GROUNDWATER RESOURCES ASSOCIATION OF CALIFORNIA
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The 14th Biennial Symposium on Managed Aquifer Recharge

By Adam Hutchinson, Orange County Water District, and Chris Petersen, West Yost Associates

GRA convened the 14th Biennial Symposium on Managed Aquifer Recharge (BSMAR 14) on July 31 to August 1 in Orange, CA. This symposium continues a tradition started in 1978 when the Salt River Project (Phoenix, AZ) convened the first symposium on artificial recharge. Following the inaugural symposium, twelve additional symposia were held in Arizona with the last symposium held in Phoenix in 2007 as a joint conference with the 6th International Symposium on Managed Aquifer Recharge (ISMAR 6).

The GRA and the Arizona Hydrological Society (AHS) joined forces to re-start this symposia series. Going forward, the series will alternate between California and Arizona with the GRA and AHS taking the lead in their respective states. The 15th Biennial Symposium on Managed Aquifer Recharge (BSMAR 15) will be combined with the 9th International Symposium on Managed Aquifer Recharge (ISMAR 9) and is planned for Mexico City in spring 2016 (see http://recharge.iah.org/recharge/downloads/ISMAR8/ISMAR9_Flyer.pdf).

A unique feature of BMSAR is the presentation of the ***Herman Bouwer Award***. The late Dr. Herman Bouwer was one of the world's leading researchers in water resources management, particularly in the area of managed aquifer recharge. He authored more than 300 publications, including 12 book chapters and the textbook *Ground Water Hydrology* (McGraw-Hill, 1978). He was also a key driver in organizing numerous BSMAR and ISMAR events. To honor his legacy, the Herman Bower Award was created. The award, which will have no monetary value, is to be given to the person or agency that has significantly advanced the understanding or utilization of MAR. The inaugural Herman Bouwer Award was presented at BSMAR 14 to **Robert C. Rice**. Mr. Rice is a fitting recipient of the first award as he worked closely with Herman for 40 years. Together they pioneered new methods of data collection and pushed forward the use of sewage effluent for recharge purposes. Herman's son, **Dr. Ed Bouwer**, who is Department Chair, Geography and Environmental Engineering at Johns Hopkins University, had this to say about Mr. Rice:

> "I am delighted to learn that Robert Rice is the inaugural recipient of the Herman Bouwer Award. I clearly remember Bob's collaborative work with my father on infiltration and soil clogging studies. This work eventually helped to optimize the performance of the Flushing Meadows project and other MAR projects. Congratulations to Bob for his contributions over his long career and for starting this pioneering work with my father."

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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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Groundwater Sustainability – A Common Goal

By Ted Johnson

In July, I began my annual drive up I-5 from Long Beach to Anacortes, Washington to enjoy a few weeks of vacation in the beautiful San Juan Islands. I have made this drive for 13 summers, and the 2,500-mile round trip doesn't bother me a bit, because I enjoy the changing scenery.

But this year was a memorable shocker. As I arrived at Lake Shasta and drove across the Pit River Bridge, I couldn't believe how low the lake level was. Never before had I seen so much red earth where lake water used to be. The usual "bathtub ring" reminded me of the Grand Canyon; I could barely see the tiny boat docks below, lowered in an attempt to stay wet. I since learned that the lake level is at half of its average for this time of year, and the lake is at a third of its capacity. In fact, most of the state's major reservoirs are at less than half their average August levels. A few miles ahead, Mt. Shasta came into view; barren rock covered most of the mountain where plentiful snow usually exists. So much for any meaningful melt waters coming off the mountain to help feed Lake Shasta the rest of the year.

These sights really hit home for me the seriousness of the current drought. I'm no farmer, so I'm undoubtedly slower than they are to realize the seriousness of our water supply situation. We hear about the drought in the media almost daily, and many of us in the business are working with public and private entities to find solutions, but to see such depleted lake and snow reserves first-hand made an immediate impact on me. I wanted to know more. I learned that the cause of the 3-year drought has been attributed to the so-called "Ridiculously Resilient Ridge," an extraordinarily persistent region of high pressure parked over the northeastern Pacific Ocean, forcing mid-latitude winter storm tracks around California, resulting in minimal precipitation and the hottest years on record (www.weatherwest.com/). Unfortunately, no one knows how long it will last, and normal to wet conditions next year will not make up for the cumulative losses over the past few years. We need several years in a row of above-normal precipitation to get us out of the drought.

So how does all of this relate to California groundwater? To grossly summarize: drought reduces surface supplies and therefore increases reliance on groundwater, from a normal 40% of the state's supply to reportedly 75% or more this year. Record numbers of water wells are being constructed deeper and deeper to tap the ever-declining groundwater, especially in the San Joaquin Valley, where drilling backlogs of a year or more are reported. More groundwater is being extracted than replaced in many basins, leading to new or increased overdraft. Land subsidence of a foot or more per year is being reported in some areas due to extreme overdraft, leading to permanent loss of aquifer storage space and damages to surface infrastructure. Replenishment agencies are struggling to obtain the surface water they need for managed aquifer recharge (MAR) to overcome their basins' overdraft. Some groundwater basins are at their historic lows. Satellites are witnessing the statewide groundwater depletion. Some regions are at real risk of running out of water. California has no comprehensive groundwater sustainability plan (yet). It is not a pretty picture.

The solutions to groundwater sustainability seem obvious to hydrogeologists: obtain the necessary data; develop an understanding of the hydrogeology of groundwater basins/subbasins; monitor and report on the water balance; avoid long-term overdraft by matching pumping and other forms of discharge to natural and enhanced recharge; manage water quality and environmental impacts; develop sound storage projects and water banks; and since this is California, expect and plan for drought by recharging basins before the drought, allow groundwater to decline during the drought, then restore the basins post-drought to be ready for the next one. This is easier said than done. These efforts take stakeholder willingness and consensus; extensive and expensive monitoring, analysis, and reporting networks; strong leadership and management; and institutional and political will to take the necessary steps if basins are not being managed sustainably.

One positive result of the drought is that the crisis has brought groundwater into the forefront of activity within the California administration and legislature. At the time of this writing there are two bills in progress to make groundwater

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Groundwater Sustainability – A Common Goal *– Continued*

sustainability a requirement in California: AB1739 (Dickinson) and SB1168 (Pavley). These bills will make it state policy that groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses. The bills state that sustainable groundwater management is best achieved locally through the development, implementation, and updating of plans and programs based on the best available science; but if locals cannot achieve sustainable basins, then the state will step in for them. These bills are a great advancement towards reliable groundwater in the state. As good as they are, they allow for a lot of time to pass for basins to reach sustainability (20 years or more). Unfortunately, some basins are currently in critical overdraft and are experiencing major problems. These critical basins should work immediately to reduce or eliminate overdraft, versus waiting too long; at some point, it may be too late to avoid additional serious consequences.

At GRA we are doing our best to help educate and promote the science behind responsible groundwater management. In addition to the input GRA is giving to the legislature on the sustainability bills, on July 30-August 1 we held the 14th Biennial Symposium on Managed Aquifer Recharge in conjunction with the Arizona Hydrological Society to supply the latest information on replenishing and sustaining groundwater resources. On September 9th is the GRA Land Subsidence Symposium to highlight the technical challenges and financial impacts that occur when groundwater overdraft results in subsidence. And on October 15–16 will be GRA's 23rd Annual Conference and Meeting, with the theme 2014 – the Year of Groundwater. This conference will cover the drought and other key drivers for recent and ongoing groundwater depletion issues, the administration's efforts to address groundwater management, local perspectives on these efforts, and more. Check out our website at http://www.grac.org for more information on these and other educational opportunities.

The drought may have been caused by the Ridiculously Resilient Ridge, but our convictions to solve the associated and longer-term problems must be equally resilient. Significant challenges exist, but with the development of meaningful management plans based on sound science, along with support, recognition, and agreement by local stakeholders that their groundwater is a common resource pool that they all rely upon, there is no reason that all groundwater basins in the state cannot be brought into sustainability to meet our needs indefinitely. That is a goal we can all hopefully stand behind and help achieve. I think we can.

Rock on!

TJ

The 14th Biennial Symposium on Managed Aquifer Recharge *– Continued from page 1*

Robert C. Rice, Inaugural Herman Bouwer Award Recipient

Field trip participants see imported water being delivered to OCWD's surface-water recharge system (on left behind fence). Mini-Anaheim recharge basin is in upper right.

In addition to creating the Herman Bouwer Award, the GRA has teamed with the Arizona Hydrological Society Foundation (AHSF) to create the ***GRA Herman Bouwer Endowment***. In 2004, Herman received the Prince Sultan Bin Abdulaziz International Prize for Water for his work on underground water movement with emphasis on managed aquifer recharge, water reuse, and surface and groundwater interactions. Herman took a significant portion of the award money and gave it to the AHS to establish the AHSF with the intent to provide long-term assured funding for annual scholarships to assist outstanding and deserving students in water resources. The AHSF awards scholarships and internships each year to students in hydrology, hydrogeology, or any other water resources related field at an Arizona university or college. The GRA Herman Bouwer Endowment will use new funds raised in California to award similar scholarships and internships to students in California.

On July 30, prior to BSMAR 14, the GRA and the California State Water Resources Control Board sponsored a half-day workshop on "Tracers in Managed Aquifer Recharge." Contributors to the workshop included ***Ate Visser***, ***Michael Singleton***, and ***Bradley Esser*** from Lawrence Livermore National Lab and **Jean Moran** from California State University at East Bay. During the workshop a morning field trip to the Orange County Water District's (OCWD) Groundwater Replenishment System and seawater intrusion barrier was provided. At the conclusion of the workshop, an afternoon field trip to OCWD's surface-water recharge system was provided.

A total of 36 oral presentations were given during the 2-day symposium on a wide range of topics centered on managed aquifer recharge. Poster presentations were also provided. Attendees came from a wide area, including 12 states and three countries. All presenters were required to submit extended abstracts, which were included in the conference proceedings. You can view the BSMAR 14 proceedings and proceedings from prior BSMAR symposia at http://www.grac.org/bsmar-proceedings.asp.

