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Nanotechnology for Environmental Cleanup and Pollution Control – Science, Implementation, and Regulatory Issues

Symposium Highlights and Summary

By Zhong (John) Xiong, Ph.D., P.E., AMEC Geomatrix, Inc.,
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Denis O'Carroll, Ph.D., University of Western Ontario

Nanomaterials represent a promising new technology for rapid environmental cleanup and pollution control. Research into and development of innovative engineered nanomaterials such as nano-scale zero-valent iron (nZVI) for site remediation has increased dramatically in the past decade. Because of the small particle size, nanomaterials achieve treatment rates that are significantly greater than micron-scale treatment media. Another expected advantage of nanomaterials is that they are small enough to be mobile in aquifer systems and can be injected directly into the subsurface to treat contaminated source zones. At the same time, there are many unknowns and uncertainties regarding the risk of nanomaterials throughout their life cycle, which has attracted significant attention from the research, regulatory, and industrial communities.

In response to this, GRA hosted the 22nd Symposium in the Series on Groundwater Contaminants, titled



Symposium attendees enjoying the Exhibit Hall. PHOTO BY ZHONG (JOHN) XIONG.

“Nanotechnology for Environmental Cleanup and Pollution Control - Science, Implementation, and Regulatory Issues,” on November 3, 2009, in Burlingame, CA. The symposium attracted over 80 participants from locations around the country. Experts, researchers, regulators, and stakeholders from academia, consulting, state and federal agencies, and the legal arena delivered presentations and engaged in lively

discussions on the science of nanotechnology, the latest development of environmental nanotechnologies, and current regulatory policies related to nanotechnology. The symposium was organized as a single-track moderated session over one day, which is described in detail below.

Section 1: Nanotechnology for Groundwater Remediation

Martha Otto of the U.S. EPA provided an overview of EPA's initiatives on the application of nanotechnology such as nZVI for site remediation and pollution control. Ms. Otto highlighted the Nanotechnology for Site Remediation Fact Sheet that was published in October 2008 by the U.S. EPA. A number of different nanotechnologies and their uses for remediation are presented in this publication. Ms. Otto also presented select projects where nZVI was used for groundwater remediation at Superfund sites.

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Greetings from Fresno

By Bill Pipes

Greetings from Fresno, deep in the heart of the great bread basket they call the San Joaquin Valley – and home to the most prolific and robust groundwater aquifer in the state! I am honored to be named by the GRA Board of Directors as the new GRA president for 2010. Allow me to introduce myself – I am a native Californian and a product of our great UC system (Santa Barbara). Though I traveled back East to get a graduate degree, I returned home in 1978 to start my career as a professional geologist and have worked as a consulting groundwater geologist in Fresno since 1991. I have been part of the GRA family since 2002, when a handful of us resurrected the San Joaquin Valley Branch. In 2003, you elected me to the Board of Directors. Since then, my activities have included co-chairing numerous GRA events; chairing Board committees, including membership and communications, and serving as secretary and vice president of GRA. Assisting me this year at the helm will be Sarah Raker as Vice President, Ted Johnson as Secretary, and David Von Aspern as Treasurer. Jim Strandberg, or immediate Past President, also will provide assistance and guidance. I look forward to working with the new officers and Jim, Kathy Snelson, our Executive Director, the Board of Directors, and YOU, to fulfill GRA's mission and to continue establishing GRA as the pre-eminent voice for California's most precious resource.

Each year, the GRA Board of Directors devotes a weekend to discussing the state of the organization and plans going forward (some call it a "retreat"

– I'd rather call it an "advance"). We review the current state of GRA, identify the opportunities available to GRA, and brainstorm about the future of the organization. In 2001, GRA developed a comprehensive strategic plan that outlined long-term strategies for meeting the organization's goals and objectives. The plan was updated during our annual planning meeting in 2009. We will soon be posting the strategic plan on the website, and I encourage you to read it. Initiatives for 2010 and beyond include strengthening GRA events by making them more timely, relevant, oriented to your needs, and innovative in format; building GRA Branches through membership growth and greater involvement in local groundwater issues; growing the overall membership; and maintaining sustainable financial health.


With the leadership of Ted Johnson, Elie Haddad, and Tom Mohr, I predict a banner year for GRA events content, attendance, and innovations. GRA seeks to inform, educate, and provide forums for providing insight into, and finding solutions for California's thorniest water issues. Event content will be relevant to the challenges and issues we face as groundwater practitioners in California. Event topics this year will include boring logs, watershed hydrology, solvent release sites, geophysics, numerical groundwater modeling, well performance issues, forensic geochemistry, and statistics. Don't forget GRA's Annual Meeting on September 15-16 in San Francisco; this is YOUR meeting for networking with other members, seeing a variety of excellent technical presentations, and

participating in GRA's yearly business meeting. You can find more information about all of GRA's programs and the Annual Meeting in *HydroVisions*, at www.grac.org, and in the various emails we will be broadcasting to you throughout the year.

I want to thank all of GRA's volunteers – Board members, Branch officers, event chairs and committee members, Board committees, and members – for their hard work and dedication that is the root of GRA's strength. I encourage more members to become involved in GRA; during this time of economic challenges, your help is needed more than ever. Start with your Branch – attend the meetings, become an officer, be a speaker, help arrange a field trip. The Board and I are convinced that the best way to grow and strengthen GRA for the long term is from the ground up at the local level. The benefits to active members are wide-ranging, including the opportunity to network with others in your profession; keeping up on the latest news, trends, legislation, and technical advances; and the satisfaction of taking part in growing a worthy organization. I would be very happy to discuss with you ways to get involved in GRA – please call me directly at (559) 264-2535 or email me at bill.pipes@amec.com.

Thank you for reading *HydroVisions*! Until next time,

Bill Pipes

Bill Pipes
GRA President 

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Nanotechnology for Environmental Cleanup and Pollution Control – Continued

Dr. Wei-xian Zhang of Lehigh University gave an overview of the development of nZVI technology for groundwater remediation. The unique benefits of nZVI, such as significant surface area, high reactivity, and ability to react with various organic and inorganic contaminants were summarized. A new nanomaterial developed for light non-aqueous phase liquid (LNAPL) remediation in groundwater also was introduced.

Dr. Dongye Zhao of Auburn University discussed his group's innovative research related to *in-situ* reductive destruction of chlorinated solvents and immobilization of toxic metals in soils and groundwater using polysaccharide-stabilized nanoparticles. Dr. Zhao's group developed a nanoparticle stabilization strategy using starch or carboxymethyl cellulose (CMC) as a stabilizer, which effectively controls nanoparticle size, delivery and transport and has resulted in much faster reaction rates. Dr. Zhao presented both laboratory and field studies that used nZVI for *in-situ* destruction of chlorinated solvents and reductive immobilization of Cr(VI).

Dr. Paul Tratnyek of Oregon Health and Science University provided an overview of the major issues with the ZVI nanotechnology for groundwater remediation that relates to the reactivity, longevity, transport, and performance assessment. Dr. Tratnyek described a recent study on the effect of natural organic matter (NOM) on the mobility of ZVI nanoparticles. Methods for detecting nZVI transport were discussed and it was noted that oxidation-reduction potential (ORP) is currently the most widely used method. However, ORP response is a mixed potential, the composition of which may vary with other factors, and relationships between measurable ORP and nZVI still needs clarification. Dr. Tratnyek commented that the nZVI technology is still at an intermediate stage of development.



Murray Einarson (right) and Peter Bennett, AMEC Geomatrix.

PHOTO BY BRIAN LEWIS.

Dr. Mamadou Diallo of California Institute of Technology presented an overview of recent advances in developing perchlorate-selective and recyclable ion exchange media for groundwater remediation. Dr. Diallo's research group developed a new generation of high-performance and recyclable anion-selective ion exchange media. The new ion exchange media have much higher exchange capacity and perchlorate binding capacity than commercial ion exchange resins. They also can be regenerated using a low-concentration salt solution such as 2.5-5% NaCl.

Dr. David Cwiertny of University of California Riverside presented a strategy to extend the reactive lifetime of nZVI using dithionite. Laboratory tests show that dithionite extends, and in some cases can enhance, the removal of two model groundwater pollutants (1,1,1,2-tetrachloroethane and Cr(VI)) in nZVI systems. The efficiency of the dithionite regeneration process depends strongly on the prevailing geochemical conditions which dictate the products of nZVI oxidation and the redox-active species generated from the reaction between passivated nZVI and dithionite.

Section 2: Nanotechnology for Surface Water Treatment and Pollution Control

Dr. David Sedlak of University of California Berkeley described contaminant oxidation by nZVI in the

presence of O₂ or H₂O₂. Unlike most researchers' work that explores the reductive property of nZVI, Dr. Sedlak's research focuses on the oxidative capability of nZVI. It was reported that in the presence of oxygen, nZVI undergoes a series of rapid oxidation reactions that convert O₂ into hydroxyl radicals (OH). This process can be used for *in-situ* remediation using clays or nanoparticles and *ex-situ* applications for waste treatment.

Dr. Jaesang Lee of Rice University presented his study on photochemical and antimicrobial activities of water-soluble C₆₀ derivatives. The photodynamic antibacterial and antiviral activities of hexakis derivatives and fullerol toward *E. coli* and MS-2 bacteriophage displayed the efficacy of functionalized C₆₀ as a photocatalytic disinfectant.

Section 3: Fate and Transport of Nanomaterials

Dr. Chris Mackay of AMEC Earth & Environment discussed methods for the prediction of nanoparticle fate and transport in gaseous and aqueous environments. Traditional methods used to predict the behavior of chemicals in the environment have been firmly rooted in the principles of solution chemistry, such as molarity, partition, fugacity, etc. However, Dr. Mackay commented, new considerations that take into account conditions of surface chemistry are needed to evaluate and

Continued on the following page...

Nanotechnology for Environmental Cleanup and Pollution Control – Continued

predict the behavior of nanomaterials in the environment. These include environmental and material properties such as buoyancy, surface area, viscosity, charge accumulation, steric factors, and Hakman forces. Applications of this new approach were discussed.

Dr. Denis O'Carroll of University of Western Ontario described a series column experiments, and associated modeling, that was conducted to explore the mobility of polymer stabilized nanometals in sand systems. For the range of conditions tested, the nanometals exhibited good mobility. Dr. O'Carroll also presented results from a numerical simulator that was developed to further explore the utility of nanometals for site remediation. Challenges that were discussed include pumping a viscous polymer solution into the subsurface and an assessment of the time required for the injected nanometals to reach the target contaminated zone. Longer travel times to the target zone will require greater nanometal stability. Insights gained from modeling field-scale application of remediation via nanometals were discussed.

Section 4: Case Studies

Peter Bennett of AMEC Geomatrix presented a field-scale study assessing the carboxymethyl cellulose stabilized nZVI for chlorinated solvent source-zone treatment. This field study was conducted at an industrial site in the Bay area. A stabilized nZVI suspension was prepared on site and injected to the subsurface by a series of Push-Pull tests to assess *in-situ* transport and reactivity of nZVI particles. Results from this field study indicated that nZVI particles appear to be mobile in the subsurface, but lose mobility over time (within less than 12 hours). Rapid production of ethane was observed, suggesting rapid dechlorination.

Suzanne O'Hara of Geosyntec Consultants presented a pilot-scale field demonstration of dense non-aqueous liquids (DNAPL) treatment using

emulsified zero-valent iron (EZVI) at a former dry cleaning site in Parris Island, SC. EZVI consists of a surfactant-stabilized, biodegradable emulsion that forms emulsion droplets composed of an oil-liquid membrane surrounding micro- or nano-scale ZVI particles in water. Two injection technologies, i.e. pneumatic injection and direct injection using a direct push rig, were used to deliver EZVI to the subsurface. Results showed a significant decrease in PCE and TCE downgradient of the treatment area following EZVI injection and significant increase in ethene was observed, indicating complete PCE degradation.

Dr. Timothy Malloy of University of California Los Angeles stated that California is out in front on emerging environmental issues once again. Using authorities provided under AB 289, the Department of Toxic Substances Control (DTSC) recently issued a call to manufacturers for information relating to carbon nanotubes manufactured in, or imported into California. Carbon nanotubes have received significant attention given their growing level of use in commerce, and a series of studies suggesting that they may present significant health hazards. Given the uncertainties associated with the use of nanoparticles in terms of fate and



Attendees enjoying a presentation. PHOTO BY ZHONG (JOHN) XIONG.

Section 5: Regulatory Issues with Nanomaterials and Nanotechnology

Dr. Todd Rees of Golder Associates presented Golder's experiences with bench, pilot, and field-scale application of nZVI for environmental remediation in the United States, Canada, Europe, and Australia. A "lessons learned" perspective on certain non-technical issues that are governing the implementation of nZVI for environmental restoration was also discussed. Dr. Rees introduced that nZVI for environmental remediation has received regulatory acceptance in the U.S., Germany, Italy, and Czech Republic, while nZVI is not accepted in Finland and Denmark.

transport, safety, etc., if their use resulted in damage or harm, one could make a case for negligence.

Dr. Arianne Neigh of nanoComposix presented a small business' perspective on nanotechnology regulation. Dr. Neigh described that much of the fabrication of nanomaterials takes place in small-business think tanks that develop methods and produce materials, often in small batches. She said some of the scare tactics within the media and from activist groups had unfairly targeted small business manufacturers that do not have the marketing and lobbyist resources to refute unfounded claims.

