GROUNDWATER RESOURCES ASSOCIATION OF CALIFORNIA

HYDROVISIONS

VOLUME 19, NO. 2 SUMMER 2010

Solvent Release Sites Characterization, Cleanup, and Closure

By Elie H. Haddad, Haley & Aldrich, Inc., Tom Mohr, Santa Clara Valley Water District, and Rula Deeb, Malcolm Pirnie

Twenty years after CERCLA, solvent release sites continue to represent challenges regarding cleanup and closure. On one hand, heterogeneities and low-permeability soils limit delivery of substrates and cause long-term matrix diffusion; on the other hand, several decades may be needed to achieve the low levels of cleanup standards of several solvents. Accordingly, it was fitting for GRA to organize the April 1, 2010 GRA conference on Solvent Release Sites, which was held in Santa Clara, California, and was attended by more than 130 participants from various disciplines. The one-day conference was packed with a wide range of topics, including diagnostic tools for site characterization and remediation, use of mass flux/mass discharge as a metric to achieve closure, source cleanup using innovative technologies or treatment train approaches, and alternative site closure strategies. In addition, the conference included a luncheon panel discussion featuring experts on site closure.

GRA would like to acknowledge the conference's co-sponsors, ARCADIS, CH2M Hill and Haley & Aldrich, and the numerous exhibitors that made this event possible.

Conference co-chairs from left: Tom Mohr, Rula Deeb, and Elie Haddad

Session 1: Diagnostic Tools for Site Characterization and Remediation of Solvent Sites

Stephen Koenigsberg of Environ International Corporation started the session with a discussion of advanced diagnostics for expedited closure of solvent release sites. Various tools were discussed, including the use of molecular biological protocols, emergent chemical analyses tools, isotope analyses and state-of-the-art geophysical techniques. He concluded that the industry is moving away from capital- and energy-intensive cleanup methods in favor of in-situ remediation, and that in-situ technologies are being increasingly supported by advanced diagnostic tools that employ biotechnology, advanced chemistry and "enviro-tomography." He further concluded that expedited site closure strategies are further enhanced by incorporating traditional risk analyses, novel fate and transport models, and sustainable remediation logic.

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

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Geology Gone Wild

By Bill Pipes

Earthquakes in Haiti, Chile, and China; a volcanic eruption in Iceland; flooding in Tennessee; exploding oil wells – its "geology gone wild" this year. It seems lately that I am often quoting Mr. Durant to my friends and family. His observation about geology and civilization is as apt for groundwater as it is for volcanic ash clouds stranding air travelers on both sides of the Atlantic. First and foremost, groundwater is a geologic phenomenon. Sure, groundwater conditions do not change as abruptly or cataclysmically as a volcanic eruption or an earthquake – but they do change in ways beyond our control. Although we know they are coming, doesn't it seem that we still are caught by surprise by droughts and wet years, and their associated impacts on groundwater conditions?

No state in the union is as blessed as California with such diverse geologic settings and productive groundwater basins. About 20% of all groundwater pumped in the US is removed from Central Valley aquifers alone, and statewide groundwater use is expected to increase with population and the effects of climate change. It's a resource that is indeed robust and serves the state well, but like all shared natural resources, it needs to be managed and legislated from a strong foundation of scientific and engineering principles and an understanding of the geology that controls the occurrence, movement, and availability of groundwater.

On April 28, GRA held its 9th annual Legislative Symposium and Lobby Day; the theme this year was "Looking Back and Marching Ahead." The program was outstanding – we heard from a number of key legislators, administration officials, and committee consultants on groundwater as it is understood and addressed in the political realm of Sacramento. GRA members interacted with the presenters in learning about how pending and potential legislation will have an impact on how California manages the water supply, particularly how we will manage and preserve the incredible resource beneath our feet. Throughout the day, GRA members introduced them to key scientific and engineering principles, and geologic understanding necessary for informed and effective policy making.

GRA can have an important and lasting impact by continuing to interact with the Legislature. Groundwater legislation and regulations are coming, whether we like it or not. GRA's mission is to promote the informed and proper management and preservation of the state's groundwater resources, primarily through technical leadership. We do that via our lobby days and numerous conferences, symposia, and workshops held every year – such as the upcoming "Geophysics at the Beach" on May 24 and our annual meeting on September 15. We also do it with our website, one of the premier sites for California groundwater information. We especially provide technical leadership through the GRA Branches, each representing a major region of the state and committed to understanding local groundwater issues. Finally, we roll it all up into our quarterly newsletter *HydroVisions*, which you now hold in your hands or behold on your computer screen.

If you are a groundwater stakeholder (is there a Californian who is not?), and are as passionate as we are about technical leadership on this very important component of California's water supply, then join GRA – its easy to join online at www.grac.org – and you will immediately start reaping the benefits and helping the organization fund its technical leadership activities. Come to our events – as a member you will receive a significant discount on the program fees. Be sure to visit our website, and get involved at the local level through the Branches…and of course, keep reading *HydroVisions*.

> "Civilization exists with geologic consent, subject to change without notice." – *Will Durant*

Until next time, may we all be graced with geologic consent!

Bill Pipes

Bill Pipes
GRA President

Solvent Release Sites Characterization, Cleanup, and Closure – *Continued*

Conference attendees

Robert Pirkle of Microseeps, Inc. presented on optimizing in-situ chemical oxidation performance monitoring and project management using compound specific isotope analysis (CSIA). Combined CSIA and concentration data confirm chemical destruction and characterize delivery limitations that would not have been identified using concentration data alone. More specifically, CSIA can be used to evaluate whether compound concentrations in groundwater are rebounding following ISCO applications.

Allen Waldman of WSP Environmental and Energy talked about advanced diagnostic tools for natural attenuation and bioremediation applications. Data were presented from several sites in Connecticut, California, Florida, Georgia and Tennessee illustrating the novel use of molecular biological tools to aid in site assessment, remedial selection and remedy performance. He concluded that advanced diagnostic tools are quick and easy to implement, save money, and provide real-time actionable performance monitoring data.

Peter Bennett of AMEC Geomatrix, Inc. discussed the use of CSIA and BioTraps to demonstrate aerobic vinyl chloride biodegradation within an aerated granular activated carbon vessel. Using pilot test data, he was able to demonstrate that the enrichment of 13C/12C ratios of vinyl chloride corresponded with decreasing vinyl chloride concentrations with distance from the influent end of the bioGAC system, suggesting that aerobic biodegradation was occurring and was responsible for vinyl chloride removal. The BioTraps baited with 13C-labeled vinyl chloride provided direct evidence of microbial growth of aerobic bacteria using vinyl chloride as an energy source. A full-scale bioGAC system was constructed following the pilot study at the site, and it remains in operation resulting in cost savings of $100K per year.

Sanford Britt of ProHydro, Inc. gave a presentation on a mixing-limited, passive sampling approach for multi-level sampling in traditional monitoring wells. He indicated that passive samples collected within portions of screens, isolated by packers, can yield results that correspond to the adjacent aquifer. A case was discussed where mixing inhibitor baffles were installed between sampling intervals, resulting in a strong concentration gradient. He concluded that a passive method that operates without pumping, such as passive sampling, is required to collect samples using this approach.

Yi Wang of Zymax Forensics concluded Session 1 and discussed CSI forensics at chlorinated solvent release sites. Forensics is used in characterization and remedy optimization. He discussed a case study involving a PCE/TCE plume and sampling strategies utilizing 3D-CSIA. He indicated that an isotope study during electrical resistance heating of TCE at a site demonstrated that the incorporation of isotopic constraints into remediation projects can guide remediation decisions and help achieve site closure. While isotope data can be used to determine if biodegradation of chlorinated solvents is occurring, it may also help to identify the process of degradation as aerobic or anaerobic, and in some cases determine the rate and extent of degradation.

Session 2: Use of Mass Flux/Mass Discharge to Achieve Closure at Solvent Sites

Fred Payne of Arcadis started this session and presented ITRC's integrated DNAPL Site Strategy Team perspective on measurements and use of mass discharge and mass flux to improve decisions at contaminated sites. He indicated that an estimate of the strength of a source or plume will improve the assessment of natural attenuation rates or risks to downgradient receptors. Available measurement and estimation techniques and several case studies were discussed. In their draft document, Dr. Payne indicated the ITRC team concluded that mass discharge and flux estimates have proven to be valuable for site management and should be used more frequently. The team, however, also concluded that the uncertainty involved can be significant and should be recognized and quantified to the extent possible.

Murray Einarson of AMEC Geomatrix, Inc. compared four field methods used at Vandenberg Air Force Base to establish contaminant mass discharge. For the four methods evaluated, he concluded that synoptic sampling of

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Solvent Release Sites Characterization, Cleanup, and Closure – *Continued*

wells in transects are simplest to implement and fairly accurate if well spacing is smaller than sub-plume width. Based on the field testing, he suggested that although the method is potentially accurate, the steady-state pumping of wells in transects is difficult to implement since it results in relatively large volumes of wastewater. He concluded that the deployment of passive flux meters in wells in transects is simple to implement but can be tricky to interpret, and that the accuracy was unclear from the Vandenberg study because it depended on diverging assumptions. Finally, Mr. Einarson indicated that recirculation between wells in transects proved to be the most difficult to implement and required longer times, and that the accuracy could not be determined since trials did not succeed.

Exhibitors hall

Luncheon Panel

Following the conclusion of the second technical session, a panel discussion on site closure strategies was moderated by Tom Johnson of ARCADIS and Mike Kavanaugh of Malcolm Pirnie during lunch. The panelists included Alec Naugle of the San Francisco Bay Regional Water Quality Control Board, Brian Haughton of Barg Coffin Lewis and Trapp, Lenny Siegel of the Center for Public Environmental Oversight and George Cook of the Santa Clara Valley Water District. Each of the panelists gave a short presentation summarizing his opinions (or his organization's perspective) on site closure associated with chlorinated solvent releases. Alec Naugle discussed regulatory issues and concerns at chlorinated solvent sites with a focus on low-threat closure sites. Lenny Siegel gave a compelling presentation highlighting public concerns associated with contamination left behind at these sites. Brian Haughton gave a captivating history of regulatory requirements related to closure with a focus on non-degradation policies. George Cook presented his district's perspective and responsibilities dealing with site closure. Finally, Mike Kavanaugh gave a presentation titled "Closure Strategies for Solvent Release Sites: The Final Challenge" in which he provided an overview of national efforts addressing contamination at complex sites with a focus on a new National Research Council (NRC) committee on future options for management in the nation's subsurface remediation efforts. The diverse points of view presented by the panelists converged when all the panelists agreed that site closure is often complex at chlorinated solvent sites, and that leaving residual contamination behind at low-risk sites may be a future consideration, although continued controversies about cleanup levels remain.

Session 3: Source Cleanup Using Innovative Technologies or Treatment Train Approaches.

John Farr of Farr Associates discussed enhanced in-situ bioremediation at a former industrial manufacturing facility in Willits, CA. The remedial approach involved substrate injection of sugar, emulsified oil, yeast extract, pH buffer and vitamin B12 using direct-push rigs. A pilot study was conducted in 2003 followed by a large-scale application that began in spring 2009, and a second application in January, 2010. During the pilot test, typical lag time between the injection and the initial decline of chemical concentration ranged from 6 months to one year. However, the lag time was significantly shorter for the 2009 application (possibly due to the addition of pH buffer and vitamin B12). Concentrations of VOC breakdown products decreased significantly at the site following the 2009 application and the subsequent 2010 implementation, which included 140 injection points.

Cindy Schreier of Prima Environmental, Inc. presented a simulation of biodegradation of carbon tetrachloride (CTC) using emulsified vegetable oils. Addition of emulsified oils enhanced the biodegradation of CTET in bench tests with higher doses of oils, resulting in faster CTET removal. The bench studies revealed the generation of chloroform and methylene chloride, confirming CTC destruction. She suggested that the secondary effects were minor, and that dissolved arsenic increased from

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Solvent Release Sites Characterization, Cleanup, and Closure – *Continued*

0.0079 mg/L to a maximum of 0.024 mg/L, and that no change in sodium concentrations was observed. Multiple lines of evidence indicated increased biological activity; for example, DO, nitrate, sulfate, pH, ORP and dissolved chromium concentrations decreased, whereas dissolved iron, manganese and plate counts increased. Based on the promising laboratory results, a field pilot test is being conducted.

Herb Levine of EPA Region IX presenting

Jennifer Triplett Kingston of Haley & Aldrich, Inc. reviewed two case studies to assess the feasibility of in-situ thermal technologies at contaminated sites. She concluded that thermal technologies are no longer "experimental" and that they work. Consideration of thermal methods requires accounting for several challenges, including geology and hydrogeology, energy, costs, remedial goals and performance metrics. Past applications have provided opportunities to avoid contracting issues, limit characterization needs and eliminate unnecessary pilot testing. The limited number of biased vendors makes it difficult to optimize the approach. "Failures" often are attributable to disconnects between client strategy, regulatory goals and vendor understanding.

