

Summary of Groundwater Issues and Water Management – Strategies Addressing Challenges of Sustainability and Drought in California

*A GRA Conference Organized in Cooperation with USCID,
The U.S. Society for Irrigation and Drainage Professionals*

By Chris Petersen (West Yost Associates), Matt Zidar (GEI Consultants Inc.), Steve Macaulay (Macaulay Water Resources), Dr. Karl Longley (Central Valley Regional Water Quality Control Board), Vicki Kretsinger (Luhdorff & Scalmanini, Consulting Engineers), and Steven Phillips (U.S. Geological Survey)

GRA, in cooperation with the United States Committee on Irrigation and Drainage (USCID) organized this two-day event (March 4-5, 2014) to provide a forum for discussion of challenging groundwater issues which rise to critical importance in times of drought. The last few decades have seen mounting water management challenges, particularly those associated with increased reliance on groundwater resources throughout the West. This growing reliance on groundwater is due largely to the expansion of permanent crops, more intensive irrigation practices, increased urban and environmental competition for water supplies, and reduced surface-water supplies due to drought and increasing regulatory restrictions. Coupled with overdraft, land subsidence and other ongoing issues associated with groundwater use, this increased reliance on groundwater resources heightens the concern over the long-term sustainability of the resource. This conference provided a unique opportunity for attendees to access simultaneously the technical and policy challenges facing groundwater resources from both the GRA and USCID viewpoints. More information on USCID can be found at: <http://www.uscid.org/>.

A half-day field tour kicked off the joint event, followed by lunch and USCID/GRA Plenary Sessions featuring a wide range of technical presentations. Presentations during concurrent USCID and GRA Technical Sessions and a Poster Session

occurred the following day. Participants were able to attend the Wednesday concurrent Technical Sessions of either organization.

GRA wishes to thank our conference exhibitors who showcased their latest products and services for sustainable groundwater resources management; these included: Accutest Laboratories, Inc., BSK Associates, Cascade Drilling, EnviroTech Services, Kleinfelder, Roscoe Moss Manufacturing Company, Smart Ditch, West Yost & Associates, Blaine Tech Services, and McCampbell Analytical. We also appreciate our Refreshment Sponsor, Hopkins Groundwater Consultants.

Field Tour

Participants in the field trip visited the Regional Water Authority (RWA) in Citrus Heights, California, where they were welcomed by RWA's executive director (ED) John Woodling, who provided an overview of the field trip. Tom Gohring, ED of the Water Forum, explained the role of the Water Forum in reaching peaceful agreement on the use of surface and groundwater resources along the Lower American River. Rob Swartz (RWA Project Manager) provided an overview of the institutional and technical framework within Sacramento County that enables effective groundwater management and promotes regional conjunctive use. The City of Roseville's Aquifer Storage and Recovery Program, an example of a

Continued on page 5...



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Inside this Issue

Features

Summary of Groundwater Issues and Water
Management – Strategies Addressing Challenges
of Sustainability and Drought in California 1

California Water Foundation Releases Report:
Land Subsidence from Groundwater Use in California 25

Columns & Corners

President's Message 3

Upcoming Events 10

Technical Corner 15

California Legislative Corner 17

Federal Legislative/Regulatory Corner 19

Chemist's Corner 21

Student Research Corner 22

Organizational Corner 26

Branch Highlights 28

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2014 – The Year of Groundwater!

By Ted Johnson

This is the appropriate theme for GRA's upcoming 23rd Annual Conference and Meeting to be held October 15–16 in Sacramento. Mark your calendars now. Never before have I seen so much attention being spent on California groundwater issues and potential solutions. Prolonged droughts have occurred in California, but the current three-year drought has put a spotlight on groundwater as a key player in the state's water portfolio. The government, water districts, farmers, organizations, environmental groups, academia, and others are coming together with like minds to recognize the importance of groundwater as a critical resource that must be managed in a sustainable fashion to avoid serious consequences such as long-term depletion, land subsidence, water-quality degradation, and negative environmental and economic impacts. The common phrase "out of sight, out of mind" can certainly be prescribed to groundwater in the past, but not this year.

According to the California Department of Water Resources (DWR), calendar year 2013 closed as the driest year in recorded history for many areas of California. On January 17, Governor Brown declared a drought state of emergency and directed state officials to take all necessary actions in response. On April 25, Governor Brown reiterated the serious condition, asked all Californians to redouble their efforts to conserve water, and cut the red tape to get water to farmers more quickly, ensure that people have safe drinking water, protect vulnerable wildlife species and prepare for an extreme fire season. The National Climatic Weather Center declared in late April that for the first time in 15

years, the entire state was in drought conditions, ranging from moderate to exceptional. Last year at this time, none of the state was under extreme or exceptional drought conditions.

With the zero allocation of State Water Project water (recently upgraded to 5%) to urban and agricultural areas, and the curtailment of surface-water deliveries, many are looking to groundwater for a more reliable water supply. There is a boom in the water-well drilling business across the state, especially in the Central Valley. Backlogs of up to a year have been reported for drilling, and the number of water-well permits has doubled to tripled from a year ago. Because groundwater is being used to replace the loss of surface water, much of the state is in a condition of severe overdraft, leading in some areas to land subsidence. A recent report titled "[Land Subsidence from Groundwater Use in California](#)," written by Luhdorff & Scalmanini Consulting Engineers, James Borchers and Michael Carpenter, and released by the California Water Foundation, reports that current subsidence rates in areas of the San Joaquin Valley are about 20 times the historical rates. [USGS Scientific Investigations Report 2013-5142](#) documents at least 540 mm (1.8 ft) of subsidence about 6 miles south of the town of El Nido from 2008–2010.

On April 30, the DWR released a [report](#) on groundwater showing that throughout California, groundwater resources are at historically low levels. Some of the major findings of the report were as follows:

- Groundwater levels have decreased in nearly all areas of the state since spring 2013, and more notably since spring 2010.



- Since spring 2008, groundwater levels have experienced all-time historical lows (for period of record) in most areas of the state.
- In many areas of the San Joaquin Valley, recent groundwater levels are more than 100 feet below previous historical lows.
- Thirty-six alluvial groundwater basins that have a high degree of groundwater use and reliance may possess greater potential to incur water shortages as a result of drought. The basins exist in the North Coast, Central Coast, Sacramento River, Tulare Lake, and South Coast hydrologic regions.
- Of California's 515 alluvial groundwater basins, 169 are fully or partially monitored under the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. Forty of the 126 High and Medium priority basins are not monitored under CASGEM. There are significant CASGEM groundwater monitoring data gaps in the Sacramento, San Joaquin River, Tulare Lake, Central Coast, and South Lahontan hydrologic regions.

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2014 – The Year of Groundwater! – Continued

The focus and depletion of groundwater has led to broad attention across the state, with numerous agencies, organizations, and the legislature offering recommendations for solutions with the common goal of obtaining sustainable groundwater management. Consensus is building to manage groundwater basins and sub-basins at the local level followed by state intervention and action should the local agencies fail to effectively manage their groundwater. The Association of California Water Agencies (ACWA) in April released their document “[Recommendations for Achieving Groundwater Sustainability](#).” The California Water Foundation (CWF) in May released their document “[Recommendations for Sustainable Groundwater Management](#).” GRA also released in May its own document titled “[Recommendations for Sustainable Groundwater Management in California](#),” which embraces many of the rec-

ommendations of ACWA and CWF and provides our own recommendations.

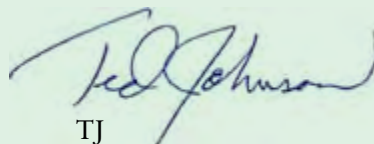
The California legislature is using this information to craft for the first time groundwater sustainability bills. Both SB 1168 (Pavley) and AB 1739 (Dickinson) are attempting to define groundwater sustainability and the actions to be taken to demonstrate compliance. Time will tell how these bills fare, but it is clear that the highest levels of the state are focused on ensuring reliable water supplies, and groundwater is recognized as a primary player to meet that goal.

GRA will continue to offer numerous conferences, webcasts, and publications to provide the latest information on groundwater conditions in CA. In July will be an event on Managed Aquifer Recharge to highlight the latest effective techniques for groundwater replenishment. In September will be a symposium on land subsidence caused by ground-

water depletion. And in October will be our two-day Annual Conference and Meeting to cover many items related to groundwater resources in the state, including the Brown Administration's efforts to improve groundwater management. Just check our web site for the latest information on events related to California groundwater.

No doubt about it – 2014 is the Year of Groundwater. Welcome to the Party! Let's all do our best to ensure protection and preservation of this precious water resource, and get involved at your jobs and volunteer work to promote conservation and sustainable, high quality, groundwater resources statewide. 💧

Rock on!



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Summary of Groundwater Issues and Water Management – Continued from page 1



The USACE Project Manager, Katie Huff, describes the Folsom Dam modifications.



Field trip participants view Folsom Dam modifications.



Brian Wagner, USGS, describes innovative approach to groundwater management in Klamath Basin.

successful groundwater storage project in the Sacramento region, was co-presented by **Derrick Whitehead** (project inspiration), **Cathy Lee** (project challenges) and **Chris Petersen** (technical considerations). **Rick Johnson** of the Sacramento Area Flood Control Agency provided an overview of Folsom Dam Modifications currently under construction to improve Sacramento's flood protection. The group then traveled to the Folsom Dam construction site where **Katie Huff**, project manager from the US Army Corps of Engineers, described the construction activities and answered questions.

Opening Plenary Sessions

Two plenary sessions followed the field trip. The first was moderated by **Thaddeus L. Bettner** of Glenn-Colusa Irrigation District and included irrigation stakeholders addressing California's current debate over facilities and ecosystem investments that are critical to long-term surface and groundwater reliability and sustainability. Panel members included **Lewis Bair** of Reclamation District No. 108, **John Sweigard** of Merced Irrigation District, **Roger K. Patterson** of Metropolitan Water District of Southern California, **Dee Dee D'Adamo** of State Water Resources Control Board, and **Richard Roos-Colins** of Water and Power Law Group PC.

The second plenary, moderated by **Chris Petersen** of West Yost Associates, focused on groundwater quantity and quality challenges facing many areas of California, and practical management actions being considered and implemented to improve conditions for the future. **Daniel Wendell** of The Nature Conservancy explained how overexploitation of groundwater has led to adverse impacts to people and the environment in the Central Valley, particularly with respect to streamflow depletion. Dan explained that overdraft and associated effects on streamflow can only be addressed by reductions in pumping or an increase in recharge.

Barbara Dalgish of Luhdorff & Scalmanini Consulting Engineers provided an informative overview of efforts underway to advance Salt and Nitrate Management Planning for California's entire Central Valley. She explained that four zones have been identified as areas with the highest concentrations of salt (TDS) in the southwestern portion of the Central Valley; six zones were identified as areas with the highest nitrate concentrations, mostly in the southeastern portion of the Valley. These areas serve as examples for building the foundation for future Management Zones or local Salt and Nutrient Management Plans

that will ultimately support regulatory decision-making.

