTS AND LIMITATIONS
Groundwater level monitoring near streams[17]	Relies on monitoring water levels in wells on a seasonal or finer-scale basis. Well levels can be compared to surface water elevation to determine the direction of flow (into or out of the stream).	Simple; low cost (if existing network is adequate); relies on existing groundwater monitoring well network. Very useful for monitoring long term trends.	May be overly simple in many cases; does not provide a full picture of complex groundwater-surface water dynamics; existing well network may be inadequate.
Streamflow gaging and hydrograph analysis[18]	Estimating baseflow by examining hydrographs to separate groundwater-derived flow from stormwater flows.	Relatively simple and low cost if streamflow gages already exist at appropriate locations. Provides a direct measure of streamflow contribution from groundwater.	Requires continuous stream gaging at appropriate (often multiple) locations. May not provide a full picture of complex groundwater-surface water dynamics.
Seepage meters[19]	Using a device to directly measure flow between surface water bodies and groundwater. Commonly used to measure water losses from irrigation canals.	Device is low cost and simple to operate.	Numerous sources of error exist. Not well suited for surface water bodies with currents or fast water, rocky sediment, or very soft sediment.
Monitoring of physical and geochemical properties[20]	Monitoring of properties such as water temperature, isotopes, electrical resistivity, and salinity.	Ability to track movement of groundwater through a connected system. Useful in combination with other methods.	Possibly expensive data collection and analysis.

TOOL / METHOD	DESCRIPTION	BENEFITS	COSTS AND LIMITATIONS
Mapping groundwater dependent ecosystems (GDEs), streams, and seasonally dry streambeds[21]	Mapping GDEs, interconnected streams, and seasonally dry streambeds to understand groundwater-surface water connections.	Contributes a detailed understanding of the characteristics and spatial distribution of streams and GDEs. Focuses on identifying locations where groundwater is ecologically important. Maps of potential GDEs are available statewide through DWR.	May be labor intensive to map all GDEs, although statewide tools are in development to aid in mapping.[22] Does not provide information about aquifer dynamics.
Water balance[23]	Calculating groundwater contribution to streamflow in the form of baseflow on an annual, seasonal, or monthly basis. Basin-scale groundwater contribution is estimated as a closure term based on estimates of water inputs and outputs within a basin.	Relatively simple and low cost.	Does not provide a full picture of complex groundwater-surface water dynamics. Relies upon accurate water balance data, which may be limited.
Analytical modeling: stream-depletion function[24]	Simple analytical model that calculates stream depletion from well pumping, along with stream recharge, taking into account the distance of pumping/recharge from the stream.	Incorporates basic aquifer characteristics; allows for basic modeling of stream depletion/repletion; simpler and lower cost than a numerical model; provides good working knowledge of trends, overall impacts.	Assumes uniform aquifer conditions, which does not account for complex groundwater dynamics, limiting predictive accuracy. Many wells are not gaged, limiting data availability.
Numerical modeling: integrated groundwater-surface water modeling[25]	Computer model of groundwater system or integrated hydrologic system, which typically includes basin geometry and hydrogeological parameters.	Ability to simulate and predict groundwater flows. Ability to account for three-dimensional complexity of groundwater dynamics.	Accuracy depends upon quality of input data. Building a model that is accurate enough to be useful can be expensive and labor intensive. Used in conjunction with other methods above for calibration.

III. Legal relationships between groundwater and surface water

This section provides a brief review of the principles of groundwater and surface water law in California in order to provide a basis for understanding SGMA's impacts. The section discusses groundwater and surface water rights and regulation before SGMA, and then describes the changes that SGMA introduces.

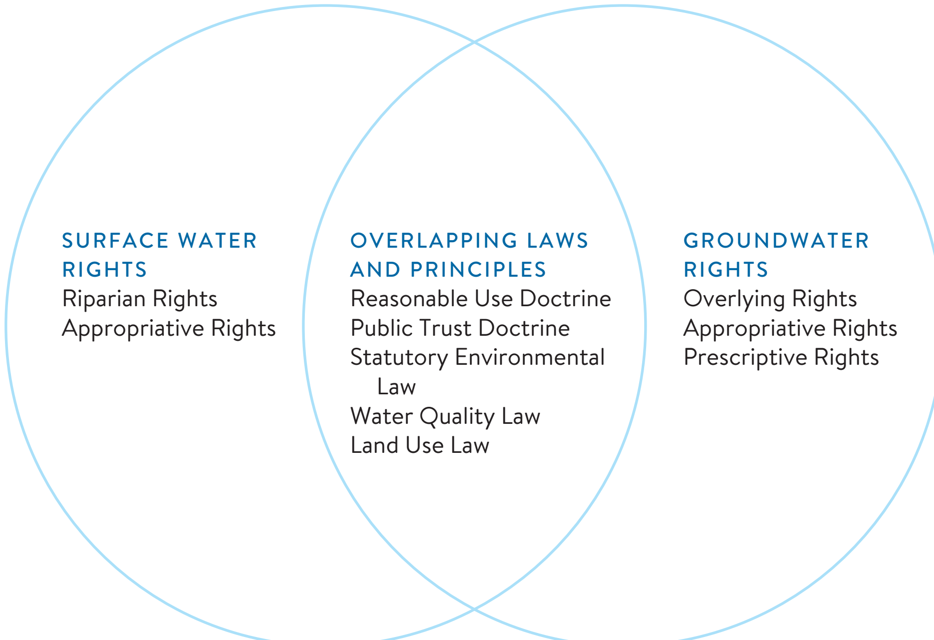
A. GROUNDWATER AND SURFACE WATER RIGHTS AND REGULATION IN CALIFORNIA BEFORE SGMA

There are several main categories of surface water rights in California.[26] Riparian rights entitle riparian landowners to make reasonable use of water on land adjacent to the waterway so long as natural surface flows are present.[27] These rights are correlative so that, in times of shortage, all riparian users share in the shortage.[28] Appropriative rights are not based on land ownership but on temporal priority (i.e., "first in time, first in right,") with the earliest appropriators enjoying the most secure right to use water. Appropriative surface water rights are divided into pre-1914 and post-1914 rights, with post-1914 appropriative rights requiring permitting by, and traditionally being subject to greater regulation from, the SWRCB.[29] The extensive statutory system for regulating post-1914 appropriative rights, which includes a permitting and licensing process administered by the SWRCB,[30] is an important distinction between surface water rights and groundwater rights, which are governed primarily by common law.[31]

Groundwater rights in California are based on several analogous principles.[32] Overlying groundwater rights are largely similar to riparian rights. These rights allow landowners above a groundwater basin to make reasonable use of groundwater on that land, and during times of shortage, overlying users are limited to their correlative share of the safe yield based upon reasonable need.[33] Appropriative rights to use groundwater (for basin export or for non-overlying uses within the basin) may be exercised if there is surplus groundwater beyond what is needed for the reasonable beneficial uses of those with overlying rights.[34] Similar to appropriative rights to use surface water, these appropriative rights have temporal priority. They are considered secondary to overlying users, so in times of shortage appropriative rights, beginning with the most junior uses, are, in theory, the first to be curtailed.[35] Prescriptive rights may be acquired if a water user has continued to use groundwater for a non-overlying use when no surplus was available for five or more years. The water right then can "ripen into" a prescriptive right.[36] As is also the case with surface water, several other, less common types of groundwater rights exist, including pueblo rights and federal reserved rights.[37] Subterranean streams, defined as a body of groundwater flowing through known and definite channels,[38] present a special circumstance for water rights, because withdrawals from these subterranean streams are regulated by California's surface water rights system (see section IV.B of this report for further discussion).

Unlike surface water users, groundwater users have historically faced little regulation or enforcement of legal limits of their rights, and no mandatory statewide system has required permitting and licensing of groundwater use. There were limited efforts to encourage voluntary local management of groundwater before 2014. At the state level, the Groundwater Management Act of 1992 (AB 3030) allowed for voluntary development

Figure 2: Systems of groundwater and surface water rights and regulation



of groundwater management plans in unadjudicated basins. In 2002, SB 1938 modified the Groundwater Management Act by introducing financial incentives for the development of groundwater management plans. SB 1938 also introduced specific minimum requirements for plan elements, but did not require that plans be implemented or that plan objectives be met.[39] In the absence of statewide regulation, some local governments took ambitious steps to manage their groundwater.[40] Many, however, did not.

Despite the lack of integration of surface water rights and groundwater rights,[41] there are several commonalities between the two systems. First, California's constitutional requirement for reasonable use applies to both surface water and groundwater, as do many other laws (Figure 2). Second, there are parallels between riparian surface water rights and overlying groundwater rights, which are both correlative, and between the temporal-priority-based systems of appropriation that exist for both groundwater and surface water. Additionally, resolving conflicts between correlative and appropriative rights in each context has sometimes been difficult.

While the groundwater and surface water rights systems are not integrated, there are historical precedents for reconciling them. In some cases, groundwater and surface water rights have been jointly adjudicated.[42] In other cases, surface water users have used litigation to protect their rights from injury by groundwater pumping,[43] and vice versa.[44] California courts have generally treated all correlative rights as one joint senior priority class, and based the priority of all appropriative rights on their priority dates. Applying these priority rules is complicated by the specifics of hydrologic connectivity in each location, which will affect whether and to what extent actions would actually injure other water users. Where resolving conflicts purely on the basis of water right priority would result in waste or unreasonable use, courts have sought physical solutions designed to reasonably protect more senior rights, consistent with Article X, Section 2, of the California Constitution.[45]

B. GROUNDWATER-SURFACE WATER INTERACTIONS UNDER SGMA

The passage of SGMA in 2014 was a historic step towards sustainably managing the state's groundwater resources.[46] SGMA adopts a state policy of managing groundwater resources "sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses."[47]

SGMA defines sustainability as the avoidance of six "undesirable results" (Figure 3). Under SGMA, groundwater sustainability agencies (GSAs) must form in groundwater basins designated as medium- or high-priority, which are responsible for developing and implementing groundwater sustainability plans (GSPs) or alternatives.[48] GSPs must demonstrate how GSAs will attain sustainability.

A particularly important—and difficult—aspect of SGMA is that it recognizes the interconnections between groundwater and surface water and requires GSAs to consider them. One of the undesirable results SGMA requires GSAs to avoid is "[d]epletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water."[49] Because beneficial uses include environmental as well as human consumptive uses, this mandate protects groundwater-dependent ecosystems. SGMA defines "interconnected surface water" as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted."[50]

While this obligation may sound far-reaching, SGMA qualifies it by setting a temporal baseline. "The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015. ... [A] groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015."[51] In other words, SGMA limits the scope of GSAs' legal *responsibilities*—at least under SGMA itself—to addressing post-2014 impacts—but does not limit GSA's *authority* to address earlier impacts (see Section IV. C of this report for further discussion of this topic).