Bruce Marvin of Geosyntec Consultants followed with a presentation on in-situ chemical oxidation concepts for chlorinated solvent sites. An overview was provided of a range of oxidants (permanganate, hydrogen peroxide, persulfate, ozone, and percarbonate), and there was a focused discussion of oxidant, activator, and site characteristics that affect oxidant selection and field performance. Studies were presented indicating that "sterilization" of soil by ISCO does not occur, and that ISCO designs intended to enhance post-ISCO biological activity can be successful. He concluded that successful ISCO programs require a balance of technical, logistical, and regulatory elements.

Session 4: Alternative Site Closure Strategies

Thomas Mohr of the Santa Clara Valley Water District discussed lessons learned from 1,4-dioxane case studies. The case studies included 1,4-dioxane releases in alluvial valley fill, fractured bedrock, glacial outwash plains and carbonate formations. He addressed lessons learned from site characterization, remedial feasibility studies, choices in laboratory analysis, interaction with regulators, disposition of treated water and community relations. He also discussed the May 2009 US EPA release of draft toxicity review of 1,4-dioxane, which proposes an increased cancer slope factor that could translate to a lower drinking-water threshold and possible regulation of the chemical in more states.

Elizabeth Hawley of Malcolm Pirnie, Inc. discussed alternative endpoints and remedial strategies for groundwater cleanup based on a recently-completed study for ESTCP. The study evaluated a number of federal and state cleanup programs, including technical impracticability and other ARAR waivers, state and local designations (e.g., groundwater management zones) and alternate concentration limits. She concluded that there are a variety of ways to manage remediation risks, such as TI waivers at CERCLA sites (~70 examples documented for groundwater) due to DNAPL and/or complex hydrogeologic settings. Also, numerous case studies have been documented that provide good examples of tools, metrics and processes used at sites.

Stephen Osborn of Fugro West, Inc. gave a presentation entitled "Anatomy of a Solvent Site Closure." He used a case study to argue that the keys to closure included the implementation of soil and groundwater interim remedial measures, being responsible for the release and the lead in the remedial process, using flexible remedial technologies, and maintaining the dialog with the regulators. After soil remediation and implementation of groundwater cleanup technologies (groundwater extraction and substrate injection) at a San Leandro site, the remedial action changed to monitored natural attenuation, 42 of 49 monitoring wells were

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abandoned, three treatment plants were demolished, and the highest groundwater concentrations were reduced by two orders of magnitude over a period of 2.5 years.

Herbert Levine of the EPA Region IX ended the session with a talk on the use of technical impracticability waivers at Superfund sites. EPA's regulatory framework for groundwater cleanup and factors that influence groundwater restoration were discussed. He mentioned that TI decisions have primarily been made at sites where dense nonaqueous phase liquids were present and groundwater contamination occurred in fractured bedrock. He stressed that effective cleanup and closure of a site involve open and honest communications between the regulators and the responsible parties.

Poster Presentations

During the breaks, lunch, and the reception, posters were presented by Jay Hodney of W.L. Gore & Associates, Inc. (Assessing Solvent Sites Accurately and Optimizing Remedial Programs Using High-Resolution, Advanced Passive Soil Gas and Sub-Slab Soil Gas Sampling), Kevin Brown of the San Francisco Bay Water Quality Control Board (Closure Strategies for Chlorinated Solvent Cases in the San Francisco Bay Region), Richard Cramer of AECOM (Sequence Stratigraphy: Critical to the Success of Solvent Release Cleanup), Samantha Curtis of AMEC Geomatrix (Bench-Scale Evaluation of In Situ Bioremediation of Chlorinated Solvents in Groundwater), Sandra Dworatzek of SiREM (Bioaugmentation for Remediation of Chlorinated Solvent Contaminated Sites in California and in Source Zones), Michael Finch of the Department of Toxics Substances Control (Field Comparison of Helium and Freon as a Tracer Gas in Soil Gas Sampling), Richard Fink of Kleinfelder, Inc. (Implementation of Department of Toxic Substances Dry Cleaner Site Discovery Process for City of Visalia, CA), Patrick Hicks of Wavefront (Innovative In-Situ Injection Technology), Donovan Smith of JRW Bioremediation Products/EBS (All Electron Donors Are not Created Equal), Greg Stemler of AMEC Geomatrix (3D Fence Diagrams- A Cost Effective Method to Accurately Depict Subsurface Geology, Hydrogeology, and Contaminant Distribution), and Gustavo Valdivia of Bureau Veritas North America (Documenting Enhanced Dechlorination Results Under a Performance-Based Contract).

Acknowledgements

We thank all the organizers, sponsors, presenters, and attendees of this successful conference. The organizing committee for this event included Rula Deeb of Malcolm Pirnie, Inc., Elie Haddad of Haley & Aldrich, Inc., Thomas Mohr of the Santa Clara Valley Water District, Pawan Sharma of Camp Dresser and McKee, Dennis Maslonkowski of TRC, Terry Feng of CH2M Hill, Nancy Bice of Geosyntec, and Kelley Houston of ARCADIS. We also thank Tom Johnson of ARCADIS and Michael Kavanaugh of Malcolm Pirnie for organizing the panel discussion. Sponsoring the event were ARCADIS, CH2M Hill, and Haley & Aldrich. Our lunch sponsor was TRC. Exhibitors included Accutest Laboratories, ASC Tech Services, Inc., Blaine Tech Services, Inc., Cetrus, Columbia Technologies LLC, Confluence Environmental, Inc., EOS Remediation LLC, FMC Corporation, Gregg Drilling & Testing, Inc., In-Situ, Inc., JRW Bioremediation Products/EBS, Prima Environmental, Inc., ProHydro/SnapSampler, Regenesis, RSI Drilling, and Vironex.

About the Authors

Elie H. Haddad, PE. has more than 20 years of experience in the San Francisco Bay Area managing large environmental projects for the private and public sector. Mr. Haddad has been responsible for overall technical strategy and project management for several large- to small-scale projects. Technically, Mr. Haddad specializes in development and implementation of remedial investigation and feasibility study (RI/FS) programs, remedial engineering designs, vapor intrusion investigations, risk assessments, planning and strategy, hydrogeological activities, computer modeling, and operation and maintenance programs. Mr. Haddad is co-chair of the GRA events committee, is a faculty member of the Northwestern Environmental Training Center, and serves on the Sustainable Remediation Forum where he co-authored a white paper on sustainable remediation.

Rula A. Deeb is a Vice President at Malcolm Pirnie, Inc. focusing on Applied Research, Strategic Consulting and Environmental Services to Counsel. Her technical expertise includes the cross-media fate and transport of environmental contaminants. Dr. Deeb's recent focus on emerging contaminants has promoted awareness and improved the understanding of the sources, occurrence, fate and transport and behavior of these compounds (including MTBE and other fuel oxygenates, perchlorate, NDMA, 1,4-dioxane, and others) in natural and treatment environments. Dr. Deeb's expertise also includes the remediation of complex soil and groundwater sites impacted by nonaqueous phase liquids (NAPL) with a focus on chlorinated solvents.

Thomas Mohr has more than 25 years experience working with groundwater supply and groundwater protection, and has worked the past 10 years as a hydrogeologist at the Santa Clara Valley Water District. Mohr is the author of Environmental Investigation and Remediation: 1,4-Dioxane and Other Solvent Stabilizers (CRC Press, 2010). Mohr currently serves on GRA's Board of Directors and was President of GRA in 2006 and 2007.

All photo credits to Mary Meggary.

Dates & Details

GRA EVENTS & KEY DATES

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

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
Thinking Outside the Pipe— Exploring Local Water Supplies
Sep. 15-16, 2010 | Burlingame, CA

Groundwater Resources Association of California Presents A Short Course:

Principles of Groundwater Flow & Transport Modeling

SEPTEMBER 13-15, 2010
SEAPORT CONFERENCE CENTER – REDWOOD CITY, CA

The use of computer modeling tools has become a standard practice in many groundwater investigations. Groundwater resources evaluation, groundwater quality assessment, contamination site assessment and remediation, environmental impact review, and other groundwater related activities frequently rely on computer models as a means of understanding groundwater flow and the fate of contaminants in the subsurface. 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. The first half of the course reviews the concepts of groundwater flow and transport, and of finite difference and finite element methods. It provides an overview of various software programs for ground water flow and transport modeling and accompanying pre- and post-processing programs. The second half of the course features hands-on exercises based on the USGS MODFLOW flow model and a compatible transport model. Exercises include site-specific models as well as basin/watershed wide models. The course is taught by experienced instructors familiar with many aspects of groundwater modeling and California hydrogeology. At the end of the course, participants should be able to understand and actively engage in planning, supervision, and/or review of groundwater modeling projects.

The short-course is intended for professional consultants, technical personnel in engineering/geology firms and irrigation/water districts, regulatory agency specialists and managers, and those in the legal community specialized on groundwater issues. Participants should have a working knowledge of the principles of groundwater hydrology and be familiar with the PC Windows 95 (or Windows 2000) environment. No formal training in computer programming is necessary.

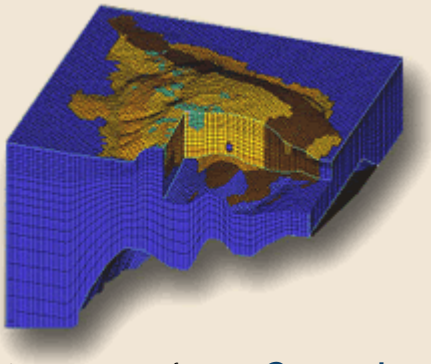


Image courtesy of HydroGeoLogic, Inc.

Course Topics (a partial list)

- principles and concepts of groundwater modeling
- conceptual model development
- data collection and preparation
- boundary conditions: concepts and application
- implementing rivers, lakes, recharge, drainage, and other special situations
- sensitivity analysis, model calibration and verification
- contaminant transport modeling

Course Instructors

Graham E. Fogg, Ph.D., is a professor of hydrogeology with the Hydrology Program of the Department of Land, Air, and Water Resources, University of California, Davis.

Thomas Harter, Ph.D., is a professor of hydrogeology with the Hydrology Program of the Department of Land, Air, and Water Resources, University of California, Davis.

Peter Schwartzman, M.S., is an associate at Pacific Groundwater Group in Seattle, Washington.

19th Annual Conference & Meeting: Think Outside the Pipe – Exploring & Protecting Local Water Supplies

Presented in Cooperation with Department of Toxic Substances Control & International Association of Hydrogeologists

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.

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

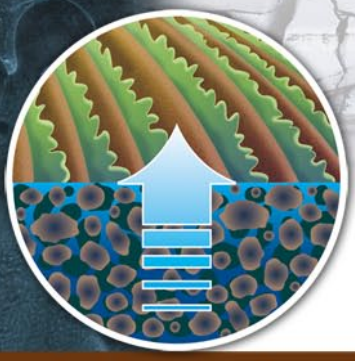
Surface water imported through large-scale water delivery projects is a primary drinking water source for many urban regions. However, as climatic and environmental impacts continue to reduce the yield of these surface water systems, local water suppliers and others are facing significant water management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



Toward Sustainable Groundwater in Agriculture

An International Conference Linking Science and Policy

REGISTRATION IS NOW OPEN

June 15-17, 2010

Hyatt Regency at the San Francisco Airport
Burlingame, CA

With additional Groundwater Workshops on June 14 and an Agricultural Groundwater Tour on June 18

REGISTER TODAY!

Sponsored by the Robert M. Hagan Endowed Chair

This three-day conference will provide scientists, policymakers, agricultural and environmental stakeholders, local, state and federal governmental officials, and consultants with the latest scientific, management, legal and policy advances for sustaining our groundwater resources in agricultural regions around the world.