The panel session concluded with an insightful presentation on groundwater management innovations in the Upper Klamath Basin by **Brian Wagner** of U.S. Geological Survey. Brian explained how he and his colleagues developed a decision framework that links groundwater simulation and optimization to identify and develop groundwater management practices to help balance agricultural and environmental demands for water.

Groundwater Management

The session on Groundwater Management kicked off the second day of the conference. **Matt Zidar** of GEI Consultants moderated the session, which started with a presentation by **Rob Swartz** of the Sacramento Groundwater Authority (SGA) titled *A Local Approach to Groundwater Management in Sacramento County*. The SGA is a joint powers authority that has been managing the basin cooperatively through conjunctive use since 1998. Rob discussed SGA actions that have helped to raise groundwater levels, but that these benefits have not been equally distributed throughout the basin. To address this concern, the local water purveyors worked on a co-

Continued on the following page...

Summary of Groundwater Issues and Water Management – Continued

operative, incentives-based approach, versus a regulatory one, to establish an appropriate conjunctive-use program for the basin; this resulted in a Water Accounting Framework that recognizes the investments made by SGA members to develop the conjunctive-use program and support groundwater banking. Framework components include quantified basin-sustainability groundwater-extraction goals for member agencies and a method for determining the volume of water available for banking and exchange operations.



Rob Swartz, SGA, explains how groundwater is being managed in Sacramento County.

John Ayers of GEI discussed the Lassen County Basin Management Objectives and Program, and how these are manifest in a collaborative Groundwater Ordinance. Under the Program, the county monitors, interprets, and communicates long-term groundwater conditions to their Board of Supervisors. Monitoring information collected under the CASGEM program is compiled into an annual report that is reviewed and investigated by committees. When a long-term negative trend is identified, it is investigated and reported to the Board of Supervisors, who can then develop appropriate policy to remedy conditions at their discretion.

Derrick Whitehead of Municipal Consulting Group then described an

approach for conjunctively using surface water and groundwater supplies to help to meet the Sacramento region's needs regardless of jurisdictional boundaries. The approach includes technical, regulatory, and stakeholder involvement, and uses institutional analysis to create a framework that considers governance, banking and exchange, and project implementation. **Derrick** discussed the issues and opportunities presented by such an approach.

Colorado River

Sue McClurg of Water Education Foundation chaired the session on the Colorado River. **Jason Keller** of GeoSystems Analysis, Inc. described the Lower Colorado River Multi-species Conservation Program, a federally sponsored effort to manage soil and groundwater salinity in riparian corridors adjacent to the river by monitoring and adjusting irrigation application rates.

Mike Tietze of Jacobson James & Associates, Inc. discussed groundwater/surface-water interaction in the Lower Colorado River Basin. The 2006 Consolidated Decree entered by the US Supreme Court in *Arizona v. California* requires the US Bureau of Reclamation to account for all consumptive use of water from the Colorado River mainstream in the Lower Colorado River Basin, including "... water drawn from the mainstream by underground pumping." Mike highlighted the challenges and limitations of the methodology under current development by the USBR and the USGS to identify and regulate well production in the affected areas. Mike proposed an alternative methodology for evaluating wells within a fixed distance from the river.

Groundwater Banking

Moderated by **Steve McCauley** of McCauley Water Resources, this session consisted of three presentations on technical aspects of groundwater storage and use, and potential policy implications. **Dr. Steve Bachman**, independent consulting groundwater hy-

drogeologist, described the challenges of implementing a landmark aquifer storage and recovery (ASR) program for Calleguas Municipal Water District, a member agency of the Metropolitan Water District of Southern California. This ASR program involves complex hydrogeology that has had impacts on recovery of stored groundwater. Lessons learned from this project will help in future operations, and provided valuable information for other ASR projects.

Professor Thomas Harter of UC Davis described groundwater modeling tools that were developed to evaluate aquifer dynamics and associated management options for increasing summer flow in the Scott River. His presentation addressed significant concerns over base flows in the Scott River as they relate to protection of instream uses, a critical resource in the Klamath River watershed.

Trevor Joseph presented work by the Department of Water Resources regarding water transfers from the Sacramento Valley that involved increased groundwater pumping. These "groundwater substitution transfers" continue to generate controversy with regard to the interaction and time delays between additional pumping and



Trevor Joseph, DWR, describes DWR's groundwater substitution transfer program.

Continued on the following page...

Summary of Groundwater Issues and Water Management – Continued

potential impacts to stream systems. The presentation covered a range of essential factors in evaluating this type of water transfer, recognizing the increasingly important role water transfers play in drought relief.

Water Quality Management

This session was moderated by **Dr. Karl Longley**, Central Valley Regional Water Quality Board. **Ray Reece** of Utility Service Company, Inc. opened the session with a presentation entitled *Water Well Asset Management Programs: A New Sustainable Approach to Maintaining Well Performance and Water Quality*. Mr. Reece pointed out that all wells experience plugging and stressed the importance of well management for the purpose of increasing service life of the well. He described well rehabilitation technologies and discussed the steps necessary to assure effective rehabilitation.

Phillip Chandler of Ionex, Inc. described a unique ion exchange process that has a reduction of about 96% in brine production by continually advanced regeneration of the ion exchange resin with the return of the bicarbonate and sulfate ions to the product water. Mr. Chandler also described the electrocatalytic treatment for the removal of nitrate.

Steven Hoch of Morris Polich & Purdy LLC provided a legal overview of the liability related to product defects that water providers assume with the installation of point-of-use (POU) devices and the measures that they may take to lower their liability risk. Mr. Hoch pointed out that POU devices are often maintained by laypersons (the user) and this increases potential liability. If a utility is to be involved in any way in the use of POU's, they should first consult with an attorney knowledgeable in this area of law to ensure that they understand and take appropriate measures to minimize their liability risks.

Groundwater/Surface Water Interaction

The session on groundwater/surface-water interaction, moderated by **Steve Phillips** of the USGS, began with a case study of the effects of increasing flow in the Kern River near the City of Bakersfield. **Dr. Stephen Cullen** of Daniel B. Stephens & Associates described the plan for restoration of flows in the Kern to address long-term groundwater declines and associated effects on water quality, wellfield efficiency and pumping cost; and to support riparian restoration, recreation and aesthetic opportunities. Water-budget and flow modeling showed the potential for up to 4 million acre-ft of increased recharge over a 20-year period of increased flows.

Dr. Stephen Hatchett and **Ms. Lisa Porta** of CH2M HILL discussed the use of regional groundwater and agricultural economic production models to assess impacts of water policy, such as supply reduction – how will farmers, the regional economy, and the aquifer system react? There are various approaches for this, but the speakers favor the coupling of robust standalone models, and demonstrated this using the UC Davis Statewide Agricultural Production Model (SWAP) and the USGS Central Valley Hydrologic Model (CVHM). The CVHM, which includes agricultural processes, provides realistic responses to changes in crop type and various hydrologic stresses; combining with SWAP allows for optimal scenario analysis, yielding information important for consideration by farmers and policy makers.

Jon Traum of the USGS presented the use of Pareto analysis to quantify model uncertainty, and how it was applied with respect to river seepage for the San Joaquin River Restoration Program. The method involves forcing the solution of the model away from the optimal calibrated seepage value, and calculating new optimal seepage values with greater overall model error.

The set of solutions within acceptable model error defines the range of uncertainty. In the case of seepage, the optimal calibrated value was about 370,000 acre-ft/yr, and the range was 230,000–520,000 acre-ft/yr. Jon showed that a traditional sensitivity analysis results in a much narrower range of uncertainty, thus emphasizing the utility of the Pareto method.



Lisa Porta of CH2M HILL discussed the use of regional groundwater and agricultural economic production models.

Water Quality & Technology

Tom McCarthy of MWH Americas, Inc. moderated this session, which began with **John Dodge** of Daniel B. Stephens and Associates, Inc. giving an overview of the efforts of Orange County Department of Public Works and stakeholders of the Nitrogen and Selenium Management Program to develop a hydrogeologic characterization, water balance, and selenium transport evaluation in an area known as the former “Swamp of the Frogs (Cienega de las Ranas).” The goal is to better understand, and ultimately control, selenium flux so it can be reduced or eliminated to meet the total maximum daily load (TMDL) requirements.

Noah Heller of BESST Inc. presented the use of tracers and laser-induced fluorescence to determine flow conditions during low-flow purging and

Continued on the following page...

Summary of Groundwater Issues and Water Management – Continued

sampling versus sampling during ambient conditions using grab samplers. In the two conditions studied, the results show that under low-flow purging and sampling, much of the monitoring well screen is hydraulically engaged – even with minimal drawdown. The results of these studies conclude that without a proper, basic understanding of flow dynamics inside monitoring wells with either of these practices, groundwater hydrogeologists and remediation engineers alike are at risk of significant errors in contaminant mass estimates for groundwater cleanup.

Jake Torrens of AMEC concluded the session with an informative presentation of a Sustainable Remediation Forum (SURF) initiative that promotes the conservation and reuse of groundwater at clean-up sites. Jake's presentation highlighted noteworthy case studies where reuse of treated groundwater has been successful in California.

Groundwater Management and Policy

Moderated by **Chris Petersen** of West Yost Associates, this session featured three pertinent groundwater management and policy issues facing California; subterranean streams, climate uncertainty, and sustainability in coastal groundwater basins.

Meredith E. Nikkel of Downey Brand LLP tackled the issue of subterranean streams by explaining that California is unique among western states in regulating surface water, but leaving the legal treatment of groundwater to the courts. However, the state's regulatory reach extends to "subterranean streams flowing through known and definite channels." Meredith's presentation examined the legal factors for distinguishing percolating water from subterranean streams and invited conversation about technical details that might inform the legal analysis.

Scott D. Warner of ENVIRON International Corporation stated that

leading national science affiliations predict a continuing trend of big heat and rain events, less total rainfall, more rain than snow, and longer dry periods in currently arid to semi-arid areas, such as California and much of Australia. The conditions associated with these predictions will severely test our ability to develop effective and robust contaminant clean-up and water resource protection measures. Challenges may be focused on (1) developing passive measures that can withstand large changes in groundwater flow conditions, and (2) developing measures that can tolerate gradual changes in geochemical conditions that may accompany the hydraulic changes.

Continued on the following page...



Meredith E. Nikkel, Downey Brand LLP, discusses subterranean streams.

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Summary of Groundwater Issues and Water Management – Continued

Robert Schultz presented *Using Modern Tools to Re-Estimate the Sustainable Yield from a Coastal Groundwater Basin*. Robert explained his methodology for developing a conceptual site model using innovative data collection equipment, such as surface geophysical tools, high-frequency water-level data loggers, and GIS-based methods. The resulting re-interpretations of the hydrostratigraphy of the groundwater basin and its evolution provided the necessary framework for engineering a sustainable water supply for his client.

