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The Devil is in the Data: The Role of Science, Data, and Models in California's Historic Sustainable Groundwater Management Act

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Introduction

Although California is known as a leader when it comes to climate change, its approach to groundwater has been more reminiscent of the Wild West. While groundwater provides up to 60 percent of the state's water supply in dry years (California Water Foundation 2014), most of the state's groundwater basins have remained unregulated since the Gold Rush era. The consequences of this approach are being seen across the state, exacerbated by increased demand during California's severe drought, now in its fifth year.

Impacts include land sinking at alarming and unprecedented rates in the Central Valley due to overpumping to make up for surface supplies that have been cut during the drought (Sneed et al. 2013), valuable coastal aquifers becoming saline due to seawater intrusion, and over 2,000 domestic wells going dry. In 2014, California took a major leap forward into the 21st century as Governor Jerry Brown signed three bills into law aimed at protecting groundwater for current and future generations, together known as the Sustainable Groundwater Management Act (SGMA, often pronounced as "sigma").

Like most major pieces of legislation, SGMA was the result of negotiation and compromise. It set a goal to achieve sustainable management of the state's groundwater resources by 2040, yet it left many of the details of its implementation to be worked out through subsequent regulations. Arguably, the California Department of Water Resources (DWR) developed the most important of these regulations this year regarding how the state should evaluate local Groundwater Sustainability Plans, which SGMA requires local agencies to create. SGMA was clear that if a local plan was deemed inadequate or threatened the ability of another plan to achieve its stated goals, DWR would turn it over to the State Water Board for potential enforcement actions.

Therefore, the ability to successfully enact and enforce the law will be determined by the soundness of Groundwater Sustainability Plan (GSP) regulations recently finalized by the Department and approved by the California Water Commission, presumably so local agencies can start to make their plans as soon as possible. These regulations, to a large degree, determine how and whether we transform the current unregulated chaos into a system that will preserve and enhance our water resources for years to come.

Despite their importance, these regulations have received little media attention or independent review. Here, we offer our independent analysis of a key aspect of the regulations and focus on the role of science, data, and models that will be critical for SGMA's material and institutional success. In particular, we draw on our previously published research regarding sustainability

metrics (Christian-Smith and Abhold 2015), the role of stakeholders (Dobbin, et al. 2015), and the importance of good governance (Kiparsky, et al. 2016). We conclude with a series of general principles for ensuring scientific transparency.

The Importance of Transparent Groundwater Modeling in Sustainable Groundwater Management

When managing surface water, there are visible indicators of the health of our water system from the amount of snow in the mountains, to the level of reservoirs, to the rate of streamflow, to the condition of riparian habitat. Water managers can literally see the impact of different management strategies and climatic stresses, like drought. When it comes to groundwater, however, there is no way to see declining groundwater tables. Rather, we rely on measurement, monitoring, and modeling to visualize and understand how changing practices and pressures are impacting the water stored underground in a network of aquifers.

Models are calibrated to empirical data, meaning that they are adjusted so they can recreate measured conditions. This gives people confidence that the model can accurately project how an aquifer may respond to changing management. However, models can also have large amounts of uncertainty, particularly where data is lacking to accurately calibrate a model to real world conditions. Models can actually be useful in this respect as they can often provide uncertainty estimates or be run multiple times to understand the probabilities of certain outcomes (using statistical techniques, such as Monte Carlo sampling).

In terms of access to data, there are two general categories of models: open source, or public models, and proprietary or private models. Open source models publicly release the calculations and computer codes that drive their model results. Open source models also do not require user licenses and therefore can be downloaded by anyone with access to the internet. This makes it easier to understand how the model works and to learn how to run the model. On the other hand, private models require user licenses that often need to be purchased annually to continue to have access to the model. Private models do not publicly release the calculations and codes that drive model results. Therefore, they can be less transparent and more difficult to understand without purchasing a user license.

Models are particularly critical to SGMA implementation since the act requires that groundwater managers use a 50-year planning horizon to examine how the aquifer has behaved in the past and how it may respond to different management scenarios in the future, virtually requiring some sort of modeling. Given this requirement, and the SGMA's stated goal to achieve sustainability by 2040, it is likely that most GSPs will use integrated groundwater-surface water models to describe and justify their sustainability goal and trajectory.

Models are also the mechanism by which minimum thresholds will be translated into management objectives in GSPs. For example, if a basin chooses the lowest groundwater elevation on record as its minimum threshold, a model can translate that threshold into the amount of pumping that is allowable in different portions of the basin so as to maintain groundwater elevation at or above the historic low. Models can be used to test different management approaches and, in the end, often provide the basis for choosing one approach over another.

SGMA is not only a historic law because it requires sustainable groundwater management statewide but also because it requires an unprecedented level of transparency and stakeholder engagement. Table 1 (originally published in Dobbin, et al. 2015) summarizes nine separate statutory requirements for stakeholder engagement in SGMA. It is clear that SGMA calls for a

Table 1. Summary of Statutory Requirements for Stakeholder Engagement in SGMA

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During GSA Formation:

- ✓ "Before electing to be a groundwater sustainability agency... the local agency or agencies shall hold a public hearing" (CA Water Code Sec. 10723 (b)).
- ✓ "A list of interested parties [shall be] developed [along with] an explanation of how their interests will be considered" (CA Water Code Sec. 10723.8.(a)(4)).

