

HYDRO VISIONS

Volume 16, No. 1

GROUNDWATER RESOURCES ASSOCIATION
OF CALIFORNIA

Spring 2007

High Resolution Site Characterization and Monitoring — Symposium Highlights

BY MURRAY EINARSON, GEOMATRIX CONSULTANTS

On November 14 through 16, 2006, GRA held the 2nd Symposium in its Tools and Technologies Series: High Resolution Site Characterization and Monitoring, in Long Beach, California. The symposium was attended by nearly 300 environmental consultants, regulators, and academic and government researchers. The event included two days of invited presentations at the Westin Long Beach hotel, followed by a third day where technology developers and vendors gave hands-on demonstrations of their equipment at a nearby contaminated site. Symposium sponsors included BESST, Inc., Geomatrix Consultants, Inc., Schlumberger Water Services, and Solinst, Canada. The event was held in cooperation with California EPA, Dept. of Toxic Substances Control (DTSC), State Water Resources Control Board (SWRCB), International Association of Hydrogeologists (IAH), National Ground Water Association (NGWA), USEPA, USGS, and the University of Waterloo, Canada.



Steve Knobbe from Geoprobe Systems demonstrates Geoprobe's dual-tube soil coring system.

By all measures, the High Resolution Site Characterization and Monitoring symposium was a success. Overall attendance was the second largest of any GRA event. Especially noteworthy was the number of environmental regulators that attended the event: more than 100 total, with over 50 from USEPA alone. Feedback from attendees was overwhelmingly positive, with many commenting on the high quality of the invited presentations and the information gained from the field demonstrations.

There are several reasons for the success of this symposium. Many attendees were drawn to the event because of the impressive list of invited speakers and technology vendors. The speakers, who came from as far away as the UK and Denmark, were hand-picked by the conference organizers because of their contributions in the area of high-resolution subsurface investigations. Technology developers and vendors were also carefully selected to

INSIDE

President's Message	2
Upcoming Events	3
Technical Corner	4
California Legislative Corner	6
Federal Legislative/Regulatory Corner	7
Chemist's Corner	8
Alliance Corner	9
Organizational Corner	10
Branch Activities	22

ensure that the attendees were introduced to the key technologies that have made high-resolution subsurface characterization possible. Many of the attendees said that they came to the event because they wanted to gain a deeper level of knowledge about high-resolution site characterization technologies, including geophysical methods and direct-push (DP) sampling tools and chemical sensors. In addition, many attendees wanted to understand how the new generation of high-resolution technologies could be optimized to reduce the cost of subsurface assessments. Finally, many attendees shared a sense of frustration about the "low-resolution" approach to environmental site characterization that is currently the "state of the practice" and were hoping to gain some insights into ways to overcome barriers that are

Continued on page 15

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



President's Message

BY THOMAS K.G. MOHR

In Groundwater We Trust

Long-range water supply planning for California's growing population is fraught with the challenge of matching demand with distant supplies, and resolving competing claims to water for agriculture, urban supply and new development, recreation, and habitat preservation. Surface water storage and a statewide network of canals has historically been the backbone of California's complex water distribution system. In a growing number of groundwater basins, the network of canals supply conjunctive use projects, in which imported surface water is percolated into aquifers to sustain pumping rates, which recharge from local rainfall and runoff alone cannot. These projects are by no means a new development; conjunctive use has been underway in Orange and Santa Clara counties for more than 70 years. While the history of the state's water supply infrastructure has been primarily dams and canals, the future of California's water supply planning will place a great deal more emphasis on groundwater basin operations through artificial recharge and aquifer storage and recovery projects.

Recently, Governor Schwarzenegger proposed funding for two dams at a cost of \$4 billion in the 2007-08 budget, and included \$500 million for groundwater projects. The proposed dams address flood control and long term changes in the runoff patterns from the Sierra Nevada expected

to result from climate change. While more surface water storage may have a role in future water supply planning, there is ample reason to allocate more funding to groundwater projects now: more acre-feet for the money, and quicker delivery of tangible results. Dams take decades to build and probably won't provide enough water to justify the cost; new aquifer storage and recovery projects can come on line in just a few years – perhaps even within a legislative term of office.

In looking for more water, careful consideration must be given to the tradeoffs between very costly projects that may not produce results for a generation and have complex environmental impacts, and the less tangible but higher yielding alternatives available from aggressive water conservation and groundwater projects. Our elected officials are growing impatient for water supply solutions. Senate President Pro Tem Don Perata was recently quoted as saying, "We want more water supply . . . as cheaply and as quickly as possible." GRA has a role to play in educating our legislators about the dynamic advantages of groundwater in sustaining a safe and reliable water supply for California's growing population.

At this year's GRA Legislative Symposium and Lobby Day, moving groundwater planning to a central role in future water supply projects will be the hot topic. Initiatives to fund more storage projects are already underway, and the newly elected

Continued on page 18

The statements and opinions expressed in GRA's HydroVisions and other publications are those of the authors and/or contributors, and are not necessarily those of the GRA, its Board of Directors, or its members. Further, GRA makes no claims, promises, or guarantees about the absolute accuracy, completeness, or adequacy of the contents of this publication and expressly disclaims liability for errors and omissions in the contents. No warranty of any kind, implied or expressed, or statutory, is given with respect to the contents of this publication or its references to other resources. Reference in this publication to any specific commercial products, processes, or services, or the use of any trade, firm, or corporation name is for the information and convenience of the public, and does not constitute endorsement, recommendation, or favoring by the GRA, its Board of Directors, or its members.

HydroVisions is the official publication of the Groundwater Resources Association of California (GRA). GRA's mailing address is 915 L Street, Suite 1000, Sacramento, CA 95814. Any questions or comments concerning this publication should be directed to the newsletter editor at editor@grac.org or faxed to (916) 442-0382.

EXECUTIVE OFFICERS

President, Tom Mohr
Santa Clara Valley Water District
Phone: 408-265-2607, ext. 2051
Email: tmohr@grac.org

Vice President, James Strandberg
Malcolm Pirnie, Inc.
Phone: 510-735-3020
Email: jstrandberg@pirnie.com

Treasurer, David Von Aspern
Sacramento County EMD
Phone: 916-875-8467
Email: VonAspernD@sacounty.net

Secretary, William Pipes
Geomatrix Consultants, Inc.
Phone: 559-264-2535
Email: wpipes@geomatrix.com

DIRECTORS

David Abbott, Todd Engineers
Phone: 510-595-2120
Email: jorysue@msn.com

Susan Garcia, Colin L. Powell Academy
Phone: 310-631-8794
Email: ssgarcia55@verizon.net
sgarcia@lbusd.k12.ca.us

Stephanie Hastings, Hatch & Parent
Phone: 805-882-1415
Email: shastings@hatchparent.com

Roy Herndon, Orange County Water District
Phone: 714-378-3200
Email: rherndon@ocwd.com

Ted Johnson, Water Replenishment District of Southern California
Phone: 562-407-1919
Email: tjohnson@wrđ.org

Thomas M. Johnson, LFR Levine Fricke
Phone: 510-652-4500
Email: tom.johnson@lfr.com

Vicki Kretsinger, Luhdorff & Scalmanini
Phone: 530-661-0109
Email: vkretsinger@lsce.com

Brian Lewis
Cal/EPA, Dept. of Toxic Substances Control
Phone: 916-255-6532
Email: blewis@dtsc.ca.gov

Jean Moran
Lawrence Livermore National Laboratory
Phone: 925-423-1478
Email: moran10@llnl.gov

Tim Parker, Schlumberger Water Services
Phone: 916-329-9199
Email: tparker2@slb.com

Sarah Raker, MACTEC
Phone: 510-628-3234
Email: slraker@mactec.com

Eric Reichard, U.S. Geological Survey
Phone: 619-225-6134
Email: egreich@usgs.gov

EXECUTIVE DIRECTOR

Kathy Snelson
Phone: 916-446-3626
Email: executive_director@grac.org

EDITOR

Floyd Flood
Email: editor@grac.org

WEB AND DATABASE MANAGER
Kevin Blatt, Ihappi Web Design
Phone: 510-845-9623
Email: kblatt@ihappi.com

GRA's First Groundwater Law Conference

JUNE 1, SAN FRANCISCO, CA

The Groundwater Resources Association's First Annual Groundwater Law Conference will be held June 1, 2007 at the Hotel Nikko in San Francisco. This event is chaired by Hatch & Parent's Stephanie Hastings and Steven Hoch and will feature presentations and discussion by California's foremost legal experts on timely and important groundwater law topics, including recent changes in the law affecting groundwater supply and quality issues; legal controversies in groundwater: basin adjudication, regulation of aquifer storage and recovery, contaminant disputes; practical legal mechanisms for groundwater use and management, and analyses of the availability of groundwater for future development and associated legal issues. Check for future updates on <http://grac.org/law.asp> and be sure to save June 1, 2007 for this event.

If you are interested in being an event sponsor, please contact Mary Megarry at mmegarry@nossaman.com or 916-446-3626. GRA welcomes co-sponsors, lunch, and refreshment sponsors. 💧

Water Resources Series Symposium on Increasing Groundwater Storage

JUNE 20-21, 2007
LONG BEACH, CA

See full announcement on page 14 and visit www.grac.org/gwstorage.asp

Upcoming Events

Principles of Groundwater Flow & Transport Modeling

MAY 1-3, REDWOOD CITY, CA

CO-SPONSORED BY THE UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION GROUNDWATER HYDROLOGY PROGRAM

This course introduces the conceptual principles and practical aspects of groundwater modeling in an intuitive yet comprehensive manner. The course objective is to demystify the use of groundwater models by providing solid understanding of the principles, methods, assumptions, and limitations of groundwater models, as well as hands on experience with the planning, preparation, execution,

presentation, and review of a modeling project. Course Instructors include Graham E. Fogg, Ph.D., Thomas Harter, Ph.D., and Peter Schwartzman, M.S.

