

## STEM Refocuses Water Education in Arizona

by Jacob Prietto, WRRC Graduate Outreach Assistant

In recent years, U.S. employers have been reaching out internationally in order to fill job vacancies in highly skilled science, technology, engineering and math (STEM) fields. This situation has led to calls for better STEM education in the United States. Innovative educational initiatives have emerged to answer the call for more professional competence in these STEM areas. In his 2012 State of the Union address to Congress, President Barack Obama again emphasized the need to interest and educate young people to become the scientists, engineers and mathematicians of the future. "Growing industries in science and technology have twice as many openings as we have workers who can do the job." The challenge, he said, is providing the right educational environment for teachers and students to excel.

Proponents of STEM education may have found a superstar spokesperson this August with NASA's Mars rover landing of *Curiosity*. A Flight Director on the mission, Bobak Ferdowsi aka "The Mohawk Guy", became an overnight internet sensation, with his red-streaked and star studded mohawk hairdo, captivating the online social networks and viral news feeds. In an interview with Shira Lizar, for *What's Trending*, Ferdowsi speaks about the potential influence the Mars landing mission could have on STEM education. "I hope it encourages a lot of people to get into math and science, and technology and engineering." He says, "It's a lot of fun... you could be whatever you want, as long as you have a passion."

In 2001, Judith A. Ramaley was the first person to conceptualize STEM. As director of the National Science Foundation's education and human resources division, Ramaley began developing curriculum to advance the education

*STEM continued on page 9*



*Students gather to inventory plant and animal diversity as part of WIP's interactive Riparian Areas and Biodiversity Unit. Source: Arizona Project WET*

## The Water Investigations Program Inspires Tomorrow's Scientists and Engineers

by Kerry Schwartz, Holly Thomas-Hilburn and Candice Rupprecht, WRRC Arizona Project WET

Imagine middle school students calculating water use at their school, faucet by faucet; and then installing water saving technology. Then imagine a team of student scientists, studying river macroinvertebrates or mapping the locations of animal tracks or laying out transects to inventory plant species, all in a pristine riparian setting. If you can imagine this, you will be imagining how real students in Arizona schools were spending their time last school year in Arizona Project WET's Water Investigations Program (WIP).

These experiences define educational best practices: hands-on, student-driven questions, real data, relevance and purpose. WIP represents a new full-year approach to modeling these practices for teacher professional development. Their middle school students benefit from the program by learning about urban water use and riparian systems through a year-long exploration.

The WIP was piloted in 2010-2011 with five teachers, thanks to a small Arizona

*WIP continued on page 2*

C O N T E N T S		
ANNOUNCEMENTS..... 4	NEWS BRIEFS..... 5	GUEST VIEW ..... 6
SPECIAL FEATURES ..... 7	STUDENT SPOTLIGHT..... 8	RESOURCES ..... 10
	PUBLIC POLICY REVIEW..... 11	



*A student installs water saving faucet aerators in his school's bathroom sinks as part of a Water Investigations exercise to understand the school's water use. Source: Arizona Project WET*

Department of Environmental Quality grant. Students from these classes conducted their investigations at The Nature Conservancy's San Pedro River and Three Links Farm Preserves.

The Nature Conservancy of Arizona became a full partner in 2011, and the Program expanded to the Phoenix Valley. Nineteen teachers were recruited for the 2011-2012 school year. These teachers participated in a three-day summer academy, followed by three more training days over the school year. By the end of the year more than 1,800 students had taken part in the WIP. In the coming year, 1,900 more students are slated to join the ranks of Water Investigators in their communities.

The approach is interdisciplinary. In the 2011-2012 school year students learned about the natural systems within the larger hydrologic cycle as well as the human constructed water distribution system. They also explored the connections between urban water use and the water in Arizona's rivers and riparian systems.

A 2011 Gallup poll shows that water issues are Americans' top environmental concern, however a recent Nature Conservancy study found that 75 percent of adults cannot identify where their water comes from when asked. Filling that gap – helping youth and their families understand where their water comes from – is a



*A student captures samples to study a riparian area's macro invertebrates. Source: Arizona Project WET*

focal point of Arizona Project WET's WIP.

The WIP is incorporated into students' existing curriculum over an entire year. Students can dig deeply into the study of water through projects that integrate all subject areas. WIP students work their way through three thematic units, starting with the Water Resources & Supply Unit, which focuses on understanding Arizona's natural systems and the urban water distribution system. Lessons are interactive and employ physical models

Water Use is the second thematic unit. This is the unit in which the students take part in a water audit of their school. The exercise of performing the audit themselves teaches good scientific practice. This unit provides a fundamental understanding of all the ways water is used in daily life and challenges students to ask questions and propose solutions to conserve water.

Stepping through a program of scientific investigation, students first measured faucet flow at bathroom faucets, then they installed faucet aerators and measured the flow again. An



*In their field study, students design and conduct their own riparian area investigation to test water quality parameters. Source: Arizona Project WET*

aerator lowers the amount of water coming out of a faucet each minute by mixing in air. Next they were asked to identify what else they would need to know to figure out the number of gallons used in the school bathrooms in a year. They then designed a scientific procedure to determine the frequency and duration of faucet use in the school. Students had to bring their math skills into play in order to quantify their school's water use. By knowing the before and after flow rates and the amount of water used, the students were able to calculate water savings. Finally, students taught their parents to audit their bathroom faucets at home and install water efficient aerators that save their families water and money. The school and home water audits in Maricopa County resulted in an annual water savings of 10.3 million gallons from the installation of 2,075 aerators.

The WIP concludes with the Riparian Areas and Biodiversity Unit. The high point of this unit is a field study in a local riparian

area or preserve. After a year of learning to develop testable questions, students are challenged to design and conduct their own riparian area investigations. Students developed questions on a wide range of topics, from testing water quality parameters to inventorying plant and animal species diversity. The scale of this activity was tremendous. On 14 different days, 1,500 of these students visited the Hassayampa River Preserve. There they conducted their own investigations, with mentor scientists from the University of Arizona and Prescott College on hand to facilitate learning.