Salts and Nutrients

Vicki Kretsinger of Luhdorff & Scalmanini Consulting Engineers moderated this session, which began with **Dr. Mohsen Mehran** of Rubicon Engineering Corporation presenting *Nitrogen in Recycled Water: Threat to Groundwater Quality*. Dr. Mehran described variable nitrogen concentrations in recycled water and the implications relative to the beneficial use of recycled water. His presentation included an example of how awareness of the nitrogen content in recycled water, potential transformations that may occur, and opportunities for high efficiency of plant uptake can minimize nitrogen leaching losses. By managing the nitrogen applied through the use of recycled water, and carefully planning supplemental fertilizer use, application rates and irrigation methods, the potential for environmental impact can be reduced.

Rob Gailey of the Source Group provided a presentation on *Considering Local Hydrogeologic Conditions and Regulatory Requirements of California's Irrigated Lands Regulatory Program*. Rob began with the premise that a single set of regulatory requirements is unlikely to be sufficient to adequately address all regions. This is largely because hydrogeologic factors play such a significant role in transport processes, including (but not

limited to) time lags between what was practiced historically and subsequent groundwater quality observations; the vadose zone becoming a repository for agricultural-related constituents and therefore a contributing source area for many years; and horizontal migration from the initial application location, thereby confounding understanding of the actual source area(s). Especially in regions with large depths to groundwater, a large challenge will be differentiating the effects of current and future agricultural practices, given that the effects on groundwater quality from historical practices may continue for many decades.

Fisayo Osibodu of the San Diego Regional Water Quality Control Board presented the *Development of Salt and Nutrient Management Plans*

in the San Diego Region – A Collaborative Stakeholder Process. As part of a stakeholder process, a guidance document was created for salt and nutrient management plans (SNMPs). The guidance document outlines steps for stakeholders that, at a minimum, cover the required components of the State Water Resources Control Board's Recycled Water Policy. All the agencies in the San Diego Region are on track to complete their SNMPs by the May 2014 deadline. Where water quality objectives are being exceeded, the Board will review and revise the Basin Plan as needed. The completed SNMPs are anticipated to establish the framework necessary for effective salt and nutrient management on a watershed basis; this will also facilitate expedited and streamlined permitting of recycled water projects. 💧



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Dates & Details

GRA EVENTS & KEY DATES

(Please visit www.grac.org for detailed information, updates, and registration unless noted)

GRA Symposium

14th Biennial Symposium on Managed Aquifer Recharge
Jul. 31-Aug. 1, 2014 | Anaheim, CA

GRA Symposium

Land Subsidence in California – A Continuing Problem
Sept. 9, 2014 | Davis, CA

GRA Course

Groundwater Modeling Short Course
Sept. 9-12, 2014 | Redwood City, CA

GRA Annual Conference and Meeting

Oct. 15-16, 2014 | Sacramento, CA

GRA Course

Groundwater-Watershed Short Course
Nov. 17-18, 2014 | Davis, CA

Groundwater Resources Association of California and the Arizona Hydrological Society Present:



JULY 31 - AUGUST 1, 2014 – ORANGE, CA

Cooperating Organizations: Orange County Water District | University of Arizona Water Resources Research Center | California Association of Groundwater Agencies | Water Replenishment District of Southern California | United States Geological Survey | Lawrence Livermore National Lab | National Water Research Institute Salt River Project (Phoenix, AZ) | California State University East Bay | California Water Boards Orange County Water District Groundwater Guardian Team | City of Phoenix | The Recharge Initiative (University of California Santa Cruz)

Register for this Event: <http://www.grac.org/bsmar14-reg>

From 1978 to 2007, thirteen symposia on Managed Aquifer Recharge (MAR) were held in Arizona at approximate 2 year intervals. These symposia were important venues for policy-makers, practitioners, researchers, and educators to learn about the policies, regulations, and technical challenges affecting MAR. The information shared at these symposia moved the understanding and utilization of MAR rapidly forward. Today, MAR is understood as being a key part of a sustainable water resources management strategy. Even so, there is still much work that needs to be done to better understand how MAR can be used to more efficiently utilize our increasingly scarce water supplies.

The Groundwater Resources Association of California and the Arizona Hydrological Society are proud to team up to restart this symposia series with the location of the event alternating between California and Arizona. The 2014 event was designed with families in mind as the hotel is only two miles from Disneyland. The hotel offers discounted Disneyland tickets and has a dedicated shuttle that runs to and from Disneyland every hour. More information will be forthcoming about the venue and the many nearby attractions. **Symposium attendees will be provided a special link to purchase discounted tickets to Disneyland® immediately after registration.**

Participants Will Learn

- Advantages and limitations of introduced (extrinsic, added) and natural (intrinsic) tracers
- Detailed explanations of methods of tracer introduction and measurement
- How to choose a tracer based on water volume, cost, and expected travel times
- Infrastructure and labor requirements for a successful project
- Survey of case studies from spreading ponds and injection wells.

Continued on the following page...

14th Biennial Symposium on Managed Aquifer Recharge – Continued

Why Attend the Workshop?

Meeting California's water needs will require a combination of recycled water use and managed aquifer recharge. Current CDPH regulations require that recycled water used in managed aquifer recharge operations remain in the subsurface for at least three months, and gives guidance on acceptable methods for demonstrating compliance. Application of both natural (intrinsic) and introduced (extrinsic) tracers in managed aquifer recharge operations can accurately and precisely constrain transit times and mixing/dilution between recharged and ambient groundwater.

About the Workshop Leaders

Dr. Bradley Esser leads the Environmental Radiochemistry group at Lawrence Livermore National Laboratory. His research interests are in the use of groundwater age-dating, isotope biogeochemistry, and reactive transport modeling to develop better tools for water resource management, along with innovations in analytical methods for isotopes and trace elements.

Dr. Michael Singleton is a research scientist in the Environmental Radiochemistry group at Lawrence Livermore National Laboratory. He has ten years of experience researching stable isotope and dissolved gas tracers for water resources management and manages the Stable Isotope Laboratory at LLNL.

Dr. Ate Visser is research scientist in the Environmental Radiochemistry group at Lawrence Livermore National Laboratory. His expertise includes applying environmental tracers in hydrology, particularly groundwater, to gain a better understanding of the processes of groundwater flow and contaminant transport. With Michael Singleton, he developed a membrane inlet mass spectrometer for noble gases (NG-MIMS). The NG-MIMS enables the cost-effective use of noble gas isotopes as tracers in managed aquifer recharge studies.

Dr. Jean Moran is on the faculty of Earth and Environmental Sciences at California State University East Bay. Her expertise is in isotope hydrology and hydrogeochemistry and she has applied intrinsic and extrinsic tracers at MAR sites with spreading ponds and ASR wells at various sites in California over the last fifteen years.

Workshop Agenda

7:30 am	Registration, Continental Breakfast
8:00 am	CDPH regulations for indirect potable reuse, travel time, dilution, accuracy & precision

8:45 am	Intrinsic tracer options including TDS, chloride, stable isotopes of hydrogen and oxygen, heat, total dissolved gas pressure; intrinsic tracer examples and case studies
9:45 am	Break
10:00 am	Extrinsic (added) tracer choices – properties, costs
10:30 am	Introduction methods (spreading ponds, injection wells, ASR wells)
11:00 am	Sampling and analysis of tracers, design of monitoring plan
12:00 pm	Lunch with Q&A and Lessons Learned from prior and ongoing tracer tests
1:00 pm	Calculating expected initial tracer concentration and C/C0 at receptors, tracer curve analysis
2:00 pm	Trip to OCWD surface spreading area – tracer introduction equipment demonstration

Optional Workshop and Field Trips: July 30

Jean Moran (California State University East Bay), Ate Visser, Michael Singleton and Brad Esser (Lawrence Livermore National Laboratory) will offer a workshop on application of extrinsic and intrinsic tracers in MAR. Two field trips will also be offered with a morning trip to the Orange County Water District's (OCWD) Groundwater Replenishment System (www.gwrssystem.com) and seawater intrusion barrier and an afternoon trip to OCWD's surface recharge system. More information about the workshop and field trips will be forthcoming.

Herman Bouwer Award: July 31

In honor of Dr. Herman Bouwer's contributions to the field of MAR, an award named for Dr. Bouwer will be presented during a special luncheon on July 31. The award will be given to an individual or agency that has had a significant impact on increasing the understanding or utilization of MAR. A description of the award can be found at <http://www.grac.org/bouwer-award.pdf>. To nominate someone for the award, go to <http://www.grac.org/bouwer-nomination.pdf>.

Sponsor and Exhibitor Opportunities

If you are interested in exhibiting your organization's services or products, or being an event co-sponsor, please contact Sarah Kline at skline@grac.org or 916-446-3626.

For additional information: contact Adam Hutchinson (ahutchinson@ocwd.com; 714-378-3214) or Chris Petersen (cpetersen@westyost.com; 530-792-3239). 💧

SAVE THE DATE & CALL FOR POSTER ABSTRACTS

Groundwater Resources Association of California



SEPTEMBER 9, 2014 – DAVIS, CA

Cooperating Organizations: U.S. Geological Survey | California Department of Water Resources
Water Education Foundation | Association of Environmental & Engineering Geologists
International Association of Hydrogeologists Association of California Water Agencies
California Groundwater Association

Conference Co-Sponsor: Robert M. Hagan Endowed Chair, University of California at Davis
California Water Foundation

Exhibitor & Sponsor Opportunities

GRA is organizing a symposium on the subject of land subsidence to be held on September 9, 2014 at the UC Davis Conference Center. The prevalence of drought conditions in California since 2007, and the related decline in surface-water supplies, has led to extensive groundwater extraction and associated subsidence rates approaching 1 foot per year; it is likely that subsidence rates will increase this summer. Concern over these very high rates of subsidence and the resulting costly damages to flood-control, water-delivery and other structures is driving the need for this symposium.

Groundwater extraction is known to cause compaction of clay layers in the alluvial deposits of the Central Valley and other locations in the state, but there is no statewide program to monitor or address subsidence. The various causes of subsidence include those tied to geologic processes and those associated with man's extraction of groundwater and petroleum. Subsidence caused by petroleum extraction was addressed many years ago by the legislature. Subsidence caused by groundwater extraction, however, is like the wild west—there is little organized monitoring, little organized control, and minimal awareness of the issue despite California's notorious historic subsidence problems.

This symposium will discuss the mechanics of subsidence caused by groundwater withdrawal, damages related to that subsidence, monitoring methods, and the technically challenging aspects of managing this complex process.

