

The 16th Biennial Symposium on Managed Aquifer Recharge

By Adam Hutchinson, Orange County Water District



Andrew Stone, Executive Director, American Groundwater Trust and David Pyne, President, ASR Systems.

The Groundwater Resources Association (GRA), in association with the Arizona Hydrological Society, convened the 16th Biennial Symposium on Managed Aquifer Recharge (BSMAR 16) from March 5 to 7 in San Diego, CA. This symposium continues a tradition started in 1978 when the Salt River Project (Phoenix, AZ) convened the first symposium on artificial recharge in Arizona. In 2014, GRA and the Arizona Hydrological Society (AHS) joined forces to continue this symposia series with the location alternating between California and Arizona.

On March 5, two workshops were held, one focused on subsurface recharge and the other on surface recharge. David Pyne, President of ASR Systems LLC, presented the subsurface recharge workshop, "Aquifer Storage Recovery (ASR): How to Identify and Resolve Technical and Other Issues Associated with Successful Groundwater Recharge Through Wells." Mike Milczarek of GeoSystems Analysis, Inc. and Adam Hutchinson of Orange County Water District presented in the surface recharge workshop the "State of the Art Techniques in Characterizing, Constructing and Operating Optimum Surface Spreading Groundwater Recharge Projects." In addition, the symposia included, a field trip to the Carlsbad Desalination Plant. The plant, constructed by the San Diego County Water Authority (SDCWA), is the largest plant of its type in the western hemisphere and produces 50 million gallons per day of desalinated seawater.

After the conference, Dr. Catalin Stephan and Ralf Junghanns from Technical University of Dresden, Germany presented a workshop to introduce the INOWAS DSS, which is a decision support system containing a collection of free web-based simulation tools for planning and management of managed aquifer recharge applications. For more, go to: <https://tu-dresden.de/bu/umwelt/hydro/inowas/research/fields/mar-web>.

The 1½ day conference featured 43 oral presentations on a wide range of topics. Poster presentations were also provided. Attendees came from 10 states and seven countries.

The conference started with a plenary session featuring presentations on increasing recharge in California, particularly with storm water. Kamyar Guivetchi of the California Department of Water Resources (DWR), discussed DWR's Flood Managed Aquifer Recharge (Flood MAR) initiative. Rob Gailey of UC Davis presented a case study in on-farm recharge. Mehdi Ghasemizade of GEI Consultants discussed

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

Photo: Cosumnes River Preserve, approximately 40,000 acres (62 square miles) located near Interstate 5 about 25 miles south of Sacramento. Photo by John Karachewski, Ph. D.

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What's a Bison got to do with it?

By Steve Phillips, U.S.G.S.



The answer to that question is nothing, really, it's just an excuse to share some fun I had during the last week of March. I joined five others on a guided tour of northernmost Yellowstone National Park in search of wildlife, including several species of deer, elk, bighorn sheep, moose, a variety of raptors and other birds, coyotes, red foxes, grizzly bears, and the elusive wolves. We saw all of these creatures in and around our country's first national park, but the animal I was most awed by was the bison. They are massive, and their thick, dark coats stand out against the snowy surroundings as they amble effortlessly up steep hillsides; it is truly a sight to see in person, but meantime, enjoy the photo. I couldn't resist including one of Mammoth Hot Springs as well!

Now I'll catch you up on what GRA has been up to lately, and where we are heading.

GRA's popular Legislative Symposium was held on March 21 in Sacramento; as always, it provided a unique opportunity to engage with those involved in developing the state's groundwater-related legislation. Please see the summary of this well-received event in this issue of *HydroVisions*.

GRA's first annual Groundwater Sustainability Agency (GSA) Summit will likely be over by the time you read this; it will be held in Sacramento on June 6–7, preceded by a one-day technical workshop creatively titled *Turning Theory, Fear and Loathing into Sustainable Success*. GSA representatives are involved in the planning process; many will be speaking, and providing input and feedback as panel participants, on a wide variety of SGMA-related topics. The presentations from this event will soon be available to all attendees and GRA members, so stay tuned.

My gratitude goes to Tim Parker and the Planning Committees for organizing the two events described above. Tim, a long-time GRA Director and Chair of the Legislative Committee, led the development of both events, and even stepped in for the ill Chris Frahm as MC for the Legislative Symposium. That's dedication!

Led by intrepid GRA Director and Treasurer R.T. Van Valer, and backed by a strong Planning Committee, the inaugural [Western Groundwater Congress](#) is coming September 25th – 27th. This will be a three-day, quad-track event covering SGMA, contaminants, groundwater replenishment, agricultural issues and solutions, oil and gas, groundwater law, and many other topics. No-cost hands-on workshops, poster sessions, and a variety of fun networking opportunities

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will also be provided at this can't-miss event. Registration is now open, with special discount pricing for those who register early.

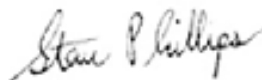
I'd like to take this opportunity to thank GRA's 2017 David Keith Todd (DKT) Distinguished Lecturers, and to welcome those for 2018. Last year's DKT lecturers were Dr. Rosemary Knight of Stanford's Center for Groundwater Evaluation and Management (GEM), and Dr. Claudia Faunt of the USGS California Water Science Center. Each gave many inspiring lectures at universities, GRA Branches, and other venues; on behalf of GRA, I thank them for the inspiration and for their time. The DKT lecturers for 2018, actively on the circuit, are [Dr. Jeffrey Mount](#), Senior Fellow, Public Policy Institute of California; and [Kirby Brill](#), P.E., former General Manager of the Mojave Water Agency. I attended Jeff Mount's first lecture, which was fascinating, and I'm looking forward to seeing Kirby's. I thank you both for your service to the groundwater community.

Begging the indulgence of those of you not particularly interested in SGMA, I'll describe where GRA is currently heading on this topic. As we have from the start, GRA is providing key educational and knowledge-sharing opportunities through conferences and webinars, but we've taken additional steps to better serve and integrate with the SGMA stakeholder community. One key step in that direction was

reaching out to a number of GSAs to involve them directly in event planning and participation. Another step was to recruit Paul Hendrix to GRA's Board of Directors. Paul, who was the GM of Tulare Irrigation District for 17 years, was recruited to strengthen ties with the agricultural community and related GSAs; he now manages the Mid-Kaweah GSA, which is a Joint Powers Authority comprising the Tulare Irrigation District and the cities of Tulare and Visalia. He also, is a civil engineer, bringing to GRA a broad background in water resources engineering, planning, and management.

If you are a member of a GSA, we would value your involvement in GRA, whether it be as an event planner, participant or attendee, committee member, etc. The better we know you, and the issues you face, the better we can design our programs to support your needs. Please feel free to contact me, or anyone else on the [Board](#), for more information.

As always, we welcome all ideas on future events and directions. If you are not a GRA member, consider becoming one!



Cheers,
Steve

Picture Your Research Featured in HydroVisions

Call for Submissions

HydroVisions is looking for submissions from students engaged in groundwater research, to highlight in our Student Corner.

Do you know of a student with something to share?

- Articles
- Research Papers
- Summary Blurbs

For further information, please contact:
editor@grac.org, subject "Student Corner"



The 16th Biennial Symposium on Managed Aquifer Recharge –

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BSMAR 16 Key Facts

Oral Presentations: **43**

Poster Presentations: **5**

Attendees: **148**

Workshops: **3**

Field Trip:

Carlsbad Desalination Plant
(Sponsored by
Collier Consulting)

Event Co-Sponsors:

- The Water Replenishment District of Southern California
- Geosystems Analysis, Inc.

Exhibitors:

- BESST, Inc.
- ASR Resources, LLC
- SGS North America, Inc.
- BakerCorp.
- Roscoe Moss Manufacturing

Reception/Lunch Sponsors:

- Orange County Water District
- Montgomery & Associates
- Dudek & Associates
- Geo-Logic Associates, Inc.
- Hopkins Groundwater Consultants, Inc.

