ARIZONA
WATER RESOURCE

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Fossil Creek Unbound

Restored Creek May be National Model

by Joe Gelt

A good environmental deed was done when the full flow of Fossil Creek was recently restored after nearly 100 years of restricted flows. It was the familiar river-and-dam tale told in reverse, this time with power plants decommissioned to restore the flow of a river.

Fossil Creek holds special interest to researchers who view the project as a possible national case study in ecosystem restoration, with results from research useful as dams are decommissioned throughout the nation. (Dam removal is occurring more frequently in the United States, with 145 dams removed since 1999, 65 of them decommissioned in 2004 alone.) The facility is located northwest of Payson, in a remote area between Strawberry and Camp Verde.

The Fossil Creek saga began in 1909 when its waters were diverted by the Fossil Springs Diversion dam to operate a hydroelectric power plant at Childs on the Verde River. In 1916 the Irving plant, on the banks of Fossil Creek, came on line. Time and the

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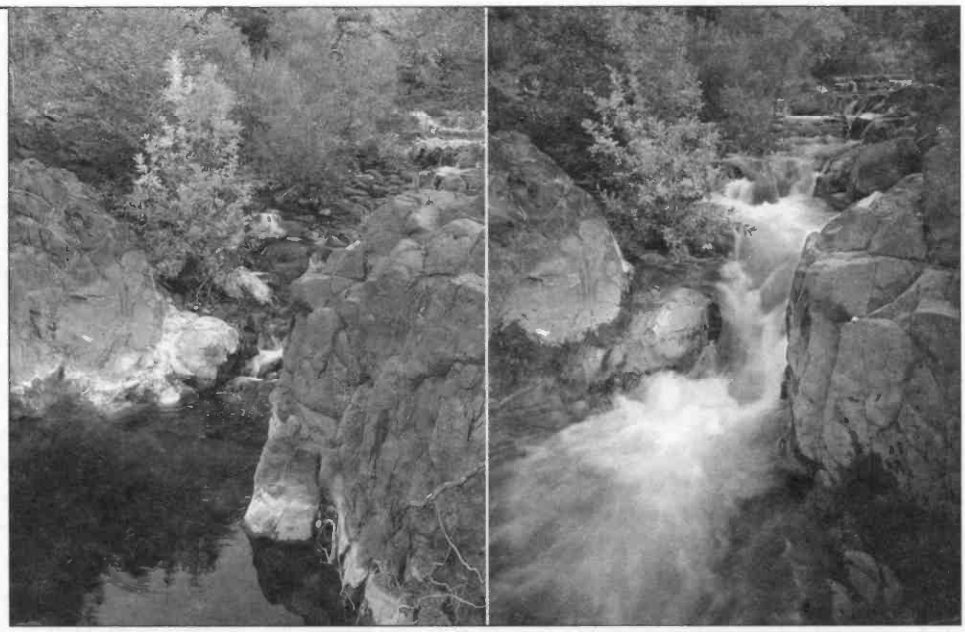

A flow restored: Fossil Creek before decommissioning of power plants and after. Photo by Nick Berezenko, courtesy of Arizona Public Services

Researchers Study DNA to Determine Human Response to Contaminants

Genetic variability may one day help set water quality standards

by Joe Gelt

In seeking to determine why people differ in their responses to environmental toxins — some will develop a disease while others remain unaffected and healthy — researchers have set their sites at the DNA level. Their research may have implications in determining future drinking water quality standards.

Water quality standards are now set in reference to the general population, with consideration given to sensitive subpopulations; i.e., infants, children, the elderly and those with compromised immune systems. Research is now finding that within the general population a variability exists, with some people much more susceptible to the effects of a contaminant than others.

Consider arsenic, a contaminant much in the water quality news lately. The U.S. Environmental Protection Agency's deadline for utilities to meet a more stringent drinking water standard for arsenic is approaching. A University of Arizona research team is studying the reasons that some people appear to be more susceptible than others to the effects of arsenic in drinking water.

Walter Klimecki, research assistant professor of medicine at the UA's Respiratory Center and member of UA's BIO5 Institute, heads the research team that is undertaking work in this relatively new field of study. Recent advances in human and molecular genetics are providing tools to help researchers understand how genes and genetic changes interact with environmental stimuli to either preserve health or cause disease.

Each of us carry different versions of DNA sequences for any given gene. The

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question facing Klimecki and his associates is whether those of us with one sequence variant metabolize arsenic differently than others with another sequence variant. He found that arsenic is in fact metabolized differently depending upon DNA sequences; a strong possibility is thus raised that the risk of developing an arsenic-related disease differs among individuals depending upon their genetic makeup.

The team analyzed arsenic levels in urine samples from 135 individuals, ranging from 7 to 79 years of age, from the Yaqui Valley in Sonora, Mexico. The participants' drinking water sources had contained arsenic. DNA samples from these individuals were analyzed for variations in three genes known to play roles in arsenic metabolism. Matching arsenic levels in the urine samples to the variations in the genes, the researchers noted that the distribution of arsenic metabolites differed in urine samples from people with a certain variation of the CYT19 gene.

Klimecki's and his team found that the association between the particular form of CYT19 and altered urinary arsenic metabolites was only evident in children; adults with the same variant of CYT19 did not metabolize arsenic differently. The results suggest that the genetic variation affects arsenic metabolism only during childhood.

The study was published in the June edition of Environmental Health Perspectives and is co-authored by Maria Mercedes Meza, Lizhi Yu, Yelitza Y. Rodriguez, Mischa Guild, David Thompson and A. Jay Gandolfi. It is available online at http://ehp.niehs.nih.gov/members/2005/7780/7780.html

Setting Water Quality Standards

Jay Gandolfi, director of the UA Superfund Basic Research Program, speculates about the possible implication of his colleague's work in setting water quality standards: "In Walt's work we are finding that selected groups of children handle arsenic differently, that they may be more at risk. ... We may find that down the road new levels of (drinking water) standards may be needed for children."

Will officials in fact need to consider genetic variability in the future when they set water quality standards? This question will become increasingly more important as additional research is done and more becomes known about the variable effects of different water quality contaminants on the general population.

Consider what now occurs when identifying and assessing a water quality risk: for example, a community exposed to x parts per billion of arsenic in its drinking water is examined to determine bladder, lung or skin cancer rates. The data is then compared to cancer rates in areas without arsenic exposure. An excessive prevalence of cancer in the arsenic exposed area is one critical factor to consider when regulating arsenic in drinking water. The higher the cancer rate, the more aggressive the regulation.

Issue Gets Complicated

The type of research that Klimecki conducts may alter that picture. He says, "Potentially one day — and that is not today — this type of data will take us to a different scenario ... for (evaluating) risk to a community exposed to toxicants."

He says, "We are talking about all community members having the same level of exposure, but people with one DNA 'version' having a different risk of disease than people carrying another DNA 'version.' You are now confronted with a complicated problem. You have a relatively resistant group, and you have a relatively sensitive group. How do you regulate the toxicant?

"Other questions arise: How big is the resistant group? How big is the sensitive group? In other words, if you identify a genetic marker of susceptibility what is the frequency of people having that marker? Imagine a scenario in which people with the marker have a large excess cancer risk; but what if the occurrence of that genetic marker is only one in a million people? For the regulator this is critical information; the situation becomes complicated."

Determining a person's genetic makeup is not a complicated procedure. Klimecki says, "It is extremely simple. Take a toothbrush, scrub down the inside of the cheek for about 10 seconds, and you come up with enough DNA do thousands of genetic tests."

Gandolfi sees regulatory change ahead. He says, "It is going to come. Regulatory standards have to get more sophisticated. ... The one-size-fits-all is not going to work anymore."

Perchlorate, another water contaminant getting attention lately, also is the subject of a recent genetic variability study attempting to identify genetic biomarkers that could help define subpopulations sensitive to environmental perchlorate exposure. The research results were published in the article, "Genetic Factors that Might Lead to Different Responses in Individuals Exposed to Perchlorate."

The authors state at the outset that developments in sequencing of the human genome has increased interest in gene-environment interactions. They believe this will become increasingly relevant in defining public health policies.

The article is co-authored by Franco Scinicariello, H. Edward Murray, Lester Smith, Sharon Wilbur and Bruce A. Fowler and will be published in Environmental Health Perspectives. An online version is available at http://ehp.niehs.nih.gov/docs/2005/8076/abstract.html

EPA Considers Genetic Influences

Although not at the level discussed above, the Environmental Protection Agency currently considers genetic variability when developing risk assessments. Edward Ohanian, director of Health and the Ecological Criteria Division in EPA's Office of Water, says, "When we do a complete risk assessment we take everything into consideration. ... Genetic variability is always a component."

Most of the genetic information available to the agency, however, has a much broader focus than the above research. Ohanian says, "What we can say now is there is a certain genomic phenomenon which might lead to certain diseases. We need more specifics; we need to get into the DNA and say that a particular gene is responsible (for a disease.)"