SGMA is explicit that it does not modify, alter, or determine any groundwater or surface water right.[52] But by linking groundwater and surface water, SGMA connects the two water rights regimes.

In order to operationalize its substantive mandates, SGMA requires GSPs to include monitoring and management of not only groundwater levels, but also of changes in surface water flow and surface water quality as well as impacts on groundwater dependent ecosystems.[53] SGMA also directs DWR to consider adverse impacts on local habitat and local streamflows in the prioritization of groundwater basins and subbasins.[54]

A crucial upshot of these statutory provisions is that understanding, and in many cases acting to manage, groundwater-surface water interactions is an obligation for GSAs. GSAs must gain sufficient understanding

Figure 3: SGMA sustainability indicators. Six undesirable results to be avoided. Source: DWR

of surface water quantity and quality, groundwater-dependent ecosystems, appropriative and riparian surface water rights, and how groundwater management actions might affect all of these things.[55] GSAs will also need to develop a working knowledge of the basin hydrogeology that mediates these interconnections. SGMA thus creates new needs for data collection and analysis regarding groundwater-surface water interactions.[56]

In addressing surface water depletion and other undesirable results, GSAs play a lead role but do not act alone. DWR regulates and assists in SGMA implementation at the statewide level, and is responsible for providing data, information, and technical support and for reviewing GSPs for adequacy. SWRCB is the enforcing agency, and may intervene and create an interim plan if a GSA fails to develop and implement an adequate GSP. The federal government, tribal interests, other local governments, and other stakeholders may provide input, participate in GSP development and implementation, and provide comments during review periods.[57]

DEFINITIONS FROM SGMA AND DWR GSP REGULATIONS

- **"Sustainable groundwater management"** means the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon **without causing undesirable results.** (Cal. Water Code § 10721(u))
- **"Undesirable result"** means one or more of the following effects caused by groundwater conditions occurring throughout the basin… **(6) Depletions of interconnected surface water** that have significant and unreasonable adverse impacts on beneficial uses of the surface water. (Cal. Water Code § 10721(w))
- **"Significant depletions of interconnected surface waters"** means reductions in flow or levels of surface water that is hydrologically connected to the basin such that the reduced surface water flow or levels have a significant and unreasonable adverse impact on beneficial uses of the surface water. (Cal. Water Code § 10735(d))
- **"Groundwater dependent ecosystem"** refers to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. (23 Cal. Code Regs. § 351(m))
- **"Interconnected surface water"** refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. (23 Cal. Code Regs. § 351(o))
- **"Minimum threshold"** for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. (23 Cal. Code Regs. § 354.28(c)(6))

CONSIDERATIONS FOR DEVELOPING SUSTAINABLE MANAGEMENT CRITERIA RELATED TO DEPLETION OF INTERCONNECTED SURFACE WATER

DWR regulations specify required components of groundwater sustainability plans.[58] GSAs are responsible for establishing minimum thresholds that provide quantitative metrics for each of the six sustainability indicators. The GSP must describe how the minimum threshold was chosen, including how basin conditions at each minimum threshold will avoid undesirable results.[59] Regarding surface water depletion, the regulations specify that the minimum threshold metric for depletion of interconnected surface waters shall be expressed as "a rate or volume of surface water depletion caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results."[60] This rate or volume can be demonstrated using a numerical groundwater and surface water model or another equally effective method, tool, or analytical model. To better account for uncertainty, including climate variability, minimum thresholds should take into account water year type as well as historical trends and projected water use in the basin.[61]

DWR's recent draft best management practice (BMP) document[62] summarizes some considerations for GSPs establishing minimum thresholds for depletions of interconnected surface water caused by groundwater extraction, including:

- What are the historical rates of stream depletion for different water year types?
- What is the uncertainty in streamflow depletion estimates from analytical and numerical tools?
- What is the proximity of pumping to streams?
- Where are groundwater dependent ecosystems in the basin?
- What are the agricultural and municipal surface water needs in the basin?
- What are the applicable state or federally mandated flow requirements?

This list of considerations highlights several of the issues discussed in the rest of this report, including the importance of considering groundwater dependent ecosystems, surface water users, and instream flow requirements, as well as recognition of the uncertainty that characterizes understanding of groundwater-surface water interactions in many basins.

IV. Understanding legal constraints and opportunities associated with groundwater-surface water interactions under SGMA

To ensure that their GSPs and implementation actions are defensible, GSAs will need to understand the interactions between groundwater rights, surface water rights, and other relevant legal principles. But many of these interactions implicate partially unsettled areas of law. This section attempts to clarify, as much as is possible, some key areas of interaction between groundwater and surface water law that are likely to be important under SGMA. Key points from each area of discussion are summarized in Table 1 on page 10.

A. THE CONSTITUTIONAL REQUIREMENT FOR REASONABLE USE

Key Point: *Groundwater use, like all water use in California, is subject to the reasonable use doctrine. But the practical implications of the doctrine are not entirely clear. Reasonable use is, by nature, a flexible and highly context-dependent concept that is based in part on value judgments.*

Article X, Section 2, of the California Constitution requires that all water use be reasonable and beneficial. It states:

> The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.

Consequently, a basic foundational principle of water rights in California is that there is no right to an unreasonable use of water.[63] Article X, Section 2, states that "the Legislature may also enact laws in the furtherance of the policy." Additionally, California's courts have recognized that the reasonable use doctrine empowers legislators and government regulators to constrain water use, either through generally applicable regulations or through individual enforcement actions.[64]

California's reasonable use doctrine applies to groundwater as well as surface water. For example, in *City of Barstow v. Mojave Water Agency*, the California Supreme Court explicitly applied the reasonable use doctrine to groundwater rights.[65]

While the reasonable use doctrine clearly applies to groundwater use, the practical implications for GSAs are not entirely clear. In practice, the doctrine has not been stringently applied; California courts have rarely invoked the reasonable use doctrine to impose limits on water users, and they (and the courts of other western states) have sometimes concluded that seemingly profligate uses of water are reasonable.[66] However, the doctrine remains potentially powerful. When courts have invoked the doctrine, they have stated that what is reasonable "depends on the circumstances of each case," as well as "statewide considerations of transcendent importance" which may evolve over time in response to changing conditions and societal needs.[67] And they have repeatedly affirmed that government regulators, not just the legislature and the courts, can shape and apply the doctrine, including through enforcement actions against individual water users.[68] Consequently, the reasonable use doctrine remains underdeveloped, sometimes weak, yet potentially powerful, and its application depends on judicial discretion and on the willingness of regulators to take assertive positions.

The inchoate nature of the doctrine leaves GSAs with a challenge and, potentially, an opportunity. The challenge is that, while they can be sure that the reasonable use doctrine applies to the water uses they regulate, no one has provided them with a formula to figure out exactly what the doctrine allows or prohibits. The opportunity, which we explain in more detail in Part IV, is for GSAs to use their regulatory authority under the reasonable use doctrine to craft legally defensible solutions to the water management challenges they face.

B. SURFACE WATER RIGHTS, GROUNDWATER RIGHTS, AND SGMA

While SGMA is California's first attempt at statewide groundwater regulation, California's groundwater has long been governed by a common-law system of groundwater rights. Similarly, California's system of surface water rights has existed for well over a century. These systems of rights sometimes conflict with each other. The discussion below briefly explains the implications for SGMA implementation of these water rights challenges.

RECONCILING SURFACE WATER AND GROUNDWATER RIGHTS

Key Point: *SGMA explicitly does not alter surface water or groundwater rights. However, the process of bringing a groundwater basin's water budget into sustainable balance may impact both. SGMA does not provide a formula for resolving conflicts between surface water and groundwater rights, but it does provide opportunity and a potential forum for doing so—if GSAs are ambitious.*

SGMA expressly states that it does not alter groundwater or surface water rights.[69] But complying with its requirements will often lead to impacts on the exercise of both groundwater and surface water uses that occur under claims of right. The combination of a disclaimer of any alteration of rights and requirements that will impact the exercise of those rights creates some obvious interpretive challenges, particularly when surface and groundwater rights come into conflict. At first glance, several interpretations may seem possible. On the one hand, one might think that SGMA exempts groundwater regulators from worrying about any impacts on surface water rights, unless those impacts arise after January 1, 2015. On the other hand, one might think that SGMA does not do anything to resolve conflicts between groundwater and surface water rights, and instead leaves the resolution of those conflicts to other laws.

We think the latter interpretation is stronger, and that SGMA does not make surface water rights subordinate to groundwater rights. A basic principle of statutory interpretation is that the interpreter should attempt to harmonize different laws, not create conflict.[70] Yet such conflicts would arise if SGMA were to override any claims that might arise under California's traditional systems of surface water rights. Consequently, the stronger interpretation is that, while SGMA does not establish any *new* obligation for GSPs to correct old impacts to surface water users or rights, it does not *eliminate* any obligations that groundwater users might have under preexisting law. But the question has not yet been resolved by any court.

More broadly, GSAs and other relevant agencies will need to allocate responsibility for surface water depletions by determining the portion of surface water depletion caused by SGMA-regulated pumping as opposed to the portion attributable to the actions of surface water users themselves, an exercise that may be conceptually straightforward but technically challenging.

SUBTERRANEAN STREAMS

"Subterranean streams" may present a particular challenge for interpretation and operationalization of the connections between groundwater and surface water rights. Under California law, so-called "subterranean streams flowing in known and definite channels"[71] are addressed under the surface water rights system. This suggests a need to identify such subterranean streams, as well as which wells are pumping from them, in order to determine whether wells are subject to SGMA regulation or regulation as surface water . But that will be difficult, both because of uncertainties about hydrology and because the phrase "known and definite streams" is a lawyers' creation, and has little correspondence with concepts used by scientists.

SGMA AND TAKINGS

Key Point: *Water rights in California are property rights, and surface or groundwater users may bring takings claims if they believe regulatory restrictions on use have effectively taken their property. However, inherent in those rights is some susceptibility to reasonable regulation. GSAs can limit the risk of takings liability by managing groundwater in a manner generally consistent with California water rights.*

Both the United States Constitution and the California Constitution protect property rights from being taken by government authorities without just compensation.[72] This prohibition extends to "regulatory takings," in which government regulation accomplishes the functional equivalent of a taking through regulatory controls.[73]

Rights to use surface water and groundwater in California are property rights.[74] Because regulation of groundwater use inevitably limits the exercise of some groundwater rights (while also protecting other rights), and groundwater management decisions may affect rights to use interconnected surface water, GSAs may fear that their efforts to manage groundwater could trigger takings claims. That fear might be heightened by language in SGMA itself, which expressly disclaims making any change to those rights.[75]

Nevertheless, GSAs likely do not face major threats from takings claims. Both California and federal courts have grounded their takings jurisprudence in an understanding that "'government regulation—by definition—involves the adjustment of rights for the public good,' … [and that] '[g]overnment hardly could go on if to some extent values incident to property could not be diminished without paying for every such change in the general law.'"[76] In the context of water law, California courts have repeatedly affirmed that water rights are subject to government regulation.[77] And in the specific context of groundwater use regulation, California courts, like the courts of other states, have affirmed that use restrictions do not effect takings unless they fail to meet the United States Supreme Court's *Penn Central* test.[78] That test is generally favorable to government defendants.[79]

That does not mean that the takings doctrine is irrelevant to a GSA's decision making. If a GSA manages groundwater in a way that creates a major redistribution of water away from surface water users and to groundwater users, it may be vulnerable to takings claims by the affected surface water users. Similarly, if a GSA were to effectively redistribute water rights from one class of groundwater users to another, it may be vulnerable to takings claims.[80] But if a GSA makes a good-faith effort to resolve water conflicts in an even-handed way, and takes into account the traditional requirements of surface and groundwater law, then its position is likely to be highly defensible.