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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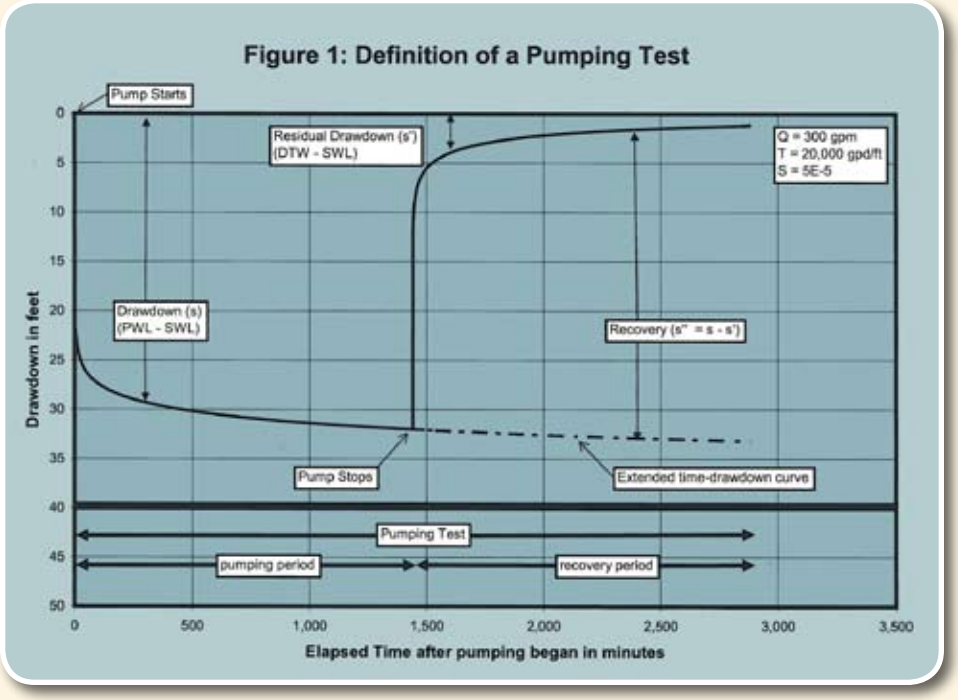
Wells and Words

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



David W. Abbott *Todd Engineers*

A Pumping Test Primer with Specific Reference to Time-recovery Data

A pumping test consists of two parts: (1) the pumping period, and (2) the recovery period. The pumping period begins when the pump starts and ends when the pump stops; the recovery period begins when the pumping period ends. Together, the pumping and recovery periods constitute a pumping test (also referred to as an aquifer test). The pump discharge and depth to water (DTW) in the well are measured during a pumping test. The DTW is measured from a convenient reference point (RP) and is the vertical distance between the RP and the water level in the well. The non-pumping or static water level (SWL) and pumping water level (PWL) are measured before pumping begins and during the pumping period, respectively.

The discharge and PWL are measured systematically during the pumping period and their corresponding times since pumping began are recorded; similarly, the DTW is measured during the recovery period. Recovery is the amount of water-level rise in the well after the pump stops. Water levels collected during the recovery period can be used to analyze aquifer and well parameters, providing an independent estimate to those calculated using data collected during the pumping period.

The drawdown (s) is the distance between the PWL and the SWL, and the residual drawdown (s') is the distance between the DTW during the recovery period and the SWL. These (and discharge) are the fundamental measurements that are collected during the pumping test. Figure 1 shows their relationships. The x-axis is the elapsed time since pumping began, and the y-axis is the corresponding s or s' during the pumping test.

When the pump stops pumping, the well "thinks" that it is still pumping. Virtual drawdown continues to increase after the pump stops, unless a recharge boundary has been encountered during the pumping period. The virtual drawdown is shown on Figure 1 as the dashed extended time-drawdown (t-dd) curve. The recovery (s") is the distance between this extended t-dd curve and the residual drawdown (s - s'). Typically, the water level in the well rises during recovery at the same pace as observed during the pumping period. The recovery curve is essentially an inverted image of the t-dd curve, but is offset by small drawdown increments caused by the projected t-dd trend. This adjustment results in a recovery that approaches, but never quite reaches the SWL; note that s' approaches zero as a function of the recovery time.

Analytically, the recovery period model superimposes the drawup (analogous to s) response of an imaginary injection well onto the extended t-dd curve of the pumping period. Note that s' (the measurement we make during a pumping test) is not s", which mirrors the pumping period drawdown.

Percent recovery is a poor guideline for determining the sustainability of production in a water well because s' is affected by aquifer boundary conditions, the steepness of the extended t-dd slope, and the well efficiency; also, the recovery rate can be obscured by water released instantaneously into the well if a foot-valve has not been installed in the pump column. If a recharge boundary is encountered during the pumping period, then complete recovery to the SWL will occur by the elapsed time

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Wells and Words – *Continued*

of the pumping period or sooner. The steeper the t-dd slope, the longer the time for complete recovery. The steepness of the t-dd slope depends on the aquifer parameters (transmissivity and storativity) and the pumping rate.

We often hear bragging about a well with a fast recovery, implying that the well is productive and sustainable, and that an instantaneous recovery means the aquifer is a good producer. This is an example where the percent recovery criteria can be very misleading! Actually, a rapid recovery response suggests that the well has either encountered a recharge boundary or that it is inefficient. A recharge boundary would be recognized by the stabilization (no drawdown) of the t-dd slope during the pumping period. If no recharge boundary is encountered, then the pace of recovery should be almost identical to the pumping period t-dd.

An inefficient pumping well will produce steep hydraulic gradients between the inside of the casing and the aquifer outside of the casing. Excessive drawdown in a pumping well is caused by turbulent flow losses adjacent to the well screens due to poor well design and construction factors, incomplete well development, and over-pumping. The rate of recovery in the pumping well will depend on the hydraulic conductivity (K) of the aquifer, the effective radius (re) of the well/aquifer interface, the thickness (b) of the aquifer, and the hydraulic gradient between the inside of the casing and aquifer outside the casing. The first three elements (K, re, and b) cannot change for a specific well; the hydraulic gradient can be different depending on the well efficiency. An overly steep hydraulic gradient (low well efficiency) will increase the rate of recovery when the pumping period ends.

Rapid recovery signals that the pumping period has encountered a recharge boundary or that the well pumps inefficiently. If the latter is true, then additional well development may be needed to reduce long-term operating and maintenance costs and to extend well longevity. Paying close attention to, and correctly interpreting recovery responses is one part of a pumping test that can add valuable information to the success and reliability of a well.

Legislative Update

By Tim Parker, GRA Legislative Committee Chairman, Chris Frahm and Duncan McFetridge, GRA Legislative Advocates

The 2010 legislative session is currently in full swing. In February, state legislators introduced over 2,000 bills on a wide range of important public policy issues. To no one's surprise, water continues to dominate the political and policy discourse at the Capitol. As a result of GRA's legislative program, many policymakers on both sides of the aisle are aware of the importance of protecting groundwater resources. While many lawmakers have focused their attention on the Delta and newly formed Delta Stewardship Council, the Legislature also is focused on addressing other critical water policy issues during this legislative session, including groundwater protection, water recycling and rainwater capture.

This year GRA and the California Groundwater Coalition (CGC) are cosponsoring AB 2304, which is aimed at increasing coordination and consultation between California's water supply agencies and land use approval agencies for the protection of recharge areas overlying California's groundwater basins. This important measure is being authored by Assembly Member Jared Huffman, Chairman of the Assembly's Water, Parks and Wildlife Committee. Assembly Member Huffman is among the Legislature's top policymakers on water issues and strongly believes that this measure is essential to protect California's groundwater resources.

AB 2304 makes modest but important changes to state law. It requires identification and mapping of recharge areas in groundwater management plans. The bill requires that identification and mapping of recharge areas be provided as part of a General Plan notification requirement for water systems of 3,000 or more service connections. AB 2304 is currently making its way through the legislative committee process where GRA's legislative advocates and members of GRA's Legislative Committee will be providing expert testimony to legislative committees and educating legislators and staff on the importance of passing this legislation.

Like the groundwater monitoring provisions advocated and supported by GRA in last year's water bill, GRA's sponsorship of AB 2304 continues to keep GRA at the forefront of the groundwater debate and as the "go-to" organization for policymakers in the state legislature.

In addition to our work on AB 2304, GRA's Legislative Committee and its advocates also are closely tracking a number of bills related to water recycling and rainwater capture. These measures include:

SB 918 (Pavley) – Directs the State Department of Public Health to adopt uniform water recycling criteria for indirect potable water reuse for groundwater recharge by 2013 and develop and adopt uniform water recycling criteria for indirect potable reuse through reservoir augmentation by 2016. **Status: Senate Appropriations Committee.**

SB 1173 (Wolk) – Would declare that the use of raw or potable domestic water for nonpotable municipal or industrial uses is a waste or unreasonable if recycled water is available, and would prohibit such uses if suitable recycled water is available. **Status: Senate Appropriations Committee.**

AB 1774 (Saldana) – Authorizes government agencies to require a state agency to use recycled water for irrigation, provided certain conditions exist, such as the recycled water is of adequate quality, available at reasonable cost, and does not affect existing water rights. **Status: Assembly Appropriations Committee.**

AB 1834 (Solorio) – Authorizes a landowner to install, maintain and operate on the landowner's property a rainwater capture system meeting specified requirements. **Status Assembly Appropriations Committee.**

As we go to publication on this issue of HydroVisions, we have just concluded GRA's Annual Legislative Symposium and Lobby Day for 2010. We were proud to once again have featured an outstanding line-up of legislators and key Administration officials who participated with a "standing room only" audience that included a "who's who" of the state's groundwater management professionals. We look forward to briefing GRA members on the success of the Symposium and the progress of AB 2304 and other important legislative matters in the next Legislative Update.

California Council of Geoscience Organization CCGO

An Advocate for the Profession in the Public Interest

By James A. Jacobs, P.G., C.H.G., C.P.G., CCGO President

Who We Are

We are a group of leading California professional geoscience organizations and employers. CCGO has numerous geology-related professional organizations and businesses as members, representing thousands of geologists in California.

What CCGO Does

We come together in the spirit of professionalism and public service to advocate the use of sound geologic knowledge and practice by proposing, reviewing, and monitoring statutes, regulations, and public policies.

Our 2010-2011 advocacy program focuses on:

1. increasing the efficiency with which geoscientists can serve their clients,
2. assuring that vital geoscience factors are considered in infrastructure project development, design, and construction, and
3. monitoring and evaluating the effects of legislative changes in the regulation of the professions of geology and geophysics.

Legislative and Regulatory Recommendations to Improve Business Efficiency and Public Protection from Geologic Hazards

1 A. Professional geologists and geophysicists are denied access to water well drillers' logs, or even Department of Water Resources (DWR) forms as basic input to their analyses of groundwater conditions because these logs and information have been classified as confidential by the state (California Water Code Section 13752). Access to these logs would give the geologist a first look at the groundwater conditions in a project area, and provide an efficient initial framework for designing an exploration program to define contaminant plumes and control their migration. In light of the great threat of pollution to California's groundwater, there is no longer adequate justification for barring public access to drillers' logs. By increasing the efficiency of hydrogeologic investigations and reducing delays caused by lack of basic data, making drillers' logs public would reduce costs to clients, owners, responsible parties, and the state Underground Storage Tank Cleanup Fund (USTCF). CCGO supports legislation to make water well drillers' logs publicly available to all design professionals (geologists, hydrogeologists, geophysicists, engineers, land surveyors, and architects).

1 B. Dry-cleaning fluid contamination clean-up fund: CCGO, working with CORE Environmental Foundation and others, will try to play a role in developing a dry cleaner cleanup fund for California to address a widespread groundwater contamination problem that still lacks a reasonable funding mechanism.

2 A. Seismic Safety of Bullet Trains: AB 928 (Blakeslee) did not make it out of committee, and therefore is not currently active. The bill would have required the California High Speed Rail Authority to develop a statewide earthquake early warning system in cooperation with others. The ability to detect early seismic wave signals at many locations and transmit an estimate of magnitude to the operators of critical facilities is becoming a reality. This capability is of critical importance to high

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CCGO – An Advocate for the Profession in the Public Interest – *Continued*

speed rail, and also has the potential to aid emergency response, reduce the severity of damage and save lives. CCGO supports further efforts, by legislative authority and direction if necessary, to develop this life-saving and damage-reducing technology for application to all major infrastructure facilities. CCGO recommends including the California Geological Survey as the state's Center of Excellence in geohazards on the team of agencies needed for this work.

2 B. Levee stability is an area where sound geologic knowledge and understanding must be brought into public policy. If the levees in the Bay-Delta area failed due to rising sea levels, heavy storms, earthquakes, subsidence or other reason, major loss of life and property are likely to result. A significant loss of fresh water supplies may also occur. CCGO advocates geologists being involved in the discussion regarding levee safety and stability.

