

### Water Management Plans Have Common Ground

To most people — if they thought about it at all — water management is a relatively modern concept based, if not on scientific theories, then on tried-and-true, take-charge principles. At some point in the past, perhaps during the industrial revolution, management as a specialized activity took shape. Whereas people once made do or worked things out, they now managed.

Perhaps management should not be so narrowly defined. For example, water is managed when society takes certain actions intending to influence the occurrence, movement or collection of water. A recent book, *Precolumbian Water Management: Ideology, Ritual, and Power*, takes a broad view of water management to include water symbolism and ritual and the religious views of the times. (See page 8 for information about the book.) Not likely to be found in today's water management plans, these elements, which were understood to have power and influence, were sufficiently important to past cultures to be part of their water management plans.

In that sense, Tlaloc would certainly figure in the Precolumbian Aztec water management plan. The god of fertility and rain, Tlaloc, usually depicted as a goggle-eyed blue being with fangs, was believed to be responsible for both floods and droughts. To win his favor, humans were often sacrificed, usually children,

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Tlaloc, as shown in the late 16th century Codex Rios. Tlaloc, the Aztec god of rain and drought, was the patron god for the month Atlacacauallo which scholars believe roughly corresponds to our month of February. See story at left.

### Study Says Northern Arizona's Water Supplies Unsustainable

*Alternative Supply Strategies Offered*

by Joe Gelt

North-central Arizona's dilemma is the same confronting many other areas of the state: a growing population and limited water supplies. A recently released Bureau of Reclamation report both documents the extent of the water shortage and identifies possible solutions.

The report's results confirm what is generally believed in the region: that a serious future water shortage looms on the horizon. Factoring in population growth — according to Arizona Department of Economic Security figures, population in the area will double, from 96,125 in 2000 to 184,650 in 2050 — and present water use and supplies the report indicates that by 2050 the region's groundwater pumping will

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not be sustainable and that unmet water demands will total about 7,000 acre feet.

The threat of water shortages, along with the onset of drought conditions, were on the minds of the region's stakeholders when they requested Reclamation to conduct the study that was funded in October 2000. Although such appraisal studies are usually completed in two years, this one was in progress for five years to take advantage of ongoing and related studies.

In fact, it was the results of a 1998 Arizona Department of Water Resources report that added impetus that Reclamation undertake the appraisal study. The ADWR report concluded that a pipeline from Lake Powell was essential to supply water to the region. ADWR asked Reclamation to peer review the study; the federal agency recommended that alternatives be considered and raised concerns about the continued and future development of aquifers in the region. The present Reclamation study in a sense is a further response to the ADWR report.

In conducting the feasibility study Reclamation responded to the region's stakeholders request to determine if adequate water supplies would be available to meet regional water demand projected to the year 2050. If supplies were found to be inadequate, Reclamation then was to identify a regional option or alternative to meet future demands. Finally, stakeholders wanted to determine whether an identified regional water supply plan would meet a federal objective. This would open the door to federal funding.

As part of the project, the federal study team examined the course of action communities in the region would likely pursue if a federal water supply project did not pan out. If left solely to their own devices, most would continue developing groundwater while intensifying water conservation and reuse efforts. Increased groundwater development, however, would likely be at a cost: seeps, springs and perennial reaches of some streams in the study area could be impacted.

Noting results of previous studies, the report states that continued development of the Coconino Aquifer and the Navajo Aquifer could result in portions of these aquifers becoming unsustainable within the next few decades. The Navajo and Hopi people rely on these aquifers for current and future supplies. Further development of the Redwall-Muav Aquifer could result in high-visibility notoriety by threatening spring flows below the south rim of the Grand Canyon. The Havasupai Tribe consider these springs "the life-blood of the earth and the Havasupai."

After reviewing likely water supply strategies and finding them wanting for not likely meeting future water demands, the study team then worked out alternatives for increasing regional water supplies to meet future demands.

In the first alternative a pipeline would deliver Lake Powell water to the Navajo Nation and Hopi Tribe. Flagstaff would get its

## **EIS Released on Proposed Black Mesa Pipeline**

A draft environmental impact study has been recently released that considers the effects of a proposed pipeline project that would tap water from the Coconino Aquifer near Leupp northwest of Winslow for use by the Black Mesa mine. The pipeline would extend about 120 miles across the Navajo and Hopi reservations from the wells to the coal slurry preparation plant.

According to the EIS social and environmental costs would result from the project. These include the relocation of 17 Navajo families; some wells in the Leupp area could go dry; and the survival of threatened fish in nearby creeks during dry seasons could be jeopardized.

The city of Flagstaff also taps into the C-aquifer and considers it a possible source to meet future increased water needs. (See story to the side.)