Lester Snow, former head of the California Department of Water Resources,

BSMAR 14 Key Facts

Oral Presentations: 36

Poster Presentations: 11

Attendees: 136

Co-Sponsors: California Water Foundation, Baski, Geosystems Analysis, Rosco Moss Company

Exhibitors: Inflatable Packers International, Blaine Technical Services, Torrent Resources, QED Environmental Services, Sigmund Linder, Water Replenishment District of Southern California, JPR Systems, Electronic Data Solutions, Clear Creek Associates

Reception/Lunch Sponsors: Dudek, Geosystems Analysis, Todd Groundwater

Keynote Speaker: Lester Snow, California Water Foundation

Herman Bouwer Award: Robert C. Rice

Attendee Origin: Arizona, California, Colorado, Florida, Idaho, Michigan, Montana, Nevada, New Mexico, Oregon, Utah, Wisconsin, Australia, Germany, Mexico

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The 14th Biennial Symposium on Managed Aquifer Recharge – *Continued*

gave the keynote address at the Herman Bouwer Awards luncheon. He is currently the Executive Director of the California Water Foundation (CWF). Some key points he made include:

- California is in deficit spending when it comes to groundwater and is the only state without a groundwater management framework
- Currently there is a 6.6 million acre-feet deficit in water supplies, resulting in 5.1 million acre-feet of increased groundwater pumping; this 1.5 million acre feet shortage will cost the California economy an estimated $2.2 billion
- According to surveys done by the CWF, the drought is currently a bigger issue than jobs or the economy
- The willingness of the public to pay to fix the problem, per household per month, is: $4 (51%), $3 (59%), $2 (63%), $1 (67%).

Field tour participants look at Miraloma Basin, which has received only GWRS water since it was put into operation. It has sustained recharge rates of 10 ft/day with minimal clogging.

Best Student Poster Winner: Stephanie Uriostegui, UC Santa Barbara

Lester Snow gives keynote address at BSMAR 14.

During the second day of the symposium, there was a lunch-time panel discussion on the challenges and opportunities of using storm water for managed aquifer recharge. The first panelist, **Raina Fulton** from the US Army Corps of Engineers reviewed what it takes to use a Corps facility to capture storm water for recharge. This is something that Orange County Water District has been doing for years, but it is a long, challenging process. The second panelist was **Bruce Phillips**, Vice President of Storm Water Management Division, Pace Advanced Water Engineering. He presented the extensive work that Orange County did to evaluate the appropriate locations of infiltration Best Management Practices (BMPs), which are required in the Multiple Separate Storm Sewer System (MS4) permitting process. Examples of areas where infiltration BMPs would not work are those characterized by groundwater contamination, shallow groundwater, low-permeability soils, and high sewer infiltration. Finally, **Peter Dillon** of CSIRO Land and Water, Australia, presented the results of evaluating the cost and public acceptance of using storm water for potable supplies. His work showed that the cost of treating storm water for potable supply is relatively high compared to other sources, such as recycled water, because of the intermittent nature of stormwater runoff.

Two students were awarded $500 for the best poster presentation and best oral presentation. **Stephanie Uriostegui**, UC Santa Barbara, won best poster for her presentation of "Quantifying groundwater travel

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The 14th Biennial Symposium on Managed Aquifer Recharge – *Continued*

Mario Lluria and Sharon Megdal. Mario spearheaded the first BSMAR symposia in 1978. Sharon is the Executive Director of the Water Resources Research Center at the University of Arizona.

Adrianna Palma and Peter Dillon confer. Adrianna Palma of National Autonomous University of Mexico and Peter Dillon of CSIRO Australia will be involved in planning ISMAR 9/BSMAR 15 in 2016.

times near Managed Aquifer Recharge Facilities using a novel S-35 intrinsic tracer method." **Sarah Beganskas** of UC Santa Cruz won the best student oral presentation for her presentation of "Coupling Storm Water Capture and Managed Aquifer Recharge."

The GRA implemented some new features at this event. First, the event was essentially paperless. A printed program was provided, but the conference proceedings, which included all of the abstracts and speaker biographies, were provided to the attendees on a jump drive that was theirs to keep. Second, the abstracts and speaker biographies, as well as the conference schedule, was available over the internet via the "Guidebook" application. This free application could be downloaded to any mobile device, making this information available to any attendee. Third, we set up a dedicated text number that attendees could use to text the session moderator questions for the speaker in real time. This allowed for smoother question-and-answer sessions and maximized the discussion time. Be looking for some of these new features at future GRA events.

Storm Water Lunch Panel. From left to right, Peter Dillon, Adam Hutchinson, Bruce Phillips and Raina Fulton.

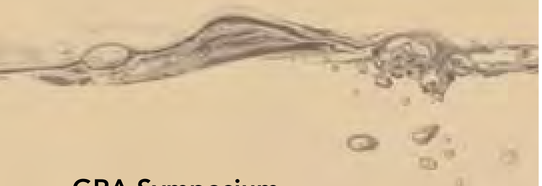
Tim Parker, GRA Board Member, and Adrianna Palma having some fun.

In closing, given the current drought situation in California, this conference could not have come at a better time. We are very good at extracting groundwater and are doing it at an unsustainable pace. However, we are not as good as replacing this water and putting it back into the ground. This conference brought together some of the best researchers and practitioners in MAR from around the USA and the world to discuss how we can do a better job of recharging our precious aquifers. Be sure to peruse the conference proceedings at GRA's website and we look forward to seeing you at the next GRA event.

Dates & Details

GRA EVENTS & KEY DATES

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



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

GRA Course
Principles of Groundwater Flow and Transport Modeling Course
Sept. 10-12, 2014 | Redwood City, CA

23rd Annual Conference and Meeting
Oct. 15-16, 2014 | Sacramento, CA

Board of Directors Meeting
Nov. 15, 2014 | Los Angeles, CA

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

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

23rd Annual Conference and Meeting

2014 – The Year of Groundwater

OCTOBER 15-16, 2014 – SACRAMENTO, CA

Cooperating Organizations: California Department of Water Resources, U.S. Geological Survey, California Department of Toxic Substances Control, International Association of Hydrogeologists

Co-Sponsors: California Water Foundation, GEI Consultants, Bookman-Edmonston Division

2014 is shaping up to be a landmark year in California's water history, and groundwater is the focus. As groundwater levels decline and the land surface subsides during one of the worst series of droughts the state has experienced, Governor Brown's administration is working to provide legislative and other support to local entities to improve groundwater management. Recent hearings held by the state on groundwater sustainability also indicate that industry associations, grower groups and the state are evaluating targeted efforts to preserve and protect local control over groundwater management, and also to allow for state intervention where local efforts are unsuccessful or nonexistent.

GRA's 23rd Annual Conference and Meeting will focus on this topic with targeted sessions on the administration's efforts, associated legislation, and perspectives of local entities. Session topics, primarily in dual-track format, include:

- Administration's Efforts to Improve Local Groundwater Management
- Drought – our Dependence on Groundwater
- Legislation, Policy & Legal Issues
- Collegiate Groundwater Colloquium
- Modeling Advances & Applications
- Wastewater Reuse & Recycling
- Groundwater Quality Monitoring Plans for Well Stimulation Treatment Pursuant to Senate Bill 4
- Climate Variability and Change – Simulation of Effects & Adaptation Strategies
- Regional-Scale Management of Groundwater Quality
- Site Assessment & Remediation
- Challenges in Local Groundwater Management
- Developing and Implementing Groundwater Management Plans to Preserve Local Control

For speaker and other information for each session, please see the agenda.

Student Activities & Opportunities

GRA seeks to increase participation by university and college faculty and students in its programming. The **Collegiate Groundwater Colloquium** features students who are conducting highly relevant research in the general area of the conference theme. Five exciting presentations have been arranged!

Student Poster Competition – we are seeking abstracts for student posters! Student poster presenters will be giving 1-minute flash presentations to share

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2014 – The Year of the Groundwater *– Continued*

their exciting research with conference attendees during the Colloquium, before the poster session. An award will be given to the best student poster. To submit a poster, please contact Jean Moran at jean.moran@csueastbay.edu.

Both **Colloquium** and **Student Poster Competition** participants are eligible for cash prizes. These events provide students with an excellent opportunity to showcase their research, and attendees an opportunity to learn from the frontier of groundwater science.

Hotel Information and Registration

http://www.hilton.com/en/hi/groups/personalized/S/SMFHIHF-GRA-20141014/index.jhtml?WT.mc_id=POG

Deadline for Discount Hotel Reservations is Sept 30th.

Sponsors & Exhibitors

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

Additional Information

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

Groundwater Resources Association of California presents

Introduction to Groundwater and Watershed Hydrology: Monitoring, Assessment and Protection

NOVEMBER 17-18, 2014 – DAVIS, CA

Co-Sponsor: University of California Cooperative Extension Groundwater Hydrology Program

Registration: www.grac.org/hydrologyreg

Course Description

Groundwater and watershed management, monitoring, assessment and protection is an integral part of many water-related programs at the local, state, and federal level designed for sustainable development and protection of water resources in California. Professionals, executives, and employees of diverse background and in a wide variety of private, non-profit, and government responsibilities at the local, state, and federal level are directly or indirectly involved in the management and assessment of groundwater and surface water, including the implementation of groundwater management plans, source water assessments, and integrated regional water management plans. Yet many participants find themselves lacking the multidisciplinary background, expertise, or means to meet the technical and regulatory challenges related to groundwater, water and drinking-water resources management. The amount of technical information available often seems overwhelming.

This shortcourse will review the fundamental principles of groundwater and watershed hydrology, water quality, and water contamination in an intuitive, highly accessible fashion. It will then provide an overview of the most common tools for measuring, monitoring, and assessing groundwater and surface-water resources. And it will review current local, state, and federal programs dealing with groundwater, groundwater management, and watersheds. The course is specifically geared towards an audience that is, or is planning to be, involved in the management, assessment, and protection of groundwater and water resources. Course attendees who may have some experience with, but no formal training in, hydrology or related engineering and science fields, will benefit from the basic and intuitive, yet comprehensive approach of this course.

Experienced instructors with broad in-depth knowledge of California groundwater and watershed hydrology will teach the course. Topics include:

- Surface Water Hydrology and Watersheds
- Groundwater Hydrology
- Water Rights and Water Law
- Surface Water Quality
- Groundwater Quality, Sampling, and Monitoring

Continued on the following page…

Introduction to Groundwater and Watershed Hydrology: Monitoring, Assessment and Protection – *Continued*

- Surface Water Contaminants
- Groundwater Contamination
- Defining Watersheds and Groundwater Recharge Areas
- Vulnerability Assessments
- Understanding Potentially Contaminating Activities
- Protecting Water Resources

Who Should Attend

This shortcourse is directed toward technical staff, consultants, and technical and management personnel in private and public water-supply companies, irrigation districts, water districts, local and state agencies, and in resource conservation districts. The course also serves as an excellent introduction to hydrogeology, water-resources assessment and monitoring for watershed advisors, watershed-group participants, and members of environmental and other stakeholder groups and citizens alliances.