The WIP culminates with a Student Symposium at a local Community College or University. Just as at a scientific conference, students deliver Prezi or Power Point presentations to

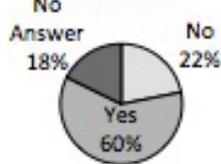
peers, teachers and community members.

The Student Symposium for the 2010-2011 WIP was held at the University of Arizona for 200 students. At the end of the 2011-2012 WIP, Phoenix College hosted 300 students who gave over 50 presentations and nearly 300 additional students participated in symposium events at their schools.

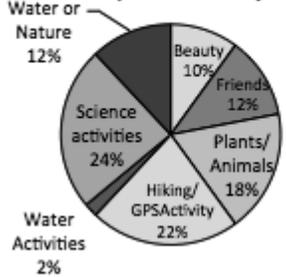
Kerry Schwartz, APW Director, looks on the WIP as a model of effective water education, "WIP students are learning to make a difference in their communities. They're becoming interested in investigating scientific questions and engineering solutions. They're getting comfortable with thinking critically about complex issues. Students like these are Arizona's future." 

### Hassayampa Field Day Assessment

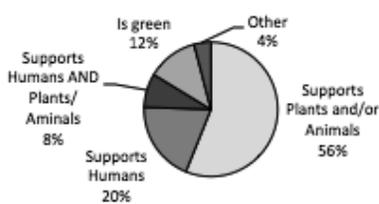
**Have you ever been to a river before?**



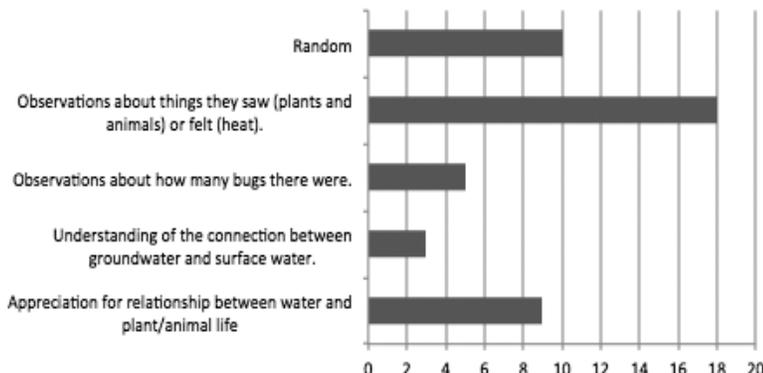
**What did you value most about your experience today?**



**What do you think is important about water in the desert?**



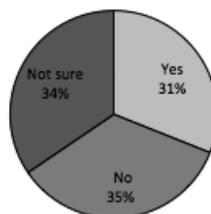
**What discovery or insight did you make about the Hassayampa River?**



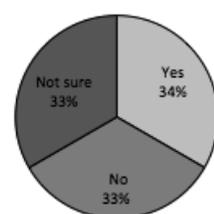
### Symposium Student Survey

**What is your interest in STEM fields?**

**Do you think you could become a scientist or engineer?**



**Do you think you will go to school after high school in a STEM field?**



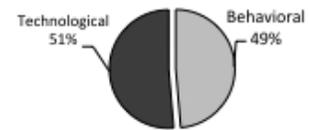
For comparison, 10.7% of all degrees awarded in 2008-2009 were in STEM fields.

**Name some technological and some behavioral ways to save water.**

**Pre-Test Answers**



**Post-Test Answers**

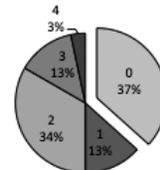


On average, students named about 3 more ways to save water in the post test.

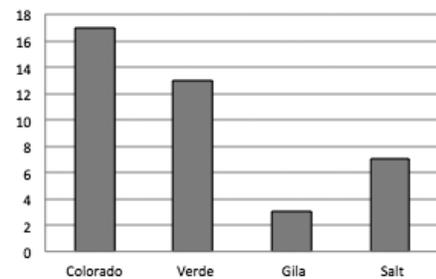
**Where does your water come from?**

63% of students listed at least one body of water that is part of their water source.

**What specific bodies of water are a part of your water source? (By number of bodies listed)**



**Water Bodies Students Identified**



# ANNOUNCEMENTS



## Arizona Research: Communication! Connection! Collaboration!

The AZWater Research Committee in collaboration with the University of Arizona's Water Resources Research Center has organized a one-day interactive workshop dedicated to Arizona's water industry. The workshop is organized around panel discussions on the roles of regulatory and institutional players, universities, water utility companies and the water industry. The panel discussion will include but is not limited to topics such as research on drinking water, wastewater, potable and non-potable reuses and soil aquifer treatment. This interactive workshop is designed to bridge the gaps between scientific research and utility/industry needs. It will inform those who are interested on emerging water quantity and quality issues, cutting edge water science and technologies, upcoming regulatory requirements and industry trends. Discussions are intended to promote communication and collaboration by sharing available resources, partnership opportunities, and funding sources. This event will facilitate discussion and form connections between water industry leaders, research universities, city and state governments, water utility companies and others interested in the future of Arizona's water. The workshop will be held at the City of Phoenix Burton Barr Central Library on October 16, 2012 from 9am to 5pm. The registration fee is \$40 per person and includes lunch.

## Workshop on Creating Sustainable Landscapes at AHS Symposium

A workshop, "Using Low-impact Development (LID) and Smartscape to Create Sustainable Landscapes", will be held September 18 from 1:00 - 5:00 pm, at the event site, preceding the regular sessions of the Arizona Hydrological Society's 2012 Annual Symposium. It will provide an overview of LID practices that use new technologies in combination with natural materials to collect runoff and provide stormwater attenuation and other benefits. It will also introduce Smartscape principles and demonstrate how they can be integrated to create sustainable, low maintenance,

multi-functional landscapes. Instructors will include: Summer Waters, CFM, Water Resources Agent, University of Arizona Cooperative Extension, Maricopa County; Evan Canfield, PE CFM, Chief Hydrologist, Pima County Regional Flood Control District; Haley Paul, Water Resources Program Coordinator, University of Arizona Cooperative Extension, Maricopa County; Jenna Cleveland, Research Assistant, Water Resources Research Center, University of Arizona. Registration is \$35 for Symposium registrants and \$45 for the workshop only. Register for this and other water workshops at: <http://azhydrosoc.org/2012Symposium/registration.html>.