Water from the C-aquifer is being sought to replace groundwater that the Black Mesa mining operation has been drawing from the Navajo Aquifer. Controversy has dogged the mine's use of the N-aquifer; some claim that after more than 40 years of pumping the N-aquifer is seriously depleted. The N-aquifer is a water source to the Navajo and Hopi people.

The Black Mesa mine is closed until Southern California Edison, the owners of the Mohave Generating Station, installs about \$1 billion worth of air pollution controls. This they refuse to do until an alternative water source is identified.

The proposal to use the C-aquifer would allow the Navajo Nation and Hopi Tribe to construct lateral pipelines tapping into the main trunk to provide water for people living along the pipeline route.

According to the proposal, C-aquifer water would allow expanded mining operations, from 4.8 million tons to 6.35 million tons a year. This would increase tribal royalties by 10.5 percent and add about 220 jobs.

The draft EIS is available at [www.wrcc.osmre.gov/WR/BlackMesaEIS.htm](http://www.wrcc.osmre.gov/WR/BlackMesaEIS.htm). Public meetings are being conducted to discuss the report.

water from the C-Aquifer and Williams from the RM Aquifer. Water for the Grand Canyon and Tusayan would come from a Bright Angel Creek infiltration gallery located at Phantom Ranch in the Grand Canyon.

The second alternative is the same as the first except that Flagstaff also would receive Lake Powell water.

In alternative three, everyone gets Lake Powell water: the Navajo Nation, Hopi Tribe, Flagstaff, Williams, the Grand Canyon and Tusayan.

Common to all the alternatives is the building of a pipeline, the key to all the strategies for bringing new water supplies into the region. The 1998 ADWR report also favored a pipeline in its strategy to import water into the region. What the Reclamation report does is not offer alternatives to the pipeline concept, but alternatives to the pipeline route recommended by the ADWR study.

The recent report is considered an appraisal study, a preliminary step along the way in securing federal support for a regional water supply strategy. It is now up to the Coconino Plateau Water Advisory Committee to work with its congressional delegation to get the federal government to conduct a feasibility study. This would provide a more in-depth look at the alternatives, including identifying environmental issues, reviewing design specifications and

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## Water Vapors

# Busy WRRC Revives Publication, Plans Conference, Gets Funding Authorized

### It's Back — The Arroyo



The WRRC once published two newsletters, this one — the *Arizona Water Resource* — and the *Arroyo*. Whereas the bimonthly *AWR* provides wide coverage

of state water news and events, the *Arroyo* is a single-issue newsletter, with each edition focused on a particular water issue. Issues addressed by *Arroyo* have included rural water affairs, watershed management, aquaculture and constructed wetlands. It was written with a wide readership in mind, in a nontechnical, nonacademic style, to appeal to the interested citizens as well as water professionals.

As it turned out, the *Arroyo* lived up to its name; it proved not to be a channel for a perennial flow. In fact, the last *Arroyo* was published in May 2002, with a long dry spell following. The *AWR* became WRRC's publication priority.

The *Arroyo* series will begin to flow again soon with an edition focusing on artificial recharge and will be mailed to people whose names are on the WRRC mailing list. It will continue the *Arroyo* tradition of providing a readable review of an important water issue. Extra copies are available for educational purposes.

The *Arroyo* will continue as an occasional publication, with editions published as resources become available and appropriate topics identified.

### WRRC Plans June 5 Conference

As you fill in your new 2007 daily planning calendar don't forget to note on June 5 the Water Resources Research Center's annual conference. The title of the conference is

"20th Anniversary of the Environmental Quality Act and ADEQ: Assessing, Protecting and Remediating the State's Water Quality. What Future Challenges?" The event is cosponsored by the Arizona Water Institute and the Arizona Department of Environmental Quality. As befits the event, the tentative agenda is an anniversary agenda, celebrating the origins of Arizona's EQA, reviewing the current situation and considering future challenges. Issues to be addressed include the history of the act; the state of water quality science; emerging policy challenges; regulatory approaches; and the future of ADEQ.



Photo: ADEQ

To include your name on a mailing list to receive additional information about the event contact us at [wrrc@ag.arizona.edu](mailto:wrrc@ag.arizona.edu). Check the WRRC web site for conference planning updates.

### Law Authorizes WRRC Funding

The program that provides federal funding to the UA's Water Resources Research Center, along with other state water institute

programs throughout the nation, received a five-year extension when President Bush signed H.R. 4588 into law on Jan. 11. The law authorizes appropriations for the state water institutes for FY2007-FY2011.

Congressional appropriations have annually funded WRRRA's 104B and 104G grants program supporting water research. WRRRA has strong congressional support; both the House and the Senate unanimously passed the recent reauthorization.

WRRC Director Sharon Megdal says, "Reauthorization is great news. It is a measure of national support for a program that makes an impact at the state level in the vital area of water. Funding from the program enables WRRC to support research on important state and regional water-related issues." (See Special Projects, page 9, for description of Arizona projects awarded 104B support for 2007.)