For more information, contact Mary Megarry at GRA, mmegarry@nossaman.com or 916-446-3626, or to register - <http://www.grac.org/modreg.htm>. MCLE credits will be available. 💧



Geomatrix

- Site Characterization
- Groundwater Modeling
- Water Resources Engineering
- Groundwater Remediation
- Integrated Watershed Management

Fresno, CA (559) 264-2535
Newport Beach, CA (949) 642-0245
Oakland, CA (510) 663-4100
Please visit www.geomatrix.com
for career opportunities - EOE

Wells and Words

BY DAVID W. ABBOTT, P.G., C.H.G.
TODD ENGINEERS

Logging Pumping Water Level Data: Digits or Digital?

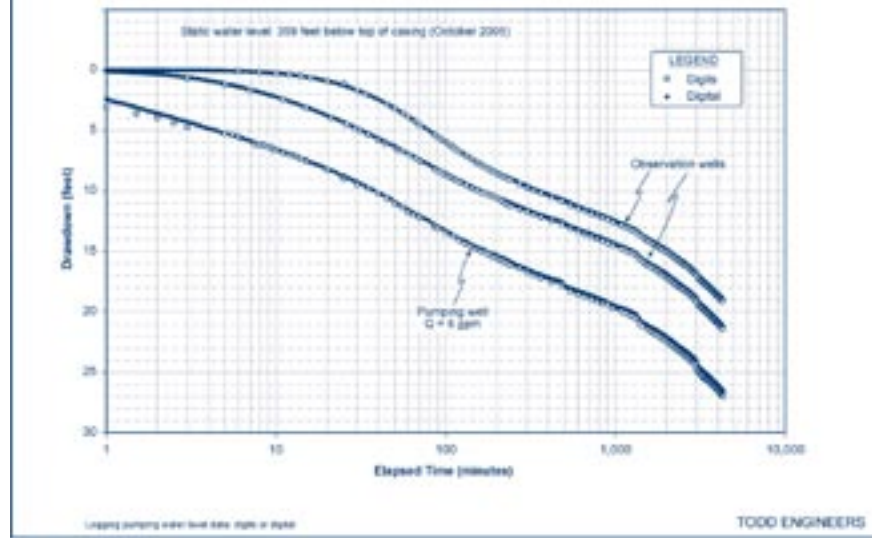
A variety of methods and tools can be used for measuring the depth to water in wells during pumping tests. Currently, the most popular tools are electric sounders (coaxial and single wire) and pressure transducers that are coupled to data loggers. Electric sounders are simple devices that are powered by a 9-volt battery that directly measure the depth to water in length units from an arbitrary and convenient reference point near the ground surface. These devices are so simple that an electric sounder can be easily assembled in the field with a short visit to the hardware store. The electric sounder method is often referred to as hand-measurements (digits). Data are recorded in a field book or special-purpose field sheet.

A stationary and submerged sonde measures the weight of water overlying the transducer (in pounds per square inch) and automatically converts the data into length units (digital); the data are then electronically stored. In many circumstances, electronic flaws of the data logger and sonde require factory diagnosis and repair. It is important to note that an electric sounder is required to calibrate digital data to an absolute depth.

Often times during a pumping test, both digit and digital data are collected and provide two sets of virtually identical data; having a very high correlation coefficient, as it should be. Irregularities in digital data memory and storage can occur, allowing the pumping test to be evaluated using the digit data. In contrast, errors in digit data can occur, allowing the test to be evaluated with the digital data. One method can serve as a back-up source for the other method. However, paramount to the

Technical Corner

Figure 1: Comparison Between Digits and Digital



successful completion of an aquifer test, real-time field data analysis should be conducted during the pumping test to assist in adjusting well discharge and to determine the length of the test. This real-time analysis is usually performed with digits rather than digital data.

It doesn't matter whether hand-measurements, transducer data or both types are collected during a pumping test. The precision and accuracy of the measured drawdown data are similar. The error associated with digit or digital measurements is smaller than the acceptable variation of the pump discharge (± 5 percent).

Digital data is no more accurate than digit data and vice-versa. Figure 1 shows a comparison between digit and digital data for a recent pumping test conducted in a fractured rock aquifer using two observation wells and the pumping well. The digit and digital data are identical and display the same time-drawdown trends. In this example, the digital method recorded 541 data points/well (total of 1,623 points for 3

wells) while the digit method recorded only 109 points/well (total of 326 points). Digital data may be described as overkill, particularly if the data logger is set to record every 20 seconds, since it only takes a minimum of 3 data points to define a straight line, not thousands of data points. Review of many digital data sets suggests that the sets could be reduced by 85 percent without sacrificing any accuracy in the analysis. Casing storage phenomena, determined by the radius of the pumping well and the permeability of the aquifer, may impact early time-drawdown data. Detailed water level measurements (10-second intervals), especially in a pumping well for the first couple of minutes of a pumping test, are not usually required, because they will not be used in the data analysis because of casing storage.

Digital data methods applied to pumping tests provide convenience, not accuracy. For pumping tests with a single well, the pump can be turned on and data automatically collected for 24-, 48- or 72-hours without onsite

Continued on page 20

Fingerprinting Water

BY WILLIAM E. MOTZER,
TODD ENGINEERS

Introduction

In the past decade stable and other isotope analyses have become common in hydrologic and hydrogeologic investigations. Because surface water and groundwater can originate from a variety of sources (e.g., hot springs, precipitation, imported water, etc.) stable isotopes of oxygen and hydrogen are most useful in fingerprinting such sources.

Defining Isotopic Ratios

Isotopic ratios are used for fingerprinting sources utilizing a delta (δ) notation derived from the following equation:

$$\delta \text{ (isotope) in mils (‰)} = \left[\frac{R_{\text{(sample)}} - R_{\text{(standard)}}}{R_{\text{(standard)}}} \right] \times 1,000$$

Where: $R_{\text{(sample)}}$ = the ratio of the first and second isotope such as oxygen-18/oxygen-16 ($^{18}\text{O}/^{16}\text{O}$), and $R_{\text{(standard)}}$ = the ratio of the isotopes used in international or other standards.

A δ value with a positive (+) sign corresponds to an increase of the more massive (“heavier”) isotope (i.e., ^{18}O) over the second (^{16}O) with respect to a standard, indicating that the sample is enriched with the heavier isotope. A minus (-) sign indicates a decrease of the heavier isotope with respect to the standard indicating that the sample has more of the lighter isotope.

Isotopic Fractionation

Fractionation or separation of naturally occurring oxygen and hydrogen isotopes in water occurs in the hydrologic cycle during evaporation and condensation. Isotopically light water molecules evaporate before heavy ones. As a result, surface water exposed to evaporation tends to be enriched in heavy isotopes relative to meteoric water and will have a less negative or more

Technical Corner

positive oxygen-18/oxygen-16 ($^{18}\text{O}/^{16}\text{O}$) ratio as indicated by the evaporative trend line on Figure 1. Oxygen isotope fractionation also occurs at different rates at different latitudes and climates because water vapor condensation is temperature-dependent. Therefore, the ratio of $^{18}\text{O}/^{16}\text{O}$ in rain and snow will change with latitude and elevation and also with seasons. The higher the latitude or the elevation, the more negative the $\delta^{18}\text{O}$ value; these vary from approximately 0 ‰ for Vienna Standard Mean Ocean Water (VSMOW), at the equator to about -50 to -55‰ VSMOW at the poles. VSMOW is the standard for $^{18}\text{O}/^{16}\text{O}$ established by the International Atomic Energy Agency and the National Institute of Standards and Technology.

Hydrogen (protium and deuterium) also fractionates from water in a similar manner and therefore, δD ($^2\text{H}/^1\text{H}$) ratios are directly proportional to $^{18}\text{O}/^{16}\text{O}$ fractionation. A plot of the $\delta^{18}\text{O}$ versus δD will show unique characteristics for water samples collected from different latitudes, climates, seasons, hydrologic

basins, evaporative conditions, and thermal springs. In general, worldwide precipitation isotopic data plots along a straight line, known as the Global Meteoric Water Line (GMWL) as shown on Figure 1. The GMWL actually is an average for many worldwide local meteoric water lines, each controlled by local climatic factors, including the vapor mass origin, secondary evaporation during rainfall, and seasonal precipitation. A local MWL based on $\delta^{18}\text{O}$ and δD in local precipitation can be compared with $\delta^{18}\text{O}$ and δD of local surface and groundwater. An example of local groundwater line is also shown on Figure 1. The average monthly and annual $\delta^{18}\text{O}$ and δD for local precipitation based on latitude, longitude, and elevation can be determined using a web-based calculator hosted by Purdue University.

Although the isotopic composition of water can be influenced by ion exchange reactions, sorption to aquifer materials, and biologic activity, it is generally unaffected by infiltration, recharge, and groundwater movement.