Herman Bouwer Award:

David Pyne

Attendee Origin:

Arizona, California, Florida,
Nevada, New Mexico,
Wisconsin, New Jersey,
Washington, Texas, Mississippi,
Australia, Germany, Spain,
Costa Rica, Germany,
China, Korea

integrated approaches towards groundwater banking in the southern Central Valley. Lastly, Andrew Fisher of UC Santa Cruz, discussed a novel approach to incentivizing land owners to participate in recharge by providing recharge credits.

Due to the large number of abstracts received, concurrent sessions were required for the remainder of the conference that centered on the following topic areas:

- California MAR
- Aquifer Storage and Recovery (ASR)
- Evaluation Methods
- Arizona MAR
- International MAR
- Conjunctive Use
- Stormwater Recharge

The complete agenda for the conference can be found [here](#). Individual presentations from each session are on our website. With current membership you will have access to them as well as presentations from other events.

Herman Bouwer Award

A unique feature of BSMAR is the presentation of the **Herman Bouwer Award**. Dr. Herman Bouwer, who was instrumental in prior BSMAR events, was one of the world's leading researchers in water resources management, particularly in managed aquifer recharge. He authored more than 300 publications, 12 book chapters and the textbook *Ground Water Hydrology* (McGraw-Hill, 1978). He was also a key driver in organizing numerous BSMAR and International Symposium on Managed Aquifer recharge (ISMAR) events. To honor his legacy, the Herman Bower Award was created. The award is given to the person or agency that has significantly advanced the understanding or utilization of MAR.

Andrew Stone, Executive Director of the American Groundwater Trust, presented the 2018 Herman Bouwer Award to R. David G. Pyne on March 6, 2018. His professional career in water resources engineering changed the industry's application of aquifer recharge technology and significantly advanced the understanding and use of Managed Aquifer Recharge. He is best known for pioneering the development of the Aquifer Storage Recovery (ASR) concept for water storage via wells in fresh, brackish, and saline aquifers. He coined the term "aquifer storage recovery" back in 1982 and in 1995 published *Aquifer Storage Recovery: A Guide to Groundwater Recharge Through Wells* (expanded, updated, and republished in 2005).

After receiving a B.S. in Civil Engineering from Duke University in 1966, David graduated with a M.S. in Environmental Engineering Sciences from the University of Florida, specializing in Water Resources. His 50 years of professional water resources engineering experience began with a Florida engineering company, Black, Crow and Eidsness (BC&E). Early assignments included water supply, wellfield development, injection wells and other water management projects in Florida. In 1976 BC&E was acquired by CH2M HILL. Between 1978 and 1983 David was involved with a Recharge Recovery (RR) project at the Lake Manatee Reservoir in Manatee County. The project, financed by the Southwest Florida Water Management District, involved storing water underground during wet months and recovering it during dry months. Under David's guidance the program was designed, permitted, constructed, tested, and set into successful operation. In 1984 the Manatee ASR

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program, originally proposed and then developed by David, received a Grand Award from the American Consulting Engineers Council.

In 1982 David changed the original terminology of Recharge Recovery (RR) to Aquifer Storage Recovery (ASR). Not only was this a more accurate description of the process but adding the word Aquifer also helped avoid some of the resistance from people who opposed deep well injection of wastewater. With the growth in nation-wide implementation, ASR became an accepted technical term and for many water professionals throughout the world, the name David Pyne and ASR are synonymous.

In addition to providing ASR consulting services for United States water districts and clients, David was involved with aquifer recharge projects in at least twenty overseas countries. He gave direction and technical input for almost half of the approximately 140 ASR wellfields in the US and many water supply and aquifer recharge master plans. David is well known to many aspiring (and now established) aquifer recharge geologists and engineers because of the one-day and two-day courses on Managed Aquifer Recharge which he co-presented with Dr. Herman Bouwer between 1994 and 2007 and later with Daniel B. Stephens.

At CH2M HILL, (1976 – 2001), David served in several positions, including firm-wide Director of Water Resources Engineering and Water Resources Discipline Director for the Eastern District. In 2001 he left CH2M Hill and established ASR Systems LLC to provide water resources and ASR system

consulting services to clients in North America and overseas. As President of ASR Systems, he provided consultant assistance to organizations such as the World Bank, International Atomic Energy Agency, UNESCO, and USAID and served as an expert witness in numerous legal and administrative hearings in the areas of hydrology, hydrogeology, and water resources engineering.

His engineering responsibilities as advisor and consultant included water resources and hydrogeologic investigations, design of wells, wellfields, and related wellhead and pipeline facilities; construction services, startup, and operational assistance, and permitting. His demonstrated technical expertise includes principles and applications of groundwater hydrology, surface water hydrology, water quality, hazardous wastes, water supply, and wastewater systems planning, storm water management, environmental studies, deep injection wells, bank filtration, and aquifer recharge.

As a tireless advocate for aquifer recharge technology and its many beneficial applications David provided guidance during development of ASR regulatory frameworks in California, Florida, Wisconsin, Iowa, North Carolina, South Carolina, Georgia, New Jersey, Texas, New Mexico, Utah, Oregon, Washington, and at the US Environmental Protection Agency.

David is a frequent invited presenter at professional and technical conferences and workshops, presenting a logical progression of technical, economic, and regulatory arguments used to persuasively promote aquifer recharge as a solution to many water management situations.

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



From right to left, Andrew Stone, Executive Director, American Groundwater Trust; Bob Rice, 2014 Award Recipient; David Pyne; and Mario Lluria, 2016 Award Recipient.

The Groundwater Resource Hub: Tools and Resources for Addressing Groundwater Dependent Ecosystems under SGMA

By Melissa M. Rohde and Sandi Matsumoto, The Nature Conservancy]

The Nature Conservancy has launched the Groundwater Resource Hub (www.GroundwaterResourceHub.org)—the go-to resource on Groundwater Dependent Ecosystems (GDEs). The Groundwater Resource Hub contains tools and resources to assist Groundwater Sustainability Agencies (GSAs), their consultants, and interested stakeholders in successfully implementing the Sustainable Groundwater Management Act (SGMA) in a manner that reduces costs, shortens timelines, and increases benefits for both people and nature. Here are some key questions that the Groundwater Resource Hub can help answer:

What are GDEs and why are they important under SGMA?

GDEs are plant and animal communities that require groundwater to meet some or all of their water needs. Under SGMA, GDEs are defined as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.” California’s GDEs encompass a wide range of natural communities, such as wetlands, rivers, streams, estuaries, seeps, springs, and terrestrial vegetation.

In addition to serving as an essential source of water for California’s residents and businesses, groundwater is critical for many types of plants and animals, particularly during dry summers and droughts. GDEs exist across a range of landscapes from mountains to desert springs and coastal wetlands. During dry periods, groundwater keeps many streams, springs, and seeps flowing, and provides water necessary to sustain plants without access to surface water. When groundwater levels decrease because of drought and unsustainable pumping practices, springs and groundwater wells can go dry and cause important ecosystems to lose access to groundwater, resulting in degradation or loss of plants and animals.

For more than a century, unregulated groundwater pumping has chronically lowered groundwater levels in many areas of the state (most notably in the Central Valley) and caused depletions of surface water in rivers and wetlands (The Nature Conservancy, 2016). Historical assessments have also indicated that less than 5% of wetlands and 6% of habitat along rivers in the Delta remain from what naturally occurred (Robinson et al, 2016; The Bay Institute, 1998). Similarly, a recent study indicated that if current trends continue that nearly half of California’s native salmon, steelhead, and trout could become extinct in 50 years (Moyle et al., 2017). These findings indicate that we are at a true tipping point in our ability to sustain California’s important natural resources. If we fail to improve water management and sustainably pump groundwater, we risk losing some of our most iconic species, our fishing industry, and our favorite places to recreate. SGMA provides a new opportunity to sustain and enhance our rivers and streams by preventing unsustainable groundwater pumping from causing further impacts to GDEs.