C. THE PUBLIC TRUST DOCTRINE

Key Point: *If groundwater pumping within a GSA's jurisdiction draws water from aquifers that are tributary to surface waterways, the public trust doctrine is relevant.*

The public trust doctrine protects the recreational, ecological, navigational, and commercial values of navigable waters. That protection, as the California Supreme Court held in *National Audubon Society v. Superior Court*, is not limited to direct diversions from the navigable waterways themselves.[81] It also extends to diversions from their tributaries.[82] The *National Audubon Society* decision addressed diversions from surface tributaries, not groundwater, and no California appellate court has decided whether diversions of tributary groundwater also implicate the public trust doctrine. But a superior court in Siskiyou County recently held that tributary groundwater is subject to the public trust doctrine.[83] The authors of this report anticipate, based on analogy to the reasoning of *National Audubon Society*, that the appellate court will reach a similar holding. If we are correct, then pumping of tributary groundwater clearly will be subject to the public trust doctrine. However, there is disagreement within the broader legal community on this premise, and while the discussion that follows assumes we are correct on this point, that assumption may not hold. Similarly, a second contested issue in that litigation is whether SGMA completely subsumes the public trust doctrine or whether some independent duties will remain. The discussion that follows considers the scenario in which the latter principle will prevail. In that scenario state and local government decision makers would need to consider the public trust doctrine as they make SGMA-related decisions that will impact public trust waterways.[84]

If the doctrine applies to groundwater, then some obligations clearly exist while other questions remain unresolved. The primary obligation is for the state and its subdivisions to consider the public trust when making decisions that allocate water.[85] GSAs are subdivisions of the state, and for that reason, and also because state agencies must review and approve GSPs and exercise ongoing oversight over their implementation, this obligation will extend to policies set and actions taken by GSAs. Another important principle is also clear: the public trust doctrine can authorize, and even require, changes in use (for example, limits on quantity of water use) even when those uses are authorized by established water rights.[86]

Less clear, in some circumstances, are the implications of the public trust doctrine for the content of GSPs. If the state has established public trust flow requirements for waterways affected by groundwater pumping, then the state probably cannot lawfully determine that a GSP that is inconsistent with those requirements is adequate. But where the state has not set those requirements, the public trust doctrine calls for a balancing of the trust against other uses, with trust uses to be protected "whenever feasible."[87] That language suggests a thumb on the scales in favor of public trust protections, but it does not indicate how hard the thumb should press.

Similarly, even if public trust protections do apply, ambiguity will sometimes exist about the degree to which different water users are obligated to provide for public trust flows. Many waterways that are affected by groundwater pumping are also likely to be affected by surface water diversions, and the public trust doctrine contains no formula for allocating responsibility where multiple users are responsible for excessive cumulative impacts to public trust resources.

Consequently, GSAs seeking to avoid undesirable results due to significant and unreasonable depletions of interconnected surface water caused by groundwater extraction are advised—at a minimum—to minimize risk by considering the public trust impacts of their plans, and to document consideration of those impacts in their GSPs. SWRCB and DWR must also consider the potential public trust impacts of plans they review, and the actual public trust impacts of plan implementation. That consideration is likely to take into account any public trust flow requirements that the SWRCB has set, and it may also be informed by flow requirements established by NOAA Fisheries or FWS in Biological Opinions for species listed under the Endangered Species Act. Finally, although the obligations of GSAs and state oversight agencies are not yet crisply defined, plans will in general be less legally vulnerable if they are more protective.

D. STATUTORY ENVIRONMENTAL CONSIDERATIONS

Many environmental laws have implications—often indirectly—for groundwater uses and groundwater management decisions that affect surface water flows. This section discusses some of the most important laws and their potential implications for GSAs. While the particulars may differ, there are two general themes to this discussion. First, how environmental laws might apply to GSA's management decisions and actions is hard to predict with precision. Second, the legal risks borne by GSAs, and by the groundwater users they regulate, will be lower if environmental impacts on surface water flows and habitats are reduced.

FEDERAL AND STATE ENDANGERED SPECIES ACTS

Key Point: *Endangered species laws apply to groundwater allocation decisions that may impact listed species. GSAs seeking to avoid consequences under the ESA should be aware of these species within the basin and explicitly address their needs when developing GSPs.*

In general, both the state and federal Endangered Species Acts apply to water allocation decisions. Groundwater allocation decisions may impact endangered species and their habitats—including streams and other groundwater-dependent ecosystems such as wetlands. GSAs seeking to avoid consequences under the Endangered Species Acts should consider whether listed species might be affected by groundwater use within their basins. The nature of these laws' applicability is somewhat complicated, however, and does involve some legal ambiguity.

The federal Endangered Species Act (ESA) establishes two primary prohibitions: (a) Section 7 prohibits federal agencies from authorizing, funding, or carrying out actions that are likely to jeopardize the continued existence of listed species, or that are likely to adversely modify their designated critical habitat;[88] and (b) Section 9 prohibits anyone—not just federal agencies—from taking actions that will "take" listed species, unless that person has obtained an incidental take authorization or permit.[89] The former obligations will rarely affect GSAs, which are subdivisions of the state and generally will not need federal authorization for their actions (unless, for example, GSAs are seeking federal funding). The latter obligations, however, could apply, particularly because NOAA Fisheries and the USFWS have defined "take" to include actions, like modifying habitat, that proximately cause harm to members of a listed species.[90] So, for example, groundwater pumping that dewaters a surface stream while coho salmon are present would cause prohibited takes.

The California ESA (CESA) contains a similar restriction. It prohibits "takes" of listed species unless the person or entity[91] committing the take has obtained an incidental take permit.[92] The California Fish and Game Code defines the term "take" somewhat more narrowly than does the federal ESA, and the term "harm"[93] is absent from the state definition.[94] Nevertheless, that narrower definition would not insulate water users from liability if their pumping was demonstrably the cause of deaths of listed species.

While the possibility of takes is clear, the likelihood of GSAs bearing liability in their regulatory roles is less certain. There are two reasons for this uncertainty. First, proving that groundwater pumping proximately caused harm to a protected species might be difficult. Impacts to surface water resources typically arise from a variety of sources, and plaintiffs in Section 9 cases involving water diversions have sometimes struggled to adequately show causation.[95] Second, some legal uncertainty exists about the extent to which regulators face take liability for actions taken by the entities they regulate. Some courts have construed regulatory authorizations as granting permission for actions that otherwise *would not* occur, and thus have concluded that regulators can face take liability.[96] Other courts have construed regulation as a partial prohibition on actions that otherwise *would* occur, and therefore have held that the regulatory decisions only caused a *reduction* in impact, not any of the harms resulting from the regulated action.[97] The former mode of reasoning, if applied to GSAs (or to DWR and the SWRCB), would create potential take liability; the latter would not unless the GSA's regulatory decisions resulted in increased harm to listed species.

GSAs and the entities they regulate can avoid take liability by developing habitat conservation plans (HCPs), which compensate for unavoidable impacts to listed species through other actions to protect or restore habitat.[98] Habitat conservation planning is generally not a quick or cheap process, and if a GSA is concerned about take liability, avoiding impacts may be more efficient than developing an HCP. But if a GSA's planning will be linked to broader and more integrative water resource planning, including an HCP as an element of that planning may make sense.

It is important to note that take liability depends on context. While this discussion focuses primarily on GSAs as regulatory bodies, GSAs may also act as operators who build infrastructure or move water. In that operational capacity, GSAs' potential take liability is clearer.

Of course, the entire regulatory environment will generally be simpler if species are not formally listed as threatened or endangered in the first place. Collaborating with other local entities and working to help species of concern avoid declining to the point where they are formally listed may therefore be a useful strategy for GSAs. This is a common practice, and regulated and governmental entities sometimes formalize these efforts through negotiated deals known as "candidate conservation agreements."[99] To that end, GSAs seeking to avoid liability with regard to endangered species may choose to minimize their risk by a) considering impacts on species that are potentially at risk as they develop their GSPs, and b) strongly considering measures to minimize such impacts.

CALIFORNIA ENVIRONMENTAL QUALITY ACT

Key Point: *The preparation and adoption of GSPs is specifically exempt from CEQA. However, implementation actions taken by a GSA under a GSP would remain subject to CEQA. Compliance with CEQA would include analyzing and mitigating potential negative impacts on interconnected surface waters.*

When California state or local agencies take actions with potentially significant environmental impacts, they normally must comply with the California Environmental Quality Act (CEQA).[100] GSAs are local agencies, and impacts of groundwater management practices on interconnected surface water may be significant, so the prerequisites for CEQA's applicability exist. SGMA, however, specifically exempts "the preparation and adoption" of GSPs from CEQA.[101] That removes CEQA from GSAs' list of potential concerns as they develop their plans.

However, this exemption does not extend to "a project that would implement actions taken pursuant to a plan adopted pursuant to this chapter."[102] Consequently, GSAs will need to comply with CEQA during the plan implementation stage. Compliance with CEQA would mean, among other things, disclosing environmental impacts upon interconnected surface waters, considering alternative implementation measures that will avoid or reduce those impacts, and adopting, to the extent feasible, mitigation measures for those impacts.