Continued on page 20

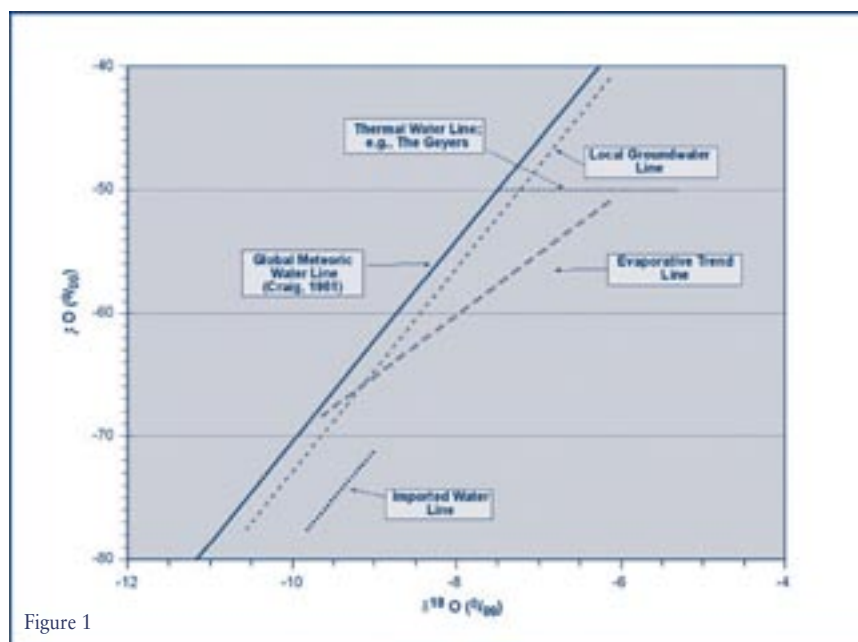


Figure 1

California Legislative Corner

Sacramento Legislative Update

BY CHRIS FRAHM, HATCH & PARENT, AND TIM PARKER, SCHLUMBERGER WATER SERVICES

Not surprisingly, 2007 is shaping up to be the “Year of Implementation” as the Legislature is now tackling the tough issues about how to spend the funds voters approved in the infrastructure bond package last November. The GRA Board’s timely action to form the California Groundwater Council (“CGC”), along with the Association of Ground Water Agencies and the American Ground Water Trust, will give a strong, unified voice to the groundwater community as these decisions are made. Go to the GRA website to learn more about CGC and how your agency or business can participate in this important effort.

CGC is at the table now as bond implementation legislation is being developed. This past week we met with the leading legislative staff members in the Capitol to formally announce the formation of the CGC and to affirm that CGC supports GRA’s ongoing mission to educate and provide information to the Legislature as it considers vital groundwater programs. Our message has been extremely well-received as we embark upon an aggressive program over the next few weeks to raise the level of awareness about California’s groundwater resources.

Governor Arnold Schwarzenegger announced in his State of the State speech that he would be pursuing a water bond which we outlined for you in our previous HydroVisions article. The Governor’s proposal is contained in Senate Bill 59 by Senator Dave Cogdill (R- Modesto). Of the \$3.95 billion bond, \$500 million is designated for groundwater purposes. In response

to the bond bill’s introduction, Senate President Pro Tem Don Perata convened a press conference along with the Senate Democrats’ “Water Leadership Team” - Senators Darrell Steinberg, Mike Machado and Dean Florez - to announce that his number one objective in the water policy arena is to spend the funds approved in Propositions 1E and 84 in the most responsible, timely manner possible. He is not prepared at this time to approve more bond funds, for surface storage or for any other purpose. Senator Perata wants to know how much of the State’s storage needs could be met by taking advantage of our groundwater storage capacity. Senator Steinberg raised the possibility that groundwater storage could also be used to address flood control needs. These will be the topics at upcoming legislative hearings and CGC and GRA will be on selected panels to talk about the answers to these important questions.

Senator Darrell Steinberg, the new Chairman of the Senate Natural Resources and Water Committee, has reintroduced the groundwater provisions of SB 1640 as SB 178. GRA readers will recall that SB 1640 was authored by Senator Sheila Kuehl last year and vetoed by Governor Schwarzenegger; and, that it had reintroduced the groundwater provisions of SB 820, also authorized by Senator Kuehl and also vetoed by the Governor in 2005. We will be working closely with the Senator and his staff as the bill progresses through the legislative process.

Senator Dean Florez has introduced SB 201 in response to the e. coli outbreak affecting leafy spinach. While

the outbreak has been traced to the activities of wild pigs and not to the use of recycled water, Senator Florez has introduced legislation which will require the Department of Health Services to adopt regulations requiring growers to obtain, review and maintain all water quality reports issued by the agency supplying recycled water to the farm. The regulations will also require a farmer to test the recycled water for various contaminants weekly during the growing season. We will keep you apprised of developments relating to this legislation as it moves through the process.

Our 2007 Legislative Symposium and Lobby Day - “Groundwater - California’s Buried Treasure” - will be timed perfectly to get the critical groundwater issues on the table and provide an excellent opportunity for us to both share information with policy makers and play an important role in influencing the course of legislation this year. There is sincere interest on the part of the Administration and Legislature to use our groundwater resources in sustainable programs to help meet California’s long term water supply reliability needs. The Symposium will be held on March 20 in Sacramento; go to www.grac.org to reserve your space now. 💧

USEPA HAPPENINGS

BY JOHN UNGVARSKY, EPA

Revisions to the Unregulated Contaminant Monitoring Regulation

The Unregulated Contaminant Monitoring Regulation supporting the second cycle (UCMR 2) of monitoring was signed on December 20, 2006. The UCMR 2 requires monitoring for 25 contaminants using five analytical methods during 2008-2010. Together EPA, the States, laboratories and public water systems (PWSs) are participating in UCMR 2.

EPA is requiring select PWSs to monitor for 25 chemicals using five different analytical methods. All PWSs serving more than 10,000 people, and a representative sample of 800 PWSs serving 10,000 or fewer people, are required to conduct Assessment Monitoring for 10 chemicals during a 12-month period during January 2008-December 2010. All PWSs serving more than 100,000 people, 320 selected PWSs serving 10,001 to 100,000 people, and 480 selected PWSs serving 10,000 or fewer people are required to conduct the Screening Survey for 15 contaminants during a 12-month period during January 2008-December 2010. For more information, and for the lists of chemicals and contaminants, see: <http://www.epa.gov/safewater/ucmr2/basicinformation.html#one>.

Internet Seminars and Educational Tools

Over the past 7 years, EPA's Hazardous Waste Cleanup Information program (aka, CLU-IN) has presented internet seminars covering a wide variety of technical topics related to hazardous waste characterization, monitoring, and remediation. CLU-IN's ongoing series of internet seminars (e.g., "Perchlorate: Overview of Issues, Status, and Remedial Options" on January 9) are free, web-based slide presentations with a companion audio portion. Two

options are provided for accessing the audio portion of the seminar: by phone line or streaming audio simulcast. More information is available at <http://www.cluin.org/live/>. If you are not able to make one of CLU-IN's live offerings you can also view archived seminars.

The Drinking Water Academy (DWA) is a long-term training initiative whose primary goal is to expand EPA, State, and Tribal capabilities to implement the 1996 Amendments to the Safe Drinking Water Act (SDWA). The DWA offers a variety of courses, including some focused on groundwater issues (e.g., "Introduction to the Underground Injection Control Program"). DWA's Electronic Workshop contains training modules, short presentations, and links to other information sources. With few exceptions (e.g., copyrighted graphics

we have reproduced only with permission), DWA modules are in the public domain and may be downloaded, reproduced, and modified for your own use. They can be used as a starting point for preparing briefings or other information materials. Finally, the Workshop provides links to other EPA web sites where you may obtain regulatory and implementation information. For more information, visit: <http://www.epa.gov/safewater/dwa.html>.

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 and NV. For information on any of the above topics, please contact John at 415-972-3963 or ungvarsky,john@epa.gov.

Federal Legislative/Regulatory Corner

TO ADVERTISE IN HYDROVISIONS CALL 916-446-3626 TODAY

HYDROVISIONS 2007 Advertising Rates

4 Issues Annually

Blue & White cost per issue	1x	4x
Business Card	95.00	90.00 PER
1/4 page	185.00	160.00 PER
1/2 page	365.00	290.00 PER
Full page	750.00	600.00 PER

Color advertisements are additional based on current printing rates.
The above prices assume advertisements are received as high-resolution PDF files.
For additional information, visit GRAC's Web site at www.grac.org or contact Kathy Swanson, GRAC Executive Director, at executive_director@grac.org or 916-446-3626.

Prime Time for Isotope Analysis

BY BART SIMMONS

Stable isotope analysis – the measurement of non-radioactive isotopes – is becoming an increasingly powerful tool for solving groundwater problems. Compound-specific isotope analysis (CSIA) is used for determining the fate of selected compounds, and recent work has shown that nitrogen bonds can be added to carbon or hydrogen bond methods already validated. One basis for isotope analysis is the isotope effect: the different rate of reactions when cleaving a bond involving different isotopes. For the most part, compounds made with different stable isotopes behave the same. This has led to the wide use of non-naturally occurring stable isotopes, e.g., ^{13}C , as internal standards in environmental analysis. Since the ^{13}C labeled standards behave similarly to the naturally-occurring ^{12}C

compounds, the internal standards can be spiked early in the method. The final quantitation involves measuring the ratio of the internal standard to the compounds of interest. The wide availability of Gas chromatography-high resolution mass spectrometry and inductively-coupled plasma-mass spectrometry has facilitated the development of isotope methods.

Environmental applications of isotope analysis are varied. Generally, the isotope effect will be specific to the chemical bonds, so bond-specific isotope effect factors are needed. Groundwater investigations have used the isotope effect for carbon and hydrogen, measuring the $^{13}\text{C}/^{12}\text{C}$ and $^2\text{H}/^1\text{H}$ ratios (see article on fingerprinting water on page 5 in this issue).

Isotope analysis poses a challenge to the traditional system of laboratory accreditation, which is largely dependent in the U.S. on U.S. EPA-approved methods and consensus quality assurance standards. Internationally, lab accreditation is based on ISO 17025, which is a general standard for testing laboratories. However, a specific method like isotope analysis needs performance testing by independent performance test sample providers. As with any relatively innovative field, isotope analysis will depend on the quality systems of individual laboratories until consensus performance testing is developed. The National Institute for Standards and Technology (NIST) provides a variety of Standard Reference Materials (SRMs) for stable isotope analysis.

A recent expansion of isotope testing involves nitrogen-containing compounds (*Env. Sci. Technol.*, 2006, 40, 7710-7716). Many organic nitrogen compounds are of environmental concern, e.g., TNT and other nitroaromatic explosives and pesticides. Bond-specific isotope effect factors will be needed in order to widely use these new methods.