Symposium Agenda

Subsidence Processes and Subsiding Areas

- Causes of Subsidence in California
- Subsidence and Groundwater Extraction – the Process
- Historical and Active Subsidence in California

Effect of Subsidence on Infrastructure

- Structural Damage and Operational Effects of Subsidence
- Panel – Subsidence Effects and Remediation Costs from the Federal, State, Water District and Farm Viewpoints

Subsidence Monitoring and Analysis

- Monitoring & Analysis Methods – GPS, InSAR, LIDAR, extensometry, etc.
- Earth Fissures
- Simulation and Prediction

Subsidence Management – Case Studies and Statewide Considerations

- Case Studies in California & Beyond
- Panel – Framework for Subsidence Monitoring in California

POSTER AND EXHIBITOR RECEPTION

Continued on the following page...

Land Subsidence – Continued

Call for Poster Abstracts (due July 15)

Abstracts are invited for posters on all topics related to land subsidence, and those topics listed below; abstracts are due on July 15. Please see links below for submission guidelines and the online submission form.

In addition to abstracts addressing subsidence issues, the following topics are encouraged:

- Streamflow depletion by wells
- Long-term groundwater depletion – ecological, economic, and other effects
- Water budgets
- Recharge opportunities (Managed Aquifer Recharge)
- Impacts of groundwater depletion on the hyporheic zone

Guidelines for Submitting an Abstract for a Poster Presentation:

- Word 2010 documents are preferred.
- Abstracts must be one page in length or less, and should be titled and include all contributing authors' names and affiliations. Please identify the name of the person who will be presenting the poster and add biographical sketches of the authors as a second page. The sketches should be 50 words or less in paragraph form, and full mailing and e-mail addresses and phone and fax numbers must be included.
- Margins should be 1-inch top, bottom, and 1¼-inch right and left margins. The text should be single-spaced, 12-point size, Arial font, with no pagination, footers and headers. Paragraphs should be justified.
- Major headings should be 16-point bold; minor headings should be 12-point italicized not bolded. There should be one blank line above and

below all headings, except above major headings, which should have two blank lines.

- Graphics should not be used in abstracts.

By virtue of submitting an abstract, the submitter(s) grants GRA the right to publish any accepted abstract or the right to decline any abstract. The Conference Committee will review abstracts and make final selections. If your abstract is accepted for a poster presentation and you agree to present, you will be expected to register and pay for the event using GRA's online registration.

[Submission form](#)

Exhibitor & Sponsor Opportunities

If you are interested in exhibiting your organization's services or products, or being an event sponsor, please contact Sarah Kline (skline@grac.org; 916-446-3626).

Additional Information

For more information about this event, contact Sarah Raker (sarah.raker@amec.com, 707-793-3841) or Sarah Kline (skline@grac.org; 916-446-3626). 💧

The advertisement features the West Yost Associates logo at the top left, which includes a green stylized mountain graphic. The main title 'GROUNDWATER FOCUS' is displayed in a dark blue box. Below this, a list of services is provided: Groundwater management planning, Hydrogeologic field investigations, Groundwater modeling, Well design & construction inspection, and Conjunctive use and groundwater banking. The background of the ad shows a large drilling rig on a construction site. At the bottom, a dark blue banner contains the slogan 'Water is what we do and we do it well' and the website 'westyost.com'. A row of five small images is at the very bottom, depicting various water-related activities: a colorful geological map, a hand holding a water sample, a water treatment tank, a modern house, and a water discharge pipe.

SAVE THE DATES

Groundwater Resources Association of California

23rd Annual Conference and Meeting 2014 – The Year of Groundwater

OCTOBER 15-16 – SACRAMENTO, CA

[Attendee/Speaker Registration](#) | [Sponsor/Exhibitor Registration](#)

This year is shaping up to be a landmark year in California's water history, and groundwater is the focus. As groundwater levels decline and the land surface subsides during one of the worst series of droughts the state has experienced, Governor Brown's administration is proposing to provide legislative and other support to local entities to improve groundwater management. Recent hearings held by the state on groundwater sustainability also indicate that industry associations, grower groups and the state are evaluating targeted efforts to preserve and protect local control over groundwater management, and also to allow for state intervention where local efforts are unsuccessful or nonexistent.

GRA's 23rd Annual Conference and Meeting will focus on this topic with targeted sessions on the administration's efforts, associated legislation, and perspectives of local entities. Other related session topics include:

- Integrating groundwater management with flood control, environmental aspects, land-use decisions, sustainable development, etc.
- Drought – our dependence on groundwater
- Climate variability and change – simulation of impacts & adaptation strategies
- Hydraulic fracturing & Senate Bill No. 4 – Well stimulation
- Regional-scale management of groundwater quality
- Site assessment & remediation
- Wastewater reuse & recycling
- Modeling advances & applications

Collegiate Groundwater Colloquium

GRA seeks to increase participation by university and college faculty and students in its programming. The **Collegiate Groundwater Colloquium** features students who are conducting highly relevant research in the general area of the conference theme. The Colloquium and reception provide students with an excellent opportunity to showcase their research, and attendees an op-

portunity to learn from the frontier of groundwater science. If you are a student interested in participating in the Colloquium, please contact Dr. Jean Moran at jean.moran@csueastbay.edu.

Sponsors & Exhibitors

If you are interested in exhibiting your organization's services or products, or being an event sponsor, please contact Sarah Kline (skline@grac.org, 916-446-3626) or register online (link provided below).

Sponsor Exhibitor Registration:

<http://www.grac.org/am14-se-reg>

Sponsor Exhibitor Info Sheet:

<http://www.grac.org/se.pdf>

Additional Information

For more information about this event, contact Sarah Kline (skline@grac.org; 916-446-3626) or Steve Phillips (sphillip@usgs.gov; 916-278-3002). 💧

Picture Your Research Featured in HydroVisions

Call for Submissions

HydroVisions is looking for submissions from students engaged in groundwater research, to highlight in our Student Corner.

Do you know of a student with something to share?

- Articles
- Research Papers
- Summary Blurbs

For further information, please contact:

editor@grac.org, subject "Student Corner"

Wells and Words

By David W. Abbott P.G., C.Hg., Consulting Hydrogeologist

Tools in the Hydrogeologist's field kit – The Water-Level Sounder

Water levels measured in a well from a consistent datum are the *most* important measurements that *must* be made in order to evaluate the characteristics and long-term performance of the aquifer and the well. The usual datum is the reference point (RP), which is typically the top of the well casing or base of the pump pedestal, but any RP location near the well head will work as long as measurements are made from it consistently. At some point, the RP elevation is measured relative to mean sea level or other established datum. Water-level sounding devices, or sounders, are used to measure the fluctuations in water levels to evaluate and demystify the status and properties of the aquifer including: (1) groundwater occurrence and direction of flow, (2) hydraulic and well properties (transmissivity, storativity, hydraulic conductivity, and well efficiency), and (3) short- or long-term temporal changes in water levels. Static (non-pumping) water levels (SWL) and pumping water levels (PWL) are measured using sounders. Sounders are an essential component of the hydrogeologist's field kit.

There are several types of sounders and measuring methods that vary in accuracy, ease and speed of use. The more common sounders and methods are the following: wetted or chalked steel-tape method¹, electric sounders (E-sounders), pressure transducers^{2,3}, float-operated devices³, airline gauge⁴, pressure gauges for flowing artesian wells, popper devices¹, rock and bong method⁵ (...no kidding!), and acoustic sounder⁶. The remainder of this article will discuss the E-sounders because they are the most often used tool and are typically used to calibrate several of the other devices, including transducers, float-operated de-

vices, and airline gauges. The E-sounder is a device for measuring the depth to water within a well, and is composed of a weighted, insulated electrical wire with gradations, a probe at the end of the wire, and a light, ammeter, or annunciator that indicates the sounder has made contact with the water surface⁷. Access to the water surface must be clear and unobstructed between the pump column and the inside diameter of the casing in production wells in order to use an E-sounder.

E-sounders are provided by various manufacturers in various forms, but all operate on the same principle of completing an electrical circuit when the bared-end of the wire makes contact with the water surface in the well. The basic components of an E-sounder are: a battery (typically 9 volts) to supply voltage to the electrical circuit, a spool of insulated wire to lower down the well, a plumb or weight to keep the wire taut and assist in lowering the wire, and an indicator of when the circuit has been completed by contact of the weighted probe with the water surface.

Coaxial and lamp-wire (dual-wire [2-w]) or bell-wire (single-wire [1-w]) systems are used depending on the manufacturer and sounder application. The circuit is completed to the indicators either via the second wire of the 2-w system (i.e., both bared-ends of the 2-w system are submerged) or the steel well casing for the 1-w system. Clearly, 1-w systems will not work with PVC casing. Some sounding wire is graduated or scaled using metal crimp-on tags (that sometimes unintentionally move) or permanent markings; these marks usually are at 5-foot intervals such that water levels can easily be measured using an engineer's tape from these marks. The sounder shown in Figure 1a has mated wheels that the bell-wire travels



Figure 1a: Note the unique type of sounder to the right of the driller during an 8,000 gpm pumping test (drawdown of about 4 feet) circa 1976⁹.

between and the depth measurement is made using an odometer-type counting device as the wire is lowered down the well. Homemade sounders and portable indicator devices can be constructed easily for less than \$20.00, plus the cost of the sounding wire (about \$38 for 500 feet). An inexpensive indicator device consists of a battery and connector, a micro-ammeter, two short leads, four washers, and alligator clips (Figure 1b).

For 1-wire systems, the working end of the E-sounder consists of the wire and the weight. Prior to 1991, ¼-inch diameter lead (Pb) fishing wire (or lead shot) was used for the plumb because of its density and malleability; note that Pb was also used for well packers, which seal the annular space between the casing and the telescope screen assembly, and for some parts of pumps. The fishing wire was cut into 8- to 12-inch lengths and a small hole was drilled in one end of the weight. About 1 inch of the Teflon-coated insulated wire was stripped about 1 foot from the bared-end of the bell-wire. The bell-wire was then threaded through the hole of the

Continued on the following page...

Wells and Words – Continued

weight and looped back to the 1-inch stripped portion of the sounding wire. The bared-end of the wire was wrapped around the stripped spot to allow the Pb to dangle from a loop. The connection was tight, but loose enough so the weight would break off if it got stuck, thus salvaging the wire. For the 2-wire system, the ends of the wires were bared and separated by about 2–3 inches.

After the US EPA Lead and Copper Rule⁸, the plumb materials changed to brass or other relatively heavy and less harmful metals. This change caused concern during well development and pumping tests because the weight may get drawn into the pump; brass and other less malleable materials can jam the impellers and damage or destroy the pump. In contrast, Pb is malleable and the pump impellers simply chopped it up. To allow effective well development for a new water supply well, the test pump usually does not have a foot-valve or pump intake screen installed. On a couple of occasions, I have accidentally lowered the sounding wire too close to

the pump intake during aggressive (and needed) well development; I noticed that the Pb weight and a large portion of the sounding wire was drawn into the pump – however, the pump did not notice the error and merely spewed the Pb shavings and small pieces of wire on the ground. If I had been using a less malleable material, such as brass, I may have been responsible for damage to the pump and required to replace it!

