December 16, 2016

Introduction

The following are summary notes from a one-day workshop on groundwater model development under the Sustainable Groundwater Management Act (SGMA). This workshop was the first of a four-part workshop series convened by Stanford University's Water in the West program and the Gould Center for Conflict Resolution, in conjunction with California State University's Center for Collaborative Policy in order to understand the groundwater data-related challenges and opportunities that local, state and federal agencies are likely to face during the development of Groundwater Sustainability Plans (GSPs) under SGMA.

Held on November 16, 2015, the workshop was convened while the California Department of Water Resources was in the process of writing regulations for evaluating and implementing GSPs under SGMA. This workshop sought to inform that process, as well as to identify data-related challenges and opportunities during SGMA implementation.

The workshop was organized around three central themes with two to three questions guiding each theme. Central themes were: 1) Understanding the range and diversity of modeling needs in meeting SGMA requirements; 2) Groundwater model and data coordination; and 3) Groundwater model development. Questions used to guide the discussion for each theme can be found in the attached meeting agenda. The summary notes are arranged by key themes jointly agreed upon by meeting participants.

Workshop Themes

1. **Groundwater Model Adequacy - SGMA Requirements and State Standards:** Groundwater models[1] are likely to be a valuable tool used by both local and state agencies to meet their respective legislative requirements under SGMA. These requirements include developing GSPs to avoid undesirable results from groundwater use, forecasting the likely outcome of groundwater management actions over the 50-year planning and implementation horizon required under SGMA, and evaluating the adequacy of GSPs to meet sustainability goals and their potential impacts on adjacent basins. However the modeling needs of various basins are highly variable from none (e.g., maintaining stable groundwater levels) to complex (long-term forecasting and

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[1] This summary uses the term groundwater model to refer collectively to groundwater models and model codes used to represent groundwater systems and the surface water hydrology to which they are connected, whether directly (interconnected groundwater and surface water systems) or indirectly (through groundwater recharge and pumping).

planning), and from local-scale water resource problems (e.g., local-scale contaminant modeling) to regional (e.g., evaluation of impacts between adjacent basins).

<u>Model Use and Adequacy</u>

The state should establish criteria and datasets for model development (see the section on Data Collection and Monitoring below).

In order to ensure that models are effective in meeting these goals, the state should develop clear criteria and/or best management practices (BMPs) for:

a. when groundwater models will be required; and
b. groundwater model development (see “Model Development” section below).

<u>State Standards</u>

The state should establish datasets to support model development. These data should include:

a. Climate data: precipitation, temperature, snowpack, runoff, climate projections.
b. Surface water system: reservoir storage and releases, stream flow, surface water rights information, surface water availability.
c. Land use data: land use data, land use projections, consumptive water use, recharge areas.
d. Regional water budgets.
e. Groundwater data: independent groundwater level and water quality information, well logs, land subsidence data and projections, subsurface hydrogeology (i.e. subsurface geology, the location and connectivity of aquifer units, and confining layers.

2. **Model Coordination:** SGMA requires *coordination* of data and methodologies within basins that are developing multiple GSPs. However, it is important to note that the decisions that agencies make around GSA formation will ultimately set the tone for GSP development and ongoing SGMA implementation. Agencies should take steps to collaborate and communicate wherever possible with agencies within their basin and with adjacent basins.

   <u>Intra- and Inter-basin</u>

   a. State agencies need to provide guidance on what “the same data and methodologies” mean (Cal. Water Code **§**10727.6) and how these requirements will be applied to datasets and assumptions used for groundwater model development.
   b. There was some discussion regarding whether a single model code should be developed regionally or statewide to foster model coordination and avoid potential conflicts in model code choice. Another consideration was whether standardized model assumptions and datasets would be adequate to address these concerns.

c. In basins with multiple current or potential undesirable results associated with groundwater use, GSAs will need to decide which factors are going to drive management decisions and how to use models to help address those concerns (i.e., GSAs will need to identify the scenarios that are most likely to constrain their management actions in the future and make management decisions accordingly).
d. While Cal. Water Code **§**10727.6 requires *intra-basin* coordination of water budgets, the state should provide guidance on coordination of data and methodologies both within and between inter-connected basins.
e. Developing statewide datasets, methodologies and assumptions for GSP and model development will help in both intra-basin and inter-basin coordination to:
    1. ensure that multiple GSPs developed within a basin will minimize the likelihood of conflicting sustainability goals;
    2. enable agencies to compare their respective models; and
    3. better understand the basis for differences between models.