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Figure 1: A spring in the Ash Meadows National Wildlife Refuge, fed by an aquifer. Photo credit: Rick Loomis, The New York Times

The Groundwater Resource Hub provides educational information, including animations and photos to help you communicate what GDEs are, how groundwater depletion impacts them, and why they are important.

Where do GDEs exist?

The first step to sustainably manage GDEs is to identify where they are, which is also a specific requirement in the GSP regulations (23 CCR §354.16(g)). To assist GSAs in identifying which ecosystems are most likely to use groundwater, a statewide spatial dataset was compiled to provide locations of seeps and springs, wetlands, and vegetation known to depend on groundwater. All of these are indicators of GDEs (iGDEs), meaning that these areas contain features known to be groundwater dependent in some places. Actual groundwater dependence can vary, based on local conditions, and the iGDE database needs to be validated by local hydrological knowledge. The iGDE database is therefore a starting point to identify GDEs.

This iGDE database* was developed by scientists from the California Department of Water Resources (DWR), the California Department of Fish and Wildlife (DFW), and The Nature Conservancy, and it builds upon previous work published by scientists at The Nature Conservancy (Howard & Merrifield, 2010). In addition, experts from numerous water agencies, state agencies, academics, and technical consultants

reviewed the methods used to develop the database (Klausmeyer et al., 2018). *Note: DWR refers to the same dataset as the “Natural Communities Commonly Associated with Groundwater (NC Dataset)”.

The California Department of Water Resources is the host and steward of the database and mapping tool, which is available on DWR’s website (<https://gis.water.ca.gov/app/NCDataSetViewer/#>) and the Groundwater Resource Hub.

DID YOU KNOW?

GDEs are Biological Hotspots

iGDEs only exist over 6% of the land surface area of the 517 delineated groundwater basins, they contain 90% of listed species found in groundwater basins.

Nearly half (1.2 million acres) of the iGDEs mapped in California exist in desert groundwater basins.

How can impacts to GDEs be considered?

SGMA requires that all beneficial uses, including GDEs, be considered in the development and implementation of Groundwater Sustainability Plans (GSPs). The GSP Regulations include specific requirements to identify and consider GDEs when determining whether groundwater conditions are having potential effects on beneficial uses. GSAs must also assess whether sustainable management criteria (including minimum thresholds and measurable objectives) may cause adverse impacts to beneficial uses. In addition, monitoring networks should be designed to detect potential adverse impacts to beneficial uses.

Since many GSAs will be identifying and considering GDEs for the first time, The Nature Conservancy has created a five-step process that guides GSAs on how to identify GDEs, determine whether potential effects on GDEs are occurring or may occur due to groundwater conditions, and consider GDEs when setting sustainable management criteria (Rohde et al., 2018). Numerous water agencies, state agencies, academics, and technical consultants conducted expert review of the scientific principles and methods used to develop the guidance. This systematic and defensible approach was designed to inform local decision making. Rather than prescribing approaches or outcomes, this guidance provides a flexible process meant to enable GSAs and stakeholders to make decisions based on the best available science in a manner that promotes transparency and accountability.

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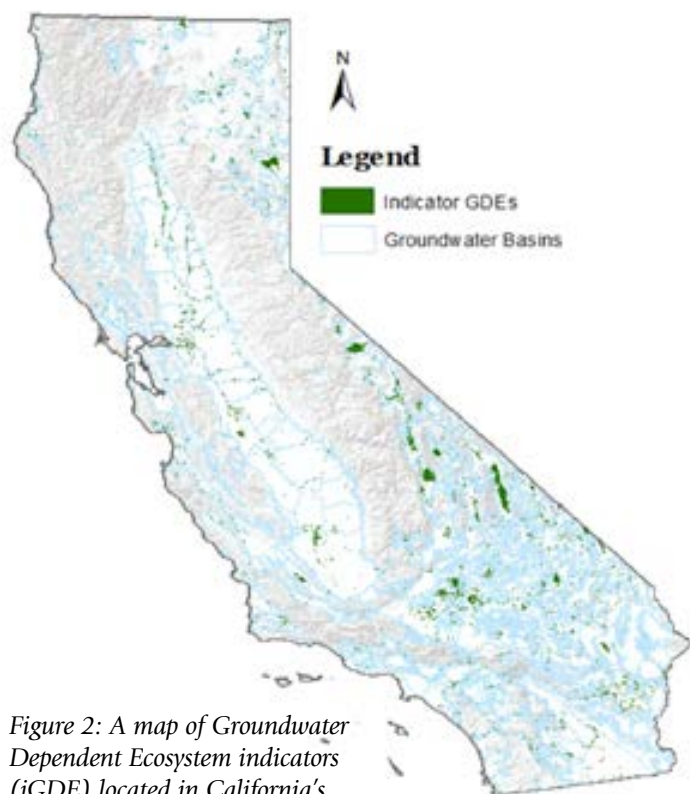


Figure 2: A map of Groundwater Dependent Ecosystem indicators (iGDE) located in California's groundwater basins.



Figure 3: The 5-step GDE guidance process for preparing GSPs.

The Nature Conservancy's GDE guidance, titled "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available on the Groundwater Resource Hub. Downloadable worksheets that can easily be inserted into GSPs are also available.

What other information is available to help the GSP process?

Groundwater-dependent vegetation includes riparian vegetation, wetlands, and purely terrestrial ecosystems like valley oak woodlands. The vegetation relies on the availability of groundwater within the rooting depth of plants. Plants draw water from a few inches to feet above the water table.

Plant rooting depth information can provide a useful insight on the groundwater levels that may be needed to sustain GDEs. The Nature Conservancy has compiled a species-specific maximum rooting depth database that can help provide information on whether groundwater-dependent plants are accessing groundwater. Actual rooting depths will depend on the plant species and site-specific conditions, such as soil type and availability to other water sources. Site-specific knowledge of depths to groundwater combined with rooting depth information can help provide an understanding of the potential groundwater levels needed to sustain GDEs. Rooting depth data were compiled from published scientific literature and expert opinion through a crowdsourcing campaign.

The rooting depth database is available on The Groundwater Resource Hub. The database will be updated as more information becomes available.

How have other management entities dealt with GDEs?

Sometimes the best way to learn is by learning from others. To help facilitate shared learning, The Nature Conservancy has developed case studies that provide real-world examples of the processes, tools, and techniques being used to implement sustainable groundwater management.

The Groundwater Resource Hub features case study examples of the processes, tools, and techniques that California agencies have developed to address GDEs as part of sustainable groundwater management. Additional case studies will be added as sustainable groundwater management progresses in California.

Help us help you!

The Nature Conservancy is looking for feedback on what assistance is necessary to identify and consider GDEs under SGMA. If you have any questions or suggestions, please email Sandi Matsumoto (smatsumoto@tnc.org).

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From Shorelines to Aquifers: Late Cretaceous through Pliocene Fill of the Northern Sacramento Valley

Pacific Section SEPM (Society for Sedimentary Geology)

FALL FIELD TRIP, SATURDAY & SUNDAY, SEPT. 29–30, 2018

Todd J. Greene, Russell S. Shapiro, David Maloney, California State University, Chico



Field Trip Information

Participant Limit: 100+. We encourage teachers to bring their stratigraphy/sedimentology class.