## City Data Now Available at Data.gov

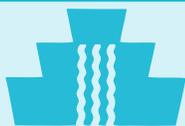
The U.S. Government's Data.gov recently launched its new cities community. The Data.gov provides access to data and applications to specific "communities" including, among others, business, developers, education, energy and health. The new cities community gathers local city data from across the country. Residents of a city can find new ways to explore city services and information. Developers can learn more about challenges to using the data to produce interesting analysis and applications. The data and the applications created to increase usability are clearly accessible on the website, and a user can access as a resident, city official or developer. Visit City Data at <http://www.data.gov/communities/cities>.

## AHS 2012 Annual Water Symposium

The Arizona Hydrological Society 2012 Annual Symposium, "CONFLUENCES 25 years of bringing water, people, and ideas together," will be held in Phoenix, September 18 - 21, 2012, at the Desert Willow Conference Center, 4340 E. Cotton Center Boulevard. This year's program is jam-packed with technical sessions on topics ranging from drought and climate to subsidence and the water/energy nexus to water sustainability. Optional workshops and field trips are also part of the mix. Student scholarships are available. To find out more go to: <http://www.azhydrosoc.org/2012Symposium.html>

## Colorado River Topic of New Film and Panel Discussion

The WRRC is cooperating with the Redford Center, the Sonoran Institute and the Tucson Audubon Society to host the screening of a new documentary on the Colorado River. The film "Watershed: Exploring a New Water Ethic for the New West" is a series of vignettes that illustrate the character of the river and the challenges and choices facing everyone who depends it. Following the screening, a panel of regional leaders will discuss the information and messages presented in the film. Panelists include Mark Decena of Kontent Films, the Director of the film, as well as Luther Propst, Sonoran Institute; Osvel Hinojosa, Pronatura Noroeste; and Sharon Megdal, WRRC Director. The program will be held at the Loft Cinema, 3233 E Speedway Blvd, Tucson, AZ, on September 19th, 7:00pm - 9:00pm.



Arizona Water Resource is published quarterly by the University of Arizona Water Resources Research Center. AWR accepts news, announcements, and other information from all organizations.

Editor: Susanna Eden

Designer: Lisa Watanabe

Newsletter Link: <http://wrrc.arizona.edu/publications/awr>

WRRC Website: <http://wrrc.arizona.edu>

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# NEWS BRIEFS



## Tucson Showcases Its Water Leadership to a National Audience

October 15-17, Tucson water leaders will make their way to Cincinnati for the 3rd annual Urban Water Sustainability Leadership Conference. The meeting brings together urban leaders steering their cities away from gray toward green infrastructure to accelerate the pace of resource recovery in the name of urban sustainability. The Leadership Conference organizers want to inspire greater integration of policies among water, land use, parks, forests, transportation, energy, agriculture, and other sectors. They see integrated, multi-benefit projects that produce triple bottom-line results as the pathway to revitalizing cities.

Tucson will be among the five U.S. cities - Cleveland, Denver, Kansas City, Syracuse, and Tucson - that will showcase their innovations and collaborations at the Leadership Conference. The Spotlight on Tucson/Pima County panel will feature Jackson Jenkins, Director, Pima County Regional Wastewater Reclamation Department; Ed Curley, Senior Program Manager, Pima County Regional Wastewater Reclamation Department; Claire Zucker, Sustainable Environment Program Director, Pima Association of Governments; Shane Snyder, Ph.D., Professor, Chemical and Environmental Engineering, and Co-Director, Arizona Laboratory for Emerging Contaminants (ALEC); Alan Forrest, P.E., Director, City of Tucson Water Department; and Paul Green, Executive Director, Tucson Audubon Society.

The Leadership Conference is organized annually by the Clean Water America Alliance's Urban Water Sustainability Council. It is being co-hosted in 2012 by CONFLUENCE Water and Technology Cluster of Greater Cincinnati.

## 2012 CAP Announces Awards for Water Research

Central Arizona Project (CAP) has announced the winners of its 2012 CAP Award for Water Research. The Award recognizes excellence in graduate or undergraduate student research addressing water issues facing the lower Colorado River basin states (Arizona, California and Nevada).

The 1st Place Award winner is Matthew Stroud, a graduate researcher in Hydrology and Water Resources at the University of Arizona, for his research paper titled "Solar Desalination in The Southwest United States." Mr. Stroud will receive \$1,000 from CAP. The 2nd Place Award winner is Elizabeth Martin, a Ph.D. student in Water Resources Engineering at Arizona State University, for her paper "Value Intensity of Water Used for Electrical Generation in the Western U. S.; An Application of Embedded Resource Accounting." Ms. Martin will receive \$500 from CAP.

Award recipients will be recognized during a special luncheon at the Arizona Hydrological Society Annual Symposium and will present their research during regular conference sessions. The winning papers will be published in the conference proceedings and on the CAP web site (<http://www.cap-az.com/PublicInformation/AwardForResearch.aspx>).

## New Conservation Tool from Pacific Institute

The Pacific Institute's Water-Energy-Climate Calculator (WECalc): A Tool for Greater Efficiency estimates water and energy use based on response to questions about personal home water use habits. The tool is accessible and the questions are specific. The connections between energy and water use are clearest to homeowners when it affects what they pay. A non-homeowner may struggle to answer all of the questions. The tool provides default answers for the average users when they are unsure about their answers.