During GSP Development and Implementation:

- ✓ "A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing" (CA Water Code Sec. 10728.4).
- ✓ "Prior to imposing or increasing a fee, a groundwater sustainability agency shall hold at least one public meeting" (CA Water Code Sec. 10730(b)(1)).
- ✓ "The groundwater sustainability agency shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents" (CA Water Code Sec. 10723.4).
- ✓ "Any federally recognized Indian Tribe... may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan or groundwater management plan... A participating Tribe shall be eligible to participate fully in planning, financing, and management under this part" (CA Water Code Sec. 10720.3(c)).
- ✓ "The groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan" (CA Water Code Sec. 10727.8(a)).

Throughout SGMA Implementation:

- ✓ "The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater" (CA Water Code Sec. 10723.2).
- ✓ "The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin" (CA Water Code Sec. 10727.8(a)).

greater level of transparency in groundwater management decision-making than in the past, specifically requiring new groundwater sustainability agencies to establish a list of interested persons with whom they will share technical documents related to GSP preparation (California Water Code Section 10723.4) and requiring that diverse stakeholder be actively involved in the planning and implementation process (California Water Code Section 10727.8(a).

These requirements for public engagement and transparency in combination with the role of modeling in determining the future of groundwater management mean that the accessibility of modeling assumptions and data are crucial. Three main reasons argue for the need for publicly accessible models and data: (1) to ensure local understanding by both public agencies and interested stakeholders, (2) to improve the assessment of neighboring basin impacts and understanding between neighboring basins that share water inflows and outflows, and (3) to facilitate local and state understanding and enforcement. For instance, the state will need to reconcile how different models handle boundary conditions such as flows across basins is critical to successful implementation of SGMA since groundwater is a shared resource and moves across physical and jurisdictional boundaries.

Unclear Data and Modeling Standards: Last Minute Changes to GSP Regulations Create Confusion

In the final version of the GSP regulations, significant changes were made to Article 3 "Technical and Reporting Standards" (Section 352.4). The requirement in the draft regulations for local groundwater entities to use public domain open source software was deleted, opening the door to the use of private data and m joshua eggers oaklandodels that the public may not have the ability to access unless DWR specifies certain disclosure requirements. Figure 1 shows the changes between the draft and final GSP regulations.

This change also introduced new language regarding "publicly available supporting documentation" that had not been recommended by any of the public comment letters on file nor previously discussed in front of the California Water Commission. The term "publicly available supporting documentation" is not defined and could be interpreted to only require a general description of how the conceptual model works. This may greatly limit public access to the data and calculations that underlie model results. Public access to the assumptions that govern the modeling upon which decisions are made is critical to ensure that water managers in adjacent basins can understand the planning assumptions in neighboring basins, as well as to ensure that public stakeholders can understand and meaningfully comment on plans.

Finally, this change may make it more difficult for DWR to successfully implement SGMA. In particular, SGMA requires that DWR "evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin" (California Water Code Section 10733). Given the range of proprietary models available and the different ways that they function, it will require significantly more staff time and, therefore, budget to reconcile numerous proprietary models with DWR's own open source code (C2VSIM).

Lessons Learned: Groundwater Modeling in Texas

The Texas Water Development Board allows each groundwater conservation district to set "desired future conditions," which essentially define a threshold for groundwater elevation, aquifer thickness, or spring flows within the basin. The board then runs an open source code developed by the U.S. Geological Survey (MODFLOW) to determine how much pumping can be allowed locally without crossing that threshold (called the modeled available groundwater or MAG).

While the Texas Water Development Board uses a consistent open source code to assess groundwater across the state, it allows certain groundwater districts to use proprietary models. However, they must follow clearly specified standards for developing, calibrating, and documenting groundwater models and provide all datasets of input and output files in a geodatabase format that is made available to the public (TWDB 2016). If California allows GSPs to use proprietary models, following Texas' example to ensure that datasets could be made available would help ameliorate the problems with transparency that such models may create.

Figure 1. Strike-Out Version of the Final GSP Regulations, Showing Changes from the Draft GSP Regulations to Section 352.4(f)

(~~e~~f) Groundwater and surface water models ~~developed or utilized as part of or in support of~~used for a Plan shall ~~be consist of public domain open-source software that meets~~meet the following ~~requirements~~standards:

(1) ~~Shall have publically~~The model shall include publicly available supporting documentation ~~that establishes its ability to represent groundwater and surface water flow.~~.

(2) ~~Shall be calibrated against site-specific field data.~~

General Principles for Ensuring Transparency of Scientific and Technical Information

Building on criteria established by the Union of Concerned Scientists' Center for Science and Democracy for grading government transparency (Goldman, et al. 2015), we recommend the following principles to ensure the transparency of scientific and technical information that is at the heart of sound groundwater planning and decision-making:

1. Data, including modeling data, are publicly accessible and available electronically;
2. There are consistent standards for developing, calibrating, and documenting groundwater models;
3. Input and output files are available in a spatially explicit format to allow mapping of the information;
4. Open source tools are available to visualize data and model results across basins;
5. Best practices are developed around data transparency and communication.

Given the importance of modeling to the success of SGMA implementation, we hope the state will revisit the issue of transparency in GSP regulations and provide clearer definitions to ensure that all of the principles above are applied.

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