Vehicles Recommended: no requirements

Highlights

This year's Pacific Section SEPM Fall Field trip will take place in Chico and along the Black Butte Reservoir, California. We will explore the Pliocene aquifer stratigraphy as well as the Cretaceous shorelines exposed along the flanks of the northern Sacramento Valley. We will visit key outcrops of the Tuscan and Tehama formations, as well as the fossiliferous Cretaceous Chico Formation. With the implementation of the Sustainable Groundwater Management Act (SGMA) in California, the need to better understand aquifers has never been more critical. Aquifer stratigraphic architecture is one of the most salient elements in building defensible basin conceptual models and reasonable estimates of sustainable operational yield, as is now required pursuant to the new SGMA groundwater management regulations. The development and implementation of Groundwater Sustainability Plans is also already proving to provide a significant new employment opportunity for California geologists.

Sierra Nevada Brewery, a prolific user of Tuscan groundwater, will be offering on-site sustainability tours along with a tasting for interested participants. Come join us for an adventure in northern California geology among friends of PS-SEPM!!

Itinerary:

On Friday night, everyone should meet at the Buckhorn Group Campground site at Black Butte Reservoir. The campground is 105 miles north of Sacramento International Airport. Take I-5 North to Orland, turn left (west) on to Newville Road and drive 12 miles, turn left onto Buckhorn Rd., drive 0.8 miles, turn right towards the group campground. If you're arriving Saturday morning, you have an option of meeting the group in Chico, at the Chico Park and Ride along Highway 32 just east of the Highway 99 intersection.

On Saturday, we will drive east across the valley to Chico and spend most of the day on the Big Chico Creek Ecological Reserve observing outcrops of the Pliocene Tuscan Formation and Late Cretaceous Chico Formation. Hikes will be moderate, with occasional steep portions along trails. Steady footwear is recommended. We will also have the option of participating in a Sustainability Tour at the Sierra Nevada Brewery Saturday afternoon. After visiting outcrops and the optional tour, we will head back to Buckhorn Group Campground at Black Butte Reservoir. A catered BBQ will be provided on Saturday night.

On Sunday, we will visit outcrops surrounding the Black Butte Reservoir including the Great Valley Group, the Tehama Formation, and other aquifer units. We will conclude the outcrop stops at approximately 12pm.

Continued on the following page...

Fees:**Lodging/Camping Options:**

Option 1: Buckhorn Group Campground at Black Butte Reservoir. Spacious campground holds up to 80 people on a first-come, first-served basis. Overflow will be accommodated in individual sites depending on the number of registered participants.

Option 2: Alternative accommodations at hotels in Orland or Chico. If you do not camp on Friday or Saturday night, you will be responsible for reserving and paying for your own hotel. Chico is located ~37 mi (~60 km) west of Buckhorn Group Campground and Orland is located ~14 mi (~21km) west of the campground. A listing of alternate motels in Chico and Orland will be provided. Rates vary.

Meals:

Lunch, Saturday only: (included in professional and student registration fee), vegetarian or meat sandwiches, bag of chips, cookie, and beverage, plus snacks, fruit, and water.

Saturday Night: catered BBQ at Buckhorn Group Campground: meat entrees, salad, sides, and appetizers. Veggie-style will be available.

You will be responsible for providing your own dinner for Friday night, breakfasts for Saturday and Sunday, and lunch for Sunday.

Guidebook in Color:

Included in professional and student registration fee.

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Wells and Words

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

The Hydrologic Budget – Part 5

Part 5 discusses soil moisture changes (a CHANGE IN STORAGE element) and a shout-out to the Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS) (formerly Soil Survey Geographic Database [SSURGO]) for the data needed for the Thornthwaite and Mather (T&M)^{1,2} monthly accounting method for estimating the annual or monthly total available water (AW) for runoff. AW includes Runoff and Detention. Runoff (RO) is the portion of precipitation that eventually appears in surface water courses or water bodies³ and Surplus Water or Detention is the remaining water retained in the watershed (subsoil, groundwater, small lakes, and channels) that is available for runoff during the next month. As a first approximation, the total AW is usually divided in half between RO and Detention for larger watersheds¹. RO and Detention can vary with soil depth and texture, watershed physiography, vegetation, and precipitation intensity.

The T&M method is basically a monthly soil water accounting model that is fully described in Dunne and Leopold¹ and other documents^{2,4}. Soil moisture (soil water) is water diffused in the soil in the upper part of the unsaturated zone. It is the water available for discharge by the transpiration of plants or by direct evaporation (or when combined evapotranspiration [ET])⁵. The monthly unknowns for the T&M method include Precipitation (P), Potential ET (PET), and Available Water Capacity (AWC). The monthly Soil Moisture (SM) is the water retained and accumulated in the soil. P and PET can be downloaded from various websites (PET can also be calculated from incoming solar radiation, tem-

perature, etc.⁶ or standard evaporation pan measurements), analyzed for a site for average monthly values, and adjusted, if needed, from precipitation (isohyetal) map distributions over the Area of Interest (AOI). The SM (or soil retention) can be estimated for each month from Figure 8-3 of *Water in Environmental Planning*¹ or from tables in *Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance*⁴. The AWC (or water holding capacity) of the soil can be estimated using the program accessed with the WSS button at the [NRCS website](#).

The WSS “provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA NRCS and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation’s counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.”⁷

The NRCS website (or paper equivalents⁸) for County or area-wide soil distributions can be used to determine soil physical parameters within an AOI including their AWC. Prior to computer and internet technology, the NRCS published paper documents that contained soil descriptions and soil distributions on aerial photographs which required a mechanical polar planimeter to measure the area occupied by each soil type. The WSS button on the NRCS website can be used to obtain custom-made soil reports for the AOI resulting in a tabulation of areas (percentage of the total AOI) and the water holding capacity for each soil type. Figure 1a shows the title cover and table of contents of a recent and custom report that was easily down-loaded from the NRCS website. The document produced by NRCS for this 7,655-acre site of the watershed of Rodeo Creek in western Contra Costa County, CA is 95 pages long, tailored to meet this specific site, and suitable for client/public distribution and consumption.


Custom Soil Resource Report for Contra Costa County, California	
Rodeo Creek, Rodeo, CA	
	
November 13, 2017	
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Figure 1a – Custom NRCS report for the Rodeo Creek Watershed (outlined in teal), Western Contra Costa County, CA

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		Wet Season												WY
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	P	0.94	3.30	7.49	6.46	6.04	3.26	1.11	1.16	0.14	0.00	0.15	0.18	30.23
2	PET	3.71	1.70	0.98	0.90	1.63	3.50	4.78	6.26	7.26	7.72	6.59	5.26	50.30
3	P-PET	-2.77	1.60	6.51	5.56	4.42	-0.25	-3.67	-5.10	-7.12	-7.72	-6.44	-5.08	-20.07
4	Acc Pot WL	-38.15					-0.25	-3.92	-9.02	-16.14	-23.86	-30.30	-35.38	
5	SM	0.00	1.60	4.00	4.00	4.00	3.74	1.46	0.47	0.00	0.00	0.00	0.00	
6	Delta SM	0.00	-1.60	-2.40	0.00	0.00	0.26	2.28	0.99	0.47	0.00	0.00	0.00	
7	AET	0.94	1.70	0.98	0.90	1.63	3.52	3.39	2.15	0.61	0.00	0.15	0.18	16.15
8	D	2.77	0.00	0.00	0.00	0.00	-0.01	1.39	4.11	6.65	7.72	6.44	5.08	34.15
9	S	0.00	1.70	3.49	2.46	2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.69
10	Tot Av. RO	0.02	1.70	4.34	4.63	4.36	2.18	1.09	0.54	0.27	0.14	0.07	0.03	
11	RO	0.01	0.85	2.17	2.31	2.18	1.09	0.54	0.27	0.14	0.07	0.03	0.02	9.68
12	Detention	0.01	0.85	2.17	2.31	2.18	1.09	0.54	0.27	0.14	0.07	0.03	0.02	

Figure 1b – Typical Table for the Thornthwaite and Mather Soil Moisture Water Balance accounting method (all numbers in inches), Lagoon Valley, CA (abbreviations explained in text; methodology explained in Dunne and Leopold, 1978)

A graphical user interface (GUI) polygon is used to define the AOI on the [WWS site](#) map. The GUI tool that draws the polygon for an irregular AOI is somewhat awkward because the tool cannot easily delineate the details of the watershed boundaries. The free report is generated in minutes (or less than an hour) from the NRCS database; when the specific-site report is complete, NRCS informs the “buyer” by email that the report is ready for down-load and can be retrieved with the included link. The report contains all soil types in the AOI (in this case, 26 soils), urban land, and water, a map showing the soil distributions, soil property descriptions, and their percentages. The descriptions of soils include the water holding capacity in the soil profile. The AWC or available moisture capacity is the capacity of soil to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point¹. The *field moisture capacity* (field capacity) is the quantity of water held by soil or rock against the pull of gravity³ and the *wilting point* is the point at which the water content of a soil becomes too low to prevent permanent wilting of plants³. It is commonly expressed as inches of water per inch of soil.