### U.S.G.S. Sponsors Supplement

This edition of the *AWR* contains a 4-page supplement sponsored by the U.S. Geological Survey titled "Trends in Streamflow of the San Pedro River, Southeastern Arizona." By sponsoring the supplement, the agency is supporting the publication of this newsletter. We appreciate the opportunity to work with U.S.G.S. and the agency's generous support.



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#### Arizona Water Resource Staff

Editor: Joe Gelt  
[jgelt@ag.arizona.edu](mailto:jgelt@ag.arizona.edu)  
 Editorial Assistant: Gabriel Leake

WRRC web site:

<http://cals.arizona.edu/azwater/>

WRRC Director: Dr. Sharon Megdal

#### Arizona Water Resource

Water Resources Research Center  
 College of Agriculture and Life Sciences  
 The University of Arizona  
 350 North Campbell Avenue  
 Tucson, Arizona 85719

520-792-9591 FAX 520-792-8518

email: [wrrc@cals.arizona.edu](mailto:wrrc@cals.arizona.edu)



## News Briefs

### Report Addresses Prescott AMA's Overdraft Problem

The recent release of a report with suggested strategies for the Prescott Active Management Area to halt groundwater overdraft is part of an ongoing effort in the area to address the problem. Prepared by a subcommittee of the AMA's Groundwater Users Advisory Committee, the report, "Safe Yield Impediments, Opportunities and Strategic Directive," lists obstacles to achieving safe yield as well as recommendations for reaching the goal. The AMA is currently out of compliance with safe-yield rules

Impediments include lack of access to other water supplies; the ongoing dispute regarding Prescott's plan to import Big Chino Sub-basin groundwater; lack of consequences for not reaching safe yield; insufficient public understanding; and dearth of legislative assistance.

Recommendations include organizing a group to take action on the report's findings; legislation to address the problem of exempt wells, possibly by imposing impact fees and installing meters; creation of special regional water management districts; gathering data on residential well water uses; and improved public education.

The report is the result of municipalities and major water users in the area deciding to cooperatively address the issue. By organizing themselves as a subcommittee of the GUAC, however, the group limited its options. The subcommittee, which included major municipalities, tribes, small water utilities and Yavapai County, is a state entity and thus is precluded from lobbying the Legislature to implement its recommendations.

A disclaimer in the report states that it does not express the views of the Arizona Department of Water Resources. Prescott AMA Director Gerry Wildeman says, "From our viewpoint the (report) was not presented to myself or the DWR director as recommendations. It was given to us for information purposes."

She says, "The department views it as

a good baseline, the first stab at information gathering for the fourth management plan. It identifies what people in this area believe to be the issues."

After dissolving the safe-yield subcommittee its former members are now considering forming a new group outside the auspices of the GUAC that will have the freedom to engage in political action, possibly working with Senator Tom O'Halleran to implement legislative changes.

### Page Eyes Lake Powell for Flow of Tax Revenues

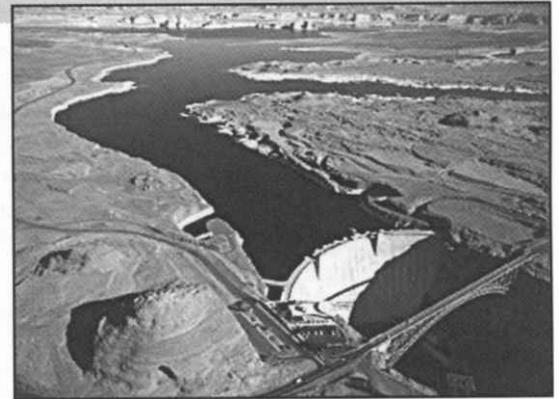
In a twist on the usual theme of a town or municipality staking an interest in a lake to ensure a water supply, the city of Page, Arizona, is attempting to annex more than 21,000 acres, north and west of town, an area that includes Glen Canyon Dam and a significant portion of the Glen Canyon National Re-creation area as well as Navajo land, not for new water supplies but for the sales tax revenues from Lake Powell's Wahweap and Antelope Point marinas. Page officials say the move would net the city \$400,000 to \$600,000 annually and double its size.

It a grandiose scheme by a city of 7,000 people to take on the U.S. Bureau of Reclamation, the National Park Service and the Navajo Nation. A Salt Lake Tribune writer reporting on the issue says it is like Jonah trying to ingest a whale.

All three entities vigorously object to the proposal, arguing against it during a November public hearing. The hearing was part of a year-long process of collecting the required number of signatures in favor of the proposal.

Page Mayor Dan Brown claims there are precedents to the city's annexation plans, pointing to Sierra Vista's annexation of Fort Huachuca and Peoria's annexation of Lake Pleasant and its marina.

