GROUNDWATER RESOURCES ASSOCIATION OF CALIFORNIA
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2014 – The Year of Groundwater GRA's 23rd Annual Conference & Meeting

By Steven Phillips, Chair; Co-Chairs Alyx Karpowicz, Emily Vavricka and Matt Zidar; and Moderators Kevin D. Brown, Rob Gailey, Brad Herrema, Vicki Kretsinger Grabert, Jean Moran, Lisa O'Boyle, Tim Parker, Jim Strandberg, and Scott Warner

2014 is a landmark year in California's water history, and groundwater is the focus. As groundwater levels declined and the land surface subsided during one of the worst series of droughts the state has experienced, Governor Brown initiated a process to improve groundwater management in the state, making it clear that groundwater is not being adequately managed in many basins, and that the time has come to do so. On August 29th, the Legislature passed landmark bills to require sustainable groundwater management in the state to protect and preserve this vital water resource. Governor Brown signed these bills into law on September 16th. The intent of these bills is to facilitate 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 focused on this topic with targeted sessions on the administration's efforts, associated legislation, policy and legal issues, and perspectives of local entities. Additional sessions covered a broad range of groundwater issues facing California, including the drought, wastewater/water recycling, fracking, climate change, and groundwater quality and remediation. The conference also included GRA's 2014 David Keith Todd Distinguished Lecturers; the popular Collegiate Colloquium, which showcased cutting edge science being conducted by California's college students; and a poster session. A summary of these sessions follows.

The Administration's Efforts to Improve Local Groundwater Management

The plenary session focused on the new Sustainable Groundwater Management Act (Act), which becomes effective January 1, 2015. **Tim Parker**, Parker Groundwater Management, GRA Director and Legislative Committee Chairman, introduced the session with a brief summary of the Act and introductions of the session speakers.

Tim Parker moderates the plenary session. Photo by Brian Lewis.

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The Groundwater Resources Association of California is dedicated to resource management that protects and improves groundwater supply and quality through education and technical leadership.

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Sustainable Groundwater Management

By Ted Johnson

Congratulations! We did it! We got the job done. And by "we," I mean a whole host of dedicated, passionate Californians who helped get both the Sustainable Groundwater Management Act and Proposition 1 passed into law to help secure our future water supplies to the enormous benefit of the state's citizens, businesses and environment. A big thanks and pat on the back to the many people and organizations that contributed to these amazing efforts, including Governor Jerry Brown and his staff, Senator Fran Pavley and Assemblymember Roger Dickinson and their staffs, the Association of California Water Agencies (ACWA), the California Water Foundation (CWF), UC Davis, our own organization—the Groundwater Resources Association of California (GRA)—and many others.

For GRA, we had enormous efforts from Tim Parker, Rosanna Carvacho, Thomas Harter, Chris Frahm and others to inform and educate the legislature on the importance of groundwater as a key factor in the reliability of the state's water supply; they also led a grass-roots effort to petition our membership for letters of support and provided updates on the evolving legislation.

The Sustainable Groundwater Management Act is a package of three bills, AB 1739 (Dickinson), SB 1168 (Pavley) and SB 1319 (Pavley), that for the first time in California history will comprehensively regulate groundwater in the state. Details on this Act will be presented later in this issue of *HydroVisions* and in upcoming GRA webcasts and conferences, but in short the Act promotes local control over groundwater basins and requires that basins become sustainable within a specified period of time. Sustainability generally means that basin inflows and outflows are balanced over a long period of time, and are neither experiencing serious chronic overdraft nor other "undesirable results" (not defined in the Act).

Groundwater Sustainability Agencies (GSAs) must be created under the Act to develop and implement sustainability plans. Adjudicated basins and other specified basins are exempt. The GSAs will have broad powers to manage their areas, including the ability to register groundwater wells, measure their production, and reduce extractions if necessary to achieve sustainability. GSAs must be in place by June 30, 2017, and sustainability plans completed by January 31, 2020 for critically overdrafted basins or January 31, 2022 for other basins. If the Department of Water Resources determines that GSAs have not been created, or that sustainability plans are not sufficient, then the State Water Resources Control Board may intervene and assist in GSA or plan development, or adopt and enforce its own plans for the basin.

Proposition 1 is the Water Quality, Supply and Infrastructure Improvement Act of 2014 that was placed on the ballot by a near-unanimous, bipartisan vote of the Legislature and approved by Gov. Brown. It was passed by the California voters on November 4, and sets up $7.545 billion in general obligation bonds for statewide water supply infrastructure projects. The breakdown in funding categories is as follows: $2.7 billion for surface and groundwater storage projects, $1.89 billion for watershed and flood management, $900 million for groundwater sustainability projects, $810 million for regional water reliability, $725 million for water recycling and saltwater-removal projects, and $520 million for safe drinking-water programs. The money is not tied to specific projects; the funding will go through a public competitive process to award grants to fund the most critical and needed projects.

Although all these measures passed largely because of the public's awareness of and concern over the current exceptional drought in the state, it is unlikely the measures will help us in the current water shortage due to the length of time (years to decades) it will take to design, permit, do environmental reviews, and construct new projects and to bring sustainability to challenged groundwater basins. The Winston Churchill quote, "Never let a good crisis go to waste," certainly applied this year, as awareness of the drought led to consensus on, and bipartisan support of these measures to help future water supplies. Unfortunately, we are still faced with the current drought, and if this winter is as dry as the three previous, there will likely be more serious water rationing and even more demand on the already stressed groundwater basins.

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Groundwater Sustainability – A Common Goal – *Continued*

Changing topics, I want to give a brief report on the "State of GRA" in 2014, which I presented at our 23rd Annual Meeting on October 15–16 in Sacramento. In a nutshell, your Association is doing great! We've had an amazing year with the success of many events, including Emerging Contaminants, Groundwater Management, Legislative Day, Managed Aquifer Recharge, Land Subsidence due to Groundwater Withdrawal, and the Annual Meeting. Separate workshops on watersheds and modeling, along with numerous topical GRACasts were very well attended and positively received. Our membership now tops 1,400; over a year ago it was less than 1,200. Our finances, always a closely monitored concern for a volunteer non-profit organization, are very healthy. We are reaching out to our members more frequently, and promoting greater access to the Board by implementing term limits, thereby making room for the election of new Board members bringing new energy and new ideas. So the "State of GRA" in 2014 is fantastic, and with your help we can make 2015 even better.

I want to close with announcing the recipients of the President's Awards that I was privileged to present at the Annual Meeting. President's Awards allow the sitting GRA President to provide special recognition to those individuals that he/she feels went above and beyond in their service to the organization over the past year. Although GRA is volunteer based and we are only successful because of the amazing efforts that all of our volunteers and associates provide, a few people really stood out in my mind this year, which is why I presented the following awards: Tim Parker and Rosanna Carvacho received awards for their dedicated and timely work on the Groundwater Sustainability bills. Lisa O'Boyle received an award for her leadership and tenacity on the Education Committee, David Keith Todd Lecture Series, and Student Scholarship program. Abigail McNally received an award for leading the team to develop the striking new logo and branding for GRA that we unfurled this year. Special President's Awards were presented to retiring Board members Sarah Raker, GRA Founding Father Brian Lewis, and GRA Founding Mother Vicki Kretsinger, whose dedication to the Association goes unmatched and whose leadership, passion, drive, and examples helped form GRA into the incredible organization that it is today. Enough thanks cannot be given to them, and more is to come on that subject in the next issue of *HydroVisions*. I feel very lucky and humbled to be serving with such dedicated and knowledgeable professionals. GRA is by far the most engaged, most relevant and most outstanding association with which I have ever been involved.

Rock on!

TJ

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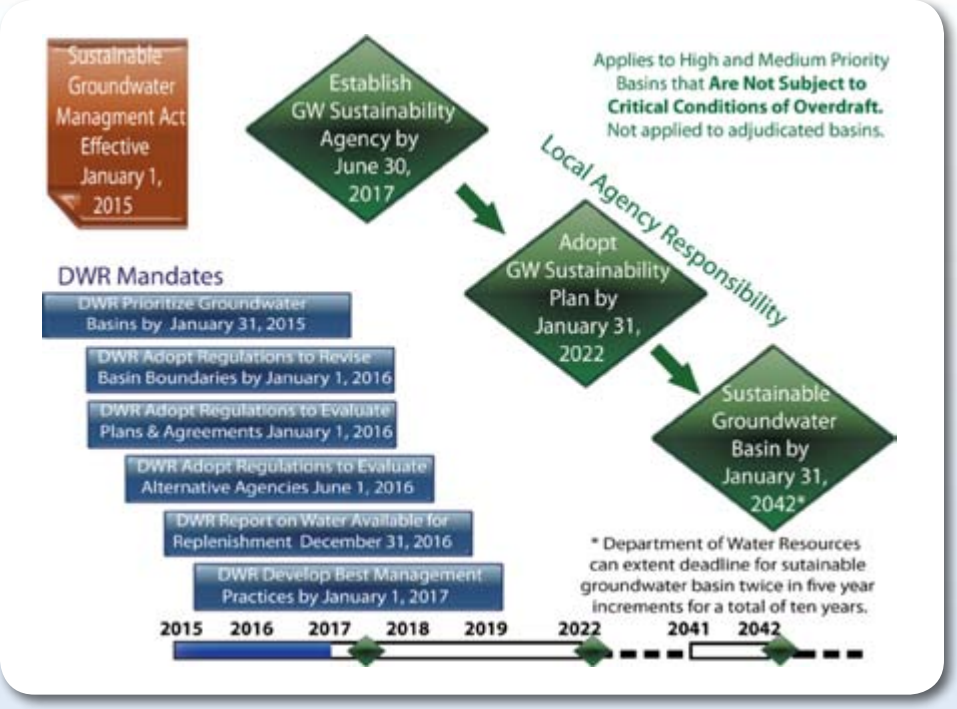

The Act requires that within the next two years the California Department of Water Resources (DWR) prioritize groundwater basins, adopt regulations for local agencies to revise basin boundaries, adopt regulations to evaluate groundwater sustainability plans and agreements, adopt regulations to evaluate alternative agencies, report on water available for replenishment, and develop best management practices. The schedule for DWR mandates is provided in the figure above. Based on DWR's groundwater basin prioritization, all high- and medium-priority non-adjudicated basins are required to establish groundwater sustainability agencies by June 30, 2017. These basins are required to adopt groundwater sustainability plans by January 31, 2022, and to be sustainable by January 31, 2042. An exception is the subset of these basins subject to critical conditions of overdraft, which must have plans in place by January 31, 2020, and be sustainable by January 31, 2040. Adjudicated basins are exempt, and have only to provide the documentation on the adjudication, and annually report specific data to DWR. DWR can extend the deadline for sustainability by five years, up to two times. If the requirements above are not met, the State Water Resources Control Board (SWRCB) has the authority to step in as a 'backstop,' make the basin 'probationary,' and develop an interim plan that may include developing a physical solution, curbing pumping, and administering surface-water rights.

Mark Cowin, DWR Director, led off discussing the importance of the Governor's Water Action Plan (Plan), published in January 2014 and spanning some five years of proposed actions. The Governor directed the California Natural Resources Agency, the California Environmental Protection Agency, and the California Department of Food and Agriculture to identify key actions, through 2018, that address urgent needs and provide the foundation for the sustainable management of California's water resources. This was developed with public input received from a wide range of industry, government and nongovernmental organizations to inform the revisions and led to a more comprehensive and inclusive Plan. The Plan specifically identifies increasing storage and improving groundwater management with legislation as key actions. The drought has been a key driver and motivator in many areas, with the state in the third consecutive series of driest years on record, and potentially moving into a fourth consecutive dry year. The state has fared moderately well (some areas better than others) because of previous investments made, and the availability of groundwater. Now we all need to manage our groundwater resources more sustainably. The legislation behind the Act is complex and includes the six mandates for DWR (listed above). DWR will have five major areas of focus: (1) development of groundwater sustainability assessments, (2) technical assistance and analysis to local agencies to provide building blocks for sustainability, (3) statewide planning assistance for entire hydrologic cycle, (4) local and regional funding assistance, and (5) inter-regional assistance

Karen Ross (left), Mark Cowin and Felicia Marcus participate in the plenary session. Photo by Brian Lewis.

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including a surface water-groundwater initiative. DWR is re-tooling to better meet the groundwater sustainability mandates, and is also looking to industry practitioners and basin managers for input on needs to move forward successfully.

Felicia Marcus, Chair of the SWRCB, started off by saying that everyone should look at the Governor's Water Action Plan. The Plan is one of action, versus static, and emphasizes that state agencies need to work together, with stakeholders, and across traditional divides. This groundwater legislation is really a big deal; it is a time for action, for locals to get moving first, and for folks on the ground floor to make progress and get assistance where needed. SWRCB continues to work under the existing authorities of Porter Cologne. Programs include the groundwater ambient monitoring and assessment program (GAMA), addressing new oil and gas well stimulation requirements under SB4, underground storage tank (UST) programs, the Department of Public Health drinking water program (which recently moved to SWRCB), stormwater management, evaluation of recycled water for direct potable reuse, and much more. SWRCB really has its hands full, and would be very happy if they do not have to step in and do interim plans as discussed above. Whether iron fist in a velvet glove or 800-pound gorilla, possibly think of SWRCB as a friendly helper; they are ready to assist DWR and locals, will go where invited, be tactfully helpful, and have a light touch.

We all have to eat healthy food to have good nutrition, said **Karen Ross**, Secretary of the California Department of Food and Agriculture. In talking with some farmers, if they had known where they were headed 10 years ago, they would have taken a different approach. Approximately 95% of the tomatoes and 50% of the fruits, nuts and vegetables in the US come from California. Regarding stewardship of the land and resources, and the new groundwater legislation, people in agriculture are rolling up their sleeves, want to make this work and want a secure water future. This is requiring people to come together, knowing they will be asked to make very hard decisions in the future. The challenge is how to bring people together to talk about a different and challenging future. Litigation will just slow us down. We really need to think about the human side in our deliberations. The lack of surface water has grown over the past decade and longer, with the recent drought making the situation worse, which will kick in more draconian state action. The legislation does not declare groundwater recharge as a beneficial use, and this needs to be sorted out. Does DWR have the resources they need to provide the help the locals need? This is a big concern going forward. The legislation emphasizes protection of existing water rights, but in many basins, to reach sustainability will require ratcheting down pumping. Will this cause many small farms to die and large ones to suffer? This will likely change the face of agriculture in California.

Drought – Our Dependence on Groundwater

This session, moderated by **Alyx Karpowicz** of the SF Bay Regional Water Quality Control Board, began with **Lorraine Flint** of the U.S. Geological Survey presenting *Implications of Extended Drought on Recharge Across California*. Her work using the Basin Characterization Model has shown that the decline in groundwater availability is highly variable around the state and that the interaction between dynamic processes affecting recharge, soil water, the unsaturated zone, and the relative proportion of recharge and runoff that may occur as a result of storms is accentuated across the landscape during extended drought. The bottom line is,

Lorraine Flint, USGS. Photo by Brian Lewis.

in dry years there is more recharge than runoff due to soils being so dry.

Abdul Khan, with the Department of Water Resources, presented *Creating Drought Resilience: Conceptualizing a California Groundwater Bank and Infrastructure System*. He described simulating (1) what would happen to already-depleted groundwater basins if water levels continue to decline at the same rate they are now for the next 20 years, (2) what would happen to those same basins if we could augment supply by capturing some of the excess outflow from the Delta, and (3) what would happen if we reduced demand on groundwater. The best-case scenario suggests that if we can both capture 30% of excess outflow and reduce demand on groundwater by 30%, we can return depleted groundwater basins back to pre-drought levels in the Central Valley.

Gerhardt Huber, Deputy Director with Ventura County, presented *Emergency Ordinance E- The Fox Canyon Groundwater Management Agency's Response to Groundwater Conditions and the Drought*. Groundwater supplies 65% of the demand in Ventura County, and with many of the basins well below mean sea level during this extended drought, an emergency ordinance was put in place to reduce usage

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by 20% over 18 months in working to achieve groundwater basin sustainability. In addition, the emergency ordinance prohibits installation of new extraction wells and limits the accrual and use of conservation credits.