The T&M method predicts the Actual ET (AET), accumulated potential water loss (Acc Pt WL), change in soil moisture Delta SM, Total available runoff (Tot. Av. RO), SM deficit (D), and SM surplus (S). Figure 1b shows the calculations for Lagoon Valley, CA (near Vacaville in the Central Valley) which are based on P (line 1- total annual P = 30.23 inches), PET (line 2 – total annual PET = 50.30 inches), and SM (line 5 – weighted average of the AOI SM capacity = 4 inches). Note that the PET is much greater than the annual P. Calculations show that the average annual AET is about 16.15 inches or about 55% of the precipitation. As shown in Figure 1b, excess rainfall between November and February contributes to stream flow and a minor amount of ET, while the period between March

and October has a moisture deficit. SM is removed from the balance between March and June, while soil moisture is replenished between October and November. Using this method, annual RO is about 9.68 inches or about 32% of precipitation.

The WSS interface provided by NRCS is a valuable tool to evaluate soil properties and parameters in a watershed and can be used to predict stream flow and groundwater recharge. To summarize this series of articles on the water balance: Part 1 defined some of the definitions of the hydrologic budget and furnished common URLs for various sets of raw or processed precipitation data; Parts 2 and 3 provided URLs for raw or processed ET and stream flow data, respectively; and Parts 4 (groundwater level) and 5 (soil moisture) discussed two elements for estimating changes in water storage in a groundwater basin and its contributing watershed, respectively.

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Summary of GRA's 17th Annual Legislative Symposium

By Tim Parker, Parker Groundwater, GRA Director and Legislative Committee Chair

On March 21st, GRA hosted its Annual Legislative Symposium at the Sutter Club Hotel in Sacramento. The Symposium theme was Replenishing California's Thirsty Aquifers. The Symposium was hosted again, in cooperation with the California Groundwater Coalition, and sponsored by Brownstein Hyatt Farber Schreck, Dudek, Golden State Water Company, Gordon Hess & Associates Inc., and Water Resources Consultants Inc. Ken Manning, California Groundwater Coalition President, and Chris Petersen, the past President of GRA welcomed attendees and made opening remarks.

Our 16th Legislative Symposium featured a wide-ranging group of speakers, including legislators and other state officeholders, such as Joaquin Esquivel, the newest State Water Resources Control Board Member; CalEPA Undersecretary Gordon Burns; and California Department of Water Resources Deputy Director Taryn Ravazzini. Each speaker shared their perspective on recent and ongoing developments in state water policy, including how to address areas in adjudicated basins that are not part of the adjudication but are under SGMA jurisdiction aka "fringe areas", new agency funding challenges under SGMA, and how to significantly increase recharge of California's depleted aquifers.

How SGMA addresses adjudicated basins was discussed by a panel of groundwater experts including Toby Moore Chief Hydrogeologist of Golden State Water, Tom McCarthy, General Manager of Mojave Water Agency, and Sam Boland-Brien, SGMA Program Manager for the State Water Resources Control Board, moderated by GRA Director Brad Herrema, Shareholder with Brownstein Hyatt Farber Schreck. Adjudicated basins are managed based on a court decision (judgment) using a physical solution that assigns water rights. A watermaster oversees the proper execution of the court order. Additionally, the court periodically reviews the basin. SGMA requires adjudicated basins to submit the judgment and annual reports to DWR. However, adjudicated areas characteristically do not cover the entire SGMA priority basin, leaving "fringe areas" uncovered by the adjudication or a GSA or GSP. This poses a problem of unassigned responsibility. Additionally, some of the fringe areas are quite large, for example, in the Chino basin there are 1,000's of parcels which would require significant resources and time to address. DWR indicated these areas need to be covered under SGMA, and that in reviewing submittals DWR will consider management of the entire basin.

Adjudications provide some certainty in assuring protection of water rights, and it is likely there will be additional adjudications in the future. The panelists discussed potential solutions to address including developing a process to evaluate fringe areas in the future.

Trevor Joseph, Supervising Engineering Geologist with DWR's SGMA Program, gave an overview of their intent for the SGMA program and highlighted some of their current tasks. DWR is looking at the viability of aerial electromagnetics (AEM) for improving hydrogeologic understanding and storage estimates. Twenty-two alternative plans were submitted, and four were withdrawn (by Mojave Water Agency). The alternative plan submittals are undergoing review by DWR, with feedback expected later in the year. DWR is looking at the fringe areas in adjudicated basins, which range in size; for example the Chino basin is 4% uncovered by adjudication whereas the Scott's Valley is 84% uncovered by adjudication. DWR is obligated to look at these areas in SGMA high- and medium- priority basins and is trying to find solutions.

Gordon Burns, CalEPA Undersecretary, spoke of the many (7,000) small water systems statewide that fall under the Safe Drinking Water Act. Over 300 of these systems regularly cannot meet drinking water standards. The state is considering the consolidation of these small systems into large systems, and methods to fill funding gaps including grants and loans. Many disadvantaged communities in the San Joaquin Valley are drinking nitrate contaminated water, and Senate Bill 623 (Monning) Safe and Affordable Drinking Water Fund would provide a funding solution by setting fees on specific dairy products, nitrate applications and a water tax (public goods charge) – there is also an identical budget trailer bill. The successful negotiation on the fees on agriculture has been remarkable. ACWA does not support the water tax, and instead proposes balancing it with the general fund.

Paul Massera, DWR California Water Plan Program Manager, gave an overview of the Water Plan 2018 Update. The Update includes the root causes of system challenges and recognizes that sustainable water resources requires long term planning. The Update lists five goals and 34 actions and priorities including modernizing infrastructure, which require legislative action. The Update implementation budget is \$98B over 50 years, -a one-quarter trillion-

Continued on the following page...

dollar- shortfall. This shortfall could be met with a tax or fee of \$8 per month per household. Historically, these types of funding needs have been met with general funds or general obligation bonds.

Senator Bill Dodd Member, Senate Agriculture Committee discussed his past and current legislation. Assembly Bill 1755 Water Platform passed in 2016, and now DWR (working with several agencies and partners) are making progress on the platform framework and data protocols. Last year he also successfully managed the controversial SB 252 requirements for making discretionary well permits in a critically overdrafted basin a public process. This year, SB 919 is moving through the Senate Natural Resources and Water Committee. It addresses the need for stream gages in the state by requiring DWR to determine stream gage needs. There used to be 3,600 active stream gages, but more than half have been lost over the last two decades therefore nearly 86 percent of California's streams are now poorly gaged. Senator Dodd also mentioned his support for the Senate Bill 623 (Monning) the Safe and Affordable Drinking Water Fund.

Assemblymember Marc Levine, Member, Assembly Water, Parks and Wildlife Committee, represents the 10th State Assembly District in the State Assembly, that encompasses communities in Marin and Southern Sonoma. He discussed representing the local interests of Marin and Sonoma, protecting our environment, supporting our schools and universities, and improving California government after years of budget problems and government dysfunction.