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Nanotechnology for Environmental Cleanup and Pollution Control – Continued

Dr. Richard Canady of McKenna Long & Aldridge LLP presented the status of U.S. regulation of nanotechnology. Dr. Canady described that nanoscale materials generally are “covered” under existing regulations such as the Toxic Substances Control Act. The coverage, however, seems to require guidance and science policy decisions in order to clarify application of “new” material consideration and data needs. EPA is considering rule-making to generate more information about nanomaterial uses and risk management needs.

Summation and Discussion of Key Points

The symposium concluded with a summation and discussion of key points led by Dr. Denis O’Carroll of University of Western Ontario. Key points summarized were that nanotechnology offers tremendous possibilities, but prior to the widespread implementation of these technologies for environmental applications, regulator and public perceptions have to be addressed. There was a stimulating question and answer session, some of which pointed out that nZVI would only be considered applicable at extremely contaminated sites and that remediating existing contamination with potential contaminants should not be considered lightly.

Many Thanks to Our Organizers and Sponsors


Many thanks to all the organizers, sponsors, presenters, and attendees of this symposium! The organizing committee for this event included Dr. Zhong (John) Xiong and Murray Einarson of AMEC Geomatrix, Brian Lewis and Dr. Jeff Wong of California EPA / Department of Toxic Substance Control (DTSC), Dr. Denis O’Carroll of University of Western Ontario, Dr. David Cwiertny of University of California Riverside, Dr. Chris Mackay and Laurie Gneiding of AMEC Earth and Environment, Dr. Feng He of Golder Associates, and Dr. Sushil Kanel of U.S. EPA. Sponsors for this symposium

included AMEC Geomatrix, Cal EPA/DTSC, and Golder Associates. Exhibitors included Adventus Americas, Frac Rite Environmental Ltd., RSI Drilling, and Wavefront. Special thanks are also extended to Kathy Snelson and Mary Megarry of GRA.

About the Authors

Zhong (John) Xiong, Ph.D., P.E., is a project environmental engineer at AMEC Geomatrix, Inc. in Newport Beach, CA. Dr. Xiong is interested in the development and application of innovative and cost-effective technologies for site remediation, including environmental nanotechnology. He has published on nanotechnology and nanomaterials and is a co-inventor of two innovative nanotechnologies for site remediation uses.

Murray Einarson, P.G., CHG., is a principal hydrogeologist at AMEC Geomatrix, Inc. in Oakland, CA. Mr. Einarson is a pioneer in the development and application of expedited site assessment technologies and practices to characterize contaminated sites quickly and cost-effectively, and has co-authored industry and regulatory guidance documents on this subject.

Denis O’Carroll, Ph.D., P.Eng., is an Assistant Professor in Civil and Environmental Engineering at the University of Western Ontario. Dr. O’Carroll has significant experience in laboratory studies developing innovative remediation schemes in addition to site remediation consulting experience. 

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Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective

By Lynne Baumgras, BSK Associates and AEG San Joaquin Valley Chapter Chair; Devin Galloway, U. S. Geological Survey (USGS); Claudia Faunt, USGS; Michelle Sneed, USGS; Paula Landis, Calif. Dept. of Water Resources; Chris White, Central California Irrigation Dist.; Robert Martin, San Luis & Delta Mendota Water Authority; Marti Ikehara, National Geodetic Survey; Mike Rucker, AMEC Geomatrix; Sarge Green, California Water Institute; Karl Longley, California Water Institute; Paul Betancourt, Fresno County Farm Bureau; Chris Johnson, AEGIS Groundwater Consulting and GRA San Joaquin Valley Branch President; Dr. Nigel Quinn, Berkeley National Laboratory; Steve Phillips, USGS; Albert Steele; and William Pipes, AMEC Geomatrix and GRA President.

A one-day symposium to discuss groundwater withdrawal-induced land subsidence in the San Joaquin Valley was held on November 4, 2009 in Fresno, California. The symposium objective was to explore current research and issues related to San Joaquin Valley land subsidence caused by groundwater withdrawal. The event was hosted jointly by the San Joaquin Valley Chapter of the Association of Environmental and Engineering Geologists (AEG) and the San Joaquin Valley Branch of the GRA, and sponsored by BSK Associates and AMEC Geomatrix in cooperation with the USGS. Special thanks are due to the exceptional speakers, panelists, moderators, and volunteers who made this symposium possible.

Land subsidence associated with aquifer-system compaction has been a recurring issue in California since the 1920s and was measured at high rates in several California groundwater basins during the 1950s and 1960s. In the 1970s surface-water use helped to augment the water demands and mitigate the subsidence. Figure 1 shows a representation of the large magnitude of land subsidence near Mendota, California as of 1977.

Currently, the San Joaquin Valley is faced with reduced surface water deliveries owing to three years of drought and environmental restrictions on Delta water exports, which has led to increased groundwater pumping

and rapid water-level declines. This “perfect storm” of water shortages has created a setting where land subsidence again threatens the San Joaquin Valley infrastructure and economy. Renewed subsidence on the west side of the San Joaquin Valley due to groundwater pumping is a cause for concern. Fortunately, advances in the understanding of aquifer-system compaction and development of technologies such as remote sensing provide better tools to characterize and manage subsidence.

An impressive cross-section of technical and policy specialists attended the symposium, including representatives from:

- U. S. Department of the Interior (Interior)
- USGS
- U. S. Bureau of Reclamation (Reclamation)
- California Department of Water Resources (DWR)
- Water districts and municipal governments from California
- Scientists, engineers, and policy advisors from throughout the U.S. and Canada.

The symposium was attended by Mr. John Tubbs, the Deputy Assistant Secretary for Water and Science for the Department of the Interior. Water and Science oversees the Bureau of Reclamation and the USGS. Mr. Tubbs, the Distinguished Lunchtime Speaker,



Figure 1. Approximate location of the maximum measured subsidence in the San Joaquin Valley, near Mendota, California. Land surface subsided approximately 29 feet from 1925 to 1977 due to aquifer-system compaction from groundwater withdrawal. Signs on the pole are positioned at the approximate former elevations of the land surface in 1925 and 1955. Photograph by R.L. Ireland, USGS, ca 1977.

addressed the audience and discussed the overall problems related to western water supplies and pledged support from the Department of the Interior for assistance in mitigation of San Joaquin Valley groundwater issues.

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Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective – Continued

Summary of Speaker Presentations

Devin Galloway, Western Region Groundwater Specialist for USGS, presented the Keynote Address entitled “Perspectives: Aquifer-System Compaction and Land Subsidence Accompanying the Development of Groundwater Resources.” Mr. Galloway gave an overview of the mechanics of aquifer system compaction and land subsidence. He described historic and ongoing subsidence in California and addressed the following topics: land subsidence processes and their manifestations and mechanisms; detection, identification, measurement, and analysis of subsidence; and subsidence management. In the San Joaquin Valley, about 5,200 square miles of land have undergone one or more feet of subsidence due to aquifer compaction. The extents of observed subsidence in the San Joaquin Valley correlate closely with decreasing water levels in the deep confined aquifer system. The three San Joaquin Valley regions that have been most impacted by land subsidence are the Los Banos-Kettleman City area, the Tulare-Wasco area, and the Arvin-Bakersfield-Maricopa area. Mr. Galloway also discussed the history of San Joaquin Valley land subsidence due to groundwater overdraft, which began in the 1920s, and the mitigation of subsidence in the late 1960s and early 70s by the importation of surface water.

He also discussed subsidence mitigation techniques, including enhancement of groundwater recharge, reduction of groundwater demand, management of groundwater withdrawal and use, and development of supplemental water supplies. The focus of these mitigation techniques is to maintain groundwater levels above critical thresholds. Mr. Galloway gave an overview of research techniques currently being used by the USGS for subsidence identification including reconnaissance subsidence

mapping, hydrogeologic evaluations, and the evaluation of correlations between hydrogeologic information and observed subsidence magnitudes.

Ms. Paula Landis, PE, Chief of the San Joaquin District, DWR, gave a briefing on Subsidence and California Water Policy. She discussed subsidence impacts on surface-water deliveries, flood conveyance capacity, and river systems, and associated economic impacts. Her talk also addressed water regulation, oversight, and management in light of California Water Policy.

With respect to surface-water deliveries, Ms. Landis described the impacts of subsidence on the water conveyance systems. The Eastside Bypass, which was built in the 1960s, has subsided up to 5 feet in some areas. Subsidence-related changes in river drainage grade have affected the transport characteristics of the San Joaquin River and have altered levee requirements. Differential subsidence steepened the channel of the San Joaquin River by about 6.6 ft from 1926-72 in the 15 miles before it

reaches the valley trough, and flattened the river channel by about 6.6 feet over the next 31-mile reach. Differential subsidence also has created problems for the maintenance of water-transport structures; the Delta-Mendota Canal and California Aqueduct have required remedial work because of subsidence.

Ms. Landis discussed California water policy and its relationship to groundwater overdraft. Surface-water rights became regulated in 1914 through a permitting process, but groundwater has never been regulated by the State—groundwater management has remained a local responsibility. Ms. Landis highlighted the public opinions in support of local control of groundwater supplies, including:

- diverse physical characteristics of groundwater basins
- availability of alternative water supply sources
- diverse water uses between regions.

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Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective – Continued

Ms. Landis also described methods for achieving groundwater sustainability, including:

- management by local agencies under authority granted in the California Water Code or other applicable State statutes
- local government groundwater ordinances or joint powers agreements
- court adjudications.

Mr. Robert Martin, PE, San Luis & Delta-Mendota Water Authority (SL&DMWA), discussed historic and current impacts of subsidence on Delta-Mendota water delivery structures. The Central Calif. Irrigation Dist. (CCID) and SL&DMWA are faced with subsidence-related repair and maintenance issues on water conveyance facilities. The Delta-Mendota Canal (DMC) traverses the subsidence area on the west side of the San Joaquin Valley (as does the parallel CCID Outside Canal). The DMC was originally designed to deliver 3,211 cfs into the Mendota Pool. Today, even after the canal lining was raised circa 1977 because of subsidence, the capacity has been reduced to around 2,950 cfs (see figure 2). Similarly, the capacity of the Outside Canal has been reduced from about 700 cfs in the 1940s to about 350 cfs; expensive repairs to the Outside Canal are ongoing.

The Mendota Pool is another problematic area. Water impounded in the Mendota Pool is checked or pushed upstream to the Mendota Wildlife Area, James, Tranquility and a portion of Westlands Water Districts. Fifty years ago, all diversions could be made at a Pool stage of 12 feet at Mendota Dam. Today, due to subsidence, the Pool stage needs to be at least 14 feet to meet minimum diversion requirements. The additional head differential across the Mendota Dam structure has created serious undermining and stability problems at the Dam, which must now be dewatered, inspected and repaired semi-annually to sustain the



Figure 2. Reduced Canal Freeboard in the Delta Mendota Canal Downstream of Check 18 due to Subsidence (Source: Central California Irrigation District)

structure. Two extensometers and associated Continuous Operating Reference Stations (CORS) are now in place to continuously monitor differential subsidence in this area.

Dr. Claudia Faunt, a Hydrologist with the USGS, presented “A Regional Hydrologic Model of California’s Central Valley.” Dr. Faunt gave an overview of the USGS Central Valley Hydrologic Model (CVHM), which simulates land subsidence related to groundwater pumping. The CVHM is a three-dimensional numerical model developed by the USGS to help characterize the aquifer system of California’s Central Valley and assess changes in groundwater availability. Dr. Faunt described three key elements of the CVHM: a texture analysis, estimation of the water budget, and development of the model.

The texture analysis incorporated over 8,500 drilling logs to characterize aquifer system sediments for estimation of hydraulic properties. The water budget for the CVHM was developed using the FARM process, a new feature within MODFLOW that allows

simulation of processes associated with irrigated agriculture. The FARM methodology begins by estimating the consumptive use of water by plants and the associated irrigation requirement; available surface water deliveries, effective precipitation, and groundwater uptake are then used to meet this demand; the residual demand is assumed to be met using groundwater. The third element was the development of the CVHM for use in assessing changes in groundwater availability.

Dr. Faunt discussed the model outputs with respect to changes in groundwater storage over time and also cumulative subsidence. Between 1962 and 2003, the Tulare Basin portion of the San Joaquin Valley lost about 70 million acre-feet of groundwater from storage (figure 3). During this period, several regions in the San Joaquin Valley experienced 10 to 25 feet of cumulative subsidence (figure 4).