He says the type of work Klimecki is doing is "getting into the sub-clinical level, a few inches below whatever modern medicine risk assessment is now showing us. He is opening the door."

Ohanian says the research is identifying individuals who might be susceptible. "What we need to do next is look for the reasons for the susceptibility. For example, is it part of a family's history, from offspring to offspring? There are lots of questions to address before you can come up with a bottom line verdict saying x percentage in a certain community will be definitely impacted with this kind of response."

Water Vapors

Free Drought Planning and Water Supply Workshop

The Arizona Hydrologic Society, in cooperation with the University of Arizona's Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA), UA's Climate Assessment for the Southwest (CLIMAS) and UA's Cooperative Extension, is sponsoring a drought and water supply planning workshop Sept. 21 from 1-5:30 pm at the Radisson Woodlands Hotel, Flagstaff. The workshop will focus on using drought history and forecasting in drought planning, with additional information provided on ocean/atmospheric controls, potential effects of climate change and integrating drought planning with water supply planning. Instructors are Gregg Garfin (CLIMAS), Michael Crimmins (Extension), Kathy Jacobs (Water Resources Research Center/SAHRA/Extension) Although water providers are targeted, all who are interested in drought planning are welcome.

Sign up online by Sept 12 at www.azhydrosoc.org/symposium_registration05.html NOTE: you do not have to register for the AHS Symposium on the following days to participate in the workshop, and there is no charge for participation. Address questions to Kathy Jacobs at kjacobs@ag.arizona.edu

Or Skiing the Las Vegas Strip

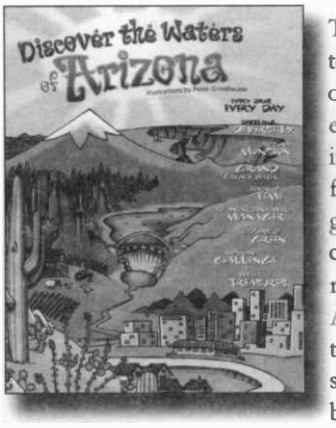
"It would be tantamount to trying to walk down the streets of Anchorage in a bikini in the month of March. It makes just about as much sense."

The above quote from Pat Mulroy, general manager of the Southern Nevada Water Authority, is from the documentary film "Running Dry." Mulroy is describing the incongruity of hoards of folks moving into the Southwest and wanting to recreate the environment of their former locale.

Chronicling the global water crisis, "Running Dry" focuses on desperate life-and-death water and sanitation problems that plague China, India, Kazakhstan, South Africa and the Middle East. Las Vegas and the Colorado River are worked into the film to provide a familiar focus to American audiences whose water problems are relatively insignificant compared to what other parts of the world suffer.

Information about the film is available at the web site: http://www.chroniclesgroup.org/

Booklet Offers Wealth of Arizona Water Information



The teaching of water education in the fourth grade classrooms of Arizona this year should be more lively and engaging with the use of a new student booklet, "Discover the Waters of Arizona." Its range of water topics and varied information, its level of coverage, the attractive and informative illustrations and graphics, and the interesting activities will spark student interest in the state's water resources.

Students will learn much about water — or "waters" as the title states — from this publication. Water is plural to emphasize that Arizona has many water issues and many water places. Kerry Schwartz, director of Arizona Project WET, says that in her experience students and even many adults in Arizona don't know what an amazingly diverse state we live in, with many beautiful water places. The idea for this booklet emerged from discussions with these people.

Arizona Project WET's contribution to the publication included identifying key topics, providing appropriate content including photographs, and coming up with activity ideas — and lots of editorial work. The Arizona Department of Water Resources and the Bureau of Reclamation funded the project to meet a need for a student booklet explaining the state water resources and their value. The 20-page booklet is written for use as content material for elementary teachers.

Governor Janet Napolitano has arranged that the booklet be distributed to all 4th graders within Arizona by the second week of October.

Water Research Supplement

This edition of the Arizona Water Resource newsletter includes a supplement describing water research conducted at the University of Arizona and supported by UA's Technology and Research Initiative funds.

Arizona Water Resource is published 6 times per year by the University of Arizona's Water Resources Research Center. **AWR** accepts news, announcements and other information from all organizations

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News Briefs

Alliance Acts to Protect Colorado River Water Quality

The Clean Colorado River Alliance was recently formed to protect and improve water quality in the Colorado River. The Arizona Department of Environmental Quality is coordinating the efforts of the alliance; members include federal, state and local government officials together with business and community leaders.

The alliance got its start at a meeting in Bullhead City in April. Governor Janet Napolitano directed the alliance, made up of about 30 leaders from communities along the river and throughout the state, to work out recommendations that address water quality problems of the Colorado River. The work of the CCRA is expected to lay the foundation for a future regional effort to protect the river's water quality.

ADEQ Director Steve Owens listed the main pollutants of concern that are potentially affecting Colorado River water quality; these will provide the focus of the group's work. The pollutants include nutrients such as nitrogen, nitrates, and ammonia; metals including chromium and uranium; perchlorate; endocrine-disrupting compounds; pathogens; salinity; and sediment.

Some sources of the pollutants also have been identified. Septic tank systems in several Colorado River communities contribute to nitrate concentrations. The primary source of uranium that may pose a problem to the river is a large uranium mill tailings pile near Moab, Utah. (The federal government recently announced plans to remove the tailings from the area.) The Kerr-McGee manufacturing facility outside of Las Vegas is the primary source of potential perchlorate contamination.

The CCRA will hold meetings throughout the summer and fall; its recommendations and proposed action plan are to be presented to the governor in December. For more Information about the CCRA check the ADEQ web site: www.azdeq.gov/environ/water/ccra.html.

Many Water Options ID'd for Northern Arizona

Officials in northern Arizona have a number of water resource options to consider as they ponder their water future. The U.S. Bureau of Reclamation has come up with 21 water supply alternatives that hold potential of providing water to an area greatly in need of such resources.

The options are the result of a study done by BuRec and funded by the Arizona Department of Water Resources. The goal of the study was to identify alternatives for meeting the water supply needs of northern Arizona. BuRec recently presented its alternatives at a meeting of the Coconino Plateau Water Advisory Council and its technical advisory committee. The options have attracted mixed reviews, with some found useful and others considered impractical for various reasons. Identified alternatives include projects that are already under consideration; these include the Navajo pipeline project and pumping water from the Coconino aquifer east of Flagstaff. Other more far-fetched projects include constructing a pipeline from Lake Mead and shipping water to Flagstaff in tank cars.

The alternatives are options that have been considered at one time by either the technical advisory committee, BuRec or the U.S. Geological Survey and are presented at this point regardless of cost and legal issues. Each is still under appraisal by BuRec.

Ron Doba, director of utilities for the city of Flagstaff and technical advisory committee member, says not much time or money will be spent on some of the options. He says, "I am sure it is not going to take putting the pencil to the paper too much to determine that either because of cost or for environmental reasons some are going to fall off the table real fast."

He says, "I think we are going to eventually get down to two or three options that are worth looking at more closely with the Bureau. ... We are hoping to have some projects or a project by the end of the year that floats to the top."

The alternatives have been presented to ensure early and thorough input into the process of selecting a water resource plan for the region.

The Coconino Plateau Water Advisory Council is serving as a forum to discuss the plans and will likely make a recommenda-

Fossil Creek...continued from page 1

river, its waters now reduced, flowed onward. In 1999 Arizona Public Service signed a historic agreement with the Yavapai-Apache Nation and various environmental groups to voluntarily give up its hydropower license.

Even before the turbines were permanently shut down amidst ceremonially fanfare on June 18, work was underway to promote natural conditions along the creek once it was restored to full and unobstructed flow.

Jane Marks of Northern Arizona University examined creek conditions above and below the dam to determine the dam's effects. She found native fish thriving above the dam in a pristine river with natural flow; the native species were not threatened by non-native fish or crayfish. Conditions differed below the dam: non-native fish, primarily bass and sunfish, were top predators to the disadvantage of the native fish.

Also aquatic insects such as damselflies, mayflies and dragonflies were forced to compete for limited resources below the dam. Due to water diversions that reduce habitat complexity fewer niches exist. Insects and snails living above the dam on the other hand are able to feed on greater amounts of algae and leaf litter and are in turn eaten by the native fish. Emerging from the water the insect life becomes a food source for birds, lizards and frogs that populate the riparian forests.

The study of conditions above and be-

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Reason Sought for Tree Die-Off Along Santa Cruz River

Concerned citizens and various organizations representing government, nonprofits, businesses and the scientific community have formed an ad hoc committee in an attempt to figure out why a large number of trees along the Santa Cruz River are dying off within Santa Cruz County.

Aerial view of tree die-off along the Santa Cruz River. Photo by Murray Bolesta taken on LightHawk flight.