Assemblymember Blanca Rubio, Member, Assembly Water Parks and Wildlife Committee worked tirelessly to give her constituents a voice in the Capital, advocating for children, women, families, students, and immigrants. Before coming to the Assembly, Blanca spent 16 years as a teacher and 20 years in elected office, serving on the Valley County Water Board, and working for the Baldwin Park Unified School District. She discussed her experience with the Water Boards and the challenges with the application and regulatory processes. She recommended to "not get married to your bills", for example AB 1668, long term water use setting. Assembly Bills 968 and 1654 were coauthored by Blanca Rubio to promote a water-industry supported approach, but legislation related to long-term water conservation standards took several forms and turns, ultimately moving forward in AB 1668 (Friedman) and SB 606 (Hertzberg/Skinner/Friedman) in the final month of the session.

Assemblymember Bill Quirk, Chair, Assembly Environmental Safety and Toxic Materials Committee told the audience about his groundwater outreach to organizations. Last year he successfully moved AB 574 forward to provide a framework for the safe application of direct potable reuse, and last week the State Water Resources Control

Board adopted regulations on augmentation. Quirk is also interested in addressing emerging contaminants with a scientific process via his bill AB 2072. It would require the State Board, to establish and maintain a dedicated program to research the potential effects of constituents of emerging concern in water on human and ecosystem health. Quirk also mentioned the Safe and Affordable Drinking Water Fund and the water fee and expressed uncertainty that the bill would pass this year.

Taryn Ravazzini, DWR Deputy Director of Special Initiatives, was the symposium luncheon keynote. She explained that watersheds are part of the water supply infrastructure, with storage in upper meadows, surface reservoirs, and groundwater. She recognized the need for more local projects and actions to reach sustainability. She also discussed the need for the WaterFlx with the potential loss of nearly 20 percent of the deliveries equivalent to about 1 million acre-feet annually. Cape Town, South Africa, was cited as an example of a city on the verge of losing its water supply because it relied on surface water, which became scarce during dry years. They were able to reduce water usage to avert their predicament, and now want to look at groundwater and other management options to increase water resiliency. The aquifer is threatened by sea level rise and seawater intrusion.

Discussing the topic of increasing recharge in California were Tony Zampietro-Main San Gabriel Basin Watermaster, Kamyar Guivetchi-DWR, Graham Fogg-UC Davis, Tim O'Halloran-Yolo County Flood and Water Conservation District, and Erik Eckdahl-State Water Resources Control Board. The San Gabriel Basin withdrew 400 thousand acre-feet out of the basin as a result of the five-year drought. At the end of the drought, steps were taken to purchase additional imported surface water for recharge. Flood-Managed Aquifer Recharge (Flood-MAR) is a relatively new approach to capture the peak flows and place the water in roughly engineered surface impoundments that are actually permanent crops. This is a way to take advantage of extreme weather events. There are multiple public benefits with Flood-MAR. Agriculture is being framed as green infrastructure with Flood-MAR. There is a desire for additional data and research into crops response to flooding for periods of days and weeks. DWR is developing a white paper on Flood-MAR that should be available in draft form soon. GRA and UC Water jointly conducted a roundtable of approximately 40 groundwater industry leaders to respond to the "Call to Action to Recharge California's Aquifers." The challenges for increasing recharge include water transportation, recharge efficiency, legal uncertainties, groundwater quality degradation, and how to incentivize water projects. A series of actions are identified to significantly increase recharge including:

Continued on the following page...

- Identifying the high-magnitude flows
- Identifying site conditions and appropriate methods for recharge
- Developing the means to reduce regulatory and permitting bottlenecks
- Providing funding, guidance, and goals to incentivize 1,000's of recharge projects
- Identifying ways to optimize reservoir operations and expand conjunctive use
- Demonstrating improving water quality through increased recharge.

The Yolo County area has approximately 200,000 irrigated acres, with large changes in flow from precipitation events. The policy there is to not line canals but use them to recharge the subsurface. Recently, Yolo County tried to use the recent temporary permitting process of the State Water Board. This permitting process was discussed and indicated to be lengthy and time-consuming. Sometimes the water availability analysis in applications is insufficient leading to delays. The State Water Board is looking at increasing the fees to cover costs, and ways to streamline the process.

Dennis O'Connor, Principal Consultant, Natural Resources and Water Committee, a familiar face at GRA's Legislative Symposiums, came as a substitute for Senator Hertzberg, Senate Natural Resources and Water Committee Chairman. So far 2018 is looking like a pretty light year for water related legislation, although there are still a number of spot bills. In his opinion the Safe and Affordable Drinking Water Fund may fall short in the Assembly.

Gerald Meral, Director, California Water Program, Natural Heritage Institute, discussed the proposed new \$8.9B Water Supply and Water Quality Bond that will be on the November ballot, which is entirely for water. The bond funds categories include drinking water, safe wastewater disposal, wastewater recycling, de-salting of groundwater, water conservation, and watershed restoration. There is a total of 100 funding categories for water items in the measure. The bond also funds implementation of SGMA. It partly funds the repair of the Oroville Dam, which was a huge public safety problem, and the repair of the Friant-Kern Canal, which is a key water delivery element for more than a million acres of the best farmland in the world. The proposed bond also provides funding to help address the Salton Sea's environmental problems. The proposed bond does not provide funding for the WaterFix. Water organizations should consider putting this water bond on their agendas and providing support and endorsements.

Joaquin Esquivel, Board Member, State Water Resources Control Board, the newest Board Member, discussed the incredible moment we are experiencing with SGMA especially its integration of surface and groundwater. Also talked about the use of Lidar in the United Kingdom.

Senator Bill Monning, Member, Senate Natural Resources Committee, informed attendees that the new Senate Pro Tem Toni Atkins was sworn in, and that most of California relies on groundwater for supply, with overdraft a key issue. He also said desal of seawater and brackish water are potential solutions. California has approximately 1.5 to 2 million people who don't have access to safe drinking water, and this may be comparable to our Flint Michigan, with many disadvantaged communities drinking nitrate contaminated water in the Central Valley. The Senator spent most of last year working on SB 623, the Safe and Affordable Drinking Water Fund, to help address this issue by raising about \$2B through a new water fee, tax on dairy products and fertilizer applications, which were negotiated with agricultural stakeholders, a historic achievement. This would call for Californians to pay up to \$95 per month to help give clean, safe drinking water to communities, which was established as a human right through legislation passed in 2012. ACWA opposes the legislation but has not provided a solution in its place that all can agree on. The bill is now in budget committees and requires a two-thirds vote to move forward.

The 17th Legislative Symposium was another resounding success, providing attendees with timely information on what is being discussed in the Capital. The GRA Legislative Committee and our Legislative Advocates and their staff, Rosanna Carvacho, Chris Frahm and Gianna Setoudeh with Brownstein Hyatt Farber Schreck, were praised for providing attendees with timely information on what is being discussed in the Capital and delivering another outstanding program. Thank you, GRA members, for again supporting this event, making it the "go-to" groundwater legislative event in the Capital. GRA would again like to thank our sponsors and our partner for this event, the California Groundwater Coalition. Together we are educating lawmakers through providing and presenting sound science as a foundation for policy-making.

The Federal Corner

By Jamie Marincola, U.S. EPA

EPA Announces Up to \$5.5 Billion in New Funding for Water Infrastructure Projects.

The U.S. Environmental Protection Agency (EPA) announced the availability of funding that could provide as much as \$5.5 billion in loans through the Water Infrastructure Finance and Innovation Act (WIFIA) program. WIFIA credit assistance can be used for a wide range of projects, including drinking water and distribution, wastewater conveyance and treatment, enhanced energy efficiency at drinking and wastewater facilities, desalination, aquifer recharge, alternative water supply, water recycling, and drought prevention, reduction, or mitigation projects. Prospective borrowers seeking WIFIA credit assistance must submit a letter of interest (LOI) by July 6, 2018. To find out more about WIFIA, read here: <https://www.epa.gov/newsreleases/us-epa-announces-new-funding-water-infrastructure-projects>.