Course Instructors, all from the Department of Land, Air, and Water Resources, University of California, Davis:

Randy A. Dahlgren, Ph.D., is a professor of Soil Science and Biogeochemistry. His research program in biogeochemistry examines the interaction of hydrological, geochemical, and biological processes in regulating surface and groundwater chemistry. He is currently chair of the Department of Land, Air, and Water Resources.

Helen E. Dahlke, Ph.D., is an assistant professor in Integrated Hydrologic Sciences. Her research focuses on contributing to a better mechanistic understanding of hydrological processes and their links to climate and biogeochemical cycling. Helen is currently managing a project that is exploring the feasibility of using agricultural fields as recharge sites for groundwater banking.

Thomas Harter, Ph.D., and his research group have done extensive modeling, laboratory, and field work to evaluate the impacts of agriculture and human activity on groundwater flow and contaminant transport in complex aquifer and soil systems, and to improve management of groundwater resources for agricultural production.

Samuel Sandoval Solis, Ph.D., focuses on designing sustainable water resource systems through shared vision water planning, collaborative modeling, decision support systems (simulation, optimization and hydrologic models), environmental restoration and conservation policies, risk analysis and climate change.

Continuing Education Credits

Continuing education credits are available for DHS Drinking Water Treatment and Distribution Operators (14 contact hours).

Additional Information

For more information, contact Sarah Kline at GRA, skline@grac.org or (916) 446-3626.

Wells and Words

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

Tools in the Hydrogeologist's field kit – Devices and Methods to Measure Pumping Rates

The pumping rate (volume of water per unit time) of a well is the *second most* important measurement that must be made in order to evaluate the long-term performance and hydraulic characteristics of the aquifer and the well; the *most* important measurement is water levels, as discussed previously[1]. Some of the more common units for pumping rates associated with water wells are gallons per minute (gpm), cubic feet per second (cfs), acre-feet per day (AFD), and liters per second (L/sec). Pumping rates can be measured using a variety of methods, including the following: (1) volumetric measurements; (2) circular orifice and pipe; (3) rectangular or v-notch weirs; (4) flumes; (5) weir tank[2]; (6) mechanical, electro-magnetic, and other in-line commercial flow meters – even with micro-chip technology to download stored long-term and temporal data; (7) discharge from a vertical (flowing artesian wells), horizontal, or inclined pipe; (8) orifice buckets; (9) current meters; (10) variable-area flow meters; (11) differential pressure meters; and (12) pitot tubes and venturi meters[3]. Many of these methods are more practically applied to dynamic field situations (i.e., during well development and formal pumping tests) than to static situations[3] (i.e., production-well pumping and consumer/customer usage); this article will focus on the former situations. A good and succinct discussion on many of these field methods is provided by Anderson[4,5]. Figure 1 shows some of the field devices that are used.

Pumping rates (Q) or discharge measurements are based on a volume (V) of water per unit time (t), or the velocity (v) of the water times the cross sectional area (A). Various physical properties, including the Reynolds (Re) number (turbulent or laminar flow), viscosity (varies with temperature from 1.79 centipoises at 32 °F to 0.85 centipoises at 80 °F)[6], density (essentially 1 g/cm3 at 60 °F)[4], and the friction coefficient of the pipe, can affect Q, and the estimate of Q from some of these devices. Note that elevated turbidity and/or total suspended solids (TSS) can increase the density of pumped water during well development, which can affect both the estimated Q and water-level measurements.

A very simple volumetric method involves measuring the time it takes to fill a container of known volume (Figure 1A). Typically, a 5-gallon (gal) bucket is an excellent tool for measuring Qs of less than 100 gpm (3 seconds to fill a 5-gal bucket); flows exceeding 100 gpm are difficult to obtain and require more accurate time pieces. Note that a full 5-gal bucket is typically greater than 5 gals (can be close to 6 gals). Very low flow rates can be measured using a graduated beaker, cylinder, or baker's measuring cup. Sometimes 55-gal drums are used, but are unwieldy because of the weight of the water when full (about 460 lbs). Large, graduated water-storage tanks are also used, provided they have been calibrated and/or the shape of the tank has straight or uniform sides, which allow estimation of Q from standard volume formulae[4].

The orifice and pipe method (Figure 1b) is one of the most favored methods of the author for measuring Q because there are no mechanical parts that can clog or jam, especially during well development. The photo above shows the author using this method to measure Q during a pumping test in San Bernardino County while inspecting the

water using an imhoff cone to check for TSS content and to visually assess the turbidity.

The orifice and pipe method consists of a 6-foot-long pipe, that must be level, and a machined circular orifice that is located at the end of the pipe. Various orifice sizes and pipe diameters can be used for a wide range of Qs from less than 75 gpm to greater than 1,600 gpm. A clear glass or plastic piezometer tube is located 2 feet upstream from the orifice and must be tapped into the center of the side of the pipe to measure the back pressure caused by the orifice[7,8]; the pipe must be full of water to correctly operate. A measuring tape is placed next to the piezometer tube to measure the height of water above the center of the pipe. Tables are used to estimate Q from the height measurement, pipe diameter and orifice diameter. This method is accurate to within 2% if properly done.

Mechanical flow meters are also often used to measure Q (Figures 1C and 1D). Flow meters must be calibrated for accuracy; at low Q, this can easily be done using volumetric measurements; at high Q, a testing laboratory is needed. During well development, the impellers of the meter may wear down

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Wells and Words – *Continued*

from abrasion by silts and sands that are discharged from the well and produce faulty readings. Mechanical flow meters come in a variety of sizes that range from 1 or 2 gpm to 1,000's of gpm; often they include an odometer-type cumulating meter that provides the total volume of water that passes through the meter. Pay special attention to the volumetric units stamped on the meter and record the meter numbers prior to initiating a pumping test. In addition, there may be a multiplier (typically 10 or 100) on the odometer setting to record the actual volume of water discharged. Many in-line meters have a sweep second hand that can be used to estimate the instantaneous Q. The sweep second hand needle can be used to measure the time it takes to move between two volumetric tick marks on the dial face of the meter.

There are numerous types of meters and measuring methods that vary in accuracy, ease, and speed of use. Field persons with experience, creativity, and versatility can facilitate a successful well development and pumping test program using any one of these various methods and devices.

[1] Abbott, David W., Summer 2014, Wells and Words, *HydroVisions*, a publication of the Groundwater Resources Association of California.

[2] Brassington, Rick, 2007, *Field Hydrogeology*, John Wiley & Sons, LTD, West Sussex, England, 264 pages.

[3] American Water Works Association (AWWA), 1986, *Water Meters - Selection, Installation, Testing, and Maintenance*, AWWA Manual M6 (Third Edition), published by AWWA, Denver, CO, 100 pages.

[4] Anderson, Keith E., 1984, *Water Well Handbook* (Fifth Edition), Missouri Water Well & Pump Contractors Association, Inc., Belle, MO, 281 pages.

[5] Anderson, Keith E., 1993, *Groundwater Handbook*, National Groundwater Association, Dublin, OH, 401 pages.

[6] Weast, Ph.D., Robert C., 1970, *Handbook of Chemistry and Physics*, The Chemical Rubber Company, Cleveland, OH.

[7] UOP, 1975, *Ground Water and Wells*, Johnson Division, UOP Inc., Saint Paul, MN, 440 pages.

[8] US Department of the Interior Water and Power Resources Service, 1981, *Ground Water Manual: A Water Resources Technical Publication*, John Wiley & Sons, New York, 480 pages.

[9] Helweg, Otto, Verne H. Scott, and Joseph C. Scalmanini, 1984, *Improving Well and Pump Efficiency, American Water Works Association*, Denver, CO, 158 pages.

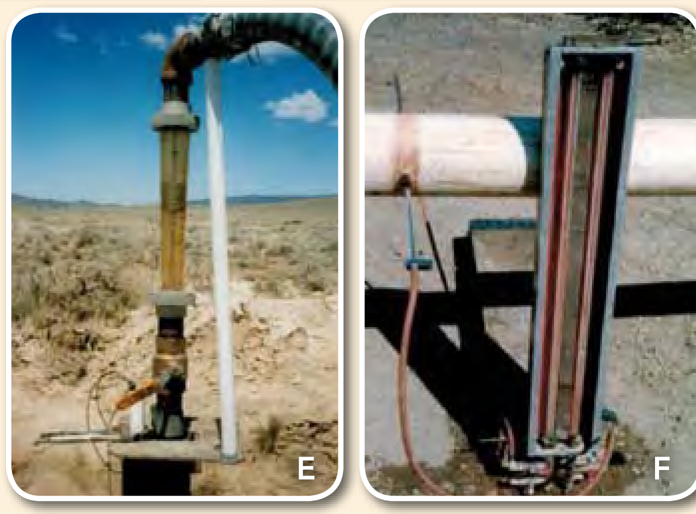

Figure 1: Various discharge measuring devices: (A) 5-gallon bucket and stop watch – Mulegé, Baja California Sur, Mexico; (B) Pipe and circular orifice – Sumner, WA; (C) in-line flow meter – Petaluma, CA; (D) in-line flow meter – Livermore, CA; (E) variable area flow meter – Minden, NV; and (F) differential pressure flow (velocity probe[9]) meter using Pitot tubes and manometer – Healdsburg, CA.

Legislative Update

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

After working to pass another on-time, balanced budget that included some reduction in the State's ongoing debt and money set aside in a rainy day fund, the Legislature adjourned for Summer Recess at the beginning of July. Upon their return, on August 4th, a bevy of bills await their action and must be passed by August 31st, when the Legislature adjourns for the year.

The composition of the Legislature will be different at the start of the 2015-16 Legislative Session, following the November 4th General Election. The newly composed Legislature will begin its work on January 5, 2015.

Water, including the ongoing drought, continues to dominate discussions throughout the Capitol. With some community water supplies running critically low and the threat of an unprecedented wildfire season, Legislators from every district are grappling with water issues. There has also been a substantial focus on groundwater, under the leadership of the Governor's office. More details on the groundwater discussions are below.

Sustainable Groundwater Management

As GRA members read in the summer Legislative Update, there was a push from the Administration to get feedback and recommendations from stakeholders to help them craft legislation to sustainably manage groundwater in California. GRA submitted comprehensive recommendations, in early May, which can be viewed here.

GRA and the California Groundwater Coalition advocated against passing comprehensive groundwater management legislation as part of the 2014-15 state budget, due to the complexity of the issues and time needed for discussion. Consequently, the Governor did not include a substantive groundwater management proposal in his May Revision Budget; instead, he expressed his commitment to passing legislation by the end of August, when the Legislature adjourns. He also indicated willingness to work through the summer to allow for more stakeholder input and discussions.