CLEAN WATER ACT AND PORTER-COLOGNE ACT

Key Point: *Although water quality is also addressed separately within SGMA,[103] it is relevant to groundwater-surface water interactions, including through effects on streamflow volume and temperature.*

The Federal Clean Water Act and the California Porter-Cologne Water Quality Control Act both protect designated beneficial uses of surface water, and the Porter-Cologne Act also protects groundwater. These beneficial uses include fish and wildlife uses as well as human uses.[104]

Both of these acts focus primarily on protecting water quality from pollution, not on systems of water allocation. However, water quality still is relevant to groundwater-surface water interactions. Broadly speaking, flow is a part of water quality.[105] Additionally, some aspects of water quality are highly related to groundwater-surface water interactions. For example, streams may become excessively warm if groundwater contributions to streamflow are inadequate.[106]

The *legal* connections between GSAs' activities and water quality law are less direct. Because GSAs will regulate the removal of groundwater from aquifers, rather than discharging pollutants into surface water, their activities generally will not trigger the federal Clean Water Act's prohibitions on unpermitted pollutant discharges.[107] Federal Clean Water Act issues instead are most likely to arise under Section 303, which requires states to set water quality standards and also requires them to establish total maximum daily loads (TMDLs)—which essentially are pollution budgets—for impaired waterways.[108] A state may then use its TMDL as a basis for imposing regulatory controls on stressors that are impairing those waterways, and those additional regulatory controls could include measures to limit groundwater pumping.[109] Nevertheless, whether those additional controls exist and under what laws they arise are matters of state discretion; the Clean Water Act itself does not require states to turn TMDLs into actual controls on groundwater users.[110]

Unlike the Clean Water Act, the Porter-Cologne Act contains many provisions that discuss groundwater. But these provisions tend to focus on protecting groundwater *from* contamination, not on protecting surface waterways from groundwater pumping (for this reason, groundwater recharge projects, which GSAs may pursue, will have Porter-Cologne implications, but those implications are outside the scope of this report).

One exception is California Water Code Section 13149, which pertains specifically to cannabis cultivation. That section requires the SWRCB, working with CDFW, to "adopt principles and guidelines for diversion and use of water for cannabis cultivation in areas where cannabis cultivation may have the potential to substantially affect instream flows." Section 13149 then states that "[t]he principles and guidelines may include requirements that apply to groundwater extractions where the board determines those requirements are reasonably necessary for purposes of this section." Section 13149 does not specifically reference SGMA, but these requirements would authorize constraints that GSPs would then need to address—if the GSP regulates groundwater

CASE EXAMPLE: TEMPERATURE TMDL IN THE SCOTT RIVER

Managing the intersection between groundwater, surface water, water quality, and the public trust is complex. Efforts to fully integrate all of these considerations have been rare, but the Scott River provides a promising example of ongoing efforts.

The Scott River, a major tributary to the lower Klamath River, provides important habitat for steelhead trout, Chinook salmon, and coho salmon (the latter listed as threatened under both the federal and California ESAs). These fish require minimum flows at sufficiently low temperatures. Before reaching the Klamath River through a long, steep gorge, the Scott River flows across Scott Valley, a large montane alluvial basin nestled adjacent to the Marble Mountains. Agricultural groundwater pumping in Scott Valley has reduced the amount of cooler groundwater contributing to the Scott River's baseflow. This has reduced late summer and fall streamflow and raised surface water temperatures, which in turn has affected fish habitat.

In 2005, in recognition of the importance of cool temperatures for salmonids in the river, the North Coast Regional Water Quality Control Board established a sediment and temperature TMDL for the Scott River.[111] Because of the relationship between groundwater input and surface water temperatures, groundwater management has become an essential element of meeting the temperature TMDL requirements. In 2008, a Community Groundwater Study Plan was developed to provide a road map toward better understanding of Scott Valley's groundwater resources, their use, and groundwater connectivity to streams. Ensuring that fish habitat is protected in this river—while also protecting other beneficial uses, including agricultural needs—requires developing a solid understanding of groundwater-surface water hydrology, collecting baseline data, developing models, and examining potential approaches to management, as identified in the Study Plan.

Since then, Siskiyou County developed a groundwater management plan under pre-SGMA legislation. An extensive network of private wells has been monitored monthly for water level fluctuations;[112] UC Cooperative Extension has investigated irrigation rates, consumptive water use, and soil moisture dynamics of alfalfa, the major irrigated crop in Scott Valley; and University of California Davis researchers have developed the Scott Valley Integrated Hydrologic Model (SVIHM) in collaboration with the Scott Valley Groundwater Advisory Committee and local stakeholder groups. The SVIHM provides wet, average, and dry year water budgets, detailed information on groundwater-surface water flow dynamics, and a basis for assessing future management activities. Results indicate that groundwater recharge during winter and spring may enhance groundwater accretion into the Scott River as late as September and October, when Chinook salmon migration into Scott Valley begins. With the help of SVIHM data that demonstrate potential beneficial uses to streams, Scott Valley Irrigation District obtained temporary water rights permits to pilot a UC Davis-led study of managed aquifer recharge on agricultural lands during winter months.

In 2017, Siskiyou County Flood Control and Water Conservation District became the governing GSA for Scott Valley. The GSA may collaborate with the North Coast Regional Water Board on the continued implementation of the TMDL,[113] by implementing some of the proposed groundwater management strategies, which would also address the state's groundwater sustainability planning requirements. The latter require that groundwater-dependent ecosystems do not deteriorate beyond baseline conditions prior to 2015.

A recent lower court decision,[114] currently under appeal, established that groundwater pumping in the Scott Valley constitutes a diversion of water from the Scott River that is subject to the public trust doctrine. The court affirmed the county's responsibility in administering the state's public trust doctrine responsibilities. However, the decision explicitly does not elaborate on the specifics of those responsibilities.

In 1980, the Siskiyou County Court adopted the Order of Determination issued by the SWRCB in the Scott River adjudication. The decree allocates water rights to all surface water users on the Scott River, including those with pre-1914 water rights, appropriative rights, and riparian water rights to the Scott River. The decree also establishes a zone of interconnected groundwater along the Scott River, for which groundwater pumpers have been assigned adjudicated water rights. It is the only adjudication in Northern California for which the rights of groundwater pumpers were adjudicated, and remains notable in that it has made linkages between groundwater and surface water explicit. The adjudicated area is explicitly excluded from the 2014 public trust doctrine court decision and from SGMA implementation. Members of the area have been active partners in the existing Groundwater Advisory Committee and in the implementation of the TMDL action plan, and SVIHM scenarios have identified the area as a potentially important area within the Scott Valley for winter and spring groundwater recharge that could benefit summer and fall Scott River flow contributions from the aquifer.

While the Scott River controversy involves a number of unique physical and institutional elements, its progress in generating new options provides some hope that with sufficient will, creativity, and engagement among key stakeholders, it may be possible to find solutions for seemingly intractable conflicts involving groundwater and surface water.

withdrawals for cannabis cultivation. Otherwise, these requirements do not apply to groundwater withdrawals.

INSTREAM FLOW CRITERIA AND OBJECTIVES

Key Point: *To avoid significant and unreasonable adverse impacts on surface water, minimize risk of litigation, and maximize their GSPs' defensibility, GSAs will need to be aware of instream flow requirements set by the SWRCB and consider them when developing and implementing GSPs.*

Together, the Public Trust Doctrine, the Federal and State Endangered Species Acts, and the Federal Clean Water Act and Porter-Cologne Act form much of the legal basis for protecting surface water quality and quantity in California. However, other laws create similar or additional obligations.

For example, CDFW develops instream flow recommendations (criteria) that identify the instream flows necessary to maintain healthy conditions for aquatic and riparian species. The program is based on the streamflow protection standards under California's Public Resources Code,[115] as well as Fish and Game Code § 5937, which requires maintenance "in good condition" of below-dam fisheries.[116] CDFW communicates its recommendations to the SWRCB, which considers these instream flow needs when making decisions related to water allocation.[117] As of October 2017, instream flow criteria were available for twenty-two streams located throughout California.[118]

The SWRCB can build on non-binding flow criteria, developed by CDFW or through contracted instream flow studies, to set and implement requirements for the quantity, quality, and timing of instream flows needed to protect public trust resources. Unlike flow criteria, these requirements, commonly known as instream flow objectives, have regulatory effect.[119]

The effects of instream flow requirements upon GSAs may be largely indirect. GSA's are unlikely to be primarily and directly responsible for ensuring specific instream flow levels. But instream flow objectives might inform the state's willingness to approve a GSP that would result in significant reductions in the baseflow of surface waterways. Consequently, GSAs may decide to factor these streamflows into their decision making, even if the legal connections between streamflow standards and groundwater management are somewhat uncertain and attenuated.

E. SGMA BASELINE DATE AND THE "GRANDFATHER CLAUSE"

Key Point: *SGMA does not require GSAs to address impacts on surface water that occurred before January 1, 2015. However, SGMA probably does not remove the responsibility of GSAs to address requirements stemming from other laws. Further, this grandfather clause likely does not extend to impacts that were caused by pre-2015 pumping but did not emerge until after January 1, 2015.*

As previously mentioned, SGMA does not require GSAs to address impacts on surface water that occurred before January 1, 2015.[120] This raises several questions. First, the text does not address whether GSAs have obligations under other laws to address pre-2015 impacts to surface water or surface water users, and, if so, the extent of GSAs' obligations. Second, some readers might wonder whether impacts of pre-2015 pumping that do not emerge until after January 1, 2015 must be addressed under SGMA.

We think the stronger answer to the first question is that, while SGMA clearly creates no responsibilities to address pre-2015 impacts, it also does not remove any responsibilities that might be created by other laws. This view is based on a classic principle of statutory interpretation. As the California Supreme Court has stated, "[r]epeals by implication are not favored, and are recognized only when there is no rational basis for harmonizing two potentially conflicting laws."[121] That principle would be violated if SGMA had impliedly repealed laws that otherwise would have obligated a GSA to address pre-2015 impacts.

The second question asks about impacts caused by pre-2015 pumping. Groundwater flow is an often slow process of seepage through small pore spaces. This means that the impacts of groundwater pumping can be delayed.[122] It is our reading that, in focusing on the timing of *impacts* rather than the timing of groundwater extraction itself, SGMA does not extend its grandfather clause to impacts that were caused by pre-2015 pumping but that did not emerge until on or after January 1, 2015. This means that undesirable results emerging after this date that result from pre-2015 pumping still must be addressed. Consequently, GSAs may need to generate sufficient technical understanding to trace the impacts of pumping, such as through the development of stream depletion functions described in Table 2 on page 16, or develop a defensible heuristic to account for temporal lags in impacts.

Additionally, it is important to remember that while SGMA does not require GSAs to address pre-2015 impacts, this does not mean that GSPs must use a January 1, 2015, baseline. A GSA may decide to set minimum thresholds and measurable objectives to address undesirable results that occurred earlier.[123]

V. Institutional roles in addressing groundwater-surface water interactions

In addition to substantive legal questions, SGMA's recognition of the intersection of groundwater and surface water raises questions about decision-making processes and institutional responsibilities. These questions arise partly because acknowledging the physical connections between groundwater and surface water means bringing groundwater law into contact with elements of surface water law that entities other than GSAs have traditionally implemented. These questions also will arise because, just as SGMA does not resolve every question about substantive law, it also leaves unresolved some key questions about procedures and roles. Finally, these questions will arise because many GSAs must confront complex decisions with limited resources, and drawing upon the institutional capacity of other agencies with complementary responsibility and expertise may be a practical necessity.