USGS Releases New Web-Based Groundwater Model Visualization Tool.

A new U.S. Geological Survey groundwater model visualization tool is now available to help users visualize the inputs and outputs of complex groundwater models across the country. This new web-based mapping tool, called GW-WebFlow, allows water managers and the public to visualize complex groundwater models in a more understandable way. GWWebFlow supports most MODFLOW-based groundwater models; new models will be added in the future with little modification or customization. Currently, there are three USGS groundwater models available for viewing from the USGS Texas Water Science Center while the USGS plans to add other existing groundwater models from around the country. For more, visit: <https://www.usgs.gov/news/usgs-releases-new-web-based-groundwater-model-visualization-tool>.

EPA Prioritizes Cleanup of Casmalia Superfund Site.

U.S. EPA released an updated Administrator's Emphasis List of Superfund sites, representing sites that will benefit from the Administrator's targeted, immediate, and intense attention. The Casmalia Resources site in Santa Barbara County, California, was added to the list to spur action on cleanup and redevelopment efforts. The site is a 252-acre

former commercial hazardous waste management facility that accepted about 5.6 billion pounds of wastes between 1973 and 1989 contaminating soil, air, surface water, and groundwater. To read about the site clean-up, please visit: <https://www.epa.gov/newsreleases/us-epa-prioritizes-cleanup-casmalia-superfund-site>.

Technology Innovation News Survey Corner Available on EPA CLU-IN.

The Technology Innovation News Survey on U.S. EPA's Contaminated Site Clean-Up Information (CLU-IN) website contains market/commercialization information, reports on demonstrations, feasibility studies and research, and other news relevant to the hazardous waste community interested in technology development. Example resources in recent issues include Estimating the High-Arsenic Domestic-Well Population in the Conterminous United States, Rapid Assessment of Remedial Effectiveness and Rebound in Fractured Bedrock, and NMR-Based Sensors for In Situ Monitoring of Changes in Groundwater Chemistry. Recent issues, complete archives, and subscription information is available at: <https://clu-in.org/products/tins/>.

Jamie Marincola is the California Coordinator at the U.S. Environmental Protection Agency Region 9 Water Division. For more information on any of the above topics, please contact Jamie at 415-972-3520 or marincola.jamespaul@epa.gov.

A Roundup of Findings on Glyphosate

By Bart Simmons, Ph.D., retired DTSC

Glyphosate [N-(phosphonomethyl)glycine] and Glyphosate-based products (GBPs) are the most widely used herbicides in the world. They have increased crop productivity and provided critical food supply in developing countries. The use of genetically-modified crops, such as Roundup-ready soybeans, has prompted even greater use. Glyphosate is a non-selective herbicide that expresses its toxicity by inhibiting 5-enolpyruvylshikimic acid-3-phosphate synthetase. This enzyme is not present in mammalian tissues; therefore, glyphosate was expected to be non-toxic to mammals. The principal degradation product for glyphosate is aminomethylphosphonic (AMPA).

Although once considered benign, GBPs have recently come under attack, primarily for possible health effects. In 2015, the International Agency for Research on Cancer (IARC) listed glyphosate as a "Probable" human carcinogen. However, the US EPA, in its draft risk assessment, called glyphosate "Not Likely to be Carcinogenic to Humans." Much of the disagreement focus on risk of Non-Hodgkin Disease or Multiple Myeloma. In its draft risk assessment, EPA concluded that there is no evidence to support a causal relationship between glyphosate exposure and leukemia, multiple myeloma, or Hodgkin lymphoma. A "consensus statement" published in the journal *Environmental Health* noted numerous data gaps and recommended several additional studies, primarily on toxicity.

In its "Preliminary Ecological Risk Assessment for Glyphosate and its Salts," EPA states that glyphosate has a half-life of 14 to 518 days in aerobic water-sediment systems and 199 to 208 days in anaerobic water-sediment systems. Glyphosate and AMPA bind tightly to soil and move with suspended particulate matter. Although glyphosate and AMPA are relatively non-persistent, studies have found them in stormwater, surface water, and groundwater, although mobility is very limited. Glyphosate accumulates in sediment and is biodegraded to AMPA. In a Canadian study, four of five urban sites contained them in shallow riparian zones. Because the concentrations of these compounds are low, data can be mis-interpreted. One study showed that calculated median concentrations were 10,000 to 100,000 times higher if they excluded the non-detect results. They have been measured using ultra high-pressure liquid chromatography-mass spectrometry with electrospray ionization (UPLC-MS/MS ESI).

For perspective, the risk posed by glyphosate and AMPA is likely dwarfed by other leachable contaminants, such as coliforms and nitrates.

We have learned much about glyphosate since its introduction, and there is more certainty regarding its environmental fate. The potential impact on human health, however, remains murky. The public comment period for the various EPA draft documents is closed. It remains for EPA to decide the fate of this most widely used herbicide.

Bart can be reached at bartonps@aol.com.


2018 Advertising Rates

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For additional information, visit www.grac.org or contact Sarah Erck, GRA Administrative Director, at serck@grac.org or 916-446-3626.

TO ADVERTISE IN HYDROVISIONS CALL 916-446-3626 TODAY

GRA Welcomes the Following New Members

JANUARY 1 - MAY 2, 2018

Aaron Collier	Gerard Aarons
Abdullahi Arabi Suleiman	Glenn Knapp
Alan Becker	Grace Su
Alec McConnell	Grant Ohland
Alice Towey	Greg Hamer
Amanda Lopez	Gregory Korose
Amer Hussain	Hughbert Collier
Amy Ewing	Jake Perry
Ana Paine	Jana Marquez
Anna Schiller	Jean Moran
Araceli Serrano	Jennifer Pensky
Berry Hecht	Jillian Brown
Bill Leever	Jim Meier
BJ Lechler	Jim Mulligan
Brad Gleason	Joe Bahde
Brett Storey	Jon Gamble
Brian Wallace	Jon Swope
Briana Seapy	Jorge Perez
Bryce Johnson	Joseph Kingsbury
Burton Gilpin	Joshua Sobolew
Calvin Hardcastle	Julie Randol
Cameron Dobbs	Karen Lancelle
Cary Keaton	Katherine Howe
Chris Silva	Kathryn Oehlschlager
Christine Pham	Kelye McKinney
Christopher Guillen	Ken Ames
Craig Divine	Ken Minn
Craig Stewart	Kent O'Brien
Cristobal Loyola Agnosto	Kiersti Ford
Cynthia Fischer	Kim Holland-Chominsky
Dana Dean	Kristin Sicke
Dana McCarthy	Linda Conlan
Danyun Wang	Lucas Budny
Dave Zuber	Lynne Baumgras
David Cameron	Madeline Schofield
Dejan Pavic	Maile Gee
Don Lee	Mark Edwards
Duane Paul	Mark Nicholls
Dwayne Campeau	Martin Bradshaw
Eileen Bailiff	Matt Stone
Erica Key	Matt Parker
Geoff Vandenheuvel	Melissa Thaw

Dates & Details

GRA EVENTS & KEY DATES

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

First Annual Western Groundwater Congress

September 25-27 | Sacramento, CA

Groundwater Sustainability Bootcamp – A Short Course

February 5-6, 2019 | Davis, CA

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

Meng Ma	Robin Mahoney
Michael Sayre	Sage Montenero
Miranda Kahrilas	Sevim Onsoy
Natalie Stork	Steffany Loeb
Nathan Collier	Stephen Bradbury
Nigel Crook	Susan Hubbard
Olin Applegate	Tara Rolfe
Pascual Benito	Thandar Phyu
Patrick Devericks	Thet Naing
Paul Gosselin	Thomas Mohr
Paul Nelson	Tim O'Halloran
Peter Corral	Tom McCarthy
Rachel Mills	Tony Martin
Ralf Junghanns	Vincent Robino
Rebecca Smith	Wendy Bagnasco
Rick Viergutz	Wesley Henson
Rob Tribble	William Ward
Robert Kovacs	Ying Song
Robert Tweidt	
Robert Wagner	

Thank You to Our Contributors

Special thanks goes to David Abbott for his donation to GRA's Scholastic Fund in the amount of \$369.33.