Opponents of annexation say federal law prohibits such a move if annexing federal holdings results in a "potential for fric-



A predrought Lake Powell

Photo: USGS

tion" between the annexing entity and federal government. They also argue that the city would not be in position to provide the essential services an enlarged city requires including law enforcement, firefighting and homeland defense. Annexation also would interfere with certain federal responsibilities such as protecting Glen Canyon Dam

Undaunted, the city of Page soldiers on. It will be a year-long battle, the time that is allowed for supporters to collect required signatures and opponents to halt the procedure.

### System in Place to Clean Up Scottsdale Superfund Site

Significant progress was marked at the Indian Bend Wash contamination site, one of the largest groundwater cleanup projects in the nation, when the Environmental Protection Agency recently declared "construction complete."

This does not mean rehabilitation work is complete; work is ongoing with much more to be done. The EPA designation means that a treatment system has been developed that will cleanse all the contaminants from the groundwater.

In other words, the situation, although still very much a cause for concern, is under control, with all treatment systems at the Scottsdale Superfund site now in place. Still, estimates vary that it will be between 30 to 50 years before the solvent is totally cleansed from the sites.

Contaminant concentrations in the spill have measured as high as several hundred parts per billion, far exceeding the governments' drinking water standard of five parts

## Legislation Seeks Increased Availability of Colorado River Supplies

### New Reservoir to Capture Water for Nevada

During the closing hours of 109th Congress, lawmakers passed a bill with language that directs the Bureau of Reclamation to construct a new reservoir in Southern California to enable states to better manage Colorado River waters and to increase Nevada water supplies.

Called the "Drop 2 Structure," the reservoir is meant to ensure a more efficient delivery of water from Lake Mead to downriver farmers or irrigation districts. Water now released from Lake Mead for downriver agricultural use may take several days to reach its destination. Meanwhile changing conditions such as rain may result in the water not being needed. Unclaimed by U.S. agricultural interests, the released water then flows to Mexico.

The 8,000 acre-foot reservoir, which would be located in California about 25 miles outside Yuma, along the All-American Canal, would provide temporary storage until the water is returned to the system for use. The Southern Nevada Water Authority will pay most of the estimated \$84-million cost to construct the reservoir, in exchange for rights to up to 40,000 acre feet per year for seven years.

Pat Mulroy, general manager of the SNWA calls the reservoir, "... yet another tool to help us protect the reliability of this community's water supply.

"Like the Arizona and California water storage banks we have created, this new reservoir allows us to optimize our use of the Colorado River."

Reclamation's estimations indicate that the reservoir will conserve an average of 60,000 acre-feet of water annually, with a total water savings of 3-million acre feet over the reservoir's projected 50-year lifespan.

Environmentalists have expressed concern that the reservoir will reduce flows to the Colorado River Delta, once a thriving wetland, now suffering the consequences of seven states drawing shares from the river.

The reservoir project was included in a recently released U.S. Bureau of Reclamation 2007 Annual Operating Plan for Colorado River Reservoirs that included strategies to increase available water

supplies. The Reclamation plan also calls for the restarting the Yuma desalter.

### Bill Backs Canal Lining "Without Delay"

In the latest action in the ongoing controversy regarding the lining the All-American Canal, Congress passed a bill ordering the U.S. Secretary of the Interior to proceed with the project and to complete it "without delay." The legislation was buried in a late-session tax bill.

The project, originally authorized by Congress in 1988, has been on hold since August when the 9th U.S. Circuit Court of Appeals ordered a halt to work pending the hearing of an appeal filed to block the canal lining. The case went to the appeals court after a federal judge denied a petition by two California environmental groups and a Mexican business coalition to block the project.

Water has flown in the All-American Canal to Imperial Valley since the 1940s. At a cost of \$251 million officials now want to

line the canal to prevent seepage along a 23-mile segment. According to the Bureau of Reclamation, owner of the canal, this would save 67,700 acre-feet of water per year, enough water for 135,000 families in the San Diego area.

The canal-lining is considered essential if California is to reduce its take of Colorado River water per a 2003 agreement among seven the Colorado River states. Arizona and Nevada support lining the canal.

Mexico opposes canal-lining, arguing that farmers in the Mexicali Valley rely

on the cross-border seepage and have established rights after four decades of continuous use. Environmentalists also oppose the project; they say it would deprive a Mexican wetland of water.

Those favoring the project, which has a deadline of the end of 2008, have complained that the delays will set work back a year and significantly raise its cost by tens of millions of dollars. Further, California taxpayers and San Diego County ratepayers will confront higher costs.

Opponents say legal action will continue.



*The Lower Colorado River, Photo: Bureau of Reclamation, Andy Pernick*

per billion, although not as high as is found at other Superfund sites.

The treatment facility "strips" water of contaminants by mixing it with air. Water is pumped from contaminated wells and filtered through three treatment columns that mix the water and air, with the contaminants attaching themselves to the air. The treated water then is pumped to a reservoir for further treatment. What makes this operation unusual in that the water is then delivered

to Scottsdale's drinking water system. Activated carbon filters remove contaminants from the air before it is released.