Ms. Marti Ikehara, State Geodetic Advisor with the National Geodetic Survey/National Oceanic and Atmospheric Admin., presented “Geodetic

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Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective – Continued

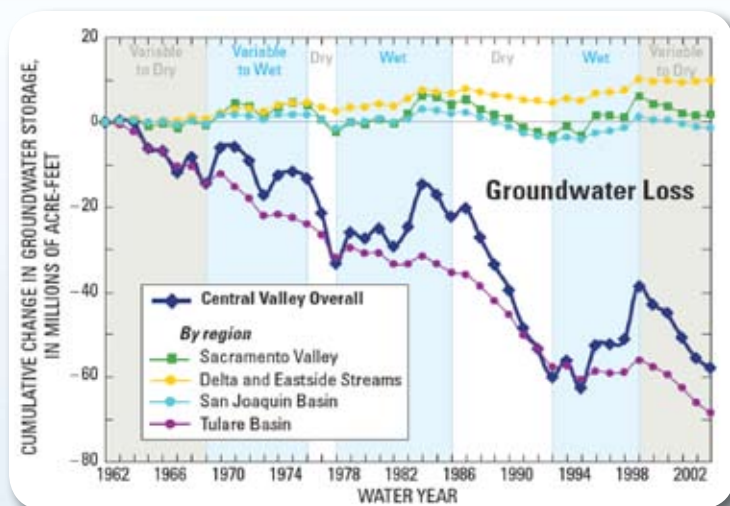


Figure 3. Groundwater Loss in the Central Valley from 1962 to 2003. Source: Faunt, C.C., ed., 2009, *Groundwater Availability of the Central Valley Aquifer, California*: U.S. Geological Survey Professional Paper 1766, 225 p.

Measurement of Land Subsidence in the San Joaquin Valley.” Ms. Ikehara addressed historical subsidence and described Global Positioning System (GPS) surveys done in 2004, which showed continued subsidence along California Highways 198 and 152 in the San Joaquin Valley.

The Highway (Hwy) 198 leveling effort started near Interstate 5 (I-5) and extended eastward through Kings, Tulare, and Fresno counties. A subsidence “trough” was observed along Hwy 198 for about 70 miles between I-5 and Visalia, near Hwy 99. The axis of the subsidence trough, or area of deepest subsidence, was found at a distance of roughly 42 miles east of I-5, in Armona, CA. The total subsidence measured here was 9.2 ft from the 1960s to 2004 (Figures 5 and 6).

The leveling route along Hwy 152, in the northern San Joaquin Valley, extended from west of I-5 to Hwy 99. Land subsidence was observed over a 16-year period from 1988 to 2004 along almost the entirety of the surveyed route. Similar to results observed in the Hwy 198 leveling effort, a trough of subsidence was also identified. The point of maximum subsidence was observed about 33 miles east of I-5, south of the town of El Nido. Further analysis of additional data for

the period 1972 to 2004 indicated that about 5.2 feet of cumulative subsidence occurred in El Nido, California over that 32-year period.

Ms. Michelle Sneed, a Hydrologist with USGS, presented “Land Subsidence Investigations using InSAR, San Joaquin Valley, California,” describing the incorporation of Interferometric Synthetic Aperture Radar (InSAR) techniques for USGS studies of land subsidence in the San Joaquin Valley. Ms. Sneed is leading a USGS study of land subsidence along the California Aqueduct/San Luis Canal, and participating in a USGS study of the Delta Mendota Canal on the west side of the San Joaquin Valley. These studies will incorporate InSAR interferograms and paired land-surface elevation and groundwater level data from four continuous GPS Stations and nearby wells, respectively. The objectives of these studies include:

- Determine the location, extent, and magnitude of subsidence along the canals from 2003 to 2010
- Develop and implement an approach to use InSAR to monitor subsidence in these agricultural areas
- Compute aquifer-system storage properties at selected locations using stress/strain relations.

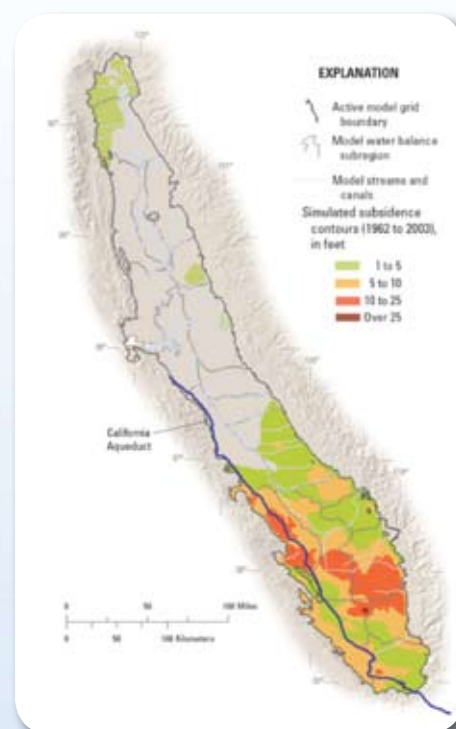


Figure 4. Simulated Subsidence in the San Joaquin Valley, 1962 to 2003. Source: Faunt, C.C., ed., 2009, *Groundwater Availability of the Central Valley Aquifer, California*: U.S. Geological Survey Professional Paper 1766, 225 p.

The location, extent, and magnitude of subsidence along the canals will be characterized using a combination of InSAR, leveling, GPS, and extensometer data. The application of InSAR will be challenging, because conventional InSAR applications yield poor results for much of the San Joaquin Valley because agricultural land use disturbs the ground surface. The InSAR technique is very sensitive to small changes (sub-centimeter level) in the vertical position of the ground surface; however, agriculture activities that disturb earth surfaces, such as tilling, create significant “noise” in the InSAR imagery (called interferograms) so that often it is not possible to resolve subsidence using traditional InSAR

Continued on the following page...

Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective – Continued



Figure 5. Location of maximum subsidence measured along Hwy 198 in Armona (Source: Ikehara, NGS/NOAA, 2009)

techniques. In these areas, Ms. Sneed's team will be employing a breakthrough method referred to as "Persistent Scatterer (PS) InSAR." The PS-InSAR™ technique incorporates the detection of fixed "Persistent Scatterers" such as buildings, roads, and potentially levees, and produces elevation-change time series for the persistent scatterer pixels only. These time series of observed changes in the land surface elevation will be compared to elevation changes measured by GPS, leveling, and extensometer data.

The PS-InSAR technique will be developed and implemented as a subsidence-monitoring tool by obtaining a new measurement every few months (dependent on data availability and quality). Such a tool could be very helpful for informing management decisions related to subsidence mitigation (e.g., groundwater pumping timing and distribution) and identification of incipient subsidence problems before infrastructure is threatened.

Mr. Michael Rucker, PE, presented "Monitoring Land Subsidence in the Phoenix Area and Potential Applications to the San Joaquin Valley." He identified the geotechnical keys to understanding subsidence: soil geometry, material properties, and pore pressure change. Mr. Rucker uses a combination of hydrogeologic analysis, extensometers, geophysical techniques, and

InSAR data. Several geophysical survey methods were discussed, including seismic refraction, downhole electrical resistivity, gravity surveys, refraction microtremor, and resistivity soundings. The geophysical surveys are used to characterize site bedrock and lithologic characteristics and to identify fine-grained soil layers that are susceptible to subsidence.

Mr. Rucker discussed the integration of geophysical survey data, geotechnical stress-strain models, and InSAR data to develop earth-fissure risk zonation maps. He has successfully used this technique to identify areas of high subsidence-related earth fissure risk at several sites in Arizona, including the McMicken Dam near Surprise, Arizona.

The Policy and Technical Round Table discussions at the end of the day fostered dynamic and thought-provoking exchanges between the variety of stakeholders affected by groundwater withdrawal-induced land subsidence. The round table sessions were conducted in order to assemble input from stakeholders and to develop ideas to mitigate this problem. Some of the issues identified during the Technical session (moderator: Mr. Chris Johnson, AEGIS Groundwater Consulting; panelists: Dr. Nigel Quinn, PE, Berkeley

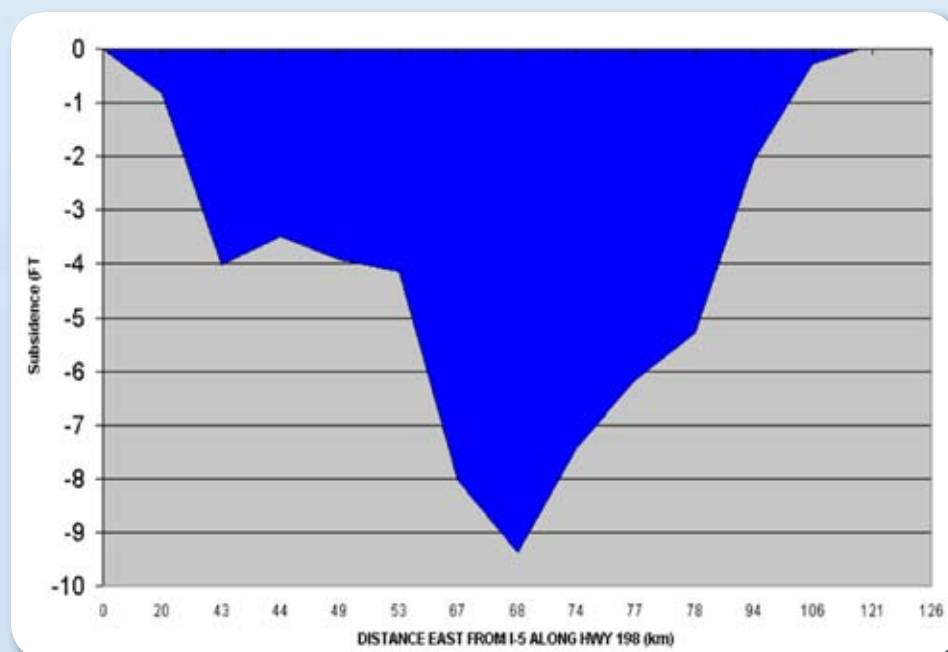


Figure 6. Representation of maximum subsidence along Hwy 198 at Armona (note: horizontal scale is shown in kilometers) (Source: Ikehara, NGS/NOAA, 2009)

Continued on the following page...

Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective – Continued

National Laboratory; Steven Phillips, Hydrologist, USGS; Al Steele, Senior Engineering Geologist, DWR (retired)) included:

- the need for more effective monitoring and reporting of groundwater conditions, specifically pumping volumes and water levels
- concerns about over-pumping and its effects on surface water delivery facilities (a sort of “Catch-22” situation)
- the need for simple, basic data collection
- better coordination between the agencies affected by the problem.


Specific issues addressed during the Policy Round Table (moderator: Mr. Sarge Green, California Water Institute; panelists: Dr. Karl Longley, PE, DEE, Emeritus Professor, California State University, Fresno; Thomas Glover, PE, Deputy General Manager-Resources, Westlands Water District; Paul Betancourt, Fresno County Farm Bureau) included the role of legislation in addressing the problem. Legal and regulatory tools for addressing the impacts of subsidence include Section 2100 adjudication by the State Water Resources Control Board (for protecting groundwater quality) and legal actions by injured parties that could initiate full groundwater adjudication. If subsidence causes changes in the movement of water such that water quality is degraded, the State Water Board can initiate adjudication on their own volition. Injured parties, including those with facilities damaged by subsidence, could enter a legal action for groundwater adjudication. Finally, it was noted in the panel that newly passed legislation has groundwater monitoring and reporting requirements that should assist in better understand-

ing where and how much groundwater is being extracted, thus allowing scientists and managers to better predict subsidence occurrence.

In summary, “Groundwater Withdrawal-Induced Land Subsidence in the San Joaquin Valley: A 2009 Perspective” brought leading experts in subsidence together to explore the current state of this vexing problem, discuss water policy issues that affect the situation, present techniques for monitoring and measurement of the problem, and advance ideas to help mitigate and control the problem. AEG and GRA plan to conduct a future symposium to focus on hydrogeologic, engineering geology, and geotechnical engineering approaches to help cope with this ongoing phenomenon.

The symposium received support from the following sponsors:

- BSK Associates (Platinum)
- AEGIS Groundwater Consulting (Gold)
- AMEC Geomatrix (Silver)
- Kleinfelder (Silver)
- Provost & Pritchard Engineering Group (Silver)
- California Geotechnical Engineers Association (Silver)
- Welenco, Inc. (Silver)
- American Society for Photogrammetry and Remote Sensing (Bronze)
- Circle K Ranch (Bronze) 💧



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Dates & Details

GRA EVENTS & KEY DATES

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

GRA Shortcourse

Introduction to Groundwater & Watershed Hydrology

Mar. 1 & 2, 2010 | Davis, CA

GRA Symposium

Solvent Release Sites: Characterization, Clean Up & Closure

Apr. 1, 2010 | Santa Clara, CA

GRA Annual Legislative Symposium & Lobby Day

April 28, 2010 | Sacramento, CA

GRA Board and Planning Meetings

May 1 & 2, 2010 | San Diego, CA

GRA Geophysics Course/Symposium/Field Demo

Geophysics at the Beach

May 24-26, 2010 | Santa Ana, CA

GRA-sponsored Conference

Groundwater In Agriculture: An International Conference Linking Science & Policy

June 15-17, 2010 | Burlingame, CA

GRA Short Course

Principles in Groundwater Flow and Transport Modeling

Sep. 12-15, 2010 | Redwood City, CA

GRA 19th Annual Conference

Think Outside the Pipe—Exploring Local Water Supplies

Sep. 15-16, 2010 | Burlingame, CA

Solvent Release Sites: Characterization, Cleanup, and Closure

APRIL 1, 2010

SANTA CLARA MARRIOTT HOTEL, SANTA CLARA, CA

Co-Sponsors: ARCADIS, CH2M Hill, Haley & Arldrich

GRA is pleased to announce a symposium on Solvent Release Sites. While major improvements in regulation, management, and handling of solvents have nearly eliminated new solvent releases to the subsurface, legacy releases from past decades continue to present numerous technical and institutional challenges to society and to environmental and public health professionals. Many contaminated sites seem to be mired in never-ending active remediation with little improvement observed in restoration results, particularly where a well-designed remedy using appropriate characterization methods is lacking. Without a clearly defined closure strategy, it is not possible to reach agreements among the stakeholders as to when to stop active remediation or monitoring.