3. Monitoring the Integrity of Professional Licensure of Geoscientists: CCGO performs monitoring of the profession and protection of the public, in part by monitoring the performance of the former Board for Geologists and Geophysicists (BGG) for many years. CCGO has always found that the board and staff were performing well in protecting the public interest in the practice of the professions. These CCGO duties have changed recently; AB 4X 20 transferred the functions of the former BGG to the Board for Professional Engineers and Land Surveyors (BPELS). The proper and timely integration of BGG functions into BPELS is of great concern to CCGO because the legislation did not authorize the transfer of sufficient BGG staff to BPELS to properly administer the geology and geophysics licensure and enforcement programs. In addition, no public participation was allowed during the decision to eliminate the BGG. Presently, the experienced professional staff of the BGG has been lost; thus, BPELS faces learning about the geology and geophysics licensure and enforcement programs with no history and no corporate memory available. Some examinations already have been cancelled, denying qualified applicants the ability to take the exam and denying the public their services as professionals. CCGO believes this legislation was hastily constructed, passed without public input, and does not provide for the energetic administration of geologists and geophysicist licensure in California. CCGO will monitor the performance of BPELS as it integrates these new responsibilities into its program. Because AB 4X 20 did not provide for adequate staffing and professional seats on BPELS consistent with the structure of the BGG, CCGO will work to correct these lapses and will recommend major legislative changes if the system does not function in an appropriate manner to maintain the integrity of the geoscientist licensure and professionalism.

The Federal Corner

By John Ungvarsky, U.S. EPA

EPA Administrator Jackson Outlines New Vision for Clean, Safe Drinking Water

EPA Administrator Lisa P. Jackson announced the agency is developing a broad new set of strategies to strengthen public health protection from contaminants in drinking water. The aim is to find solutions that meet the health and economic needs of communities across the country more effectively than the current approach. EPA also intends to revise the existing drinking water standards for four contaminants that can cause cancer.

This shift in drinking water strategy is organized around four key principles:

- Address contaminants as a group rather than one at a time so that enhancement of drinking water protection can be achieved cost-effectively
- Foster development of new drinking water treatment technologies to address health risks posed by a broad array of contaminants
- Use the authority of multiple statutes to help protect drinking water
- Partner with states to share more complete data from monitoring of public water systems.

In the newly finalized review of existing drinking water standards, EPA determined that scientific advances allow for stricter regulations for the carcinogenic compounds tetrachloroethylene, trichloroethylene, acrylamide and epichlorohydrin. There are ongoing efforts on 14 other drinking water standards. EPA also has ongoing health risk assessments or information gathering for chromium, fluoride, arsenic, and atrazine. EPA continues to consider whether to regulate perchlorate. When these efforts are complete, should additional action be required, EPA will move ahead to address any risks in an expedited manner. For more information on the strategy, see: http://www.epa.gov/safewater/sdwa/dwstrategy.html.

EPA Initiates Hydraulic Fracturing Study

EPA will conduct a comprehensive research study to investigate the potential adverse impact that hydraulic fracturing may have on water quality and public health. Hydraulic fracturing is a process that involves creating cracks underground to help withdraw gas, or oil, from coalbeds, shale and other geological formations. The process involves vertical and horizontal drilling, taking water from the ground, injecting fracturing fluids and sands into the formation, and withdrawing gas and separating and managing the leftover waters. There are concerns that hydraulic fracturing may impact groundwater and surface water quality. EPA is in the very early stages of designing a hydraulic fracturing research program. To support this initial planning phase and guide the development of the study plan, the agency is seeking suggestions and comments from the EPA Science Advisory Board—an independent, external federal advisory committee.

Monitoring the Nation's Groundwater Resources

Groundwater supplies a majority of the nation's community water systems and almost half of its irrigation, but there isn't a system in place that can provide a nationwide assessment and evaluation of the conditions, availability or water-quality trends of the country's groundwater resources. In response, five pilot projects have been chosen to test the concept of a National Ground Water Monitoring Network. Federal, regional, state and local governments monitor groundwater resources, but the data are neither easily compiled nor readily accessible across political boundaries. The USGS, EPA and pilot partners from Illinois, Indiana, Minnesota, Montana, New Jersey and Texas will collaborate to assess currently available data, review methods of data collection and storage, pinpoint data gaps and test data-sharing feasibility. The pilot phase will provide valuable lessons learned, so, if funding becomes available in the future, the project can grow into a truly nationwide network. For more information, visit the Subcommittee on Ground Water's web site.

Decentralized Wastewater Management E-Handbook

The EPA Office of Wastewater Management has recently posted online its Decentralized Wastewater Management E-Handbook. The E-Handbook focuses on individual and clustered wastewater systems that discharge to the soil, but the information also can be applied to small systems that discharge to surface waters through federal or state National Pollutant Discharge Elimination System permit programs. The E-Handbook is intended for health departments, wastewater system management entities, local governments, and others involved in managing multiple individual or clustered treatment systems. The resource guides in the E-Handbook can be accessed via hot-links in the current Management Handbook posted at http://www.epa.gov/owm/onsite.

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The Federal Corner – *Continued*

Combined Dual Isotope and Dissolved Gas Analyses Used to Evaluate Nitrate Contamination

Lawrence Livermore National Laboratory (LLNL) has developed an integrated approach using groundwater nitrate (NO3) isotopic composition and dissolved gas analyses to help identify nitrate sources and demonstrate natural attenuation at the LLNL Site 300 Superfund site, east of San Francisco, CA.

The combined stable isotope and dissolved-gas analyses provided evidence of saturated-zone denitrification by way of microbial degradation, rather than dispersion and dilution, as the primary attenuation mechanism for low nitrate concentrations in downgradient groundwater. As a result, monitored natural attenuation was selected as a remedy for nitrate in this area. More information about the use of this approach is available in EPA guidance, Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 2. For more information contact Brad Esser at LLNL (925-422-5247) or see the story in EPA's Technology News & Trends newsletter.

National Report on Human Exposure to Environmental Chemicals

The Center for Disease Control and Prevention has released the Fourth National Report on Human Exposure to Environmental Chemicals. The report presents exposure data for 212 environmental chemicals—75 of which have never before been measured in the U.S. population—in people's blood and urine.

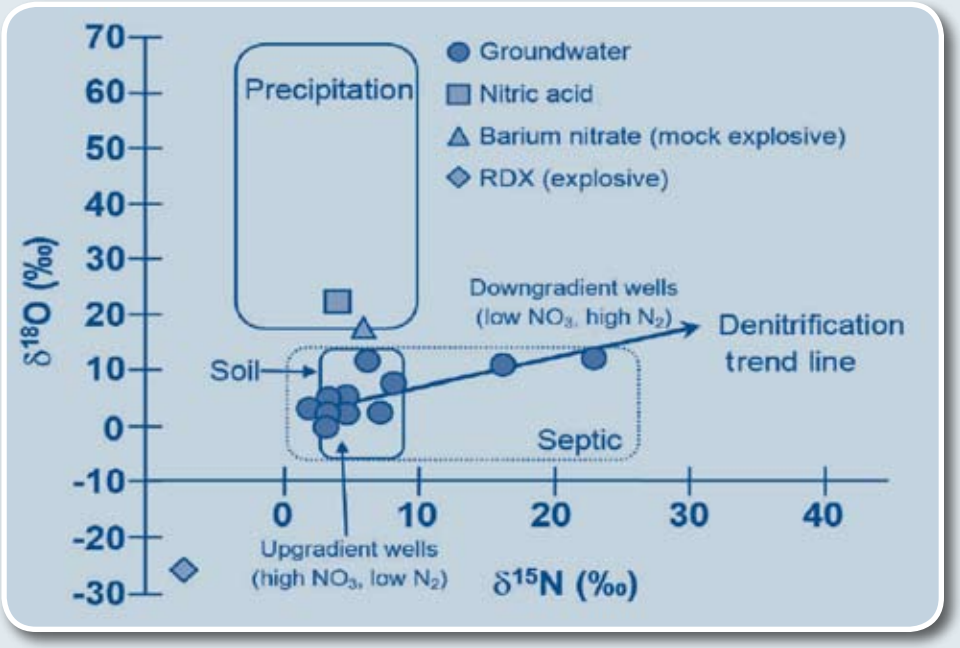

Figure 1. Nitrate isotopic compositions measured in Site 300 groundwater and potential source materials relevant to high explosive operations provided discrete markers, as compared to range values of nitrate isotopic compositions of soil, septic effluent, and precipitation reported in previous literature.

Results of Demonstration Project to Remove Arsenic from Drinking Water

This Final Evaluation Performance Report documents the activities and results for an arsenic removal treatment demonstration project at Golden Hills Community Services District located in Tehachapi, CA. The objectives of the project were to evaluate (1) the effectiveness of Magnesium Elektron, Inc.'s Isolux™ treatment system in removing arsenic to meet the maximum contaminant level of 10 µg/L; (2) the reliability of the treatment system; (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.

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.

Sustainable Chemistry

By Bart Simmons

Sustainable Chemistry was the theme of the national meeting of the American Chemical Society, held recently in San Francisco. One definition of sustainable comes from the Brundtland Commission of the United Nations on March 20, 1987: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Debate continues on what "sustainable" really means. However defined, the concept of sustainability has stimulated considerable research and development, particularly in "Green Chemistry." Green Chemistry is generally considered part of the sustainability movement, although Green Chemistry was promoted by the US EPA in the 1970s under the leadership of the late Joe Breen. One view of green chemistry is clear: the redesign of chemical products and processes to require less energy and have less environmental impact.

Major developments in sustainability were discussed at the ACS San Francisco meeting. Two interesting examples:

Forward Osmosis – Reverse osmosis, of course, is the basis of current water purification, including desalination. Forward osmosis uses the same principle: that water will flow through a semi-permeable membrane from a lower concentration of solute to a higher concentration of solute. In the case of forward osmosis, the solution to be purified (Solution A) has ammonia and/or carbon dioxide dissolved in it, giving it temporarily a higher concentration of solute than the waste (brine) solution. Water moves into Solution A, without pressure, lowering the solute concentration. The ammonia and carbon dioxide are then volatilized, using low quality heat, resulting in purified water.

Forward Osmosis requires little electricity; instead, it only requires low quality heat, which could be provided by geothermal sources or waste heat from power plants.

Microbial Fuel Cells – Another exciting development is the use of microbial fuel cells (MFCs). In MFCs, naturally occurring bacteria are used to seed an electrochemical cell; some bacteria develop a biofilm on the anode, others form a biofilm on the cathode. Through processes not completely understood, the electrochemical cell develops a current, which continues as long as the bacteria are fed a nutrient, such as an acetate solution. MFCs also can run on wastewater. If conversion were completely efficient, the solid waste from one person could generate 25 watts, or, put another way, the solid waste from 100,000 people could generate 2-3 megawatts.

Many lines of research undoubtedly would have developed without the high interest in sustainability, but there is no mistaking the enthusiasm for the revived field of green chemistry.

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An Investigation of Surficial Recharge through an Ephemeral Stream in the Lucerne Valley Groundwater Basin, Mojave Desert, CA

By Shelby R. Barker, California State University, Fullerton, CA

Abstract

To better understand surficial recharge within the Lucerne Valley groundwater basin, a series of infiltration tests and soil analyses were conducted in Lucerne Creek; these data were used to constrain several computer simulations. Increasing groundwater levels and geochemical analysis of groundwater samples indicate that additional recharge exceeding that estimated in a recent water budget analysis is occurring within the valley. Studies elsewhere in the Mojave Desert have suggested that recharge can occur during heavy precipitation as infiltration of stream flow in ephemeral channels. Tests were conducted in Lucerne Creek. Using field investigations, laboratory analyses and numerical modeling, recharge volumes were estimated for precipitation events of up to a 5-year frequency interval.

Introduction

The increasing scarcity of groundwater in arid environments requires better understanding of groundwater recharge to maintain a sustainable supply of water (Scanlon et al. 2006; Dahan et al. 2007). This is especially true in areas that have growing populations, such as the town of Lucerne Valley in the western Mojave Desert (Figures 1 and 2), that depend on groundwater as a primary source.

Beginning in the early 1900s, water levels sharply declined in the Lucerne Valley groundwater basin due to increased groundwater production for agricultural purposes (Schaefer 1979; Laton et al. 2005). For political and business reasons, agriculture signifi-

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Figure 1: General Location of Lucerne Valley and Este Sub-Basin in California.

An Investigation of Surficial Recharge through an Ephemeral Stream in the Lucerne Valley Groundwater Basin – *Continued*

cantly declined during the 1980s (Laton et al. 2005). Although a few alfalfa and pistachio farms continue today, much of the area is reclaimed agriculture (Laton et al. 2005).

Since adjudication in 1996, groundwater production and water-level records indicate that the groundwater levels have remained relatively constant and, in fact, have begun to rise in some locations (Mojave Basin Area Adjudication 1996; Laton et al. 2005). This rise suggests that modern groundwater recharge is similar to, or exceeds, the volume of groundwater production (Laton et al. 2005). The primary source of recharge is in the form of mountain front recharge from the San Bernardino Mountains (Schaefer 1979; Laton et al. 2005). Recharge from Lucerne Creek, a large ephemeral stream that enters the northeast region of the basin and flows towards Lucerne (dry) Lake, has not previously been considered in the water budget calculations for Lucerne Valley groundwater basin. The stream channel is well developed and the stream bed is predominantly composed of loose, coarse sediments, which may allow for significant infiltration during intense precipitation events. Since surface-water flow into the closed basin is limited to the ephemeral streams, additional recharge to the aquifer may be derived from precipitation in the upper highlands and the surrounding desert mountains (Laton et al. 2005).