A simple and cost effective way to measure water levels in observation or monitoring wells is to permanently leave a sounding wire hanging in the well. While visiting the well for a measurement, the homemade indicator shown in Figure 1b can be connected simply and quickly to the sounding wire and the electrical ground, then water-level measurements can be made from a permanent reference mark placed on the sounding wire during installation and calibration. This is an effective way to measure water levels during a pumping test with multiple observation wells.

The main disadvantage of most manufactured coaxial sounders is that they can be very difficult to repair in the field – but it can be done. In addition, the pre-measured and scaled wire has its own surmountable issues; if the wire breaks, the scaling has to be adjusted (and remembered) to match the new length. Un-scaled single-wire systems have their drawbacks as well, which include physically measuring the RP distance using measuring tapes, unless systems like that shown in Figure 1a are used.

Many things can go wrong in the field when measuring water levels: sounders don't work, plumb gets stuck, wire gets entangled on down-well stuff, circuit shorting out, batteries dead, etc.; I have seen most of them. Know how your equipment works. This may provide an easy solution to the field problem. Rather than return to the office without data, a nearby electrical supply place or hardware store may

have the right pieces to fix the sounder or make your own homemade sounder to salvage the trip.

Field work can be logistically challenging, complex, and difficult to complete, but field personnel with flexibility, ingenuity, and the ability to quickly improvise is one key to a successful field program. Having my compact homemade sounder (and black electrical tape) in my field kit has saved the day for me several times, especially in remote areas. 💧



Figure 1b: Homemade water level indicator device consisting of 9V battery, micro-ammeter, two leads (red and black) from the back of the meter, battery connector, four washers, and alligator clips in order to attach one to the casing and other to the bared upper-end of a sounding wire.

¹ US Department of Interior Water and Power Resources Service, 1981, *Ground Water Manual: A Water Resources Technical Publication* (Revised Reprint), John Wiley & Sons, NY, 480 pages.

² Mogg, Joe L., 1977, New Instrument Expands Water Well Technology, The Johnson Drillers Journal, Johnson Division, UOP Inc., St. Paul, Minn., May-June.

³ Brassington, Rick, 2007, *Field Hydrogeology*, Wiley & Sons LTD, England, 264 pages.

⁴ Driscoll, Fletcher G. (editor), 1986, *Groundwater and Wells* (second edition), Johnson Filtration Systems, St. Paul, Minn.

⁵ Stewart, David M., 1970, The Rock and Bong Techniques of Measuring Water Levels in Wells, NGWA Ground Water, Volume 8, No. 6, Nov/Dec. Authors note: The Rock and Bong method uses bbs or uniform-sized pellets; let the bb free-fall from the RP, counting the number of times the bb hits the casing, (audio), and measuring the time for the bb to hit the water (audio).

⁶ accessed May 3, 2014; http://www.edspumps.com/_docs/WELL%20SOUNDER%202000%20-%20USER%20MANUAL%20-%202001.pdf

⁷ Poehls, D.J. and Gregory J. Smith, (editors), 2009, *Encyclopedic Dictionary of Hydrogeology*, Elsevier and Academic Press, Amsterdam, 517 pages.

⁸ US EPA, June 2008, Lead and Copper Rule: A Quick Reference Guide, EPA 816-F-08-018 from the US EPA website at <http://water.epa.gov/drink>.

⁹ Carr, James R., 1976, Tacoma's Well Field Might Be World's Most Productive, The Johnson Drillers Journal, Johnson Division, UOP Inc., St. Paul, Minn., September-October.

Legislative Update

By Tim Parker, GRA Legislative Committee Chairman,
Chris Frahm and Rosanna Carvacho, GRA Legislative Advocates

It was apparent at the outset of 2014 that water would be a big issue in the Capitol and across the state this year. What was not clear was how much of that focus would be on groundwater. Today, groundwater is in the news on a daily basis with a call for action from the Governor's Office and his Administration, as well as the Legislature.

The water bond, still on the November ballot, remains uncertain. There are currently 11 bills before the Legislature seeking to revise or remove the 2009 bond and replace it with a different proposal.

GRA's Annual Legislative Symposium and Lobby Day

On April 8th, GRA hosted its Annual Legislative Symposium and Lobby Day at the Citizen Hotel in Sacramento. The topic was Groundwater – *The Great Integrator*. The Symposium was again hosted in cooperation with the California Groundwater Coalition.

The Symposium featured a diverse group of speakers, including both Legislators and other state office holders, including Governor Brown's Deputy Legislative Affairs Secretary, Martha Guzman-Aceves, Water Board Member Dorene D'Adamo, and many Legislators, including Senator Lois Wolk. Each of these distinguished speakers provided GRA members with their perspectives on what is happening this year in the state and their predictions of what may materialize on groundwater management, and the water bond.

Presenting Legislators included Assembly Minority Leader Connie Conway and Assemblymembers Bigelow, Dickinson and Logue. Representing the upper house were Senators Jackson, Monning and Wolk. GRA members heard directly from the authors of a number of the water bond bills, including AB 1445 (Logue), AB 2043 (Bigelow and Conway), and SB 848 (Wolk).

Keynote Speaker John Laird, California Secretary for Natural Resources, updated GRA members on the statewide drought and water picture, including the need for a solution in the Bay Delta and water bond. Always a popular presenter at GRA's Legislative Symposium, Secretary Laird took extra time to respond to questions from GRA members on a host of issues.

Anton Favorini-Csorba from the Legislative Analyst's Office presented his report, *"Improving Management of the State's Groundwater Resources,"* which was prepared for the Assembly and included many recommendations; his report is available [here](#). Following his report was a roundtable discussion involving Scott Slater of Brownstein Hyatt Farber Schreck, Maurice Hall of The Nature Conservancy, Eric Oppenheimer of the State Board's Office of Research, Planning and Performance, Chris White of the Central California Irrigation District and Toby Moore of Golden State Water Company. Following these informative presentations, GRA members engaged in a lively discussion on a wide range of issues relating to the State's groundwater. At the end of the day, GRA Legislative Symposium attendees met Senator Fran Pavley at the west steps of the capitol for discussion and a photo op.

The 2014 Legislative Symposium and Lobby Day was another success, providing attendees with timely information on what is being discussed in the Capitol and Sacramento. The GRA Legislative Committee has been lauded for delivering another outstanding program. Thank you, GRA members, for once again supporting this event, which has become the "go-to" groundwater event in the Capitol. GRA would also like to thank our partner for this event, the California Groundwater Coalition. Together we continue to educate policy makers through sound science.

Sustainable Groundwater Management

As GRA members know, as the availability of surface-water supplies dwindle, there is an increased reliance on groundwater to meet water supply demand. In mid-February, the Administration convened a large group of stakeholders to work with them to "provide local and regional agencies the authority to manage groundwater sustainably and to ensure no groundwater basin is in danger of being permanently damaged by overdrafting; and provide the State the tools to step-in when necessary." This meeting was led by Martha Guzman-Aceves, Deputy Legislative Affairs Secretary to Governor Brown. Also in attendance from the Administration were Mark Cowin, Director of the Department of Water Resources; Felicia Marcus, Chairwoman of the State Water Resources Control Board; and a representative for Karen Ross, Secretary of the Department of Food and Agriculture.

Since this initial meeting, the Administration has held two public workshops. At the original stakeholder meeting, and in both workshops, the Administration was seeking feedback from stakeholders on how to meet the goal of sustainable groundwater management in California. This feedback was due to the Governor's office at the end of April. It is expected that the Administration will use the information received to craft a budget proposal that will be in the Governor's May Revision Budget that is due out in mid-May. It is also expected that the feedback and recommendations will be used by the Legislature as a beginning point to develop new policy for sustainable groundwater management. GRA, California Water Foundation and the Association of California Water Agencies (ACWA) all submitted

Continued on the following page...

Legislative Update – Continued

comprehensive recommendations for sustainable groundwater management. GRA's recommendations can be viewed [here](#). More information and additional background material on the Administration's efforts can be found [here](#).

GRA Supported/Opposed Legislation

There are two bills from 2013 that GRA took a position on that can still be acted on this year: AB 69 (Perea) and AB 145 (Perea). For more information on these bills, please see prior Legislative Updates. Currently, GRA has taken an oppose position on one bill, outlined below. The Legislative Committee is continuously reviewing bills as they are amended and is closely monitoring two key bills on sustainable groundwater management: AB 1739 (Dickinson) and SB 1168 (Pavley). GRA will provide comments on both pieces of legislation and likely will take positions on these two bills as the process moves forward.

AB 2189 (Garcia) – Requires the replenishment assessment now imposed by the Water Replenishment District of Southern California (WRD) to be based upon the proportion of costs actually incurred by the operator of a groundwater well instead of costs associated with replenishing and maintaining water quality in the groundwater basins. This bill would also prohibit the WRD Board of Directors from imposing a replenishment assessment if there is a majority protest, in which case there would be no groundwater assessment that year.

Water Bond

The \$11.14 billion water bond that was passed by the Legislature in 2009 is still currently on the November 2014 ballot. To date, Governor Brown has not stated whether he wants the current bond to go forward on the November ballot or to replace it with a different proposal. The Legislature is in the process of debating the merits of the 11 different bills to replace the current bond with a smaller bond.

The date of June 26th has been provided to the Legislature as the deadline to remove the 2009 bond from the November ballot. This date is also seen as the deadline to pass a replacement bond. With the deadline coming up very quickly, we will know soon whether the 2009 bond will be voted on in November, replaced or removed.

More information on the 11 water bond bills can be viewed at: <http://leginfo.legislature.ca.gov/>.

Continued Changes in the Legislature

As of December 1, 2013, Senator Bill Emmerson, who represented the 23rd Senate District, resigned. A Special Primary Election was held on March 25th; Assemblymember Mike Morrell was elected to fill the vacancy in the California State Senate. Assemblymember Morrell's election to the Senate created a vacancy in the 40th Assembly District.

This vacancy will be filled during the November General Election.

There has been only one change in the committees most important to GRA – Assemblymember Brian Dahle took over as Vice Chair of the Assembly Natural Resources Committee for Assemblymember Shannon Grove.

Looking Ahead

As expected, 2014 has shaped up to be a very important year for water, and more specifically, groundwater, in California. With the persistence of the drought and expanded groundwater pumping, both the Administration and Legislature will continue to focus on groundwater.

As the year and legislative session progresses, GRA's Legislative Committee and its Legislative Advocates will continue to monitor issues and legislation important to GRA. GRA will continue to be a key source of information and sound science for Legislators and the Administration. 💧

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The Federal Corner

By Jamie Marincola, U.S. EPA

EPA, Army Corps of Engineers Clarify Protection for Nation's Streams and Wetlands

The U.S. EPA and the U.S. Army Corps of Engineers jointly released a proposed rule to clarify protection under the Clean Water Act for streams and wetlands that form the foundation of the nation's water resources. The proposed rule will benefit businesses by increasing efficiency in determining coverage of the Clean Water Act. The agencies are holding discussions around the country and gathering input needed to shape a final rule. Learn more at: www2.epa.gov/uswaters.