Attempting to effectively and efficiently address solvent release sites involves not only difficult technical issues, but also policy challenges such as establishing effective performance monitoring objectives and methods, including mass flux evaluation and risk-based cleanup standards. This symposium will provide a valuable forum for dissemination of leading-edge research and innovative field applications that demonstrate advances in solvent site characterization, remediation, and closure. Professional education and discussion among members of the academic, consulting, and regulatory communities are critical in advancing our understanding of the ongoing cleanup challenges, evaluating successes and lessons learned in this field, and effectively deploying limited economic resources while also protecting human health and groundwater resources.

We are pleased to announce presentations on the following topics:

1. Innovative tools in site characterization
 - Field applications
 - High-resolution data collection
 - Visualization, data management, and site conceptual model development
 - Evaluation of biodegradation processes with compound-specific isotope analysis, biotrap, and molecular probe techniques
2. Source cleanup using innovative technologies or treatment train approaches
 - In situ chemical oxidation (ISCO) - Enhanced in situ bioremediation (EISB)
 - In situ thermal technologies
 - Other innovative technologies
 - Physical removal methods: pump and treat, soil vapor extraction, air sparging
3. Plume management
 - Mass Flux and Mass Discharge measurement and tools
 - Emerging technologies for monitored natural attenuation (MNA) assessment
4. Alternative Site Closure Strategies
 - Alternative endpoints and alternative remedial strategies for groundwater cleanup
 - Use of Technical Impracticability (TI) Waivers at Superfund sites
 - Regulatory perspectives 💧

Geophysics at the Beach Course/Symposium/Demo

in cooperation with
Environmental & Engineering
Geophysical Society

MAY 24 - 26, 2010
DOUBLETREE CLUB HOTEL
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SANTA ANA, CA AND PENINSULA
PARK, NEWPORT BEACH, CA

Groundwater will be relied upon more in the future to meet the increasing demands in a changing climate of hydrology, socio-economic pressures, decreasing surface water availability and rising surface water fees. More reliance on groundwater means an increasing need for better information on subsurface hydrogeology, water quality, and improved predictability of returns on groundwater storage projects.

Geophysics is a discipline that utilizes a suite of high resolution tools that will play an increasing role in clean and contaminant hydrogeologic investigations to obtain high quality and cost effective subsurface information to make better informed management decisions.

Who should attend: The symposium is intended for technical professionals, public agency and regulatory agency staff, university staff, responsible parties, case managers, and anyone else interested in the latest geophysical tools and technologies for application to hydrogeologic problems.

Geophysics at the Beach includes the following optional program elements (see www.grac.org for more information): Short Course: Basic and Advanced Borehole Geophysics – May 24 Symposium: Geophysics at the Beach – May 25 Field Demonstration: Geophysics at the Beach, in the surf, sand, and grass on the Pacific Ocean – May 26. 💧

Joint 2010 Annual Meeting

Cordilleran Section of the Geological Society of America – Pacific Section of the American Association of Petroleum Geologists

MAY 27-29, 2010

Plan to attend the 2010 Joint Annual Meeting of the Cordilleran Section of the Geological Society of America (GSA) and the Pacific Section of the American Association of Petroleum Geologists (AAPG) on May 27-29, 2010 at the Anaheim Marriott, in Anaheim, California. The Cordilleran Section meeting is being hosted by California State University Fullerton.

See the meeting web site at <http://www.geosociety.org/sectdiv/cord/2010mtg/index.htm> for details. More than 1,000 participants are anticipated to attend the more than 30 technical sessions that span most Earth Science disciplines. Ten field trips, both pre- and post-meeting, are scheduled. One of the technical sessions is on Managing Groundwater in the Cordillera. W. Richard Laton and John Foster at California State University (CSU)-Fullerton, Matthew W. Becker at CSU-Long Beach, and Barry Hibbs at CSU-Los Angeles are the conveners. This session will focus on groundwater management in the multi-varied basins of the Cordillera.

Please contact Jeffrey Knott (Technical Program Chair), Associate Professor at the Dept. of Geological Sciences, California State University Fullerton at jkknott@fullerton.edu or Phil Armstrong (Joint Meeting Chair), Associate Professor of Geology, Department of Geological Sciences, California State University Fullerton, parmstrong@exchange.fullerton.edu if you have any questions. 💧



Save the Date

GRA Annual Legislative Symposium and Lobby Day

APRIL 28, 2010 – SACRAMENTO, CA

Agenda will include:

- Briefings on important current legislative issues of interest to groundwater professionals
- Dialogue with key legislators on the future of California groundwater
- Visits with legislators and decision makers, including your local representatives to educate them on the concerns and technical expertise of GRA members.

Questions? Contact Tim Parker at tparkergwguy@aol.com.



Toward Sustainable Groundwater in Agriculture

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REGISTRATION IS
NOW OPEN

Program Highlights:

Groundwater is the lifeline for many rural and agricultural regions and their associated cultures and populations around the globe and a cornerstone of global food production. Groundwater constitutes nearly half the world's drinking water and much of the world's irrigation water supply. Over use; groundwater salinity; nonpoint source pollution from agricultural activities, animal farming, ranching, and forestry activities; agricultural groundwater impacts to surface water; and groundwater quality and quantity conflicts at the urban-rural interface have reached global dimensions and threaten the very livelihood of this planet.

Topics to be addressed in plenary sessions and technical sessions include:

- Socioeconomic Aspects of Agricultural Groundwater
- Climate, Energy, and Agricultural Groundwater
- Agricultural Groundwater Quality and Contamination
- Conjunctive Use, Agricultural Water Use, and Groundwater Management, Policy, and Regulation
- Groundwater at the Agriculture-Urban Interface
- Groundwater Linkages to Surface Water and Estuaries

Abstracts are now being accepted until January 18, 2010.
Check the conference website, www.ag-groundwater.org, for details

The Groundwater Resources Association of California is coordinating exhibits.
Contact Mary Megarry at mmegarry@nossaman.com or 916-446-3626 for more information.

Sponsorships are welcome. Contact Beth Stern at bstern@watereducation.org or 916-444-6240 for more information.

Watch the website, www.ag-groundwater.org, for updates.



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19th Annual Conference & Meeting "Think Outside the Pipe ~ Exploring & Protecting Local Water Supplies"

SEPTEMBER 15-16, 2010

HYATT REGENCY AT THE SAN FRANCISCO AIRPORT, BURLINGAME, CA

SEPTEMBER 17, 2010

FIELD TRIP: LOCAL WATER AND GROUNDWATER PROJECTS

Co-Sponsor: Erler & Kalinowski, Inc.
Cooperators: DTSC & IAH

This two-day conference will provide the latest scientific, management, legal and policy information regarding sustainable use of our local water resources in urban regions. The conference will cover opportunities and solutions for increasing water use efficiency, integrating local and alternative supplies, reducing and capturing urban run-off, minimizing conveyance and energy costs, issues associated with the protection, enhanced recharge, and expanded use of local groundwater supplies.

Who Should Attend

Scientists, policymakers, planners, urban, rural, and environmental stakeholders, local, state and federal governmental officials, and consultants involved in water resources.

Program Focus

Surface water imported through large-scale water delivery projects is a primary drinking water source for many urban regions. However, as climatic and environmental impacts continue to reduce the yield of these surface water systems, local water suppliers and others are facing significant water management challenges. Such challenges include increasing the use of groundwater and other local water sources to meet local demands, protect-

ing and enhancing the quality of the groundwater and other water sources, conjunctively managing surface and groundwater to improve supply reliability, and integrating water management with energy reduction strategies. Additional issues that pose water management challenges include nonpoint source pollution from stormwater, surface water impacts and TMDLs, water use efficiency, overdraft, groundwater salinity, industrial impacts to water supplies, water rights, and water quality and quantity policy conflicts.

Topics for Plenary and Technical Sessions Include

- Stormwater Capture and Reuse - permitting and water rights
- Urban Water Recharge – water quality and permitting
- Brackish water supplies – inland and coastal
- Recycled water – what are the remaining challenges
- Low Impact Developments for water
- Rainfall Rooftop Harvesting
- Graywater Permitting – Black & White, or Still a Lighter Shade of Pale?
- Water Conservation as a New Source
- Water Demand – Using Less and Growing More
- Conjunctive Use and Local Storage

Potential – Addressing Related Issues

- Pollution Prevention and Protecting Local Supplies
- Hurdles to Contaminant Site Water Reuse
- Groundwater Policy and Data
- Recycled Water Reuse for Residential Areas
- Emerging Contaminants
- The use of Geographic Information Systems (GIS) to enhance and protect local supplies
- The role of non-traditional local water supply in Integrated Water Supply Plans

Collegiate Groundwater Colloquium

GRA seeks to increase participation by university and college faculty and students in its programming. In pursuit of this goal, GRA launched a new annual meeting module in 2008 called the "Collegiate Groundwater Colloquium." The Collegiate Groundwater Colloquium presents students who are conducting highly relevant research in the general area of the conference theme. The Colloquium and reception provide students with an excellent opportunity to showcase their research and attendees an opportunity to learn from the frontier of groundwater science. 💧

Wells and Words

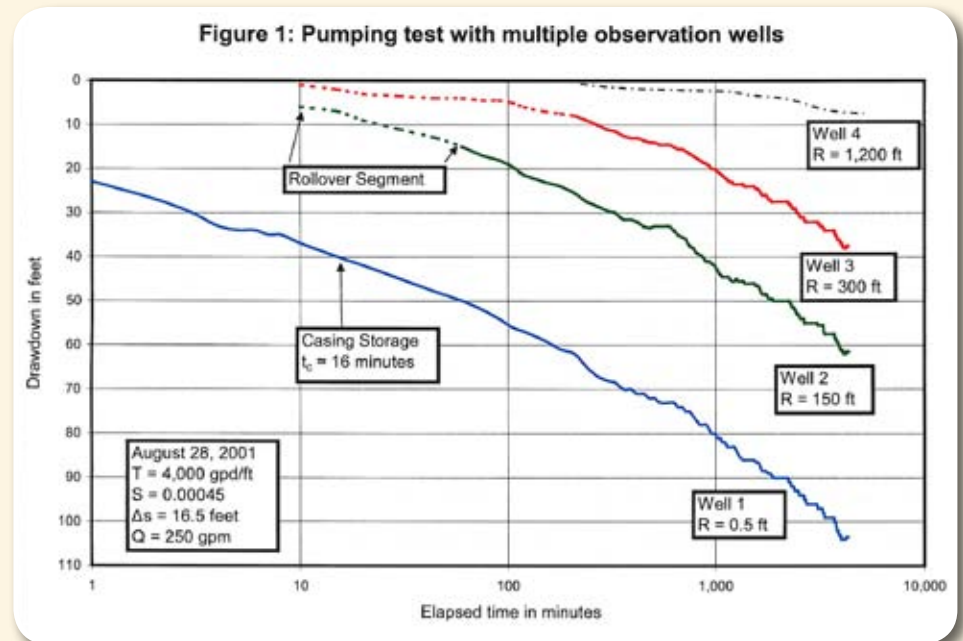
By David W. Abbott, P.G., C.Hg., Todd Engineers

The Constants of Constant-Rate Pumping Tests

Presentation, evaluation, and interpretation of pumping test data have been greatly simplified with the advent of the personal computer. Computers allow for easy manipulation, hydraulic correction, and transformation of time-drawdown data and corresponding coordinate axis scales; long gone is the tedious task of manually re-plotting data at various scales to evaluate well and aquifer responses. Evaluation of tests can be achieved effectively using standard spreadsheets and manual curve-matching techniques using full-logarithmic (log-log), semi-log, and full-arithmetic plots, but also can be accomplished using manual and automated methods available in commercial software. Basic data needed to evaluate aquifer parameters and well hydraulics from constant-rate tests include a time series of discharge (Q) and drawdown (dd) measurements taken during pumping. Site-specific conditions and project goals may require corrections for barometric and tidal changes, partial penetration, and well field operations; these adjustments are easily accomplished using spreadsheets.

Q is usually quantified using a flow meter (cumulative and instantaneous), weir arrangements, orifice and pipe methods, or measuring the time to fill a container of known volume, and is reported in volume per time (US or Imperial gallons/minute, cubic feet/minute, liters/second, etc.). Q should be kept within five (± 5) percent of the average Q during a constant-rate test, especially for low-yield aquifers, where dd is sensitive to small changes in Q .

The vertical distance between the non-pumping or static water level (SWL) and the pumping water level (PWL) is the dd (feet or meters). Various methods with varying accuracy are



David W. Abbott – The constants of constant-rate pumping tests.