At this point there are two groundwater bills moving through the Legislature—AB 1739 (Dickinson) and SB 1168 (Pavley)—and a proposal from the Governor, which can be viewed here. The authors of both bills have committed to working together to avoid competing bills. AB 1739 is the Association of California Water Agencies' (ACWA) proposal and SB 1168 includes the California Water Foundation's proposal.

As part of the commitment from these authors and the Governor's office to work together and with all of the stakeholders, they jointly held Groundwater Legislative Stakeholder Meetings throughout the month of July. Meetings were held on July 2nd, 10th and 16th; additional meetings may be held during the week of July 28th, after this article was written. Senator Pavley and Assemblymember Dickinson, or their staff, were present at these meetings, along with Martha Guzman-Aceves, Deputy Legislative Affairs Secretary to Governor Brown, and staff from the Governor's Office of Planning and Research, the Environmental Protection Agency and the Department of Water Resources.

The meetings were run by a facilitator who provided stakeholders an opportunity to speak and answer specific questions provided the day before the meeting. At the time of writing, it is expected that AB 1739 and SB 1168 will be amended when the Legislature returns on August 4th to include the same bill language, and that subsequent amendments will be taken throughout August with the goal of sending a bill to the Governor by August 31st. GRA's Legislative Committee and Legislative Advocates are working hard to stay up to date on the bills and related discussions, and will continue to do so throughout August.

GRA Supported/Opposed Legislation

***AB 2189 (Garcia)* –** Requires the replenishment assessment now imposed by the Water Replenishment District of Southern California (WRD) to be based upon the proportion of costs actually incurred by the operator of a groundwater well instead of the costs associated with replenishing and maintaining water quality in the groundwater basins. This bill would also prohibit the WRD Board of Directors from imposing a replenishment assessment if there is a majority protest. GRA took an "Oppose" position on this bill. Status: AB 2189 was held on the Assembly Appropriations Committee's suspense file and is now dead.

***AB 1739 (Dickinson) and SB 1168 (Pavley)* –** As discussed above, these are the two groundwater bills moving through the Legislature. Given that the bills will be substantially amended, GRA has taken a "Support in Concept" position on both bills, and identified 14 essential issues that need to be addressed. Both letters and the essential issues can be found here. Status: both bills are awaiting hearings in the Appropriations Committees of both houses.

More information on all of these bills can be found at: http://leginfo.legislature.ca.gov/.

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Legislative Update – *Continued*

Water Bond

As of this writing, the $11.14 billion water bond that was passed by the Legislature in 2009 will still be on the November 2014 ballot. The Legislature has been working on alternative bond proposals all year. One of the main proposals has been SB 848 (Wolk), which was taken up on the Senate Floor on June 23rd, and at the time was a $10.5 billion bond. SB 848 failed passage on the Senate Floor but was granted reconsideration.

After the failure of SB 848, Governor Brown engaged on the issue for the first time this year, expressing to the Legislative Leaders that he does not want a water bond to exceed $6 billion. Subsequently, Senator Wolk amended SB 848 to reduce the amount to $7.5 billion and Speaker Atkins has stated publically that the Assembly's proposal is $8.25 billion. The Assembly has not yet put their proposal in print.

Given that both the Assembly and Senate versions are significantly higher than the Governor's $6 billion limit, there is expected to be ongoing negotiations to reach a compromise that can be placed on the November ballot, replacing the 2009 bond. If a compromise cannot be reached, the 2009 bond can stay on the November ballot or the Legislature can once again postpone it.

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 will assume office on October 15th. Additionally, Assemblymember Toni Atkins was sworn in as Speaker of the Assembly on May 12, 2014. She succeeds Assemblymember John A. Pérez who is also termed out this year. With Assemblymember Atkins taking over as Speaker, Committee Chairs and Members may change as soon as August, and again after the November election. Committee changes in the Senate are not expected prior to the Legislature adjourning on August 31st, but changes may occur after Senator De León takes over and will certainly occur after the November election.

Appointments

In July, the Governor re-appointed Andrew Ball, Joseph Byrne, Daniel Curtin, Jose Del Bosque, Jr., Kimberly Delfino, Luther Hintz and Anthony Saracino to the California Water Commission. Additionally, the Governor made one new appointment to the Commission, Armando Quintero.

Armando Quintero has been director of development at the University of California, Merced Sierra Nevada Research Institute since 2008. He was an independent environmental educator from 1998–2008 and held multiple positions at the U.S. National Park Service from 1977–98. Quintero is president of the Marin Municipal Water District Board of Directors and is a member of the Los Cenzontles Mexican Arts Center Board of Directors. This position requires Senate confirmation.

Also in July, Governor Brown announced Mariano-Florentino Cuéllar as his choice for associate justice of the California Supreme Court to fill the vacancy created by the retirement of the Honorable Marvin R. Baxter. Cuéllar has been a Stanford Law School professor since 2001 and was appointed Stanley Morrison Professor of Law in 2012. The full announcement of his appointment can be found here.

Looking Ahead

As has been true to this point, 2014 has been, and will continue to be, a very important year for water and groundwater. Given the drought, dwindling surface-water supplies, increased groundwater pumping, and a proposed Water Bond, the Administration and Legislature will continue to focus on the management of California's water resources, including how to sustainably manage our groundwater statewide. As the legislative session winds to a close, GRA's Legislative Committee and its Legislative Advocates will continue to track the Water Bond bills, actively participate in the groundwater stakeholder discussions and monitor all remaining issues and legislation important to GRA. Throughout this process, GRA will continue to be a key source of information and sound science for Legislators and the Administration.

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The Federal Corner

By Jamie Marincola, U.S. EPA

Climate Change Adaptation Technical Fact Sheet

EPA's Superfund Program has undertaken efforts to identify potential impacts of climate change on site remediation projects and to identify adaptation strategies. As part of this effort, EPA has developed a fact sheet that addresses contaminated site remedies involving landfills and source containment systems. The fact sheet is intended to serve as an adaptation planning tool by both providing an overview of potential climate change vulnerabilities and presenting possible adaptation measures that may be considered to increase a remedy's resilience to climate change impacts. To learn more about climate change adaptation in the Superfund Program, visit http://www.epa.gov/superfund/climatechange.

New Report Details Land-Subsidence Trends in Coachella Valley

While most of the Coachella Valley has been relatively stable since 1995, land surfaces declined about nine inches to two feet in some areas of Palm Desert, Indian Wells, and La Quinta. An important recent exception was observed in La Quinta where groundwater levels have stabilized and risen, and the rate of land subsidence substantially decreased after groundwater replenishment systems were installed in 2009, according to a new scientific report published by the U.S. Geological Survey and the Coachella Valley Water District. The positive trend in La Quinta was detected in the vicinity of CVWD's Thomas E. Levy Groundwater Replenishment Facility that replenishes groundwater using Colorado River water. To read more, visit: http://ca.water.usgs.gov/news/2014/CoachellaSubsidence.html.

Ditch the Myth

In response to concerns over their proposal to protect clean water, U.S. EPA and the U.S. Army Corps of Engineers are providing clarifications on how their proposed rule cuts through red tape to make normal farming practices easier while also ensuring that waters are clean for human health, communities, and the economy. The proposed rule—also known as the "Waters of the U.S." rule—clarifies protection under the Clean Water Act for streams and wetlands that form the foundation of the nation's water resources. To read the facts about the proposal, please visit: www.epa.gov/ditchthemyth.

USGS Finds Large Rivers in U.S. are Becoming Less Acidic

Several large rivers in the U.S. are less acidic now, due to decreasing acidic inputs, such as industrial waste, acid mine drainage, and atmospheric deposition. A USGS study showed that alkalinity, a measurement of a river's capacity to neutralize acid inputs, has increased over the past 65 years in 14 of the 23 rivers assessed in the U.S. The study, published in the journal Science for the Total Environment, can be found here: http://www.sciencedirect.com/science/article/pii/S0048969714005646. For more information on USGS long-term water-quality monitoring, please visit: http://water.usgs.gov/nawqa/.

EPA Kicks Off Third-Annual Campus RainWorks Challenge

EPA is launching its third-annual Campus RainWorks Challenge, a prize contest that engages college students in developing innovative green infrastructure systems to reduce stormwater pollution and build resilience to climate change. Through Campus RainWorks, teams of undergraduate and graduate students, working with a faculty advisor, develop a proposed green infrastructure project for their campuses, showing how managing stormwater at its source can benefit the community and the environment. Registration for the 2014 Challenge opens Sept. 2 and ends Oct. 3. Registrants must submit their entries by Dec. 19. EPA will announce winning entries in April 2015. More information can be found here: www.epa.gov/campusrainworks.

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.

Multimedia is the Message

By Bart Simmons

One of my first complicated encounters with multimedia issues was with a proposed South Coast Air Quality Management District (SCAQMD) rule that essentially banned the use of hydrocarbon solvents in vehicle repair shops. The intent was, of course, to reduce emission of compounds which could produce photochemical smog. Other issues involved were: (1) worker exposure to methylene chloride, which some workers would spray into the aqueous parts cleaner in the hope it would improve cleaning effectiveness; (2) disposal of spent aqueous parts cleaner as wastewater; and (3) potential hazardous waste classification for the spent aqueous cleaner. The publicly owned treatment works in this case indicated that the discharge could cause them to exceed their effluent criteria, particularly Methylene Blue Active Substances (MBAS). In addition, contaminated parts cleaner could meet the criteria for hazardous waste. Nevertheless, the rule was adopted. The lesson for me was that multimedia considerations are important, but they can be complicated.

Many problems benefit from a multimedia approach, for example: radon (drinking water, soil, indoor air); organophosphate pesticides (diet, local applications); and solvents for plastic pipe (drinking water, air, skin absorption). Biomonitoring can measure total chemical dose, e.g. pesticides from several media. MTBE should have had a better multimedia analysis prior to its use as a fuel oxygenate (groundwater, air). The MTBE multimedia problem also revealed a lack of communication among regulators, testing laboratories, and industry.

The Air Resources Board recently adopted a regulation that forced diesel truck drivers to install filters for diesel particulate emissions. Truckers opposed the rule, as it increased the cost of operation. The issues included: (1) improvement in air quality through removal of diesel soot, which has been identified by OEHHA as a carcinogen; (2) potential exposure to workers during the high-temperature filter cleaning process; (3) potential wastewater problems if the dust is discharged into wastewater and (4) potential hazardous waste issues if the dust is trapped in oil and the oil is mismanaged.

Multimedia fate models (MFMs) are now available to predict the fate of chemicals in several compartments. Multimedia issues may need to be multinational as well. The Canadian government used a MFM for chlorobenzene sources only to find that chlorobenzene drifting from the U.S. overwhelmed the predictions for local sources.