The extent of the problem became evident in June when members of the nonprofit organization Friends of the Santa Cruz River took a flight along the river to get photos for its web site. The aerial photos showed what was not as obvious from the ground: a very distinct pattern of tree stress and die-off. The problem was not as noticeably at ground level since die-off areas often were alongside rows of healthy trees, which added to the mystery.

Ann Phillips of the Friends of the Santa Cruz River says that people organized to discuss the potential causes of the die-off. Phillips calls the potential causes "suspects."

One suspect is Texas root rot. The soil fungus was a problem in the county when cotton was grown in the area and may still be in the soil. Phillips says, "Some of the die-off areas are actually rectilinear; they look like the pattern of an old field."

Other suspects include conditions that result in groundwater not reaching tree roots. Localized groundwater pumping may be one such condition. Another condition may be reduced water infiltration along the river due to the formation of a "biomat" downriver from the Nogales international wastewater treatment plant. The ammonia and the high-nitrogen compounds present in treated effluent released from the treatment plant create nutrients, enabling algae and other microorganisms to grow. These can form biomats that plug up the sand in river bottoms, reducing infiltration of water into the sands below the river.

Phillips says, "What this means is that plants that had grown up in an environment in the 1990s when there had been a lot of infiltration due to large flood flows that broke up the biomat, may not be getting enough water now to sustain them."

Another suspect is climatic. June recorded a rather large number of days with temperatures over 100 degrees. Added to this is the drought. The five-year drought — and still counting — may have stressed the trees. Insect damage also is a suspect, among others.

Phillips describes the course of action to be taken to identify the problem: "To help pinpoint the problem we want to G.P.S. the perimeter of the areas where trees are experiencing stress and die-off. We also intend to re-fly the river to determine if any of the stressed areas are coming back as a result of the monsoon flows. Satellite photos in the infrared spectrum obtained from past years can help us see if this may have started some years ago and is just getting bad enough now for people to take notice. We also want to do some sampling of soils and water quality.

"There is a lot of information to be gathered to get a better understanding. It will probably turn out to be a combination of factors — that is more like real life than anything else."

Phillips says the issue has been taken up as a community project. "It is a very inclusive community process with all kinds of people at the table. Everybody wants to find out; everybody has been very forthcoming and co-operative."

tion. Water suppliers of the towns and tribes in the area will then decide whether a recommended plan meets their needs.

NAU to Host Climate Change Research Institute

Northern Arizona University will soon make a greater contribution to efforts now underway in Arizona to study climate change with a new grant the institution recently received. NAU is one of four national universities to have been selected to host regional centers of the National Institute for Climatic Change Research. The other institutions are Duke, Penn State and Michigan Tech.

NAU will serve as the "host university" or center of the 13-state western region which includes Alaska and Hawaii. Principal investigators Bruce Hungate and George Koch, professors of biology, will administer the center which is to receive $10 million over the next five years. They will select projects for funding in the western states.

"I'm very pleased for NAU and for this opportunity to help shape climate change research," Hungate said.

Koch added, "Given the potential impacts of climate change in the West, this is a great opportunity to foster research that can inform climate change policy."

The U.S. Department of Energy, through its Office of Science, established the NICCR to support research by academic scientists studying the effects of climate change on ecosystems and the atmosphere. The institute will support research in four geographic regions, covering all 50 states.

The DOE's Office of Science spent about $3.6 billion on scientific research this year, supporting scientists at universities, national laboratories and other research institutions.

Guest View

Consistent, Long-Term Hydrologic Databases are Valuable Resources

Nick Melcher, director of the U.S. Geological Survey's Arizona Water Science Center, and Jeff Phillips, USGS supervisory hydrologist, contributed this Guest View

Hydrologic data are needed for a diverse set of basic societal needs that include urban planning, problem assessments, land management, economic development, and environmental monitoring. All of us that work in the hydrologic sciences hear complaints regarding the lack of basic descriptive hydrologic data. In reality, the volume of hydrologic data collected by government, corporate, and non-governmental interests is staggering and tabulating the data or even accurately identifying its sources can be difficult. The problem is not so much the amount of hydrologic data that is collected, but more the usability of the data.

Typically, hydrologic data are collected during an economically driven short-term assignment to assess a specific condition or problem. Too often the purpose and methods for collection are not fully documented. Consequently, collateral use of the data is limited and the likelihood that uninformed use of the data will result in inaccurate conclusions is increased. In many instances, the data set never leaves the original collector and over time loses its identity and purpose. There are far more hydrologic data collected than are being used or that are readily accessible. A few minor adjustments to the data-collection process can result in usable data that are accessible for multiple purposes.

The U.S. Geological Survey hydrologic database is populated largely with data collected for specific purposes. Over time, however, procedures and standards have been developed that ensure the data are consistent and reproducible, documented and archived, and easily accessible to the public. First, the data are collected using nationally consistent methods. These methods are tested and documented in widely distributed publications. Periodic reviews are conducted by both local and national experts to ensure compliance with methods and standards. Second, the data are compiled and permanently archived in formatted databases. These databases contain fields for documenting collection methods, data purpose, and special considerations. All data collected for all projects must be archived in permanent databases. All USGS hydrologic data are public domain, and most databases are Internet accessible. This process enables the data to serve many purposes and provides for future access and comparison.

One of the most important benefits of consistent, long-term hydrologic databases is that they can be used to determine long-term, as well as short-term, trends. The ability to assess the sustainability of present or planned water-management plans is a critical need throughout the Southwest and the Nation. Long-term data and the ability to analyze trends are fundamental to the resolution of many of the most complex hydrologic problems. Hydrologists are only now beginning to understand the effects of climatic variability and the importance of considering that variability in management decisions. The most important water adjudication in the Southwest, the Lower Colorado River apportionment, was based on flow records from 1895 to 1922, resulting in an estimated mean annual flow of 16.1 million acre-feet per year at the Lees Ferry compact point. Consequently, a total of 15 million acre-feet per year was apportioned between the upper and lower States. Subsequent data indicate that the long-term mean annual flow for 1895-2003 is only 12.2 million acre-feet, creating a serious social, economic, and legal dilemma for us and for future generations (Webb and others, in press).

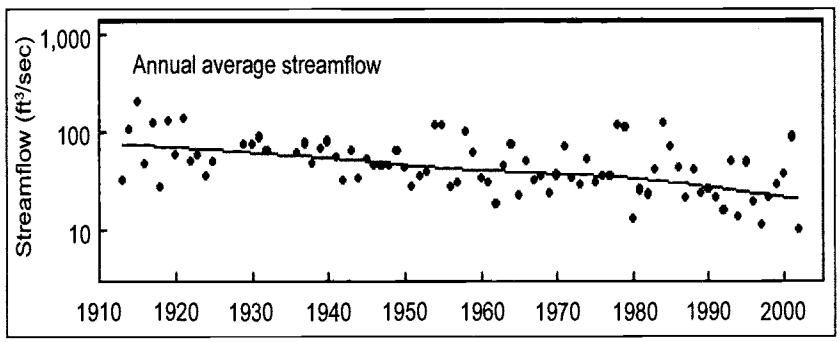


Figure 1. *Trends in annual streamflow of San Pedro River at Charleston, Arizona.*

The use of streamflow records for the San Pedro River Basin is another excellent example of the need for long-term hydrologic data. The USGS has been operating the San Pedro River at Charleston gaging station (09471000) since 1904, and growing concerns about the water needs for basin development verses riparian habitat illustrate the need for determination of long-term trends in streamflow. Utilization of trend-analysis methods, along with streamflow records for this station, has allowed USGS hydrologists to determine that annual flow diminished by more than 50 percent during the past 100 years (fig. 1; Thomas and Pool, in press). On the evening of July 6, 2005 zero flow was recorded in this reach of the river for the first time during the 101 year period of record.

Analysis of long-term records is enabling scientists and observers to assess substantial changes in streamflow and the factors that can contribute to those changes.

–*Webb, R.H., Hereford, Richard, and McCabe, G.J., in press, Climatic fluctuations, drought, and flow in the Colorado River, in Gloss, S.P., Lovich, J.E., and Melis, T.S. eds., The state of the Colorado River ecosystem in Grand Canyon: U.S. Geological Survey Circular 1282.*

–*Thomas, B.E., Pool, D.R., in press, Trends in streamflow of the San Pedro River, southeastern Arizona, and regional trends in precipitation and streamflow in southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Professional Paper 1712.*

WaterSustainability
THE UNIVERSITY OF ARIZONA.

Arizona Water Resource Supplement
July-August 2005

UA Grant Program Funds Water Research, Education, Outreach

New, continuing, and concluding projects focus on Arizona water issues

The University of Arizona's Water Sustainability Program funds UA faculty and staff water resource projects. The diverse and assorted WSP-funded projects described in this supplement further in various ways the program goal of ensuring a sustainable, high-quality water supply for Arizona.