<u>Between Local, City, County, State and Federal Agencies</u>

a. Agencies adopting or amending a general plan must refer the plan to any GSA that has developed a GSP (Cal. Water Code **§** 65352). Upon receiving a general plan, GSAs must provide the adopting agency with: the current GSP; maps of recharge and percolation ponds, extraction limits, and other relevant information; and a report on the anticipated effect of the general plan on GSP implementation (Cal. Water Code **§** 65352.5).
b. Coordination between GSPs and general plans should employ consistent assumptions and methodologies for long-term water planning (e.g. they should employ consistent population growth projections, land use change projections and water demand projections).
c. It is important that agencies clearly report model assumptions to enable reconciliation of discrepancies in the data presented in publications (General plans, California Water Plan, GSP, etc.).

3. **Model Uncertainty:** Uncertainty is inherent in all models. Effectively managing and communicating model uncertainty for groundwater management planning is crucial to ensure that decision makers, groundwater users and other interested parties can make well-informed management decisions.

<u>Model Development</u>

a. Agencies should leverage existing datasets during model development.
b. There is a trade-off in model development, as higher model confidence requires more resources for model development.
c. There was discussion about how models and model uncertainty should be addressed. In some cases, GSAs may choose to develop less complex models that are faster to develop. However, they will need to work closely with decision

makers to ensure that model uncertainty and its potential implications for management decisions is clearly articulated and understood.

d. In some cases, it may be beneficial to model the same basin with multiple models and/or model codes to better understand the magnitude and significance of errors inherent in different model codes or model assumptions. Similar to climate change models, developing multiple models can provide a more accurate estimate of model uncertainty. In cases where project costs are high, the development of multiple models may be warranted to ensure decision makers understand the range of potential outcomes from management actions. In such cases, however, it is essential that model developers work together to avoid competing models and rather use the process to improve understanding of the basin and the underlying assumptions in the models.
e. As in other environmental fields, the technical "risk assessment" needs t be separated from the policy driven "risk management". Groundwater models are ideally part of a "risk assessment" strategy. They are used to evaluate future scenarios/alternative actions against management triggers that stakeholders and other decision makers can collectively tolerate. Models are used to help prioritize actions for dealing with undesirable results.
f. Model development will be an iterative process. Costly management decisions (projects or pumping cutbacks) that are based on predictive model simulations will lead to the desire for more data and a more complex model.

Data and Thresholds

a. Focusing on model uncertainty isn't the whole picture. Model inputs need improvement for optimum model outputs. Here in California, we are often missing key data (e.g., groundwater pumping rates, aquifer hydraulic data). This can ultimately lead to a high degree of uncertainty in model outputs, regardless of how good the model is.
b. Monitoring metrics will be required by DWR to continuously measure the sustainability status in a basin. Trigger points along those sustainability metrics guide adaptive management strategies and initiate actions to avoid further undesirable results. Trigger points must be set to reflect the degree of uncertainty in groundwater model predictions that assess (predict) the impact of management actions (future scenarios) on future outcomes in a basins groundwater sustainability status. With high model uncertainty, triggers need to be set more cautiously, requiring actions earlier (adaptive management) that with less model uncertainty.

Opportunities

a. There are two very good models (IWFM and MODFLOW) that encompass the entire Central Valley. An in-depth study that compares the two models, e.g., in one or several key regions could help identify areas of conceptual and data differences in both models and ultimately be used to improve both.

4. **Model Development:** The State needs to develop a set of BMPs for groundwater model development and use. BMPs need to address the social, technical, and reporting requirements associated with model development.

   a. Social

      i. Stakeholders should be actively involved in groundwater model development. In particular, they should have a role in defining groundwater model objectives and the level of risk or uncertainty they are willing to tolerate for groundwater management planning purposes.
      ii. Some agencies have successfully included stakeholders in the modeling process by establishing model advisory committees (i.e., stakeholder advisory committees that inform model objectives and potential planning scenarios).
      iii. Coupling groundwater models and economic models may better support management decision-making and stakeholder communication.

   b. Technical

      i. The state should develop clear criteria on the technical requirements for "adequate" groundwater model development (i.e., underlying assumptions, the range of physically-plausible parameters, etc.).
      ii. Technical advisory committees can and should incorporate a range of technical expertise from local, state, and federal agencies.

   c. Communication and Reporting

      i. Groundwater model development should be open and transparent.
      ii. Communication about groundwater model development should be done throughout the process. Formal reporting should be required at specific points in the process (i.e., after formalization of the model planning process, after model development, and after model calibration).