Isotope analysis has the promise to better understand the fate of contaminants, groundwater flows, and groundwater recharge. A wise application of the methods will add to the tool chest for solving groundwater problems.

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

There's a powerful new tool to characterize in-situ degradation processes

Compound Specific Isotope Analysis characterizes the isotopic fractionation of individual compounds. This data can be used to:



- unambiguously determine that biodegradation is occurring
- identify the mechanisms of degradation
- determine the rate and extent of degradation in some contaminants of concern

Microseeps is the first environmental laboratory in North America to offer CSIA.

To learn more, visit:
www.microseeps.com



Or call:
800-659-2887

California Ground- water Association/ National Ground Water Association

BY MIKE MORTENSSON,
CGA EXECUTIVE DIRECTOR

Californian Elected to NGWA Board of Directors

CGA member Dan Meyer of Gregg Drilling & Testing in Signal Hill, CA was elected to the NGWA Board of Directors at the 2006 NGWA Expo. Meyer becomes the first Californian to serve on the NGWA Board since John Schrack was NGWA President in 1985. Dan's election to the NGWA Board builds on the expanding relationship between CGA and NGWA. His background in accounting and technical drilling expertise will now assist groundwater professionals on a national scale. His election highlights the high esteem given California's groundwater professionals by the groundwater industry in other states. An Iowa "farm boy," Meyer moved to California in 1968, got an accounting degree and worked in a "Big Eight" firm, then decided to get back to the dirt. In 1979 he entered the drilling business and in the 1990s joined Gregg Drilling & Testing, providing financial and technical drilling services in the western US, Mexico and Vietnam.

March 11-17 is National Groundwater Awareness Week

Every week should be groundwater awareness week as we talk to clients and friends letting them know about the valuable water resource beneath them. But just in case you want a bit more emphasis, tell them that March 11-17 is National Groundwater Awareness Week.

Continued on page 21

Alliance Corner

NGWA Working to Develop Ground Water Science Education Pilot Program

BY CLIFF TREYENS, NGWA

The National Ground Water Association (NGWA) is working with the Environmental Education Council of Ohio (EECO) to develop a program that could be the pilot for a future NGWA initiative to get more ground water-related science in schools nationwide. During a December meeting with EECO, which included a representative of the Ohio Environmental Protection Agency, it was tentatively decided to concentrate efforts on developing an Ohio pilot project focusing on grades 5-8. The intent is to design a pilot program that conforms to both

Ohio's curriculum standards and national science curriculum standards. Its compatibility with national science curriculum standards should make it more readily useable by other states.


"NGWA wants to be a leader in facilitating the use of ground water science in schools. But we understand the importance of providing information that is relevant and useful to educators and students," said Cliff Treyens, NGWA's public awareness director. "We've found willing partners eager to help us in that effort."

Continued on page 21

Integrated Watershed Management

AMERICAN INSTITUTE OF HYDROLOGY ANNUAL MEETING
APRIL 22-25, 2007

There is increasing recognition by governing agencies and industry, for the need of technical integration in water-resources planning and management. The AIH conference is intended to present an opportunity for scientists and managers in all water-related disciplines to gather and interact together. The conference will offer research and project case studies from all over the country, providing learning opportunities to all attendees. In addition to offering a wide range of technical topics, areas of social and legal interaction, and current interests will also be covered. The conference

will give a chance to discuss the effects of urbanization, agriculture, industry, forestry, etc. and the research done and needed to better define these effects. The conference will give a chance for managerial viewpoints of cities, factories, farmers, fisheries, foresters, etc. to answer questions on how technical problems are brought together and solved, and how management issues are decided between competing resources. For more information contact AIH at (770) 384-1634, by E-Mail at aihydro@aol.com, or view the program at <http://www.aihydro.org>. 

Organizational Corner

2007 Directors Election Results

The election for GRA's 2007 Board of Directors is officially completed. Board incumbents David Abbott, Stephanie Osler Hastings, Sarah Raker and Jim Strandberg were re-elected. Roy Herndon and Ted Johnson were elected as new members of the Board. Ted Johnson will serve a two-year term ending in 2008, and all other Directors elected will serve three-year terms ending in 2009.

GRA extends its sincere appreciation and best wishes to Martin Steinpress and Bob Van Valer as they retired from the GRA Board of Directors at the end of 2006 (see related article on page 11). ♠

GRA Requests Nominations for the 2007 "Lifetime Achievement" and "Kevin Neese" Awards

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

1. To provide recognition to individuals who have demonstrated leadership and continuous dedication in the field of groundwater;
2. To provide recognition for unique contributions to the field of groundwater in 2005-2006.

All nominations for the Lifetime Achievement and Kevin Neese Awards must be received by Brian Lewis at admin@grac.org no later than June 15, 2007. Nominations should be completed using the nomination forms available on the GRA's 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's Board of Directors at GRA's 16th Annual meeting in Sacramento on September 18-19, 2007.

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.

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. ♠

RSI Drilling Services



- Geoprobe 5400's, 6600's, AMS Power Probe 9700's and Sonic Drill Rigs
- CME-75 HT, DPT/HSA Combo Rigs
- Remedial Injection Services
- Well Development & Abandonment
- Vacuum Extraction (Air Knife) & Concrete Coring

Woodland
(530) 668-2424
Alameda
(510) 532-2424
Los Angeles
(714) 778-2424

220 N. East St., Woodland, CA 95776 • Ph: (530) 668-2424 • Fx: (530) 668-2429

Organizational Corner

2007 Contributors to GRA — Thank You

Founder (\$1,000 and up)
Hatch and Parent

Patron (\$500 - \$999)
DrawingBoard Studios
Geomatrix Consultants, Inc.

Corporate (\$250-\$499)
David Abbott
Brian Lewis
Luhdorff & Scalmanini
Consulting Engineers
Malcolm Pirnie
Thomas Mohr

Charter Sponsor (\$100-\$249)
Stanley Feenstra
EMAX Laboratories, Inc.

Sponsor (\$25-\$99)
ARCADIS Geraghty & Miller, Inc.
Richard Amano
Suzanne Baehr
Thomas Ballard
Jenifer Beatty
Richard Booth
Kate Burger
James Carr
Joyce Clarke
Thomas Cooper
Daniel B. Stephens & Associates, Inc.
Nat Dellavalle
H.R. Downs
Scott Dressler
Gilberte Duerig
Earth Tech
Entech Analytical Labs, Inc.
Environmental Resolutions, Inc.
Martin Fenney
Fred Flint
Avram Frankel

Laura Frost
Scott Furnas
Susan Garcia
Geomatrix Consultants, Inc.
Elie Haddad
Sachiko Itagaki
Ted Johnson
Tom Johnson
Carol Kendall
Mark King
Taras Kruk
James Malot
John McAssey
Sally McCraven
Peter Mesard
Steven Michelson
Greg Middleton
Jean Moran
Aaron O'Brien
Kent O'Brien
William O'Brien
Frederick Ousey
Peter Quinlan

John Reay
Eric Reichard
George Reid
Roscoe Moss Manufacturing Company
Sandra Ross
David Sederquist
Thomas J. Shephard, Sr.
Schlumberger Water Services
Jordon Smith
Robert Strahan
Eddy Teasdale
David Thompkins
Kurt O. Thomsen
Susan Trager
David Tucker
Gus Yates
Frank Yeamans
William Zavora

Supporter
Bruce Marvin

Changes on the Board of Directors

BY THOMAS MOHR, GRA PRESIDENT

The Board of Directors has undergone some changes. We bid a fond farewell to Bob Van Valer, CEO of Roscoe Moss, who served two terms as a Director and Chair of the Finance Committee, as well as Treasurer of GRA for two years. Bob's innate business sense provided a great backstop for Board decision making, and he cheerfully crunched GRA's numbers and offered great advice to the Board. Bob is a true gentleman and served GRA's Board with dedication and a focus on resolving and completing matters before the Board.

We also celebrate the service given by Martin Steinpress, Chief Hydrogeologist at Brown and Caldwell, and

a Director for two terms and GRA's Communications Chair throughout that time. Martin pioneered development of GRA's electronic communications tools, including our website and informative e-mail updates. In addition, Martin managed and continues to manage the production of *HydroVisions*. Martin brought leadership and balance to the Board and was universally respected by all on the Board. Bob and Martin stepped down so that others may serve on the Board, but we're glad they remain active members of GRA!