Ruth Landgridge, professor at UC Santa Cruz, presented *Accounting for Climate Change and Drought in Defining Sustainable Yield for Groundwater Systems*. Her presentation compared two basins, Goleta and Soquel, and their plans to reduce water usage and extend existing supplies through more dry seasons. Goleta established a drought reserve in the 1970s, but recently set a 25% water use reduction goal and imposed new construction limits to preserve its water supply. Soquel relies solely on groundwater, and the basin is in overdraft during this drought. Soquel is considering a collaborative project with neighboring Santa Cruz Water Department to build a desalination plant; during wet years, produced water would go to recharge Soquel's basin, and in dry years water would go to Santa Cruz which relies solely on surface water.

The Sustainable Groundwater Management Act: How Did We Get Here and Where Are We Going?

A panel of insiders, moderated by GRA Director **Brad Herrema**, Brownstein Hyatt Farber Schreck, LLP, discussed the development and implementation of the recently adopted Sustainable Groundwater Management Act (Act). **Dennis O'Connor**, principal consultant to the California Senate Committee on Natural Resources and Water, set the stage for the Act's adoption, describing California groundwater law, historical recommendations for groundwater management in California, and the existing framework of permissive groundwater management legislation. The panelists then provided insight into the considerations that went into the development of the Act, and its anticipated effects on the roughly 80 groundwater basins that will be subject to its planning requirements.

Kate Williams, Program Coordinator, California Water Foundation, which in early 2014 had outlined a proposal for further groundwater management within California, discussed the uncertainty and potential for conflict in the designation of a Sustainable Groundwater Agency, under the Act. **Bob Reeb**, Reeb Government Relations, LLC, who represented stakeholders in the negotiations, discussed their concerns regarding the manner in which compliance with the Act will be funded.

Dan Dooley, University of California, Senior Vice President for External Relations, who had worked to facilitate discussion among the stakeholders in the negotiations, provided his perspective on the process and the resulting legislation. **Russell McGlothlin**, Brownstein Hyatt Farber Schreck, LLP, who worked with the Association of California Water Agencies in evaluating the legislation, discussed the uncertainties remaining under the Act as to the manner in which groundwater rights will be respected in the creation of sustainable conditions in affected groundwater basins. He also discussed his recommendations for the development of a "streamlined" groundwater basin adjudication process that would, hopefully, provide for a more rapid and less expensive means of adjudication. Mr. McGlothlin stated that he was hopeful that legislation might be enacted in 2015 that would address this issue.

From the panel's discussion, it is clear that there are many issues yet to be resolved in how the Act will actually be implemented, and that groundwater stakeholders will be very busy in the next few years in addressing those issues.

Collegiate Groundwater Colloquium

Six students presented their research findings during the oral portion of the sixth annual Collegiate Groundwater Colloquium. The Collegiate Colloquium offers an opportunity for practicing groundwater professionals to learn about students' recent research, and gives students an opportunity to present their work to an audience of groundwater professionals. Submissions are solicited from undergraduate

2014 Collegiate Groundwater Colloquium speakers and poster presenters (from left to right) Jiro Ariyama, Peter Dennehy, Sarah Beganskas, Katie Markovich, Stephanie Urióstegui, Anne Jurek, Kirsten Rudestam, and Abigail Brown, and moderator Jean Moran (center). Missing is poster presenter Andrew Renshaw.

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and graduate students through their faculty advisors and can be on any topic related to groundwater occurrence, contamination, remediation or management. This year, six graduate students from California universities gave excellent presentations on topics ranging from unsaturated zone modeling to factors motivating groundwater decision making.

Sarah Beganskas, a PhD student at UC Santa Cruz, described an active, ongoing project in the Pajaro Valley, where stormwater is captured for recharge at an instrumented 2.5-acre infiltration basin (figure 1). Findings from studies of native and accumulated sediment grain-size analysis show that fine-grained material preferentially travels through the system and accumulates in the infiltration basin, potentially decreasing hydraulic conductivity by one to two orders of magnitude. Also, the relationship between precipitation and sediment accumulation indicate that total precipitation has a greater influence than storm intensity, and that significant sediment accumulation takes place, even in dry years.

Figure 1. Site of sediment and recharge studies in Pajaro Valley Groundwater Basin.

Jiro Ariyama, a master's student at UC Davis, described a model of On-farm Flood Flow Capture (OFFC) that aims to understand the amount of recharge and nitrate transport in the unsaturated zone when river overflow is captured and applied to farm lands. The OFFC project is a vineyard in Helm, CA, where nitrate is stored in the unsaturated zone and may be mobilized after an OFFC event. The groundwater flow and transport is modeled using MODFLOW, MT3DMS, and HYDRUS for nitrate fluxes. Results of the modeling show that an initial nitrate concentration spike, which could exceed levels recommended for nitrate-sensitive grapes, is followed by dilution at the recharge site (figure 2).

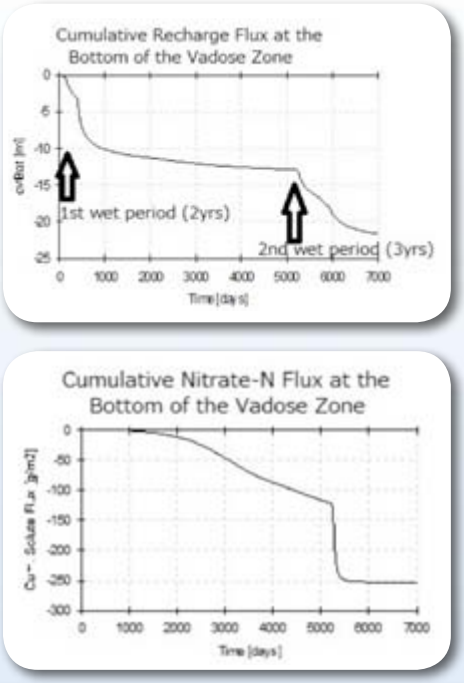

Figure 2. Preliminary results from partially calibrated model of recharge and nitrate load.

Anne Jurek, a recent graduate from the master's program at San Jose State University, showed the results of vulnerability assessments for the Niles Cone Groundwater Basin to perchloroethylene (PCE) contamination from dry cleaners. She used a modified DRASTIC index method with multiple hydrogeologic variables, source assessments of historic and presently operating dry cleaners, and well data to assign a threat ranking to each source. The shallow aquifer of the Below Hayward Fault subbasin is identified as the most sensitive area (figure 3), and the analysis provides a screening tool for prioritizing investigations of dry cleaner sites.

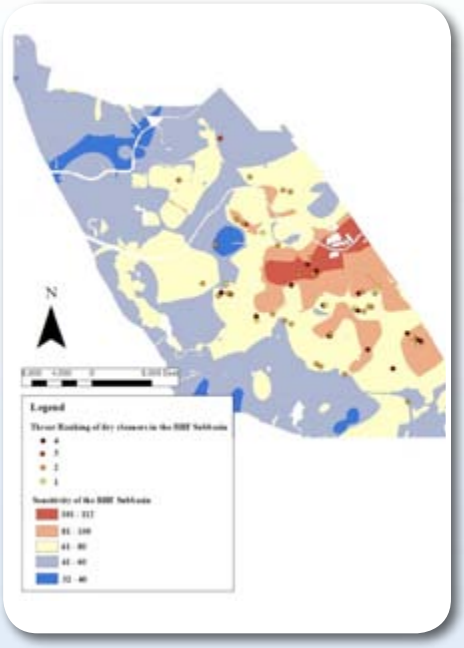

Figure 3. Vulnerability map for PCE from dry cleaners for the Below Hayward Fault subbasin of the Niles Cone Groundwater Basin in Alameda County.

Peter Dennehy, a student in the M.S. program at UC Davis, discussed an in-situ approach to determining biodegradation rates and identifying functional microbial communities that degrade persistent contaminants such as MTBE. The experimental device (figure 4) has an amendment chamber and reaction chamber designed to fit within a two inch monitoring well, where native microbes can be supplied with amendments or nutrients, and flow, contaminant concentrations, and geochemical parameters are monitored. Following deployment, MTBE-degrading bacteria are enumerated by quantitative PCR. Results from a site at Travis AFB showed relatively slow degradation of MTBE.

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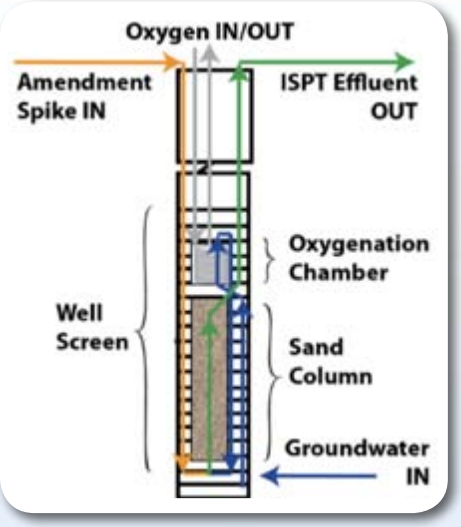

Figure 4. Schematic diagram of in-situ pilot test under aerobic conditions.

Kirsten Rudestam and **Abigail Brown**, both graduate students in Sociology at UC Santa Cruz, teamed up to outline a research project that focuses on the factors motivating groundwater decision making in the Pajaro Valley. They presented two research themes – one investigating the application of common-pool resource theory (in which individuals sharing a resource act in ways that promote the longevity of the resource; Figure 5), and the other considering collaborative governance for watershed management. They are addressing questions about the conditions under which local control can work to reverse unsustainable groundwater extraction and examining the structures in groundwater decision-making groups and how they relate to processes of exclusion.

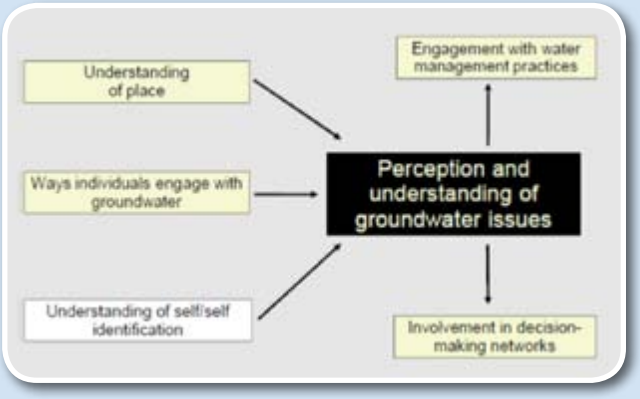

Figure 5. Schematic diagram of application of common-pool resource theory

Modeling Advances & Applications

Moderated by **Steven Phillips**, USGS, this session began with an overview befitting the conference theme, by **Thomas Harter** of UC Davis, entitled *Groundwater Models: A Key Tool for Successful Groundwater Management*. After describing the key elements of managing groundwater sustainably, he focused on the central role that groundwater modeling plays in such a planning effort. Developing a model involves organizing available information, estimating the unknowns (e.g., irrigation pumpage, recharge, etc.) and comparing model results to observed data. Going through this process with the involvement of water managers and stakeholders builds a collective understanding of the aquifer system and associated level of confidence in the model's ability to simulate it, which is critical when using the model to evaluate alternative water management actions for attaining and maintaining groundwater sustainability.

Claudia Faunt of the USGS presented *The Central Valley Hydrologic Model – Updates and Applications*. The first version of the CVHM simulated the period 1962–2003 and included 21 water-balance regions simulated using MODFLOW's Farm Process, which rigorously simulates irrigated agriculture. The distribution of hydraulic parameters was based primarily on sediment texture from 8,500 well logs. CVHM was calibrated to groundwater levels, streamflow, and land subsidence, which is ongoing in the valley during drought and non-drought conditions – which spurred an ongoing effort to update the model. The updated CVHM is extended through 2013; has highly refined water-budget regions along the Delta-Mendota Canal; includes agricultural drains, water banks, and other additions; and includes code enhancements that allow for improved simulation of subsidence, the water table, and wellbore flow.

Sorab Panday of GSI Environmental presented *Overcoming Model Barriers and Challenges in California using MODFLOW-USG*, the unstructured-grid version of MODFLOW, which is well suited for addressing the complex hydrogeologic environments often encountered in California. MODFLOW-USG was first released in 2013, and is currently being used extensively. Supporting software is growing quickly and currently includes versions of ZONEBUDGET, MODPATH, PEST, and several commercial GUIs. USG was designed to allow for grid refinement to accommodate simulation of streams and other small-scale features or areas of interest, and to better handle complex basin geometry, including faults, pinch-outs, and other geologic structures that often are difficult to simulate using a rectilinear grid. It also has capabilities for simulating tunnels, drains and other similar features.

Rob Gailey, Consulting Hydrogeologist, discussed a very different type of model used for *Estimating Groundwater Concentrations of Total Dissolved Solids from Apparent Resistivity Profiles*. New California regulations for well stimulation operations require monitoring of water quality, often below the depth of existing water wells. Rob discussed the development of a method for monitoring total dissolved solids (TDS) by estimating TDS profiles from borehole resistivity logs. Samples

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and resistivity logs were collected in a 1,600-ft borehole; after adjusting for the effects of drilling mud, Archie's-Law equation parameters were calibrated using the sampling and geophysical results, followed by model prediction uncertainty analysis, resulting in a useful tool for evaluating these new groundwater monitoring requirements.

Kapo Coulibaly of Schlumberger Water Services presented *Applying the Multiphase Reservoir Simulator Petrel-Eclipse to Hydrogeological Modeling: the Mojave River Project*. Eclipse, a multi-phase petroleum reservoir simulator, was enhanced to better simulate water-related processes, and Petrel, a 3D geologic model, was used as a preprocessor. This modeling combination was used to develop a model of the Mojave River basin to aid in evaluating a Regional Recharge and Recovery program designed to help address long-term overdraft in the basin. The geologic model integrated surface geologic maps, drillers' and geophysical logs and geologic cross sections. Previous work, the geologic model, and results of infiltration tests along the river were used to constrain model calibration. The next phase of work is to use the model to help design the recharge and recovery system.

Wastewater Reuse & Recycling

Moderated by **Kevin Brown** of the San Francisco Bay Regional Water Quality Control Board, the session began with a presentation on *A Guide to Wastewater Reuse and Recycling Post-Merger*, by **Fran Spivy-Weber** of the State Water Resources Control Board. She emphasized that recycled water use is a high priority for California. In September 2013, Governor Brown signed SB322, which requires the Department of Public Health and the State Water Board to "investigate the feasibility of developing uniform water recycling criteria for direct potable reuse by September 2016." She also discussed the recent merger of DPH's Drinking Water Program with the State Water Board, and how this consolidation will ensure the safe use of recycled water.

Dr. David Sedlak of UC Berkeley presented *California's Drought and the Fourth Generation of Urban Water*. He provided a fascinating overview of the significant technological "revolutions" in water supply, treatment and disposal over time. Starting with "Water 1.0," which ranged from the early Roman water supply system to New York City's early water system, he kept the audience enthralled with the "windows of opportunity," including the construction of Pardee Dam in the 1930s to aid nine East Bay cities experiencing a severe drought-induced water shortage. Water 2.0 touched upon how outbreaks of typhoid fever in several US cities advanced water filtration and chlorination techniques to protect public health. Water 3.0 detailed how additional engineering advances, and public and private capital expenditures, enhanced the treatment of urban wastewater and runoff through the 1990s. Finally, Water 4.0 forecasts the next generation of urban water use, featuring a centralized vision of advanced wastewater treatment, including desalination, water reuse, managed surface waters, and controlled aquifer recharge.

Dr. Val Frenkel of Erler & Kalinowski, Inc. discussed *Water Reuse Without Membranes*, an overview of current membrane technologies and applications for wastewater treatment, water reuse, and desalination. Because we will need more water in the future, Dr. Frankel raised key points that must

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be addressed for water reuse, including availability, long-term sustainability, the quality of source water and treatment required, regulatory compliance, and costs. Key themes of the presentation included where and how membrane technologies can benefit municipal and industrial projects, the types of membrane technologies to fit certain solutions (including MBR and IPR), the benefits of applying membrane technologies and limiting factors, and new membrane technologies.