The treatment system, one of largest pump-and-treat operations in the nation, has the potential to treat 5.8 billion gallons of a years to drinking water standards.

The cleanup project dates back to 1983, two years after Scottsdale found trichloroethylene or TCE, which is considered a carcinogenic, in some of the drinking wells

in the area. Those responsible for the contaminants, including Motorola, Siemens and GlaxoSmithKline, have paid most of the cleanup costs.

The TCE-tainted groundwater spread under a 13 square-mile area in Scottsdale and Tempe, with about three-quarters of the contamination located in Scottsdale. Groundwater pumping to support growth north of Scottsdale caused the plume to drift northward.



## Guest View

# Now is the Time to Consider Replenishing Aquifers in Areas of Hydrologic Impact

Tom Buschatzke, Water Advisor for City of Phoenix, contributed this Guest View. He can be reached at: [tom.buschatzke@phoenix.gov](mailto:tom.buschatzke@phoenix.gov)

Central Arizona has a tremendous asset in its extensive groundwater aquifers. The Groundwater Management Act of 1980 recognized this fact and created a framework for moving aquifer management in Active Management Areas toward sustainability. Programs such as mandatory water conservation, assured and adequate water supply requirements for municipal water providers, and underground storage and replenishment have positioned the State of Arizona as a leader in aquifer management and increased the level of certainty that water supplies will be available for existing populations, and for growth now and in the foreseeable future.

However, much has changed since the inception of the GMA and the work of water managers to achieve long-term water supply sustainability is not done. One particular issue that needs further dialogue is where replenishment of mined groundwater should take place, i.e., “replenishment within the area of hydrologic impact.”

The use of mined groundwater by municipal water providers within AMAs that have a goal of safe yield is essentially prohibited.

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*It is incumbent upon prudent water managers to address the issue of replenishing aquifers in areas where the water is actually withdrawn.*

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However, mined groundwater can be used as long as it is replaced, or “replenished” within an AMA. Currently that replenishment may legally occur anywhere within an AMA. To date this policy has served the state well, but factors that were not in play at the time of the passage of the GMA have arisen that call for a reexamination of this policy.

The water resources management landscape has changed significantly since the inception of the GMA in 1980. Some of those changes include: (1) accelerated growth in areas that have little or no access to surface water supplies or Colorado River water, aided by the state’s creation of the Central Arizona Groundwater Replenishment District; (2) areas that have renewable supplies are experiencing growth at rates that may require acquisition of additional renewable supplies or the increasing use of aquifers, with replenishment of mined groundwater; (3) tree-ring research has come to light that shows pre-historic droughts of two to three times greater duration on both the Colorado River and within the state and a greater correlation for periods of simultaneous drought between the Colorado River and in-state streams; (4) population growth rates have far exceeded projections; (5) growth has proceeded toward the margins

of the groundwater basins in areas where aquifers contain less water in storage and where detrimental impacts of aquifer dewatering such as earth fissuring are more likely to occur; (6) environmental impacts of water use have become “a part of doing business”; (7) climate change models have raised the specter of reduced Colorado River and in-state stream flows and reduced natural recharge to aquifers; (8) significant quantities of water have been stored underground for recovery at a later date for a variety of purposes that include drought protection, Indian water rights settlements and use by the State of Nevada. In summary, aquifers have evolved beyond being simply a source of water into a resource that is used to conjunctively manage renewable water supplies and groundwater resources.

All these factors add up to one indisputable truth: reliance upon groundwater aquifers to manage water supplies in the AMAs will increase over time. Aquifers will not simply sit there, untapped, for use in drought or as a hedge against future uncertain conditions. The disconnect between where water is pumped and where that water is replenished, must be addressed.

It is inevitable that groundwater recharge and pumping to utilize the water storage capabilities that aquifers provide will increase over time. It is incumbent upon prudent water managers and the State of Arizona to address the issue of replenishing aquifers in areas where the water is actually withdrawn, i.e., the “area of hydrologic impact.” This issue was most recently debated on a large scale by the Governors Water Management Commission in 2000. Despite the inability of that process to resolve the issue, it has not gone away. The issue has been raised recently in smaller forums including the Arizona Department of Water Resources well rules stakeholder process and the Central Arizona Project’s Strategic Plan.

This issue is not restricted to a specific sector of water providers. Rather, it will impact all water users that rely on the same aquifer to manage their water supplies. In some cases the facts will likely show that local groundwater level declines are occurring to a degree that replenishment within the area of hydrologic impact is a necessity, while in other situations that may not be the case. A concentrated effort to examine local impacts is needed and a dialogue among water users that rely on aquifers must follow. Equity for those who have invested and relied upon the current system for replenishment will be a huge issue, as will the need to maximize the use of future supplies, such as reclaimed water in a cost effective manner.