We welcome our two newest Directors, Roy Herndon of Orange County Water District, and Ted Johnson of Wa-

ter Replenishment District of Southern California. Both are hydrogeologists and both bring a wealth of expertise in modeling, groundwater recharge, managing groundwater quality, and developing appropriate policies for sustaining groundwater supplies. Roy and Ted help to balance the Board composition with respect to the types of organizations represented, as well as balancing the Board geographically. Roy has stepped up to help GRA revise and update its Bylaws, and Ted is GRA's new Membership Chair. You can meet GRA's Board of Directors at the Legislative Symposium and Lobby Day on March 20th – see you there! 💧

GRA Welcomes the Following New Members

NOVEMBER 17, 2006 THROUGH FEBRUARY 14, 2007

Abbott, Kathleen	BBL	Hurd, Jessie	Johnson Wright, Inc.
Alward, Ryan	GEI Consultants, Bookman-Edmonston Division	Jakub, Barbara	ENSR Corporarion
Ashe, Steven	ADR Environmental Group	Johnson, Christopher	Iris Environmental
Baehr, Suzanne	Kennedy/Jenks Consultants	Knight, Jay	Kennedy/Jenks Consultants
Baldassari, Chris	PES Environmental, Inc.	Konzen, Anthony	Brown & Caldwell
Bauer, Paul	Hatch & Parent	Langtry, Peter	TRC Lowney
Bayley, Aubrey	Leighton Group	Lee, Curtis	GEI Consultants, Bookman-Edmonston Division
Behrens, Randy	Santa Clara Valley Water District	Lee, Kathryn	Michael Brandman Associates
Blaine, Jonathan	Robinson & Cole	Loaiciga, Hugo A.	UCSB
Blaisdell, Mark		Lofstrom, Dottie	California Dept. of Toxic Substances Control
Broderick, Anthony	ERRG, Inc.	Lunceford, Sandra	TechLaw Inc.
Brown, Damon	EBA Engineering	Ma, Matheson	MACTEC E&C
Brusca, Joe	Raney Geotechnical, Inc.	Mangine, Joe	URS Corporation
Bryson, James	LFR Inc.	Matell, Nora	Iris Environmental
Budny, Lucas	Geomatrix Consultants, Inc.	Mattes, Martin	Nossaman Guther Knox & Elliott LLP
Burgett, Darren	LFR Inc.	McClellan, Wendy	Malcolm Pirnie, Inc.
Burke, Michael	Pueblo Water Resources, Inc.	McGill, Robert	hydroGEOPHYSICS, Inc.
Buttress, Mitch	PES Environmental, Inc.	Morss, Christopher	4LEAF, Inc.
Calhoun, Michael	Geomatrix Consultants, Inc.	Nakamoto, Dennis	BSK Associates
Callegari, Christopher	Stoel Rives, LLP	Nash, Sarah	Michael Brandman Associates
Chambers, Steve	S.S. Papadopulos & Associates, Inc.	Nichols, Sandi	Stoel Rives, LLP
Chendorain, Michael	Treadwell & Rollo, Inc.	Nicolay, Philip	ARCADIS Geraghty & Miller, Inc.
Cisneros, Sonia	LFR Inc.	Nielsen, David	Nielsen Ground-Water Science Inc
Clarke, Joyce		Nottoli, Eileen	Allen Matkins
Cleary, Bob	Princeton Groundwater	Nyman, Jennifer	Malcolm Pirnie, Inc.
Crews, Michael	Brown & Caldwell	Olguin, Angela	Geomatrix Consultants, Inc.
Cröse, Justin	GEI Consultants, Bookman-Edmonston Division	Orr, Wendy	Kleinfelder
Cuevas, Guillermo	Blasland, Bouck, & Lee	Orsi, Caroline	Malcolm Pirnie, Inc.
Custis, Kit	Kit Custis, CEG/CHG	Pagano, Nichole	ENSR Corporarion
De Felice, Diane	Hatch & Parent	Partmann, Anne	The Source Group, Inc.
Deane, Thomas	Deane Consulting, Inc.	Patton, Avery	Geomatrix Consultants, Inc.
Diehl, Trent	Ellison, Schneier & Harris	Pensa, Rhianna	SFPUC
Downs, H.R.	O.W.L. Foundation	Perez, Javier	Blasland, Bouck, & Lee
Dysert, Mark	Entech Analytical Labs, Inc.	Poole, Melissa	Nossaman Guther Knox & Elliott LLP
Ehlers, Lisa	Brown & Caldwell	Porter, Shaun	H2O Engineering, Inc.
Elliott, Jim	Layne Christensen	Richards, Kate	Geomatrix Consultants, Inc.
Filippi, David	Stoel Rives, LLP	Robino, Vincent	Geomatrix Consultants, Inc.
Furnas, Scott	California Laboratory Services	Robinson, Jack	Geomatrix Consultants, Inc.
Garbiero, Marcello	LFR Inc.	Roth, Daren	LFR Inc.
Geasler, Christine	LFR Inc.	Sabol, Stacy	MACTEC E&C
Gee, Byron	Nossaman Guther Knox & Elliott LLP	Schuetz, Melissa	LFR Inc.
Gleeson, Kathy	Paramont Petroleum	Seeno, Timothy	Brown & Caldwell
Goerz, Matt	Geomatrix Consultants, Inc.	Shephard, Sr., Thomas J.	Neumiller & Beardslee
Goloubow, Ron	LFR Inc.	Shipley, Jay	LFR Inc.
Gomes, Daniel	Schlumberger Water Services	Sicke, William	Weiss Associates
Gonzales, James	LFR Inc.	Soby, Matthew	ENSR Corporarion
Grivetti, Mark	GeoSyntec Consultants	Sohl, John	Columbia Technologies
Hague, Simon	Entech Analytical Labs, Inc.	St. Germain, Randy	Dakota Technologies, Inc.
Hill, Wesley	Duke Energy Field Services, LP	Stanton, Dale	Michael Brandman Associates
Hundley, John	World Oil Corp.	Tanner, Stephen	Pueblo Water Resources, Inc.

Thom, Craig	Entech Analytical Labs, Inc.
Thomas, Gary	PES Environmental, Inc.
Thomsen, Kurt O.	KOT Environmental Consulting, Inc.
Trask, Kim	ENSR Corporation
Triolo, Jason	LFR Inc.
Van Antwerp, Alan	LFR Inc.
Venegas, Rosa	McCampbell Analytical
Vora, Niraj	TRC
Wagner, David	Western Technologies Inc.
White, Jim	H2O Engineering, Inc.
Whiting, John	CA RWQCB
Wilhite, Coralie	Kleinfelder
Wood, Kristen	
Woodburne, Keith	TRC
Xu, Lijun	MACTEC Engineering & Consulting, Inc.
Yanagihara, Gregory	Earth Tech
Zamora, Jennifer	Malcolm Pirnie, Inc.

Renew Your Membership Online - It's Quick and Easy

If you haven't already, it's time to renew your GRA membership for 2007. 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 grac@ihappi.com. 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.

With nearly 1,350 members at the end of 2006, the goal of having 1,500 members by the end of 2007 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 for only \$100.

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



It's 7:20 PM.

**Do you know where
your groundwater
data are?**

- Open Systems
- "The Microsoft of EDD data checking.."
- GeoTracker EDF support
- Over 300 clients in CA



EarthSoft

www.earthsoft.com

info@earthsoft.com

(978) 369-2201

Increasing Groundwater Storage to Meet California's Future Demand — Challenges and Solutions

June 20-21, 2007 - The Westin Long Beach, Long Beach, CA

Los Angeles Area Groundwater Recharge Field Trip

June 22, 2007 - Beginning at the Westin Long Beach

Groundwater, the State's subsurface reservoir of water, will be relied on more in the future to meet increasing water demands from population growth, balance natural variations in precipitation and temperature, and improve water supply reliability in the face of climate change concerns. Building additional surface reservoirs is a difficult water storage option due to environmental, economic and political challenges. As a result, there are increasing efforts to manage aquifer recharge, implement conjunctive use of surface and groundwater resources for conservation and optimal use, and expand the utilization of groundwater storage. Groundwater has and will continue to take on an expanding and pivotal role in national, state and regional water supply planning. The increasing emphasis on groundwater will require improved management, planning, policy and resources to provide citizens with safe, reliable water supplies.

June 20-21 — Symposium on Increasing Groundwater Storage to Meet California's Future Demand: Challenges and Solutions

Working Draft Program

This Symposium will provide the opportunity to discuss many critical factors related to groundwater storage and recharge, through two days of invited and submitted presentations. Sessions currently under consideration include:

- ◆ Perspectives on the science and needs for managed aquifer recharge, groundwater storage, and conjunctive use in California
- ◆ Climate change: impact on groundwater storage strategies
- ◆ Challenges of getting the water into the ground – hydrologic and economic
- ◆ Stored water issues - recovery percentage and ownership
- ◆ Source and receiving water quality – what are the issues and considerations
- ◆ Case studies in California and other areas of the US/world
- ◆ Transformation and degradation of disinfection byproducts and other related constituents
- ◆ Risk assessment and selection of drinking water standards
- ◆ Regulations for groundwater storage
- ◆ Cost and economics of groundwater storage – case studies

Experts from academia, consulting, regulatory agencies and industry will participate in moderated speaker sessions and posters sessions. The combination of invited speakers and experts from key disciplines, along with talks selected from submitted abstracts, will make this an important event for all professionals considering or currently involved with managed aquifer recharge and conjunctive use projects.

June 22 — Los Angeles Area Groundwater Recharge Field Trip

Optional Third Day - Limited to First 50 Sign-ups

- ◆ Overview of the Central and West Coast Groundwater Basins
- ◆ San Jose Creek Water Reclamation Plant
- ◆ San Gabriel Coastal Spreading Grounds
- ◆ Leo J. Vander Lans Water Treatment Facility
- ◆ Long Beach Groundwater Treatment Plant
- ◆ City of Long Beach's New ASR Well

Exhibitors and Sponsors

If you are interested in exhibiting your organization's services or products, or being an event sponsor, please contact Mary Megarry at mmegarry@nossaman.com or 916-446-3626. GRA welcomes cosponsors, lunch, refreshment and reception sponsors. ◆

High Resolution Site Characterization and Monitoring — Symposium Highlights — Continued from Page 1

impeding more widespread use of new, high-resolution site characterization tools and technologies.