Todd Engineers

used to measure the depth to water (DTW); accuracy also can depend on the clear and unobstructed access to the well. The SWL and PWL can be measured manually (rock and bong¹ [no kidding], ploppers, airline, sonic water-level meter, chalk and steel tape, and single or coaxial electric sounder methods) or with pressure transducers and recording data loggers. The rock and bong, plover, and airline are not very accurate, whereas the chalk and steel tape, electric sounder, and transducer methods are more accurate; sounding tubes placed between the pump column and the casing can improve water-level monitoring in many pumping wells. The chalk and steel tape and sonic water-level meter methods have their own limitations and cannot easily be used in wells with deep water levels and crooked casings, especially with installed pumps. A network of transducers installed in multiple observation wells during pumping tests can significantly offset the number of field personnel required to conduct a long-

term test; these continuous water levels can provide a better understanding of well and aquifer responses, particularly during the first few minutes of a test.

During the pumping test, the elapsed time and dd should be plotted on semi-log graphs (modified non-equilibrium equation) in the field to easily determine the real-time trend and shape of the time- dd plots. Time is plotted on the X-axis (log) and the dd (or DTW) is plotted on the Y-axis (arithmetic). In many applications semi-log plots are visually more diagnostic than log-log plots. Curvilinear patterns (log-log) are more difficult to interpret than straight lines² (semi-log). The hydraulic interpretation of a pumping test must also include an evaluation of the design of the wells, geologic framework, and proper application of analytical methods, including an estimate of the value of u , casing storage, geologic and hydraulic boundaries, antecedent water-level trends, well efficiency, etc.

Continued on the following page...

Wells and Words – Continued

Field evaluation allows adjustment of the Q (if needed), revision of pumping test protocols, and decisions to suspend the test. It is better to plot data from each observation well on the same chart using the same scales, as shown in Figure 1, rather than plot the time-dd on different charts; this is not a new idea. Often, time-dd plots for the pumping and observation wells are parallel, creating a family of dd curves (Figure 1). Estimation of aquifer parameters using this family of dd (or recovery) curves should be based on equivalent and parallel time-dd segments. Non-parallel observation well responses suggest aquifer anisotropy or wells completed in different aquifers. Comparison between dd plots allows determination of the best segments for use in estimating aquifer parameters and responses.

Distant observation wells typically have the shallowest time-dd slopes (i. e., largest apparent transmissivity). Figure 1 shows that dd at Well 4 has not completely stabilized and the time-dd slope is shallower than the intermediate and final slopes of Wells 1-3, but is parallel to the initial segments of the other wells. This early time-dd slope is often referred to as the rollover portion of the time-dd curve, representing a slow hydraulic adjustment of the potentiometric surface surrounding a pumping well; this segment should not be used to estimate aquifer parameters.

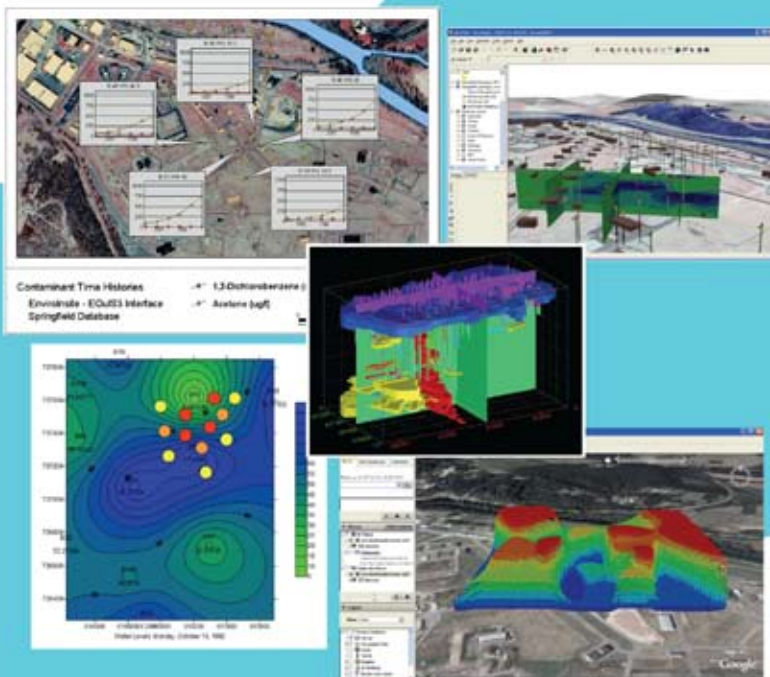
Identification of a family of parallel dd responses is a powerful means of visually demonstrating the consistency of hydraulic parameters within the hydrogeologic framework; this likely would not be a visible pattern using individual

charts with different dd scales. Data presentation³ can be the key to data analysis and understanding of aquifer systems. If the curves are shown to be parallel, then the transmissivity is identical, and only one transmissivity needs to be calculated for the pumping test; –note that usually there is only one transmissivity (representing the average of the aquifer volume tested) that can be computed from a pumping test. 💧

- 1 Stewart, D.M., 1970, The Rock and Bong Techniques of Measuring Water Levels in Wells, Ground Water, vol. 8, no. 6, p.14-18.
- 2 Helsel, D.R. and R.M. Hirsch, 1992, Statistical Methods in Water Resources, Studies in Environmental Science 49, Elsevier Science Publishers, Amsterdam, 522 pages (see page 27). 2002 edition free and downloadable at <http://www.practicalstats.com>
- 3 Tufte, E.R., 2001, The Visual Display of Quantitative Information, Graphics Press, Cheshire, CT.

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Legislative Update

By Tim Parker, GRA Legislative Committee Chairman, Chris Frahm and Paul Bauer, GRA Legislative Advocates

Following the success of last year's passage of a comprehensive water package, the Governor and a diverse array of stakeholders now begin the arduous process of ensuring the passage of the \$11.14 billion water bond which was its cornerstone. It won't be easy. Critics point to a stale economy, a state budget deficit that is once again in the double digits and the fact that almost \$8 billion of \$9.4 billion in water-related bonds authorized by voters in 2006 remain unspent. Also, unlike past water bond measures, this water bond may face stiff opposition by environmental groups, including the powerful Planning and Conservation League and Sierra Club. Further, Delta interests that staunchly opposed the water package are expected to join the opposition.

No organized campaign has yet been formed or funded by water bond opponents; however, the Alliance for Clean Water and Jobs, sponsored and largely funded by the Conservation Action Fund and California Alliance for Jobs (FPPC ID# 1317616), was recently formed and boasts a sturdy list of supporters. These include environmental, business, and agricultural supporters, and water industry groups and leaders, e.g., the CA Chamber of Commerce, Association of CA Water Agencies, Southern CA Water Committee, The Nature Conservancy and Western Growers Association – to name just a few.

The water bond includes an unprecedented amount of funding for groundwater-related projects, including provisions for drought relief (\$455 million), water supply reliability (\$1.4 billion), statewide operational improvement (\$3 billion), groundwater protection and water quality (\$1 billion) and water recycling and water conservation (\$1.25 billion). The groundwater monitoring

provisions of the water bill package were strongly supported by GRA over the past several years. The Legislative Committee will be working with the Department of Water Resources on implementation issues. GRA will be coordinating these activities with ACWA and with the California Groundwater Coalition.

2010 promises to be yet another interesting year for water supply and groundwater issues in California. While the state budget deficit and election year will undoubtedly dominate the landscape in the Capitol, we expect issues of importance to GRA to remain "front and center." In the final analysis, no issue holds more promise for the state's success or failure than the assurance of a reliable water supply. 💧

HOLD THE DATE! GRA Legislative Symposium

APRIL 28, 2010

HYATT REGENCY SACRAMENTO

This year's GRA Legislative Symposium will focus on implementation of the groundwater monitoring bill and will include discussions with Legislators and Legislative staff, and presentations by DWR on the CA Water Plan Update. Afternoon visits to Legislator's offices in the Capitol will be followed by a hosted reception to debrief the day's events. This important event educates GRA's membership on the legislative process, and educates members of the legislature on GRA's key initiatives. 💧



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The Federal Corner

By John Ungvarsky

Study of Basin-Fill Aquifers in the Southwest

The National Water-Quality Assessment Program of the U.S. Geological Survey (USGS) is conducting a regional analysis of water quality in the principal aquifers in the southwestern U.S. The Southwest Principal Aquifers study is building a better understanding of the susceptibility of basin-fill aquifers. For an overview of the basin-fill aquifers in the southwestern United States and description of the completed and planned regional analyses of ground-water quality being performed by the SWPA study, go to <http://pubs.usgs.gov/fs/2009/3015>.

Central Valley Subsidence Study Launched

This USGS research will address growing concerns that increased groundwater pumping in the San Joaquin Valley may be causing the land surface to sink, or subside, damaging the California Aqueduct. The research will focus on the west side of the San Joaquin Valley in the area of the Westlands Water District. USGS scientists will use Synthetic Aperture Radar data from satellites to create maps (interferograms) of changes in land-surface elevation at selected locations over the last several years. For more info., go to http://ca.water.usgs.gov/news/ReleaseSept4_2009.html.



California Aqueduct/ Photo by California Department of Water Resources

USGS Receives Neese Award

The USGS has been given the Kevin J. Neese Award by the GRA. The award recognizes USGS for their significant contribution to the “understanding, development, protection and management of groundwater” resulting from their report on groundwater availability in California’s Central Valley. The report can be found at <http://pubs.usgs.gov/pp/1766/>.

Safe Drinking Water Act 101

A new Safe Drinking Water Act 101 module has been posted on EPA’s Drinking Water Academy web site. For more info., go to <http://www.epa.gov/safewater/dwa/training.html#two>.

EPA’s ETV Program

EPA’s Environmental Technology Verification (ETV) Program has verified the performance of 420 innovative environmental technologies that can be used to monitor, prevent, control, and clean up pollution. For more about the program and a full list of ETV verifications, visit: <http://www.epa.gov/etv/verifiedtechnologies.html>.

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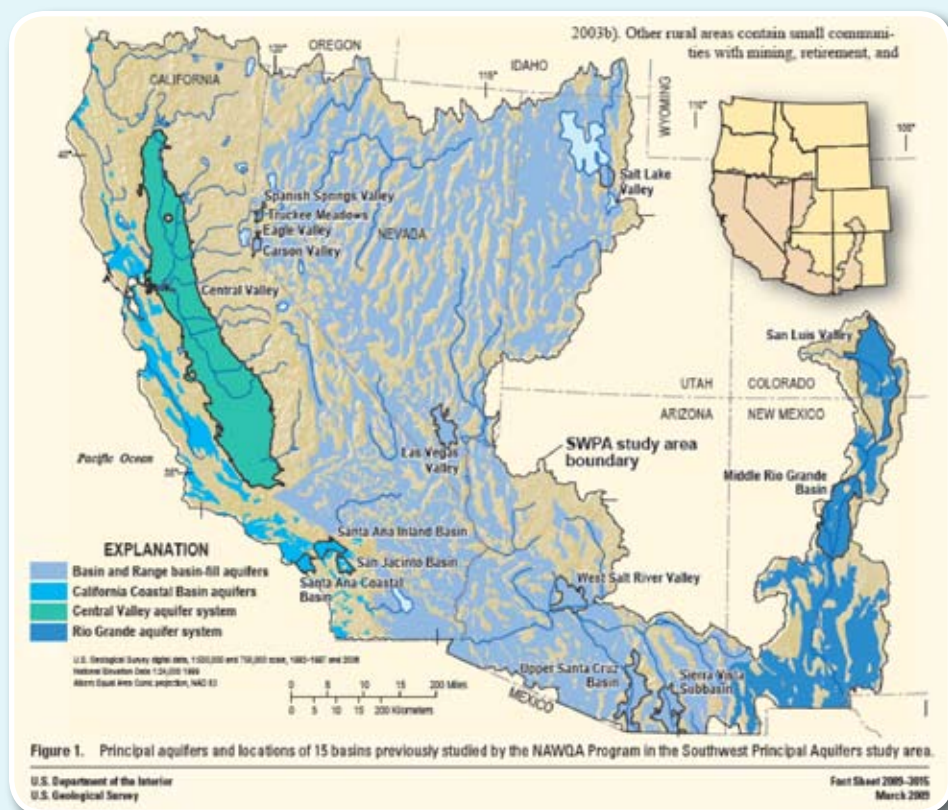


Figure 1 from Fact Sheet 2009-3015. Principal aquifers and locations of 15 basins previously studied by the NAWQA Program in the Southwest Principal Aquifers study area.