EPA Publishes Reference Guide to Treatment Technologies for Mining-Influenced Water

EPA's report highlights select mining-influenced water treatment technologies used or piloted as part of remediation efforts at mine sites. Included in the report are short descriptions of treatment technologies and information on the contaminants treated, pre-treatment requirements, long-term maintenance needs, performance, and costs. View or download at: <http://clu-in.org/techpubs.htm>.

High Concentrations of Trace Elements More Prevalent in Southern Desert Groundwater than Statewide

Inorganic trace elements—fluoride, arsenic, molybdenum and boron—were detected at high concentrations in 42 percent of groundwater used for public supply in the Borrego Valley, and southern desert areas of California, according to a recent study by the U.S. Geological Survey. These findings are significant because elsewhere in the state, high concentrations of trace elements generally



Congressman George Miller (fourth from left) alongside Jared Blumenfeld, EPA Regional Administrator for the Pacific Southwest (to the right of the Congressman) at Breuner Marsh restoration groundbreaking.

are found in only six to 28 percent of the groundwater used for public supply. High concentrations generally are the result of natural processes, but human activities may have some influence. Read more about the findings here: <http://pubs.usgs.gov/fs/2014/3001/>.

In Situ Bioremediation of Groundwater

EPA released its Introduction to In Situ Bioremediation of Groundwater, which describes the ISB process of utilizing indigenous bacterial populations to metabolize target contaminants through the addition of various amendments to the subsurface environment. ISB of groundwater has become one of the most widely used technologies for contaminated site treatment because of its relatively low cost, adaptability

to site-specific conditions, and efficacy when properly implemented. To view or download EPA's overview of this emerging practice, visit: http://www.clu-in.org/download/remed/introductiontoinsitubioremediationofgroundwater_dec2013.pdf.


EPA Announces \$5 Million in Grants to Restore S.F. Bay Water Quality and Habitats

At a ceremony held at Breuner Marsh in Richmond, CA, EPA announced nearly \$5 million in grants to state and local agencies to restore water quality and wetlands throughout the San Francisco Bay watershed. Funded projects include removing mercury in the Guadalupe River Watershed, reducing nutrients in SF Bay through wastewater treatment,

Federal Legislative & Regulatory Corner – Continued

and restoration projects at Breuner Marsh, Napa River, and South SF Bay Salt Ponds. The ceremony was attended by the EPA Regional Administrator, senior officials from East Bay Regional Park District, and U.S. Representative George Miller. For more about the fund, visit: <http://www2.epa.gov/sfbay-delta/sf-bay-water-quality-improvement-fund>.

USDA, EPA Partner to Improve Access to Clean Water, Improved Infrastructure in U.S.-Mexico Border Region

The U.S. Department of Agriculture and EPA announced last week a joint initiative to improve access to clean water and wastewater infrastructure for U.S. communities along the Mexico border. This initiative is part of USDA and EPA's ongoing partnership to increase the sustainability of rural drinking water and wastewater systems. USDA and EPA have conducted an initial needs assessment for water and wastewater infrastructure in the border region. USDA plans to award up to \$500,000 through Rural Development's Technical Assistance and Training Grant program to a private, non-profit group for an in-depth priority assessment of the counties identified in the report. The assessment will include recommendations on the best way to deliver technical assistance. Based on this analysis, USDA and EPA will target technical assistance to the neediest communities and establish partnerships to provide or improve access to safe drinking water and basic sanitation. Read the initial needs assessment here: http://www.rurdev.usda.gov/SupportDocuments/RD_RUS_Phase1ResearchRpt.pdf. 

Jamie Marincola is an Environmental Engineer at the U.S. Environmental Protection Agency, Region 9. He works in the Water Division on Clean Water Act permitting and community outreach. For more information on any of the above topics, please contact Jamie at 415-972-3520 or marincola.jamespaul@epa.gov.



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Are "Hot Spots" a Myth?

By Bart Simmons

Hot spots" have been used as justification, particularly by regulatory agencies, for requiring detailed groundwater or soil sampling, particularly "step-out" sampling. The justification for pursuing a "hot spot" is often dubious, at best.

As noted by the Interstate Technology & Regulatory Council (ITRC), the terms "hot spot" and "source area" are sometimes used interchangeably. "Hot spots" are considered to be soil or groundwater volumes with relatively high concentrations that could be present at a site but whose locations and dimensions cannot be anticipated prior to sampling.

"Hot-spots" sampling should only be attempted when a decision level for the concentration of contaminant is determined in advance and agreed to by the parties involved. Otherwise, resources will likely be expended to generate data which is not used for decision-making. ASTM D6982 – 09, "Standard Practice for Detecting Hot Spots Using Point-Net (Grid) Search Patterns," provides calculations for estimating the probability of finding a "hot spot" with concentrations above a pre-established criterion.

Risk assessment is primarily concerned with mean concentrations and the Upper Confidence Limit of the mean (or median). EPA has developed [Pro UCL](#) to aid in the sampling design and statistical evaluation of sampling results.

ITRC has published "[Incremental Sampling Methodology](#)," which notes that "hot spot" sampling is inappropriate if the goal is to estimate a mean or median:

"Historically, discrete soil sample results with concentrations above an action level have often been assumed to represent a significant volume of soil containing sufficiently high concentrations of contaminant to warrant concern. These assumed volumes have been considered to represent hot spots.

The relative nature of this definition results in a wide range of interpretations and typically leads to subsequent remobilization and resampling intended to define the extent of the hot spot, often with insufficiently specified objectives."

"Hot spots" may also be confused with environmental variability or waste variability. In this case, the "hot spot" sampling is futile, because:

- 1) No matter how many samples are collected and tested, there is always a probability that a higher concentration of a contaminant is present at the site. When "step-out" sampling occurs without a pre-established criterion, the sampling will be not cost-effective and potentially endless.

- 2) The act of sampling introduces a moderating effect, raising concentrations of uncontaminated material and lowering the concentrations of contaminated material; thus the mass of the sample will always limit the highest concentration and the lowest concentration found. When sampling for arsenic in the surface of the McColl waste, a 0-12" sample contained about 150 mg/kg (ppm), but a sample of the efflorescence on the surface had 10,000 mg/kg (ppm).

"Hot spots" are mostly mythical, and the pursuit of "hot spots" should be replaced with more explicit data quality and project objectives. 💧

Bart can be reached at bartonps@aol.com.



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Characterizing Basin Percolation Dynamics Using Fiber Optic Distributed Temperature Sensing

By Emily Allen, California State University, Long Beach; Matthew Becker, California State University, Long Beach; Adam Hutchinson, Orange County Water District

Artificial recharge basins have become an increasingly popular approach to the management of groundwater in Southern California. In January of 2014 we began to investigate the vadose zone dynamics beneath a recharge basin at the Orange County Water District (OCWD; Figure 1) by installing soil moisture probes, pressure transducers, and fiber optic distributed temperature sensing (FODTS) at multiple depths beneath the basin. The purpose was to measure the diurnal temperature flux using heat as a tracer of infiltrating water to gain insight on the influence of basin stage on infiltration rate.

Recharge basins, such as Mini-Anaheim Spreading Basin at the OCWD, have the benefit of avoiding injection costs, but they must be maintained to allow for sustained adequate infiltration rates. Over time, infiltration rates decline as source-water sediments are deposited and microbial growth occurs. This accumulation of sediments and biomass creates a clogging layer at the basin surface. Clogging layers can be much less permeable than the native material and can reduce percolation, becoming the controlling factor in the infiltration process. Consequently, infiltration rates must be monitored in both space and time to allow for optimal recharge facility management.

A basin under classic percolation maintains a unit vertical hydraulic gradient, so the water level in the basin does not influence percolation rate. However, Bouwer (2002) proposed that increasing stage in a basin with a clogging layer may in fact reduce percolation rate due to compression. Compression occurs because increasing the water depth in the basin with



Figure 1: Outline of the Los Angeles Hydrologic Basin and Orange County Groundwater Basin (Orange County Water District, 2013).

unsaturated flow below the clogging layer increases the intergranular stress in the layer (Bouwer and Rice, 1989). When the infiltration rate in a recharge basin declines to less than the hydraulic conductivity of the sedimentary materials below the clogging layer, those materials become unsaturated. The corresponding unsaturated hydraulic gradient is then numerically equal to one, and flow is due entirely to percolation (Figure 2). Due to the variability of water quality and sediment properties, each recharge basin has unique infiltration characteristics. Thus, the basin stage, level of water quality, and basin pre-treatment to achieve maximum infiltration is generally site specific.

Prior FODTS experiments in the Mini-Anaheim Spreading Basin (Becker et al., 2012) found that basin stage had a strong positive correlation with infil-

tration rate, suggesting that a clogging layer did not control infiltration. The more recent experiments were designed to understand the controls on infiltration and the dynamics of percolation in the basin.

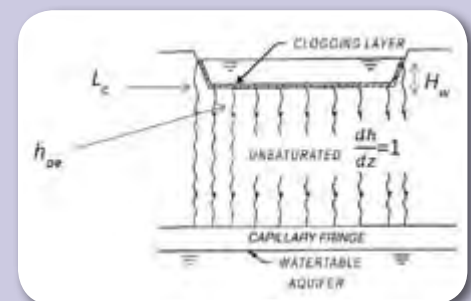


Figure 2: Infiltration basin with clogging layer showing unsaturated flow to aquifer (Bouwer, 2002).

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Student Research Corner – Continued

Methods

The FODTS system utilized for this project is a SensorNet Oryx Fiber Optic Distributed Temperature Sensing system that exploits Raman scattering. The principal of operation is to pulse a laser light signal down the fiber optic cable and monitor the small amount of backscattered photons that return to the instrument (Becker et al., 2012). The photons return at wavelengths below and above the prevailing wavelength of the incident light. The wavelengths below are referred to as anti-Stokes, and those above are referred to as Stokes. Anti-Stokes are comparatively sensitive to temperature; therefore, the ratio of Stokes to anti-Stokes provides an estimation of temperature. By measuring the return time of the anti-Stokes and Stokes backscatter along the fiber optic cable, the average temperature with a resolution of 0.01°C over every meter, up to 5,000 meters, can be obtained concurrently and continuously in time (Selker et al., 2006). This resolution was further improved through the use of fiber optic cable that is coiled in a 5 cm diameter sheath (BRUsens Brugg Cable International). The coiled cable improves the sampling interval along the cable from every 1 meter to every 10 cm. This coil was installed using direct-push technology to a depth of 10 m. A 10-cm-diameter probe was advanced into the sediments, the cable installed in the annulus, and the probe withdrawn leaving the formation to collapse around the cable.