We want to know how much it costs us and how much can we save. WECalc offers individuals a personalized estimate of water and energy use (how much is being used at home for various home appliances) and recommendations for reducing use. The delivery and treatment of water for home use requires energy that is often overlooked. This tool emphasizes the fact that reducing water use reduces energy use and the emission of greenhouse gases. Its potential for changing behavior lies in its emphasis on these connections. <http://www.wecalc.org/>

*News continued on page 8*

## The WRRC's 2013 Annual Conference Takes on Groundwater Security

For its 2013 Annual Conference on March 5, 2013, the Water Resources Research Center at the University of Arizona is collaborating with the United States Geological Survey, Arizona Water Science Center, to tackle the large and complex subject of groundwater security. The conference, "Water Security from the Ground Up", will examine water security from multiple angles. It will present perspectives from scientists and water policy and management experts on sustainable use, augmentation and protection of groundwater resources from over-exploitation, contamination and other hazards, including drought and climate variability. Speakers will discuss issues of groundwater policy and the role sound governance plays in safeguarding human values and ecosystem functions that depend on groundwater. Experts will inform us on current trends and strategies for securing the supplies to support our quality of life now and in the future.

Please join us as we explore the path to groundwater security.



## My Summer in Singapore

by Shane Snyder, UA Department of Chemical and Environmental Engineering

What could possibly motivate a person to pack up a family of five, including twin one-year olds, and travel for 30 hours to live on a crowded island in South East Asia for 10 weeks? I asked this question many times before leaving for Singapore in May of this year to work as a visiting professor at the National University of Singapore. Despite the epic travel challenges and adapting to life in Singapore, the summer was full of amazing opportunities. Without question, Singapore has some of the most advanced water research and management programs in the world. To understand why this relatively small City-Country would invest so heavily into water, it is important to understand the context in which investment into water occurred.

Singapore is an island on the southern tip of the Malay Peninsula, separated from Malaysia by less than one-half mile and just 85 miles north of the equator. With a population of approximately 5.2 million people living on a land area of just 272 square miles, Singapore is the third most densely populated country in the world. Singapore also has the third highest per capita income in the World and is ranked as a leading financial center. Despite average annual rainfall of just over 92 inches, Singapore has struggled to maintain a reliable and sustainable supply of fresh water for its people and industries.

Singapore has a long history of striving for water independence. In 1868, the British built the first water reservoir in Singapore. In 1932 a pipeline was built to bring freshwater from Malaysia into Singapore. When Singapore became an independent nation in 1965, Malaysia threatened that if Singapore exhibited foreign policy “prejudicial to Malaysia’s interests” that its water could be turned off. This threat led then Prime Minister Lee Kaun Yew to set a goal of water “self-sufficiency” for Singapore.

The Singapore Public Utility Board (PUB) continued to develop reservoirs and dams on the island through the 1980s, but these measures still could not provide ample water for the rapidly growing nation. In the 1990s, Singapore negotiated with Malaysia for additional water supplies. These negotiations were not entirely successful; however, as Malaysia requested payments that began to approach the cost for ocean desalination. In 1998, Singapore initiated a study (known as the NEWater study) to determine if municipal wastewater could be purified to produce safe and reliable potable water.

Around 2001, Singapore developed the concept of having “four taps”, a diversified water supply that would extend their resources to gain self-sufficiency as envisioned by Lee Kaun Yew. The four taps consist of on-island supplies (reservoirs), imported supplies (Malaysia), recycled water, and desalination. The first two taps, local and imported supplies, continue to be important components of Singapore’s water portfolio. As of 2011, nearly two-thirds of Singapore’s land area is used as catchment to harvest water, and they have established a goal of 90 percent by 2060. Singapore continues to import water from Malaysia, but their water agreement expires in 2061 and the future of water importation remains in question. Most recently, Singapore has added the Marina Barrage,

which creates the largest reservoir in Singapore covering nearly one-sixth of the island’s area and has the capacity to meet about one-tenth of the total water demand.

Perhaps Singapore’s most visible and well-known action in water self-sufficiency is development of NEWater. Today, Singapore can supply up to 30 percent of their water needs through recycled water and they aspire to reach 50 percent by 2060. Their NEWater gained notoriety when they began to bottle and distribute purified municipal wastewater for drinking. The NEWater has undergone extensive testing and uses advanced water treatment, including reverse osmosis, in order to produce extremely pure and safe water suitable for human consumption and for industries requiring high-purity water (i.e., semiconductor industry).

The fourth tap for Singapore is ocean water desalination, which currently produces 30 million gallons per day, meeting approximately 10 percent of Singapore’s water needs. The goal is to increase the desalination capacity 10-fold by 2060 to meet approximately 30 percent of projected water demands. Thus, Singapore is well on their way to the water self-sufficiency envisioned by Lee Kuan Yew in the 1960’s.

Today the City-Country of Singapore is a global leader in water resource management and technology and a global hub for water research and innovation. The Singapore International Water Week (SIWW) has been held there annually since 2008. In 2011, more than 13,500 people from 99 countries attended and more than 600 companies exhibited at the expo. An estimated \$2.37 billion US dollars of deals were struck during the 2011 meeting alone. While the 2012 SIWW statistics are not complete, early registration counts exceeded 15,000 people and even more exhibits than previous years. In the future the SIWW will be held biennially, the next in July 2014.

The Singaporean government funds foreign professors to bring in new expertise to Singapore through their visiting professorship program. This program is allowing me to conduct research at the National University of Singapore, Environmental Research Institute (NERI) for five years. One great synergy of working at NERI results from its similarity with the Arizona Laboratory for Emerging Contaminants (ALEC), which I co-direct with Professor Jon Chorover. Both the NERI and ALEC hold a wide variety of state-of-the-art analytical instruments for advanced monitoring of water quality. Students proficient with our equipment at ALEC are able to work in NERI laboratories with minimal training and thus are able easily and rapidly to begin research in Singapore.

As the University of Arizona expands its partnership with Pima County and the City of Tucson to develop the Water & Energy Sustainable Technology (WEST) Center, it is likely that additional collaborative research initiatives will develop between Singapore and the UA. The WEST Center will provide a proving ground for new water and energy technologies, much as the Singapore PUB has done in Singapore. I encourage those interested in collaborating with the water research programs in Singapore to contact me for additional information, as bilateral opportunities exist through various government and private sector programs. The summer was truly productive and memorable for me and my family and we hope to see other UA faculty, students, and staff in Singapore next summer. 