In this section, we discuss these issues. We attempt to clarify the roles and responsibilities of GSAs, state and federal agencies, and other entities. We also describe potential options for collaborative solutions where ambiguities remain.

A. ROLES AND RESPONSIBILITIES FOR ENGAGEMENT

Some issues around groundwater-surface water interactions will fall partly within and partly outside of GSAs' expertise. Many of those issues also fall outside GSAs' direct regulatory authority or in regulatory arenas where regulatory authority is shared with other agencies. Questions therefore will arise about the roles and responsibilities of GSAs, state and federal agencies, and other basin stakeholders.

Table 3 summarizes some of the main roles and responsibilities of GSAs and other agencies—particularly DWR and SWRCB—for the legal areas outlined in the sections above. It is important to note that while GSAs are generally not responsible for enforcing these state and federal laws, the validity of a GSP is at risk if GSAs do not adequately address them. Additionally, these responsibilities may represent expanded roles for state agencies. DWR, for example, will need to consider some aspects of water law, like water rights and reasonable use doctrine, that have been historically the domain of the SWRCB (though we see nothing in the statute that prevents DWR from asking the SWRCB for help). If, for example, DWR approves a GSP without considering claims that the GSP is inconsistent with reasonable use doctrine, or that it might unlawfully interfere with existing water rights, the fact that another agency has more expertise on these subject areas is not likely to be an acceptable defense to a legal challenge to that approval.

As Table 3 illustrates, GSAs have a particular set of responsibilities, while other entities have authorities and responsibilities in relevant and related areas. In some cases, responsibilities may be relatively clear: for example, the SWRCB has the authority and responsibility to set instream flow requirements for rivers to protect public trust resources, and is under direction from the Governor to do so in the five streams identified in the California Water Action Plan. But, the SWRCB is not mandated to do so in every stream,[124] and public trust obligations still apply to state and local agencies in their decision making. In other cases, it may not be clear: binding decisions may not have been made yet, or it may not be clear how GSAs can or should translate them into the context of SGMA implementation. Additional or different obligations under these laws may also arise if GSAs decide to take on projects themselves—for example, active groundwater recharge projects, or projects that involve importing and distributing water—rather than functioning solely as planners and regulators.

In particular, there may be an unmet need for additional technical assistance and planning assistance for GSAs. While SGMA assigns DWR the general role of technical assistance provider, many of the topics outlined here more closely align with the

Table 3: Roles and responsibilities of GSAs and other agencies related to groundwater-surface water interactions

SOURCE OF RESPONSIBILITY	GSA	DWR	SWRCB	OTHER STAKEHOLDERS
General SGMA	**Planning and implementation.** Develop and implement GSPs (or alternatives) to avoid undesirable results. Set local standards for what constitutes a significant and unreasonable surface water depletion.	**Assistance and oversight.** Identify basin boundaries; prioritize basins. Evaluate and assess the adequacy of GSPs and their implementation. Provide planning and technical assistance to GSAs.	**Enforcement.** Help DWR determine when a GSP or its implementation is inadequate. If so, intervene.	GSAs are required to engage and consider the interests of a wide range of other stakeholders throughout GSP planning and implementation.
Reasonable use	Define and avoid locally undesirable results, including significant and unreasonable surface water depletions. Be cognizant of legal precedents for what is reasonable and unreasonable. Avoid authorizing unreasonable uses.	In evaluating GSPs, consider whether GSPs allocate water (e.g., through groundwater extraction allocations) consistent with reasonable use requirement.	Enforce reasonable use requirement.	Water users bear primary responsibility for avoiding unreasonable uses; a wide variety of stakeholders may bring administrative claims or lawsuits against allegedly unreasonable uses.
Water rights	Develop GSPs with a general understanding of groundwater and surface water rights, and develop actions that are generally consistent with those rights.	In evaluating GSPs, consider their impacts on water rights. Protect DWR's own water rights.	Enforce water rights. Provide compliance assistance as feasible.	Other water right holders and stakeholders: Provide input and feedback on undesirable results and how to avoid them; protect their own water rights.
Public Trust Doctrine	Consider how GSPs will meet public trust-related minimum instream flow requirements, if applicable, and how to provide other feasible protections of public trust resources.	In evaluating GSPs, consider whether they protect public trust resources to the extent feasible.	Set and enforce public trust-based instream flow requirements. Provide compliance assistance as feasible.	CDFW: Develop instream flow recommendations. Federal wildlife agencies: Inform instream flow requirements. All wildlife agencies: Monitor implementation.

SOURCE OF RESPONSIBILITY	GSA	DWR	SWRCB	OTHER STAKEHOLDERS
Endangered Species Act	Develop GSPs in a way that avoids management actions that are likely to result in further take of listed species.	General evaluation and assessment of GSPs.	Set instream flow requirements to protect listed species. Provide compliance assistance as feasible.	USFWS, NOAA Fisheries: Produce biological opinions, review and approve habitat conservation plans, designate critical habitat, issue incidental take authorizations and permits, enforce federal ESA. CDFW: review habitat conservation plans, issue incidental take authorizations and permits, enforce CESA
Clean Water Act	Consider how groundwater management may impact water quality standards meant to protect beneficial uses of interconnected surface water and address / prevent significant and unreasonable impacts.	General evaluation and assessment of GSPs.	Set, implement, and enforce water quality standards, including through instream flow requirements. Provide compliance assistance as feasible.	Regional Water Quality Control Boards: Implement, and enforce water quality standards. US Environmental Protecton Agency: support and oversee state enforcement.

expertise of the SWRCB and other agencies. DWR and the SWRCB may need to work together to ensure that GSAs have access to the expertise they need, and to make sure that roles are sufficiently clear.

B. APPROACHES FOR ENGAGEMENT AROUND GROUNDWATER-SURFACE WATER INTERACTIONS

As the previous section attempts to convey, GSAs do not operate in a vacuum. Their purview for achieving sustainability is closely tied to the mandates of other local, state, and federal entities, as well as consideration of the interests of a broad range of stakeholders who are specifically called out in the legislation. This requires GSAs to make decisions about how to work with other agencies.

Engaging with relevant stakeholders is not just a potentially beneficial idea for GSAs: as outlined in SGMA, GSAs must engage with relevant stakeholders. SGMA requires GSAs to "consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans."[125] The relevant interest groups include, but are not limited to, holders of overlying groundwater rights (including agricultural users and domestic well owners); municipal well operators and public water systems; local land use planning agencies; environmental users of groundwater; surface water users (if groundwater and surface water are hydrologically connected); the federal government; California Native American tribes; disadvantaged communities; and entities monitoring and reporting groundwater elevations. At the same time, other entities also have motivation to engage proactively with GSAs. Doing so may help them ensure that their interests are represented and their issues are addressed.

GSAs will need to weigh the benefits and costs of different potential approaches for engagement with other entities around groundwater-surface water interactions under SGMA. Below, we propose a collaborative approach to groundwater-surface water management, and discuss the potential benefits, as well as risks and costs, associated with this approach. In weighing approaches to collaboration, GSAs may need to make risk- and effort-based management decisions. In Table 4, we outline potential benefits, costs, and risks to help frame deliberation about how GSAs might

CASE EXAMPLE: RECONNECTING THE DISCONNECTED COSUMNES RIVER THROUGH COLLABORATIVE EFFORTS

The Cosumnes River, located in Northern California on the western side of the Sierra Nevada and flowing into the Mokelumne River in the Sacramento-San Joaquin Delta, is one of the last undammed rivers flowing from the Sierra Nevada. The river has ecological and cultural values and supports endangered Chinook salmon. As a result of decades of extensive groundwater pumping for agriculture and urban growth, significant reaches of the Cosumnes River are now hydraulically disconnected from the underlying aquifer.[126] Because these impacts on groundwater-surface water connections largely occurred before SGMA's baseline date of January 1, 2015, SGMA does not *require* the local GSA to address them.

However, the Cosumnes Coalition, a group of local stakeholders, including the American River Conservancy, Cosumnes Culture and WaterWays, the Fishery Foundation of California, Landmark Environmental, and Trout Unlimited, has been working with USFWS, CDFW, US Bureau of Land Management, and UC Davis researchers on plans to recharge groundwater via floodplain restoration in the Cosumnes basin.[127]

Despite the fact that SGMA does not *require* this action, the coalition is utilizing SGMA as a way to promote multi-benefit natural infrastructure projects that could ultimately reconnect the aquifer and the river. In this case, SGMA may provide an *opportunity* for stakeholders to come together for the purpose of furthering environmental goals that center on restoring the river's baseflow. Whether the efforts will ultimately be successful remains to be seen.

approach the issues at stake, and whether and how entities other than the GSA itself might become involved.

As Table 4 illustrates, there are distinct benefits to taking a collaborative approach to addressing conflicts and issues that may arise with regard to groundwater-surface water interactions.

First, conflicts between groundwater and surface water users may be resolved through the process of forging mutually advantageous institutional relationships. For example, an institution that is primarily a surface water user may provide institutional support and funding to ensure better groundwater planning. So, for example, a downstream surface water user that relies at least partly on groundwater recharge for its supplies may have a strong incentive to help upstream GSAs plan (see, for example, the case example describing the Ukiah Valley Groundwater Basin GSA on page 39)—and may also have the financial resources to support such assistance. The resulting collaborative process may involve going beyond baseline legal requirements in order to resolve conflicts between groundwater users, surface water users, and environmental uses of water in a given basin.

Second and relatedly, multi-stakeholder processes can lead to creative and possibly win-win solutions. For example, stakeholders can use strategies associated with conjunctive use, the practice of coordinating use of surface water and groundwater.[128] Such strategies include intentional groundwater recharge; the use of groundwater aquifers for water storage; in-lieu recharge; and agricultural and stormwater recharge programs to directly or indirectly protect or increase baseflow or water levels that support GDEs. Stakeholders also might allocate money to stormwater management projects designed to augment water supplies and alleviate stress on groundwater and surface water. Alternatively, or additionally, groundwater markets may be a potential strategy for allocating the burdens of water use reductions (although water markets come with many considerations).[129]

While these processes are promising, turning them into legally binding arrangements can be tricky. For example, so-called 'physical solutions' can be developed within or outside of an adjudication.[130] Participants in a multi-stakeholder process can use contracts to memorialize their agreements, and if the agreement emerges out of a legal proceeding, the parties can seek judicial approval of a settlement. Both contractual and settlement agreements can be quite creative and need not exactly track California water law, so long as all the affected parties are in agreement. The challenges to these creative deals tend to arise if there are affected holdouts who do not agree to the deal. The parties to a contract cannot negotiate away the legal rights of a third party, and while judges have some equitable discretion to impose a solution even on a reluctant party, that discretion does not allow wholesale abrogation of traditional water rights.[131] A judge also cannot exercise that discretion until judicial proceedings are complete, and that can take years.