You Won't Find What You Don't Look For – Emerging Contaminants and Recycled Water Testing, was presented by **Dr. Andrew Eaton** of Eurofins Eaton Analytical Inc. Highlights of the presentation included discussions on improvements in laboratory detection limits due to increased instrument sensitivity, the importance of reliable methods, a case study, and examples of why choosing the correct analyte list is essential. As detection limits in the laboratory are lowered, the frequency of detecting multiple chemicals increases, as does the potential for false positives. The case study was a cautionary tale on the Santa Ana Watershed Project Authority (SAWPA) project in southern California, which involves a large number of wastewater dischargers to the Santa Ana River. The State Water Board and SAWPA established lists of compounds for water analysis, including emerging contaminants. However, several years of laboratory studies demonstrated a list of frequently detected compounds, many of which were not on the analyte lists. The take-home messages were that standard regulatory monitoring lists may miss the most effective monitoring indicators, and casting a wide net to determine the best indicators at a site is prudent.

Finally, **Pam John** of the Santa Clara Valley Water District presented *Fortifying a Diverse Water Supply Portfolio with Advanced Treated Water in Santa Clara County, California*, starting with a heartfelt account of why clean water is important to her and to us all. She explained the role her agency plays in providing clean and reliable water for Santa Clara County's inhabitants and the environment, and gave an excellent overview of the history of groundwater withdrawal and subsidence issues, which prompted the district to import water and develop a groundwater management strategy. Their water supply system is diverse, with recycled water playing an important role. The Silicon Valley Advanced Water Purification Center is the centerpiece of the district's goal to increase the potable reuse of recycled water. She discussed the technological aspects of the project, and the importance of getting the science right and properly engaging and educating the public to gain acceptance on recycled water reuse.

Groundwater Quality Monitoring Plans for Well Stimulation Treatment Pursuant to Senate Bill 4

Moderated by **Rob Gailey**, R.M. Gailey Consulting Hydrogeologist, this session entailed panel presentations and discussion among representatives from the interested constituencies (Regulatory perspective: the California Department of Oil, Gas, and Geothermal Resources [DOGGR] and the California State Water Resources Control

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Board [SWRCB]; Petroleum operator perspective: California Resources Corporation (CRC); Water supplier perspective: Rosedale-Rio Bravo Water Storage District [RRBWSD]; Environmental advocacy perspective: Frac Tracker Alliance [FTA]). **Marilu Habel**, Manager of DOGGR's Program Development Unit, summarized the regulation of oil and gas development in California, including the new regulations related to well stimulation treatment (including hydraulic fracturing). She also provided statistics related to recent well stimulation in California (i.e., numbers of applications and average volume of water used per project). **John Borkovich**, Chief of SWRCB's Groundwater Monitoring and Assessment Section, spoke about the current interim regulations for groundwater quality monitoring of well stimulation treatment operations and the monitoring criteria being developed for the final regulations to become effective July 1, 2015. **Mike Glavin**, Director of Environmental Services at CRC, spoke about current activities performed by the petroleum industry in California to protect the environment and comply with the new monitoring regulations. **Eric Averett**, General Manager of RRBWSD, spoke about the areas of spatial overlap between groundwater and oil production in the Kern County Groundwater Subbasin and the potential for coordinating monitoring of well stimulation treatment with other efforts (i.e., those related to the Irrigated Lands Regulatory Program). **Kyle Ferrar**, California State Coordinator for FTA, spoke about the need for groundwater quality monitoring of a wider range of petroleum operations, and the need for more transparency regarding important data (i.e., exempt aquifers; municipal supply-well locations, well logs and monitoring data). Discussion after the presentations focused on details of the current interim regulations and the recent draft of the final regulations. It was clear that there is more to come on this and related topics and attendees were encouraged to enroll in the GRA symposium on Oil, Gas and Groundwater scheduled for this coming February.

Climate Variability and Change – Simulation of Effects & Adaptation Strategies

Moderated by **Scott D. Warner**, Principal Hydrogeologist with ENVIRON, the session began with a presentation from **John Coleman**, President of the Association of California Water Agencies (ACWA), who discussed *Water Resource Adaptation Strategies Considering Long-Term Climate Change: An Agency Perspective*. John was a longtime Board member (including former President) of the East Bay Municipal Utilities District and currently is the Executive Director of the Bay Planning Coalition. His presentation focused on the anticipated effects of climate change on the security, reliability, and sustainability of California's water resources; the role that California's water agencies have in developing and delivering a reliable supply for the state's economic and environmental security; and our challenges in managing the supply and delivery for the long term. The take-home messages focused on water-system investments, including: intensify local resources development, increase storage, fix the Delta, manage groundwater, and invest in habitat and watersheds for environmental and economic reasons.

Dr. Andrew Fisher of UC Santa Cruz presented a fascinating study titled *From Measurements to Models to Monetization: Climate Change, Reduced Infiltration, and Strategies for Recharging More Groundwater*. His presentation focused on discussing the following issues: how might past and future climate changes influence groundwater recharge; where can managed recharge be enhanced through capture of stormwater; and what incentives might encourage stormwater capture to become a program of managed recharge. With emphasis on the latter concept, his presentation used a study for the Pajaro Valley Groundwater Basin in coastal California as an example of how managing stormwater recharge under a program of managed aquifer recharge (MAR) can be highly suitable for improving long-term supplies, particularly when the MAR concept can be incentivized through monetization.

Dr. Abhishek Singh of INTERA presented *Assessing the Impact of Climate Change on Regional Water Resources*. He focused on defining demand and supply projections, and then developing robust water resources planning programs by quantifying the uncertainties in the planning process, including influence from climatic variability and change. Dr. Singh used a case study for Albuquerque, New Mexico to demonstrate how using large-scale dynamic models can help identify crucial planning issues by testing long-range scenarios and quantifying the likelihood of occurrence; this process helps to evaluate risk and vulnerability associated with water resource reliability.

Dr. Kwabena Asanti of GEI Consultants completed the session with a presentation on *Preparing Local Groundwater Systems for Climate Variability and Change*. He used the study of the Lompoc, California water system as an example of how climate change planning should be infused into long-term infrastructure planning with respect to water supply and demand. By focusing on historical changes in both demand and flux, a local agency can develop a successful planning approach. A major take-home message from this presentation was the recommendation that water agencies and municipalities charged with delivering a reliable supply should strongly implement a program that

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evaluates historical demand information, climate change predictions, and infrastructure vulnerability. Specific emphasis on developing a projects database and entering this into an adaptation plan is crucial for smaller local agencies as well as regional systems.

Regional Management of Groundwater Quality

Moderated by Vicki Kretsinger Grabert, Luhdorff and Scalmanini Consulting Engineers

Miranda Fram, Chief of the USGS team for the State Water Board's Groundwater Ambient Monitoring and Assessment Program (GAMA) Priority Basin Project (GAMA-PBP) gave an overview of the GAMA-PBP Phase 2, which focuses on the assessment of shallow groundwater. Thus far, Phase 2 has included sampling of over 300 private domestic and small-system wells in three high-priority areas: the Napa-Sonoma Valleys and surrounding uplands areas; the Monterey-Salinas Valleys and surrounding uplands areas; and the Kings, Madera, and Chowchilla subbasins of the San Joaquin Valley. Sampling for the fourth study unit—the Kaweah, Tule, and Tulare Lake subbasins of the San Joaquin Valley and adjacent uplands area in the Sierra Nevada—will begin in November 2014. The study areas (or units) were prioritized based on the number and density of households using domestic wells. Over a ten-year period, the assessment will cover 90% of the groundwater resources used by private domestic wells and small-system wells statewide.

Sandra Eberts, hydrogeologist and coordinator of the USGS National Water Quality Assessment Program, Groundwater Modeling and Mapping Team, presented research and activities related to the recent USGS Circular 1385, *Factors Affecting Public-Supply*

Sandra Eberts, USGS. Photo by Brian Lewis.

Well Vulnerability to Contamination: Understanding Observed Water Quality and Anticipating Future Water Quality, and other newly released tools and publications. She emphasized how groundwater vulnerability to contamination and public-supply-well vulnerability to contamination are not the same. Groundwater vulnerability is not uniform throughout an aquifer and wells "sample" only part of an aquifer. It is important to recognize that the vulnerability and water quality of every well is unique because of the numerous factors that contribute to the water quality observed in the produced water. She noted that aquifer-wide vulnerability assessments based on data from wells constructed in one or more parts of the aquifer system may identify differences in the vulnerability of the used part of the resource, but may miss differences in the vulnerability of the aquifer to contaminant fluxes across the water table.

Ken Manning, Executive Director of the San Gabriel Water Quality Authority (WQA), provided highlights of the progress achieved over the past 24 years on the Nation's largest Superfund site for the remediation of contaminated groundwater, which was first detected in 1979. Following administration of cleanup through a Joint Powers Authority, the WQA was created by the state legislature in 1993. He described the way the WQA provided the funding and administrative mechanism necessary to coordinate and manage cleanup of the critical groundwater contamination in the San Gabriel Valley while preventing local ratepayers from being saddled with the financial burden. He also reported the good news and not so good news. As of June 2014, about 1.3 million acre-feet of contaminated water has been treated and over 73 tons of waste removed; however, the estimated total cost is $1.4 billion and cleanup is ongoing.

Till Angermann, hydrogeologist at Luhdorff and Scalmanini Consulting Engineers, provided perspectives related to the review of agricultural orders under the Dairy Program and the Irrigated Lands Regulatory Program. He illustrated how higher irrigation efficiencies and better nutrient management, while reducing subsurface mass emissions, lead to higher salt concentrations and potentially non-unique nitrate concentration responses in deep percolating soil water and at the water table. He concluded that farming practice evaluation and regulatory enforcement of salt and nitrogen mass emission based on groundwater concentrations is technically questionable. He advocated for an accelerated effort to define and verify crop-specific application/removal (A/R) ratios to support on-farm nutrient management and, ultimately, enforcement. He emphasized the importance of comprehensive education and training programs, including certification of key on-farm personnel and professionals advising producers on irrigation and nutrient management. His perspective on these issues reflects that of the Agricultural Expert Panel (of which he is a member), which was convened by the State Water Resources Control Board in the context of SBX2 1.

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Site Assessment and Remediation

This session was moderated by **Emily Vavricka**, with EEC Environmental. **John Karachewski** of the Department of Toxic Substances Control, opened the session with a presentation entitled *A Regional Approach to Prioritizing Cleanup Sites – An Improved Methodology for Evaluating Groundwater Contamination in California*. He provided an overview of DTSC's efforts to evaluate impacts to groundwater and public supply wells throughout California by using a Spatial Prioritization Geographic Information tool. This tool will allow DTSC to identify and prioritize sites that are impacting groundwater, and to better collaborate and communicate with other agencies. He also provided several case studies of groundwater basins where this tool is being implemented.

Shahla Farhat of GSI Environmental, Inc., described the importance of understanding matrix diffusion in the subsurface at contaminated sites. She presented three analytical matrix diffusion models and went through the pros and cons of each. She then described the Matrix Diffusion Tool Kit, which guides the use of these models for providing estimates of mass discharge, mass contamination and concentration in low-permeability zones such as silt and clay layers. The tool kit can help answer questions regarding the potential effectiveness of remediation in low-permeability zones.

Uta Hellmann-Blumberg of the San Francisco Bay Regional Water Quality Control Board presented an overview of Trichloroethene (TCE) vapor intrusion and short-term toxicity, and the recent issues regarding indoor air exposure. She discussed the adverse health effects of TCE, short-term versus long-term toxicity, the developmental effects and methods used to mitigate

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Jay Famiglietti – GRA 2014 Southern California David Keith Todd Lecturer

Dr. Jay Famiglietti, Professor at U.C. Irvine and Senior Water Scientist at the NASA Jet Propulsion Laboratory (JPL), gave an entertaining but sobering presentation entitled "How the West was Lost." The assessment of California's epic drought chronicled the increasing severity of water shortage in this state, and its socioeconomic implications for a west that boomed when a surplus of water was first harnessed in the arid land.

Key points of the lecture:

1. In the western United States, we use far more water than is renewable by natural precipitation and snowmelt. Our rivers and reservoirs have become insufficient sources.
2. Groundwater is critical in supplementing surface water resources. For example, under recent severe drought conditions, over-allocation of the Colorado River Basin by as much as 30% left groundwater filling the gap between supply and demand.
3. If we continue to rely on groundwater as a strategic reserve, then we must embark on strategic management, before aquifers drop to irrecoverable levels.

In detailing the current status, Famiglietti described his work using NASA's Gravity Recovery and Climate Experiment (GRACE) to track freshwater availability. With tandem satellites working like a scale, his research team measures local fluctuations in Earth's gravitational force due to the perched mass

Lisa O'Boyle, Chair of GRA's Education Committee, conveys GRA's appreciation to Jay Famiglietti, NASA, JPL, for his role as the 2014 David Keith Todd Distinguished Lecturer for southern California. Photo by Brian Lewis.

of snow pack and groundwater. These fluctuations cause a deflection in the satellites' path, allowing the team to model the magnitude of water stores with startling accuracy. The audience was granted a view of the control room that directs this satellite mission. The peek at NASA's JPL was as Hollywood might imagine, with glowing LCD screens and illuminated maps clustered throughout the busy room. The data emerging from this project tracks changes in freshwater availability and groundwater depletion around the globe.

The groundwater shortage is compounded in the long-range forecast. Projections indicate that weather severity will increase in coming decades, through more frequent severe droughts, and through rainfall events clustered with

Jay Famiglietti continued on the following page…

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Eta Hellmann-Blumberg, SF Bay Regional Water Quality Control Board. Photo by Brian Lewis.

vapor intrusion. She then described how TCE vapor intrusion is being addressed at contaminated groundwater sites given the new guidelines issued by EPA, which recommend new TCE interim short-term indoor air response action levels (RALS) and indoor air screening levels for TCE.

Challenges in Local Groundwater Management

Moderated by **Jim Strandberg** of West Yost Associates, this session comprised four panelists who provided their perspectives on three questions: (1) what are your top one or two challenges in local groundwater management; (2) how will the Sustainable Groundwater Management Act help you, near-term and long-term; and (3) what are key challenges you foresee to comply with the Act?

Walter Ward, Stanislaus County Department of Environmental Resources – *Governance*: counties have a broader perspective then traditionally more narrowly-focused water agencies/districts and cities, enabling broad-based trust building with various stakeholders, yet lack the infrastructure of those agencies and cities; there are potential benefits of coordinating with other counties. *Technical*: counties may overlie multiple basins; needs exist for data collection standards, a comprehensive database with much-improved access, development of ordinances to restrict export and prevent "mining," and improved understanding of surface water-groundwater interaction.

Scott Matyac, Yuba County Water Agency – *Governance*: close relationship with county is beneficial, clear roles and responsibilities are important, there is a general concern that development of GSAs may upset stable situations, transition of agricultural to municipal and industrial water use is ongoing, and increased coordination with land-use decisions is needed.

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Jay Famiglietti – *Continued*

greater intensity, causing inefficient recharge of our reserves. Although this trend is undeniable, Famiglietti cautioned that charted trends are inherently obsolete, as plotted data points represent the past and not the ongoing progression. In plain English: We should assume things are getting even worse, and plan accordingly.

Although focusing on California's Central Valley, Famiglietti also described his work on the Colorado River Basin, which attracted widespread media and congressional attention. For context, Famiglietti also mentioned India and the Middle East as hot spots for water stress and groundwater depletion.

The outlook was not entirely pessimistic. Famiglietti underscored the importance of immediate action while there is opportunity for course correction. On the heels of the recent water bill, he underscored the importance of aggressive strategic management and a regulatory framework that jointly manages surface and groundwater resources as 'one water.' Otherwise, he cautioned, groundwater levels will continue to fall, basin managers will be challenged to meet future allocation commitments, and the water security of the western U.S. will be jeopardized. The speaker was earnest about conveying his message, directing the audience to his many available recorded presentations and articles on the Internet. These include:

- "Last Call at the Oasis," a documentary on the impacts of global water shortage featuring Famiglietti, available from several video streaming services;
- Articles "Can We End the Global Water Crisis?" and "How the West was Lost," both published on National Geographic's Water Currents website; and
- His recent appearance on 60 Minutes.

Dr. Famiglietti balanced his lectureship with competing obligations, as the severity of this year's drought led to presentation of his research before state legislators, congressional committees, water agencies, and the news media. The conference talk included such footage, showing the powerful delivery to general audiences of Famiglietti's complex technical message. GRA extends our heartfelt thanks to Jay Famiglietti for his contributions as the Southern California David Keith Todd Lecturer for 2014.