In order to build a strong technical foundation for the rest of the symposium, the event started out with invited presentations by five world-class scientists involved in academic or government-sponsored field research. These speakers shared their knowledge about various aspects of the subsurface environment gained from extremely detailed, high-resolution characterization

and monitoring at field research sites. Of particular note, the speakers described the scales of the various features they were studying, which provided valuable insights into the minimum data density and scale of measurements, number of sampling points, etc., that are necessary during subsurface assessments of real contaminated sites. Beth Parker from the University of Waterloo presented data from a controlled DNAPL release in Ontario, Canada. She showed that the dissolved plumes emanating from the residual DNAPL formed discrete plumes containing concentrations of chlorinated solvents that varied by several orders of magnitude over distances of several inches. She pointed out that in a typical dissolved plume emanating from a DNAPL source zone, most of the contaminant mass is flowing through a very small cross-sectional area, thus requiring very detailed monitoring if one's goal is to map out all of the high-strength plume cores. Jim Butler, from the Kansas Geological Survey – and the 2007 NGWA Darcy Lecturer – described his work on hydrogeological methods for estimation of spatial variations in hydraulic conductivity. His presentation showed how detailed vertical profiles of hydraulic conductivity can be generated using innovative DP testing methods. Further, he showed how the hydraulic properties of the earth materials between those vertical profiles can be estimated using hydraulic tomography. Gary Wealhall, from the British Geological

Survey, described the challenges associated with characterizing the distribution and flux of dissolved contaminants in a fractured chalk aquifer in the UK. He pointed out the importance of multi-depth groundwater sampling at both research and non-research sites. Next, Susan Hubbard from Lawrence Berkeley National Laboratories

gave an insightful presentation on the role of geophysics in characterizing hydrogeologic properties and monitoring bioremediation projects. Finally, Mette Broholm from the Danish

Technical University presented results from some vadose zone controlled release experiments performed in Denmark. In her presentation, she showed how petroleum hydrocarbon vapors migrate and are attenuated in the vadose zone. To cap off this first session, Doug Mackay from UC Davis spoke at lunch about the high-resolution ethanol controlled release experiments that he has overseen at Vandenberg Air Force Base in Central California.

In addition to Jim Butler's presentation, there were several other presentations on cutting-edge DP technologies for subsurface characterization. Tom Christy from Geoprobe Systems described a suite of complementary DP sensors that facilitate rapid, cost-effective characterization of subsurface geology and contamination. Mark Kram of the Naval Facilities Engineering Service Center (NFESC) described a new high-resolution piezocone and methods to integrate high-resolution CPT data into three-dimensional

site conceptual models. Randy St. Germain from Dakota Technologies described new laser-induced fluorescence sensors for characterizing subsurface contamination, including polynuclear aromatic compounds (PAHs) at manufactured gas plant (MGP) sites.

Many speakers spoke about the importance of collecting depth-discrete groundwater samples during subsurface assessments due to the large vertical variations in contaminant concentrations that exist in most contaminant plumes. This point was emphasized by Beth Parker, Gary Wealhall, Mette Broholm, and Doug Mackay in the first session, and later on by Seth Pitkin of Stone Environmental, who described the use of a multi-depth, DP groundwater sampling tool to quickly characterize dissolved plumes of volatile organic compounds (VOCs). There were also several presentations on innovative multi-level groundwater monitoring systems. Mike Taraski

from MACTEC gave a platform presentation comparing the Westbay, Waterloo, CMT, FLUTE, and BARCAD multilevel monitoring systems. Peter Zeeb from Geosyntec Consultants also compared several multi-level monitoring systems in a poster presentation that focused on multi-level monitoring in karst aquifers. For those who wanted more information about multi-level monitoring technologies, the manufacturers of each of the above-mentioned five multi-level systems had booths at the symposium.

While new and innovative site characterization technologies were highlighted throughout the conference, there were several presentations focusing on ways to collect higher-resolution data from

Education is the most important way to overcome the obstacles that impede wider use of the new high-resolution site characterization and monitoring technologies



Kirstin Cooper from Solinst, Canada shows attendees a new three-channel multilevel monitoring system designed for direct push installation. Fluted bentonite cartridges seal the borehole between the sampling zones.

Continued on page 16

High Resolution Site Characterization and Monitoring — Symposium Highlights — Continued from Page 15

existing, low-resolution conventional monitoring well networks. Louise Parker from the Cold Regions Research and Engineering Laboratory (CRREL) presented an overview of depth-discrete sampling devices, including diffusion bag samplers, which can sometimes be used to collect depth-discrete groundwater samples from existing monitoring wells. Sandy Britt from ProHydro, Inc. also had a poster presentation where he described the Snap Sampler, a device that can be used to collect depth-discrete samples from existing wells with minimal disturbance. Mark Varljen of SCS Engineers showed some numerical simulations of the zones of inflow when monitoring wells are pumped. The utility of collecting depth-discrete samples from existing wells was tempered, however, by several presentations that showed that in-well flow and mixing can cause significant biases that cannot be eliminated simply by collecting samples from multiple depths within a monitoring well. Presenters on this latter topic were Gary Robbins from the University of Connecticut, James Martin-Hayden from the University of Toledo, and Fred Molz from Clemson University. Dr. Molz was the invited luncheon speaker on the second day of the symposium.

High resolution characterization and monitoring in assessments of vapor migration was also an important topic at the symposium. In addition to Mette Broholm's invited presentation described above, there were excellent presentations by Cynthia Puls from USEPA's Kerr Research Center and Blayne Hartman from H&P Mobile Geochemistry. Ms. Puls' presentation was titled "Vertical Profiling of VOCs in Groundwater and Soil Vapors to Evaluate the Risk of Vapor Intrusion." Dr. Hartman's presentation was titled "Collection and Interpretation of High Resolution Vapor Concentration Data to Assess Risks Due to Vapor Intrusion."

The first day of the symposium ended with an ice-breaker social hour where attendees viewed more than a dozen excellent technical posters and met with technology developers and vendors at their

booths. Many attendees also attended an evening presentation by Beth Parker (University of Waterloo) titled "High Resolution Approaches to Characterize Aquitard Integrity" that was organized by GRA's Southern California Branch.



Mark Knolle from Prosonic Corp. displays soil cores collected using Prosonic's new difficult-access sonic drilling rig.

The second day of the symposium started off with several presentations focusing on managing, modeling, and visualizing high-resolution site characterization data. Richard Hammond from USEPA described how high-resolution data can be managed during expedited, TRIAD assessments. Mr.

Hammond's presentation was followed by three excellent case studies by Tim Mote (Geomatrix), Zafer Demir (Lawrence Livermore National Laboratories), and Ken Stelman (Geomatrix).

The application of high-resolution characterization and monitoring approaches and technologies in water resources projects was another important session at the symposium. Graham Fogg from UC Davis started off the session by describing geology-based geostatistical methods for high-resolution simulations of subsurface geology. John Izbicki's (USGS) presentation showed insights that can be gained by performing depth-discrete flow measurements and collecting depth-discrete groundwater samples from pumping supply wells. Roy Herndon from the Orange County Water District (OCWD) described some detailed tracer tests that were performed by OCWD and UC Santa Barbara to define groundwater flow paths downgradient of an artificial recharge facility in Orange County, California. David Rudolph from the University of Waterloo gave an impressive presentation on methods his research group used to define contaminant source terms for regional flow and water quality models in Ontario, Canada. Dr. Rudolph's case study focused on road salt, which has been recognized

THE SNAP SAMPLER™
BY PROHYDRO, INC.

A No-Purge Alternative for Quality Groundwater Monitoring

- Repeatable sampling methodology
- *In Situ* sample collection
- No-purge ease and cost savings

"...more consistently representative..."
"...less expensive than the conventional approaches..."
--Parsons, 2005

WWW.SNAPSAMPLER.COM

as a significant source of groundwater contamination in some Sierra Nevada communities. Moreover, the concepts and methods he presented are applicable to non-point sources of contamination such as perchlorate and fertilizers that are of significant concern throughout California. Chris Peterson from Montgomery Watson Harza showed how high-resolution subsurface data has been collected and utilized at an aquifer storage and recovery (ASR) project in Roseville, California. Also, Bob Will from Schlumberger Water Services gave a thorough presentation on a suite of high-resolution borehole logging, monitoring, and simulation products that are useful for ASR projects.

The symposium finale was a panel discussion that focused on overcoming obstacles to better and more cost-effective subsurface characterization. The invited panelists, representing a cross section of the environmental industry, consisted of Curt Stanley (Shell Global Solutions), Kevin Graves (SWRCB), Gary Robbins (University of Connecticut), Richard Hammond (USEPA), Matt Small (USEPA), and Bill Pence (Akerman Senterfitt). The panel discussion was scheduled to last for 45 minutes but ended up going for over two hours as audience members lined up at the microphones to voice their opinions. While many important points were raised during the panel discussion, there was a consensus that education is the most important way to overcome the obstacles that impede wider use of the new high-resolution site characterization and monitoring technologies. Conferences and short courses -- like the GRA symposium -- are very important, but updated technical guidance documents from California regulatory agencies and USEPA are also needed, said many of the attendees.

The platform presentations ended on Wednesday, but nearly 150 people stayed on for the hands-on field demonstration of innovative site characterization technologies the following day. The field demonstration, held at a fuel-release site at the nearby Long Beach airport, consisted of 13 stations where invited technology developers and vendors demonstrated their equipment. Technologies demonstrated at the field site included sonic drilling

(Prosonic and Boart Longyear), cone penetrometer testing (Gregg In Situ and FUGRO), DP sampling and geophysical/geochemical sensors (Geoprobe and Vironex, Inc.), specialized groundwater sampling services (Blaine Tech Services), environmental instrumentation (Solinst Canada, Schlumberger Water Services, InSitu, Inc., and BESST, Inc.), geophysical logging (Norcal Geophysical), and mobile laboratories (H&P Mobile Geochemistry).

On Thursday morning, busses ferried the attendees from the hotel to the field demonstration site. When they arrived, they were given an overview of the site conceptual model (SCM) by Dennis Parfitt, the SWRCB hydrogeologist working on the site. Next, the large group was broken into 13 smaller groups, each of which was directed to one of the demonstration stations. The technology developers/vendors then gave short verbal presentations to the people at their stations, followed by demonstrations of their equipment. After 20 minutes, a siren was sounded, signaling that it was time for each of the 13 groups to move on to the next station. The vendors then repeated the presentations and

demonstrations to the new groups. In this way, the small groups rotated through each of the 13 stations throughout the day.

