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Editors: Leonard Konikow, Gary Robbins

CONTENTS

Cover Photos: Drilling and collection of vadose zone sandstone cores in Spanish Valley, near Moab, Utah. The pore waters from the cores (shown in inset) are being processed and analyzed for tritium, stable isotopes, and chloride to better understand aquifer recharge rates and processes (e.g., diffuse versus focused infiltration). Photos courtesy of Vic Heilweil, USGS.

The Groundwater Visibility Initiative

Michael E. Campana, William M. Alley, Lisa Beutler, Sharon B. Megdal, and John C. Tracy

Respectively, Technical Director, American Water Resources Association; Director of Science and Technology, National Ground Water Association; Executive Facilitator, MWH Global; Director, Arizona Water Resources Research Center; Director, Texas Water Resources Institute

What is the Groundwater Visibility Initiative?

On 28 April 2016 in Denver, CO, a group of 25 water experts partook in a day-long *Groundwater Visibility Initiative* workshop convened by the American Water Resources Association (AWRA) and the National Ground Water Association (NGWA). This seminal event sought to elevate groundwater's status in the international discourse on water policy, governance, and management by crafting recommendations for action.

Why the title, 'Groundwater *Visibility* Initiative'? There are two components to the answer: (1) groundwater, and the boundaries that define it as a water management unit, are physically invisible to humans; unless you're in a cave, you can't see it; and (2) its lack of physical visibility has contributed greatly to its lack of visibility in many discussions of water policy, governance, and management. The attendees were ineffectual at rectifying (1), but feverishly tackled (2) through an agenda consisting of provocative talks by an all-star group of specialists, panel discussions, and breakout sessions. Ways were discussed to more fully integrate groundwater into integrated water resources management and incorporate it into policies for agriculture, energy, environment, land-use planning, and urban development.

Given groundwater's vast reserves, broad geographical distribution, generally good quality and frequent availability at or near the point-of-use, it has become the foundation of many water management systems for drinking water, irrigation, and municipal and industrial uses. Rural areas are often 100% dependent on groundwater. Groundwater also provides enormous environmental benefits by keeping streams flowing during dry periods and supporting wetland and spring habitats. With a growing population and changing climate that threaten to desiccate surface water supplies, the world needs groundwater more than ever and a number of recent popular media articles have dealt with groundwater depletion.

Corporate users are becoming more aware of groundwater. Consider this statement from a decidedly corporate vantage point in a recent report by the Earth Security Group:

> *"The exposure of multinational companies to depleting and degrading groundwater is increasing. The rapid depletion of aquifers is a systemic risk to one billion people in the world's growing economies. Aquifers are shared across national borders and have the potential to spark conflict. Companies must act beyond their site operations and help improve groundwater governance if they are to ensure their sustainable growth."* – Foreword, 'Global Depletion of Aquifers', Chapter 4 *in* *Earth Security Index 2016 Report* http://tinyurl.com/zdot9dp□

Workshop Findings and Recommendations

Despite its importance, groundwater is largely undervalued and narrowly perceived. The interrelationship between groundwater and surface water is well established by science. Yet, institutions at all levels have struggled to effectively incorporate these concepts into laws, regulations, management, and planning. Workshop findings and recommendations include:

1. Managing groundwater requires working with people

Governance is an important part of resilient aquifer management. Groundwater sustainability is a societal decision that involves tradeoffs and should be made through informed, transparent public participation.

Multidisciplinary teams and alliances among multiple governance/ management associations can provide greater expertise to solve these problems. Communications programs are required to help overcome misperceptions about groundwater and surface water interactions. Communications must demonstrate the connectivity between groundwater and surface water. Examples of good management and governance should be provided to decision-makers and other stakeholders.

2. **Data and information are keys**

Better data and information on water withdrawals and consumptive use are needed for both groundwater and surface water management. Different aquifers behave differently because of different geology, extent, and hydroclimatic settings. This means monitoring and evaluation at appropriate spatiotemporal scales are necessary to understand trends in both quality and quantity. Data collection and analyses should be transparent.

3. **Some mysteries are real**

Groundwater and climate are inextricably linked through recharge rates and demand. Science needs to improve understanding of climate impacts on both supply (quantity and quality) and demand for groundwater and its interaction with surface water. Long lag times for groundwater impacts and system responses must be accommodated and understood.