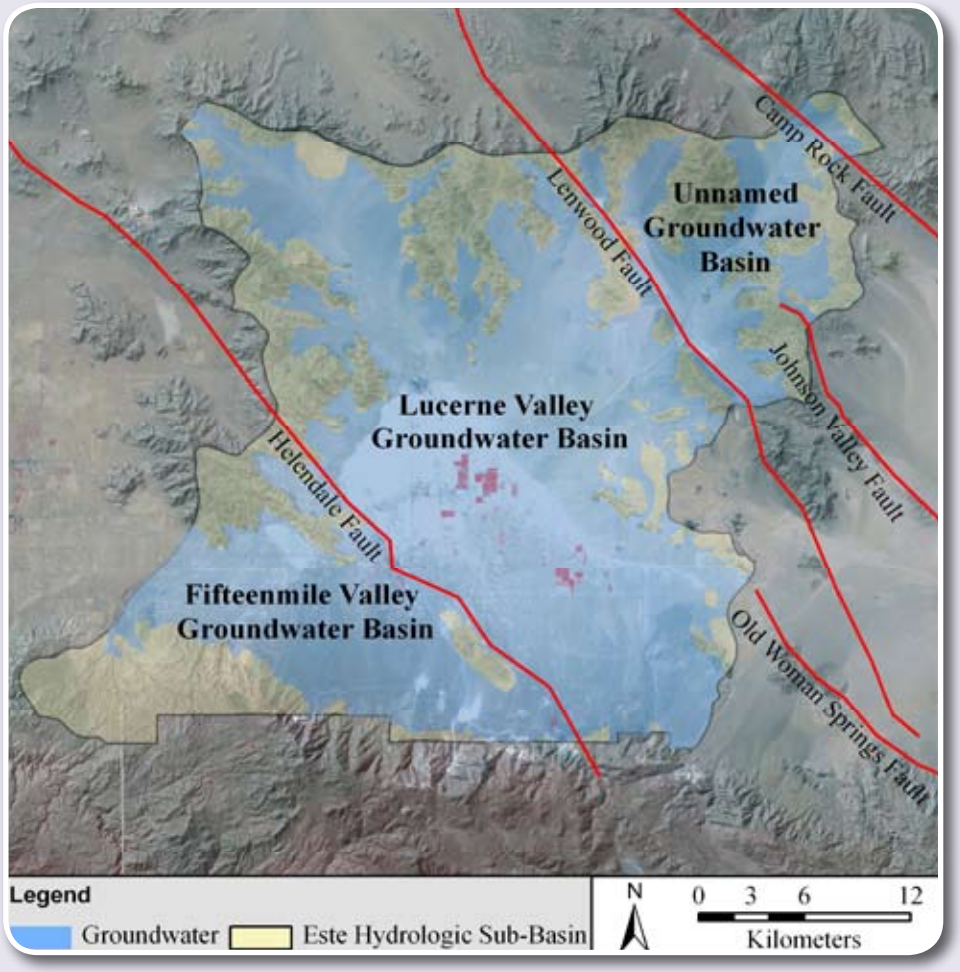

Figure 2: Groundwater Basins and Faults in the Este Sub-Basin.

The purpose of this research is to investigate the potential for surficial recharge into Lucerne Valley groundwater basin both qualitatively and quantitatively using various methods. If significant infiltration is observed to occur in Lucerne Creek, then surface recharge can be incorporated into the water budget analyses.

Background

Lucerne Valley is located within the Mojave Desert, approximately 121 kilometers (km) northeast of Los Angeles. The Lucerne Valley groundwater basin is predominantly a single aquifer in a closed-basin system with a thick, unsaturated zone (Laton et al. 2005). Groundwater production is the only discharge mechanism (Laton et al. 2005). Surface water is limited to ephemeral streams that flow radially towards Lucerne (dry) Lake during and immediately after heavy precipitation.

Previous researchers have produced water budgets for the Lucerne Valley (DWR 1967; Goodrich 1978; Brose 1987; Laton et al. 2005); however, these budgets vary greatly from one another, and estimates range from large deficits to a small surplus. One explanation for such large variation between budgets is the changes in groundwater production over the past century. The most recent report estimates recharge to the Lucerne Valley groundwater basin of approximately 6,440 acre-ft per year – a 382 acre-ft surplus (Laton et al. 2005). This estimate was based on the assumption that recharge occurs only in areas that receive a minimum of 20.3 centimeters (cm) of precipitation per year (Ganus 1973; Laton et al. 2005). Lucerne Valley receives an average annual precipitation of approximately 10-11 cm; therefore, it has previously been assumed that recharge does not occur on the valley floor (Busby 1977; Koehler et al. 2005, Laton et al, 2005). However, high nitrate levels in the shal-

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An Investigation of Surficial Recharge through an Ephemeral Stream in the Lucerne Valley Groundwater Basin – *Continued*

low aquifer, which may include modern sources such as return flow from irrigation and septic systems, suggest that recharge may be occurring through the thick unsaturated zone, and that it may reach the water table relatively quickly (Schaefer 1979; Laton et al. 2005).

Methods

Methods used to better understand the surficial recharge potential within Lucerne Creek included infiltration tests, soil sample analyses and measurement of cross sections at various locations along the Creek. Three infiltration tests were conducted in the ephemeral stream channel in order to determine the infiltration potential at the surface.

While hand augering, soil samples were collected, described and prepared for laboratory analysis to determine the hydraulic conductivity. A portion of the samples were sieved for grain size distribution. Estimated values of the hydraulic conductivity of each sieved soil sample were calculated using two empirical formulas (Beyer Method and Pavchich's Method) (Vukovic and Soro 1992; Kasenow 2002). The hydraulic conductivity of the remaining soil samples was determined by placing the sample in a falling-head permeameter. The soil samples collected in Lucerne Creek were also tested for chloride content using Quantab® chloride test strips per the manufacturer's instructions for "salt" analysis in soils.

A surface water runoff numerical model was developed for Lucerne Creek using a combination of the rational formula (modified to account for initial abstraction), Manning's Equation and the Green-Ampt Model (Rawls et al. 1983; Viessman et al. 1989; Chin 2000; Fetter 2001; Adsero 2008). The watershed that contributes to the stream was determined using a data model for water resources in ESRI® ArcGIS™. The stream was divided into three sections (zones 1 – 3) (Figure 3). The runoff for the watershed was calculated using four hourly precipitation rates (8 mm, 11 mm, 14 mm and 20 mm). The 11 mm, 14 mm and 20 mm hourly precipitation rates are based on the 1-year, 2-year and 5-year events, respectively (NOAA Atlas 14). The infiltration was calculated by using the rational formula to determine the total runoff of the drainage basin, Manning's Equation to calculate the stream velocity for each section of the stream for 1%, 5%, 10%, 15% and 25% of runoff discharge reaching the head of the stream at any given time, and the Green-Ampt model to determine the volume of infiltration in each zone. The lowest hydraulic conductivity value was used in the Green-Ampt Model.

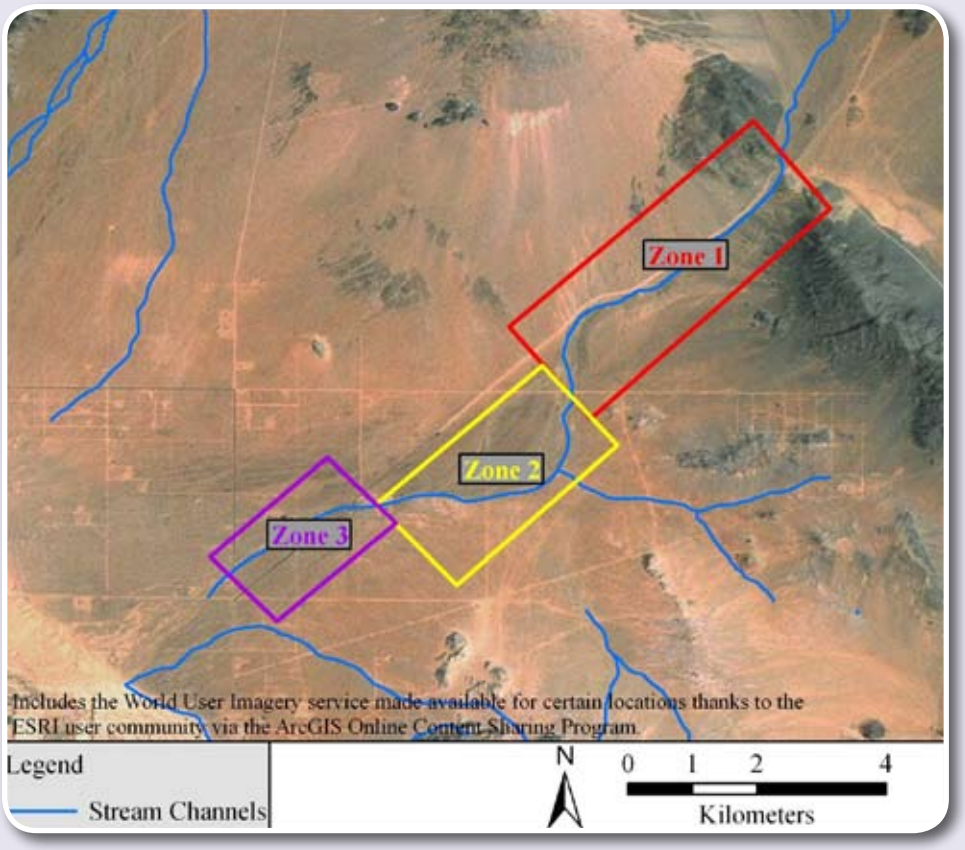

Figure 3: The Three Zones for Lucerne Creek Numerical Modeling.

Results

Field Observations

During the field investigations in Lucerne Creek (Figure 4), the upper and lower reaches of the ephemeral stream were comparable to one another in stream appearance, gradient and grain-size. However, the middle section was a wide, braided channel system with hard-packed sediment consisting primarily of poorly sorted sands with gravel and clay. A total of 22 soil samples were collected and classified as poorly sorted gravels and sands.

Of the three infiltration tests performed, none had reached asymptotic conditions. The non-asymptotic infiltration rates for the three tests ranged between 282 cm/hr and 335 cm/hr.

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An Investigation of Surficial Recharge through an Ephemeral Stream in the Lucerne Valley Groundwater Basin – *Continued*

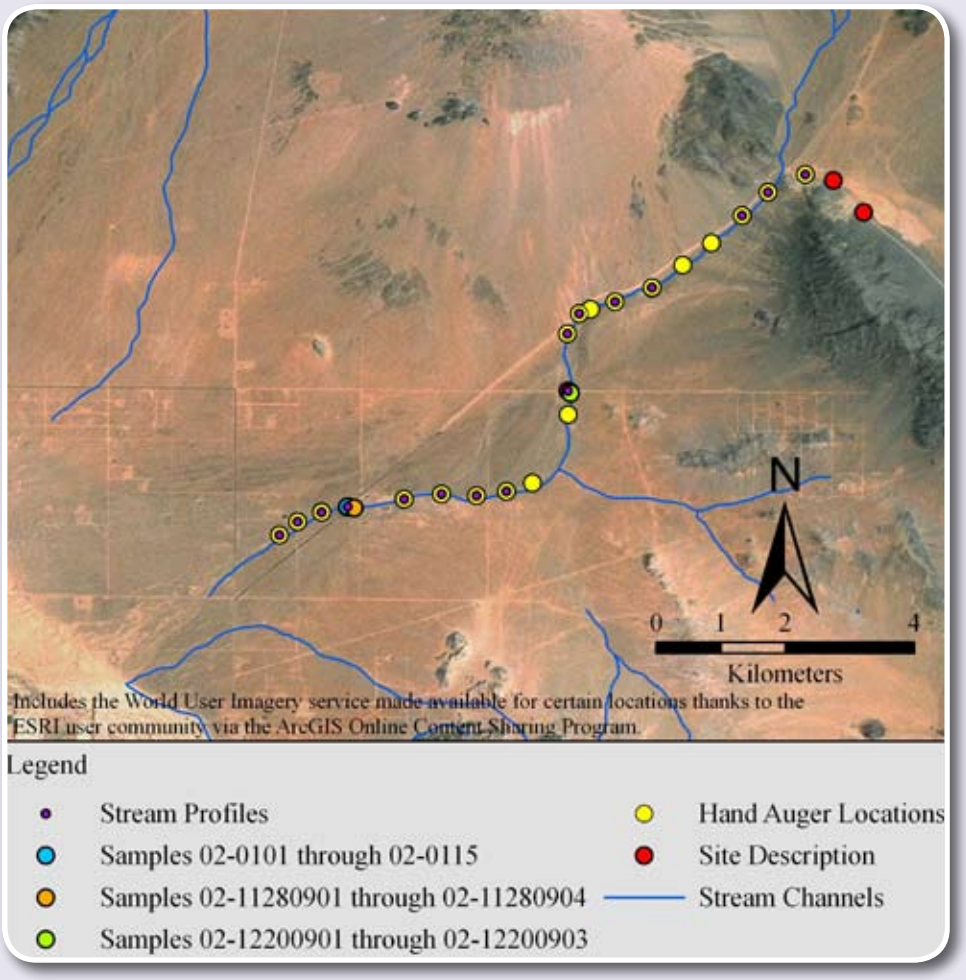

Figure 4: Locations of Field Site Visits and Sample Collections.