## Leadership Training in Action: The Nogales Water Festival

by Holly Thomas-Hillburn and Kerry Schwartz, WRRC APW



*Student organizers from the Nogales High School Science Club and their local fourth graders watch as two students race each other across the field carrying buckets of water. Source: Arizona Project WET*

7 am: It's early in the morning at Nogales High School and classes won't begin for another hour, but on the practice field, students are hustling around, carrying teaching materials, setting up tables, and putting on nametags. There are only a few adults around, offering advice and direction, but it's apparent that the students are in charge. It's the day of the Nogales Water Festival, run almost entirely by the Nogales High School Science Club, with support from the Santa Fe Ranch Foundation.

Arizona Water Festivals rely on local partnerships. In the program's twelve year history, 64 Arizona Water Festivals have



*A Nogales high school student teaches an interactive water lesson to a crowd of interested fourth graders. Source: Arizona Project WET*

been held in 23 different communities in Arizona, and in each city, the Water Festival takes on a character and life of its own. Partners, usually water providers, city governments, and school districts, work with the Water Resources Research Center's Arizona Project WET to make this interactive learning event a reality for fourth grade students and teachers. Planning takes time, dedication, and plenty of communication between all partners (teachers, schools, volunteers, and sponsors). But what happens when our primary partner is a group of thirty high school students? In Nogales, Arizona, the enthusiasm and dedication of a group of high school students is inspiring partners and sustaining the water festival experience for hundreds of Nogales fourth graders.

The students, who were roped into the program in its first year by their high school principal and the science club advisor, mastered the lessons and became facilitators of learning for 4th grade students. They became invested in the festival and in the second year, approached Arizona Project WET about a repeat performance. Due to a loss of a local partner, the students took on the responsibilities of planning and coordination the festival. They worked with APW personnel to raise funds, contact teachers, and solicit the City of Nogales to provide shade tents, a water truck and portable toilets. With the support of APW and the Santa Fe Ranch Foundation, a local environmental non-profit, the students learned



*Fourth graders gather to learn from a Project WET student volunteer about runoff from this interactive model. Source: Arizona Project WET*

to plan and coordinate a community event, gaining leadership skills. Yet facilitating hands-on learning for their younger peers is where they really shone.

This year marked the third annual Nogales Water Festival, and the students who began participating in the water festival as freshman are now juniors. Students remember each lesson and choose what they will teach according to their strengths. The volunteer training helps them solidify science concepts they may have only recently learned and become effective communicators. Students apply their knowledge from environmental science, biology, earth science and engineering classes as we model how to use teaching tools to facilitate learning about the water cycle, groundwater, water conservation, and the watershed. After the training, they take home lesson scripts and practice until they feel confident in teaching without a script.

10 am: All around the field, fourth graders are laughing, learning, and vying for the attention of the high school students who are teaching them. Teenagers are becoming community leaders; growing up before our very eyes! Tony Sedgewick, President of the Santa Fe Ranch Foundation reflects on the day: "It is amazing to see how both the science club student teachers and the 4th graders connected with each other - It is criminal to have so much fun!"



# STUDENT SPOTLIGHT



Jacob Prietto is a second year Masters student with the Department of Hydrology and Water Resources at the University of Arizona. He has a BS in Environmental Hydrology and Water Resources from the same department. This fall he will be working at the WRRC as a Graduate Outreach Assistant on a project that will bring together stakeholder and modelers to develop a modeling framework for water resource planning and

management in the face of climate uncertainty. Jacob will assist with stakeholder engagement. The project is funded by the National Oceanic and Atmospheric Administration (NOAA).

Between completing his undergraduate studies and returning for his MS, Jacob began his career in Tucson as a professional hydrologist with a civil engineering consulting firm. For four years, he conducted floodplain mapping, stormwater mitigation, and drainage infrastructure design, working with a diverse array of professionals in the private and public sectors.

Jacob joined Arizona Project WET (APW) in 2010, as a water education facilitator. Since then, he has been communicating with a vast collection of teachers and students about water. Under the supervision of Kerry Schwartz, APW Director, Jacob has worked with classes from grade school to high school, covering topics such as water conservation, watershed management, groundwater, and water resources allocations. During the past

academic year, he assisted a class at Miles Middle School to perform a water audit, using the School Water Audit Program (SWAP) platform. Students were supported as they quantified the current water usages from all the water faucets on their campus. After installation of new, more efficient, faucet aerators provided by APW, the students calculated the new water usage and annual savings created by their efforts.

Through APW, Jacob has also worked as an Earth Camp Instructor the last two summers. Earth Camp is a partnership between the University of Arizona College of Science, Arizona Project WET, the Planetary Science Institute, and the Arizona-Sonora Desert Museum. As an instructor for both the middle school and high school camps, Jacob is known by the students as the water-guy, implementing APW activities, demonstrating hydrologic field work measurements, and leading conversations about water resources.

This year, Jacob was recruited by the Pima County Regional Flood Control District (PCRFD) as a Special Staff Assistant. Under the supervision of Evan Canfield, Water Resources Engineer, Jacob is conducting sediment transport analyses of the effluent dominated Santa Cruz River downstream of the Roger Road and Ina Road wastewater treatment facilities. As part of the Pima County Regional Optimization Program (ROMP), the facilities are currently being upgraded and Jacob's team has been charged the task of characterizing the pre- and post-upgrade hydraulic characteristics of the river.

The research Jacob is conducting for his thesis includes evaluating the influence of quantitative water quality parameters have on stream bed infiltration in an effluent dominated riparian river. He expects to graduate in the spring of 2013. 

News continued from page 5

## Federal Agencies Develop Resource Guide to Assist Rural Communities

The US Department of Agriculture, the Department of Housing and Urban Development, the Department of Transportation and the Environmental Protection Agency have recently published a resource guide, Federal Resources for Sustainable Rural Communities, as a collaborative effort to support rural communities in "their efforts to promote economic competitiveness, protect healthy environments modernize infrastructure and provide services to residents." Since June 2009, the agencies involved have been working together as the Partnership for Sustainable Communities to provide support to communities nationwide. This resource provides rural communities with information on federal funding sources and technical assistance opportunities available through these agencies.