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Funding: availability of funds to prepare and implement GSPs is an issue. *Technical*: challenges include defining sustainable yield, proving actions are not creating undesirable effects, and quantifying surface water-groundwater interaction.

J. Paul Hendrix, Tulare Irrigation District – *Governance*: adjudicated basins in southern CA can provide lessons learned, and challenges include curbing total groundwater use, and addressing concern for GSA's enforcement of individual pumping restrictions. *Technical*: surface water supplies – which have been declining due to environmental reallocations – are insufficient to recover from decades-long overdraft;

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Carl Hauge – GRA 2014 Northern California David Keith Todd Lecturer

Carl Hauge, retired Chief Hydrogeologist for DWR, gives his final presentation as GRA's 2014 David Keith Todd Distinguished Lecturer for northern California. Photo by Brian Lewis.

The second day of the conference, Carl Hauge, retired Chief Hydrogeologist for the California Department of Water Resources and GRA's 2001 Lifetime Achievement Award recipient, gave a provocative talk on No Surface Water = No Groundwater. Carl began with retrospective and hearty congratulations to California. In 1913, the Legislature adopted the Water Commission Act that required permits for non-riparian diversion of surface water, yet excluded groundwater; this went into effect in 1914. He emphasized that 100 years have gone by with groundwater treated as a commons; everyone uses it, no one manages it. During 2014, the Year of Groundwater, the Legislature amended the Water Code to require 'sustainable' groundwater management. Carl punctuated this accomplishment with a big "WOW!!!" He went through many slides that outline the requirements of the new Sustainable Groundwater Management Act, including terms and definitions that are not new. With intentional irony, Carl pointed to several insights attributed to DWR's Bulletin 3, published in 1957, that are still true today:

- The hydrogeologic characteristics of many basins are unknown
- Data should be collected over the long term on the annual amount of recharge, extraction and change in groundwater storage in each basin
- It will invariably take a considerable period of time and substantial expense to obtain the data necessary to determine the safe yield of a groundwater basin with reasonable accuracy
- Without these data, the basin cannot be operated properly.

Carl commented that the Act can bring about significant change to rectify the 100 years of our history without effective groundwater management. Assemblyman Dickinson, Senator Pavley and Governor Brown deserve a lot of credit. Implementation of the Act will require a lot of work by a lot of people, including local and regional entities that collaborate to become Groundwater Sustainability Agencies (GSAs); DWR and State Water Board staff; landowners who also serve as board members for local entities; groundwater professionals; and others. He emphasized that the success of the Act will depend greatly on the attitudes of the people involved. And, whether it is through a GSA or adjudication, the same collection and evaluation of data will ultimately be required. Climate change effects will also require attention.

In conclusion, Carl stated, "The Sustainable Groundwater Management Act is a magnificent step forward for California. Let's hope that everyone hops on board to provide sustainable management of groundwater and surface water. And remember, no surface water = no groundwater."

Carl has devoted volunteer time and interest to GRA's endeavors since GRA's inception in 1992. As part of the David Keith Todd lecture tour, Carl greatly surpassed the number of requested lectures and graciously continued to offer his time to captivate mixed audiences from the lay public to groundwater professionals from all walks of the industry. GRA extends very special thanks to Carl Hauge for his contributions as the Northern California David Keith Todd Lecturer for 2014.

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long history of conjunctive use includes continuing efforts to increase recharge, yet also "losing" recharged water to heavy pumping; need to control overdraft and land subsidence. *State-wide planning and funding*: additional surface water is needed due to population growth and increased irrigated acreage; the cost of recharging groundwater is high; and need for more surface-water storage facilities to balance surplus water in northern CA and large demands in southern CA.

Peter Kavounas, Chino Basin Watermaster – *Governance*: Chino is an adjudicated basin with complex management structure focusing on optimum basin management; and decision-making authority of GSA stakeholder representatives may be highly variable. *Technical*: the resource is finite, yet population growth continues to increase; competition for groundwater is an issue within medium- and high-priority basins; water quality is not addressed to the extent of groundwater quantity, and contamination occurs from industrial and agricultural activities. *Funding*: is of less concern than finite availability of groundwater resources.

Developing and Implementing Groundwater Management Plans to Preserve Local Control

The conference wrapped up with a panel facilitated by **Matt Zidar**, GEI Consultants, which provided different perspectives on why the 'new model' of groundwater management is necessary, critical elements for success, and potential pitfalls and constraints. **Paula Landis**, Chief of the IRWM program for DWR, presented a statewide perspective, indicating that the legislation was needed because prior groundwater management plans were not being fully implemented and funded at the local level. She also noted that the state and local agencies need to be proactive and engage now to be successful; she identified the aggressive timelines for both the state and local agencies as a challenge. **David Guy**, President, Northern California Water Association, provided a regional perspective, supporting the Governor's use of "subsidiarity," (the concept of getting government and management to the lowest level possible), indicating the first step to success is deciding on the GSA and governance structures. Locals will need to pay attention to pending DWR guidelines and regulations; he noted that the Sacramento Valley is generally in good shape from the supply and quality standpoints, and that the region has learned how to work together. The counties and water districts are more active than other areas. **Mark Larsen**, General Manager, Kaweah Delta WCD, stated that one key to success was to get the legislature to dip into the general fund and commit resources so locals and the state can get moving. In his area, challenges will be to get the GSA and 'cooperative' agreements together; he noted that this is the first foray into demand-side management to achieve sustainability. Defining reliable surface-water sources is a key to success. Other success factors include facilitation to resolve conflicts, public education, stable funding, getting landowners engaged and promoting flexibility by all parties. Challenges include getting data together, limitations on local funding, potential law suits on funding and water allocations, land inspection/access, allotments of water in lieu of an adjudicated right, and local fears and territoriality. Mark noted that counties need to be involved, but are not experienced water managers. **Eric Oppenheimer**, State Water Resources Control Board program manager, noted that the state does not want to intervene so long as locals are doing the job, but would be a "backstop" to "temporarily and surgically intervene," sending control back to locals as soon as practicable.

Land Subsidence Déjà vu All Over Again

Technical Challenges and Financial Impacts

By Carl Hauge, James Borchers, Vicki Kretsinger Grabert, Steven Phillips, and Sarah Raker

Over 90 persons attended GRA's **2014 Land Subsidence Symposium** titled ***Déjà Vu All Over Again: Technical Challenges and Financial Impacts***, chaired by **Sarah Raker** of AMEC Environment & Infrastructure, Inc. Speakers and panelists provided information on the mechanics of subsidence from groundwater extraction, the damage subsidence causes, monitoring and analysis methods and results, and historical and current subsidence management efforts. The Symposium took place September 9, 2014, at the University of California at Davis Conference Center.

The high points of the presentations were:

- Land subsidence caused by groundwater extraction is a quintessential example of a *Tragedy of the Commons*, whereby individuals acting rationally in their self-interest deplete a shared resource despite the long-term consequences to all
- Damage from subsidence caused by groundwater extraction has cost California billions of dollars
- Several land subsidence processes may be active at the same time; it is therefore important to understand the potential contributions of processes other than groundwater extraction
- The rates of subsidence caused by groundwater extraction depend in part on the geologic setting and the geologic materials
- Subsidence can cause earth fissures, or cracks, near the margins of subsiding areas; these fissures can cause severe damage to structures
- How subsidence occurs – at any point in the subsurface, the weight of materials and water above that point is supported by the underlying grain-to-grain structure (aquifer matrix) and water pressure in the pore spaces between grains; as pore pressure decreases from groundwater pumping, the stress on the aquifer matrix increases, and the matrix compacts
- Permanent (inelastic) compaction of clays (the usual suspect) occurs when pore pressure is lowered below historic levels, and can continue long after pumping stops; the duration is dependent on the rate at which clay units drain—thicker units drain slowest, but will continue to drain, and compact, as pore pressure decreases and grain-to-grain stress increases within the clay units to support the overlying sediments
- Long-term monitoring of subsidence, groundwater extraction, and groundwater recharge is extremely important
- The use of multiple methods for monitoring compaction and subsidence is also important
- Maintenance of extensometers built by the U.S. Bureau of Reclamation and the U.S. Geological Survey in the 1950s and 1960s was discontinued because of funding cuts in those agencies and the California Department of Water Resources; some extensometers are now being rehabilitated
- Interferometric Synthetic Aperture Radar (InSAR) provides satellite imagery that detects sub-centimeter changes in the land surface at a high spatial resolution over large areas, making it an important tool for monitoring and analyzing subsidence
- Monitoring subsidence will cost money—unfortunately, some agency managers are not aware how important long-term monitoring is

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Land Subsidence, Déjà vu All Over Again – *Continued*

to understanding the relationship between subsidence and groundwater extraction, which differs spatially within aquifer systems

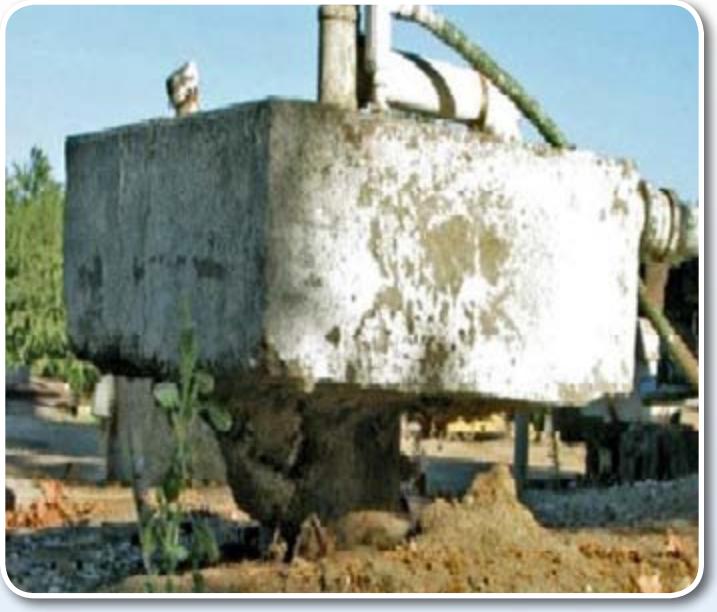
- Advances in modeling tools have enabled the simulation of historic land subsidence, the prediction of future subsidence, and the evaluation of subsidence management strategies; the accuracy of these simulations is highly dependent on the availability of water-level and subsidence data
- Successful studies of subsidence caused by groundwater extraction, and actions to reduce or prevent subsidence, require close coordination and cooperation between landowners and local, state, and federal agencies
- The solution to land subsidence is the informed management of groundwater extraction in conjunction with surface water and other water sources.

Following are summaries of the four topical sessions presented.

Subsidence Processes and Subsiding Areas

Moderated by **Steve Phillips** of the U.S. Geological Survey (USGS) the session began with a presentation on *Causes of Subsidence in California*, by **Jim Borchers**, consulting hydrogeologist. Using incredible photographs, some showing damaged structures, he described a variety of processes that cause land subsidence, including hydrocompaction, oxidation of organic matter, hydrocarbon extraction, tectonics, and the mechanism most are familiar with—groundwater withdrawal. Although this symposium concentrated on the latter, Jim emphasized the need to consider other possible causes during any subsidence investigation.

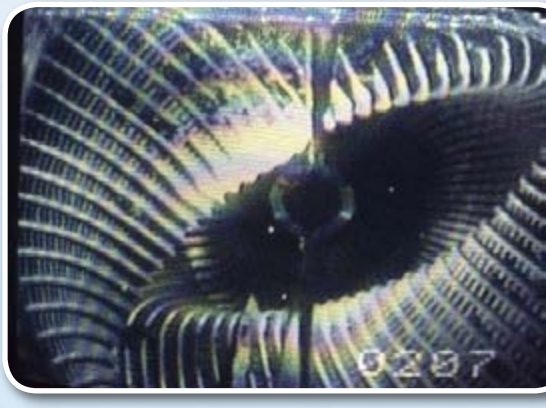
Larry Ernst of Wood Rodgers presented *Subsidence and Groundwater Extraction – The Role of Geology*. In addition to pointing out the importance of the presence and mineralogy of clays and the presence of diatoms, he shared a local case study that honed in on the probable cause for a north-south lenticular pattern of subsidence observations—damaged well casings and various measurements—in the Sacramento Valley northeast of Davis. Diatoms were found in a clay deposit within a syncline (a downward fold in geologic layers) that aligns with these observations.



Concrete well pad, and well, exposed by land subsidence; in this case, the well is intact.

Devin Galloway of the USGS discussed *Aquifer Mechanics*, covering the theory behind subsidence caused by groundwater extraction. He explained that at any point in the subsurface, the load of the water and materials above that point is supported by the underlying grain-to-grain structure (aquifer matrix) and water pressure in the pore spaces between grains. When pore pressure decreases from groundwater pumping, the stress on the aquifer matrix increases, and it compacts. If the pore pressure declines below its historic low, the compaction is inelastic, and subsidence occurs. The rate of subsidence is governed primarily by the thickness of the compacting fine-grained units. Thicker units drain slowly (decades to thousands of years), whereas thin units can drain much more quickly.

Tom Holzer of the USGS reviewed *Historical Subsidence* from groundwater



View is looking down a well in which the screen has deformed from compaction of the aquifer system.

extraction in California, a state with the dubious distinction of leading the nation in this category, with 5,200 mi^2 of affected area. Subsidence was first revealed in the US in 1919, in the Santa Clara Valley, though it wasn't truly recognized until the early 1930s. Soon after, it was measured in the San Joaquin Valley. Subsidence was largely abated in these areas with importation of surface water, but many basins in southern California experienced subsidence that is still poorly documented. The approximate cost of historical land subsidence in California may exceed $2B.

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Land Subsidence, Déjà vu All Over Again – *Continued*

Concrete sidewall of the Delta-Mendota Canal, buckled from subsidence.

Michelle Sneed of the USGS gave an overview of *Current Subsidence in the Madera–El Nido Region*, parts of which have subsided at rates approaching 1 foot per year since 2008 along the primary flood-control channel east of the San Joaquin River. The overall area affected by subsidence, measured using Interferometric Synthetic Aperture Radar (InSAR), includes the Delta-Mendota Canal, which has lost delivery capacity as a result. Her analysis of water-level, restored-extensometer, GPS (surveys and continuous), and leveling data, and field observations, show a clear cause-and-effect relationship between water-level declines, subsidence, and infrastructure damages.

Tom Farr of the Jet Propulsion Laboratory, NASA, continued on the theme of current subsidence, focusing primarily on the *Corcoran–Tulare Region*. Also using InSAR results, Tom showed the high rates of subsidence, exceeding 1 ft/yr in places, in this large area in the southern Central Valley. Continuous-GPS data agree with the InSAR results and water-level data show rapid declines that correlate well with measured subsidence. He showed an animation of the developing subsidence bowl, which has proved effective in conveying the issue to laymen and scientists alike.

Effects of Subsidence on Water Infrastructure

This 6-person panel presented information on subsidence effects and remediation costs in the San Joaquin Valley from the perspective of federal and state agencies, and water districts. **Jim Borchers**, consulting hydrogeologist and panel moderator, summarized subsidence impacts – increased extent and depth of flooding; submergence of check dams; loss of canal freeboard and capacity; upstream erosion and sediment deposition in subsided reaches of canals and streams; damaged wells, irrigation pipe networks, and storm sewers; and development of fissures that can destroy surface and subsurface infrastructure and provide pathways for surface contaminants to reach aquifers.

Boon Lek of CA Department of Water Resources, described 1-D hydraulic modeling to predict the loss of freeboard and flow capacity for the Eastside and Chowchilla flood-control Bypasses, and 2-D hydraulic modeling at 25 locations to delineate potential flood inundation areas. Subsidence is expected to decrease by more than 50 percent the flood conveyance capacity of the Bypass. If the Chowchilla Bypass is breached during a flood, an area 1–3 miles wide and about 25 miles long could be inundated to a depth of as much as 30 feet.