Lab Observations

Eight of the samples were analyzed by sieve analysis and eight were analyzed by a falling-head permeameter. An additional four samples were analyzed for moisture content for the stream flow modeling calculations.

The average hydraulic conductivity for the samples analyzed by the sieve analysis using Pavchich's Method and Beyer Method was 108 m/day and 157 m/day, respectively. The average hydraulic conductivity for the samples tested with the falling-head permeameter was 188 m/day. The hydraulic conductivities based on the sieve analyses and the falling-head permeameter are comparable.

Four soil samples were tested for chloride content. The chloride concentrations for all samples were not detected within the range of the test strip. Given the high hydraulic conductivity values and the results of the infiltration tests in the field, the non-detect concentrations are likely due to salts being flushed from the sediment during heavy rainfall events (Izbicki et al. 2002).

Surface Water Modeling

Surface-water infiltration was simulated to estimate the amount of potential recharge. The lowest hydraulic conductivity value was used to provide a conservative estimate of the volume of infiltration along the stream channel. Additionally, the middle section was assumed to have negligible recharge potential due to the field observations of the sediment in the stream bed.

Based on the stream flow and discharge volumes, 10% and 15% of the runoff volume reaching the stream at any given moment provided the most realistic values. The total infiltration for precipitation events with frequencies of less than 1-year (8 mm), 1-year (11 mm), 2-year (14 mm) and 5-year (20 mm) were based on 10% and 15% of the runoff volume; the results are shown in Table 1.

On January 21, 2010, a heavy precipitation event caused flash flooding in the Lucerne Valley. A weather station (KCAAPPLE11) located in nearby Apple Valley, CA indicates that 35.8 mm of rainfall fell in a 24-hour period. This event was in addition to 43.2 mm of precipitation that had fallen since January 1, 2010 (Weather 2010). During a field visit, at the peak of the event, the water was flowing in Lucerne Creek at Camp Rock Road at a depth of 15 – 20 cm.

Using the precipitation volume of 35.8 mm measured at the weather station, the runoff percentages of 10% - 15% and the average depth of water observed in the field, the potential infiltration volume for the January 21, 2010 rainfall event ranges between 373,800 m3 and 415,900 m3. This suggests that precipitation in excess of 20 mm is predominantly runoff towards the Lucerne (dry) Lake.

Conclusions

In the Lucerne Valley, a recent water budget and geochemical analysis of the aquifer suggests that modern recharge is occurring somewhere within the desert basin because the water levels have remained stable or risen in the past several years. Evidence from the stream channel sediments, field infiltration test results, the absence of chloride in the soil and the measured

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An Investigation of Surficial Recharge through an Ephemeral Stream in the Lucerne Valley Groundwater Basin – *Continued*

Table 1: Stream Infiltration

Precip. (mm)	zone 1 (m^3)	zone 2 (m^3)	zone 3 (m^3)	Total Infiltration (m^3)	Total Infiltration (acre-feet)
8	0 - 170,800	0 - 0	0 - 0	0 - 170,800	0 - 140
11	52,100 - 228,900	0 - 0	0 - 0	52,100 - 228,900	40 - 190
14	109,600 - 343,900	0 - 0	0 - 0	109,600 - 343,900	90 - 280
20	224,700 - 499,000	0 - 0	0 - 79,600	224,700 - 499,000	180 - 410

hydraulic conductivity values, suggest that surface water is capable of infiltrating at large volumes through the channel deposits of Zones 1 and 3 within Lucerne Creek. The numerical modeling of infiltration through the stream channel suggests that a 5-year recurrence interval precipitation event of 20 mm could potentially recharge the aquifer up to 506,500 m3. These results, along with the field and laboratory observations, indicate that, like ephemeral streams elsewhere in the Mojave Desert and other arid deserts, Lucerne Creek has the potential to contribute a significant volume of recharge to Lucerne Valley groundwater basin (a long-term maximum average of 467,800 m3 per year [approximately 380 acre-feet per year]).

Acknowledgements

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New Tool Preserves Web Content

By Linda Vida, Director, Water Resources Center Archives

Owens Lake, looking east from Olancha, circa November, 1906.

The Water Resources Center Archives (WRCA) is using a Web tool that was recently developed by the University of California's California Digital Library (CDL). The Web Archiving Service (WAS) gives users the ability to easily capture, analyze and preserve web content. The service was developed as part of the Web-at-Risk grant, funded by the National Digital Information and Infrastructure Preservation Program.

Using WAS, one can create and archive collections of web pages that will benefit a specific research community. Once the collection is established, patrons can search for terms across a collection. The harvested websites are preserved in an electronic archive and WAS will routinely and automatically retrieve and preserve revised web content. WRCA's first WAS collection, "California Water Districts Web Archives," went live on February 1, 2010 (http://webarchives.cdlib.org/a/CAWaterDistricts). If you go to this collection and enter "groundwater management" in the search box, your search will retrieve approximately 200 items from websites currently in this collection. Help screens provide additional searching tips.

The ability to create WAS archives is available to UC departments and organizations, non-UC institutions and to consortia. UC departments and organizations are charged only for the storage used. Non-UC institutional accounts are charged a yearly service fee beginning with one terabyte of allotted storage with the option to purchase additional storage. Consortia, three or more institutions, can receive discounted service fees. Any WAS repository can customize the archive with their own branding and imagery.

As a groundwater professional, do you have an idea for a specific collection of web sites that would benefit the groundwater community? Are there specific datasets of interest that should be archived and searchable? WRCA would be happy to work with GRA on creating a WAS collection.

To learn more about WAS, go to: http://webarchives.cdlib.org/.

NGWA 2010 Ground Water Summit Spotlights Cutting-edge Research, Collaboration

By Cliff Treyens

From high-tech groundwater modeling to low-tech water wells in developing nations, the 2010 NGWA Ground Water Summit and 2010 Ground Water Protection Council Spring Meeting last week spotlighted the latest in groundwater science and engineering.

The Ground Water Summit, held in Denver, was sponsored by the National Ground Water Association and its Scientists and Engineers Division. It brought together a wide variety of groundwater stakeholders, including regulators, practitioners, natural resource managers, policymakers, municipal planners, remediation site owners, academics, and those who supply knowledge and technology needed to address key water issues.

"I think we had amazing plenary sessions, some excellent panels, and some really great presentations. I hate to pick out just one or two; they were excellent," said Dr. David Kreamer, professor, University of Nevada, Las Vegas, Department of Geoscience. Kreamer was co-chair of the program along with Dr. Eileen Poeter, International Ground Water Modeling Center, Colorado School of Mines.

One phenomenon that became apparent at the Summit is a gap between technology and its use by practitioners, said Poeter, who chaired the Darcy Panel, "The Highway from Research to Practice — Navigating the On-Ramps." This panel followed 2010 NGWREF Henry Darcy Distinguished Lecturer Timothy "Tim" D. Scheibe, Ph.D., of the Pacific Northwest National Laboratory, who spoke on the subject "Quantifying Flow and Reactive Transport in the Heterogeneous Subsurface Environment: From Pores to Porous Media and Facies to Aquifers."

"The Darcy Lecture emphasized that we should try to build our [groundwater] models from basic principles and data instead of calibrating. But the reality for practitioners is that this is pretty remote and way in the future," said Poeter. "The panel, primarily consultants, found that practitioners aren't really hearing about the new research. They are so busy with running their businesses that they are not reading journals."

Among the ideas emerging from the panel was getting more practitioners to publish in journals such as NGWA's Ground Water® and Ground Water Monitoring & Remediation®, which might draw more practitioners to read them. "Some practitioners are doing really exciting things that aren't getting into journals," she said.

Another communication issue explored at the Summit involved work in developing nations. Kreamer, who has led students on overseas projects to construct water wells for impoverished people, said there are thousands of academics, professionals, and charitable organizations constructing water wells in the developing world with little or no coordination. "There are thousands of well-intentioned people working in the developing world. Some may be doing more harm than good," Kreamer said. He added that the Summit helped "push forward" a university consortium working to build ties with professional and nonprofit organizations to bring greater coordination to the humanitarian effort to install water wells in developing nations.

A partial survey of these humanitarian efforts funded by the nonprofit Water Advocates has provided some data to delineate the problem. "With the survey from Water Advocates, this effort has gotten some legs," said Kreamer, who invited individuals or organizations interested in getting involved in the consortium to contact him at kreamer@nevada.edu.

The 2011 NGWA Ground Water Summit and 2011 Ground Water Protection Council Spring Meeting will be held in Baltimore, May 1-5.

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International Exchange to Cuba

By Jim Jacobs

I have been involved with international professional exchanges over the past decade and find it to be a highly rewarding part of the professional development process. I was recently approached by a facilitator who has sent several delegations to Cuba for professional intellectual exchanges; I will admit I was a bit skeptical. As it turns out, the U.S. Treasury Department, through their Office of Foreign Asset Control (OFAC), grants visitation licenses to selected travel agents to arrange meetings in Cuba with professionals who are conducting research within their profession. This is an opportunity to meet with environmental professionals in Cuba and see how the Cubans have handled certain environmental challenges related to water and recycling, conservation, reforestation, and reclamation. The 7-day event would be professionally fascinating, but it is not a "tour" or formal conference.

The group will be traveling on an OFAC General License and is not part of any US professional society. There are various reasons one is allowed to travel on a General License, including a research trip. For those interested in attending as a delegate, the travel agent will require some supporting document that the attendee is a paid professional, such as a letter (on letterhead) from a superior, or a copy of a pay stub (amount blacked out). Over the years, this travel agent has sent dozens of researchers to Cuba, including professionals and academics. This would be a delegation for scientific research, not a tour. There is nothing unusual about this process; a reputable facilitator will handle the arrangements.

The other half of the equation is the content of the program. This is where we line up speakers to address the group, visit sites relevant to the group's orientation, and arrange visits to facilities and natural sites. The facilitators are in the process of setting up these details. The suggested itinerary is that we spend three nights in Havana, where we will have the opportunity to meet with local environmental professionals and academics. Then, one night in Vienales would allow us to explore the Pinal del Rio region's unique limestone formations, caves etc., and Sierra del Rasario Reserve (or, since the road is very good, this may be done as a day trip from Havana).

Two nights in Cien Fuegos would allow more visits with Scientists and a field trip to Zapata National Park, the largest wetland in Cuba. A final night in Havana would sum up the program.

Please contact Jim Jacobs at 510-590-1098 or jimjacobs@ebsinfo.com if you are interested or have questions.

BOOK REVIEW

One Man's Planet by Stephan M. Testa

Stephen M. Testa's most recent book, One Man's Planet, Earth in Today's Political Culture, was published in February 2010 by the American Geological Institute. It is a fast read on the importance of earth science and common sense in public policy related to water, energy, and mineral resources, and geologic hazards. The book is entertaining; the author makes his points in a subtle manner, but this is a book related to the intersection of earth science and popular culture and public policy. Unlike many policy books that contain only unsubstantiated concepts, Testa researched his facts well, and included the numbers, where needed, to back up his arguments.

Testa has been an environmental consultant for decades, and is now the Executive Officer of the California State Mining and Geology Board. He is well experienced in science and engineering, and the more subtle aspects of public policy, regulation and resource allocation. Testa is also well known in the geologic professional community as being the highly honored Past President of the American Geological Institute and the American Institute of Professional Geologists.

Testa blends great humor and an easy writing style in this book to address serious earth science issues. Although Testa is mostly known for his hundreds of scholarly articles on environmental and resource issues, Testa notes that resources and politics are heavily entwined in the nation, and specifically in California. It is therefore not unexpected that some of the essays should have an edge and a viewpoint that reflects Testa's experience as a public servant with a regulatory, appeals and policy board. Common sense seems to be Testa's guiding principle in many of his views. In the public policy arena, even when referring to others he considers misguided, Testa is a gentleman, trying to objectively explain the various issues surrounding complex interactions between resources and politics.