In this third cycle of the Water Sustainability Competitive Grants Program 53 proposals were submitted. The eight funded projects, which began July 1, were awarded approximately $360,000. Another $730,000 has been granted to 17 continuing, multi-year projects. In total, 39 projects in water research, education and outreach have been awarded $3.3 million since 2003. Summaries of all grants projects and two-page bulletins of the first 20 funded projects can be found on the WSP web site www.uawater.arizona.edu WSP also funds student water fellowship awards.

Funding for the WSP competitive grants program comes from Technology and Research Initiative funds. TRIF's origins was a November 2000 voter-approved increase in the state sales tax to support education. WSP provides a focus for a campus-wide collaboration of scientists and educators and is coordinated by four UA water centers. (Engineering Research Center for Environmentally Benign Semiconductor Manufacturing; Center for Sustainability of semi-Arid Hydrology and Riparian Areas; Water Quality Center; and Water Resources Research Center).

Following are brief descriptions of new, continuing and near-completion WSP projects. Also listed are the names of students receiving fellowships.

Above are aerators in the main ponds of the Nogales International Wastewater Treatment Plant. Research will determine the value of the Mexican effluent to southern Arizona. (See page S-2 for project summary; Sprouse and Frisvold, PIs)

NEW PROJECTS

Water Quality

Novel Desalination Technology for Potable Water Production. $49,981. (1 yr.) James C. Baygents, Dept. of Chemical & Environmental Engineering, College of Engineering. The objective of the proposed work is to develop and test a novel process technology for the recovery of potable water from aqueous feed streams of high ionic strength (e.g. saltwater and brackish waters). The basic separation scheme is predicated on multiple effect evaporation, an established method for desalination. However, the new process and equipment are radically different from conventional designs. This new approach involves lower capital and operating costs, and permits the use of inexpensive (essentially free) thermal energy sources, such as waste heat from power plants. If successful, the proposed project will dramatically lower the cost of evaporative desalination, and make it the method of choice for fresh water production.

Screening Tools to Assess the Feasibility of Monitored Attenuation for Remediation of Chlorinated-Solvent Contaminated Groundwater. $36,424. (1 yr.) Mark Brusseau, Dept. of Soil Water and Environmental Sciences, College of Agriculture and Life Sciences/ Dept. of Hydrology and Water Resources; Jim Field, Dept. of Chemical and Environmental Engineering, College of Engineering. Chlorinated solvents are the most common contaminants at the state and federal Superfund sites in Arizona and, given their myriad toxicological effects, pose a great risk to human health. The remediation of polluted soil and groundwater at the many chlorinated-solvent contaminated sites present in Arizona is of prime importance for ensuring a safe and sustainable potable water supply. Monitored natural attenuation (MNA) has recently gained great interest as a low-cost, low-tech approach for site remediation. Characterizing the occurrence, magnitude, and rate of microbial transformation processes is critical to evaluating the feasibility of MNA for a given site. The goal of this project is to investigate innovative, low-cost screening tools that will allow accurate evaluation of MNA feasibility for chlorinated-solvent contaminated sites in Arizona.

Polybrominated Diphenyl Ethers in Biosolids: Assessment of Relative Risk After Land Application. $55,000 per yr. for three years. David Quanrud, Office of Arid Lands Studies, Jon Chorover, Soil, Water & Environmental Science, Ornella Selmin, Veterinary Science & Microbiology, College of Agriculture and Life Sciences; Eduardo Sáez, Chemical & Environmental Engineering, College of Engineering; Cynthia Adamson, Sarver Heart Center, College of Medicine. Polybrominated diphenyl ethers (PBDEs), which are endocrine disrupting compounds, will be measured in the environment, focusing on their fate in biosolids during sludge

digestion and after land application. The principal objectives of the project are to perform an initial reconnaissance study to evaluate the various sources/sinks of PBDEs in the environment; determine the presence and fate of PBDEs in biosolids before and after land application; and determine the relative human exposure risk associated with land application of biosolids versus other possible routes of PBDE exposure to humans.

Autotrophic Denitrification for the Treatment of Drinking Water. $34,833 per yr. for two years. Reyes Sierra, Jim A. Field, Dept. of Chemical and Environmental Engineering, College of Engineering. The project proposes to develop a simple low-cost biological treatment process to remove nitrate from contaminated drinking water. The autotrophic microorganisms responsible utilize elemental sulfur as an electron donor to reduce nitrate to benign dinitrogen gas. The project objective is to develop, model and engineer the autotrophic denitrification process for pilot testing in Arizona.

Water Education

Arizona Project WET Evaluation: Examining Impact and Developing Water Education Assessment Tools for Students. $50,000. (1 yr.) Jerome D'Agostino, Dept. of Educational Psychology, College of Education. Kerry Schwartz, Water Resources Research Center, College of Agriculture and Life Sciences. This project will (1) examine the effectiveness of Arizona Project WET (Water Education for Teachers) and (2) develop assessment tools to measure students' understanding of water and general science principles. Project WET presently serves as an instrumental and valuable educational resource for K-12 students and teachers to study and learn about water conservation and properties. To date, however, the effectiveness of the program has not been adequately documented, especially in Arizona schools. Besides yielding program impact information, an assessment tool will be available to gauge students' learning of water across a variety of interventions.

Supply and Management

Integrated Surface and Subsurface Response of Alluvial Basins to Ephemeral Stream Channel Recharge and Urban-focused Recharge. $58,570 per year for two years. Jon D. Pelletier, Dept. of Geosciences, College of Science; Ty P. A. Ferré, Dept. of Hydrology and Water Resources, College of Engineering. Accurate basin-scale water budgets are needed to evaluate the sustainability of water resources. Recharge is the most poorly quantified component of most water budgets. Accurate field monitoring of recharge requires carefully designed measurement networks to ensure representative and cost-effective sampling. Project will determine the optimal spatial and temporal scales and distributions of recharge monitoring for the Upper San Pedro Basin of Arizona based on numerical modeling and novel direct use of soil-geomorphic maps. Research will benefit communities within the Upper San Pedro Basin and will provide a template for monitoring network design for basins across Arizona.

The Value of Binational Effluent and Sustainable Watershed Management in the Upper Santa Cruz Basin. $63,707. (1 yr.) Terry Sprouse, Water Resources Research Center, George Frisvold, Dept. of Agricultural and Resource Economics, College of Agriculture and Life Sciences. Project will place a value on the effluent that originates in Mexico but is treated and utilized in southern Arizona. Mexican effluent provides many benefits to southern Arizona; for example, recharging aquifers and sustaining riparian habitat and species diversity which attracts tourists and increases land values. However, there are several potential projects that could divert the effluent from the river to other uses in both Mexico and Arizona, including an electrical generating plant in Arizona and housing developments or re-use of the effluent in Mexico.

Irrigation

Promoting the Adoption of Subsurface Drip Irrigation by Arizona's Farmers. $20,358 per year for three years. Thomas L. Thompson, Dept. of Soil, Water and Environmental Science, Edward Martin, Dept. of Agricultural and Biosystems Engineering, Patrick Clay, Maricopa County Cooperative Extension, Mary Olsen, Dept. of Plant Pathology, Russell Tronstad, Dept. of Agricultural and Resource Economics, James Walworth, Dept. of Soil, Water and

STUDENT FELLOWSHIPS

Nine outstanding students, five graduate and four undergraduate, representing a broad cross-section of water related programs, were awarded $100,000 beginning fall semester 2004, to support and encourage their studies.

2004/05 Recipients, Graduate Student Fellowships: *Joe Abraham*, Community Water Supply Vulnerability in Northern Gila County, Advisor: Andrew Comrie, Dept. of Geography and Regional Development; *Matthew Baillie*, Quantifying San Pedro River Inflows to Improve Riparian Sustainability Efforts: A Geochemical Tracer Approach. Advisors: Brenda Ekwurzel and James Hogan, Hydrology and Water Resources; *Gina Chorover*, Living on the Edge: Mitigating the Impact of Development near Riparian Areas through Community Design and Land Stewardship, Advisor: Margaret Livingston, School of Landscape Architecture; *Carla De Las Casas*, Destruction of Gas-Phase VCS by a Coupled Adsorption/Benton's Reaction Process, Advisors: Wendell Ela and Bob Arnold, Dept. of Chemical and Environmental Engineering; *Derya Summer*, A Groundwater-Dynamic Simulation Model: Application to the Upper San Pedro, Advisor: Kevin Lansey, Dept. of Civil Engineering and Engineering Mechanics.

2004/05 Recipients, Undergraduate Fellowships: *Liese Beenken*, Water Recycle and Reuse. Advisor: Kim Ogden, Dept. of Chemical and Environmental Engineering; *Erin Gleeson*, Dynamic Simulation Modeling of Water Resources in Semi-arid Environments: Quantifying Riparian Ecosystem Structure and Water Use, Advisor: Paul Brooks, Dept. of Geosciences; *Nicholas Nelson*, The Effect of Biosolids Application on Water Quality in Arizona, Advisor, Chris Choi, Agricultural and Biosystems Engineering; *Yvonne Resendez Young*, Enhancing the Understanding and Importance of Granting Instream Flow Water Rights in Arizona. Advisor: Peter Ffolliott, School of Natural Resources.