Chase Hurley of San Luis Canal Company (SLCC) described subsidence issues affecting their water delivery infrastructure as a result of pumping from deep aquifers in areas outside of water districts where orchards and vineyards have recently replaced rangeland and row crops. Subsidence of about 0.5 ft/yr at the San Joaquin River near Sack Dam during 2008–2011, and an additional 1.05 feet since December 2011, has reduced the flow capacity of the Arroyo Canal; mangers anticipate that continued subsidence will necessitate pumping stations on this gravity-flow system. Water districts and associated farmers have absorbed the costs of subsidence damages and for evaluating management options for out-of-district farms.

Chris White of Central California Irrigation District (CCID), explained that subsidence has caused a reduction of about 20% in conveyance capacity of CCID and SLCC canals. The initial phase of subsidence remediation has cost CCID $4.5M; an additional $2.5M is required for replacement of a partly

Jim Borchers, consulting hydrogeologist, opens a panel discussion on subsidence effects. Photo by Tim Parker.

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Land Subsidence, Déjà vu All Over Again – *Continued*

submerged bridge. Despite spending $30M through 1977 and an unspecified amount since then on subsidence remediation, the San Luis Delta Mendota Water Authority (SLDMWA) has had to run high-velocity flows through the Delta Mendota Canal, wetting the area above the previously-raised concrete canal liner, near the top of earthen berms, in a reach where subsidence of as much as 10 feet has reduced flow capacity. Reduced allocations of surface water (20% of that in 2013; 0% in 2014) resulted in increased groundwater pumping in the SLDMWA service area. To reduce subsidence near the canal, the Authority no longer permits pump-ins (inflows to the canal from wells for sale of groundwater.

Alicia Forsythe of the San Joaquin River Restoration Program, U.S. Bureau of Reclamation (Reclamation), described elevation surveys by Reclamation and DWR in the SJRRP area that show maximum subsidence rates of 0.9 ft/yr, and subsidence at Sack Dam of 3.2 feet since 2008. The initial budget for the SJRRP was $800 million. Subsidence from groundwater extraction is expected to add about $90 million to the project, which is designed to account for current subsidence rates over 25 years. These costs are pending final design of a taller-than-planned replacement of Sack Dam. Reclamation is working with stakeholders to devise solutions to subsidence issues, but is unable to request congressional funding for capital-intensive subsidence solutions outside of Reclamation's expense authority.

Matt Hurley of Angiola Water District (AWD), near Corcoran, CA, described the decrease in flow capacity and lack of freeboard in the district's primary canal. Prior to subsidence, surface water flowed by gravity from the hills east of the district to lands on the west. Subsidence from groundwater pumping caused the east-west part of the canal to tilt eastward, requiring construction of a pumping station to lift water 8 feet out of the subsided reach. A sag that developed in the north-south part of the canal necessitated a new, $1M pumping station to lift water 13 feet. Subsidence rates are not slowing in this area, through which the proposed high-speed rail line runs.

Vicki Kretsinger Grabert holds discussion with David Aladjem, attorney and Partner at Downey Brand. Photo by Tim Parker.

Subsidence Monitoring and Analysis

Moderated by **Vicki Kretsinger Grabert**, Luhdorff & Scalmanini, Consulting Engineers, this session highlighted the great importance of subsidence monitoring in conjunction with analysis of hydrogeologic information and the use of modeling tools. While various areas in California have been actively monitored periodically, there is a critical need to develop a coordinated statewide monitoring and reporting program for land subsidence.

Michelle Sneed of the USGS and 2015 Northern California David Keith Todd Lecturer, began the session with her talk on *Monitoring Methods and Data Analysis*. Although a variety of monitoring and data analysis methods are available for measuring and understanding the processes and consequences of land subsidence, gradual and widespread subsidence has often gone undetected for decades. In recent years, special subsidence-related studies by the USGS, DWR, and others have revealed surprising findings. Michelle described the monitoring methods available and associated pros and cons. Hands down, InSAR is a superior tool for regional applications – Michelle exclaimed, "This is the greatest thing ever in subsidence monitoring!" Extensometers and characterization of associated fine-grained units are critical for understanding the compaction process and depth-specific intervals responding to pumping stresses. The enhanced physical conceptualization provided by the integration of subsidence measurements (from InSAR, continuous GPS and other methods), compaction measurements and related analyses also improves hydrologic modeling tools used to assess future water management scenarios.

Tom Holzer of the USGS presented vivid descriptions of fissures, or ground failure associated with land subsidence. Fissures are uncommon in the large, commonly recognized areas of subsidence in California (e.g., in the San Joaquin and Santa Clara Valleys), but at least 5 such striking features occur in Southern California. They are commonly noticed after storms when runoff contributes to erosion that enlarges the fissure. He described fissure monitoring using high-precision techniques, including InSAR and Lidar. Fissure monitoring seeks to detect small vertical and horizontal deformation. Earth fissures associated with groundwater withdrawal may pose an ongoing hazard; once a fissure has formed, it continues to open as long as subsidence continues.

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Land Subsidence, Déjà vu All Over Again – *Continued*

Steven Phillips and **Claudia Faunt**, both with the USGS, co-presented the talk *Subsidence Simulation and Management*. They described various simulation tools, including the new OWHM (One Water Hydrologic Model) version of MODFLOW, which can be used to simulate linkages between climate change, conjunctive use and related hydrologic effects, such as land subsidence. Limitations of the tools were described, such as one-dimensional assumptions; challenges include nonlinear processes and three-dimensional stresses and strains. Recent advances in subsidence simulation capabilities include accounting for delayed drainage of fine-grained deposits, changing geostatic load, and deformation of the model mesh. The USGS Central Valley Hydrologic Model is being updated and includes code changes along with more accurate details relating to the timing of subsidence processes and the nature of the subsidence occurring. Importantly, the Central Valley aquifer system has on average only about 30% coarse-grained material; i.e., there are lots of fine-grained interbeds. Although many parts of the Central Valley aquifer system are characterized as being unconfined, that is often a misnomer; more areas are characteristic of semi-confined conditions. The hydrogeologic conceptualization represented in modeling tools is particularly important to the results of the water management scenarios and the evaluation of potential land subsidence.

Case Studies of Subsidence Management

Moderated by **Carl Hauge**, retired Chief Hydrogeologist of DWR, this session began with **Yaping Liu**'s description of subsidence management by Santa Clara Valley Water District, an urban district formed in 1929. It serves 2 million persons in 15 cities in an area stretching from Palo Alto and Milpitas in the north to Gilroy in the south. The area includes 4700 well owners and 13 water retailers. Heavy reliance on groundwater caused 13 feet of subsidence in San Jose and associated damages of $750 million (1960 dollars). Subsidence was halted in 1969 as a result of managed recharge programs and imported surface water. Groundwater pumping and recharge have decreased through 2014 while surface-water imports, conservation and use of recycled water have increased. The drought, decreased managed recharge, fewer imports and increased pumping have increased the risk of subsidence.

Chris White, Manager of Central California Irrigation District, discussed subsidence that is affecting his district. In 2012, Reclamation notified CCID about subsidence in western Madera and Merced counties. Surveys show that the levees on the Eastside Bypass have subsided about 5 feet between 2008 and 2012. CCID, local landowners, and the two counties formed a group to identify the problem and develop possible solutions to stop or minimize subsidence. One estimate to build replacement wells in the shallow aquifer and turnouts for supplemental surface water and recharge facilities totals $3.6 million dollars. Local, state and federal agencies have all been involved.

Brian Conway of Arizona Department of Water Resources discussed their subsidence program. AZDWR operates an extensive program to map land subsidence and fissures throughout the state. Interferometric Synthethic Aperture Radar (InSAR) is the mapping tool. All of the InSAR data, and well logs, well construction data, groundwater extraction records, and recharge data are available to the public on the AZDWR web site. The Arizona Geological Survey publishes maps of fissures in the state, which are available on their website. So far, 153 miles of fissures have been mapped.

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Land Subsidence, Déjà vu All Over Again – *Continued*

Framework for Subsidence Monitoring in California

Moderated by **Carl Hauge**, this panel session began with **Brian Conway**, who said that groundwater levels, groundwater pumping data, well logs, subsidence data and earth fissure data should be freely accessible to the public and should be updated frequently. The areas where subsidence is occurring should be identified and the InSAR, GPS, leveling data and extensometer data should be locatable and easily available. In Arizona, InSAR has identified areas where uplift is occurring as a result of groundwater recharge. Local, state, and federal agencies and businesses involved should coordinate closely. A stable source of funding should be available.

Michelle Sneed, U.S. Geological Survey, listed the data needed for analysis of subsidence, starting with the amount of compaction, amount of land subsidence, groundwater levels, and the geology of the aquifer system—composition, layering and structure. Spatial measurements repeated over time can provide the location and rates of subsidence and the changes, if any, in rates of compaction between the high pumping season and the winter, when pumping is reduced. InSAR temporal and spatial data, and spirit and GPS leveling data (temporal), are all important components.

Steven P. Stadler, P.E., Deputy General Manager for Water Resources, Kings River Conservation District, discussed the framework for subsidence monitoring in the Kings subbasin. KRCD coordinates with many local agencies within its boundaries. The District is considering extensometers, satellite data and a GPS-surveyed grid to collect data on subsidence. They have 106 monitoring points in the grid that were surveyed between 2010 and 2013, and are further developing their program.

The organizing committee for the symposium; from left to right, Steve Phillips, Sarah Raker (chair), Jim Borchers, Vicki Kretsinger Grabert, and Carl Hauge. Photo by Tim Parker.

David Aladjem, Esq., Downey Brand, LLP, outlined the legal aspects of land subsidence, including groundwater extraction. He called subsidence a "tragedy of the commons." Overlying rights are proportionate to the safe yield. Appropriative rights are available only if the basin has a surplus of groundwater. Neither overlying pumpers nor appropriators have a right to exceed the safe yield. Therefore, subsidence will not occur. In the past this has been violated, but starting in 2015 with the Sustainable Groundwater Management Act, theoretically such violations will not occur. The question he asked is "Are engineers better problem solvers than lawyers?"

Mary Scruggs, Department of Water Resources, discussed DWR's existing subsidence monitoring, recent subsidence work and ongoing and future efforts. DWR monitors 3 pipe extensometers installed in the 1990s and 8 cable extensometers installed in 2005, makes groundwater levels available on their website and monitors 339 monuments that were first surveyed in 2008 using GPS. DWR is developing a subsidence website and is working with NASA and JPL to use InSAR data.

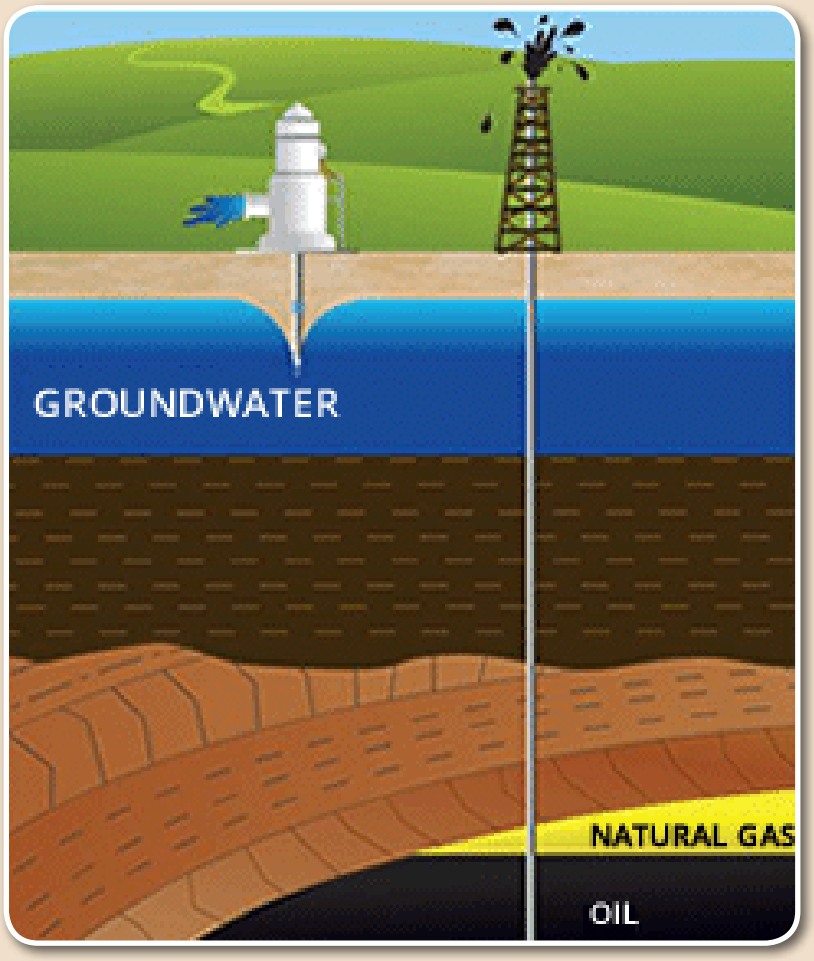
The overall conclusion of the symposium is that there is much work to be done to address subsidence caused by groundwater extraction and the damage it causes. The recurrence of land subsidence in California has focused attention on the importance of providing funds for programs that collect and evaluate data related to groundwater management. Those data needs include groundwater levels, extensometers, leveling, and InSAR spatial and temporal measurement. Land subsidence results in structural damage to buildings, and loss of channel capacity in canals, ditches, and flood control systems, resulting in significant costs. The change in stream gradients results in more local flooding potential. Data collection and evaluation will require funding. Some local water agencies are working with landowners to develop programs to mitigate subsidence. Until a balance is maintained between water supply and water use, subsidence will continue to be a problem.

GRAC and Los Angeles Basin Geological Society Present:

Oil, Gas and Groundwater in California: Wise Production and Protection of Our Valuable Natural Resources

FEBRUARY 18-19, 2015 – LONG BEACH, CA

Co-Sponsors: California Water Foundation, AECOM, Western Solutions



The "California Oil, Gas, and Groundwater" Symposium is intended to provide the latest information on current petroleum industry knowledge and practices as it relates to California groundwater, while separating fact from fiction, as described by recognized experts in the field. It is intended for petroleum and groundwater geologists, engineers, policy-makers, regulators, academia, and other interested parties to learn about current practices and operations, developing policies and regulations, proximity of hydrocarbon fields to groundwater resources, real versus perceived risks to groundwater, and the successes and challenges that create the context for the relationship between petroleum production and groundwater management in California.

Dates & Details

GRA EVENTS & KEY DATES

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

GRA Symposium
Oil, Gas & Groundwater Symposium
Feb. 18-19, 2015 | Long Beach, CA

Legislative Symposium
Apr. 29, 2015 | Sacramento, CA

For information on how to sponsor or exhibit at an upcoming event, please contact Sarah Kline at skline@grac.org.

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Wells and Words

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

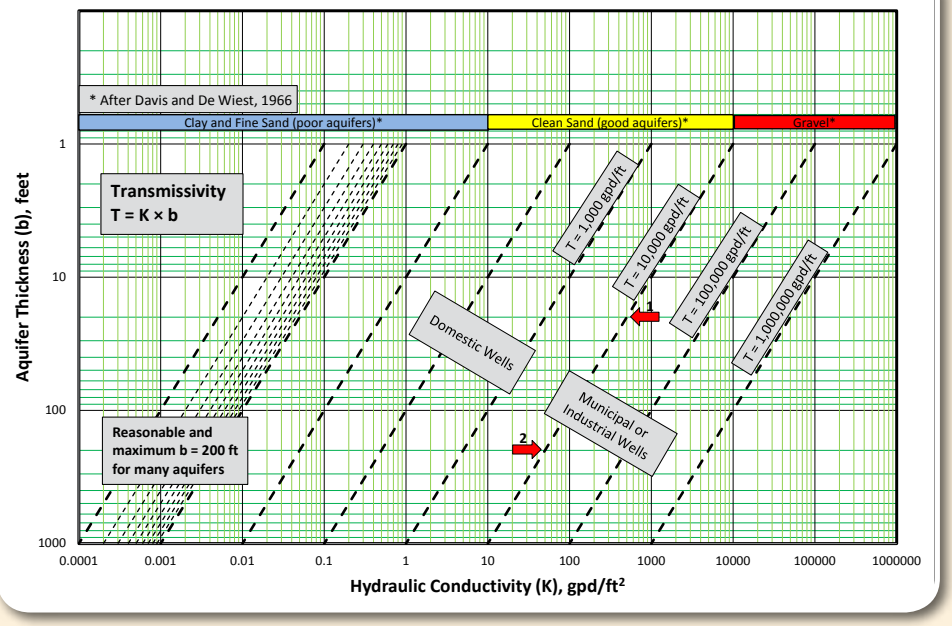
The Relationship between Transmissivity, Hydraulic Conductivity, and Aquifer Thickness

The transmissivity (T) of an aquifer is the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of aquifer under a unit hydraulic gradient[1,2]. In 1935, Theis introduced the term transmissivity (also called field permeability) to represent the transmission capability of the entire aquifer thickness[3]. A more fundamental property of the aquifer is the hydraulic conductivity (K), the quantity of water at a specific temperature that will flow through a unit cross-sectional area of a porous medium per unit time under a unit hydraulic gradient[3]. Derived as a proportionality constant by Darcy[4], K is, more simply, a measure of the resistance to movement of groundwater flowing through a porous medium[5].