The book consists of thirty-two short essays broken into four parts: Planet Earth, Energy, Mineral Resources and Geologic Processes and Hazards. Testa discusses many of the hot button topics of the day in these four categories related to resources. He discusses the historical aspects of the subject using humorous anecdotes that make his points. In some of the resource essays, Testa has developed a commentary on resource use and governmental policy which notes some of the inconsistencies between the intentions of laws and regulations and the unintended consequences of the policies.

His topics range from Pet Rocks to asbestos, to drilling in the ANWR to his non-addiction to oil, and open pit mines. He also addresses his summer vacations, state rocks, and various forms of energy, including oil, coal, nuclear and wind energy.

In an essay on mining reform, for example, Testa begins with the popular HBO western drama series Deadwood, which debuted in 2004. He then moves

Continued on the following page…

One Man's Planet – *Continued*

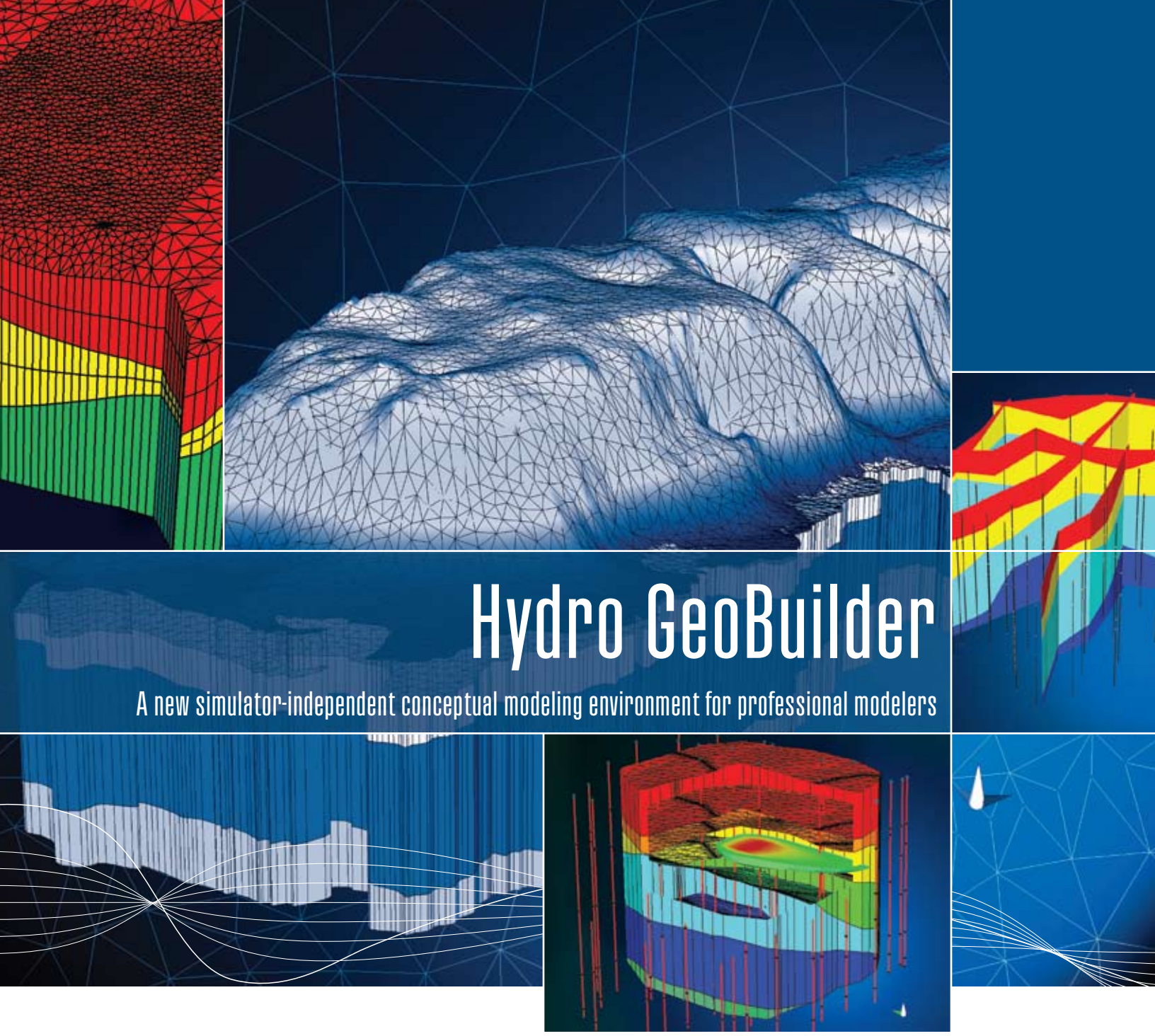
through the nearby mining camp, and we are introduced to the historical figure George Hearst. We learn of Hearst's love of gold and hear his story. Unlike most of the real miners from the Black Hills of South Dakota, "Hearst was the one who walked out alive and very rich." Hearst is likely the greatest winner in gold and silver mining in all of American history. Testa later takes us to the tycoon's 48,000-acre Piedras Blancas Ranch at San Simeon California (the future home of famed Hearst Castle).

Like a great tour guide, Testa shows us other interesting places along the way. He brings us to the 1848 California gold rush and some of the mining issues of the day. Always with a humorous tone, he describes the 1872 Mining Law and some of the important features (or lack of features) that are still causing unintended consequences on federally owned mining lands. Soon we are confronted with the amazing number of mining claims on federal lands (hundreds of thousands). Even when mining companies go to the dark side, there appears to be little that the federal government can do to void or buy out a claim to stop destructive environmental practices. We learn that the latest attempt to radically update the ineffective 1872 Mining Law was stalled in Congress in 2007. Practices by some mining companies produce adverse environmental impacts, such as abandoned open pits that are miles across, many filled with water containing toxic heavy metals. The degradation of public lands after mining operations have concluded is discussed by Testa, who aptly notes that in California, a gold and silver fee is assessed to support its Abandoned Mine Lands Program. Nonetheless, somehow, the public either receives the large bill for site restoration made necessary by some mining practices on federal lands, or the environment is not restored, leaving the environmental problems to future generations. Toward the end of the mining reform essay, we are brought back to Deadwood, South Dakota. It is here on August 2, 1876, that Wild Bill Hickok had the misfortune to be shot in the back and killed while playing poker. Concluding the essay, Testa slyly noted that the Hardrock Mining and Reclamation Act of 2007 did not fare much better than the legendary Hickok. After all the discussion of the need for mining reform, the painful knowledge of the widespread environmental damage on public lands and future liabilities, there were not enough votes in the Senate to pass the mining reform legislation.

In summary, geologists and laymen can enjoy the entertaining and humorous cultural stories and experiences that are told in this 240 page book. Testa excels by bringing short and lively discussions to serious and important social issues regarding the relevance of earth science in our lives and for our nation.

Reviewer: Jim Jacobs, P.G. #7760 is an environmental consultant in Mill Valley, California.

Avaiability: The book may be purchased through Barnes and Noble, Borders Books, Amazon.com, Kindle, etc., and also through AGI at www.agiweb.org under "publications." The cost is $24.95; the member society discount price is $22.45.



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Sacramento

By Tom Ballard,
Branch Secretary

The Sacramento Chapter did something a bit unusual for its January 2010 meeting. As his two-year term as Branch President came to an end, David Von Aspern acted on something he had always wondered about: what would it be like to devote one of our Branch meetings to a mostly social event without a guest speaker? David had consistently observed that ample conversation routinely occurs at the Sacramento Branch meetings prior to a guest speaker. Continuing that theme, why not have open discussions about all things GRA? The Sacramento Branch officers all agreed this would be a good opportunity for an open forum. The concept seemed to resonate with the attendees, as we had very good attendance for the meeting. Branch Treasurer Rodney Fricke started off and captivated all of us with a short presentation regarding the sound status of our Branch fiscal condition; he showed us an analysis of meeting attendance and the breakout of types of people attending the meetings. David then opened the floor for questions and an open forum for discussion of current issues facing the geology profession in northern California. Topics discussed ranged from possible topics for future meetings, to the final report of the UST Cleanup Fund Task Force, to Board for Geologists and Geophysicists assimilation by the Board for Professional Engineers and Land Surveyors. There was a lot of lively dialog and good information exchanged.

At the February Branch meeting, James D. Taylor, P.G., an Engineering Geologist with the Central Valley RWQCB's Federal Facilities (Department of Defense, DoD) Unit in Sacramento, gave a talk titled "Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater." Since 1993, James has been providing regulatory oversight of federal superfund sites. Since 1999, James has provided oversight for the former McClellan Air Force Base cleanup project, which is the highest-ranked Superfund site operated by the Air Force in the U.S. For his oversight role at McClellan, James received the 2003 Technology Transfer Workshop Team Member Award as a member of the ITRC Diffusion Sampler Team. Since 2001, he has been working extensively with the McClellan Base Cleanup Team to evaluate passive sampling.

The recent ITRC (Interstate Technology and Regulatory Council) guidance document on passive samplers contains protocols for five passive sampling technologies. Passive sampling is synonymous with no-purge sampling. The technologies included in the ITRC guidance include Snap Sampler™ and HydraSleeve™ Sampler – equilibrated grab samplers, Regenerated Cellulose Dialysis Membrane (Dialysis) Sampler and Rigid Porous Polyethylene (RPP) Sampler – diffusion/equilibrium samplers, and GORE™ Module, which is a diffusion and sorption sampler.

Passive samplers acquire a sample from a discrete position within a well of well water in ambient equilibrium with groundwater. Studies have shown that most wells have groundwater flow through the screened interval of the well; this screened interval, considered in equilibrium with the adjacent groundwater, can be sampled with passive samplers with little or no well water agitation that may alter contaminant concentrations. By deploying a series of samplers within the screened interval, passive samplers can provide a contaminant concentration profile of a screened interval of a well. The consensus of the ITRC Passive Sampler Team is that the samplers included in this protocol have been validated through laboratory and field-testing. When deployed appropriately, the data are reliable and accurate. A number of meeting attendees who use passive sampling techniques confirmed this assessment.

The March Branch meeting was held jointly with the Geology Dept. at Sacramento State Univ., and included two speakers: Devin L. Galloway, a Geologist with the USGS, and Sacramento State Geology student Jay Hefernan. Devin Galloway is the Western Region Ground-Water Specialist with the USGS, with whom he has worked for 32 years. His principal areas of research include aquifer mechanics, land subsidence, hydrothermal flow, and regional groundwater availability assessments. Devin has authored or coauthored numerous articles on the remote sensing, monitoring, analysis and simulation of deforming aquifer-systems. He is a member of the UNESCO Working Group on Land Subsidence and currently serves as Vice-Chair of the ASCE Managed Aquifer Recharge Subcommittee on Land Subsidence.

Mr. Galloway's talk was titled "Land Subsidence Accompanying the Development of Groundwater Resources." Land subsidence caused by the compaction of aquifer systems often accompanies the development of groundwater resources. Historically, subsidence in the San Joaquin Valley, California is notable for its magnitude, extent, and legacy of pioneering subsidence research. Presently, subsidence induced by groundwater withdrawal is a global problem—a consequence of widespread groundwater depletion, a hazard and a factor in the determination of 'sustainable' water resources. His presentation reviewed the occurrence, recognition, assessment and management of this type of subsidence.

CSUS Geology Student Jay Hefernan's talk was titled "Groundwater Flow and the American River"; he discussed field measurements to evaluate

Continued on the following page…

Sacramento – Continued

the effectiveness of an American River salmon habitat restoration project. Mr. Hefernan provided some background for the salmon habitat restoration project by describing how salmon and steelhead breed by laying eggs in riverbed gravel by using their powerful tails to sweep out circular nests in the gravel. Appropriate gravel is in short supply, however, due to a century of dam building, mining and other activities. Historically, small gravels washed out of the mountains with river flows to continually renew spawning habitat. The construction of dams blocked this movement, causing gravels to be depleted or clogged with sediment.

To address this problem, hundreds of truckloads of gravel were spread in two riverbed areas just downstream from Nimbus Dam. The project has succeeded in coaxing more fish to lay eggs in the American River. Salmon and steelhead have created at least 347 gravel nests (also called "redds") in the restored areas. In 2008 and 2009, the project added 17,500 tons of fine gravels to two large areas adjacent to the Nimbus Hatchery and Sailor Bar recreation area. Increasing the number of wild-spawning salmon and steelhead is considered important to the survival of those species. Recent research suggests most of the salmon in the Central Valley are hatchery fish, which are considered less resilient than native fish. The U.S. Bureau of Reclamation and the Sacramento Water Forum plan to add more gravel in a third location on the river later in 2010, as the habitat restoration work continues.