The online publication outlines federal programs available to rural communities, and provides case studies of communities that have successfully made use of these programs in order to enhance their quality of life and economic vitality. The guide is organized by each participating federal agency, as well as broad topics such as community planning and economic development, housing, transportation, water infrastructure and water quality, energy efficiency, and agriculture and food. Aware that it is not exhaustive, the Partnership continue to update the list of

resources online. Rural communities and small towns now have a single resource to find the menu of federal options available to them when planning and implementing future projects.

A copy of the resource guide is available in the Spotlight section of the USDA Rural Development home page at: [http://www.rurdev.usda.gov/supportdocuments/RD\\_FedResourcesSustainableCommunities.pdf](http://www.rurdev.usda.gov/supportdocuments/RD_FedResourcesSustainableCommunities.pdf).

## Critical Aquifers under Pressure from Over Exploitation

In an article published in the August 8 issue of Nature, researchers at McGill University in Montreal and Utrecht University in the Netherlands reported on the results of a study into Global groundwater stress. The results indicate the world would need 3.5 times more aquifer capacity to sustain projected demand. Although 80 percent of the world's aquifers do not show stress, aquifers in Mexico, the United States, Saudi Arabia, Iran, India and China are being heavily over-exploited. Using combined groundwater use data and groundwater supply models they analyzed trends in groundwater storage across the globe. They included in their analysis the rate of aquifer replenishment and for possibly the first time in such a study, accounted for the water flows required to sustain ecosystems. The researched applied their analysis to approximately 800 aquifers. (See map at <http://www.nature.com/news/dummy-jpg-7.5764?article=1.11143>) 



of science, mathematics, engineering, and technology. ‘SMET’ was the first acronym tossed around the office, but she didn’t like it. So, Ramaley coined STEM to showcase science and math as the bookends that hold together technology and engineering. The acronym stuck; educators and policy makers are now following her lead, engaging students with deeper understandings using integrated approaches.

Organizations and agencies at all levels are now dedicating resources to promote and improve STEM education. These resources provide added impetus to efforts to recruit students into STEM fields and to enhance their educational experiences. In Arizona, Governor Jan Brewer charged the Science Foundation Arizona (SFAz) in September of 2010 to develop a community-based statewide plan for STEM education, launch the Arizona STEM Network, and implement the first Five-Year Plan for STEM Education. The Arizona STEM Network is a strategic effort to provide the structure, tools and resources needed to integrate effective STEM education into the state’s schools. According to the Arizona STEM Network, STEM education goes beyond traditional educational practices. It is an integrated, interdisciplinary approach to learning that provides project-based and relevant experiences for students. STEM education aims for a deep understanding of subject matter and its implications in answering questions and solving problems of local and global importance.

The University of Arizona (UA), has many STEM education initiatives. The UA STEM Learning Center is the place for students, teachers and professionals to investigate all things STEM related on campus. A central clearing house, it also acts as UA’s representative in *100Kin10*, a nationwide movement introduced in 2011 to train and retain 100,000 STEM teachers in the next 10 years. With funding from the National Science Foundation, the Southwest Institute for Research on Women at the UA’s College of Science, is expanding their research and outreach to incorporate more STEM components. A new program, “i-STEM” is working with 60 Native American and Hispanic youth groups (Grade 3-8) to implement mentoring programs and educational field trips to inspire youth to become involved in the STEM fields. The UA College of Science is also offering several professional development opportunities to K-12 educators and outreach specialists, part of the college’s collaboration with the Arizona Center for STEM Teachers (ACST), with a three-year \$1.5 million grant by SFAz. The center will act as a resource and training facility to expand and improve the quality of STEM teachers in Arizona. ACST is co-funded by the Philecology Foundation and is housed at the University of Arizona’s B2 Institute, located at Biosphere 2.

Water education and outreach professionals are evaluating what STEM means for water education. Neither reinvention nor business as usual, what we are seeing is an integration of core academic subject matter into a learning experience that reflects the real world water challenges. Universities, utilities, agencies, and research facilities are using water education as an opportunity to strengthen interdisciplinary studies and provide a common platform for water knowledge.

From his experience as a teacher, Tim Bayley at UA’s Biosphere 2 has seen the traditional approaches to education isolate the critical subjects. Today’s professionals were first taught fundamental subjects separately that were spliced together later as students pursued their graduate studies and professional careers. As a hydrologist, however, Bayley knows that the core subjects, like

math and physics must be understood in an integrated fashion to pursue hydrologic investigations. Bayley is creating a model for a more integrated learning experience using water education as a platform. At Biosphere 2, middle school and high school students are invited into the facilities and explore the variety of biomes behind the glass. The students generate their own research questions, and apply STEM components to pursue their own investigations. The program emphasizes the scientific method, constructing a hypothesis and evaluating data. “Science gets interesting when it’s applied to the real world,” says Bayley, about the opportunity students get when participating in actual research done by professionals at Biosphere 2. He uses the STEM focus as an opportunity to awaken kids to the beauty of science, engineering, and technology.

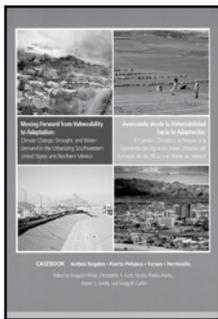
Arizona Project WET (APW) has been the leader in water education at the K-12 level for many years. Under the leadership of Kerry Schwartz, the State Coordinator for Project WET, APW has worked with stakeholders to integrate water education across the curriculum, combining STEM skills in the process of developing understanding of major water issues, through interdisciplinary instruction and the *5E* theory: engage, explore, explain, elaborate, and then evaluate.

Schwartz says “Lecturing to the audience does not work for the APW objectives.” In the past few years, the APW team has adapted professional development workshops to incorporate standards-focused Project Based Learning. This model engages students in answering questions, thinking through locally relevant problems, and applying learning. “Project Based Learning is the best way to integrate STEM subjects”, she says. Programs like the Water Investigations Program (see WIP article, this issue) and the Water Scene Investigators Program have students asking their own authentic questions and answering them by collecting data to support their claims. In the School Water Audit Program, students apply simple technological solutions to provide water savings at their schools and at their homes. Schwartz emphasizes that STEM subjects require integrated, solution oriented methods, “There’s a recognition that we have to do these things.”