The transmissivity is equal to the hydraulic conductivity times the aquifer thickness: T = K × b. T is expressed in either mixed units[3] of gallons per day per foot (gpd/ft) or with consistent units of feet squared per day (ft^2/d); similarly, K is expressed in gpd/ft^2 or ft/d, respectively. Many field personnel prefer mixed units because discharge during a pumping test is usually measured in mixed units of gallons per minute (gpm) rather than cubic feet per minute (ft^3/min)[6]. Both units are found in the literature and are acceptable, but be sure to review carefully the units used in a given equation. One cubic foot is 7.4805 gallons; dividing a given mixed unit (gpd/ft or gpd/ft^2) by 7.4805 will yield the value in consistent units, and conversely, multiplying the consistent unit (ft/d or ft^2/d) by 7.4805 will yield the value in mixed units.

Three general methods are used to estimate transmissivity[3] from field data. Most commonly, T is estimated from field experiments (i.e., pumping tests) using discharge and drawdown measurements, and various analytical methods. Pumping tests provide an estimate of T for the portion of aquifer stressed during the test; this T represents the integrated hydraulic properties and associated expectations of well and aquifer performance. T can be estimated using laboratory methods by measuring K with a permeameter[3] and then multiplying the lab-derived K by the estimated aquifer thickness (b). A third method for estimating T is to evaluate the grain size of aquifer materials[7] (i.e., mechanical sieve analysis and grain-size distributions), which can be used to estimate K; the resulting K-value can be multiplied by b to estimate T. Since pumping tests provide an estimate of T for a saturated thickness of aquifer, dividing the pumping test-derived T by that thickness will yield a bulk estimate of K for the aquifer[8].

Figure 1: Transmissivity, Hydraulic Conductivity, and Aquifer Thickness



The aquifer thickness can be estimated from downhole geophysical logs, geologist logs, geologic maps, or surface geophysics. Reasonable, useful, practical, and screenable aquifer dimensions usually range from 5 ft to a couple hundred feet thick. Some aquifers are stratified and composed of repeating geologic sequences where certain portions of the aquifer may be more permeable than others, and screened accordingly; the total length of the perforated zone is sometimes used as b rather than saturated thickness; both are usually reported, thus providing upper and lower limits. The vertical distance between the top and bottom of the screened interval is also sometimes used to represent b, depending upon the overall well design and geological situation.

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Wells and Words – *Continued*

Figure 1 is a graph of K (gpd/ft^2) on the x-axis and b (ft) on the y-axis; both axes are logarithmic. The resulting family of parallel diagonal lines represents various T-values (gpd/ft) that span at least seven orders of magnitude, from 0.01 to 1,000,000 gpd/ft. However, the lower end[3] of T-values for small domestic wells is usually >100 gpd/ft, or equivalent to well yields >3 gpm with about 50 ft of drawdown (dd). High-capacity municipal and industrial wells usually have T-values > 5,000 gpd/ft, which are equivalent to well yields >250 gpm using 100 ft of available dd[3,9]. Figure 1 also shows the range of expected geologic sediments[9,10] corresponding to the range in T- and K-values.

It follows that different combinations of K and b will produce identical transmissivities. For example: an aquifer with a T = 10,000 gpd/ft can be composed of a 20-ft thick clean sand aquifer that has a K of 500 gpd/ft^2 (Point 1 on Figure 1) or a 200-ft thick clean sand aquifer with a K of 50 gpd/ft^2 (Point 2); the former would be a very productive aquifer and the latter a marginal or low-yield aquifer. In other words, a thin aquifer (or smaller portions of a thicker aquifer) with a high K can produce the same amount of water as a thick aquifer with a small K.

Given the "right" hydraulic conditions, high-capacity efficient production wells have been designed with only 20–30 ft of screen and as little as 5 ft of screen. Many production wells are over-designed and over-screened to compensate for the lack of a full understanding of the vertical distribution of K within an aquifer system. The rationale of "more screen is better" may help to maximize the well yield, but can substantially increase the initial and long-term cost of the well because of well-development time and well-maintenance expenditures. The mantra: each foot of screen installed in a well must be thoroughly developed in order to deliver an efficient, relatively maintenance-free, and long-lasting production well. For example, spending one 10-hour day developing 25 ft of screen (24 minutes per foot [min/ft] of screen length) is probably more cost effective and productive than three 10-hour days developing a well with 200 ft of screen (9 min/ft of screen length). Knowing the vertical distribution of K is the best way to select the aquifer intervals to screen.

In addition, over-screened well designs may result in water quality impairments caused by groundwater contributions to the well from low-permeability zones (finer-grained sediments), where slow groundwater movement increases "contact" time for dissolution of minerals from the sediments.[11]

If K values are large enough at a site, then only small lengths of well screen are needed to produce a high-capacity and efficient well. For example, a well that is designed with 20 ft of screen in an aquifer with a T of 10,000 gpd/ft is *more efficiently designed* than a similar well with 200 ft of screen. In other words, the aquifer (K of 500 gpd/ft^2) tapped by the former well design is more prolific than the aquifer (K of 50 gpd/ft^2) tapped by the latter design. For the successful installation of a production well, maximum yields, and optimized water quality: be flexible on the design parameters, don't overdesign, do attempt to identify the more permeable strata, and minimize the screen lengths.

[1] Todd, David K., 1980, *Groundwater Hydrology* (second edition), John Wiley & Sons, New York, 535 pages.

[2] Lohman, S.W., 1972, *Ground-Water Hydraulics*, US Geological Survey Professional Paper 708, Washington, DC.

[3] Driscoll, Fletcher G (Editor), 1986, *Groundwater and Wells* (second edition), Johnson Division, St. Paul, MN, 1089 pages.

[4] Freeze, R. Allen and John A. Cherry, 1979, *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 604 pages.

[5] Poehls, D.J. and Gregory J. Smith (editors), 2009, *Encyclopedic Dictionary of Hydrogeology*, Academic Press and Elsevier, Amsterdam, The Netherlands, 517 pages.

[6] It should be noted that the USGS proposed abandoning mixed units (Lohman, 1972) but mixed units have persisted to be used in the groundwater industry.

[7] Vuković, Milan and Andjelko Soro, 1992, *Determination of Hydraulic Conductivity of Porous Media from Grain-Size Composition*, Water Resources Publications, Littleton, CO, 83 pages.

[8] The relative K-value between geological units and within an aquifer can also be evaluated with geophysical logs from the borehole.

[9] Davis, Stanley N. and Roger J.M. DeWiest, 1966, *Hydrogeology*, John Wiley & Sons, Inc., New York, 463 pages.

[10] US Department of Interior Bureau of Reclamation, 1995, *Ground Water Manual* (second edition), US Printing Office, Washington, DC, 661 pages.

[11] Abbott, David W., Fall 2009, Wells and Words, *HydroVisions*, a publication of the Groundwater Resources Association of California.

Legislative Update

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

GRA's Legislative Committee and Board of Directors had an exceptionally active year in the Capitol, tracking more than 60 bills. The Committee also hosted another highly successful Annual Legislative Symposium and Lobby Day, in partnership with the California Groundwater Coalition. Additionally, the Committee was very engaged with the water bond discussions that occurred in the Legislature and worked tirelessly to pass robust groundwater management legislation, making 2014 *The Year of Groundwater*.

Groundwater Sustainability Act

Beginning with the release of the California Water Action Plan in January of this year, the Administration made a clear commitment to improve groundwater management in California. A Groundwater Stakeholder group was assembled, and numerous meetings were held, in which GRA participated by providing written and oral feedback on the best way to achieve the Administration's goal of sustainable groundwater management. Through these meetings, GRA was very involved in crafting the language that was included in the three bills – AB 1739 (Dickinson), SB 1168 (Pavley) and SB 1319 (Pavley). GRA supported and lobbied for the passage of all three bills, known collectively as the Sustainable Groundwater Management Act. This included for the first time in GRA history a letter writing campaign, which resulted in support letters from 40 separate organizations, and over 90 groundwater professionals signing on to a GRA letter of support.

The three bills were passed before the Legislature adjourned for the year on August 29, and signed by Governor Brown on September 16, 2014. GRA was honored to be invited to the bill signing ceremony held in the Governor's office. Thomas Harter, Chris Peterson, Rosanna Carvacho and Tim Parker attended.

The Sustainable Groundwater Management Act (Act) requires the Department of Water Resources (DWR) to rank each of the basins or subbasins identified in Bulletin 118 as a very low-, low-, medium-, or high-priority basin based on the threat to the basin's integrity. Those designated as medium- or high-priority basins are required to designate a groundwater sustainability agency (agency) and adopt a groundwater sustainability plan (plan) within five to seven years. Adjudicated basins/subbasins are exempt, as they are managed under safe-yield criteria set and administered by the courts.

The Act requires that plans achieve sustainable groundwater management, as defined by the sustainable yield of the basin/subbasin, to avoid undesirable results, such as chronic depletion of groundwater, water quality degradation, or subsidence. Each plan must include requisite monitoring and management for the basin over a 50-year planning horizon, and plans must articulate measurable objectives to be achieved every five years. DWR will review the plans and will have the power to request changes to a submitted plan.

The Act also authorizes the designated agency to limit or curtail groundwater production, monitor groundwater withdrawals, track the location of wells, and assess regulatory fees to fund groundwater management and replenishment activities, among other powers. Agencies are not, however, authorized to issue or deny well-drilling permits, unless authorized by the county to do so.

If, within a medium- or high-priority basin, an agency has not been designated by January 1, 2017, or if a compliant plan is not prepared within designated time frames, the State Water Resources Control Board may intervene and adopt and enforce its own plan for the basin.

Additional issues are expected to be addressed in future legislation. If you have questions or concerns, please contact Tim Parker or Rosanna Carvacho.

Water Bond

After much debate, discussion and public comment, AB 1471 (Rendon) emerged as the bi-partisan water bond proposal that was passed by both houses and signed by Governor Brown in August. This bill placed on the November ballot a $7.545 billion bond measure, Proposition 1, to replace the $11.14 billion water bond that was passed by the Legislature in 2009.

If passed, Proposition 1 would authorize the issuance of $7.12 billion in new bond debt and repurpose $425 million of unissued bond revenue to be used as follows:

- $800 million for projects to prevent or clean up the contamination of groundwater that serves or has served as a source of drinking water
- $100 million for competitive grants to projects that develop and implement groundwater plans and projects, as required by the Groundwater Sustainability Act
- $2.7 billion for water storage projects, including groundwater storage projects and groundwater contamination prevention or remediation projects that provide water storage benefits
- $520 million for projects that improve water quality, including wastewater treatment projects and

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Legislative Update – *Continued*

public water system infrastructure improvements to meet safe drinking water standards, ensure affordable drinking water, or both

- $1.495 billion for multi-benefit ecosystem and watershed protection and restoration projects
- $810 million for projects that are included in and implemented in an adopted integrated regional water management plan
- $725 million for water recycling and advanced treatment technology projects
- $395 million for statewide flood management projects and activities.

The full text of the bond is available here.

GRA Supported/Opposed Legislation

AB 1739 (Dickinson), SB 1168 (Pavley) and SB 1319 (Pavley) – As discussed above, these three bills make up the Groundwater Sustainability Act. GRA supported all three bills that were signed by Governor Brown in September.

AB 2189 (Garcia) – Would have required the replenishment assessment now imposed by the Water Replenishment District of Southern California (WRD) to be based upon the proportion of the costs actually incurred by the operator of a groundwater well instead of the costs associated with replenishing and maintaining water quality in the groundwater basins. This bill also would have prohibited the WRD Board of Directors from imposing a replenishment assessment under a majority protest. GRA took an oppose position on this bill, which was held in the Assembly Appropriations Committee.

AB 2712 (Daly) – Would have prevented the Orange County Water District from implementing remediation projects to clean up groundwater contamination unless they went through a lengthy review and approval process, delaying cleanup efforts. GRA took an oppose position on this bill; however, with amendments taken in April, GRA removed opposition and was neutral on the bill.

Changes in the Legislature

On June 16, 2014, the Senate voted to elect Senator Kevin De León as President pro Tempore of the Senate, to replace Senator Steinberg, who terms out this year. Senator De León assumed the role of President pro Tempore on October 15th.

Senator Rodrick Wright announced his resignation from the Senate in September, triggering a special election for the 35th Senate District. Assemblymember Isadore Hall, III announced his candidacy for the Senate. The primary election is scheduled for December 9, 2014; if a runoff is required, that election will be held on February 10, 2015.

With the statewide general election in November, new Legislators will be elected to serve during the 2015–16 Legislative Session, which will convene on December 1, 2014. Committee Chair and membership changes are expected after the start of the new session.

Looking Ahead

As GRA expected, groundwater was a fundamental part of legislative discussions in Sacramento this year. Drastic and sweeping changes are on the horizon from the successful passage and enactment of the Sustainable Groundwater Management Act, effective January 1, 2015. Even though the bills have been passed and signed, the implementation process has only just begun. Additionally, after the November election, we will know if the voters approved the water bond which, if passed, will provide much needed funding for projects throughout the state.

Next year, with discussions already in process, the Administration has committed to work with the Legislature and industry to develop a process for streamlined adjudication. Additionally, there will be ministerial cleanup of the Act, and during this exercise we expect there will be attempts by some to weaken the current legislation. Finally, DWR has a tremendous amount of work to do over the next two years to meet the six mandates outlined in the Act. GRA will provide assistance and input to DWR as needed.

GRA will continue to be an important source of information and sound science for Legislators, the Administration, and their staff as the groundwater discussion continues, including the implementation process within state agencies and departments and any further legislation next year.

SAVE THE DATE
April 29, 2015

2015 Annual Legislative Symposium

Find out why the new groundwater legislation and water bond are important to you—and what's next!

The Federal Corner

By Jamie Marincola, U.S. EPA

40th Anniversary of the Safe Drinking Water Act

2014 marks the 40th anniversary of the Safe Drinking Water Act. The Act was passed to protect public health by regulating the nation's public drinking water supply. To mark the 40th anniversary, EPA has launched a webpage that includes an overview of the Act, a timeline of milestones since 1974, resources for K-12 educators, and more. Check out the site.

Klamath Mountains Groundwater Quality: Constituents Detected at High Levels are Less Prevalent than Statewide

Naturally occurring trace elements were detected at high concentrations in less than 3 percent of raw groundwater sources used for public water supply in the Klamath Mountain area, according to the ongoing USGS study of California groundwater quality. In comparison, high concentrations of trace elements have generally been found in 10 to 25 percent of the state's groundwater sources used for public supply. The naturally occurring trace elements that were detected at high concentrations in a small number of wells were arsenic, antimony, and boron. For more information, visit the site.

City of Santa Maria Receives Technical Assistance from the U.S. EPA for Green Infrastructure and Water Quality Planning

The EPA is providing $67,000 in technical assistance to the City of Santa Maria, CA, to help fund water and stormwater management. The City will use the funding to prioritize its investment and green infrastructure decisions for environmental and public health benefits, while reducing costs to residents and mapping a long-term funding strategy. EPA is providing similar assistance to four other communities nationwide to support integrated planning for municipal water, wastewater and stormwater management. More information on integrated planning is available here.