While collaborative, multi-stakeholder processes are challenging, SGMA does give GSAs a jump-start toward initiating such projects. The requirements for participation by multiple agencies ensure that several key players will be engaged with the process of GSA approval. The involvement of the SWRCB also means that an agency with regulatory authority over surface water rights will be involved. Consequently, if a GSA wants to link its GSP with a broader set of agreements involving surface water rights and environmental protection, a crucial participant will already be at the table. The fact that SGMA mandates the participation of at least three agencies in groundwater management—the GSA, DWR, and the SWRCB—and as a practical matter may require the participation of many more, will make management of groundwater-surface water interactions institutionally complex. But with the challenges of complexity will come opportunities to turn GSP development and implementation into an inclusive process for addressing a wide variety of water management issues.

Table 4: Proposed approach for collaboration between GSAs and other entities, weighing benefits and costs

	GSA management approach	Potential benefits	Potential costs or risks
Overarching approach	GSA works collaboratively with a range of stakeholders in order to avoid significant and unreasonable adverse impacts to interconnected surface water uses.	Potentially durable decisions, equitable outcomes, and perception of legitimacy. Access to stakeholder data and expertise.	Potentially high direct or upfront costs (including time as well as money)
Approach to monitoring and modeling	GSA robustly monitors and models groundwater-surface water interactions and related impacts in the groundwater basin. GSA collaborates with other experts and stakeholders conducting monitoring and modeling.	Potential for a defensible, durable GSP. Ability to base decisions on data. Potential for avoiding surprises of more stringent restrictions in the future. Access to stakeholder data and expertise.	May run up against technical limitations. May be resource intensive.
Approach to navigating legal context	GSA assumes that a variety of laws, including but not limited to SGMA, have important implications for addressing groundwater- surface water interactions.	Potentially decreased risk of disruptive intervention by state or federal regulators.	Potentially difficult to navigate laws. Legal expertise may be expensive.
Approach to stakeholder engagement	GSA assumes that many different interests depend on groundwater, and that the GSA has the legal responsibility and/or discretion and the societal obligation to advance those interests, as a lead agency (catalyst) or as a partner agency among a multitude of local, regional, state, and federal agencies. GSA assumes that a range of stakeholders have interests in impacts to surface waters, and those stakeholders have a legitimate claim to access the decision-making process.	Potentially decreased risk of costly and divisive lawsuits from other parties. Potential for durable, equitable decisions. Potential for a defensible, durable GSP.	Risk of near term decision failure. Collaboration may increase the chance of paralysis. Risk of catalyzing objections from surface water stakeholders. Potentially resource intensive.
Approach to decision making process	GSA decision-making processes are proactively inclusive, soliciting input (1) from environmental regulators on endangered species, water quality, and public trust flow needs in the basin; (2) from surface water users on their needs and concerns; and (3) from groundwater users. GSA uses professional facilitators to identify goals and arrive at a thoughtful balance between groundwater use and surface water protection in the basin.	Proactive communication is likely to ensure that relevant interests are voiced, understood, and can be addressed satisfactorily.	Potentially high upfront costs. Potential for decision failure.

CASE EXAMPLE: GSA COLLABORATION IN THE UKIAH VALLEY GROUNDWATER BASIN SHOWS THAT AGENCIES ARE READY FOR SUSTAINABLE GROUNDWATER MANAGEMENT

The Ukiah Valley Groundwater Basin is a medium-priority basin located in southeastern Mendocino County, one of several basins adjacent to the Russian River. The Russian River includes domestic, municipal, and agricultural water users as well as multiple ESA-listed salmonid species. Significant groundwater-surface water interactions occur within the Ukiah Valley basin. Thus, local surface water users and managers, as well as the environmental community, have a stake in SGMA implementation.

The Ukiah Valley Basin GSA is a Joint Powers Authority (JPA) that consists of the County of Mendocino, the City of Ukiah, the Russian River Flood Control District, the Upper Russian River Water District, and tribal and agricultural representatives. The GSA is initiating the preparation of a groundwater sustainability plan, whichwill need to evaluate the interaction of groundwater use with in-stream flows and surface water rights.

On the technical side, water balance models for short-term and long-term changes to the aquifer and interconnectivity impacts are being developed through a partnership between local agencies, the State Water Resources Control Board, and the US Geological Survey. A consultant retained by the GSA also is developing a discretized land and water use model. The latter model will identify areas in the surface water system that are vulnerable to potential undesirable results from groundwater pumping. These models will provide a reasonable dataset for analysis and policy making in the GSP in a timely and cost-effective way.

On the social and institutional side, agencies responsible for groundwater and surface water use have collaborated with stakeholders through a transparent public process of monthly meetings. The GSA has conducted a lengthy process of outreach to stakeholders. It also used a professional facilitator, who was funded by a DWR grant, in the GSA formation process. Challenges in the formation process were addressed through a consensus building approach rather than majority rule. Moving forward, if members of the GSA have concerns about a path forward or about a long-term project identified in the GSP, all of the members will work together to develop a solution that all of the agencies can respect and allow.

In the Ukiah Valley Groundwater Basin, groundwater and surface water—and thus the interests of groundwater and surface water users— are closely linked. This means that collaboration between different types of water users is essential. Despite their multiple and sometimes differing interests, the JPA member agencies that are a part of the Ukiah Valley Basin GSA agree that SGMA is the start of a lengthy process of collaboration which, in the long run, hopefully puts agencies on the same page. Future sustainability requires working together and finding ways to address hard questions around the intersections of managing groundwater and surface water.

VI. Conclusion

By acknowledging the connection between groundwater and surface water systems, SGMA took an important step for the future of integrative water management in California. But that step also generates many challenges and questions. Some of the challenges will arise from the need to develop a technical understanding of groundwater-surface water interactions, and others will arise from the many unresolved questions at the intersection of groundwater and surface water rights and other principles of state and federal law.

In this report, we have attempted to identify these questions and, to the extent that is possible to do so, to provide answers. Many of our answers are not definitive, but we hope they will help GSAs, state agencies, and others manage uncertainty as they navigate the challenges of sustainable groundwater management. We also hope our analysis will help GSAs and other stakeholders that choose to use SGMA compliance as an opportunity for collaboratively developing broad responses to a range of surface and groundwater management challenges.

Abbreviations and acronyms used in this report

AB Assembly Bill

BIA Bureau of Indian Affairs

BMP Best Management Practice

CESA California Endangered Species Act

CDFW California Department of Fish and Wildlife

DWR California Department of Water Resources

ESA Federal Endangered Species Act

HCP Habitat Conservation Plan

JPA Joint Powers Authority

GDE Groundwater Dependent Ecosystem

GSA Groundwater Sustainability Agency

GSP Groundwater Sustainability Plan

NOAA Fisheries National Oceanic and Atmospheric Administration Fisheries Service

SB Senate Bill

SGMA Sustainable Groundwater Management Act

SVIHM Scott Valley Integrated Hydrologic Model

SWRCB State Water Resources Control Board

TMDL Total Maximum Daily Load

UC University of California

USBR United States Bureau of Reclamation

USFWS United States Fish and Wildlife Service

USGS United States Geological Survey

Acknowledgments

This report draws on the insights of the experts who participated in the workshop series, augmented by substantial additional research by the author team. Responsibility for the report's content lies with the authors alone.

The following individuals participated in the workshop series:

Tamara Alaniz (Russian River Flood Control District)
Sam Boland-Brien (SWRCB)
Helen Dahlke (UC Davis)
Andrew Fisher (UC Santa Cruz)
Graham Fogg (UC Water)
Tim Godwin (DWR)
Vicki Kretsinger Grabert (Luhdorff & Scalmanini, Consulting Engineers)
Maurice Hall (Environmental Defense Fund)
Jay Jasperse (Sonoma County Water Agency)
Nicole Kuenzi (SWRCB)
Sandi Matsumoto (The Nature Conservancy)
Russ McGlothlin (Brownstein Hyatt Farber Schreck)
Mike Myatt (Water Foundation)
Deborah Ores (Community Water Center)
Richard Roos-Collins (Water and Power Law Group PC)
Stephen Springhorn (DWR)
DerrikWilliams (HydroMetrics)

We are grateful to all participants for sharing their time and expertise, and for their willingness to engage in open discussion of this complex and unsettled topic. We also specifically thank Tamara Alaniz, Jay Jasperse, and Russ McGlothlin for helping to structure workshop content and contributing presentations during the workshops.

The workshops were organized by Alida Cantor, Michael Kiparsky, Nell Green Nylen, Holly Doremus, Dave Owen, and Thomas Harter. Luke Sherman provided valuable organizational assistance. Special thanks to Holly Doremus for formative conceptual input and contributions to the workshops.

This work is supported by the University of California Office of the President (UCOP) through the UC Water Security and Sustainability Research Initiative (UCOP Grant No. 13941).

Review

The authors solicited review of a draft version of this report from workshop participants, as well as others with a range of perspectives and technical expertise. Review comments and the draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Tamara Alaniz
Russian River Flood Control District

Reed Benson
University of New Mexico

Thad Bettner
Glenn-Colusa Irrigation District

Timothy Godwin
California Department of Water Resources

Tyler Hatch
California Department of Water Resources

Jay Jasperse
Sonoma County Water Agency

Vicki Kretsinger Grabert
Luhdorff & Scalmanini Consulting Engineers

Nicole Kuenzi
California State Water Resources Control Board

Sandi Matsumoto
The Nature Conservancy

Roderick Walston
Best Best & Krieger, LLP

Derrik Williams
HydroMetrics Water Resources Inc.

All review comments were carefully considered. We are grateful for the efforts of reviewers, whose constructive comments and suggestions have helped us to improve the report. Reviewers were not asked to endorse the report's conclusions or recommendations, and reviewers did not see the final draft of the report before its release. Naturally, responsibility for the final content of this report rests entirely with the authors, and any errors are our own.

About the authors

Alida Cantor is an Assistant Professor of Geography at Portland State University; she was previously a Research Fellow with the Wheeler Water Institute at the Center for Law, Energy & the Environment at Berkeley Law. Her teaching and research focus on natural resource management and policy with an emphasis on water resources. Dr. Cantor holds a Ph.D. in Geography from Clark University.

Dave Owen is a Professor of Law at the University of California, Hastings College of the Law. His teaching and research focus on water resources law, environmental law, and administrative law. He holds a J.D. from Berkeley Law, where he was editor-in-chief of Ecology Law Quarterly.

Thomas Harter is a Professor and Cooperative Extension Specialist in Groundwater Hydrology, Department of Land, Air, and Water Resources at the University of California, Davis. He is the Robert M. Hagan Endowed Chair for Water Resources Management and Policy, and his research focuses on groundwater hydrology and sustainable groundwater management. He holds a Ph.D. in Hydrology from the University of Arizona.