5. **Data Collection and Monitoring:**

   a. Transparency

      i. Local, county, state and federal agencies need to work collaboratively to change the culture around groundwater data ownership and to foster a culture of data sharing for sustainable groundwater management.
      ii. Groundwater data including subsurface information acquired by private entities should be made public.

   b. Adequacy

      i. Groundwater monitoring programs should be developed and expanded in a manner that is consistent with sustainability goals.
      ii. Groundwater monitoring programs should collect, use, and report data that objectively demonstrate adherence to sustainability goals and the avoidance of undesirable results from groundwater use.

iii. Groundwater monitoring programs should identify the areas that are most likely to hinder management decisions or are most likely to be problematic. Additional data gathering and monitoring should be prioritized in these areas.

c. Coordination

i. Coordinating datasets across basins or beyond will require the development of a robust set of data collection, measurement and reporting standards and the associated training to ensure that people collecting and reporting these data are doing so in a consistent manner.
ii. Once collected, the state should make these data and their metadata readily accessible.

d. Advanced Methods for Data Collection

i. Remote sensing data can provide a significant opportunity to collect and/or supplement data about specific undesirable results (land subsidence) and groundwater extractions (e.g., evapotranspiration estimates using modeling techniques like Mapping EvapoTranspiration at high Resolution with Internalized Calibration (METRIC) or Surface Energy Balance Algorithm for Land (SEBAL). However, these technologies also have limitations, require ground-truthing and may not be adequate for all applications.
ii. In some cases, using remote sensing technologies to get information about an un-monitored or under-monitored area may incentivize additional data reporting.
iii.

6. **Surface Water/Groundwater Connectivity:** SGMA requires that GSPs avoid "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." Meeting these requirements necessitates a comprehensive understanding of the connectivity between the surface water and groundwater systems, as well as the cumulative impact that groundwater management actions will have on the surface water system over time. However, the legal separation of these two physically connected systems prior to the passage of SGMA has resulted in a limited knowledge of surface-groundwater interactions. Additional research on tools, regulations and/or policies for integrated management of this resource is needed. Given the long response times of groundwater systems, groundwater models will play an important role in determining long-term impacts of these systems. Some recommendations include:
   a. The state should support efforts to develop reasonable and practical methods that locals can use to identify the timing and location of GW pumping on nearby streams
   b. The state should work with a broad range of stakeholders to develop clear criteria and/or BMPs for effective assessment, monitoring and modeling of interconnected surface water/groundwater systems and groundwater-

dependent ecosystems. The state should require GSAs to demonstrate that they have adequately considered these criteria should be a requirement for GSP development.

   c. The state should provide technical assistance and data for the monitoring and modeling of interconnected surface water/groundwater systems, including streamflow data, surface water rights information, reservoir operations, water temperature data, maps of groundwater-dependent ecosystems and land use changes.

7. **Adaptive management:** SGMA requires DWR to evaluate a GSP upon receipt, as well as every five years to ensure that it is likely to achieve its sustainability goals and that in doing so, it will not hinder the ability of an adjacent basin to meet its own sustainability goals. Ongoing evaluation of GSPs and the assumptions underlying them will be critical for the successful implementation of SGMA.
   a. GSAs should be continuously updating groundwater monitoring networks, data collection protocols and groundwater models as new information and management protocols develop.
   b. Groundwater models can forecast and help to identify groundwater management practices that might be helpful in achieving sustainable groundwater management. These results will need to be used in conjunction with groundwater monitoring data to ensure that GSAs are making progress toward achieving their sustainability goals.
   c. Management actions will need to be adapted and models refined if the groundwater basin is not responding as the model predicted.

8. **Funding and Resources**: SGMA provides GSAs with the authority to levy fees for groundwater management activities. Additionally, there will be funds available for GSP development and implementation through Proposition 1. However, the availability, timing, and adequacy of these funds for SGMA implementation remains a concern for many local agencies. Meeting participants expressed concern about:
   a. The processes that Proposition 218 requires agencies to undertake to charge fees for groundwater management;
   b. The ability of small rural agencies to fund groundwater management long-term and defend against litigation; and
   c. The capacity of agencies to meet SGMA requirements by the required deadlines without substantial assistance from the state or other agencies.

   <u>Recommendations for state to support GSAs</u>

   d. The state needs to develop consistent, long-term technical and financial assistance to support sustainable groundwater management.