As we attempt to create sustainable environmental systems in a world with limited clean water, the multimedia concerns are likely to multiply. It will take environmental professionals who are proficient in many media to make decisions, which often include difficult tradeoffs.

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Evaluating the Impact of Groundwater Pumping on Meadow Hydrology and Streamflow in the Yosemite Valley

By Nicholas Newcomb, UC Davis and Luhdorff & Scalmanini Consulting Engineers

Introduction

Yosemite National Park is one the best known parks in the United States receiving over 3.7 million visitors annually. Concerns over user impact have resulted in a number of court decisions aimed at more effectively quantifying and mitigating environmental impacts on the Park's natural resources. As part of a 2009 court settlement, the National Park Service agreed to complete a revised Comprehensive Management Plan for the Merced River to fulfill the requirements of National Environmental Protection Act and Wild and Scenic Act (United States District Court, 2009). In order to achieve this goal, the Park has engaged in a number of studies aimed at guiding conservation and planning on the Merced River. The goal of this work is to evaluate the impacts of groundwater pumping on the Merced River and shallow groundwater hydrology in the Yosemite Valley.

Hydrogeologic Framework

The Yosemite Valley is a deep valley characterized by high (1000 m) granitic walls located in the central part of the Sierra Nevada (Figure 1). Though fluvially derived, the valley was further deepened through glacial scouring, abrasion, and plucking during early, large-scale Sierran glaciations approximately 750 thousand years ago (kya) (Sharp, 1968; Huber, 1987). Originally thought to have been deepened to 100–200 meters below the current valley bottom (Matthes, 1930), later geophysical studies (Gutenberg et al., 1956) suggest that the depth to bedrock is up to 600 meters below the current topography.

Figure 1: Location of project area in the Yosemite National Park.

The subsurface sedimentary geology of the Yosemite Valley is largely uncharacterized. However, it is generally accepted that the bulk of the valley fill is the product of deposition from advancing and receding ice sheets during successive glaciations (Matthes 1930; Gutenburg, 1956; Huber, 1987). Boring logs and previous geologic investigations indicate that unconsolidated deposits in the Yosemite Valley can be categorized into at least two aquifer systems separated vertically by a confining layer composed of silt and/or clay deposited in a proglacial lake approximately 16 kya (Figure 2). Though the continuity and extent of the confining layer are largely unknown, it is presumed that the proportion of fines tends to decrease near the maximum extent of the lake described by Matthes (1932) and Huber (1987), likely upstream of the Tenaya Creek confluence.

Groundwater pumping in Yosemite Valley provides up to 200 million gallons of water annually to serve the operational needs of the Park. During

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Evaluating the Impact of Groundwater Pumping on Meadow Hydrology and Streamflow in the Yosemite Valley – *Continued*

peak operation in the months of July through September, pumping from the three production wells near Yosemite Lodge can reach up to 700,000 gallons per day (Water Records 2004–2007). Existing data show that average daily abstraction from supply wells can reach up to 5% of the daily Merced River discharge at Pohono gage located downstream of the pumping wells.

Direct precipitation and infiltration of snowmelt recharges the shallow and deep aquifer systems during the winter and spring. Stream recharge from the Merced River and smaller tributary streams is potentially large during spring, when snowmelt in the upper watershed generates significant runoff, but likely declines as Merced River flow decreases and smaller streams run dry. Groundwater in the Yosemite Valley aquifer system is also replenished by lateral subsurface flow from the upper watershed to the east and adjacent fractured rock system (Conklin and Liu, 2008). Discharge occurs through lateral subsurface flow out of the valley to the west and through evapotranspiration (ET).

Figure3: (Top) Map of project area showing locations of piezometers, stream gages and boundary conditions assigned in the numerical model. (Bottom) Nested grid refinement in the area near production wells (not shown).

Field Monitoring

Water levels were monitored from the 3 production wells, 12 shallow piezometers and 3 stream stage recorders from fall 2010 through the summer of 2013 (Figure 3). Early efforts in the fall of 2010 focused largely on evaluating whether groundwater pumping produced immediate water-table changes or stream depletion in the Merced River or Yosemite Creek. Subsequent monitoring conducted through September 2013 was done to gather additional water-level data used to evaluate whether pumping led to substantive longer-term impacts over months or years; the latter monitoring period did not include monitoring of pumping wells.

Results from field monitoring generally indicate that groundwater pumping does not have a significant short-term impact on the water table and stream flow (Figure 4). Potential short-term effects are obscured by "blow-off" water from production wells, which is routed to the land surface during the early portions of groundwater pumping to reduce turbidity. Despite this, water-level changes appear to be more influenced by diurnal variations in plant water use and precipitation events than groundwater pumping (Figure 4). Longer term impacts of pumping through the summer and fall are difficult to discern from the water-level data. Though the majority of piezometers appear to

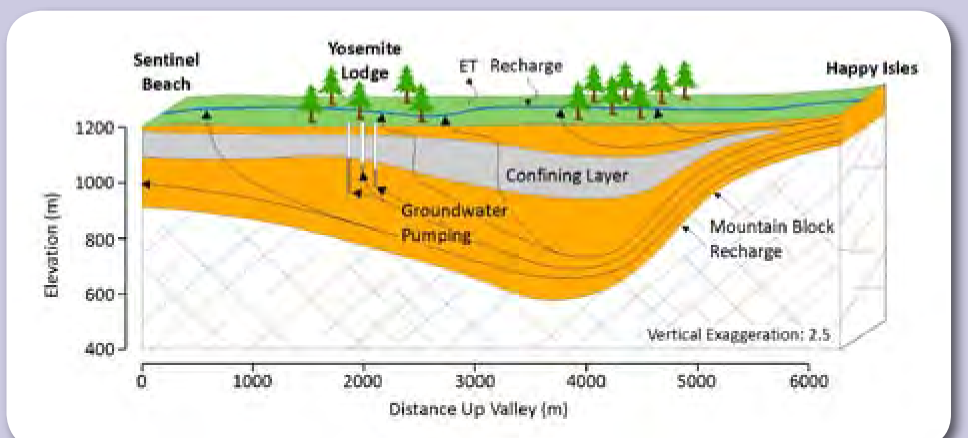

Figure 2: Conceptual hydrogeologic model of the Yosemite Valley illustrating hydrologic processes including evapotranspiration, mountain-block and distributed recharge, stream-aquifer interaction, and groundwater pumping.

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Evaluating the Impact of Groundwater Pumping on Meadow Hydrology and Streamflow in the Yosemite Valley – *Continued*

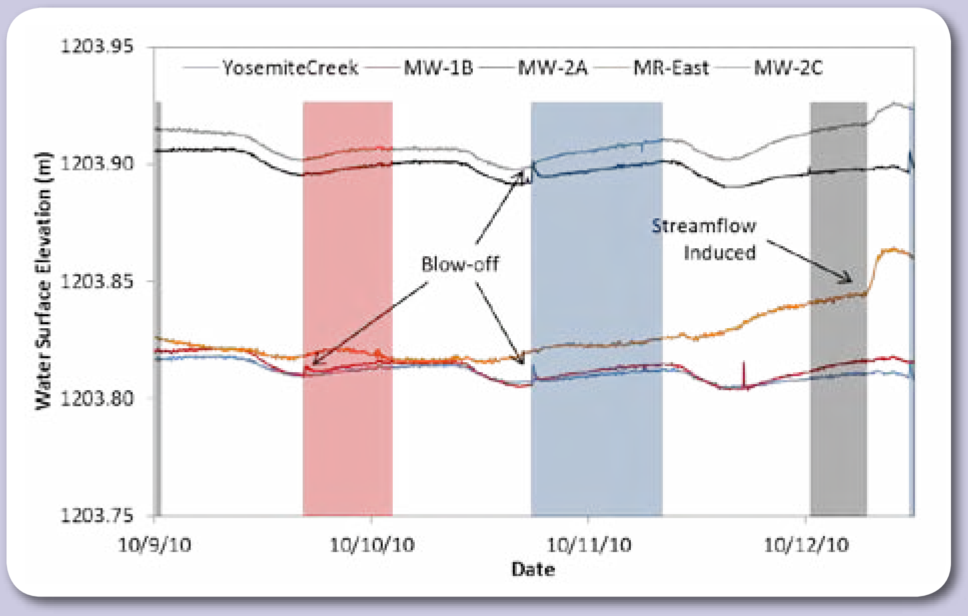

Figure 4: Observed effects of groundwater pumping from Well #1 (red), Well #2 (blue), and Well #4 (gray) at near-well piezometers and stream stage recorders. Hydrographs illustrate the impact of both "blow-off" from pumping wells, diurnal ET, and precipitation which are the dominant short-term factors affecting water levels.

be largely controlled by stream flow in Yosemite Creek and the Merced River, hydrographs from piezometers farther from the river appear to show more divergence during the summer and fall, which might be due to groundwater pumping.

Numerical Model

A transient conceptual groundwater model of the project area was developed to gain insights on important hydrologic processes and interactions in the Yosemite Valley and better evaluate the role longer-term pumping (over weeks or months) may have on streamflow and the water table. The model was developed using the code MODFLOW-USG developed by the USGS (Panday et al., 2013). A 5 km by 2.6 km portion of the Yosemite Valley was selected as the groundwater flow model domain (Figure 3). The domain was discretized into 20 m x 20 m cells and 8 model layers. In the area around the pumping wells, the grid was refined into 5 x 5 meter cells to better simulate well hydraulics and the interaction of groundwater and surface water near the production wells (Figure 3).

Lateral groundwater flow in and out of the domain was represented using a general-head boundary condition (Figure 3), which allows for flow across the boundary on the basis of the hydraulic gradient and an assigned conductance. A general head boundary with relatively low conductance was used to represent flow from fractured rock systems to the north and south. Streams were simulated using the SFR Package using an 8-point cross section to represent channel geometry (Prudic et al., 2004). Estimates of recharge and ET were made from available climate and vegetation data and applied to the model. Daily groundwater pumping from each of the three production wells was estimated from records available through the Park's SCADA system and assigned to the confined aquifer using the WEL Package.

A period from June 2012 through September 2013 discretized into daily stress periods was selected for model calibration. The model was calibrated to average daily water levels from the 12 piezometers in the unconfined aquifer. Calibration was achieved by a combination of trial-and-error adjustments and parameter estimation using UCODE-2005 (Poeter et al., 2005). Model results and computed fit statistics show a reasonable agreement between simulated and observed hydraulic heads in the unconfined aquifer (Figure 5). Model limitations stem from the amount, diversity, and distribution of available data used to constrain boundary conditions and in model calibration.