Experimental Design

An existing fiber optic cable installed by Becker et al. (2012) was employed along with coiled fiber optic cable. The existing cable ran laterally across the basin at 30-cm and 1-m depths. This cable was fused to two 10-m-long wrapped FODTS cables located at two platforms (sites A and B), to allow for continuous temperature measurements

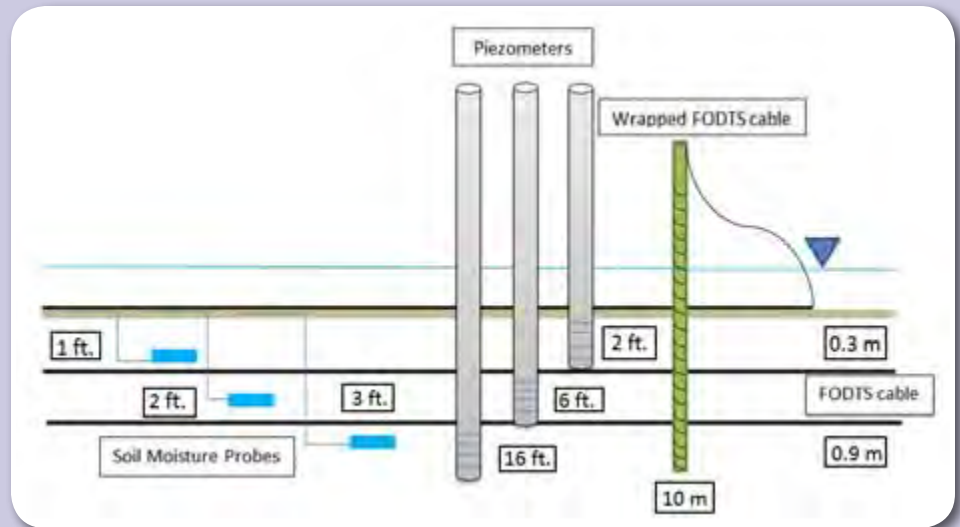


Figure 3: Schematic of monitoring locations within the recharge basin.

in both the vertical and horizontal directions. The cable then leads back to a pump house north of the basin where it connects to the SensorNet Oryx DTS system. We collected data every half hour through the experimental period.

Soil-moisture and temperature sensors (ECH20 Aquameters, and 5TM Soil Moisture and Temperature sensors) measure volumetric moisture content in the basin sediments. Each soil moisture sensor is connected to a datalogger (Campbell Scientific) that records hourly.

Hydraulic head was being measured below the basin surface in nested piezometers outfitted with pressure transducers. There are three nested piezometers at each site at 2, 6, and 16-ft depths. Each pressure transducer is connected to the dataloggers; water-level data were collected hourly. Data from both the Oryx DTS system and Campbell Scientific Dataloggers were downloaded each week for a time period of four months; data collection continues today. Figure 3 shows the instrumentation configuration at each site, and figure 4 shows the instrument platforms at sites A and B.

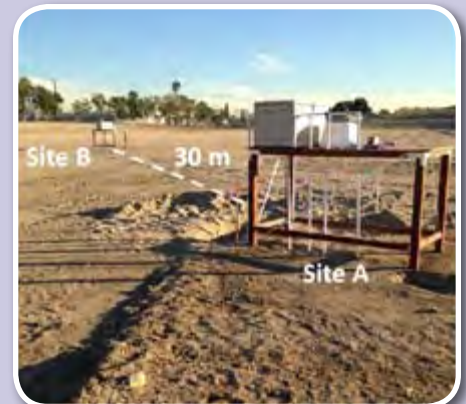


Figure 4: Instrument platforms at sites A and B housing three soil moisture probes, three pressure transducers, and one wrapped FODTS cable at each site.

Preliminary Results

Figure 5 shows the initial matrix of the DTS temperature measurements along the vertical wrapped fiber-optic cable at both platforms for the month of March. The laser light from the DTS traveled down the wrapped cable to a depth of 10 m, and then back up, providing 20 m of symmetrical data. There was an initial wetting front in the basin on the 5th of March and an increase in basin stage near the 15th of the month.

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Student Research Corner – Continued

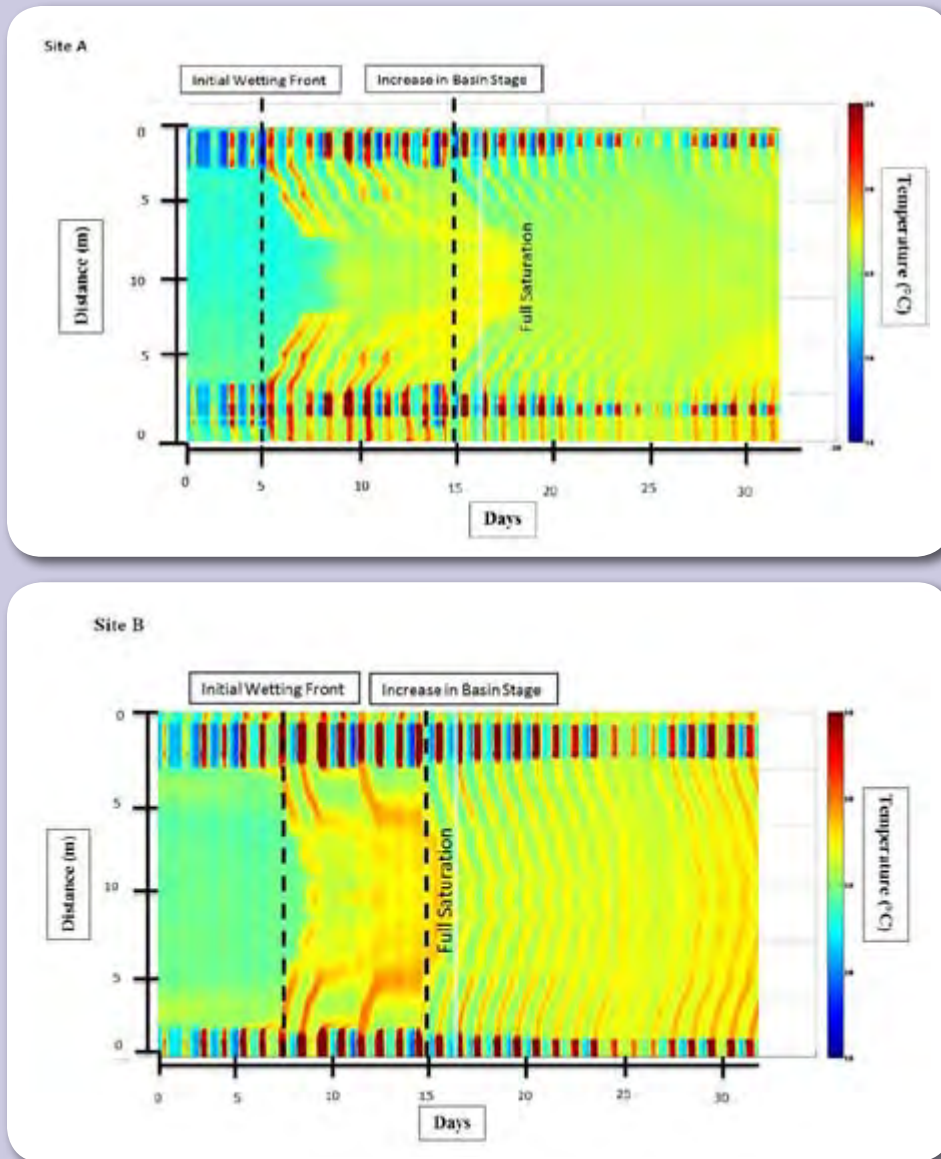


Figure 5: Initial matrix analysis of DTS data along the wrapped fiber-optic cable at sites A and B for the month of March.

Site A shows indication of the initial wetting front on the 5th of March. During this time only site A had water at the surface. The initial wetting front at site B can be identified two days later even though there was no water at the surface of site B at that time. This is indicative of shallow, subsurface, lateral flow between the two sites. There is no water at the surface of site B until about the 15th of March when there was an increase in basin stage. After the increase in stage, site A took ap-

proximately 3–4 days to fully saturate at depth; site B took approximately 1 day. The difference in temperature flux between the two sites may reflect a change in lithology at depth. We observe the downward propagation rate of the surface diurnal heat oscillation and relate this to water velocity. The change in slope with depth seen in both cables indicates changes in infiltration velocity. The diurnal signal diffuses at depth, which may be indicative of mounding. Downward migration ap-

pears to be controlled by subsurface fine-grained units, but a clogging layer has yet to develop, so this condition may change.

The reliability of the Oryx DTS system for providing data for the estimation of percolation within Mini-Anaheim recharge basin was previously demonstrated by Becker et al. (2012). The FODTS system provides a more dynamic view of percolation than is possible from the multi-level transducer system. Data from the Oryx DTS are being compared to data from the pressure transducers to determine the effects of basin stage on infiltration rate. The resulting data and analysis will help illuminate the fundamental hydraulics of infiltration basins upon which efficient recharge depends. The data set and subsequent analysis will be suitable for publication in fall, 2014. 💧

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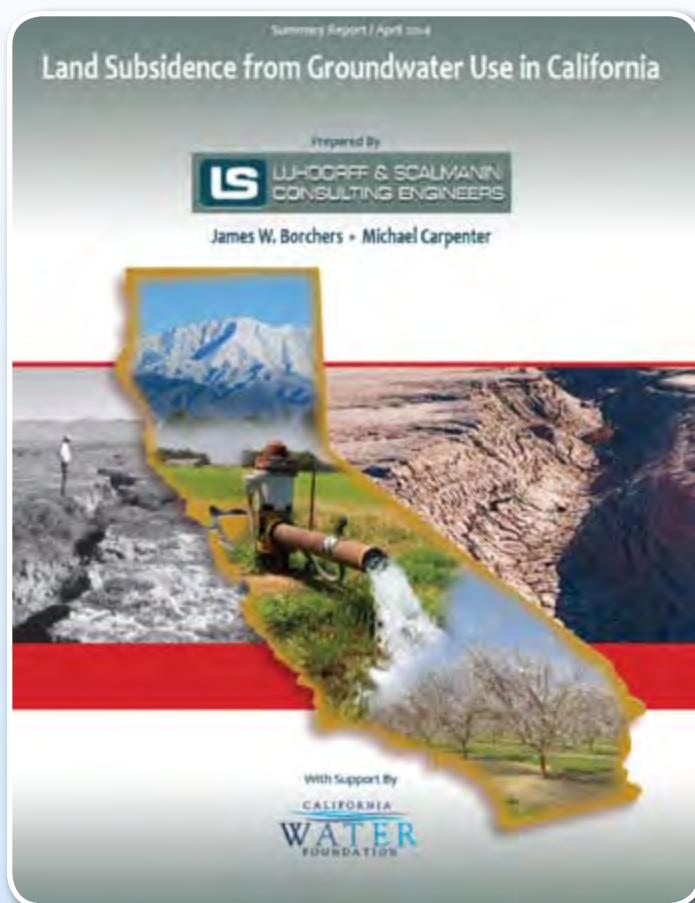
California Water Foundation Releases Report: Land Subsidence from Groundwater Use in California

The California Water Foundation recently released a report, prepared by Luhdorff & Scalmanini Consulting Engineers, James W. Borchers, and Michael Carpenter (LSCE, Borchers & Carpenter), focusing on the escalating occurrence and severity of land subsidence due to groundwater pumping in California. The report, *Land Subsidence from Groundwater Use in California*, provides key examples of significant and far-reaching impacts of subsidence and includes recommendations to avoid those impacts.