The Federal Corner – Continued

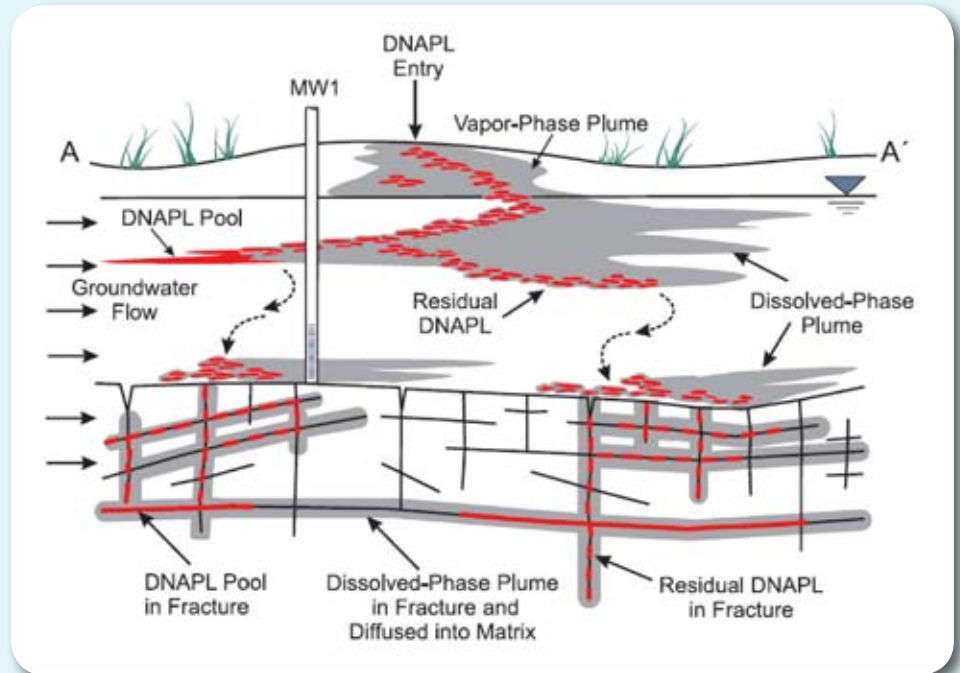
Arsenic Removal from Drinking Water by Coagulation/Filtration

This EPA report (EPA/600/R-09/113) documents the activities performed during, and the results obtained from, the arsenic removal treatment technology demonstration project at the City of Three Forks, MT facility. The objectives of the project were to evaluate: 1) the effectiveness of Kinetico's FM-248-AS Arsenic Removal System using Macrolite® media in removing arsenic to meet the maximum contaminant level (MCL) of 10 µg/L, 2) the reliability of the treatment system for use at small water facilities, 3) the required system operation and maintenance (O&M) and operator skill levels, and 4) the capital and O&M cost of the technology. The project also characterized water in the distribution system and residuals generated by the treatment process. The types of data collected included system operation, water quality, process residuals, and capital and O&M cost. For more info., go to: <http://www.epa.gov/nrmrl/pubs/600r09113/600r09113.pdf>.

Clean-Up Information and Free Web-based Seminars

EPA's Hazardous Waste Clean-Up Information (CLU-IN) web site provides a wealth of information about innovative treatment technologies to the hazardous waste remediation community. It describes programs, organizations, publications and other tools for federal and state personnel, consulting engineers, technology developers and vendors, remediation contractors, researchers, community groups, and individual citizens. The site was developed by the EPA but is intended as a forum for all waste remediation stakeholders. CLU-IN's ongoing series of Internet Seminars are free, web-based slide presentations. For more information about CLU-IN, registration for upcoming Internet Seminars, or viewing of achieved seminars, please go to <http://www.clu-in.org/training/>.

Continued on the following page...



Schematic illustration of contamination associated with a DNAPL release. Note that DNAPL migrates in three dimensions, and that residual DNAPL accumulated above bedrock is the result of the release at ground surface. Figure is not to scale.

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The Federal Corner – Continued

Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites

Groundwater contamination from classes of chemicals such as chlorinated solvents, polychlorinated biphenyls, creosote, and coal tar is frequently encountered at hazardous waste sites. This EPA document (EPA/600/R-09/119) builds on information from previous fact sheets to provide a framework for not only assessing the presence of Dense Non-Aqueous Phase Liquids (DNAPLs), but also for delineating the spatial extent of the DNAPL source zone, a priority at many sites due to the more prevalent use of in-situ remediation technologies. For more info., go to: <http://www.epa.gov/ada/download/issue/600r09119.pdf>.

Defense Department Issues Major Policy on Uses of Hexavalent Chromium

In an April 2009 memorandum, Under Secretary of Defense for Acquisition, Technology & Logistics John J. Young Jr. outlined a new, more restrictive approach for the Department of Defense's (DoD) use of hexavalent chromium. Hexavalent chromium is critical in preventing corrosion and increasing durability in many of DoD's weapons systems, platforms, and operations. With the potential human health and environmental issues, increasing regulatory restrictions, and potential disruptions to DoD supply chains in mind, the Under Secretary called for a number of DoD actions. For the full story, see: http://www.ndcee.ctc.com/newsletters/NDCEE_summer_fall%2009%20newsletter.pdf.

USGS Studies Reveal Why Drinking Water Wells are Vulnerable to Contamination

New USGS groundwater studies explain what, when, and how contaminants may reach public-supply wells. All wells are not equally vulnerable to contamination because of differences in three factors: the general chemistry of the aquifer, groundwater age, and direct paths within aquifer systems that allow water and contaminants to reach a well. More than 100 million people in the United States receive their drinking water from public groundwater systems, which can be vulnerable to naturally occurring contaminants such as radon, uranium, arsenic, and man-made compounds, including fertilizers, septic-tank leachate, solvents and gasoline hydrocarbons. The USGS tracked the movement of contaminants in groundwater and in public-supply

wells in four aquifers in California, Connecticut, Nebraska and Florida. The importance of each factor differs among the various aquifer settings, depending upon natural geology and local aquifer conditions, as well as human activities related to land use and well construction and operation. Findings in the four different aquifer systems can be applied to similar aquifer settings and wells throughout the nation. Complete findings, fact sheets, maps and decision support tools are available.

John Ungvarsky is an Environmental Scientist at the U.S. Environmental Protection Agency, Region 9. He works in the Water Division's Ground Water Office and oversees source water protection efforts in CA, HI, and NV. For information on any of the above topics, please contact John at 415-972-3963 or ungvarsky.john@epa.gov. 💧



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Falling through the Cracks – Sample Prep

By Bart Simmons

Once participated in a U.C. Davis extension class on environmental analytical techniques organized by the late Charlie Soderquist. A speaker from the State Water Board stressed the importance of including sediment in testing water samples. Charlie's response was that their lab would routinely filter a water sample and toss the solids. Charlie was certainly a competent chemist representing a competent lab, but the lesson was significant and is still valid today. Test results can be biased or invalidated by using the wrong sample preparation technique. EPA methods, such as those in SW-846, are often silent on sample preparation, leaving decisions to the lab. The client is sometimes contacted, and sometimes not.

Heterogeneous samples are particularly challenging for sample prep. Water with dense or light non-aqueous liquids, water with suspended solids, and heterogeneous waste samples, all present a problem to the lab. Some protocols, like the EPA Toxicity Characteristic Leaching Procedure (TCLP) and the California Waste Extraction Test (WET), include specific sample preparation procedures, but these procedures are not routinely followed. For example, the WET calls for grinding solids until they pass a 2 mm sieve (for metals) or a 1 mm sieve (for organics). Most environmental labs do not even have the grinders needed to follow the

protocol. Using the proper technique is critical for some methods, including metals analysis, that ultimately require only 1-2 g of prepared sample. If a sample has not been adequately homogenized, the 1-2 g sample will not be representative of the entire sample. If the data are to be used in litigation, the consequences can be dire. I once worked on a project involving groundwater with floating petroleum distillate. The Deputy Attorney General handling the case required that the TCLP sample prep be strictly followed, which required re-testing that would not normally be done.

Auto shredder residue is an example of a difficult material to prepare, and several procedures have been developed to handle that material. There are industrial-sized grinders that can reduce shredder residue to the desired size, but they are only occasionally

used. Another approach is to scale-up the test procedure to use a larger mass of sample and more reagents, but that results in increased lab waste and a requirement to validate the scaled-up procedure.

Accredited labs should be reporting the sample preparation procedure in the final lab report, but often do not. As a result, there may be no written record of how the sample was actually handled. Sample prep. can be specified in a sampling and analysis plan, but that does little good if the plan is not shared with the lab in advance, or if there is no oversight of the testing.

Sample preparation is a critical, but often overlooked part of the testing process, which often falls through the cracks.

Bart Simmons can be reached at bartonps@aol.com.

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Mining the California Water Atlas

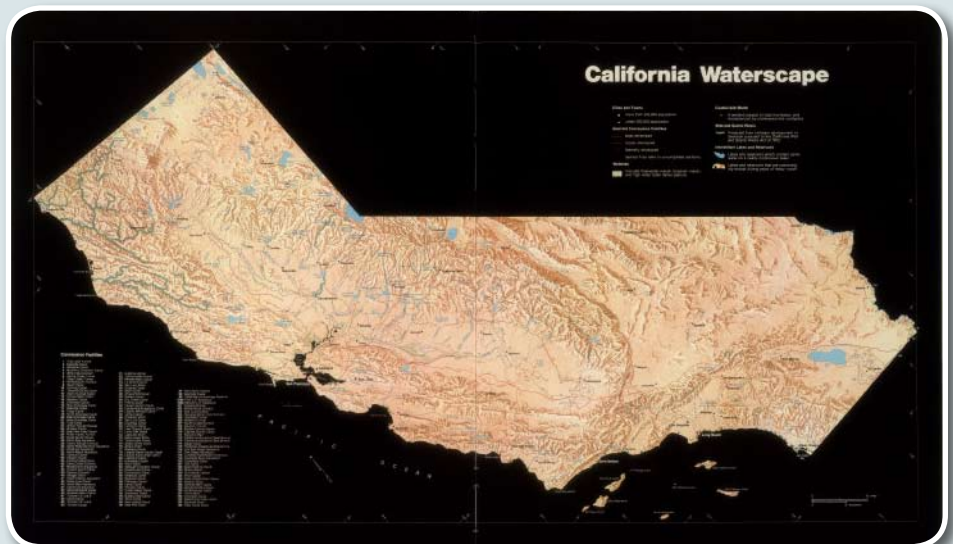
By Paul Atwood, Archivist & Head of Technical Services, Water Resources Center Archives

The Water Resources Center Archives (WRCA) is pleased to announce that the California Water Atlas, a monument of 20th century cartographic design, is now freely available online. Produced by the California Governor's Office of Planning and Research (OPR) in 1979, this work features an impressive amount of data and a variety of innovative and effective visual presentations. The artistic representations of data and geography provide an accessible means for understanding the State's complex water issues.

The atlas received numerous rave reviews upon publication. For example, the San Francisco Chronicle stated, "It seeks for the first time—in text written by some of the country's top water experts, and illustrated by artful graphs, plots, charts, and maps—to tell the full story of the element that more than any other has shaped California: water." The original work was a collaborative effort involving many individuals within and outside of the government of then-Governor Edmund G. (Jerry) Brown, Jr., including William L. Kahrl, Project Director and Editor; William A. Bowen, Cartography Team Director; Stewart Brand, Advisory Group Chairman; Marlyn L. Shelton, Research Team Director; David L. Fuller and Donald A. Ryan, Principal Cartographers; and many others.

WRCA worked collaboratively with OPR and the David Rumsey Historical Map Collection to produce the digital atlas. The atlas was scanned at a very high resolution, revealing images that can be explored in striking detail. High-resolution images of each page and lower-resolution PDFs of the entire atlas are available at the Rumsey website. An online flip-book and other electronic versions (e.g., Kindle) are also available from the Internet Archive. <http://www.davidrumsey.com/luna/servlet/view/search?q=5788> http://www.archive.org/details/The_California_Water_Atlas

Now over 30 years old, the atlas is highly relevant and germane to today's issues and will undoubtedly remain so for a long time to come. 💧



California Waterscape. Pages (70)-(71). Shows major cities and towns, selected water conveyance features, coastal salt marsh, wild and scenic rivers, and intermittent lakes and reservoirs. Has a table of Conveyance Features keyed to map.



Measured and Unimpaired Streamflows. Water Year 1975.» Pages (60)-(61). Graphically compares unimpaired and impaired monthly streamflows for numerous streams.