The field demonstration ended with the 150 participants boarding the busses for the short ride back to the hotel. As they left the field site, many attendees expressed their overall satisfaction with GRA's High Resolution Symposium. Some said that it was the best conference that they had ever attended. The field demonstration, in particular, got high marks by those who attended it. The opportunity to see the technologies in action and to interact with the vendors in small groups contributed to the success of the field demonstration.

A binder with copies of speakers' slides and related technical papers was produced for the symposium. For a copy of the binder and information about other GRA programs, please go to www.grac.org or call GRA's main offices in Sacramento at 916-446-3626.

Murray Einarson is a Senior Consultant with Geomatrix Consultants, Inc., in Oakland, California. 💧

DUDEK ENGINEERING + ENVIRONMENTAL

Creatively solving water supply challenges for California cities and water districts.

Plan | Design | Construct | Manage

WWW.DUDEK.COM
800.450.1818

San Diego | Los Angeles | Riverside
Orange | Santa Barbara | Sacramento

President's Message — Continued from Page 2

legislators need a crash course in the importance of integrating groundwater storage into water supply planning. Assemblymembers, Senators, legislative staff, agency heads, and the Governor's staff have increasingly come to know GRA as the most reliable source of information on groundwater technical and policy issues, thanks to the tireless efforts of our Legislative Committee Chair, Tim Parker, and our Legislative Advocate, Chris Frahm.

Attendance at GRA's Legislative Symposium and Lobby Day is a unique experience, one that I've enjoyed immensely in past years. Consider your work as a groundwater professional: where did the regulatory, policy, or financial framework that motivates the requirements and funding for your projects come from? I know many GRA members whose 'Prime Directive' originates from an act of the Legislature. On March 20th, GRA offers you the opportunity to speak directly with California's political leadership on groundwater issues. We will hear from veteran

water policy legislators and agency leaders in the morning, and spend the afternoon visiting Assemblymembers, Senators, and their staff in their offices. This year, we will again hand out GRA's book, "California Groundwater Management" to the legislators. I can assure you that time spent getting acquainted with the legislative process will be worthwhile. Sign up now on our website!

At the January Board of Director's meeting in Irvine, GRA's Board unanimously endorsed a proposal to join forces with other groundwater-focused associations to strengthen our advocacy for groundwater stewardship in the Capitol. GRA has joined the Association of Ground Water Agencies and the American Ground Water Trust to form the 2007 California Groundwater Coalition. The Coalition's mission is to 1) educate policy makers about groundwater; 2) represent groundwater interests and promote the benefits of comprehensive groundwater management and use in legislative and other policy arenas;

and, 3) promote a fair share of funding for statewide groundwater programs, including 2006 and 2008 water bonds. I encourage you to visit our website to learn more about the Coalition.

What can we tell our legislators about the vital role of groundwater? The growing role of groundwater storage in the state's water supply portfolio will require increased regional cooperation and coordination of groundwater management activities. Groundwater protection will remain an important factor. Increased reliance upon groundwater necessitates a stronger linkage between land use planning, watershed and floodplain management, and groundwater management planning. Where geographically favored, a mix of aggressive conservation, groundwater storage, and recycled water use can be more effective than building new dams.

The necessity of using more recycled water to meet growing demand will inevitably lead to more projects for indirect recharge with recycled water in California.



Wactor & Wick LLP is a full service environmental law firm.

Wactor & Wick LLP attorneys have over 60 years of successful experience efficiently resolving environmental issues for clients throughout California and many other states.

Subject Areas

Contaminated soil, groundwater and surface water; stormwater; vapor intrusion; due diligence; Superfund; hazardous waste; air quality; wetlands; endangered species; environmental planning; toxic torts.

Types of Services

Confidential consulting & advice; litigation in state and federal courts and before administrative bodies; negotiation and drafting of contracts and project documents; regulatory compliance; expert testimony; peer review; defense of environmental agency orders; consultant selection, management & oversight; environmental insurance placement and claims.

Types of Projects

Investigation; cleanup; permitting; brownfields redevelopment (commercial, industrial, retail, R&D, residential, mixed use); property purchase, development, finance, leasing and sale; utility plant siting.

Our clients include developers, landowners, manufacturers, environmental consultants, financial institutions and other businesses.

AV rated by Martindale-Hubbell



180 Grand Avenue
Suite 950
Oakland, CA 94612
510.465.5750
Fax 510.465.5697
www.ww-envlaw.com

Funding is needed to conduct detailed analysis to determine the appropriate degree of treatment required to protect both groundwater quality and aquifer permeability. Tertiary treated wastewater finished for recycled water use may be too salty to prevent groundwater quality degradation, and high sodium content may affect the structure of clay minerals in the aquifer matrix, reducing aquifer permeability. Groundwater managers must therefore solve the optimization problem of advanced treatment costs, protecting groundwater quality, and retaining aquifer permeability. This challenge includes marshaling the political will to finance a water supply future that is more dependent upon higher quality and higher cost recycled water subjected to advanced treatment, which is available locally, year-round. The technology to do this safely has been proven, but the expertise of groundwater professionals must be leveraged to ensure careful execution and detailed monitoring.

Climate change predictions show that more winter precipitation will fall as rain rather than snow, substantially diminishing the volume of storage available in Sierra Nevada snowpack that slowly melts, producing delayed runoff into reservoirs that sustain irrigation throughout our dry summers. Studies estimate that the snowpack could decline 25 percent by 2050 as a result of global warming. This could substantially elevate salinity in the delta, a source of freshwater for 23 million Californians.

These wholesale changes to the reliability of our water supply infrastructure would indeed be a “sea change,” for which even innovative groundwater management strategies might not be sufficient to address. It therefore becomes incumbent upon water professionals to examine the role of water management in climate change. Moving water consumes a great deal of energy! According to the California Energy Commission, water-related energy use consumes 19 percent of the state’s electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year – and this demand is growing. Aggressive water conservation can make a big difference in CO₂-producing energy consump-

tion. Accordingly, promoting aggressive conservation and water use efficiency must be an integral strategy in water agencies’ operations and planning.

In order of priority for limited funding, it’s safe to say that groundwater storage projects top the list. Advanced treatment of recycled water for indirect potable use, e.g. blending with imported water or local reservoir water for conjunctive use projects, is a close second. New dams may also address long term climate change impacts

and flood control needs. But throughout the next 50 years, aggressive water conservation and development of technology for improved water use efficiency may help to avoid accelerated global warming by reducing energy consumption and CO₂ emissions. Indeed, it is something we can do now.

Thomas Mohr is GRA’s President and a hydrogeologist with the Santa Clara Valley Water District. Your comments are welcome: tmohr@grac.org. 💧

Roscoe Moss Company
We make water work worldwide.

No single screen type is appropriate for all wells. Roscoe Moss Company is the only manufacturer in the world producing shutter screen, continuous slot screen, bridge slot screen, and slotted pipe. This ensures that Roscoe Moss Company's customers receive unbiased technical assistance directed toward solving their specific problems.

 4360 Worth Street, Los Angeles, CA 90063
Phone (323) 263-4111 • Fax (323) 263-4497
www.roscoemoss.com • info@roscoemoss.com
© 2006 Roscoe Moss Company. All Rights Reserved.

Wells and Words — Continued from Page 4

personnel. However, personnel are still needed to operate and maintain the pumping equipment and discharge measurements and to collect digit data that backs-up the digital data. For pumping tests with multiple observation wells, digital methods may reduce the number of personnel at the site for an hour during the initial phases of drawdown/recovery. However, after one hour of pumping, one person can usually measure all the wells during the pumping test; this is not a difficult task especially with dedicated electric sounders in each well.

Application of digital methods can provide easy and superior data for long-term and background water level monitoring. Data loggers are also equipped to provide synoptic barometric pressure fluctuations, which can be important in interpretation of confined aquifer tests. Digital methods can be helpful during pumping tests conducted in extremely high-yield aquifers with rapid

responses (i.e., high permeability) and are used often for slug tests with short and rapid water level responses.

Rather than being concerned about the minutiae and perceived accuracy provided by digital collection systems or the perceived inaccuracies of digits, emphasis should be placed on maintaining a constant discharge, discharge water characteristics, and analysis of drawdown/recovery data in the field. If digits and the resulting family of drawdown curves are inconsistent in light of the assumed hydrogeologic framework, then a review of the digital data may be warranted to verify the digits. The field data can be reviewed in the office to verify field computed parameters using log-log plots and re-plotting of the field data on semi-log plots.

David W. Abbott is with Todd Engineers in Emeryville and may be reached at dabbott@toddengineers.com. ♠

HATCH & PARENT
A Law Corporation

Water Law

**Environmental Quality and
Litigation**

Legislative Advocacy

Groundwater Management

h&p
HATCH & PARENT
A LAW CORPORATION

www.HatchParent.com

Los Angeles • Santa Barbara • San Diego •
Sacramento • South Lake Tahoe

Fingerprinting Water — Continued from Page 5

Sampling, Analysis and Costs

Collection of local precipitation requires that the water sample be collected during the storm event to minimize evaporation. Isotopic signatures for precipitation may also be obtained from bottled water, if it can be shown that the bottled water is from a local surface water source.

Sampling surface and groundwater is less complicated. Generally, one 250 mL plastic container is sufficient for water collected from a well. Containers should be filled to the top, and tightly sealed to prevent leakage and evaporation. Preservatives are not required.

Most stable isotopes in substances are determined by isotope ratio mass spectrometry (IRMS) analysis in which a beam of charged ions is generated from the thermal ionization of a solid sample (known as a solid source) or by ionizing a gaseous sample (gas source). Solid source IRMS is used for elements with high atomic masses such as strontium, lead, and uranium. For most light elements (i.e., hydrogen, nitrogen, and oxygen) the analyzed material is converted to a gas prior to analysis. The isotopic concentrations are then measured as a ratio of the isotope to a common nuclide. In the case of gas source IRMS for water it is measured against VSMOW. Costs are relatively inexpensive, ranging from \$40 to \$50 per sample for University laboratories, to about \$55 to \$120 for commercial laboratories.