Environmental Science, College of Agriculture and Life Sciences. Funds are to continue operation of "AZdrip," the UA Subsurface Drip Irrigation Demonstration and Research Site, at the Maricopa Agricultural Center. This project features research on and demonstration of water-saving subsurface drip irrigation on a scale relevant to commercial agriculture. The overall objective of this project is to conduct research and to demonstrate this water-saving technology to Arizona crop producers.

PROJECTS NEARING COMPLETION

That various WSP projects are completed or nearing completion, with their objectives met and results forthcoming, is a measure of the program's progress and success. Noted below are WSP projects that will conclude by December, 2005.

Effects of Water Quality on "Rapid Blight" Disease of Turfgrass. $43,065 (1 yr.) Mary Olsen, David Kopec, Mohammad Pessarakli, Donna Bigelow, Jeffrey Gilbert, Dept. of Plant Sciences. Rapid blight is a new disease of cool season turfgrass associated with poor quality water (non-potable). The project objective is to determine specific components of water quality that contribute to disease development in turf in Arizona and that define the growth parameters of the pathogen.

Landscape training booklet for Spanish speakers.

Spanish-Language Landscape Water Conservation Program for the Green Industry. $8,777 (1 yr.) Vicki S. Richards, Pima County Cooperative Extension/Low 4 Program. A large percentage of Green Industry personnel speak Spanish. Project funds are used to translate materials and sponsor landscape training series with Spanish-speaking instruction.

Microbial Mechanisms for Observed Rapid and Large-Scale Denitrification in Irrigated Desert Soils: Potential Low Cost Methods to Remediate Nitrate in Soil and Groundwater. $98,000 (2 yrs.) Edward Glenn, Environmental Research Laboratory, Dept. of Soil, Water and Environmental Science. Project is studying and developing management practices using conventional irrigation technology to inexpensively remediate aquifers and soils contaminated with nitrates and perchlorate.

Evaluation of M&I Water Conservation Measures Through Actual Water Savings & Cost/Benefit Analysis. $67,466 (2 yrs.) Val Little, Water Resources Research Center. Project is evaluating municipal and industrial water conservation programs/strategies in Arizona and the West. Analyses will determine actual water savings, costs and benefits for targeted conservation measures and a comparison between measures as well.

Quantifying Mountain Front Recharge in Southeastern Arizona. $105,240 (2 yrs.) James Hogan, Brenda Ekwurzel, Dept. of Hydrology and Water Resources. Isotopic tracers are being used to investigate mountain front recharge. Information will enable water resource managers to better quantify natural replenishment rates; an improved understanding of how climate, vegetation change and development might impact recharge rates will result.

Development of Riparian Evapotranspiration and Ecohydrologic Models to Predict Changes in and Consequences of Riparian Water Availability. $139,020 (2 yrs.) Thomas Maddock III, James Shuttleworth, Dept. of Hydrology and Water Resources; Travis Huxman, Dept. of Ecology and Evolutionary Biology. Project goal is to complete a new groundwater model for evapotranspiration and to refine an ecohydologic model to predict the hydrological and ecological changes in, and consequences of, riparian zone water availability. Project products will benefit the San Pedro River ecosystems and its stakeholders.

Occurrence and Control of Emerging Waterborne Pathogens in the State of Arizona. $92,680 (2 yrs.) Charles Gerba, Dept. of Soil, Water and Environmental Science. The parasite Naegleria fowleri and the Norwalk virus are two pathogens recently recognized as water quality problems in Arizona. Sources and potential control methods for N. Fowleri are being investigated; the work will provide critical information to public health departments, water departments, and government agencies.

Tailored Drought Planning for Arizona. $95,140 (2 yrs.) Greg Garfin, Institute for the Study of Planet Earth; Barbara Morehouse, ISPE/Dept. of Geography and Regional Development; Andrew Comrie, Dept. of Geography and Regional Development. The recent drought highlights the lack of a statewide process for identifying and addressing water management stresses. This project studies strategies for understanding and coping with the differential impacts of drought across the state.

Detection of Noncytopthogenic and Treatment Resistant Human Virus Populations in Drinking Water Using Integrated Cell Culture/PCR. $107,260 (2 yrs.) Kelly Reynolds, Environmental Research Laboratory, Dept. of Soil, Water and Environmental Science. Project is developing a rapid and reliable method to evaluate drinking and reuse water supplies and disinfectant efficacy for the elimination of a variety of human pathogenic viruses in drinking water.

Simulated Basin Model for Water Resource Planning and Education. $217,360 (2 yrs.) Kevin Lanseh, Dept. of Civil Engineering and Engineering Mechanics; Paul Blowers, Wendell Ella, Dept. of Chemical and Environmental Engineering; Paul Brooks, Steven Stewart, Dept. of Hydrology and Water Resources; Paul Wilson, Dept. of Agricultural & Resource Economics. A valuable interactive tool to improve water resources management decisions will be provided by developing an integrated decision support simulation model. In addition to identifying solutions for water managers and policy makers, the model will be critical in educating the public and generating acceptance of water plans.

MULTI-YEAR PROJECTS

Seventeen multi-year projects were granted continuation of funding through FY05-06. All of these projects are 2-3 years in duration and will conclude by December, 2006. Projects are arranged by categories and described below:

Water Quality

•Two projects focus on different aspects of arsenic contamination. A preliminary planning tool to evaluate the hydrogeologic applicability and cost-effectiveness of non-treatment methods versus conventional wellhead treatment has been developed for water utilities. Consultation with the Arizona Department of Environmental Quality will be ongoing for broad application of this tool. The second project is studying arsenic-laden sorbents in landfill sites that pose a threat to soil and groundwater. Results to date show that pH is a significant factor influencing leaching of arsenic under these circumstances.

•A low maintenance bio-filter is under development that will likely reduce perchlorate in contaminated groundwater for drinking and contaminated surface water used for irrigation.

•Work continues on the study of the potential risk of anti-biotic resistant bacteria and endotoxins in biosolids to groundwater and human health effects.

•Raman spectroscopy, adapted to field conditions, shows promise of detecting water pathogens at very low concentrations, less than 100 organisms per milliliter.

•New information is being generated about the presence and treatment of estrogenic compounds in effluent. Protocols for measuring and extracting compounds with estrogenic activity have been developed and are in use at wastewater treatment sites in Tucson and Los Angeles.

•Laboratory analysis is underway to measure the cumulative effects of exposure to endocrine disrupting chemicals in effluent on fish.

•A new version of AGWA, a modeling tool, is assisting range land watershed managers to do water quality planning for erosion and sedimentation, the leading cause of water quality impairment in the West. Developments will be a focus of workshops for stakeholders and web-based information, see: www.tucson.ars.ag.gov/agwa/ and www.agwa.srnr.arizona.edu/dotagwaforum

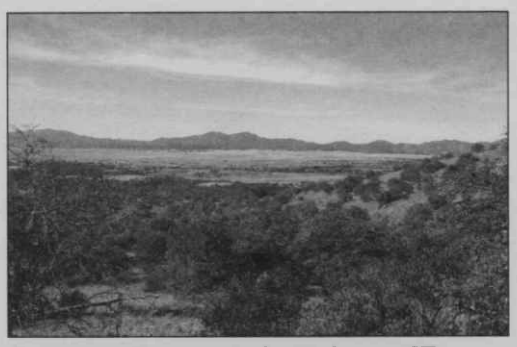
•The microbial quality of individual and small, non-disinfected drinking water systems are being assessed to identify potential sources of contamination. Further work will evaluate appropriate technology for enhancing the microbial quality of these systems.

Water Supply

•Field measurements and model simulations are being made to help develop and refine appropriate flood response mitigation tools; Sabino Canyon is the study area.

•First year results indicate that early termination of irrigation in cotton production can have favorable economic results. A 20 percent water savings was achieved compared to water used in conventional practice.

•PIs looking at reliability of the Colorado River water supply are working closely with the Bureau of Reclamation. To date they have completed stakeholder surveys, inserted a climate based hydrologic model into the Bureau's management model, made significant progress in extending paleo records, and are evaluating the economics of alternate water management responses for different water supply scenarios. The latest information can be found in the project newsletter: http://ag.arizona.edu/AZWATER/presentations/3qr.newsletter.spring.05.FINAL.pdf



Project quantifies mountain front recharge in SE Arizona. See page 3; Hogan and Ekwurzel, PIs

•The first phase of development of the Paleoflood Database including data entry and verification for Arizona and the Southwest has been completed. Preliminary results of the tree-ring studies show good paleoclimatic data that will enable reconstructions for the past 400 years.