Nuclear Energy Agency Releases Report on Nuclear Site Remediation and Restoration during Decommissioning of Nuclear Installations

Decommissioning of nuclear facilities and related remedial actions enable sites or parts of sites to be reused for other purposes. Although remediation is generally considered as the last step in a sequence of decommissioning steps, the values of prevention, long-term planning and parallel remediation are gaining recognition. The Task Group on Nuclear Site Restoration of the Nuclear Energy Agency released a report highlighting lessons learned from remediation experiences of NEA member countries that may be particularly helpful to practitioners of nuclear site remediation, regulators and site operators. The report provides observations and recommendations to consider in the development of strategies and plans for efficient nuclear site remediation that ensures protection of workers and the environment. View or download here.

USGS's Landsat Shows Fifty Percent Decrease in Shasta Lake Water Levels Since 2011

As a 3-year drought continues in the western United States, water levels have been dropping in many California reservoirs, leading to emergency water use restrictions across the state. At Shasta Lake, reservoir levels have dropped from 77 percent of total capacity in September 2011 to 27 percent capacity in September 2014. To compare stunning images of the lake, click here.

Major Findings from USGS Mercury in Stream Ecosystem Studies

Mercury contamination is widespread. Mercury was detected in all fish sampled from 291 streams across the U.S. Concentrations in about a quarter of the fish sampled exceeded the criterion for the protection of humans who consume average amounts of fish, established by the U.S. EPA. Most rivers and streams across the U.S. receive mercury predominantly via atmospheric deposition; however, elevated mercury levels in fish also are found in streams of the western U.S. that are affected by mining of mercury or gold. Wetlands, forests, and organic-rich soils can enhance the conversion of mercury to methylmercury, a toxic form that is readily available for uptake by aquatic organisms, and biomagnifies to high concentrations in fish. To learn more visit the site.

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.

Blunders

By Bart Simmons

As discussed in an earlier column, there are four sources of error in any measurement:

1) Systematic error (measured as lack of accuracy)
2) Random error (measured by standard deviation or relative per cent difference)
3) Blunders
4) Fraud.

Following are some examples of past blunders.

A consultant collected stormwater samples from a metal recycling yard and submitted them to an accredited lab. The lab reported a pH of 2.3 for one stormwater sample. The lab report was accepted as evidence in a hearing on Revocation of Probation. On further review, it was determined that the sample with low pH had been preserved with nitric acid for metals testing, and mistakenly used for pH testing.

A Superfund contract lab reported results for wells near the Stringfellow Site, along with results for local private wells. The results showed the same pattern of contamination in the local private wells as in the monitoring wells. The lab method blanks showed no contamination. Upon review of the results for a blind field blank, the same pattern of contamination existed as in the private well samples. The samples had been collected by a contractor and sent to an EPA Contract Lab Program (CLP) laboratory with a request to use a protocol for low-level contamination. As a result, the high levels of metals in a monitoring well sample seriously contaminated the ICP, resulting in fallacious reports for the subsequent samples (including the blind field blank).

A commercial lab tested a drinking-water sample from a school for TCE. The lab Director called the school official and relayed positive results for TCE. After hanging up, the lab director realized that TCE was, in fact, not detected. However, the school official had already taken action, including indefinite monitoring of the drinking water for the school.

A government lab reported PCBs in soil samples from a proposed Emeryville development. A commercial lab reported no PCBs in their split samples. The government lab reviewed its procedures and found that the PCBs were actually in a plastic cover sheet for a thin-layer chromatography plate used in a clean-up step.

A sample of groundwater from a well near a major weapons field laboratory was reported to contain 50 µg/L perchlorate. The sampling included the use of a spiked field sample with 50 µg/L perchlorate. The results for the spiked sample were negative, suggesting strongly that the samples were mixed up during collection.

A government lab reported metals results for split soil samples, but their results were consistently higher than those for the commercial lab. On investigation, the commercial lab had used its own digestion protocol, which had never been compared with the EPA digestion method; subsequent comparison showed significant negative bias.

A lab reported significant levels of thallium – a very unusual finding. On data validation, the ICP result was caused by interference associated with a secondary optical emission line from aluminum.

Lab accreditation/certification programs were created to prevent problems like those above, and they probably have helped eliminate some blunders. Nevertheless, I still recall the last sentence of my *Analytical Chemistry* book: "… it is clear that the chemist is well advised to adopt a pessimistic viewpoint regarding the accuracy of an analysis, be it his [/her] own or one performed by someone else."

Bart can be reached at bartonps@aol.com.

New, easy-to-understand information available to household water well owners

MARK YOUR CALENDARS: 2015 Groundwater Awareness Week March 8-14

With support from the U.S. Environmental Protection Agency, a complete set of new educational tools is now available through the National Ground Water Association (NGWA) to household water well owners to help them protect their water quality and care for their water well systems. The easy-to-understand information, accessible via www.WellOwner.org, includes:

- 15 short, free online lessons with quizzes and a Certificate of Completion for those who pass
- 8 free recorded webinars
- New and improved content on WellOwner.org covering water well basics.

"These educational tools are for household well owners who don't know much about their well system or water quality but would like to learn more," said Cliff Treyens, NGWA public awareness director. "This information is all free, simple, and focuses on the very basic information that all water well owners should know."

Topics addressed by the lessons, webinars, and www.WellOwner.org include:

- Water testing and treatment, including for arsenic, bacteria, nitrate and radon
- Well construction and maintenance
- Groundwater protection
- Well flooding
- Testing water near hydraulic fracturing
- Abandoned water wells
- Water conservation
- Finding a water well professional.

Another major NGWA public awareness initiative, National Ground Water Awareness Week, is set for March 8-14, 2015. "In 2014, nearly 600 web sites promoted Groundwater Awareness Week—a record number," said Treyens. "We fully expect 2015 to be even bigger. We encourage groundwater professionals and stakeholders everywhere to consider how they can use this event to promote groundwater and water well stewardship messages to the public."

Treyens said NGWA encourages persons and organizations interested in promoting Groundwater Awareness Week to link to, or share links to NGWA's www.WellOwner.org web site or to the aforementioned online lessons and webinars."We know from pre-tests and post-tests that well owners are learning the basics about their wells, water quality and groundwater protection when they take the online lessons or view the webinars," he said. "These tools work. NGWA wants to see as many well owners as possible use them so that they can better protect their water quality."

> "There is no shortage of useful information about water wells and groundwater, but it's important that more well owners know about this information. This is news they can use to protect their health and the health of their families," Treyens said.

Among the resources that can be found at the Groundwater Awareness web page are:

- About groundwater
- Groundwater stewardship — protection and conservation
- Schedule your annual water well checkup
- Get involved
- Editorial
- Sample news release
- Sample radio spots
- Promotional tools for groundwater professionals
- Promotional partners
- National groundwater use
- States' groundwater use

For more information, contact Cliff Treyens at ctreyens@ngwa.org or 800-551-7379, ext. 554.

GRA Honors Governor Brown for Leadership

2014 Becomes the Year of Groundwater with Reform Passage

Martha Guzman accepted GRA's Kevin J. Neese award on behalf of Governor Brown. With her are Tim Parker, GRA Legislative Committee chair (left) and GRA President Ted Johnson. Photo by Brian Lewis.

At this year's Annual Conference, GRA presented Governor Jerry Brown the Kevin J. Neese Award for his leadership in developing sustainable groundwater management legislation and successfully shepherding it through the legislative process. Deputy Legislative Secretary Martha Guzman was at the conference to accept GRA's 2014 Kevin J. Neese Award on the Governor's behalf.

Governor Brown's groundwater vision will change the landscape of California by providing local agencies the incentives and authority to effectively manage groundwater as well as disincentives for non-compliance.

As California continues to face a severe water shortage, groundwater management became priority for the Administration. The California Water Action Plan, released on January 27, 2014, highlights the challenges for managing the state's water resources and outlines strategic goals and an action plan to provide more reliable water supplies, restore important species and habitat, and to establish a more resilient and sustainably managed water-resource system for farms, ecosystems and communities. The plan specifically identified a number of actions to implement sustainable groundwater management practices, including authority for local and regional agencies to address groundwater challenges.

The Administration didn't stop there. They hosted a series of meetings and workshops in early 2014 to reach out and engage stakeholders and legislative leaders on sustainable groundwater management reform. Governor Brown then introduced a legislative proposal in May. With everyone keeping an "eye on the prize" and working collaboratively, SB 1168 and SB 1319 (Pavley) along with AB 1739 (Dickinson) became the successfully passed Sustainable Groundwater Management Act, and 2014 became known as the Year of Groundwater.

Governor Brown and his staff worked closely with a number of key players in forming this legislation. The California Water Foundation and the Association of California Water Agencies initiated the original comprehensive legislative proposals that ultimately became SB 1163 and AB 1739. Senator Fran Pavley and Assemblymember Roger Dickinson and their staff also played monumental roles in this success as did a number of other leaders in the Brown Administration. It was the willingness of all those involved to collaborate, partnered with the strong leadership of Governor Brown, that made this reform possible.

Governor Brown clearly represents what the Neese Award celebrates. The Neese Award recognizes significant accomplishment by a person or entity that fosters the understanding, development, protection or management of groundwater.

Thank you, Governor Brown, for your vision and leadership.

Standing Ovation Concludes Lifetime Achievement Award Presentation

Dr. Huntley Celebrated by GRA

Joined on stage by his family, Dr. David Huntley was presented the GRA Lifetime Achievement Award at the 2014 GRA Annual Conference. The GRA Board of Directors selected Dr. Huntley as the recipient of the 2014 GRA Lifetime Achievement Award for his mentorship to so many successful individuals that permeate the groundwater industry in California and for his countless career accomplishments in hydrogeology.

Sam Williams was given the honor of presenting the Lifetime Achievement Award to Dr. Huntley. With numerous former students in the audience, Williams led the audience through a colorful and thoughtful presentation spanning three decades of Dr. Huntley's life as an instructor, innovator, editor, writer, mentor, consultant, and expert witness, as well as a sailor, race car driver and successful triathlete. Attendees were entertained by pictures from the early 1980s (long-hair and beards) and moved by Dr. Huntley's influence on society through his efforts with the Challenged Athletes Foundation.

Dr. Huntley spent most of his career at San Diego State University. He has a B.A. in Geology from the University of California, Santa Barbara and his Ph.D. in Geological Engineering from Colorado School of Mines. He taught both undergraduate and graduate classes in groundwater hydrology for over 30 years and is the Associate Editor of *Groundwater* and *Groundwater Monitoring and Remediation*, both professional journals. His accomplishments in education, academic experience, consulting, honors and publications are far too numerous to mention as they covered pages in the original nomination for this award. Dr. Huntley was also chosen to speak as part of GRA's 2013 David Keith Todd Lecture Series.

Dr. David Huntley, center, surrounded by family and former students. Photo by Brian Lewis.

Living with the challenges of Amyotrophic Lateral Sclerosis (ALS), often referred to as Lou Gehrig's disease, Dr. Huntley has lost his ability to speak, so his acceptance speech was given by Matt Wiedlin, a friend, colleague and former student. He read the opening line from the famous farewell address given by Lou Gehrig, "I consider myself the luckiest man on the face of the earth." Wiedlin shared that Dr. Huntley stumbled into the groundwater field, and was blessed with two great mentors, Dave Snow and Keenan Lee, who shaped his approach to teaching and research.

Wiedlin closed the acceptance speech on behalf of Dr. Huntley by saying, "Over the years I received a number of job offers from private industry and my response was always the same; it would be exponentially better for them if I continued my research and teaching undergraduate and graduate students to be excellent groundwater hydrologists. This award validates the decisions I made throughout my career. For that, I want to thank the GRA Board of Directors for honoring me with this award, and my students and colleagues that nominated me."

Dr. Huntley, a man who has made a lasting impact on the groundwater community, was celebrated in front of family, former students, friends, colleagues and admirers to a standing ovation.

Our warmest regards and congratulations to Dr. David Huntley.

GRA's **Lifetime Achievement Award** is presented to individuals for their exemplary contributions to the groundwater industry and for contributions that have been in the spirit of GRA's mission and organizational objectives. Recipients have dedicated their lives to the groundwater industry and are pioneers in their field of expertise.

Sustainable Groundwater Management Act

(effective January 1, 2015)

The landmark Sustainable Groundwater Management Act (Act), which was signed into law on September 16, 2014, and is effective January 1, 2015, fundamentally changes management of California's groundwater basins. The Act will require a significant amount of work be done in many of California's groundwater basins over the next two to three decades; this work will be interdisciplinary and will require highly trained groundwater professionals with a variety of skill sets and backgrounds.

The Act is contained in three bills, Assembly Bill 1739 (Dickinson), Senate Bill 1168 (Pavley), and Senate bill 1319 (Pavley), and aims to give local agencies the means to manage groundwater basins in a manner that is sustainable over the long-term. The Act reflects the intent of the Legislature that the Act, its provisions and requirements respect the overlying and other proprietary rights to groundwater consistent with the Water Code. The Act and related statutory provisions are available as a code red-line markup.

Key elements of the legislation include: (1) mandates of the Department of Water Resources (DWR) to lay some of the framework for implementation of the Act; (2) requirement for the formation of "groundwater sustainability agencies" (GSAs) (i.e., one or more local public agencies that have responsibility to supply water, manage water, or regulate land use in the groundwater basin) in high- and medium-priority basins; (3) requirement for the assessment of local groundwater conditions in these basins and development of "groundwater sustainability plans;" (GSPs) and (4) authority and direction for state review and intervention.

Mandates of the Department of Water Resources

The Act mandates the DWR by January 31, 2015, to prioritize basins in the state as very low, low, medium and high using a prescribed set of criteria, including overlying population, projected population growth, number of public supply wells, total wells, irrigated acreage, groundwater reliance, and potential impacts from groundwater extractions, including adverse impacts on local habitat and streamflows. The Act applies to all high- and medium-priority basins, with one exception. Basins that have been adjudicated, and as such are administered by the courts, are required only to submit proof of the adjudication and report data to DWR annually. The Act also mandates that DWR:

- Adopt regulations for basin boundary adjustments by Jan. 1, 2016
- Adopt regulations for evaluating adequacy of GSPs and GSA coordination agreements by June 1, 2016
- Adopt regulations to evaluate alternative agencies by June 1, 2016
- Publish a report estimating water available for groundwater replenishment by Dec. 31, 2016
- Publish groundwater sustainability best management practices by Jan. 1, 2017.

Formation of New Groundwater Sustainability Agencies

Any one or more local public agencies that overlie the basin/subbasin may elect to be the GSA for that basin/subbasin, and has until June 30, 2017 to do so. An exception is that agencies that have been created by statute to manage groundwater as listed in the Act are deemed the exclusive agencies to comply with the Act within their boundaries, unless the agency elects to opt out. If no GSA is formed, the basin will be considered unmanaged, and the county will be presumed to be the GSA.

The Act gives the newly formed GSAs that adopt Plans in accordance with the legislation new tools to manage groundwater sustainably, including the authority to:

- Conduct investigations to carry out the requirements of the Act
- Require the registration of wells
- Require the installation of water-measuring devices on all groundwater wells within the basin boundaries at the expense of the operator or owner
- Require annual extraction statements or other reasonable method to determine groundwater extractions
- Impose well spacing requirements and control extractions by regulating, limiting or suspending extractions from individual groundwater wells
- Assess fees to establish and implement local groundwater management plans
- Acquire property and water rights
- Recycle water
- Undertake enforcement actions
- Request that the DWR revise the boundaries of a basin, including establishing new subbasins.

Groundwater Sustainability Plans

The newly formed GSA's are required to develop "groundwater sustainability plans" designed to achieve "sustainable groundwater management," which by Act definition, means the management and use of groundwater in a manner that

Continued on the following page…

Sustainable Groundwater Management Act – *Continued*

can be maintained during the planning and implementation horizon without causing undesirable results. The foundation of the new GSP is the goal to manage groundwater to the sustainable yield of the basin/subbasin within 20 years; the sustainable yield is defined as the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result. (Sustainable yield is equivalent to "safe yield" as defined in case law.) "Undesirable results" are defined as follows, based on a "significant and unreasonable" standard:

- Chronic lowering of groundwater levels
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses.

Groundwater basins that are listed by DWR as high or medium priority and in a state of critical conditions of overdraft will need to develop groundwater sustainability plans by January 31, 2020. The remaining high and medium priority basins will need to develop such plans by January 31, 2022.