Land subsidence is certainly not a new problem, but in the midst of drought and record groundwater pumping, it is re-emerging as an issue that demands increased attention. This report provides an analysis and examples from throughout California where groundwater pumping and land subsidence have been particularly significant. Historical subsidence in the San Joaquin Valley during 1955–72 is estimated to have cost more than \$1.3 billion in 2013 dollars. Current subsidence rates in areas of the San Joaquin Valley, where new major state infrastructure is proposed, are about 20 times the rate of historical subsidence in those areas. Groundwater overuse in the Santa Clara Valley, south of the San Francisco Bay, caused downtown San Jose to subside 14 feet between 1910 and 1995 and resulted in damages of more than \$756 million in 2013 dollars.

The report describes the lack of a state and federal agency program in California to monitor subsidence, indicates that without it there will continue to be unforeseen economic and environmental costs and disruptions for the state, and includes recommendations for improving subsidence monitoring and assessment.

Acknowledgments and appreciation are extended to members of the California Water Foundation Subsidence Resources Group, established on April 29, 2013 to act as advisors for this Report. This group, which represents those most knowledgeable on the subject of subsidence, includes 17 persons presently with and/or retired from the US Geological Survey and 5 persons from the California Department of Water Resources.



The report is intended to serve as a resource of information on subsidence and groundwater use, while also spurring solution-oriented discussions regarding how to avoid future impacts from subsidence. A summary version and also a comprehensive full version of the report are available at www.californiawaterfoundation.org. 💧

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Central Coast

By Bryan Bondy
Branch Secretary



In our last meeting Amy Steinfeld of Brownstein Hyatt Farber Schreck, LLP and Terry Foreman of CH2M Hill gave a presentation on the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz project). The Cadiz project is located in San Bernardino County south of Interstate 40 in the Cadiz Valley. Cadiz Inc. owns 34,000 acres in the valley and has developed approximately 1,600 acres for agriculture. The agricultural practice uses approximately 2,000–5,000 acre-feet per year (AFY) for irrigation.

The Cadiz Valley is located at the base of the Fenner Valley, a watershed that releases into the Cadiz Valley through the Fenner Gap. The Fenner Valley watershed is approximately 1,300 square-miles and ranges in elevation from 900 to over 7,500 feet above mean sea level. Groundwater in the Fenner Valley flows southwest through the Fenner Gap and ultimately evaporates out of the Bristol and Cadiz dry lakes. The water is of good quality for irrigation and drinking until reaching the dry lakes, where it becomes salty from the continuous evaporation.

The Cadiz project proposes pumping 50,000 AFY and selling it to the Santa Margarita Water District and potentially five other water providers. The project will construct a pipeline along an existing railroad right of way and plans to use the basin for groundwater storage once the basin level has been lowered.

The amount of groundwater in storage up-gradient and the estimated groundwater recharge was assessed. There was an estimated 16.9 to 34.1 million AF of groundwater in storage with approximately 32,500 AFY of rainfall recharge. To confirm the recharge estimations the Desert Research Institute (DRI) measured evaporation from the dry lakes using Eddy Covariance instrumentation. The DRI found that Bristol dry lake's annual evaporation totaled 7,860 AFY and Cadiz dry lake was estimated at 23,730 AFY, totaling approximately 31,590 AFY. The project is currently in litigation, awaiting results from an Orange County court.

The Branch would like to thank the Bren School of Environmental Science & Management for hosting the meeting. 💧

Sacramento

By Troy Turpen,
Branch Secretary



February's Branch meeting featured Michelle Sneed's presentation on *Land Subsidence Along The Delta-Mendota Canal And Neighboring Areas In The San Joaquin Valley, California*. Ms. Sneed, a hydrogeologist since 1994 with the U.S. Geological Survey California Water Science Center, studies aquifer-system mechanics related to fluid-pressure changes, leading to land subsidence investigations involving measurement, analyses and simulations.

Extensive groundwater withdrawal from the unconsolidated deposits in the San Joaquin Valley caused widespread aquifer-system compaction and resultant land subsidence from 1926 to 1970 – locally exceeding 8.5 meters. The importation of surface water through the Delta-Mendota Canal beginning in the early 1950s, and through the California Aqueduct in the early 1970s, resulted in decreased pumping, initiation of water-level recovery, and a reduced rate of compaction in some areas of the San Joaquin Valley. However, several droughts since the early 1970s decreased surface-water availability, causing pumping to increase, water levels to decline, and renewed compaction. Land subsidence from this compaction has reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, and other canals that deliver irrigation water and transport floodwater.

Land subsidence was assessed in the vicinity of the Delta-Mendota Canal as part of an effort to minimize future subsidence-related damages to the canal. The location, magnitude, and stress regime of land-surface deformation during 2003–10 were determined by using extensometer, Global Positioning System (GPS), Interferometric Synthetic Aperture Radar (InSAR), spirit leveling, and groundwater-level data. Comparison of continuous GPS, shallow extensometer, and groundwater-level data, combined with results from a one-dimensional model, indicated the vast majority of the compaction took place beneath the Corcoran Clay, the primary regional confining unit.

Although the northern portion of the Delta-Mendota Canal was relatively stable, land-surface deformation measurements indicated the southern portion of the Delta-Mendota Canal subsided as part of a large subsidence feature centered about 15 kilometers northeast of the Delta-Mendota Canal, south of the town of El Nido. Results of InSAR analysis indicated at least 540 millimeters of subsidence near the San

Continued on the following page...

Sacramento – Cont.

Joaquin River and the Eastside Bypass during 2008–10; this is part of a 3,200 square-kilometer area—including the southern part of the Delta-Mendota Canal—affected by 20 millimeters or more of subsidence during the same period. GPS surveys done in 2008 and 2010 are in agreement with the high subsidence rate measured using InSAR. Water levels in many shallow and deep wells in this area declined during 2007–10; water levels in many deep wells reached historical lows, indicating that subsidence measured during this period was largely inelastic (permanent). InSAR-derived subsidence maps for various periods during 2003–10 showed that the area of maximum active subsidence shifted from its historical (1926–70) location southwest of Mendota to south of El Nido. The full report can be downloaded from: <http://pubs.usgs.gov/sir/2013/5142>.

March's Branch meeting featured Dr. Duncan Austin's Central Valley Regional Water Quality Control Board (CVRWQCB) Regulatory Update. Duncan Austin, a licensed Professional Engineer, is currently serving as the Cleanup Program Manager. Prior to working for the Board, he spent 11 years at the DTSC working on Superfund sites, including Aerojet, Iron Mountain Mine and the UC Davis Radiation Research facility.

Duncan Austin covered topics ranging from:

- AB440, the “New Polanco” legislation
- Site designation when there is a change in Responsible Party, a recent decision by the Site Designation Committee (SDC)
- The applicability of the UST Low Threat Case Closure Policy to non-UST cases in the Central Valley Region
- Case studies in Targeted Groundwater Extraction from Monitoring Wells as a Site Closure Strategy.

For the first quarter of 2014, the Sacramento Branch thanks our Scholastic Sponsors: EnviroTech Services, and Active Treatment Systems. Our Scholastic Sponsors continue to allow the Sacramento Branch to financially support Geology students at California State University, Sacramento. 💧

Southern California

By Emily Vavricka,
Branch Secretary



On February 18, 2014, the GRA Southern California Branch held its bi-monthly meeting and hosted the Southern California GRA 2014 David Keith Todd Distinguished Lecture Series, with Dr. Jay Famiglietti presenting. Dr. Famiglietti is a Professor of Earth System Science and of Civil and Environmental Engineering and Director of the UC Center for Hydrologic Modeling at the University of California, Irvine. Dr. Famiglietti's lecture, titled *Epic California Drought and Groundwater: Where Do We Go From Here?*, presented data on the diminishing supply of California's freshwater and groundwater resources using remote sensing technology and satellites. While drought conditions in California have continued to take a toll on water resources throughout the state, Dr. Famiglietti's team has been tracking this decline in freshwater storage using

data from NASA's Gravity Recovery and Climate Experiment (GRACE) mission, along with other datasets. Dr. Famiglietti and his team of researchers have identified that decreasing availability of surface water has exacerbated groundwater depletion. One of the main points Dr. Famiglietti emphasized was that groundwater management is critical in order for California to survive this historic drought. Not only is Dr. Famiglietti looking at California's water resource conditions, but he is also using this data to take a global approach and track the fluctuations in water resources across the continents.

Dr. Famiglietti's lecture was well attended and provided an illuminating look at the alarming drought conditions in California. His lecture provoked a very enthusiastic and informative discussion on the intriguing technology of using satellite data to monitor groundwater levels and the reality of California's water resources.

The GRA Southern California Branch would again like to thank Yellow Jacket Drilling for sponsoring the local Branch Scholastic fund for the February meeting, and the 2014 David Keith Todd Distinguished Lecture Series sponsors, Geosyntec Consultants, Regenesys, Luhdorff & Scalmanini Consulting Engineers, and Todd Groundwater. The Branch would also like to thank GRA Members and non-members for attending the bi-monthly February meeting. 💧



Brannan Street Wharf, San Francisco

The redeveloped Brannan Street Wharf on San Francisco's Embarcadero includes three interpretive sculptural elements and yellow/black tubes that rise and fall in response to the shifting tides. Dan Hodapp, senior waterfront planner for the Port of San Francisco, told John King, San Francisco Chronicle's urban design critic, that "The tide is much more active than people realize. We're using the tidal columns to signal this." An explanatory plaque about tides is displayed near the southernmost column.

The tidal columns are a trio of aluminum pipes 20 inches in diameter, closed at the bottom and vividly painted, with each yellow/black couplet representing a height of 1 foot. The tidal columns are set inside orange steel piles that were perforated, screened, and driven into the bay sediments.

As the tides rise and fall, so do the water levels within each pipe, and the sealed yellow/black tubes bob up and down. At the time of this photo, the tide was approximately 2.5 feet above mean lower low water (MLLW). 💧

*Photographed along the San Francisco Bay Trail (<http://www.baytrail.org/>)
by John Karachewski, Ph.D. (www.geoscapesphotography.com)*