4. **We need to care for what we have**

Ensure planning and investment incorporates infrastructure rehabilitation and maintenance.

5. **Effective groundwater management is critical to an integrated water management portfolio adaptive and resilient to drought and climate change**

A diverse water management portfolio, including groundwater, surface water, conservation, recycling, etc., will contribute to greater water security and less risk. Groundwater can support instream flows, endangered species, recreation, sustainable supply for water users, and subsidence avoidance. Groundwater also supports surface-water quality and mediates its temperature.

Managed aquifer recharge is a potentially critical element of drought mitigation planning. Groundwater systems should be analyzed for their resilience and vulnerability to climate perturbations. Projects should be reviewed from a long-term resilience perspective not a short-term one. In this context, groundwater management is especially important as a tool to buffer extremes, even if groundwater is not necessarily a readily-available backup supply.

Models need to be reviewed and adaptive. Collaborative modeling can be an effective tool to obtain buy-in from stakeholders.

In a fully integrated system, repurposing dams and flood control operations for recharge is another opportunity.

6. **To be robust, agriculture, energy, environment, land-use planning, and urban development sectors policies must incorporate groundwater considerations**

Groundwater problems typically do not have a single solution. Return flows from different sectors have significant intersection with groundwater management issues. Planning and management need to be integrated across all of the sectors. This means matching quality, quantity, and use.

Land-use planning can be used to protect or enhance base flow of streams, floodplain management, and groundwater recharge. Agricultural and open space districts can be an opportunity for a win-win: overlay zones for scenic protection, agricultural preservation, etc., to enhance recharge.

Water managers should consider innovative ways of education and outreach to the agricultural sector, including: (1) key role of agricultural extension agents; (2) subsidy-based conservation programs; (3) self-

regulation with performance-based criteria; (4) “grow-off challenges” through crop yield competitions with guarantees; (5) early adopter programs; and (6) professionally facilitated communication.

Next Steps

The Denver workshop is intended as only a first step in efforts by NGWA, AWRA, and the workshop participants to make groundwater more visible. The following are recommended next steps:

1. Encourage fellow professionals to present the Groundwater Visibility Initiative (GVI) to their respective professional societies for possible adoption and other actions.
2. Present the GVI to non-professional groups.
3. Build a coalition with other professional societies and similar organizations to support the GVI.
4. Distribute the GVI statement to members of Congress and appropriate state and local political leaders and agency personnel; discuss the GVI with the aforementioned persons.
5. Give presentations and convene sessions on GVI-related topics at state, regional, national, and international meetings.
6. Write Op-Ed columns and articles in print and other media; engage journalists.
7. Produce journal articles on the GVI topics.
8. Propose a groundwater-focused agenda for the 8th World Water Forum.

This latter item has already been accomplished and was submitted by AWRA, NGWA, and IGRAC (International Groundwater Resources Assessment Centre). The agenda can be viewed here: http://bit.ly/29aMVCs

Last Words

Now is the time to disabuse society of its approach to groundwater, that ‘secret, occult, and concealed’ resource. The path identified above will help provide the tools to do just that. The hard work of making groundwater more visible has just begun.

The GVI workshop final report, list of attendees, and formal agenda have been posted online at: http://bit.ly/2b9Vglw

Comments on the GVI and support of Item (8) above are welcome. Contact Michael.Campana@oregonstate.edu

USGS Online Mapper for Groundwater Quality

According to a news release from the U.S. Geological Survey, a new online interactive mapping tool (http://nawqatrends.wim.usgs.gov/decadal/) provides summaries of decadal-scale changes in groundwater quality across the Nation. The mapper shows how concentrations of 24 contaminants, such as nutrients, pesticides, metals, and volatile organic compounds, are changing over decadal periods in 67 groundwater networks across the Nation. Each network consists of about 20 to 30 wells selected to represent water-quality conditions in a given geographical area, aquifer, and in some cases, a specific land use. Groundwater quality data were collected in about 5,000 wells between 1988 and 2001 by the USGS National Water Quality Assessment Project (http://water.usgs.gov/nawqa/). About 1,500 of these wells were sampled again between 2002 and 2012 to evaluate decadal changes in groundwater quality.