•Another tree-ring study is reconstructing hydrologic connectivity in the San Pedro National Riparian Conservation Area. False-ring chronologies are being used to demonstrate spatial and temporal patterns of channel drying and attendant decreases in groundwater depth.

Water Education

•Four sets of educational resource kits for teachers (Water Quality Monitoring and Analysis, Aquatic Life, Watershed Processes, and Urban Hydrology) have been developed and tested and are now available to teachers. Each set has been configured for basic (grades 4-8) and advanced (grades 7-12) levels. For details see: www.sahra.arizona.edu/water/

•The Water Wagon, a mobile water lab/education center, continues to roll across southeastern Arizona, with instructional visits to Graham County schools, scouts and other community groups among others. It offers in-service teacher workshops in five counties, with new curriculum materials developed to support these programs. For further information check: www.ag.arizona.edu/extension/water_wagon

•Efficient irrigation technology is being promoted in northern Arizona through a series of publications, workshops and demonstration projects and real-time information on evaporative demand, landscape water use and local meteorological conditions, all free of charge. Information can be found on the project website: www.cals.arizona.edu/azmet/naz-irr.htm

Water Sustainability Program

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WaterSustainability
The University of Arizona

WSP Arizona Water Information Site: arizonawater.org

Publications & On-Line Resources

ArizonaWater.org, A One-Stop Water Information Center

Despite booming population and drought, some argue that Arizona's immediate water problems have more to do with water management rather than water supply. Better management could more efficiently allocate the State's limited water resources. Similarly, it can be argued that there is no dearth of water information in Arizona; the problem is managing that information, identifying what is available and providing ready access to those needing the information.

ArizonaWater.org performs that task. Created by the University of Arizona's Water Sustainability Program, Arizona Water is a one-stop water information center for researchers, managers, elected officials and the general public. Its integrated network of searchable databases includes water expertise, degree programs, and research efforts at all three state universities, plus information on local, state, federal, and tribal organizations and associations with responsibilities for water.

Information is organized within various categories: Organizations, Reports & Data, Research Facilities, Expertise, Degrees, and Centers. Selecting Organizations provides access to searchable information about over 330 Arizona organizations, including state and federal agency offices, NGOs, professional associations, water districts and educational organizations. Selecting Expertise gains access to a database of over 425 water experts at Arizona universities, searchable by name, institution, geographic and research specialities and language expertise.

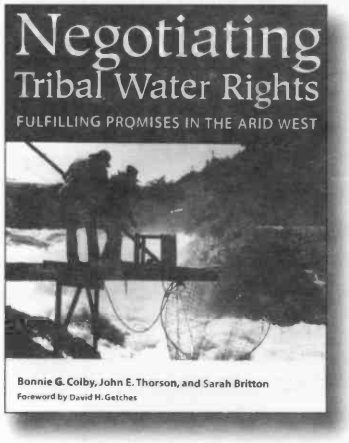
Arizona Water enables water researchers to share information about ongoing research, results of earlier research, and lab and field sites that can support future research.

Advanced searches can be performed on individual databases, or broader queries can made on all databases. The site also provides an Ask the Water Wizard feature, providing answers to frequently asked questions. Those not Web-savvy can get answers to their queries via phone or email.

Arizona Water also is playing a role in forming the Arizona Virtual Water University, an effort to coordinate research activities at Arizona's three state universities, with the goal of establishing the state as a worldwide leader in water research.

Arizona Water was developed and is hosted by SAHRA, an NSF Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas, at the University of Arizona.

Book Provides Wide Coverage of Tribal Water Rights Issue



Negotiating Tribal Water Rights: Fulfilling Promises in the Arid West by Bonnie G. Colby, John E. Thorson and Sarah Britton, University of Arizona Press, 191 pp., $35 paper.

This book takes on an exceedingly complicated and timely topic: Indian water rights. A book that does justice to this topic — and this book does indeed — must carefully and thoroughly define the issue and offer thoughtful strategies for working out viable solutions.

The authors describe tribal water rights as an issue fraught with complexities. Admittedly complexity is a characteristic of many, if not most water issues; even among such issues, however, tribal water rights stand out as an especially challenging case. The authors do a good job explicating the issue, identifying and discussing those elements to be considered if tribal water rights are to be understood in a broad context.

History, of course, figures prominently; the book provides extensive coverage, from European incursions to American Indian policy up to the modern era. Special attention is paid to the legal background of the issue, with various court decisions and congressional actions discussed. These are roots that define and interpret Indian water rights

One of the book's strength is its discussion of the complex legal, political, cultural and economic issues that beset those who undertake efforts to settle Indian water rights. For example, the authors describe complications confronting negotiators of settlements. The going can get rough for those who take on the task, with the book listing various institutions and processes that might be encountered along the way: "local, state, tribal, and federal governments; public participation, legislation, appropriations, implementation and litigation; advocacy, coercion, accommodation, and co-operation." The authors summarize: "Rarely are the solutions to public policy problems so complex and the challenges to leaders so daunting."

Discussions about Indian water rights often focus on the past; the historical injustices that have deprived Indians of water call for a remedy. This book also addresses situations and circumstances that might be expected to affect settlements today. In a chapter titled, "Indian Water Rights and the New West," the authors address vari-

...continued on page 8

Legislation and Law

Tribal Rights...continued from page 7

ous topics such as demographic shifts, U.S. presidential changes, national and international economic trends, state and tribal water management capacity and even climate change and cyclical drought. All these topics have a bearing on resolving tribal water rights.

Settlements achieved thus far and those in the works also are discussed. Some of the settlements are presented as case studies, to demonstrate a concept or a point relating to Indian water right settlements. For example, the Ak-Chin water settlement in Arizona is offered as a case study to show results obtained when a settlement is backed by strong congressional leadership.

The authors employ different methods or approaches to better present a vast array of information from various points of view. Their use of sidebars enable them to work in information and material that may be supplementary to the main discussion. The sidebars highlight a topic, providing at the same time an interesting diversion to the main text. The publication also includes "guest speakers," people very knowledgeable about a topic who have written various sections of the book. For example, in a section discussing various settlements, officials who had been directly involved in particular settlements write about them.

Chapter 5 consists of interviews with persons experienced in various aspects of Indian water rights settlements. (The interview format can allow at times a far-ranging, unstructured response. For example, Nelson Cordova, member of the Taos Pueblo tribal council, reflects in an interview on the characteristics needed by a tribal youth planning to work on tribal water issues. He said that "it takes an education that is wide in scope and includes a formal western education and training and understanding of tribal culture, traditions and values. It should cover the fields of history, archeology, and anthropology as well as the hard sciences. Certainly math is an important requirement ... also there are certain requirements that touch on economics.) This varied and assorted approach, with sidebars, interviews and contributing writers, conveys information in an appealing and interesting fashion.

The chapter the authors devote to the settlement process discusses a wide range of concerns. The intent of the chapter is to acquaint readers with what is likely to be encountered during settlement negotiations. Large and small concerns are identified: the role of state and federal governments and the ordeal of securing funding to support settlements as well as specific advice about how to successfully conduct settlement negotiations. Included within sidebars, the latter offers advice about who should be included in discussions ("include people who can make or break a deal.") and the need to "have a champion in Washington D.C. who will go to bat for the settlement over and over again." The book ranges from general concepts to nuts-and-bolts stuff.

Protecting the Fish and Eating Them, Too: The Effect of Critical Habitat Designation Under the Endangered Species Act on Tribal Consumptive Water Use

The above is an award-winning essay by Lauren Whattam Lester, a recent graduate of the University of Arizona's James E. Rogers College of Law. The UA's Udall Center for Studies in Public Policy presented Lester its 2005 Fisher Prize in Environmental Law and Public Policy.

As tribes consider development projects that would enable them to use acquired water rights they confront a dilemma. They are obliged by the Endangered Species Act to ensure protection of critical habitats for endangered and threatened species. Consumptive water use restrictions in turn can limit a tribe's economic development options. Since tribes cannot relocate projects off tribal areas, any use of their lands as critical habitat threatens future on-reservation economic development. Because tribal lands are often relatively undeveloped, some of the best remaining habitat for a species may exist within reservations. It is often due to non-Indian development that aquatic species are at the brink of extinction; tribes now shoulder a disproportionate burden in efforts to conserve listed species.

The Udall Center will print the above article as part its monograph series. It will be available in a PDF file at the Udall Center web site. (http://udallcenter.arizona.edu/) A printed version will be available at printing and mailing costs. Direct questions about obtaining a copy to Robert Merideth, merideth@u.arizona.edu or 520-626-4393.

The authors' discussion of the complexity of Indian water rights claims serves as a forewarning to those involved in such settlements of the difficult path ahead. Recognizing the true complexity of the issue is the first step to successfully resolving it. At the same time the authors realize that the big picture is not the whole story; they give the direct and personal its due. In describing what is fundamental to all settlements, they write, "Fundamentally, Indian water right settlements are about people and creating durable interpersonal relationships in western watersheds."