The task will not be easy and will likely move at the glacial pace that traditionally accompanies informed decision making in the complex world of water policy. The clock is ticking and the time to get the water resources community back to the table to discuss this issue is now! ■

Prepared in cooperation with the  
BUREAU OF LAND MANAGEMENT

# Trends in Streamflow of the San Pedro River, Southeastern Arizona



Figure 1. Location of study area.

## Introduction

Total annual streamflow of the San Pedro River at Charleston in southeastern Arizona (fig. 1) decreased by about 66 percent from 1913 to 2002 (fig. 2). The San Pedro River is one of the few remaining free-flowing perennial streams in the arid Southwestern United States, and the riparian forest along the river supports several endangered species and is an important habitat for migratory birds. The decreasing trend in streamflow has led to concerns that riparian habitat may be damaged and that overall long-term water supply for a growing population may be threatened. Resource managers and the public have an interest in learning more about the trend and the possible causes of the trend.

Thomas and Pool (2006) investigated the decreasing trends in

streamflow of the San Pedro River. Their study evaluated trends in seasonal streamflows and trends in the relation between precipitation and streamflow. The purpose of this fact sheet is to summarize results of the detailed study by Thomas and Pool (2006).

Changes in total annual streamflow of the San Pedro River at Charleston, Arizona, were greater than changes in annual precipitation at Tombstone, Arizona, for the same period (1913–2002; figs. 2 and 3). Annual precipitation decreased by 13 percent, and annual streamflow decreased by 66 percent. Winter precipitation and streamflow changed by a small amount, but summer precipitation decreased by 26 percent, and summer streamflow decreased by 85 percent.

Possible factors that could have caused the decreasing trends in streamflow were trends in precipitation, changes in watershed characteristics, and human activities. The variation in streamflow caused by variation in precipitation was statistically removed. Thus, the remaining variation or trend in streamflow can be attributed to factors other than precipitation.

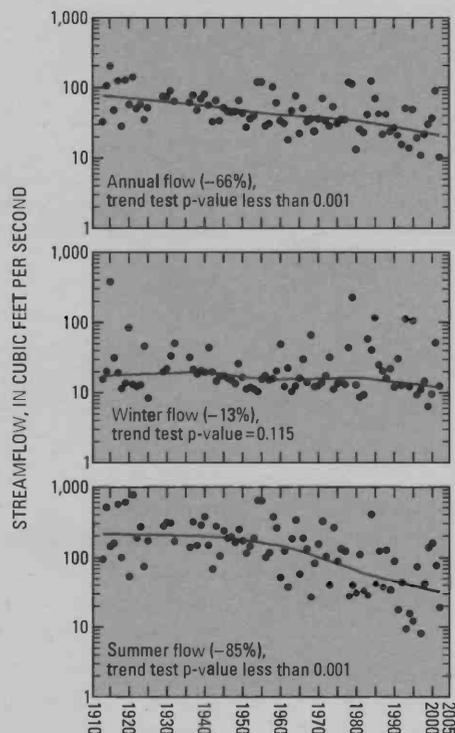


Figure 2. Trends in annual and seasonal streamflow of San Pedro River at Charleston, Arizona. Lines are LOWESS fit to data.

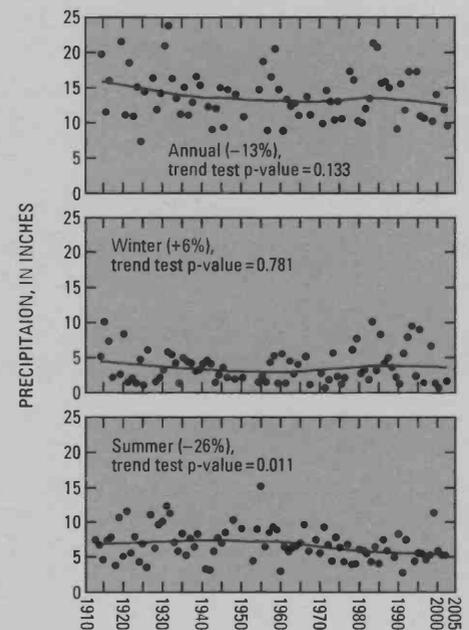


Figure 3. Trends in annual and seasonal precipitation at Tombstone, Arizona. Lines are LOWESS fit to data.

## Methods

Two methods were used to partition the variation in streamflow and to determine trends in the partitioned variation: (1) regression analysis between precipitation and streamflow and statistical tests of time trends in regression residuals, and (2) development of regression equations between precipitation and streamflow for three time periods (early, middle, and late parts of the record) and testing to determine if the three regression equations (rainfall-runoff relations) are significantly different. Method 1 was applied to monthly values of total flow (average flow) and low flow (3-day low flow), and method 2 was applied to total flows. The low flows are roughly analogous to base flow, which is ground-water discharge to the river.