Nell Green Nylen is a Senior Research Fellow with the Wheeler Water Institute at the Center for Law, Energy & the Environment at Berkeley Law. Her research engages law, science, and policy to tackle critical water issues. Dr. Green Nylen holds a J.D. from Berkeley Law, and a Ph.D. in Geological and Environmental Sciences from Stanford University.

Michael Kiparsky is the Director of the Wheeler Water Institute at the Center for Law, Energy & the Environment at Berkeley Law. He is also the UC Berkeley Director for the University of California Water Security and Sustainability Research Initiative (UC Water). Dr. Kiparsky holds a Ph.D. from UC Berkeley's Energy and Resources Group.

About CLEE

The Wheeler Water Institute develops interdisciplinary solutions to ensure clean water for California. Established in 2012 at the Center for Law, Energy & the Environment (CLEE) at Berkeley Law, the Institute conducts projects at the intersection of law, policy, and science.

The Center for Law, Energy & the Environment (CLEE) at Berkeley Law educates the next generation of environmental leaders and develops policy solutions to pressing environmental and energy issues. CLEE's current initiatives focus on reducing greenhouse gas emissions, advancing the transition to renewable energy, and ensuring clean water for California's future.

The UC Water Security and Sustainability Research Initiative is focused on strategic research to build the knowledge base for better water resources management. UC Water applies innovative science, technology, and implementation strategies to surface water and groundwater management.

Endnotes

1. Sax, J. L. (2002). We Don't Do Groundwater: A Morsel of California Legal History. *U. Denv. Water L. Rev.*, 6, 269–317.

2. Cal. Water Code, Division 6, Part 2.74.

3. Cal. Water Code § 10721(x).

4. Winter, T. C., Harvey, J. W., Franke, O. L., & Alley, W. M. (1998). Ground water and surface water, a single resource. U.S. Geological Survey Circular 1139.

5. Alley, W. M., Reilly, T. E., & Franke, O. L. (1999). Sustainability of ground-water resources. U.S. Geological Survey Circular 1186.

6. *See* Winter et al. (1998), endnote 4.

7. Eamus, D., & Froend, R. (2006). Groundwater-dependent ecosystems: the where, what and why of GDEs. *Australian Journal of Botany*, *54*(2), 91-96; Hatton, T., Evans, R., & Merz, S. K. (1998). *Dependence of ecosystems on groundwater and its significance to Australia*. Sinclair Knight Merz.

8. Howard, J., & Merrifield, M. (2010). Mapping groundwater dependent ecosystems in California. *PLoS One*, *5*(6), e11249; Murray, B. B. R., Zeppel, M. J., Hose, G. C., & Eamus, D. (2003). Groundwater-dependent ecosystems in Australia: It's more than just water for rivers. *Ecological Management & Restoration*, *4*(2), 110-113.

9. Barlow, P. M., & Leake, S. A. (2012). Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow. U.S. Geological Survey Circular 1376.

10. Patten, D. T., Rouse, L., & Stromberg, J. C. (2008). Isolated spring wetlands in the Great Basin and Mojave Deserts, USA: potential response of vegetation to groundwater withdrawal. *Environmental Management*, *41*(3), 398-413.

11. *See* Winter et al. (1998), endnote 4.

12. *See* Barlow & Leake (2012), endnote 9.

13. Taylor, R. G., et al. (2013). Ground water and climate change. *Nature Climate Change*, *3*(4), 322-329.

14. Fleckenstein, J. H., Krause, S., Hannah, D. M., & Boano, F. (2010). Groundwater-surface water interactions: New methods and models to improve understanding of processes and dynamics. *Advances in Water Resources*, *33*(11), 1291-1295; Sophocleous, M. (2002). Interactions between groundwater and surface water: the state of the science. *Hydrogeology journal*, *10*(1), 52-67.

15. Foglia, L., McNally, A., & Harter, T. (2013). Coupling a spatiotemporally distributed soil water budget with stream-depletion functions to inform stakeholder-driven management of groundwater-dependent ecosystems. *Water Resources Research*, *49*(11), 7292-7310.

16. Wu, B. et al. (2014). Systematic assessment of the uncertainty in integrated surface water-groundwater modeling based on the probabilistic collocation method. *Water Resources Research*, *50*(7), 5848-5865.

17. Taylor, C. J., & Alley, W. M. (2001). *Ground-water-level monitoring and the importance of long-term water-level data*. U.S. Geological Survey Circular 1217.

18. Wittenberg, H., & Sivapalan, M. (1999). Watershed groundwater balance estimation using streamflow recession analysis and baseflow separation. *Journal of hydrology*, *219*(1), 20-33.

19. Rosenberry, D. O., LaBaugh, J. W., & Hunt, R. J. (2008). Use of monitoring wells, portable piezometers, and seepage meters to quantify flow between surface water and ground water. In *Field techniques for estimating water fluxes between surface water and ground water.* US Geological Survey, 4-D2.

20. Hunkeler, D., Aravena, R., & Butler, B. J. (1999). Monitoring microbial dechlorination of tetrachloroethene (PCE) in groundwater using compound-specific stable carbon isotope ratios: microcosm and field studies. *Environmental Science & Technology*, *33*(16), 2733-2738.

21. *See* Howard & Merrifield (2010), endnote 8.

22. Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson (2018). Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy, San Francisco, CA.

23. Ruud, N., Harter, T., & Naugle, A. (2004). Estimation of groundwater pumping as closure to the water balance of a semi-arid, irrigated agricultural basin. *Journal of hydrology*, *297*(1), 51-73.

24. *See* Foglia, McNally & Harter (2013), endnote 15.

25. Moran, T. (2016). Projecting Forward: A framework for groundwater model development under the Sustainable Groundwater Management Act. Stanford Water in the West, Stanford Law School.

26. Littleworth, A. L., & Garner, E. L. (1995). *California Water*. Point Arena, California: Solano Press Books. For additional discussion of water rights in California, see the State Water Resource Control Board's review of the water rights process at https://www.waterboards.ca.gov/waterrights/board_info/water_rights_process.shtml

27. Cal. Water Code § 101.

28. *Id.*

29. Cal. Water Code § 1200 et seq.

30. Cal. Water Code § 1375–1677.

31. Though they are less prevalent, additional types of surface water rights also exist in California, including federal reserved rights and pueblo rights.

32. For more details in a concise overview of groundwater rights law, *see* Part III.C.1. in Green Nylen, N., M. Kiparsky, K. Archer, K. Schnier, and H. Doremus. (2017). Trading Sustainably: Critical Considerations for Local Groundwater Markets Under the Sustainable Groundwater Management Act. Center for Law, Energy & the Environment, UC Berkeley School of Law, Berkeley, CA, 90 pp. Available at: law.berkeley.edu/trading-sustainably

33. *See City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1240 (2000); Tehachapi-Cummings Cnty. Water Dist., v. Armstrong, 49 Cal. App. 3d 992, 1001 (1975).

34. *See City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 925–26 (1949).

35. *See City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 297 (2012).

36. *See City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 210–11, 251 (1975).

37. *Agua Caliente Band of Cahuilla Indians v. Coachella Valley Water Dist.*, 849 F.3d 126217 (9th Cir. 2017).

38. Cal. Water Code § 1200.

39. Existing groundwater management plans developed under this previous legislation are considered in effect until SGMA-approved groundwater sustainability plans (GSPs) are developed; however, as of 2015, new groundwater management plans cannot be adopted in medium- and high- priority basins, although they may still be adopted in very low- or low- priority basins. For more information see DWR, "Developing a Groundwater Management Plan" http://www.water.ca.gov/groundwater/groundwater_management/developingGWMP.cfm.

40. Nelson, R. (2011). Uncommon innovation: Developments in groundwater management planning in California. Woods Institute for the Environment, Stanford University.

41. *See* Sax (2002), endnote 1; *see also* Sax, J.L. (2002). Review of the Laws Establishing the SWRCB's Permitting Authority over Appropriations of Groundwater Classified as Subterranean Streams and the SWRCB's Implementation of Those Laws. California State Water Resources Control Board Report No. 0-076-300-0.

42. In the Matter of Determination of the Rights of the Various Claimants to the Waters of Scott River Stream System, Except Rights to Water of Shackleford Creek, French Creek, and all Streams Tributary to Scott River Downstream from the U.S. Geological Survey Gaging Station, in Siskiyou County, California, Jan. 16, 1980, available at https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/judgments/docs/scottriver_jd.pdf

43. *See Hudson v. Dailey*, 156 Cal. 617 (1909).

44. *See City of Lodi v. E. Bay Mun. Util. Dist.*, 7 Cal. 2d 316, 337–340 (1936); *Peabody v. City of Vallejo*, 2 Cal. 2d 351, 375 (1935); *Miller v. Bay Cities Water Co.*, 157 Cal. 256. 279–80 (1910); *McClintock v. Hudson*, 141 Cal. 275, 281 (1903).

45. *See, e.g.*, *City of Lodi v. E. Bay Mun. Util. Dist*., 7 Cal. 2d 316, 337–340 (1936); *Peabody v. City of Vallejo*, 2 Cal. 2d 351, 375 (1935).

46. Leahy, T.C. (2016). Desperate Times Call for Sensible Measures: The Making of the California Sustainable Groundwater Management Act. *Golden Gate Univ. Envtl. L. J.* 9, 5—40.

47. Cal. Water Code § 113.

48. Cal. Water Code § 10727.2.

49. Cal. Water Code § 10721(x).

50. Cal. Code Regs. tit. 23, § 351(o).

51. Cal. Water Code § 10727.2(b)(4).

52. Cal. Water Code § 10720.5.

53. Cal. Water Code § 10727.2.

54. Cal. Water Code § 10933(b)(8).

55. The Nature Conservancy. (2016). Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management. Available at: http://scienceforconservation.org/dl/GroundwaterStreamInteraction_2016.pdf

56. *See* Moran (2016), endnote 25, and generally, Cantor, A, M. Kiparsky, R. Kennedy, S Hubbard, R. Bales, L. Cano Pecharroman, K Guivetchi, C. McCready, and G. Darling. 2018. Data for Water Decision Making: Informing the Implementation of California's Open and Transparent Water Data Act through Research and Engagement. Center for Law, Energy & the Environment, UC Berkeley School of Law, Berkeley, CA. 54 pp. Available at:https://doi.org/10.15779/J28H01 or law.berkeley.edu/datafordecisions

57. California Department of Water Resources, Sustainable Groundwater Management Program. July 2016. Groundwater Sustainability Plan (GSP) Emergency Regulations Guide.

58. Cal. Code Regs. tit. 23, § 350.

59. Cal. Code Regs. tit. 23, § 354.28.

60. Cal. Code Regs. tit. 23, § 354.28(c)(6).

61. Cal. Code Regs. tit. 23, § 354.28.

62. California Department of Water Resources, Sustainable Groundwater Management Program. November 2017. Draft Sustainable Management Criteria BMP.