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GRA Welcomes the Following New Members

November 26, 2009 – February 16, 2010

Adams, Jeffrey	ENGEO Incorporated	Miller, Jeff	E2ManageTech
Aviles, Cathy	Locus Technologies	Moore, Gary	E-PUR, LLC
Bacsik, Mike	BSK Associates	Morra, Dillon	Kennedy/Jenks Consultants
Balasek, Kurt	Geosyntec Consultants	Morse, Lee	Condor Earth
Bice, Nancy	Ninyo & Moore	O'Regan, Gerald	Technologies, Inc.
Blamer, Duane	MWH Americas, Inc.		Santa Clara County
Cachine, Jamie	Environmental		Department of
Chappell, Keri	Resolutions, Inc.		Environmental Health
Choi, Tony	Placer Data LLC	Plaskett, Mandy	Sacramento State University
Churchill, Alan	Padre Associates, Inc.	Ptacek, Bob	Montara Water and
Copeland, Elizabeth (Beth)	E-PUR, LLC		Sanitary District
Depies, Kevin	Cal EPA, DTSC	Pyatt, Ellen	Taber Consultants
DeWitt, Alex	Condor Earth	Reiss, Glenn	Vapor Tech Services
	Technologies, Inc.	Roll, Laura	Larry Walker Associates
Draganic, Miljan	ARCADIS U.S., Inc.	Rosen, Suzi	Regensis
Dunwoody, Joseph	TYBRIN Corporation	Schmidt, Calla	University of California,
Duplan, Neno	Locus Technologies	Slater Carter, Kathryn	Santa Cruz
Fears, Rick	Cal EPA, DTSC		Montara Water and
Gurdak, Jason	San Francisco State	Smaira, Nicholas	Sanitary District
	University		Central Valley Regional
Haeri, Hanieh	University of California,		Water Quality Control Board
	Davis	Steele, Albert	
Hagemann, Matt	SWAPE	Strandberg, John	Strandberg Associates
Hannell, Bill	SunStar Laboratories	Tellegen, Gwen	Leighton Consulting, Inc./
Heldmaier, Clemens	Montara Water and		Accts Payable
	Sanitary District	Valdivia, Andrea	ARCADIS U.S., Inc.
Herzog, Greg	Riverside Public Utilities	Vazquez, Misty	Golder Associates Inc.
Hillstrand, Andrew	Boart Longyear,	Vivas, James	Cal EPA DTSC
	Environmental &	Waldman, Allen	WSP Environment & Energy
	Infrastructure	Wendell, Daniel	RMC Water and
	MWH		Environment
House, Brian	Aegis Groundwater	Wolf, MJR	
Johnson, Christopher	Consulting, LLC		
	Ground Zone		
Jones, Tony	Environmental Services Inc.		
	Gregg Drilling & Testing, Inc.		
Keating, Patrick			
Kullen, Lisa	Johnson Wright, Inc.		
Lake, Kimberly	Geosyntec Consultants		
Liang, Angela	Sierra Nevada Research		
Lucas, Ryan	Institute/UC Merced		
	Sacramento County		
Marcus, Barry	Environmental		
	Compliance Div.		
McDade, Cathy	Water Resources Control		
	Board		
Medina, Diana	Daniel B. Stephens &		
	Associates, Inc.		
Medrano Jr., Renato	Cal EPA, DTSC		



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2010 Contributors to GRA – Thank You

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Renew Your Membership Online – It's Quick and Easy

It's time to renew your GRA membership for 2010. You can renew online via GRA's Web site, www.grac.org, or you can request a hard copy dues renewal invoice from Kevin Blatt at dbadmin@grac.org. To save time and effort, GRA recommends that you renew online as the process is secure and seamless. It will also help GRA to keep related expenses to a minimum.

As GRA entered 2010 with nearly 1,300 members, the goal of having 1,400 members by the end of 2010 is attainable. To make this happen, please renew your membership and recruit one new member to GRA. Recruiting a new member is a way to introduce your colleagues to a credible, innovative organization that provides many benefits.

Thank you for your interest and continued participation in protecting and improving California's groundwater resources. 💧

2010 Directors Election Results

The election for GRA's 2010 Board of Directors is officially completed. Board incumbents David Abbott, Roy Herndon, Sarah Raker and James Strandberg were re-elected. Brad Herrema was elected as a new director. All Directors elected for 2010 will serve three-year terms ending in 2012.

Stephanie Hastings retired from the Board at the end of 2009. GRA extends its sincere appreciation to Stephanie for her dedicated service. 💧

GRA Requests Nominations for the 2010 "Lifetime Achievement" and "Kevin J. Neese" Awards

The purpose of the GRA Awards Program is to recognize noteworthy projects and exceptional individual contributions related to the understanding, protection, and management of groundwater resources. The objectives of the annual Awards Program are:

1. To provide recognition to individuals who have demonstrated leadership and continuous dedication in groundwater hydrology;
2. To provide recognition for unique contributions to groundwater hydrology in 2009-2010.

All nominations for the Lifetime Achievement and Kevin J. Neese Awards must be received by David W. Abbott at dabbott@toddengineers.com no later than Friday June 25, 2010.

Nominations should be completed using the nomination forms available on the GRA website at <http://www.grac.org/awards.asp>. Nominations should: not exceed one page, identify the award for which the nomination is made, and include justification for the award based on the criteria listed below.

The GRA Awards will be presented to the recipients selected by the GRA Board of Directors at 19th GRA Annual Meeting in Burlingame, September 15-16, 2010.

Awards

Lifetime Achievement: presented to individuals for their exemplary contributions to the groundwater industry, and contributions that have been in the spirit of GRA's mission and organization objectives. Individuals that receive

the Lifetime Achievement Award have dedicated their lives to the groundwater industry and have been pioneers in their field of expertise.

Previous Lifetime Achievement Award winners include:

- 2009 - Dr. T.N. Narasimhan
- 2008 - Dr. Perry L. McCarty
- 2007 - Dr. Herman Bouwer
- 2006 - Glenn A. Brown
- 2005 - Dr. Luna P. Leopold
- 2004 - Dr. John D. Bredehoeft
- 2003 - Rita Schmidt Sudman
- 2002 - Thomas W. Dibblee
- 2001 - Carl J. Hauge
- 2000 - Dr. Joseph H. Birman
- 1999 - Dr. David Keith Todd
- 1998 - Eugene E. Luhdorff, Jr.

KEVIN J. NEESE: recognizes significant accomplishment by a person or entity within the most recent 12-month period that fosters the understanding, development, protection, or management of groundwater.

Previous Kevin J. Neese Award winners include:

- 2009 - USGS California Water Science Center for the report titled "Groundwater Availability of the Central Valley Aquifer" (USGS Professional Paper 1766).
- 2008 - Orange County Water District for its Groundwater Replenishment System (GRS), a new water purification plant that produces 70 MGD of near-distilled-quality water each day.

- 2006 - Senator Sheila Kuehl for her work to improve the production and availability of information about the state of our groundwater resources, information on which reasonable and sensible groundwater management may be developed.
- 2004 - California Department of Water Resources for publication in 2003 of its updated Bulletin 118: "California's Groundwater."
- 2002 - Glenn County Water Advisory Committee for formulating a significant groundwater management ordinance that was adopted by the Glenn County Board of Supervisors.
- 2001 - American River Basin Co-operating Agencies and Sacramento Groundwater Authority Partnership for fostering the understanding and development of a cooperative approach to regional planning, protection and management of groundwater.
- 2000 - Board of Directors of the Chino Basin Watermaster for delivering a remarkable OBMP that created a consensus-based approach for making water supplies in the Chino Basin more reliable and cost effective.
- 1999 - Governor Gray Davis for his work and leadership in addressing MTBE. 💧

CORE Foundation Takes Off

Consultants, Owners, Regulators, and Enviro-vendors (CORE) was founded in 2009 as a non-profit organization. The founders recognized the challenges facing the California Underground Storage Tank Cleanup Fund (Fund) as a major threat to the viability and existence of the independent environmental consulting companies, and formed CORE to find ways to streamline the processes involved and solve many of the problems the Fund was facing.

The Fund is financed by fees levied on underground petroleum storage facilities within California and has collected about \$250 million per year. In late 2008, the Fund reserves had been depleted and 1,550 C class claims were suspended from payment in 2009. At the same time, many of the reimbursement payments to the claimants suffered significant delays.

After just one year of operation, CORE achieved significant results as it helped shape changes in the way the Fund conducts business and ensures the improvement of the Fund performance and liquidity. After numerous meetings in Sacramento, the Task Force found areas for cost savings, and was able to influence the increase in the tank storage fee; consequently, the suspension of C class claims was lifted.

CORE worked with others towards the successful passage of legislation AB 1188 (Ruskin), which is estimated to bring in an additional \$80 to \$100 million per year to the Fund. The legislation also provides for reimbursement of the cost of bridge financing for approved remedial work, enabling consultants to continue with approved remediation activities without major financial constraints. CORE also has formed relationships with financial institutions to provide its members with financing and funding information for cleanups. CORE is working on the important task of collateralization of reimbursement claims to enable private lenders or banks to more easily loan money to owners/operators or consultants for remediation projects.

Another CORE objective is to assist the UST Fund and other regulatory agencies in encouraging site closure. Many cases open for decades should be closed on the basis of science and engineering data, exposure pathway evaluations, risk analysis, economics and common sense.

CORE joined forces with the California Council of Geoscience Organizations (CCGO; www.ccco.org), which held the 10th annual Sacramento Drive-In on May 28, 2009. CORE's interest in supporting CCGO is their emphasis on encouraging the highest professional standards in the environmental and engineering fields. Although the Board for Geologists and Geophysicists (BGG) was eliminated in July 2009, CORE supported the efforts to inform the geologists, legislators and the public of the need for strong professional licensure needed for environmental and engineering professionals. The next Sacramento Drive-In is planned for March 25, 2010.

The December 8, 2009 CORE board meeting in Oakland included the election of 2010 CORE officers. CORE co-founder Jim Jacobs of Environmental Bio-Systems, Inc. of Mill Valley is President; Ami Adini of Ami Adini and Associates of Los Angeles is Vice President; Fred Ousey of EnviroTech Services Company of Martinez is Secretary and CORE co-founder Jim Arnold of The Arnold Law Practice of San Francisco is Treasurer. Rick Johnson of Milestone Lending Group is the Membership/Finances Chairman. Elie Basal of Ami Adini and Associates is the CORE Technical Advisor.

CORE information is available on two web sites (www.ebsinfo.com and www.remediationshop.com). A dedicated CORE website is under construction. For membership information, please contact Jim Jacobs (jjimjacobs@ebsinfo.com; 415 381-5195) or Jim Arnold (JArnold@arnoldlp.com; 925-284-8887). 💧

Murray Einarson Wins National Groundwater Technology Award

Murray D. Einarson, principal hydrogeologist with AMEC Geomatrix, has been selected by the National Ground Water Association (NGWA) for its prestigious Technology Award for 2009. The Technology Award is presented annually to the individual who has made the most significant contribution to the groundwater industry in the development of ideas; tools and equipment; innovative well-construction techniques; the sharing of such developments; and the protection of groundwater resources and the consuming public.

Einarson has over 25 years of experience in the development, testing and application of innovative approaches and technologies for cost-effective environmental site characterization and remediation. The award nomination notes that Einarson "lives and breathes his subject, [and] radiates his interest and ideas to others in an infectious manner...." He has authored many publications that have influenced groundwater monitoring strategies, obtained patents for a multi-level monitoring well apparatus and new soil-sampling techniques, given lectures to various governmental agencies, and participated in national efforts involving site assessment tools for underground fuel storage tanks and characterization of subsurface releases of gasoline containing MTBE.

GRA congratulates Murray Einarson for receiving this well-deserved award. 💧

Sacramento

By Tom Ballard,
Branch Secretary

At the November meeting of the Sacramento Branch, Rodney Fricke, Environmental Specialist for Aerojet Site Remediation gave a presentation on gaseous electron donor injection technology (GEDIT) biodegradation of perchlorate and nitrate in the vadose zone at a number of test sites at the Aerojet facility located in Rancho Cordova. Mr. Fricke is a Certified Hydrogeologist (#11) with over 30 years of experience in studies of groundwater contamination and evaluations of groundwater resources in California and Nevada.

The GEDIT process was tested in the upper 50 feet of the vadose zone beneath the Propellant Burn Area at Aerojet's inactive test site. The GEDIT demonstration project was done by CDM, beginning in 2006 with soil sampling and column testing to evaluate gaseous electron donors. Injection wells and probes were installed to evaluate the pneumatic zone of influence. GEDIT was tested during 2008 at an injection rate of 100 cubic feet per hour, including a 5-month period with a mixture of nitrogen, hydrogen, propane, and carbon dioxide; and a 3-month period with propane. The target area was a 10-foot radius of influence; post-test soil sampling indicates that average destruction exceeded 90% for both perchlorate and nitrate.

The December Branch meeting was held jointly with the Sacramento Chapter of the Association of Environmental and Engineering Geologists (AEG), which resulted in a capacity crowd and excellent networking opportunities for all attendees. The traditional holiday raffle to benefit geology students in the Sacramento area received generous support from the meeting attendees.

December's talk was given by David Cochrane, Vice President – Environment, Health and Safety for Sutter Gold Mining, Inc., the parent to Sutter Gold



Mining Co. Mr. Cochrane, P.G., C. E.G., has 30 years of consulting and operating experience with many industries including mining, manufacturing, oil and gas, timber, energy, land development, real estate, and waste management and resource recovery. He and his family have resided in the Mother Lode since settling there in 1992. Mr. Cochrane is responsible for the development and implementation of the Company's environmental and health and safety operating policies and programs, and is working to secure the remaining operating and construction permits and approvals needed for the Lincoln Project. He also supports the ongoing data collection and analysis to further define the geology, hydrogeology, mineral resources, ore processing and project economics for the development and production of the Lincoln Project.