San Francisco

By Abigail McNally,
Branch Secretary

Stephen Hill, the Toxics Cleanup Division Chief, and Chuck Headlee, a Senior Geologist with the RWQCB, San Francisco Bay Region, jointly presented the "*Regional Water Quality Control Board San Francisco Bay Region Annual Regulatory Update*" on January 20, 2010. Mr. Hill addressed growing concerns over the State budget woes, particularly the impact of the general fund reductions. Although the general fund accounts for only a small percentage of the funding, it still led to the loss of two Cleanup Fund positions. Mr. Hill introduced the Low Threat Closure Tool, prepared by the Groundwater Committee, which serves as a guidance tool focused on recommendations for closure of solvent sites. He was pleased to report on the State Board Recycled Water Policy resolution 2009-0011, effective May 2009, for the sustainable management of surface and groundwater. The policy directs salt and nutrient management plans for groundwater basins and addresses aquifer restoration which translates to more aggressive clean up initiatives. Mr. Hill provided a brief history of enforcement trends and reported increased efforts since the mid-2000s. He also provided the revised timeline for completion of the Soil Gas Advisory Update and the expected completion of the ESL Vapor Intrusion Update during the spring of 2010. He reflected on the accomplishments of 2009 and the priorities of 2010, and introduced the Board's performance measures.

Please reference the following web links for more information:

Low Threat Closure Tool
www.waterboards.ca.gov/water_issues/programs/ust/luft_taskforce/lowthreat_closure080609.pdf

State Water Board's Recycled Policy
www.swrcb.ca.gov/water_issues/programs/water_recycling_policy


Photo by John Karachewski

State Water Board's Enforcement Trends
http://www.waterboards.ca.gov/water_issues/programs/enforcement/docs/enf_policy_final111709.pdf

Soil Gas and Vapor Intrusion Updates

USEPA 2002 (RCRA VI guidance)
www.epa.gov/osw/hazard/correctiveaction/eis/vapor.htm

DTSC 2004 (General VI guidance)
www.dtsc.ca.gov/assessingrisk/upload/herd_pol_eval_subsurface_vapor_Intrusion_Interim_final.pdf

DTSC 2009 (VI mitigation advisory)
www.dtsc.ca.gov/SiteCleanup/upload/VI_Mitigation_Advisory_Apr09.pdf

Mr. Headlee, the Underground Storage Tank (UST) program manager, reviewed the structure of the UST program and summarized the Cleanup Fund financial problems and issues. He discussed the May, 2009 Cleanup Fund Resolutions and Agency response. Most notably, quarterly monitoring was decreased to semi-annual, agencies were required to review all UST cases for closure eligibility, and two task forces were established. As a part of the review of all cases, agencies were required to note impediments to, and benefits of closure. The Agency responses are posted publicly on the Geotracker website. The November, 2009 Cleanup Fund Resolution requires oversight agencies to close low-risk sites in accordance with State Board decisions on 14 petitions. In addition, the Cleanup Fund is required to develop ways to expedite payments of backlogged reimbursements. Mr. Headlee also covered short- and long-term measures to improve the transparency and communication regarding the Cleanup

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San Francisco – *Continued*

Program. He reported on the upgrades to the GeoTracker and Groundwater Ambient Monitoring and Assessment (GAMA) databases, which include a new map interface, analytical reports, and graphing tools (http://geotracker.waterboards.ca.gov/gama).

On February 17th, Dr. Doug Mackay and Ehsan Rasa from UC Davis presented "Role of Back Diffusion in Sustaining an MTBE/TBA Plume after Source Remediation" at a South Bay venue. After acknowledging his collaborators and funding sources, Dr. Mackay provided an introduction to back diffusion processes observed in laboratory, field, and modeling studies. He also illustrated the important role of back diffusion by highlighting tank experiments constructed with sand and clay layers and the use of fluorescent dyes and time-series photographs to show plume geometries obtained by Lee Ann Doner for her Masters thesis in 2008 at Colorado State University. He also stressed the need to understand the hydrostratigraphy of clay/silt aquitards, which store and diffuse contaminants back into aquifers through time. Dr. Mackay then transitioned to presenting a case history from a former gas station (Site 60) with a widespread but narrow MTBE plume at Vandenberg Air Force Base (VAFB). Highly controlled field experiments were conducted at Site 60 within the historic MTBE plume from 2004 to 2006, with a resolution approaching that of laboratory studies and scales; in 2005-06, experiments included the injection of MTBE and TBA to allow better resolution of their fate under anaerobic conditions. A full-scale aerobic biobarrier was operated by VAFB downgradient of the experiments; UC Davis conducted other capture or biobarrier efforts to keep experimentally created impacts within the experimental zone. Dr. Mackay speculated that anaerobic biodegradation processes at lithologic interfaces may have transformed MTBE in the silt aquitards to TBA in the sand aquifers in recent years. Although soil was excavated from the source area, the MTBE/TBA plume continued to linger above the groundwater cleanup goals. Dr Mackay used 2D modeling to examine two hypotheses for the ongoing MTBE/TBA plume, suggesting that the original gasoline spill and back diffusion from the clay/silt aquitards accounted for the current exceedence of goals since 1) more than 99.7% of the MTBE/TBA mass released to the aquifer was from that spill, and 2) much more time transpired to allow diffusion of spilled contaminants in the silts. Dr. Mackay concluded his presentation by reiterating the importance of back diffusion in preventing attainment of cleanup goals, but also indicated the need for additional modeling to understand mass loss mechanisms, including volatilization at the capillary fringe, diffusion within the vadose zone, aerobic biodegradation at or above the capillary fringe, and diffusive loss to underlying aquifers.

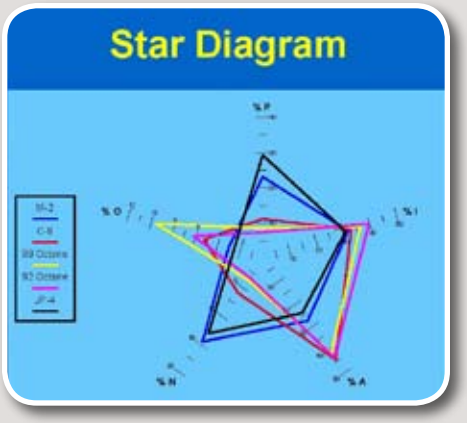
Southern California

By Paul Parmentier,
Branch Secretary

On February 9, 2010, in front of a dinner crowd of over 60 attendees, Dr. Alan Jeffrey of DPRA/Zymax Forensics presented an overview of environmental forensic techniques for petroleum hydrocarbons and chlorinated solvents, typically conducted to answer the following questions:

- what is the nature of the pollutant?
- what is the source?
- when did the release occur?
- who is responsible?
- how can we apportion costs for cleanup?

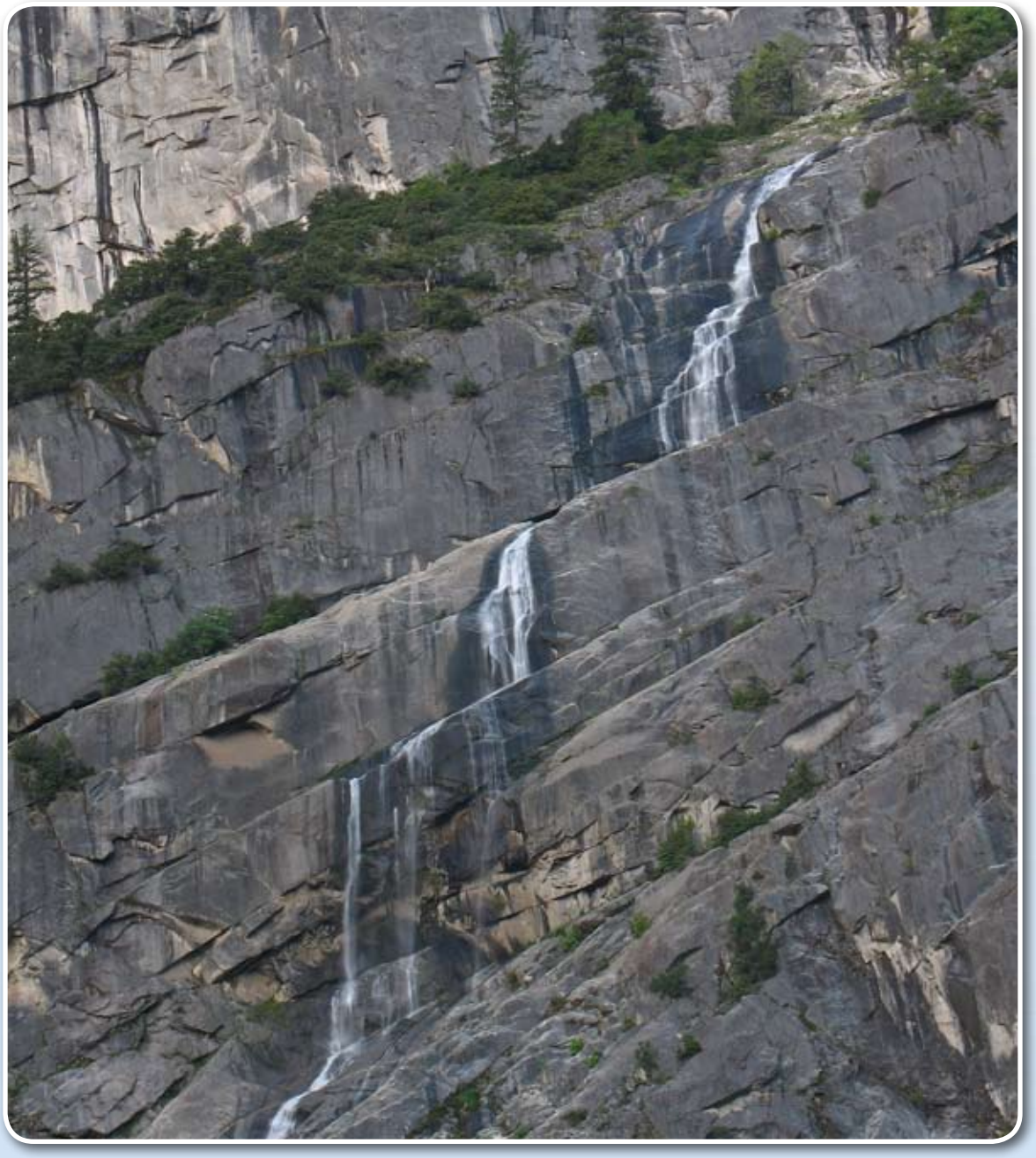
For petroleum hydrocarbons, forensic methods include US EPA methods, fingerprinting from chromatograms, evaluation of fuel additives, and stable isotope studies. For chlorinated solvents, forensic studies include evaluation of degradation compounds and several isotopic studies.



Typical standard Gas Chromatography methods may be misleading and broad; for example, orange juice was reported to contain 300 ppm of Total Petroleum Hydrocarbons (TPH) as gasoline. Of particular interest in groundwater issues is gasoline forensics, which is complicated by changing gasoline compositions with time (an 87 octane this month may be different next month) and with supplier/refiner. One of the forensic methods referred to as the PIANO method, visually plots Paraffins, Isoparaffins, Aromatics, Naphthalenes and Olefins onto a star diagram, which may allow for differentiation of fuel type. In some cases, the forensic study will also rely on the presence of lead and oxygenates to differentiate plume origins, particularly for evaluation of the age of a gasoline release. Stable isotope studies can be useful in assigning the geographic origin of the crude oil product that was used to produce the refined fuel.

Chlorinated solvent forensics typically focus on single compounds (PCE, TCE), as opposed to the fuel petroleum mixtures. However, degradation and volatilization of chlorinated solvents often complicate forensic studies. For example, during PCE degradation, lighter carbon isotopes degrade more readily than heavier isotopes; this observation can be used to demonstrate degradation.

The Southern California Branch was able to assemble, with a match from GRA, a pool of $3,250 for local area University students. The Branch officers are in the process of arranging to allocate these funds to deserving students in groundwater studies.



Staircase Falls, Yosmite National Forest

Staircase Falls provides a beautiful example of the role of joints in shaping Yosemite's landforms. Although vertical joints prevail, inclined joint sets such as the east dipping example at Staircase Falls have added to the diversity of Yosemite's landscapes. The falls descend a total of 1,300 feet into Yosemite Valley over a series of steps in Cretaceous granodiorite. Staircase Falls is ephemeral due to its very small watershed; it flows primarily after rainstorms and is usually dry by May. Most visitors to Yosemite Valley miss this unique waterfall even though it is located just south of popular Curry Village and west of Glacier Point. The white outcrop on the cliff above the waterfall in the upper left corner also shows evidence of a recent rockfall.

Photograph by John Karachewski, PhD (DTSC).