63. *In re* Waters *of Long Valley Creek Stream System,* 25 Cal. 3d 339, 354 (1979).

64. *See, e.g., Light v. State Water Resources Control Bd.*, 226 Cal. App. 4th 1463, 1482–87 (2014) (affirming the SWRCB's authority to enact reasonable use regulations).

65. *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1241–43 (2000) (citing *Peabody v. City of Vallejo*, 2 Cal.2d 351, 383 (1935); McGlothlin, R. M., & Acos, J. S. (2015). The Golden Rule of Water Management. *Golden Gate U. Envtl. LJ*, *9*, 109—132 (describing SGMA as a reflection of the reasonable use doctrine).

66. Neuman, J. C. (1998). Beneficial use, waste, and forfeiture: The inefficient search for efficiency in western water use. *Environmental Law*, 28, 919–996.

67. *Joslin v. Marin Mun. Water Dist.,* 67 Cal. 2d 132, 140 (1967); *see also Tulare Irr. Dist. v. Lindsay–Strathmore Irr. Dist.,* 3 Cal.2d 489, 567 (1935).

68. *See, e.g., Light*, 226 Cal. App. 4th at 1482–87; *Imperial Irr. Dist. v. State Water Resources Control Bd.*, 225 Cal. App. 3d 548, 573 (1990) ("All things must end, even in the field of water law. It is time to recognize that this law is in flux.").

69. Cal. Water Code § 10720.5.

70. *State Dept. of Public Health v. Sup. Ct.*, 60 Cal. 4th 940, 955 (2015).

71. Cal. Water Code § 1200.

72. U.S. Const., amend. V; Cal. Const. art. I, § 19.

73. *Murr v. United States*, 137 S.Ct. 1933, 1942 (2017).

74. *See City of San Bernardino v. City of Riverside*, 198 P. 784, 792 (Cal. 1921).

75. Cal. Water Code § 10720.5.

76. *Lingle v. Chevron U.S.A. Inc.*, 544 U.S. 528, 538 (2005) (quoting *Andrus v. Allard*, 444 U.S. 51, 65 (1979) and *Pa. Coal Co. v. Mahon*, 260 U.S. 393, 413 (1922)); *Cal. Bldg. Ind. Ass'n v. City of San Jose*, 351 P.3d 974, 995 (2015).

77. *Light v. State Water Resources Control Bd.*, 173 Cal. Rptr. 3d 200, 217 (2015); Gray, B. E. (2002). The property right in water. *Hastings W.-Nw J. Envt'l L. & Pol'y*, *9*.

78. *Allegretti & Co. v. Cnty. of Imperial*, 42 Cal. Rptr. 3d 122 (Ct. App. 2006). Owen, D. (2015). Taking Groundwater, *Wash. U. L. Rev.* 91, 253. The *Penn Central* test asks courts to consider the diminution in value caused by the regulatory restriction, the nature of the government action, and the extent of interference with investment-backed expectations.

79. Krier, J. E., & Sterk, S. E. (2016). An Empirical Study of Implicit Takings. *William & Mary Law Review*, *58*(1), 35–95 (documenting the minimal success of *Penn Central* claims).

80. Owen, D. (2013). Taking groundwater. *Wash. UL Rev.*, *91*, 253—307.

81. *Nat'l Audubon Soc'y v. Sup. Ct. of Alpine Cnty*, 33 Cal. 3d 419, 434–438.

82. *Id.*

83. Order after Hearing on Cross-Motions for Judgment on the Pleadings, Envtl. L. Found. v. Ca. State Water Resources Control Bd., Case No.: 34-2010-80000583 (Superior Ct. of Ca., County of Sacramento, July 15, 2014).

84. We make this assumption because courts have already reached similar outcomes for surface water management. In the Mono Lake case, for example, the Court held that the public trust doctrine creates obligations above and beyond those set by statutory law, even though the statutory laws applicable to surface water already were extensive.

85. *Nat'l Audubon Soc'y*, 33 Cal. 3d at 426.

86. *Id.* (stating that the doctrine "bars DWP or any other party from claiming a vested right to divert waters once it becomes clear that such diversions harm the interests protected by the public trust").

87. *Id.* at 446.

88. 16 U.S.C. § 1536.

89. 16 U.S.C. § 1538.

90. *See Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 515 U.S. 687 (1995) (upholding this definition).

91. While the statute uses the word person, court decisions have assumed and, more recently, held that the prohibition extends to government agencies. *Kern County Water Agency v. Watershed Enforcers*, 185 Cal. App. 4th 969 (2010).

92. Cal. Fish & Game Code §§ 2080, 2080.1.

93. *Babbitt v. Sweet Home*, 515 U.S. 687.

94. Cal. Fish & Game Code § 86. CESA's inclusion of incidental take provisions also suggest that an action can cause a take even if the killing of listed species was just an incidental consequence of the action and not its purpose.

95. *See, e.g., The Aransas Project v. Shaw*, 775 F.3d 641 (5th Cir. 2014) (declining to hold Texas water districts liable for withdrawals that allegedly caused a downstream die-off of whooping cranes).

96. *E.g. Strahan v. Coxe*, 127 F.3d 155, 165 (1st Cir. 1997).

97. *E.g. The Aransas Project*, 775 F.3d at 659–60; *Loggerhead Turtle v. County Council of Volusia County, Florida*, 92 F. Supp. 2d 1296 (M.D. Fla. 2000).

98. *See* 16 U.S.C. § 1539.

99. *See* United States Fish and Wildlife Service, Candidate Conservation/Candidate Conservation Agreements, https://www.fws.gov/endangered/what-we-do/cca.html.

100. Cal. Public Resources Code §§ 21000–21177; Cal Code Regs. tit. 14, §§ 15000–15387

101. Cal. Water Code § 10728.6.

102. *Id.*

103. Within SGMA, undesirable water quality results are explicitly addressed in two specific provisions: Undesirable Results 3 (Significant and unreasonable seawater intrusion) and 4 (Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies). Cal Water Code § 10721(x)(3), (4).

104. *See, e.g.,* 33 U.S.C. § 1313(c)(2)(A); Cal. Water Code § 12581.

105. *PUD No. 1 of Jefferson Cnty. v. Wash. Dept. of Ecology*, 511 U.S. 700, 719 (1994) (describing a distinction between water quality and water quantity as "artificial").

106. Temperature issues are different in different basins. While groundwater temperature tends to be relatively constant temporally with a relatively small range of fluctuations, groundwater temperatures can vary with relation to streamflow temperatures and streamflow conditions. That is, groundwater may be cooler or warmer than surface water temperatures depending upon the season and the surface water conditions. The issue of groundwater contribution to surface water temperature thus manifests in different ways in different basins at different times of year.

107. *See* 33 U.S.C. § 1311 (prohibiting unpermitted discharges).

108. 33 U.S.C. § 1313.

109. *See, e.g., Pronsolino v. Nastri*, 291 F.3d 1123, 1130 (9th Cir. 2002) (describing allegedly costly restrictions imposed in response to a TMDL).

110. *Id.* at 1140.

111. Scott River TMDL, California Water Boards North Coast R1, https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/ (last updated Nov. 1, 2017).

112. For more information, *see* UC Davis. UC Groundwater Cooperative Extension Program: Research Projects. http://groundwater.ucdavis.edu/Research/ (last visited Feb. 23, 2018).

113. California Regional Water Quality Control Board, North Coast Region. Order No. R1-2017-0031: Scott River TMDL Conditional Waiver of Waste Discharge Requirements. https://www.waterboards.ca.gov/northcoast/board_info/board_meetings/06_2017/5/170601_ScottWaiver_Draft.pdf

114. *Envtl. Law Found. v. State Water Resources Control Bd.*, No. 34-2010-80000583 (Cal. Super. Ct. July 15, 2014)

115. Cal. Public Resources Code § § 10000–10005.

116. Cal. Fish and Game Code § 5937.

117. Cal. Public Resources Code § § 10000–10005.

118. California Department of Fish and Wildlife. CDFW Instream Flow Recommendations Map. https://www.wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Recommendations (last visited Dec. 13, 2017).

119. SWRCB. Development of Flow Objectives. https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/flow_objectives/index.shtml (last updated Aug. 31, 2016).

Delta Stewardship Council (2014). Recommendations for Determining Regional Instream Flow Criteria for Priority Tributaries to the Sacramento-San Joaquin Delta. Available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/flow_objectives/docs/delta_science_rpt_022014.pdf.

120. Cal. Water Code § 10727.2(b)(4).

121. *Fuentes v. Workers Comp. Appeals Bd.*, 547 P.2d 449, 453 (Cal. 1973).

122. *See* Alley, Reilly & Franke (1999), endnote 5.

123. California Department of Water Resources, Sustainable Groundwater Management Program. November 2017. Draft Sustainable Management Criteria BMP. In particular, *see* Figure 8: Example of Depletion of Interconnected Surface Water Minimum Threshold, p. 17.

124. The 2009 Delta Reform Act required the SWRCB to rapidly "develop new flow criteria for the Delta ecosystem necessary to protect public trust resources" and to develop "a prioritized schedule and estimate of costs to complete instream flow studies for the Delta and for high priority rivers and streams in the Delta watershed" by 2012, and for other major rivers and streams by 2018. Cal. Water Code §§ 85056, 85057.

125. Cal. Water Code § 10723.2

126. Fleckenstein, J., Anderson, M., Fogg, G., & Mount, J. (2004). Managing surface water-groundwater to restore fall flows in the Cosumnes River. *Journal of Water Resources Planning and Management*, *130*(4), 301-310.

127. Johnson, M. (2017). Cosumnes River Provides Model for Floodplain Restoration in California. News Deeply. Apr. 19, 2017. https://www.newsdeeply.com/water/articles/2017/04/19/cosumnes-river-provides-model-for-floodplain-restoration-in-california.

128. Thompson Jr, B. H. (2010). Beyond connections: pursuing multidimensional conjunctive management. *Idaho L. Rev.*, *47*, 273–324.

129. *See* Green Nylen et al (2017), endnote 32.

130. Note that, shortly after SGMA was passed, the legislature imposed a set of requirements for future comprehensive groundwater adjudications to ensure that they are consistent with sustainable groundwater management under SGMA. *See* Cal. Water Code §§ 10720.8, 10737.2, 10737.8; *see also* Cal. Civ Proc. Code §§ 830–852 (establishing new rules for comprehensive groundwater adjudications).

131. *See City of Barstow v. Mojave Water Agency*, 5 P.3d 853, 858 (2000) ("We granted review to determine whether a trial court may definitively resolve water right priorities in an overdrafted basin with a "physical solution" that relies on the equitable apportionment doctrine but does not consider the affected owners' legal water rights in the basin. We conclude it may not.").