Outside the academic setting, agencies and organizations with an interest in water education are refocusing their outreach efforts on STEM objectives. Salt River Project (SRP), the electricity and water provider of the greater Phoenix metropolitan area, has been promoting water education for more than 20 years. SRP has focused on three goals when implementing their water resources education programs: present a general understanding of hydrology and the water cycle, articulate the complex industry of water resources management which most often requires difficult solutions, and maintain a direct line of communication with teachers and students. With STEM playing a more significant role in education recently, the education department at SRP is implementing stronger components of engineering and technology into their curriculum.

“Technology doesn’t always mean a *computer*,” says Alison Smith, the Sr. Community Outreach Representative. “It could be a low flow toilet or a faucet aerator.” When SRP works with teachers, they set the stage with a regionally based water resources challenge and teachers provide their own expertise to solve problems. Brainstorming and collaborative efforts are brought to bear to find the best possible solutions.

STEM continued on page 12



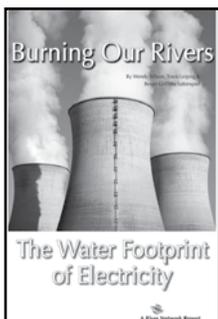
## Moving Forward From Vulnerability to Adaptation: Climate Change, Drought, and Water Demand in the Urbanizing Southwestern United States and Northern Mexico

Edited by Margaret Wilder, Christopher A. Scott, Nicolas Pineda-Pablos, Robert G. Varady, and Gregg M. Garfin, Udall Center for Studies in Public Policy, The University of Arizona, 2012.

The Udall Center for Studies in Public Policy has released a casebook of studies of water resource vulnerability and adaption to the pressures of drought, urbanization and climate change on the communities of Tucson, Arizona; Ambos Nogales, straddling the border, and Puerto Penasco and Hermosillo, Mexico. A binational team of researchers collaborated for three years on these case studies. Written in English and Spanish, the report identifies the unique challenges and possibilities of each region for improving adaptive capacity in water resources.

The region surrounding the Arizona-Sonora border has been identified as highly vulnerable because of climate and socioeconomic characteristics to the combined stresses of rapid growth, climate change and industrialization. "Ensuring future water supply is the region's highest priority challenge." Each case study provides in-depth background on the community and region, the climate and its impacts, the water infrastructure and institutional capacity for adaptation. Each case study concludes with a section on implications for policy and planning that identifies the major challenges and opportunities unique to the case.

The publication was supported by the International Consortium for Adaptation in Drylands, a collaboration among researchers at the University of Arizona and the Universidad Nacional Autonoma de Mexico (UNAM), and reports on research done under grants from NOAA and NSF.



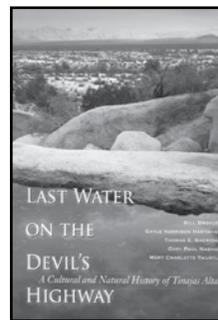
## Burning Our Rivers: The Water Footprint of Electricity

By Wendy Wilson, Travis Leipzig & Bevan Griffiths-Sattenspiel  
A River Network Report  
[www.rivernetwork.org](http://www.rivernetwork.org)

The intent of this report by the River Network is to raise concerns about the amount of water used in electricity generation, so as to move the industry toward more efficient and less water intensive technologies. Toward this end, the authors have amassed a wealth of information about how much water is used in a whole range of electrical generation scenarios. Their central finding is "Based

on the available published water-use information, we calculate that in 2009 the water footprint (WF) of U.S. electricity was approximately 42 gallons per kilowatt hour (kWh) produced." From this number they estimate the water use of the average U.S. household embodied in energy use (39,829 gals.); compare it with the water use of the average U.S. household for all commonly considered household uses, such as toilet flushing (7,337 gals.); and conclude that the average household uses five times more water indirectly as energy than all direct household uses combined.

The authors attempt to include all "upstream" water uses, as well as in-plant use, such as water use in coal mining and transportation, as well as water used in coal-fired generating plants. They admit, however, that upstream data are scarce and their picture of total water use is incomplete. They make no attempt to calculate downstream impacts to water, such as thermal pollution and acidification, but the reader will find discussion of these issues as well. Although the report's advocacy is clear, the presentation of the data and calculations is transparent and the multiple tradeoffs involved in comparing one technology to another acknowledged.



## Last Water on the Devil's Highway: A Cultural and Natural History of Tinajas Altas

Bill Broyles, Gayle H. Hartmann, Thomas E. Sheridan, Gary P. Nabhan, and Mary C. Thurtle  
University of Arizona Press, Tucson, 2012

Tinajas Altas, or High Tanks, is a series of natural rock basins where for hundreds of years the traveler could usually find water on the parched and treacherous trail, known as El Camino del Diablo, from the perennial Sonoyta River to Yuma on the Colorado River. The tanks, worn into the side of the rugged granitic Tinajas Altas Mountains by erosion, catch and hold water from the rare and unpredictable rain storms characteristic of this desert region. The rich history of Tinajas Altas testifies to how important sources of reliable water were to survival.

The authors of this entertaining and informative book bring together perspectives of archaeology, anthropology, history and natural history to paint a panorama, rich in detail and expressive of the area's unique character. Chapters carry the reader from the geologic past to the experiences of the Native people; through the first Europeans to the Gold Rush and American expansion; up to the present day. It catalogs the area's flora and fauna, and includes among the appendixes a table of Native American names and uses of plants of the Tinaja Altas region. Containing a wealth of maps, historical photos and other illustrations, *Last Water on the Devil's Highway* offers readers a revealing look at a fascinating place.