An important feature of the statistical analysis in the study is that it provides objective criteria for making decisions and interpretations about the data. The statistical tests for trends result in a *p*-value. The *p*-value is a measure of the strength of evidence (data) for determining if the change in flow over time is a random occurrence or if it is a significant trend that did not occur by chance. As the *p*-value decreases, the evidence to support a conclusion for a trend becomes stronger. A threshold significance level of 0.05 was used in the study; a *p*-value of less than 0.05 means that the trend is considered significant. A *p*-value of 0.05 means that there is a 5-percent probability that the conclusion for a trend is incorrect.

The regression analysis between precipitation and streamflow (method 1) was done by using a regression-smoothing technique called locally weighted scatterplot smoothing (LOWESS) (Cleveland, 1979; Insightful, 2001). This nonlinear technique was used because the relation between precipitation and streamflow is not linear. Examples of the nonlinear relations are shown for February and July in figure 4.

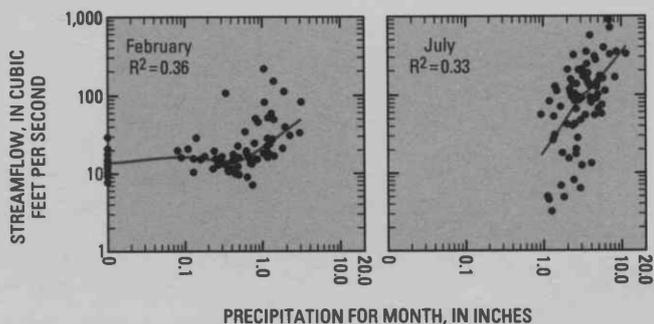


Figure 4. Examples of LOWESS fits to precipitation at Tombstone and streamflow of the San Pedro River at Charleston, Arizona, February and July.

## Results of Regressions and Trend Tests

The LOWESS analyses were successful in explaining much of the variation in streamflow (tables 1 and 2). Generally, precipitation for the same month as streamflow and precipitation for several preceding months were used in the LOWESS equations. The  $R^2$  values shown in tables 1 and 2 represent the amount of variation in streamflow that is explained by precipitation. Thus, precipitation in December, January, and February explained 80 percent of the variation in total streamflow for February. The advantage of using several months of precipitation instead of just one month of precipitation is evident in the comparison of the  $R^2$  values

Table 1. Results of LOWESS regression analyses between monthly precipitation at Tombstone, Arizona, and monthly total streamflow for the San Pedro River at Charleston, Arizona

[ $R^2$ , coefficient of multiple determination]

Month of total streamflow <sup>1</sup>	Months of precipitation used in LOWESS regression equation <sup>2</sup>	$R^2$ for regression equation
Jan.	Oct., Nov., Dec., Jan.	0.81
Feb.	Dec., Jan., Feb.	.80
Mar.	Jan., Feb., Mar.	.66
Apr.	Jan., Feb., Mar.	.50
May	Jan., Feb., Mar.	.52
June	Dec., Jan., Mar., June	.73
July	Jan., May., June, July	.70
Aug.	Feb., July, Aug.	.64
Sept.	May, Aug., Sept.	.62
Oct.	May, Sept., Oct.	.77
Nov.	June, Oct., Nov.	.74
Dec.	Oct., Nov., Dec.	.78

<sup>1</sup>Time period for analysis was 1913–2002.

<sup>2</sup>LOWESS regression model:  $\log Q_n = \log P_1 + \log P_2 + \log P_n$ , where  $Q_n$  is average streamflow for month *n*, in cubic feet per second, and  $P_n$  is precipitation for month *n*, in inches.

Table 2. Results of LOWESS regression analyses between monthly precipitation at Tombstone, Arizona, and monthly low flow for the San Pedro River at Charleston, Arizona

[ $R^2$ , coefficient of multiple determination]

Month of low flow <sup>1</sup>	Months of precipitation used in LOWESS regression equation <sup>2</sup>	$R^2$ for regression equation
Jan.	Oct., Nov., Dec., Jan.	0.80
Feb.	Nov., Dec., Jan.	.82
Mar.	Jan., Feb., Mar.	.58
April	Jan., Feb., Mar.	.60
May	Nov., Dec., Jan., Mar.	.75
June	Dec., Jan., June	.57
July	Apr., May, June, July	.81
Aug.	Dec., July, Aug.	.67
Sept.	Jan., Aug., Sept.	.60
Oct.	May, Aug., Sept.	.66
Nov.	Aug. and Oct.	.65
Dec.	Aug., Oct., Nov.	.59

<sup>1</sup>Time period for analysis was 1931–2002.