Additional Information Sources

On March 28, 2007, GRA will host a course on stable isotope use in groundwater. Course instructors will be Dr. Carol Kendall, U.S. Geological Survey and Dr. Jean Moran, Lawrence Livermore National Laboratory. A one-day symposium (March 29) will follow on uses of stable isotopes in groundwater hydrology; see announcements at www.grac.org. This article, complete with references, may also be found on the GRA site.

William Motzer is with Todd Engineers, 2200 Powell Street, Suite 225, Emeryville, CA 94608. He may be reached at bmotzer@toddengineers.com. ♠

California Groundwater Association/ National Ground Water Association

— Continued from Page 9

ness Week. You can find a wide variety of activities at the NGWA website (www.ngwa.org) - check out the Darcy's Law lesson plan for high school students. NGWA is also preparing a Public Awareness Tool Box for members with tips on how to complete a wide variety of activities to build awareness of the groundwater industry and your business. Watch for a copy later in 2007. If March 11-17 is too close to plan some activities, don't miss Water Awareness Month in California in May. Check out the California Water Awareness Campaign's web site at www.wateraware.org for info on educational materials about groundwater and other public awareness projects.

CGA & GRA Members Head to Washington DC

CGA and GRA members will again participate in the NGWA Fly-In in Washington DC in early March. Past efforts have paid benefits for groundwater industry members from funding for household wells to support for groundwater sustainability programs to training for well inspectors. This year the US Department of Agriculture has selected California as one of six states to get funding to train regulatory agency personnel involved in well inspections. A 1½ day session is being planned for 40 inspectors from throughout California. The session is tentatively scheduled for spring in Northern California and will involve classroom instruction and a visit to a drilling site.

Mike Mortenson is Executive Director of the California Groundwater Association. ♪

NGWA Working to Develop Ground Water Science Education Pilot Program — Continued from Page 9

Treyens said NGWA also is interested in making students aware of careers in the ground water professions. "Our members are concerned about where the groundwater professionals of the future will come from. At the same time, schools are looking for professionals to participate in career days and mentoring programs," Treyens said. "By making member professionals available to schools through this pilot program, NGWA can respond to its members' concerns and meet students' needs at the same time."

While work on the pilot program is just beginning, EECO members indicated that they may provide training to NGWA volunteers on making classroom presentations and possibly provide kits for use by NGWA volunteers in making presentations.

The effort to expand the use of groundwater science in schools is consistent with NGWA's Declaration on the Importance of Earth Systems Science Education adopted by its Board of Directors last February. In the declaration, NGWA joined other geoscience organizations, the state-based national alliance, and federal agencies in recognizing that "a science-literate citizenry is vital to the nation's well-being and security."

Cliff Treyens is the public awareness director for the National Ground Water Association. ♪

EnviroTech Quality Rentals
Quality Environmental Products

Every Rental comes with the Enviro-Tech
"Quality Guarantee."

This means every rental comes with...

- IF Requested Calibration Kit, Video & CD, Tool Kit
- Instrument is Charged & includes Charger
- All Accessories as needed
- Clean Foam Packaging
- Instruction Manual and Rental Agreement
- Working Instrument and Certificate of Calibration

It Looks Sharp and Professional
Our Quality Guarantee -
If we fail to provide any of this, your rental is Free* until we fix it.
*The only condition is you need to notify us immediately.

www.envirotechonline.com

Toll Free 1-800-468-8921

Central Coast Branch Highlights

BY BRAD HERRERA
BRANCH PRESIDENT

On February 8, the Central Coast Branch met in Oxnard and welcomed Will Boschman, General Manager of Semitropic Water Storage District, as its guest speaker. Mr. Boschman's talk was entitled "Been there, done that, let's do it again: Water Banking." He spoke regarding Semitropic's experience in its initial water banking phase and its plan for future additional storage operations.

On April 4, 2007, the Central Coast Branch will host local Santa Barbara area water agency managers, who will discuss their current operations and the state of the Santa Barbara area groundwater basins. The branch hopes to hold its June 2007 meeting in San Luis Obispo County. Go to www.grac.org for branch contacts. 💧

Sacramento Branch Highlights

BY STEVE LOFHOLM,
BRANCH SECRETARY

The April meeting featured Don Nasar Bateni, a civil engineer who directs the California Water Resources and Planning Group in Bookman-Edmonston's Sacramento Office. Mr. Bateni made a presentation on the Integrated Regional Groundwater Management Plan for the Modesto Groundwater Subbasin. The Modesto Subbasin comprises an area bounded on the north by the Stanislaus River and on the south by the Tuolumne River. Rainfall runoff and snowmelt support flow in these rivers, which is used by the local water districts to irrigate crops grown on the valley floor. The Stanislaus and Tuolumne Rivers Groundwater Basin Association (Association) was formed in 1994 to provide a forum in which the parties could work cooperatively to manage the groundwater resources in Modesto Subbasin. The Association's member agencies include the Modesto Irrigation District, the Oakdale Irrigation District, City of Modesto, City of Riverbank, City of Oakdale, and Stanislaus County. Mr. Bateni directed the Association's efforts to develop an Integrated Regional Groundwater Management Plan (IRGMP) in compliance with the Groundwater Management Planning Act of 2002 (SB 1672). The IRGMP provides the framework for the coordinated management of the groundwater and surface water resources to meet both urban and agricultural water needs, while protecting and enhancing the groundwater quantity and quality in the subbasin.

The Sacramento Branch's November meeting featured a presentation by Rodney Fricke, an Environmental Specialist with Aerojet. Mr. Fricke gave a presentation entitled "Deep Well Injection and Closure." Aerojet installed a deep injection well system to dispose of briny, sodium-sulfate wastewater. The system consisted of two wells with screen intervals from approximately 970 to 1600 feet below the ground surface. The deep injection zone is confined from

shallower aquifers by a 30-foot thick clay layer that dips westward at 3.5 degrees. The injection well system was subsequently destroyed in 1994 after an evaluation of well integrity and hydrogeological conditions. Aerojet has conducted investigations to evaluate the continuity of the confining layer and assess if the fluids injected into the deep injection wells may have migrated into shallower fresh water-bearing zones. Their studies showed that the confining layer was continuous and has prevented upward migration of the injected fluids.

The GRA and AEG held a combined meeting in December. The meeting featured a presentation by Dr. Jeffery Mount entitled, "Hope is Not a Strategy: Options for the Future of the Delta." Dr. Mount is a professor in the Department of Geology at U.C. Davis. Dr. Mount's presentation focused on the state of the levee system in the Sacramento/San Joaquin Delta and how failure of the levee system could result in catastrophic damage to the Delta ecosystem. The Sacramento/San Joaquin Delta is the hub of California's water supply network, providing drinking water to more than 23 million people. In addition, the Delta supports a vibrant farm economy, extensive transportation, energy and shipping infrastructure, and a booming recreation industry. The Delta also hosts one of the state's most fragile and altered ecosystems. For more than a decade, the Delta has been managed by federal, state, and local agencies under a simple principle: we will all get better together. Dr. Mount and his colleague's research indicate that this principle can not be sustained into the future. They have identified six fundamental drivers of change—subsidence, sea level rise, seismicity, runoff changes, invasive species and urbanization—that are impairing the ability to "all get better together." Dr. Mount believes that maintaining a business as usual approach insures that we will "all get worse together." A major failure of levees in the Delta would probably result in a massive saltwater intrusion and result in cessation of water supplies to southern California. The alternatives for the Delta range from abandonment to aggressive levee stabilization to construction of an isolated facility to maintain water supplies. 💧



KIFF
Analytical LLC

Your choice laboratory for

- Low Level Fuel Oxygenate and Volatile Organic Compound Testing
- Providing Personal and Proactive Customer Service

www.kiffanalytical.com
530.297.4800 phone
530.297.4808 fax
Davis, CA 95618

Leaders in Analytical Science and Service

Groundwater Solution Providers

Helping to Optimize your Groundwater Resources



Offering groundwater solutions through professional expertise and advanced technologies

Schlumberger's Water Services specializes in assessing, developing, and managing the world's groundwater resources using the most powerful and cost-effective technologies available today.

Whether you're looking for field-scale data collection, data management, modeling, or end-to-end solutions for resource management, our teams of specialists are here to help you address all your groundwater projects safely and efficiently.



Dates & Details

GRA MEETINGS AND KEY DATES

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

GRA Legislative Symposium	March 20, 2007 Sacramento, CA	GRA Symposium <i>Increasing Groundwater Storage to Meet California's Future Demand-- Challenges & Solutions</i>	June 20-21, 2007 Long Beach, CA
GRA Course <i>Isotope Methods for Groundwater Investigations</i>	March 28, 2007 Concord, CA	GRA Field Trip <i>Los Angeles Area Groundwater Recharge</i>	June 22, 2007 Long Beach, CA
GRA Symposium <i>Applications of Isotope Tools to Groundwater Studies</i>	March 29, 2007 Concord, CA	GRA Conference <i>EIMS 2—Environmental Information Management Systems</i>	August 22, 2007 Irvine, CA
GRA Board of Directors Meeting	April 21, 2007 Sacramento, CA	GRA 16th Annual Meeting/ 26th Biennial Groundwater Conference	September 18-19, 2007 Sacramento, CA
GRA Course <i>Principles of Groundwater Modeling & Transport Flow</i>	May 1-3, 2007 Redwood City, CA		
GRA Conference <i>Groundwater Law</i>	June 1, 2007 San Francisco, CA		



GROUNDWATER RESOURCES ASSOCIATION
OF CALIFORNIA

915 L Street, Suite 1000
Sacramento, California 95814

Presorted
First Class Mail
U.S. Postage Paid
Sacramento, CA
Permit No. 316