# PUBLIC POLICY REVIEW

By Sharon Megdal

## Better Understanding Needed of Link Between Water Conservation and Rates



Demand-side management is an essential and well-recognized component of our water management strategies. Yet, like most water topics, water conservation programs are complex and multi-faceted. It is my sense that there is generally a preference for conservation programs that provide incentives over compulsory regulatory programs with penalties. Many like to encourage conservation through tiered pricing programs, where the cost to the

consumer of incremental units of water increases as more is used. Yet there are some challenges associated with gaining acceptance of utility conservation programs. I'd like to discuss a few of them in this column and note that the issues are not unique to water. Rather than delve into the efficacy of alternative conservation programs, itself a difficult and not-fully-explored topic, I examine some of the implications of conservation program implementation.

Whether utilities are privately or publicly owned, large components of the costs are fixed. Only a certain proportion of the costs of delivering water vary with the amount of water delivered. Fixed and variable costs both are covered by rates. Utility rate structures vary quite significantly across Arizona. (See my article, "The Role of the Public and Private Sectors in Water Provision in Arizona, USA," *Water International*, March 2012, Vol. 37, No. 2, 156-168 and the annual survey done by the Arizona Water Infrastructure Financing Authority for summaries of this variation.) Most utilities charge a monthly service fee, which may or may not include some water, and then charge for incremental water used by the customer. For example, the charge per 1,000 gallons may be set at a fixed dollar amount, may vary by season, or may vary depending on the amount of water consumed. In other words, there are many ways a utility's revenue requirement may be met. We see those setting utility rates balancing multiple objectives, such as: enabling the utility to cover its reasonable costs, with a rate of return on investment if privately owned; keeping rates affordable for water for basic needs; and discouraging wasteful or unnecessary consumption. Over time, we have seen more adoption of increasing block rate structures, especially since the mid-1980s, when I served on the Arizona Corporation Commission, the body responsible for regulating the rates of privately owned utilities. This greater use of increasing block pricing has been encouraged and applauded as a conservation strategy because it is thought that higher water prices will lead to less water consumption.

Recently, several water utilities have seen overall water consumption and/or per capita water consumption decline. In the case of the City of Flagstaff, for example, there was a determined effort to reduce overall water consumption. In some

cases, the decrease in per capita consumption resulting from a rate increase has exceeded that projected. Whatever the cause of the decrease in consumption, the fixed costs of service have to be covered in rates. If some of the fixed costs are included in the per-unit water charge, which is often the case, rates then have to increase for the very same set of customers. Assuming the fixed costs are necessary and reasonable, it's simple math. The fixed costs are spread over fewer units sold.

Not surprisingly, customers do not like this upward spiral, as I'll call it. This summer, some letters to the editor in the *Arizona Daily Star* commented on this very matter in the context of Tucson Electric Power (TEP). On July 9, 2012, one wrote the following about TEP's request for a rate increase: "TEP is going to up your rate because you, and/or friends and neighbors did the right thing and bought more energy-efficient appliances that use less electricity—and now, TEP needs more of your money to make up for the good that you and others did? Does the expression 'No good deed goes unpunished' make sense to you now?" Another letter writer states: "I get it. Use less through conservation and good energy practices and get charged more. One of the reasons for the [proposed] rate increase is the loss of revenue due to customers using less energy...So, TEP is telling us to use less so it can charge more to make up for the shortfall. Go figure." Finally, one writer in fact connects TEP's proposed rate increase to water rates, writing: "This week in Tucson our water rates went up because we conserved. Today we read that TEP wants to raise rates because we conserved..." The writer then comments on the impacts of such rate increases on those least able to pay.

There are programs in place to help low income individuals pay utility bills, but there are also questions about whether all those eligible for such programs are aware of them.

Also affecting rates are the costs of the conservation programs themselves. If rebates are offered by a utility, unless a toilet or appliance manufacturer is offering the rebates or a grant is funding the rebates, the customers are paying for the costs of the rebate program and other components of the conservation programs.

Utility directors and those who set water rates are trying to encourage water use reductions through conservation programs and rate setting. They themselves may be in the unenviable position of being punished – that is, being criticized – for doing the right thing when rate setting time comes around.

Getting through some of these issues can be facilitated by education programs, which themselves cost money. Educating all of us about the opportunities to conserve water could go a long way toward reducing some of the rancor come rate setting time. People do not like surprises. These days water planning is about examining alternative future scenarios. We can and should do a better job of anticipating the outcomes of conservation programs and policies, including their implications on rates. 



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*STEM continued from page 9*

The Central Arizona Project (CAP), which brings Arizona’s Colorado River water entitlement to users in central Arizona, has an interest in developing a water literate public. The CAP provides a variety of K-12 programs, including H2O for Kids (K-Grade 3), offering water conservation and water history lessons. More than 500 teachers contribute insight and feedback to this program.

Another CAP program, Arizona Water Story (Grade 4-6), is co-produced with the Salt River Project. The program was updated in 2010 to include greater STEM content and more hands-on experiments were added. Crystal Thompson, the Community Relations Coordinator believes that STEM material is very important to the CAP water education objective, “math and science are very much the focal points of all our programs”. Computer games are also being used as a learning tool to connect with youths and adults alike.

As more attention is focused on integrating STEM into our education philosophy, other fundamental subjects such as reading, writing, social studies, history, and cultural studies continue to be integral to water education. Kerry Schwartz sees opportunities for teaching about water in the total curriculum. “Good education is good education,” she says. “It’s all about getting kids excited about learning, wanting to learn, and going out and doing it.”

Judith A. Ramaley, the “godmother” of STEM also sees an evolution of the current philosophy. STEM is turning into STEAM, she has said; the “A” stands for arts. 🏗️



### Calling All Photographers! Photo Contest!

The Arizona WRRC is sponsoring a Photo Contest on the theme of **Water – The Human Element**.

Now is the time to start getting creative!

Information, submission rules and guidelines can be found at: [wrrc.arizona.edu/WRRC-Photo-Contest](http://wrrc.arizona.edu/WRRC-Photo-Contest).

The deadline for entries is December 15, 2012.

Contact Jane Cripps at [jcripps@cals.arizona.edu](mailto:jcripps@cals.arizona.edu) if you have any questions.