CENTRAL COAST

By Bryan Bondy, Branch Secretary

On February 21, 2018 the Central Coast Branch was excited to have Menso de Jong, Ph.D. candidate, from the UCSB Earth Sciences Department present *"Insights From a Low-Porosity Hydrothermal Aquifer Tracer Study."* The presentation discussed a sulphur hexafluoride (SF₆) push-pull tracer experiment in sub-seafloor hydrothermal fluid circulating in the eastern flank of the Juan de Fuca plate in 2010-2014 to evaluate heat flux in oceanic crust in the vicinity of a spreading center. Previous studies measured heat fluxes that were inconsistent with theoretical (modeled) convective flux. Researchers postulated that hydrothermal fluid flow in fracture systems may be responsible for removing heat not considered in the convective flux models. The tracer experiment was performed to explore this concept.

Experiment planning and initial data analyses assumed a point-source instantaneous tracer injection, analogous to a high porosity terrestrial

groundwater system. Additional tracer breakthrough data from adjacent boreholes gave reason to reevaluate the initial conceptual model, potentially replacing the original terrestrial analog model with a completely different model with:

- Extremely limited effective porosity
- 10-100x-lateral-anisotropy controlled by ridge-parallel faulting

A near-instantaneous breakthrough downgradient of the injection site suggests that effective porosity is so limited that the injectate volume alone was sufficient to displace fluid 200-300 meters. A secondary tracer was injected in two pulses hours apart and intended to thoroughly mix in the vicinity of the borehole, effectively producing one signal. Instead, it produced two distinct breakthroughs, supporting the ultra-low porosity hypothesis. Continuous autonomous sampling systems provided high-resolution data in this fractured rock aquifer and provided opportunities to refine tracer study planning in low porosity systems and analytical techniques for dissolved gas tracers. The methods, results, and interpretations of these data have the potential to guide future sub-seafloor aquifer studies and may be useful in terrestrial fractured-rock aquifer settings for potable use studies, contaminant transport, and geothermal reservoir applications.

Our Branch members very much enjoyed Menso's presentation.



SACRAMENTO

By Linda Bond, Branch President

Scholarship activities: Over 100 professionals and students attended our annual David Keith Todd (DKT) lecture featuring Jeffrey Mount in February at the California State University in Sacramento (CSUS) Alumni Center. This year we awarded \$3,400 (Branch \$1,700 and \$1,700 from State GRA) to the CSUS Geology Department for student research.

Past speaker: May 9th: Rob. M. Gailey, PG, CHG, UC Davis and R.M. Gailey Consulting Hydrogeologist, Domestic Well Supply Reliability During Drought: Stress Testing for Groundwater Overdraft and Economic Costs.

Next Speaker: June 6th, Kirby Brill, Former General Manager of the Mojave Water Agency, Southern California David Keith Todd Lecturer (invited) in conjunction with the GRA first annual Groundwater Sustainability Agency Summit.



SAN DIEGO

By Patrick Rentz, Branch Secretary

Meetings, Accomplishments, Other Branch Activities:

The San Diego branch held the second meeting of the year on March 5th, at the GRA BSMAR 16 event in San Diego. The event was titled “IAH Commission on Managing Aquifer Recharge – a global rescue mission!” and the speakers were Peter Dillon, co-founder of IAH Commission on managed aquifer recharge and David Pyne, president of ASR Systems. Approximately 45 people were in attendance for a presentation on identifying and resolving selected technical issues related to

ASR wells, wellhead and wellfield design and operations and scientific considerations (i.e. aquifer hydraulics, mobilization and attenuation of selected water quality constituents and associated geochemistry). Real-world case studies of ASR applications were presented, and recent developments and advances were discussed.

The third meeting of the 2018 year is scheduled for June 19th and will feature Kevin McGillicuddy, chief hydrogeologist of the Roscoe Moss Company. This presentation will highlight the critical components of the well construction process with particular emphasis on the design of the well screen. Proper application of these design and construction techniques can maximize the well’s production potential and service life. Additional topics will include screen comparison studies conducted in the laboratory and field conditions and a discussion on the hydraulic losses that contribute to drawdown in the well. Included will be a discussion of pros, cons, and pricing of various screen and casing materials (e.g., PVC, low-carbon steel, high-strength low alloy steel, 304 stainless steel, 316 stainless steel, etc.).



SOUTHERN CALIFORNIA

By Herbert Vogler, Branch Secretary

The Southern California Branch, focusing on Los Angeles and Orange Counties, did not have a branch dinner meeting during the past 3 months, however the branch plans to host its next meeting at the offices of the Orange County Water District (OCWD), at 18700 Ward Street in Fountain Valley. At the meeting, Dr. W. Richard Laton of California State University, Fullerton (CSUF) will give his presentation entitled “20 Years of CSUF Research from Mojave to the Ocean.” He will discuss the research work of the more than 100 students he has guided for the past two decades. Their research topics include: geology, stratigraphy, contaminant fate and transport, aquifer characterization, and modeling. His students developed an invaluable dataset that has improved the understanding of the region’s geological and hydrogeological systems.

The Southern California Branch again, thanks all GRA Members who participate in our branch. We endeavor to be more active for the remainder of the year, and we welcome volunteers who would like to assist us. We hope you’ll attend our upcoming branch meeting and look forward to seeing you there.

GRA Communications

GRA keeps you informed on member benefits, groundwater news, legislation, and events in a lot of ways, but the primary method is email. If you’re subscribed to the email list and are not receiving messages, try reconfirming your [email subscription](#). If the confirmation doesn’t come through, please contact your IT department, and ensure they whitelist emails from @grac.org

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The Parting Shot

By John Karachewski, Ph. D.



Torrey Pines State Natural Reserve protects one of the wildest stretches of land along the Southern California coast. Its fragile environment of high, broken cliffs and deep ravines overlooking the sea includes one of the world's rarest pine trees—*Pinus torreyana*. Torrey pines are believed to be the remnants of an ancient woodland that once flourished along the southern California coast during the Ice Ages, but now grow naturally only on this small strip of San Diego coastline and on Santa Rosa Island. The 1,500-acre reserve also includes maritime chaparral, miles of unspoiled beaches, and a lagoon that is vital to migrating seabirds.

Early Spanish explorers named the grove of trees in the area “Punto de Los Arboles” or “Point of Trees.” The trees served as a landmark for sailors navigating off the coast. In 1850—the year of California’s statehood—botanist Charles C. Parry identified this pine as a unique species and named it after his friend John Torrey, a leading botanist of that

time. When Dr. Parry returned to the area in 1883, he was distressed over the lack of protection for the trees. The San Diego City Council and concerned newspaperwoman and philanthropist Ellen Browning Scripps purchased land slated for subdivision to protect the Torrey pines. By the time of her death in 1932, Ellen Browning Scripps had contributed significantly to the establishment of the reserve.

Torrey pines have extensive root systems to hold them securely in this generally poor soil and arid climate. The variety of pine shapes is dictated by the elements—dwarfed and gnarled where most exposed to wind and salty air or taller and more upright in sheltered areas.

Photographed along Parry Grove Trail. GPS coordinates of the photograph are 32°55'12" N 117°15'28" W. Information for the Torrey Pines Docent Society and for visiting the reserve is available at: https://www.parks.ca.gov/?page_id=657 and <https://torreypine.org/>.