The authors state that water rights have been quantified by litigation or settlement for only a fraction of western tribal reservations, with much work remaining to be done. Some large tribes, including the Navajo in Arizona, await action. Meanwhile 2004 saw some Arizona tribes meeting with success, with settlements approved for the Gila River Indian Community and the Tohono O'odaham. The authors posit 2008, the one hundredth anniversary of the U.S. Supreme Court's Winters decision, as a suitable date to mark progress made toward fulfilling the promise implied in that decision.

The authors caution that the job of settling tribal water rights is only half done. They view events of the last 25 years as promising, demonstrating what can be done and establishing some momentum for the future. They note, however, that scarcity of funding, limited water resources and national and international developments will complicate future settlements. Yet they conclude, "We are confident, however, that these settlements will be achieved."

Special Projects

WRRC Reports Research Results of Funded Projects

The University of Arizona Water Resources Research Center administers the Section 104B program of the Water Resources Research Act. Funded by the U.S. Geological Survey, 104B funds support small research projects investigating water issues of state and regional importance; only faculty at Arizona state universities are eligible for 104B funding.

Following are research results of recent 104B projects:

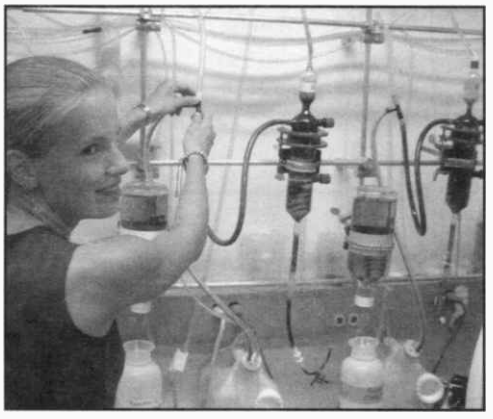
Estimation Of Acute Upper Lethal Water Temperature Tolerances Of Native Arizona Fishes, Corissa J. Carveth, Ann Widmer, Scott A. Bonar, and William Matter, University of Arizona. Stream temperatures have been rising in Arizona since the early 1900s. Although native fishes in Arizona have previously been considered tolerant to high temperature, little is known about the effects of temperature on native fishes in the Southwest. The study estimated the upper thermal tolerance of 11 native and 7 nonnative fish species found throughout Arizona. Fish were acclimated for a 2-week period at 25°C and 30°C. A rate of change of 0.3°C min-1 was then used to expose fish to increasing temperatures. Among the species acclimated to 25°C, desert pupfish mosquito fish and Gila topminnow were most tolerant to high temperature. Speckled dace, spikedace and loach minnow were least tolerant. Surprisingly, several native Arizona desert fishes are not as tolerant to high temperatures as common nonnative fish species from other areas. These native species may be sensitive to increasing water temperatures in Arizona's streams and rivers. They may also be susceptible to being outcompeted by nonnative fishes that are more heat-tolerant.

Measurement of Estrogenic Activity in Sludges and Biosolids, David M. Quanrud, Robert G. Arnold, Wendell P. Ela, Jonathon Chorover, University of Arizona. A number of organic compounds responsible for estrogenic activity in municipal wastewater readily survives conventional wastewater treatment and are either discharged to surface waters or accumulate in sewage sludge. Nonylphenol (an important estrogen mimic) and several other compounds thought to be responsible for estrogenic activity in wastewater effluent are moderately hydrophobic; they tend to separate from water and accumulate onto solid particles.

In this project, the fate of estrogenic activity and nonylphenol during secondary wastewater treatment and sludge digestion at wastewater treatment facilities in Tucson and Los Angeles was examined. Methods that were developed to extract estrogenic compounds from sludges and biosolids were used to determine how much estrogenic activity and nonylphenol survive sludge processing at wastewater treatment plants. Based on one-time sampling efforts conducted at three wastewater treatment plants, anaerobic sludge digestion was found to be not effective in degrading nonylphenol in sludge. Composting (an aerobic process) of finished biosolids reduced nonylphenol content by about 75 percent. Thus, project results indicate that aerobic processing steps (e.g. composting) should be further studied as a technique to reduce estrogenic compounds such as nonylphenol in biosolids prior to disposal.

Impact Of Drought On Management Of Salt Sensitive Plants With Reclaimed Water, Ursula K. Schuch, University of Arizona. The objective of the study was to determine the performance of salt sensitive plants when irrigated with reclaimed or potable water and to determine how those plants performed under drought stress. Plants used in the experiment included the desert willow, yellow bells, Chihuahuan sage, and moss verbena. When plants were irrigated with saline water, desert willow and yellow bells had no visual symptoms of injury; desert willow had less leaf biomass and yellow bells had less root biomass when irrigated with reclaimed water. Sage and verbena canopy sizes were smaller when irrigated with reclaimed compared to potable water. Sage also showed some signs of leaf burn during the months of July and August.

Plants were then water stressed by withholding water and their physiological response was measured. In general, plants watered previously with reclaimed water had less leaf area and took longer to wilt than plants with more leaf area that had been watered with potable water. After plants were re-hydrated, those grown with reclaimed water sustained less damage than those grown with potable water. However, accumulation of salts were measured in the root zone of plants irrigated with reclaimed water and over time may lead to problems. Salt sensitive plants can be produced with reclaimed water but depending on the species, may grow to a smaller size compared to plants irrigated with potable water. In a short-term drought experiment plants irrigated with reclaimed water sustained less damage compared to those grown with potable water. Long-term accumulation of salts in the root zone is a concern and needs to be monitored.



MS student Bridgette Howard samples her two permeable reactive barrier columns for treating acid mine drainage containing 25 mg/l copper.

Clean-up of Acid Mine Drainage by Microbes, Jim A Field, Reyes Sierra-Alvarez, University of Arizona. The uncontrolled release of acid mine drainage from abandoned mines and tailing piles in Arizona threatens the state's water resources. Acid mine drainage introduces elevated concentrations of sulfate, ferrous iron and other

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Announcements

Colorado Plateau Research Conference

The 8th Biennial Conference of Research on the Colorado Plateau will be conducted at Northern Arizona University, Flagstaff, Nov. 7 - 10. This conference provides an interdisciplinary forum for research and land management issues related to the biological, cultural, and economic resources of the Colorado Plateau. Anyone who has conducted research or has been involved with resource management issues on the plateau is encouraged to attend. The theme of this year's conference is "Preservation and Restoration of Colorado Plateau Natural and Cultural Landscapes." For more information about the conference check: http://www.usgs.nau.edu/conf2005/call.htm

Irrigation Modernization Conference

Society for Irrigation and Drainage Professionals is holding a conference October 26-29 in Vancouver, Washington, titled "SCADA and Related Technologies for Irrigation District Modernization." The conference will provide a forum to discuss modernization projects utilizing Internet applications and Supervisory Control and Data Acquisition Systems. Topics discussed will include the goals and objectives of modernization projects, implementation strategies, new management techniques and strategies of water delivery. Engineers, scientists, managers and others who are interested in irrigation and drainage and water resources planning are invited. For more information go to www.uscid.org/05scada.html

Western Wetland Conference

Scheduled Oct. 24-26 in Denver, the Western Wetland Conference is designed for those who manage, restore, study, and regulate wetlands, and is open to all who value wetlands. The conference presents an opportunity to learn about models and approaches for success, to discuss priorities and successes, and to network with people interested in wetlands throughout the 17-state western region. Participants include private, non-profit, academic, and governmental representatives from local, state, tribal and federal government. A conference focus is on successful approaches and strategies for overcoming wetland protection challenges. For more information check www.mtwatercourse.org/wwc/index.html

Membrane Technology Conference

The American Membrane Technology Association's conference "Water Resource Management: How Membranes May Fit Into Your Resource Plans" is scheduled Nov. 9 - 10 in Mesa. Sessions will focus on the following topics: water resource management: future of water resources in the desert Southwest; developing brackish groundwater in Las Vegas; building large capacity desalting plants; and a facility tour of the City of Chandler's Intel Water Reclamation Plant. Conference brochure and on-line registration are available at: http://www.membranes-amta.org/calendar.html

Tamarisk Symposium

The Tamarisk Coalition and the Colorado State University Cooperative Extension are co-hosting the Tamarisk Symposium Oct. 12-14 in Grand Junction, Colorado. The symposium will focus on issues related to tamarisk and riparian health throughout western North America. The symposium will bring together over 300 people from throughout the West including key researchers, on-the-ground program managers, environmental interests and federal/state/local agencies to better understand the nature of the tamarisk problem and to develop long-term solutions. For more information about the conference and to register go to: http://www.colostate.edu/Depts/CoopExt/TRA/Tamarisk2005.html

Research...continued from page 9

dissolved metals as well as radionuclides to groundwater and receiving surface water.