GROUNDWATER MODELS[1] IN THE SGMA CONTEXT:
Tools to Support Sustainable Groundwater Management

Monday, November 16, 2015, 8:30am to 4:00pm

Stanford University, Y2E2 Building, 473 Via Ortega Way, 2nd floor, Bechtel Conference Room

Contact: Tara Moran, 650-721-2421; tamoran@stanford.edu

Overarching Research Question: How should groundwater models best be used to support the sustainable groundwater management requirements under SGMA?

	Topic	Lead
8:00	**Arrival** (Light breakfast, coffee, sign in)	
8:30	**Opening Remarks** ➢ Welcome, meeting context & purpose, introductions ➢ Review of workshop agenda & approach	➢ **Leon Szeptycki**, Executive Director, Water in the West, Stanford University; ➢ **Jan Martinez**, Director, Gould Negotiation and Mediation Program, Stanford University; ➢ **Marci DuPraw**, Managing Senior Facilitator & Mediator, Center for Collaborative Policy, California State University, Sacramento
8:50	**Kick-off Panel: Groundwater Models Under SGMA** ➢ **Need for This Meeting**: • Meeting context and definition of terms • Modeling implications of SGMA mandate • Groundwater data survey results: ○ How water managers in California currently use groundwater models ○ Potential opportunities and challenges in groundwater model use identified by survey respondents thoughts on potential paths from current state to fulfilling needs associated with SGMA	➢ **Tara Moran**, Research Associate, Water in the West, Stanford University (25 min)

[1] The term groundwater model refers to site-specific integrated surface water-groundwater models and groundwater models developed from model codes.

	Topic	Lead
	Kick-off Panel *(continued):* ➢ **<u>Role of Groundwater Models in Successful SGMA Implementation</u>:** • <u>DWR Perspective</u>: Role of groundwater models in supporting SGMA implementation • <u>SWRCB Perspective</u>: Role of groundwater models in SGMA enforcement and Potentially Unmanaged Areas • <u>Local Agency Perspective</u>: Lessons learned on the development of groundwater models in achieving basin management objectives • <u>USGS Perspective</u>: Role of groundwater models in groundwater management in other states	➢ Dan McManus, DWR (15 min) ➢ Erik Ekdahl, SWRCB (15 min) ➢ Brian Lockwood, Pajaro Valley Water Management Agency (15 min) ➢ Bill Cunningham, USGS (15 min)
10:15	**Plenary Discussion 1 – Diversity of Groundwater Modeling Needs to Achieve Sustainable Groundwater Management** ➢ What are the different types of groundwater sustainability challenges and how will groundwater models be used to address them? ➢ Can existing groundwater model codes be used to model multiple undesirable results/scenarios at once or will multiple models be required? ➢ What additional model code elements are required to achieve SGMA's sustainability requirements?	➢ Facilitated
11:00	**Break** (with refreshments)	
11:15	**Plenary Discussion 2 - Maximizing Success: Groundwater Model and Data Coordination[2]** ➢ How should multiple GSAs developing multiple GSPs within a groundwater (sub) basin coordinate model development and model runs? With adjacent basins? ➢ What data[3] are required for groundwater model development? How can existing datasets be leveraged and what role should the state play?	➢ Facilitated
12:30	**Lunch**	

[2] The term coordination refers to the use of standard data and methodologies in groundwater sustainability plan development and potentially in groundwater model development.
[3] The term data refers to groundwater monitoring data required under SGMA (e.g., groundwater elevations data, groundwater extraction data), as well as additional data that may be required for model development (e.g., land use projections, water supply forecasts).

	TOPIC	LEAD
1:30	**Plenary Discussion 3 - Maximizing Success: Groundwater Model Development** ➢ What role should representative stakeholders have in groundwater model development? ➢ How will GSAs fund and support groundwater model development and maintenance? What role will the state play in providing technical and financial assistance? ➢ How should uncertainty be incorporated into model development and represented in model output? How should model uncertainty be incorporated into groundwater management planning?	➢ Facilitated
2:45	**Break**	
3:00	**Plenary Discussion 4: Reflection and Synthesis** ➢ Recap of major themes that emerged during the day ➢ Identify potential opportunities and tools for follow up	➢ Facilitated Discussion and Recap
3:45	**Closing Comments** ➢ Next steps in workshop series ➢ Reflections on what went well / what to do differently next time	➢ **Tara Moran**, Research Associate, Water in the West, Stanford University
4:00	**Adjourn**	

Groundwater Workshop Series - Modeling
November 16, 2015
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