Required components of the GSPs include:

- A description of the physical setting and characteristics of the aquifer system
- Historical data, groundwater levels, groundwater quality, subsidence, groundwater-surface water interaction, a discussion of historical and projected water demands and supplies
- A map that details the area of the basin and boundaries
- A map identifying existing and potential recharge areas that substantially contribute to the recharge of the basin
- Measurable objectives, and interim milestones in increments of five years, to achieve the sustainability goal in the basin within 20 years
- A planning and implementing horizon (50 years)
- The monitoring and management of groundwater levels, water quality, groundwater quality degradation, and inelastic land subsidence
- A summary of the type of monitoring
- Monitoring protocols
- A description of the consideration of other applicable local government plans and how the GSP may affect those plans.

The development of groundwater sustainability plans is exempt from the requirements of CEQA. The act authorizes GSAs to file a validation action 180 days after GSP adoption. A validation action is a unique remedy that provides a conclusive determination as to the validity of a public agency's actions.

GSAs are required to submit adopted GSPs to DWR for review. DWR has two years to review adopted plans and may request changes to the GSPs to address any inadequacies. GSAs are required to submit annual compliance reports to DWR documenting progress towards sustainability with groundwater elevation, aggregate extraction and water usage data, and any groundwater storage changes. DWR is also required to re-evaluate GSPs every five years for continued progress and compliance with sustainability requirements.

Alternative submittals in lieu of GSPs may be provided to meet the requirements, including (1) a Plan developed pursuant to Water Code section 10750, (2) management pursuant to an adjudication, and (3) analysis that indicates the basin is managed within the sustainable yield for the past ten years.

State Intervention

Under the Act, the SWRCB has the authority to intervene – a "backstop" – under certain conditions in high- and medium-priority basins where:

1) No local agency is willing to serve as a GSA (June 30, 2017)
2) The GSA does not complete a GSP as required, the plan is inadequate, or the plan is not being implemented in a manner that will achieve the sustainability goal (January 31, 2020 for critically overdrafted basins, and January 31, 2022 for overdrafted basins)
3) The GSP is inadequate, or the plan is not being implemented in a manner that will achieve the sustainability goal, and the basin is in a condition where groundwater extractions result in significant depletions of interconnected surface waters (after January 31, 2015).

Under the above conditions, and after consulting with DWR, intervention by SWRCB may include designation of a basin as "probationary." Probationary status requires a GSA to respond to the State Board and describe how it intends to rectify these shortcomings within 180 days. Failure to respond to the deficiencies in the GSP could lead to limited state intervention and the development of a State Board-created Interim Plan, including:

- Actions necessary to correct long-term overdraft
- Schedule for actions
- Monitoring program
- Process for rescission of the Interim Plan
- Additionally, SWRCB may prescribe physical solutions, pumping restrictions and administration of surface-water rights.

David Keith Todd Distinguished Lecturers for 2015

GRA proudly announces the speakers for the fifth year of its David Keith Todd Distinguished Lecture Series. **Michelle Sneed** (northern California) and **Dr. John Izbicki** (southern California) have enthusiastically accepted the 2015 David Keith Todd Lectureship. The objective of this program is to foster interest and excellence in applied groundwater science and technology through GRA-sponsored lectures at California universities, and at local and statewide GRA events. This objective furthers a key GRA objective – to develop scientific educational programs that promote the understanding and effective implementation of groundwater assessment, protection, and management.

GRA held Dr. David Keith Todd in the highest esteem for his enormous contributions to groundwater science and technology, and in 1999 awarded him GRA's Lifetime Achievement Award. We pay tribute to his legacy as a groundwater science and education leader by naming the series in his honor. Lecturers for this series go through a nomination and evaluation process that ensures highly-qualified individuals are selected to represent GRA and David Keith Todd's legacy.

Ms. Sneed will generally give presentations in northern California, and Dr. Izbicki will generally give presentations in southern California. Each lecturer will provide a minimum of five lectures, including lectures at two GRA Branch Meetings and two academic institutions along with a "wrap-up" lecture at GRA's Annual Conference and Meeting held during the fall. Lecture Series funding comes from sponsors, voluntary support from the lecturer's institution, organization or firm, and support from the universities hosting the lecturer. Universities that are interested in hosting a lecture should contact Lisa O'Boyle, Education Committee Chair (dkt@grac.org) no later than December 31, 2014. Look for the Lecture Series schedule to be posted on GRA's website and Facebook page.

Michelle Sneed
(Northern California)
Hydrologist
United States
Geological Survey

Lecture – *Land Subsidence: The Lowdown on the Drawdown*

Michelle Sneed is a hydrologist with the U.S. Geological Survey and has been with the California Water Science Center since 1994. She received her B.S. and M.S. degrees in geology from California State University, Sacramento, where she periodically teaches geology classes. She has published many studies of land subsidence related to fluid-pressure changes in areas throughout California and other areas in the Western United States. Ms. Sneed integrates various methods of land-surface elevation (and elevation change) measurement, including spirit leveling, Global Positioning System, extensometry, and Interferometric Synthetic Aperture Radar (InSAR) techniques, to leverage the diverse spatial and temporal scales of the datasets. Analyses and simulations have focused on the preconsolidation stress, vertical hydraulic conductivities, and the elastic and inelastic compressibilities (storage) of aquifer-system components based on hydrogeological structure, land-surface elevation changes, and groundwater-level changes. Recent studies in the San Joaquin and Coachella Valleys explore the impact of subsidence on water-conveyance infrastructure, and have been featured in the news media. She is a member of AGU, GRA, and NGWA, and recently was invited to join the UNESCO Working Group on Land Subsidence, the recognized leader in promoting global land subsidence studies.

John Izbicki, Ph.D.
(Southern California)
Research Hydrologist
United States
Geological Survey

Lecture – *Using Disparate, Process-Oriented Data to Solve Hydrologic Problems*

Dr. John Izbicki has worked for the U.S. Geological Survey for more than 30 years in Maryland, Massachusetts, and California. In 2000, while working for the USGS, he obtained his Ph.D. in Soil Physics from University of California, Riverside. Within California, Dr. Izbicki's studies have focused on understanding the physical hydrology of coastal and desert aquifer systems primarily through the application of chemical and isotopic tracers. Recent work includes studies of managed aquifer recharge, trace-element occurrence and management in aquifers, submarine groundwater discharge, and bacterial source identification in urban streams and nearshore ocean water. Dr. Izbicki has several patents, published more than 100 U.S. Geological Survey reports and journal articles, and worked internationally with the International Atomic Energy Agency and the Indian Government.

GRA Welcomes the Following New Members

AUGUST 26, 2014 – DECEMBER 1, 2014

Adams, Samantha	Wildermuth Environmental
Anderson, Diane	APPL, Inc.
Barry, Hamidou	Alisto Engineering Group, Inc.
Bastani, Mehrdad	UC-Davis
Bhargava, Divya	ENGEO
Bonsangue, John	Orange County Water District
Boyle, Bernadette	
Braziel, Christine	Crocker & Crocker
Burger, Kate	DTSC
Corder, Dave	QED Environmental Systems, Inc.
Eidam Crocker, Lucy	Crocker & Crocker
Gerbert, Lynnette	Brown and Caldwell
Gibbs, Alan	Terraphase Engineering, Inc.
Harker, Rick	Olam West Coast Inc.
Heidemann, Gregory	Navigators Environmental
Hersh, Alan	McClellan Business Park
Hollenbeck, John	Hollenbeck Consulting
Hopkins, Ted	Shannon & Wilson
Huynh, Nancy	LADWP
Jameson, Lora	DTSC
Jesch, Ben	Washoe County
Kamahao-Bowman, Meilani	AMEC Environment & Infrastructure, Inc.
Kraemer, Sue	CB&I
Larwood, Jim	AECOM
Lincecum, Tim	AAA Engineering (test company)
Love, Charlotte	
Luo, Hong	Chevron
Lutterman, Tom	DWR
MacGregor, Ian	Battelle
McVay, Sean	Navigators Management Company, Inc.
Mork, Eric	UC Davis
Pavelka, Anne	NJDEP
Perez, Jorge	AMEC Environment & Infrastructure, Inc.
Russell, Peter	Russell Resources, Inc.
Salcedo, Sarah	Broadbent & Associates, Inc.
Singh, Narinder Pal	Olam West Coast Inc
Soby, Matthew	Alameda County Environmental Health
Soenen, Kurt	Cornerstone Earth Group
Stumpf, Suzanne	SoundEarth Inc.
Taylor, Kate	Crocker & Crocker
Vishnevskiy, Maria	Geosyntec Consultants
White, Hal	US Environmental Protection Agency
Whitmarsh, Avery	AMEC
Wiegers, Janice	Alaska Department of Environmental Conservation
Wilcox, Beth	Alameda County Fair Association
Wilson, Jeremy	Rosso Environmental, Inc.
Woo, Teresa	SFPUC - Water Quality Division

2014 Contributors to GRA – Thank You

(as of 11/5/2014)

FOUNDER *($1,000 and up)*
Brownstein Hyatt Farber Schreck
Janie McGinn
Roscoe Moss Company

PATRON *($500-$999)*

CORPORATE *($250-$499)*

CHARTER *($100-$249)*
Bob Cleary
Stanley Feenstra
Adam Hutchinson
Sally McCraven
Steven Phillips
Brian Wagner

SPONSOR *($25-$99)*
Jerry Aarons
AECOM
Jeriann Alexander
Charles Almestad
James Arnold
Maria Barajas
Frank Brommenschenkel
Ahnna Brossy
Kendra Brown
Kevin J. Brown
Kate Burger
Regina Bussard
Andres Cano
Han-Ting Chang
Alan Churchill
Confluence Environmental Field Services
Billy Dixon
David Dunbar
Gail Eaton
John Elliott
EMAX Laboratories, Inc.
Joshua Ewert
Miranda Fram
Edana Fruciano
Scott Furnas
Jacob Gallagher
Chip Gribble
Griffith & Masuda
Haley & Aldrich, Inc.
David Harnish
Victor Harris
Katrina Harrison
Thomas Harter
J. Michael Harty
Carl Hauge
Eric Hendrix
Barbara Hennigan
Hopkins Groundwater Consultants, Inc.
Horizon Environmental, Inc.
Vitthal Hosangadi
Mike Huggins
HydroFocus, Inc.
Hydrometrics Water Resources Inc.
Alison Imamura
Iris Environmental
Charles Jenkins
Christopher Johnson
Nicholas Johnson
Ian Jones
Carol Kendall
Karl Kienow
Valerie Kincaid
Ted Koelsch
Amalia Kokkinaki
Taras Kruk
Jeff Kubran
Peter Langtry
Joe LeClaire
Stephen Lewis
Wendy Linck
Mario Lluria
Richard Makdisi
Andrew Matthew
Mohsen Mehran
Steven Michelson
Jean Moran
Alec Naugle
Aaron O'Brien
Michael Ohare
Charlie O'Neill
Jonathan Parker
Tim Parker
PES Environmental, Inc.
Rob Pexton
Bryan Pilkington
Lisa Porta
Iris Priestaf
Richard Raymond
Eric Reichard
George Reid
Tito Sasaki
William Sedlak
Marc Seeley
Pawan Sharma
Marc Silva
Tom Sparrowe
Phyllis Stanin
Sustainable Technologies
Chris Tatum
Eddy Teasdale
The Source Group, Inc.
Troy Turpen
Stephen Van der Hoven
Michael Van Fleet
Mark Wanek
Donald Weir
Tom Whitehead
WZI Inc.
Gus Yates
Steve Zigan

SUPPORTER
John W. Anthony
Guy Berger
Kit Custis
Dan Day
Christina David
Barry Epstein
Yonas Habtemichael
Chloe Mawer
Tim Rumbolz
Ben Swann

Sacramento

By Troy Turpen,
Branch Secretary

The Sacramento Branch joined with the Association of Environmental Professionals and the Professional Environmental Marketing Association for a joint mixer July 16th at Hot Italian in Sacramento for a lively, casual cross-association meeting that encouraged more and better networking between our groups. We found that although there are only a handful of individuals common to these associations, this type of mixer allows for better and more widespread dissemination of knowledge and ideas.

Our Branch meetings returned to the regular format in August and featured Richard Zipp, Principal Hydrogeologist at RJZ Associates, presenting *Taking a Closer Look At Problem Sites We Have All Dealt With*. Mr. Zipp has been conducting groundwater resource, water rights and groundwater contamination/remediation investigations in California and throughout North America since 1973. Mr. Zipp discussed a few of the newer evaluation tools that have been added to our arsenal, and those that have been removed that perhaps shouldn't have been. These changes in evaluation tools may help explain why cleanup efforts at some sites haven't been successful. Attendees were encouraged to bring their own problem sites to the discussion!

The September meeting featured *The Mars Water Story*, presented by Andy Gonzales, Senior Systems Engineer at NASA Ames Research Center. Mr. Gonzales has performed and led advanced mission concept designs for the last 15 years, with an emphasis on Mars and the Moon; he currently works in the Mission Design Center at Ames, where he has worked for 30 years. As quoted in Mr. Gonzales' biography for the presentation, "Mars has been, and will be, the subject of many investigations/Water has apparently played a role in the past/Water is now at the poles and in the subsurface, in the form of ice/Water may appear briefly and dynamically at the surface/Mars, and its water, are waiting for us!"

The Sacramento Branch thanks our Scholastic Sponsors, McCampbell Analytical, Inc. (August) and ASC Tech Services (September). 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

In September, the GRA Southern California Branch held its bi-monthly meeting and hosted two speakers from the Los Angeles Regional Water Quality Control Board: Dr. Yue Rong, Environmental Program Manager for the Underground Storage Tank Program, and Dr. Eric Wu, Chief of the Groundwater Permitting Unit. Drs. Rong and Wu discussed the regulatory framework and permitting requirements for groundwater remedial technologies. The talk focused on the new waste discharge requirements (WDRs) for In-Situ Groundwater Remediation and Groundwater Re-Injection. They explained why WDR's are needed for in-situ injection, stating that compounds injected into aquifers need to be regulated in order to protect the beneficial use of the waters of the state. Dr. Wu provided an overview of the permitting process and described the specific information required for the permit, such as discharge/injection specifications, discharge limits, and standard provisions of the permit, including operation and maintenance requirements. Dr. Rong focused on the remedial processes providing a typical full-scale in-situ injection system layout, more details on the revisions of the recently revised WDRs (such as the addition of newly approved compounds for in-situ injection), pros and cons of the revised WDR, and common questions associated with the new WDR. Their presentation was well attended by both GRA members and non-members, and sparked a lively question-and-answer session, especially amongst those actively involved in in-situ groundwater injection technologies.

The Branch would like to thank all GRA members and non-members for attending the September Branch meeting, and would also like to thank Kennedy/Jenks Consultants for being the scholastic sponsors for the meeting.

Lake Shasta

In a recent issue of *HydroVisions*, GRA president Ted Johnson discussed his observations about low water levels in Lake Shasta during a drive along Interstate 5. Similarly, I was struck by the extensively exposed shorelines of Lake Shasta during a commercial flight. This photo shows the Pit River area of Lake Shasta in mid-August 2014, when the reservoir was at approximately 32% of total capacity and 48% of the historical average.

Several government agencies compile and illustrate current and historical water data. For this Lake Shasta example, the Department of Water Resources California Data Exchange Center (CDEC) provided both a bar graph of storage conditions and a chart of lake levels by user-selected date: click here.

Bay Area web developer Victor Powell has also created a simple and graphically attractive open-source tool that uses CDEC data to show fluctuations in California's 30-largest reservoirs since 2010. A unique feature of this tool is that it provides a statewide map that proportionally symbolizes current versus maximum storage capacity for each reservoir as well as time-series graphs for the highlighted feature.

This photograph was taken using a camera on a smart phone. Although challenging, it is possible to obtain interesting photographs on commercial flights by selecting a window seat in front of the wing, using a fast shutter speed to avoid blurring, having the sun to your back or opposite side, and looking for color or textural patterns in the landscape. Early morning or late afternoon flights also generally provide better lighting and shadows for contrast.

by John Karachewski, Ph.D. (www.geoscapesphotography.com)