Mr. Cochrane started his talk by giving an overview of the geology of the Mother Lode as seen through the eyes of early geologic researchers and miners, and also from the view of modern researchers and miners. Stretching for 120 miles along the Sierra foothills and crossing five counties, the California Mother Lode produced over 13 million ounces of gold. Discovery of gold in California's Mother Lode over 160 years ago initiated an unprecedented expansion into California and the Western United States. The California Gold Rush also ushered in a new era in the global gold mining industry, which has produced over 125,000 tonnes of

gold in the past 6,000 years; 90 percent has been produced since discovery of gold in the California Mother Lode. Mr. Cochrane discussed the status of the Mother Lode today and the challenges of developing narrow-vein gold deposits that still exist in the Mother Lode using, by means of example, Sutter Gold Mining Company's Lincoln Project. Previously focused on exploration and development, Sutter Gold is poised to become an emerging gold producer focusing initial production efforts on the Lincoln Project, located in a 10-mile long section of the Mother Lode in Amador County. Historically, this section of the Mother Lode produced over seven million ounces of gold. The Company has identified inferred and indicated resources including over 680,000 ounces of gold from near-term targets within the 3.6 mile segment of the Mother Lode controlled by Sutter Gold Mining Co. Three dimensional illustrations of the projected mine workings, geology and ore shoots gave a unique perspective on the anticipated mine development. 💧

San Francisco

By John Karachewski,
Branch Secretary

Dr. W. Richard Laton from California State University at Fullerton provided his William A. McElhiney Distinguished Lecture “Boring Logs—What’s Important and What’s Not: A Scientific Viewpoint” on October 21, 2009. Dr. Laton started by discussing the history of William A. McElhiney, who was the founding president of the National Ground Water Association in 1948, and a groundwater contractor and civil engineer. He then provided an overview on the importance of boring logs in the water supply, environmental, geotechnical, and oil and gas industries. Dr. Laton discussed issues associated with confidentiality of well logs in California and provided a contrast with many other states that make this information available online. Boring logs provide critical information because “you only get one chance to collect the data, the data will outlive the well/boring, and future decisions will be based on this data.” He compared examples of logs with detailed geologic descriptions with several entertaining and bad examples, such as “sand and granite from 200 to 250 feet.” Next, he outlined the critical parameters and procedures required to prepare detailed boring logs. Dr. Laton stressed that great software for publishing logs does not substitute for detailed observations of continuous core and notes in the field! The presentation then transitioned to provide an interesting case history for an aquifer recharge project being conducted by the Mojave Water Agency. Dr. Laton and his students collected many boxes of paper boring logs and organized and digitized the water agency’s logs of 27,000 wells scattered throughout a 5,000 square mile area. Over several years, the students identified hydrofacies, created a database, provided quality assurance for the logs, and plotted cross-sections, first by hand and then by using software, to construct 3D models of the regional hydrostratigraphy. Based on

this work, Dr. Laton and his students made an important contribution by identifying four promising areas for aquifer recharge. They also illustrated how converting static paper logs into a digital database will allow the agency to significantly improve its groundwater management and decision making. Dr. Laton concluded his presentation by discussing future trends in data visualization and analysis. His lecture slides can be downloaded at: http://groundwater.fullerton.edu/Groundwater_Web/2009_McElhiney_Lecturer_files/2009%20McElhiney%20Laton%20PPT08ss.pdf.

Dr. Jeffrey Mount from UC Davis presented “Breaking the Weak Link in California’s Water Supply System (and some options for fixing it)” on November 18. Dr. Mount is a leading expert on the Delta and has spoken about the past, present, and future of this complex physical and biological system to the governor, legislature, mayors, as well as federal and state officials. He has also appeared on “60 Minutes” and National Public Radio (NPR). The Delta is really an estuary which has been modified by human activity and is NOT sustainable for future water supply, even though agriculture and over 25 million people in the San Francisco Bay Area, San Joaquin Valley, and Southern California rely on this critical resource. The dynamic Delta of the past reflected a balance between Holocene sea level rise versus deposition of sediment and accumulation of peat. The historic Delta also was known for one of the most diverse and abundant salmon runs in the western US. After completion of the transcontinental railroad in 1869, many Chinese laborers found new employment constructing levees for agricultural development in the 700,000-acre Delta. Over 1,100 miles of levees were constructed and 95% of the area was reclaimed and drained. An unintended consequence



Photo by John Karachewski

of this development was oxidation of the peat deposits and associated subsidence of the islands. Recent Light Detection and Ranging (LIDAR) data shows that some of the islands are as low as 30 feet below sea level. Thus, California’s water supply system depends on a fragile levee network that was not engineered for rising sea levels, intense winter floods, subsidence or earthquake hazards. Dr. Mount indicated that the modern Delta is unstable and near a tipping point due to a high probability of levee failure. Failure of the aging levee system could result in catastrophic loss of this primary supply of fresh water at an economic cost that could exceed \$80 billion or more. Dr. Mount concluded that future changes to the Delta will be irreversible and that the system will trend towards an open water “Chesapeake Bay” model. Changes to the Delta will harm water users but may benefit fish because export pumping of fresh water will cease due to inundation of the area by salt water. Californians face stark and costly decisions, but the “Peripheral Canal” is probably the best option for addressing future water supply and ecological challenges. 💧

San Joaquin Valley

By Bill Pipes,
Past President

I am pleased to announce new officers for the GRA San Joaquin Valley Branch starting in 2010. The new Branch President is **Chris Johnson, PG, CHg**, of Aegis Groundwater Consulting in Fresno. I have known Chris for about 20 years and I know he will be bringing new energy and some great ideas for improving the branch. He's a proud graduate of Fresno State and a well known consulting hydrogeologist in the region. Joining Chris will be **Al Steele, PG, CHg** as Vice President; Al just retired from the DWR, where he was an Engineering Geologist working out of the Fresno office. New officers at Secretary and Treasurer are **Matt Hutson, PG**, the Environmental Group Manager at BSK Associates in Fresno, and **Dave Bean, PG, CHg**, Principal Hydrogeologist at AMEC Geomatrix in Fresno. This highly qualified team has decades of groundwater experience in the San Joaquin Valley – I look forward to transitioning to the new team and helping them grow the Branch.

For 2010, we are continuing our affiliation with the newly formed San Joaquin Valley Chapter of the Association of Environmental & Engineering Geologists (AEG). We have planned Branch/Chapter meetings on alternate

months and will continue to collaborate on other activities. We plan to join forces once again on a follow-up to our very successful symposium last fall on the topic of groundwater withdrawal-induced land subsidence (see summary article in this issue).

We kicked off the New Year with a meeting on January 20. Our speaker for this meeting was Loren Harlow, PE, Attorney at Law, and former Assistant Executive Director of the RWQCB, Central Valley Region. His topic was "*Water 2010: Statutes, Bonds, Orders & Decisions That Will Impact the Central Valley*," which included updates on the California Water Deal of 2009, the Central Valley Salinity Alternatives for Long Term Sustainability (CV-SALTS) program, new trends in discharge requirements and Master Reclamation Permits for wastewater facilities, and the Dairy General Order for existing milk cow dairies in the Central Valley.

Plan to attend our meetings – and to become a member of the Branch. We generally hold dinner meetings in Fresno on the third Thursday evening of the month (both GRA and AEG); the next GRA meeting will be in March. Meeting notices are sent by mail and email, and notices are posted on the GRA website (www.grac.org). If you would like to be on our mailing/emailing list, please contact Matt Hutson at (559) 497-2880 or mhutson@bskinc.com. 💧

Southern California

By Paul Parmentier,
Branch Secretary


The December 9th meeting of the Southern CA Branch included a presentation by Dr. Randal Orton, Resource Conservation Manager at the Las Virgenes Municipal Water District, a water supply and treatment agency in the Malibu Creek watershed. During this engaging talk punctuated by active audience questioning, Dr. Orton presented technical arguments that the Monterey Formation is contributing a unique geochemical signature to groundwater and surface waters in the Malibu Creek Watershed. The Miocene marine sedimentary Monterey formation is well known for oil production in many areas of the site, but is also a significant source of rock phosphorus. Although groundwater is not typically used directly in the watershed due to poor quality (with well names like "Old stinky" and "sulfur springs"), groundwater is the main flow contributor to the creek during the summer months.

Areas of outcropping Monterey in the watershed appear strongly correlated with higher concentrations of metal, phosphorus, sulfate, TDS and TOC. Dr. Orton presented a detailed analysis of seasonal variations from historic monitoring data at 54 surface water monitoring stations and from area-specific sampling within Monterey outcrops; he presented convincing arguments that the variations are not due to potential impacts from man-made sources or general urbanization of the area. The identification of the source of localized high hydrogeochemical concentrations of some compounds as likely a natural occurrence is critical in decisions on discharge limits and on impacts to water resources well known for exceptional natural and recreational aquatic resources.

Elections for the Southern California Branch were held and the program for 2010 has been outlined. 💧

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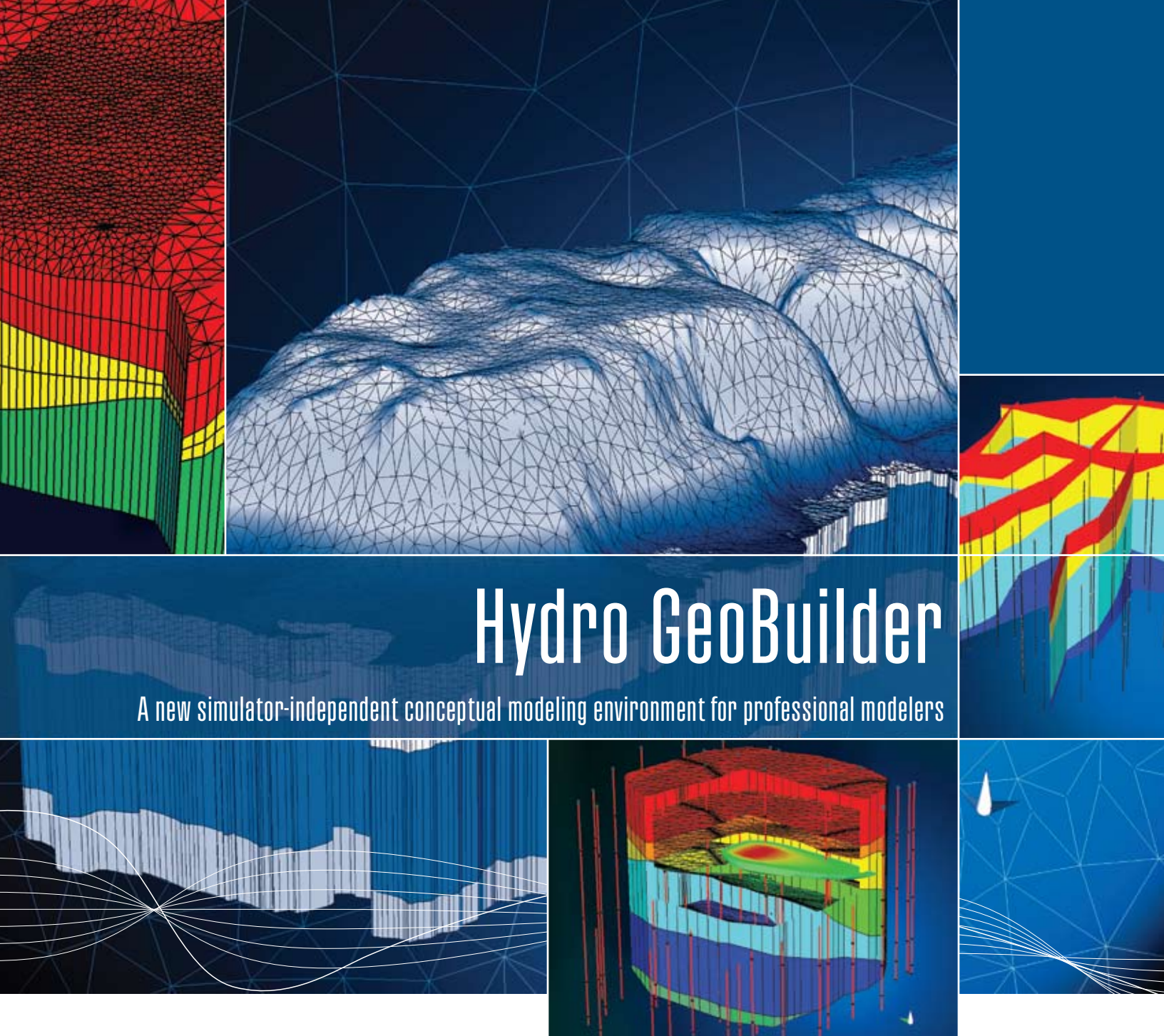
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West Walker River, Toiyabe National Forest

The Walker River is one of three drainages that originate in the Eastern Sierra Nevada, but that flow into terminal lakes in the Great Basin of Nevada. The West Walker River near Pickel Meadow, shown in this photograph, is located north of Yosemite National Park and east of Sonora Pass. The valley of the West Walker River contained one of the largest glaciers east of the Sierran crest, and these deposits are especially well exposed near Sonora Junction at the intersection of highways 108 and 395.

The West Walker River provides an excellent example of a linked surface water and groundwater system. The fall and winter are characterized by lower river discharge and decreasing water table elevations. In contrast, the melting snowpack in the spring and early summer contribute to higher river discharge and increasing water table elevations. Water table elevations can fluctuate by 5 to 10 feet or more during the year. In addition, river flooding and a rising water table also contribute to the formation of seasonal wetlands.

The West Walker River was subject to an extreme El Niño event in January 1997. After accumulation of an early winter snowpack, intense January rain events led to catastrophic melting and flooding, which destroyed riparian habitats and 10 miles of highway 395. This major thoroughfare between Reno and Los Angeles was closed for 6 months to rebuild the roadway. The sediment carried by the river floods settled in Topaz Lake along the California-Nevada border and also adversely impacted the trout population.

Photograph by John Karachewski, PhD (DTSC).

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