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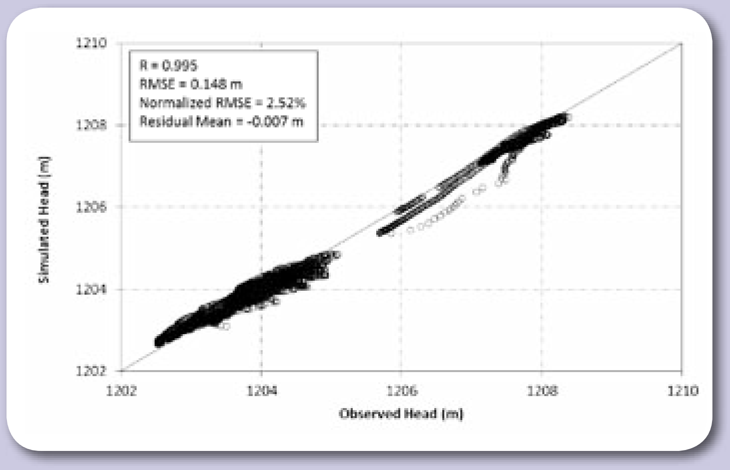

Figure 5: Simulated vs observed hydraulic head in the unconfined aquifer.

Evaluating the Impact of Groundwater Pumping on Meadow Hydrology and Streamflow in the Yosemite Valley – *Continued*

Simulated Impact of Pumping

The impact of pumping on shallow groundwater and stream-aquifer interaction was examined using the calibrated conceptual numerical model. Pumping effects were quantified by comparing output between the calibrated model and an otherwise identical scenario in which no groundwater withdrawals were simulated. The differences with respect to heads are expressed as drawdown from pumping; those with respect to streamflow are expressed as stream depletion from pumping.

In the model, pumping effects are propagated through the confining layer over time. Drawdown from pumping is most pronounced in the western portion of the model domain and is generally greater during the summer and fall. Water-table effects are also much greater farther from the stream, suggesting that the Merced River significantly mitigates the water-table response to pumping. In general, the simulated impact on meadow hydrology in the valley due to groundwater pumping is small. The average maximum drawdown calculated over all meadows in the model domain is 0.18 meters. In part, this is attributed to the distribution of meadows in the valley, which are located predominantly near the Merced River, where impacts tend to be smaller. Meadows located in the eastern portion of the model domain (east of Awhanee Hotel) are also minimally impacted, with measured drawdown generally less than 5 cm. In the western part of the domain, results within mapped meadows show a greater decrease in groundwater levels due to pumping. In some isolated areas farther from the stream, the model shows drawdown exceeding 0.5 m (Figure 5).

Pumping impacts on simulated streamflow in the Merced River are also relatively small over the simulation period, ranging from 900 m^3/day (0.37 cfs) in the spring to 1,200 m^3/day (0.49 cfs) in the fall. Since stream depletion in the Merced River is somewhat constant regardless of flow in the river, the ecological impacts of groundwater pumping on the river are likely correlated with river discharge. Climate research predicts an earlier onset of snowmelt resulting in potential decreases in summer flows in western streams, indicating that the impacts of groundwater pumping will likely be greater in the future (Dettinger and Cyan, 1995; Stewart, et al., 2004).

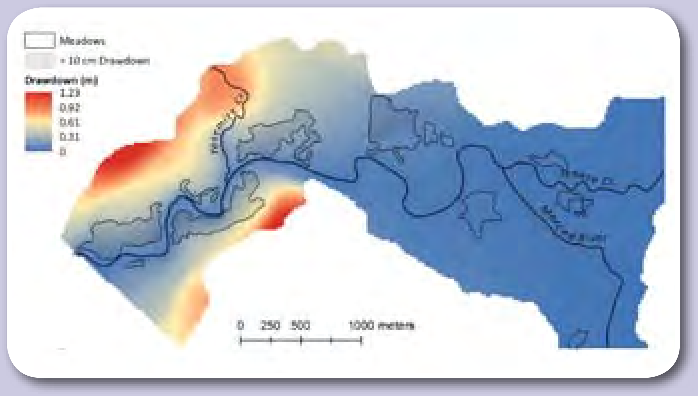

Figure 6: Simulated difference in water table between the pumping and no-pumping models on 10/15/2012.

Conclusions

Both field monitoring and numerical modeling indicate that the impact of groundwater withdrawals on the hydrology of the Yosemite Valley is fairly modest. Though field monitoring suggests that the immediate effects of pumping on the unconfined aquifer are likely mitigated by a confining layer, numerical modeling reveals that over longer time scales pumping effects are propagated to the water table. However, the simulated impact of pumping on the water table in meadows is generally small and buffered by the Merced River, which stabilizes water levels. Simulated stream depletion from pumping is also small, although this impact will likely grow as climate change brings earlier spring snowmelt and hence lower summer flows.

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GRA Council Considers the Future of Groundwater Management

By Vicki Kretsinger Grabert, GRA Director – Luhdorff & Scalmanini, Consulting Engineers
Thomas Harter, GRA Director – University of California Davis
Tim Parker, GRA Director – Parker Groundwater
with contributions by Reid Bryson – Luhdorff & Scalmanini, Consulting Engineers

On May 13, 2014, the Groundwater Resources Association of California (GRA) and the UC Davis Robert M. Hagan Endowed Chair hosted the GRA Contemporary Groundwater Issues Council (GRA Council)[1], a group of nearly 40 leaders in groundwater science, policy, management, use, economics, and regulation. The meeting followed the release of three sets of comprehensive recommendations on groundwater management reform in California from the Association of California Water Agencies (ACWA), from a broad stakeholder steering committee facilitated by the California Water Foundation (CWF), and from GRA.

The GRA Council is tasked with providing feedback on important groundwater issues, which GRA leadership uses in planning future conferences, webinars, and workshops, and in reaching out to the legislature through its legislative liaison committee.

Given the increasing public focus on water as California's drought continues for a third year, and given the Brown administration's and legislature's strong interest in moving groundwater management into the 21st century, the Council's focus this year was to engage in the ongoing groundwater management discussion. **Martha Guzman-Aceves**, Deputy Legislative Secretary for Environment, Energy, Water and Agriculture in the Brown administration, **Andrew Fahlund**, Deputy Director of CWF, **Tim Parker** of Parker Groundwater, and **Valerie Kincaid**, attorney for O'Laughlin and Paris LLP, offered perspectives from the Brown administration, from CWF's stakeholder group, from GRA, and from a legal point of view, respectively. The dialogue with this distinguished panel, facilitated by the Center for Collaborative Policy, provided the basis for an ad hoc brainstorming session around three topics:

- Success stories and impediments for local groundwater management
- Effective metrics for meeting basin management objectives at the local or state level
- Data management and information sharing

Note: A version of the GRA Council recommendations was previously published in the California Water Blog, http://californiawaterblog.com/2014/06/22/modernizing-californias-groundwater-management/

Martha Guzman-Aceves updated the GRA Council on the Governor's efforts to support improved groundwater management. She noted that requests for technical assistance to facilitate local groundwater management were a common point amongst responses to the Governor's Water Action Plan. In response, the state budget May Revise proposal included multi-year general fund allocations for the Department of Water Resources to support local and regional groundwater management agencies. Funds would be used to provide guidance and tools to local and regional groundwater managers for data collection, management plan preparation, groundwater basin assessments, water budget development, and governance structure development. Ms. Guzman-Aceves also noted the Brown administration's efforts to develop groundwater management legislation, with a focus on facilitating local agencies' assumption of management authority. She reiterated the Governor's intent that input from the public and stakeholder groups guide any legislative effort to reform groundwater management, particularly in the development of a state backstop for cases where local or regional management efforts fall short.

Valerie Kinkaid provided a review of the many unanswered questions accompanying proposals for groundwater management reform. Areas of uncertainty include the identification of suitable management entities, the scope and content of future management plans, and the grounds for state intervention if local management efforts fail. Although DWR Bulletin 118 subbasins may serve as the starting point for geographically delineating management authority among local entities, Ms. Kinkaid noted the uncertainties that will arise in situations where multiple local management agencies are active within a subbasin or, conversely, in subbasins where no local agency steps forward to assume management responsibilities. Regarding management plans, Ms. Kinkaid acknowledged questions about schedules and processes for data collection, coordination amongst local entities, schedules for management plan implementation, and the extent to which the state would be able to hold local agencies accountable for management plan implementation. Other questions relating to management plans include the extent of coordination with land-use planning and the availability of state funds for local management plan implementation. Ms. Kinkaid proposed a summary framework for a state backstop in cases where

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GRA Council Considers the Future of Groundwater Management *– Continued*

either no local groundwater management plan is developed, where a local plan is determined to be insufficient, or where a local plan is developed but not implemented. A common theme among the proposed framework was for the state to play a constructive and supportive role, and assuming management authority or issuing regulatory orders only as a last resort. She noted the limitations of existing standards and statues, including the Public Trust Doctrine, as sources of state enforcement authority and proposed that Water Code section 2100 or an amended Water Code section 10750 could provide a basis for enforcement.

Andrew Fahlund reviewed the California Water Foundation's (CWF) groundwater management recommendations and the approach used to develop them. With funding from private philanthropists and encouragement from the Brown administration to engage a diverse group of stakeholders, the CWF conducted a process to identify a subset of issues where consensus is possible and develop recommendations on those issues. The result is a comprehensive set of recommendations spanning the adoption of a statewide definition for sustainable groundwater management to providing funding for groundwater management implemented by local agencies. Mr. Fahlund also reviewed the CWF's proposed timeline for the implementation of new groundwater management measures. The timeline includes up to four or five years after the passage of new legislation for development of groundwater management plans with milestones and compliance targets; milestones and compliance targets would begin 5 years after passage, and 20 years would be allowed to attain sustainability. He noted several areas of discussion relative to any revised groundwater management efforts, including the extent to which recovery will be required in overdrafted basins and the fate of so called "white spaces" within groundwater basins that lie outside of management area boundaries that local agencies might choose.

Tim Parker followed with an overview of GRA's groundwater management recommendations. These include support for adopting the U.S. Geological Survey's definition of groundwater sustainability, from Circular 1186. The GRA recommendations also support building on the CASGEM basin/subbasin prioritizations to account for hydrogeological and watershed boundaries, fractured-rock aquifers, and boundaries of existing, functional groundwater management efforts. Overall, Mr. Parker noted several areas of agreement between the recommendations of the California Water Foundation, Association of California Water Agencies, and GRA, including the need for a state backstop with respect to local groundwater management efforts and in removing impediments to groundwater recharge and conjunctive use projects. With respect to the state's role in future groundwater management areas, the GRA recommendations go beyond those of the CWF and ACWA to call for the development of brief corrective-action work plans by DWR for basins and subbasins with documented sustainability issues and improved coordination amongst state, federal, and local agencies in conducting scientific studies and providing technical support for groundwater management.