The project studied the potential of permeable reactive biobarriers (PRBs) for the remediation of acid mine drainage. PRBs provide an innovative, low-cost solution to prevent contaminant migration in groundwater. The technology is extremely simple involving trenches intercepting contaminated plumes. The trenches are filled with porous materials, nutrients and substrates to encourage the development of an active microbial population capable of metal removal. Results indicate that there is a great potential for anaerobic biobarrier systems to remediate high influent pH, sulfate and metal concentrations in acid mine drainage with high efficiencies. A significant finding is the discovery that zero-valent iron is an effective substrate for the microbes involved in the clean-up of acid mine drainage.

Controlling Salt Accumulation to Enhance Sustainability of Subsurface Drip Irrigation, Thomas L. Thompson, Art W. Warrick, University of Arizona. Salts introduced into soils in irrigation water are difficult to effectively leach with subsurface drip irrigation (SDI), a highly efficient means of delivering irrigation water and fertilizers to crops. Growers then have to rent expensive sprinkler systems to leach out salts. An effective means to predict the need for leaching with sprinklers would be of economic benefit to growers and would improve the sustainability of SDI systems. Project goal was to measure salt distribution in SD-irrigated crops with and without the use of sprinklers, and compare actual results with salt distribution predicted by a mathematical model. Salt concentrations near the soil surface (<10 cm) were more than twice those near the SDI tubing. Model results over-predicted salt concentrations when using saline irrigation water. Therefore, model predictions need to be improved to provide a tool for effective salt management.

Public Policy Review

by Sharon Megdal

The Arizona Virtual Water University is Becoming a Reality

During last November's 85th Arizona Town Hall at the Grand Canyon, Governor Janet Napolitano announced her proposal for an Arizona Virtual Water University. Her AVWU concept was to bring together the talents of the three universities — University of Arizona, Arizona State University and Northern Arizona University — to better focus their efforts on state water needs. AVWU would ensure that Arizona has the tools needed for sustainable water supplies, provide enhanced opportunities for water resources education, and expand the state's water research and technology development.

Since the Grand Canyon meeting a lot of effort has gone into implementing this innovative concept. The Governor's Chief of Staff Alan Stephens has hosted and facilitated the efforts of a working group involving representatives of the three state universities and three state agencies, as well as water stakeholders. I have been a participant in these sessions.

Collaboration among the three state universities is not uncommon. What is unusual, however, are the universities working with the state departments of Commerce, Environmental Quality and Water Resources to identify joint projects and develop a business plan. The idea is that this concerted effort will accomplish more for our state than the typical modus operandi. Information, databases and decision tools needed for Arizona communities will be developed to assist decision makers. Enhanced research and development will boost the economy by creating jobs and providing increased opportunities to export knowledge and information. Additional and improved water resources curricula and educational program offerings will be developed.

Efforts to date include the development of a concept paper for the AVWU, which includes a proposed organizational structure. A four-person Executive Committee, comprised of the universities' three vice-presidents for research and the Chief of Staff for the Governor (or designees), will oversee the hiring and work of an executive director. Limited funds have been identified for this effort, although the Arizona Board of Regents recently awarded $150,000 to assist in hiring the AVWU executive director.

To facilitate on-campus coordination, each university has named a coordinator to work on identifying and implementing projects for both the immediate and near term. The executive director will eventually work with one or more associate directors; these are expected to be housed within one of the three state agencies, Commerce, Environmental Quality or Water Resources. The embedding of AVWU personnel in the agencies is a strategy to keep the work of the AVWU connected with the needs of the state.

Interaction with external stakeholders for input on project priorities and project formulation has occurred, and an External Advisory Committee will be formed. The chair of the External Advisory Committee is expected to serve as an ex officio non-voting member of the Executive Committee. The Arizona Department of Commerce and the Board of Regents have funded a contract with Battelle Memorial Institute for assistance in developing a business plan for the innovative water institute. A needs assessment for the AVWU is underway.

The AVWU working group has identified four projects for immediate work, with each project a collaborative effort expected to involve principal investigators from the three universities. Some limited funding has been identified to start these projects. Each has short-term and long-term objectives. Brief descriptions follow:

Arizona Hydrologic Information System The project goal is to develop AVWU's information infrastructure and to provide access to data relevant to water-related research, technology, planning, education, and outreach from multiple Southwest sources. The project's first phase is well underway. Developed at the UA, the arizonawater.org web site information tool was unveiled at the Arizona Water Summit at NAU. (See Publications, page 7, for a description of this site.) Readers are invited to visit the site which should be a very useful portal for information and interaction.

Water Quality Priority Projects Two water quality themes with long-term implications for water management have been prioritized: arsenic and other inorganic contaminants in drinking water and source waters, and emerging contaminants in wastewater. The specific projects are important for determining human health and ecosystem impacts along with the short-and long-term evaluation and remediation of Arizona water systems.

Water Conservation Technology Exchange This project will establish a forum to promote an exchange of water conservation technology among industrial water users, water providers, policy makers, research and educational institutions, and community groups.

Meeting the Water Management and Planning Needs of the Upper Verde Watershed This project, which is intended as a prototype, will focus technical expertise on the interdisciplinary objective of developing a future water supply and formulating drought management and planning scenarios for the Upper Verde Watershed. This area offers an exciting and timely location to focus the water talent of Arizona's three universities; the tools and solutions worked out to address the local issues will be applicable to regional, national and international water concerns.

The AVWU is truly an innovative concept, one promising multiple benefits to the state. A challenge for all such efforts is obtaining needed resources; it is expected that this creative venture will attract the interest of funding agencies, private donors, and others willing to provide support. This truly is just the beginning.

NOTE: Anyone interested in applying for the AVWU Executive Director position should check the UA's jobs web site, www.uacareertrack.com.

Fossil Creek...continued from page 4

low the dam profiled the extent to which the diversion of most of the creek's base flow disrupted the river's ecosystem. Restoring the river's full flow and removing non-natives to increase the native fish population would likely result in a more productive river.

A group of federal and state agencies undertook the task of eradicating non-native fish to create more favorable conditions for the native species. Native fish were removed and placed in a holding tank while the river was treated with a chemical that poisoned the non-native fish. Native fish were released back into the creek when safe conditions returned. A fish barrier will help prevent the reinvasion of non-native fish from the Verde River.

A unique feature of Fossil Creek that is expected to be enhanced with full river flows is the continual formation of travertine. The waters of Fossil Creek, coming from underground limestone, are calcium carbonate-rich. NAU researcher Abe Springer has characterized over 60 springs feeding into the creek. Water cascading over cobbles and boulders releases carbon dioxide; calcium carbonate is then deposited in the creek forming travertine dams, waterfalls and deep blue pools similar to those found at Havasu Falls. Rod Parnell of NAU's Geology Department predicts that a restored flow will increase the number and size of travertine dams. And there will be a biological payoff: NAU biologists say the increased travertine will likely create conditions conducive for the shelter and spawning of native fish.

A question was raised about the sediments behind the dam, whether the restored river would flush the sediments out without harming downriver plants and animals. Any effort to manually remove the sediment would be very costly. Based partly on work by NAU researchers Charlie Schlinger and Steve Monroe, the Federal Energy Regulatory Commission decided to require a 14-foot lowering of the diversion dam, which is slated to occur in 2007, and allow the sediment to naturally disperse downstream during flood events. Schlinger and his students are investigating the distribution and movement of that sediment both prior and subsequent to lowering of the dam. Follow-up research by Parnell and Marks will study the actual effects of the sediment release on the travertine formation and the life in the river.

With the creek restored the state will be gaining an additional 14 miles of wetland ecosystem valuable for wildlife and creek-side recreation. The creek, which flows at 46 cubic feet per second, is one of the few perennial streams left in Arizona. NAU researcher Marty Lee is working with the U.S. Forest Service to determine appropriate recreation activities for the area that will have minimum impact. Lee also is exploring options to provide stewardship of the Fossil Creek area including the possibility of forming a "Friends of Fossil Creek" group.

NAU's work thus far has focused on gathering baseline data prior to the return of full flows. Now that flows are restored NAU's research and monitoring will examine the changes that take place.

The restoration work at Fossil Creek will be the subject of a video documentary produced by NAU's Stream Ecology and Restoration Group, in collaboration with the Museum of Northern Arizona and Paul Bockhorst Productions. The video will show that the complex environmental issues that challenge researchers at Fossil Creek will likely arise at other such restoration projects. The video will present Fossil Creek as a national case study.

Fossil Creek State of the Watershed Report, a document summarizing available information on the current conditions of the physical, biological and social environment of the Fossil Creek Watershed prior to the decommissioning activities, is being finalized and will be available on the web site, along with other information about NAU's involvement in the project. Check: http://www.watershed.nau.edu/FossilCreekProject/

The Nina Mason Pulliam Charitable Trust has supported the NAU team's overall effort in Fossil Creek including research and monitoring activities. The trust also is providing partial support of the documentary video.

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