Following these presentations, the Council brainstormed and put forth specific consensus recommendations, each of which was supported by a large majority that gave a clear "thumbs up," with some recommendations getting only a "thumbs sideways" ("can live with this") vote from as many as 3 Council members. The following points are considered critical to moving forward with better groundwater management:

Support Local Management

1. To further and support local groundwater management, the state should:
   - Identify local groundwater needs and problems at the basin or subbasin level
   - Identify local and regional areas in need of more formal groundwater governance structures
   - Identify relevant local governance entities (e.g., water management agencies) and stakeholders in basin/subbasin, facilitate a process and timeline for developing local governance structure, and identify a backstop if local management is ineffective
   - Identify and/or develop financing mechanisms to support local management capacity; also, need to increase funding for state agencies to provide consistent technical support, quality assessment, and backstop capability when local efforts are insufficient
   - Facilitate development of local groundwater management plans and efforts that support and implement plans
   - Recognize the need to significantly increase and maintain funding for DWR to help local groundwater entities by providing the science and technical support, facilitating efforts, and support working with federal and state government and academia to help provide solutions to local groundwater management challenges statewide
   - Recognize that when local entities are unable to take the steps necessary to sustainably manage groundwater, the SWRCB is the backstop to step in

Continued on the following page…

GRA Council Considers the Future of Groundwater Management – *Continued*

Measurable Basin Management Objectives

2. Local basin plans should establish management objectives required to achieve groundwater sustainability. Basin management objectives should address:
   - Land subsidence
   - Ecosystem health
   - Surface water flow depletions
   - Water quality, including salinity/seawater intrusion
   - Sustaining groundwater levels
   - Economic viability of pumping costs
   - Public health
   - Manageability of groundwater basin as a storage reservoir
3. Water budgets should be established for each managed basin/subbasin to define changes in storage and assess long-term, drought, and seasonal groundwater sustainability; local and state agencies should ensure successful water budget development and document adverse impacts through comprehensive basin data collection, including:
   - Aquifer (depth)-specific groundwater levels
   - Aquifer (depth)-specific water quality measurements
   - Aquifer characterization
   - Consumptive use, including crop evapotranspiration
   - Metering of large pumpers and estimates of pumping by small pumpers
   - Precipitation
   - Stream gauging
   - Land subsidence
4. To adaptively manage local groundwater sustainably, local or regional entities should:
   - Measure, assess, and report on aquifer conditions
   - Review and recommend specific policy and management actions to meet basin management objectives (BMOs)
   - Develop mutually compatible objectives for subbasins connected to neighboring subbasins, with the state acting as a backstop

Data Management and Information Sharing

5. State and local actions should make data more accessible
   - Existing, but difficult to access, data can better inform analyses/models; CASGEM provides an example of a locally managed program, coordinated at the state level
     - CASGEM involves local entities in design of groundwater monitoring networks based on local knowledge
     - Explore similar approach for other data (e.g., pumping data)
   - Increase access to data (e.g., drillers' reports) and interpretative information
   - Current state constraints on data access are outdated; access to data with existing systems makes data compilation and use cumbersome
6. Need an improved system that allows for transparent access. Data transferability is important; many existing state and local databases are in silos, difficult to access and/or cumbersome to use. There is a need to coordinate access to data archives, to consolidate databases as applicable and appropriate, and to develop easily accessible data houses or web portals linking multiple databases (e.g., CASGEM or Advisory Committee on Water Information), to build local capacity, maintain local control and link to other data.
   - Examples of large databases include the USGS National Water Information System (NWIS), the Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI), the U.S. Bureau of Reclamation and various California agencies (California Department of Water Resources [DWR], California Department of Public Health [CDPH], State Water Resources Control Board [SWRCB], California Department of Food and Agriculture [CDFA])
   - Examples of web portals include ACWI's National Groundwater Monitoring Network, which links many state's groundwater monitoring databases via a single web portal that serves the data via a single graphical user interface http://cida.usgs.gov/ngwmn/
   - Front-end search engines can facilitate data searches
   - Databases should be available for use by Local Management Entities
7. Develop minimum monitoring standards for groundwater levels, groundwater quality, water budgets, subsidence and reporting (this recommendation is linked to Recommendations #2 and #3 above)
   - Flexible state water data collection and management standards should be compiled and adopted to facilitate data access and transferability
   - Minimum data components for all basins/subbasins (e.g., groundwater elevation, groundwater quality, water budget, and reporting guidelines)

Continued on the following page…

GRA Council Considers the Future of Groundwater Management – *Continued*

- Additional monitoring and assessment for medium/high priority basins (DWR-CASGEM ranking)
  - Pumping
  - Recharge
  - Precipitation
  - Evapotranspiration
  - Return flows
  - Surface water flows to/from groundwater basin and surface-water/groundwater interaction
  - Imported flows

8. Reporting standards, including the frequency of reporting, should have a tiered approach (for low, medium, and high priority basins)
   - Annual or biennial for medium/high priority basins/subbasins
   - 3-10 year status reports for low priority basins/subbasins
9. Implement data management components of DWR California Water Plan 2013 (see also the California Council on Science and Technology report *Achieving a Sustainable California Water Future Through Innovations in Science and Technology* (April 2014), in an Appendix to the Water Plan)
10. Statewide coordinated networks are useful for evaluating groundwater conditions on larger scales than would be managed locally by Local Management Entities. Examples of such coordinated efforts include:
    - Land subsidence monitoring and assessment program (for assessment of land subsidence and potential impacts at regional scales)
      - Would make use of InSAR data and other datasets
      - DWR to coordinate with USGS
      - Ongoing, consistent monitoring and assessment with special focus on priority basins
    - Consumptive use estimation of crops, natural vegetation, and urban landscapes via remote sensing, at the parcel level
    - Groundwater levels (locally managed; would feed into statewide database)
    - Groundwater quality (locally managed; would feed into statewide database)
    - Other special studies (e.g., Groundwater Ambient Monitoring and Assessment (GAMA) Program)
      - Systematic investigation of non-local immediate interests
      - Complements local studies/data collection
11. Better coordinate local land-use decisions with sustainable groundwater resources management. At a minimum, this should include consultation between land-use decision processes and groundwater management entities.

Groundwater resources in California, in many areas, are depleted to levels never experienced before in state history. At the same time, broad consensus appears to be evolving among California water users and policy-makers that it is high time to establish an effective, statewide framework for groundwater management. Such a framework is needed to define and protect private groundwater use rights and public interests in groundwater resources sustainability for the long term. The consensus recommendations from the GRA Council offer a very strong basis, with broad support, to move California's groundwater management landscape into the 21st century. Implementation of this framework will further require strong local/regional leadership, clear mandates from the legislature, and secure funding.

GRA Council Co-Chairs:

- Vicki Kretsinger Grabert, GRA Director
  Luhdorff & Scalmanini, Consulting Engineers
- Thomas Harter, GRA Director
  University of California Davis
- Tim Parker, GRA Director
  Parker Groundwater

Recommended Additional Readings:

- ACWA groundwater management recommendations, April 2014
- California Water Foundation groundwater management recommendations, May 2014
- Uncommon Innovation: Developments in Groundwater Management Planning in California, 2011
- 2014 California Senate Bill 1168 (Pavley)
- 2014 California Assembly Bill 1739 (Dickinson)

[1] More information about the Contemporary Groundwater Issues Council is available at http://www.grac.org/cgic.asp.

For More Than A Decade, GRA's Branches Have Been Engaged in the Scholastic Fund Program

Objective – to provide meaningful academic outreach to future scientists, engineers, and professionals working in the assessment and management of California groundwater resources.

Logistics – Program supports groundwater students through avenues including:

- Academic scholarships
- Reimbursed travel to GRA conferences
- Academic presentation/poster competition prizes
- Subsidized GRA Branch dinner meeting attendance
- Grants to university departments researching California groundwater, for discretionary distribution to deserving students or student programs

Tax-Deductible – Since 2010, the GRA-WEF Scholastic Fund Program has provided a vehicle for tax-deductible 501(c)(3) donations to this fund. This integrated program builds on more than a decade of scholastic outreach by individual Branches as well as the state organization.

Fundraising and Distributions – Since the establishment of this program in 2010 alone, the Branches and the GRA-WEF program have raised a combined $32,000 in scholastic funds. In that same timeframe, combined distributions of $22,300 have been made. Your local Branch may have additional funds available for disbursement to eligible recipients!

How can I participate?

If you know of a student or academic program engaged in exemplary groundwater research, contact your Branch treasurer to learn what scholarship opportunities may exist!

If you value groundwater research and academic outreach on behalf of GRA, consider making your contribution today! Corporate donors, contact your local Branch regarding dinner meeting sponsorship. And individual member sponsors may contribute on the GRA-WEF donation page with the click of a mouse!

GRA Welcomes the Following New Members

MAY 30, 2014 – AUGUST 25, 2014

Adams, Samantha	Wildermuth Environmental
Anderson, Diane	APPL, Inc.
Back, Warren	Rancho California Water District
Barry, Hamidou	Alisto Engineering Group, Inc.
Bastani, Mehrdad	UC Davis
Bedegrew, Tad	Department of Water Resources
Bennett, Ray	Irvine Ranch Water District
Beuhler, Mark	Antelope Valley Water Bank
Bonsangue, John	Orange County Water District
Boyle, Bernadette	
Braziel, Christine	Crocker & Crocker
Britton, Paula	Habematolel Pomo Of Upper Lake
Burger, Kate	CA Department of Toxic Substances Control
Busch, Tim	City of Woodland
Buss, Robert	Carollo Engineers, Inc.
Cassidy, Mike	Alta Environmental
Chen, Jingyi	Stanford University
Conway, Brian	State of Arizona Department of Water Resources
Corder, Dave	QED Environmental Systems, Inc.
Cordova, Darren	MBK Engineers
Donato, Frank	Antelope Valley-East Kern Water Agency
Dupont, Ryan	Utah Water Research Lab
Eberts, Sandra	U.S. Geological Survey
Eden, Susanna	UA Water Resources Research Center
Eidam Crocker, Lucy	Crocker & Crocker
Escobedo, Tamara	Orange County Health Care Agency
Farr, Tom	Jet Propulsion Laboratory
Fausel, Cassandra	University of Arizona
Fergason, Ken	AMEC Environment & Infrastructure
Ferguson, David	Kennedy/Jenks Consultants
Flory, Dan	Antelope Valley-East Kern Water Agency
Frame, Jim	Frame Surveying & Mapping
Friedman, Steve	HDR Engineering, Inc.
Fulton, Raina	U.S. Army Corps of Engineers
Galloway, Devin	U.S. Geological Survey
Garcia, Andrew	San Luis & Delta Mendota Water Authority
Gerba, Charles	University of Arizona
Gershon, Sam	Albert A. Webb Associates
Gibbs, Alan	Terraphase Engineering, Inc.
Gius, Fred	Department of Water Resources
Haag, David	AZ Department of Environmental Quality
Hancock, Tony	MWH Americas
Harker, Rick	Olam West Coast Inc
Heidemann, Gregory	Navigators Environmental
Hendrix, Paul	Tulare Irrigation District
Hollenbeck, John	Hollenbeck Consulting
Holzer, Thomas	U.S. Geological Survey
Hopkins, Ted	Shannon & Wilson
Hulst, Michel	Allwyn Environmental
Huynh, Nancy	Los Angeles Department of Water and Power
Ikehara, Marti	
Kamahao-Bowman, Meilani	AMEC Environment & Infrastructure, Inc.
Kasberg, Kevin	CH2M HILL
Koreny, John	HDR Engineering, Inc.
Lamacchia, Chad	Los Angeles Department of Water and Power
Larwood, Jim	AECOM
Lin, Chi-Feng	National Yunlin University of Science & Technology
Manghi, Fakhri	Western Municipal Water District
Marley, Robert	Daniel B. Stephens & Associates, Inc.
Martin, Russell	Australian Groundwater Technologies
McKeever, Justin	Orange County Water District
Mckenna, Juliet	Montgomery & Associates
McVay, Sean	Navigators Management Company, Inc.
Megdal, Sharon	Water Resources Research Center - University of Arizona
Mock, Peter	PMGC, Inc.
Mork, Eric	UC Davis
Morrow, Michelle	Department Water Resources Legal
Muhar, Jeevan	Arvin-Edison Water Storage District
Mulloy, Tim	Confluence Environmental Field Services
Newlin, Victoria	Butte County Water and Resource Conservation
Niknafs, Andy	Los Angeles Department of Water and Power
Nutter, Nathan	Carollo Engineers
O'Leary, David	U.S. Geological Survey
Orr, Richard	Leighton Consulting
Palma Nava, Adriana	National Autonomous University of Mexico
Panday, Sorab	GSI Environmental
Patten, Steven	Walla Walla Basin Watershed Council
Perez, Jorge	AMEC Environment & Infrastructure, Inc.
Pieters, Kevin	United States Agency for International Development

Continued on the following page…

GRA Welcomes the Following New Members – *Continued*

Scherberg, Jacob	Geosystems Analysis
Shamir, Eylon	Hydrologic Research Center
Siegel, Richard	Salt River Project
Simpson, Rob	Citizens Water Plan
Singh, Narinder Pal	Olam West Coast Inc
Snow, Lester	Water Education Foundation
Snyder, Margaret	Tucson Water
Souverville, Mark	California Department of Water Resources
Springhorn, Steven	California Department of Water Resources
Stevens, Wiliam	Zone 7/Berlogar Stevens & Associates
Swan, Lindsay	United Water Conservation District
Taylor, Kate	Crocker & Crocker
Thompson, Dick	City of Tucson
Trommer, Jeffrey	Leggette, Brashears & Graham, Inc
Underhill, Karen	Orange County Water District
Veenstra, Danielle	Almond Board of California
Visser, Ate	Lawrence Livermore National Laboratory
Walker, Don	CA Department of Water Resources
Weisenberger, Neal	Antelope Valley-East Kern Water Agency
Weiss, Garrett	State Water Resources Control Board
Whitehead, Tom	
Xiong, Zhong	Haley & Aldrich, Inc.
Young, Douglas	Alameda County Water District

GRA Extends Sincere Appreciation to the Chairs and Sponsors of the 14th Biennial Symposium on Managed Aquifer Recharge

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Orange County Water District
Chris Petersen, P.G., C.H.G.,
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Central Coast

By Bryan Bondy
Branch Secretary

In July, Paul Sorensen, Principal Hydrogeologist with Fugro Consultants, Inc., presented Paso Robles Groundwater Basin: Water Supply Framework, History, and Current Conditions. Mr. Sorensen's presentation provided an overview of the land-use history, historical groundwater conditions, pumpage, perennial yield, and a discussion of ongoing efforts to manage the Paso Robles Groundwater Basin (PRGB). The PRGB is the primary water source for northern San Luis Obispo County, which includes 29 percent of the county's population and an estimated 40 percent of the agricultural production in the county. Groundwater in the PRGB is pumped from the Paso Robles Formation, which extends to a maximum depth of approximately 2,500 feet.

In the early 1980s, groundwater use in the basin was over 100,000 acre feet per year (AF/yr), most of which was used to irrigate alfalfa. During the late 1980s and early 1990s, alfalfa production declined and groundwater pumping reached a low of approximately 65,000 AF in 1996. Since 1996, pumping has steadily increased and is now approaching 100,000 AF/yr. The increase in pumping is the result of continued vineyard plantings and population growth within the basin.

In 2005, the perennial yield was estimated to be 97,700 AF/yr, with recent pumpage estimated to be approximately 96,800 (AF/yr). Despite this seeming balance in the water balance equation, water levels have been declining since the late 1990s in some areas of the basin on the order of 75 to 200 feet. A recent draft study suggests that the perennial yield may only be approximately 90,000 AF/yr, although this study has not been finalized.

Most of the municipal and irrigation wells in the basin tap the aquifer at depths of 500–800 feet, but many of the domestic wells are only about 250 feet deep. The shallow depth of the domestic wells has been a factor, because as some of the rural homeowners' wells went dry, they pleaded for action by the San Luis Obispo County Board of Supervisors. In response to the water-level declines and concerns with overall basin health, the County Board of Supervisors adopted an Urgency Ordinance in August 2013 that placed a moratorium on new wells and requires new development to be water neutral.

The rural landowners and agricultural interests in the basin have each formed associations to promote solutions. These groups have worked together and with the county to seek the establishment of a new independent water district that can develop new supplies for the basin from Lake Nacimiento, unallocated State Water Project, recycled water, and other potential sources. AB 2453 (Achadjian) was introduced for this purpose and is currently under review by the Legislature.

The Central Coast GRA would like to thank Dudek, the scholastic sponsor for the July meeting, for their support.

Continued on the following page…

Southern California

By Emily Vavricka, Branch Secretary

In May, the bi-monthly Branch meeting hosted Dr. Hugo A. Loaiciga, Professor of Hydrology and Water Resources at the University of California, Santa Barbara. Dr. Loaiciga's talk, *Groundwater, Earthquakes, and Landslides: Opportunities for Hydrogeologists*, focused on groundwater and the role it plays in hazards dealing with landslides and slope destabilization. Dr. Loaiciga's talk presented an interesting look at how groundwater can have an adverse effect on the subsurface, especially slopes, by destabilizing them and thus creating a hazard for property and people. In conjunction with this, when slopes are destabilized by groundwater, earthquakes can exacerbate the problem by triggering landslides. Dr. Loaicga explained how hydrogeologists can help in these scenarios by understanding the hazards presented by groundwater, and assisting in the assessment of land stabilization issues. If these issues are understood in time, the devastating landslides from groundwater impacts can be minimized.

Also in May, the Branch held a special meeting at Orange County Water District and hosted the Northern California GRA 2014 David Keith Todd Distinguished Lecture Series, with Carl Hauge presenting. Mr. Hauge is a registered geologist and a certified engineering geologist, retired from his position of Chief Hydrogeologist for the Department of Water Resources, Sacramento (DWR). Mr. Hauge's lecture, *Groundwater – Past, Present, and Future*, presented a fascinating history of California's groundwater and how it was used, managed (or undermanaged), and over-utilized throughout the years. He shared how other states manage their groundwater, and compared their practices to how California has managed groundwater. He emphasized the importance of groundwater/surface-water interactions, with an explanation of the hyporheic zone, which is the area beneath and alongside a stream bed where the mixing of groundwater and surface water takes place; important processes occur in this zone. As an example, he presented the situation in the Sacramento Valley, where long-term groundwater substitution has had a detrimental effect on surface water and has caused streamflow depletion. Mr. Hauge stressed the fact that due to over-pumping and lack of good management, this vital resource is on its way to depletion. Mr. Hauge concluded that much better groundwater management needs to be done in order to preserve this vital resource.

Dr. Loaiciga's and Mr. Hauge's lectures were well attended by GRA Members, non-members, and citizens from the surrounding community. Both lecturers provided an exciting look at the role groundwater plays in both natural hazards and as a vital natural resource in California.

The Branch would like to thank all who attended the May Branch meetings, and also to extend a special thank-you to the 2014 David Keith Todd Distinguished Lecture Series sponsors, Geosyntec Consultants, Regenesis, Luhdorff & Scalmanini Consulting Engineers, and Todd Groundwater.

Northeast view of Young America Lake, and Upper and Lower Sardine Lakes

The Sierra Buttes trail to a fire lookout is one of California's best day hikes and provides grand views from the Tahoe Rim to Lassen Peak and the Yuba River watershed. The exhilarating and exposed stairs to the fire lookout overhang the glacially eroded cliffs. The Sierra Buttes and Lakes Basin Recreation Area are located in the northern Sierra Nevada.

This scene illustrates the complex geology of the region, which includes Devonian metamorphosed volcanic and sedimentary rocks, Tertiary volcanic rocks, and Quaternary glacial deposits. The Devonian Sierra Buttes Formation (foreground) consists of silicic volcanic ash and breccia that formed in an ancient island arc, probably near the North American continental margin. In contrast, Haskell Peak (right of top center) is composed of Oligocene "ignimbrites" (ash-flow tuffs) and conglomerates that correlate with formations in western Nevada. Glacial erosion carved this rugged bedrock cirque, and the lower forested slopes (center) are underlain by Quaternary glacial deposits.

The chain of lakes in this glacially eroded valley is an example of paternoster lakes. Paternoster lakes may form from differential glacial erosion of more- and less-resistant bedrock layers. The less-resistant bedrock layers become low spots where water can accumulate; the more-resistant bedrock layers form natural dams. The Sardine Lakes are also bounded by lateral moraines, and the most distant lake is dammed by a recessional moraine.

Photographed along the Sierra Buttes trail in the Tahoe National Forest
(approximate GPS coordinates: 39°35'49" N 120°39'19" W)
by John Karachewski, Ph.D. (www.geoscapesphotography.com)