<sup>2</sup>LOWESS regression model:  $\log Q_n = \log P_1 + \log P_2 + \log P_n$ , where  $Q_n$  is 3-day low flow for month *n*, in cubic feet per second, and  $P_n$  is precipitation for month *n*, in inches.

of single-variable LOWESS equations to the  $R^2$  values of multivariable equations. For February, the  $R^2$  value was 0.36 for a single-variable equation and 0.80 for a multivariable equation; for July, the  $R^2$  value was 0.33 for one variable and 0.70 for multiple variables (table 1 and fig. 4).

To determine if factors other than precipitation caused trends in total flows and low flows, the residuals from the LOWESS multivariable analyses were tested for trends using a Kendall tau statistical test (Helsel and Hirsch, 1992). The LOWESS residual (measured minus predicted value) represents streamflow with the variability caused by precipitation removed. Trends in the residuals are trends caused by factors other than variation in precipitation. Residual trends are also trends in the relation between precipitation and streamflow.

Factors other than precipitation caused significant trends in total flows for June–December and did not cause significant trends for January–May (table 3). For low flows, factors other than precipitation caused significant trends for May, June,

**Table 3.** Trends in monthly total streamflow and monthly total streamflow adjusted for variation in precipitation, San Pedro River at Charleston, Arizona, 1913–2002

[<, less than]

Month	Total streamflow, 1913–2002			
	Kendall tau trend test			
	Streamflow and time		Adjusted streamflow and time <sup>1</sup>	
	Slope <sup>2</sup>	p-value	Slope <sup>2</sup>	p-value
Jan.	n	0.017	n	0.208
Feb.	n	.930	p	.428
Mar.	n	.996	p	.487
Apr.	p	.542	p	.638
May	n	.081	n	.449
June	n	.001	n	<.001
July	n	<.001	n	.007
Aug.	n	<.001	n	.001
Sept.	n	<.001	n	<.001
Oct.	n	.029	n	<.001
Nov.	n	<.001	n	<.001
Dec.	n	.018	n	<.001

<sup>1</sup>Variation in streamflow that was caused by variation in precipitation was removed by LOWESS regression analysis.

<sup>2</sup>Slope of trend: n is negative and p is positive.

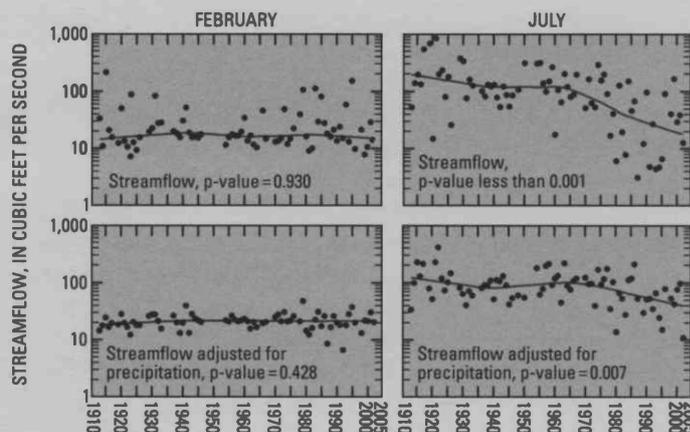
	p-value
not significant	0.05 to 1.00
n	<0.05

and August–December and did not cause significant trends for January–April and July (table 4). Thus, a seasonal pattern was determined with significant trends in summer, fall, and early winter flows, and no significant trends in late winter and spring flows. Examples of trends in streamflow and trends in streamflow adjusted for variation in precipitation (LOWESS residuals) are shown for February and July in figure 5.

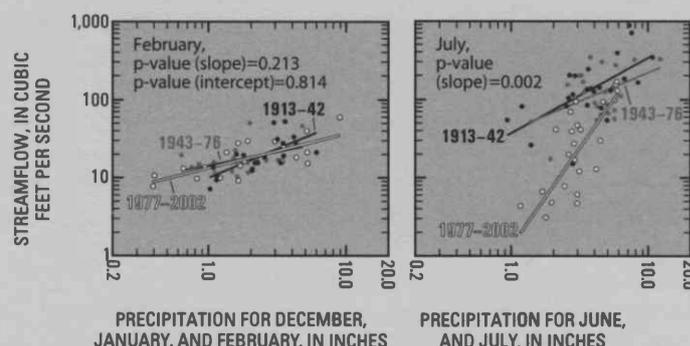
Trends in rainfall-runoff relations for three time periods were evaluated by comparing regression relations between precipitation and streamflow for 1913–42, 1943–76, and 1977–02. The difference among regression relations was determined with a nested F-test (Helsel and Hirsch, 1992). The results of the nested F-tests were similar to results of the LOWESS residual tests—trends in summer, fall, and late winter flows were significant, and trends in other parts of the year were not significant (table 5). Examples of trends in rainfall-runoff relations for February and July are shown in figure 6.

### Factors Affecting Trends

The primary factors that could have caused decreasing streamflow trends and changes in rainfall-runoff relations are decreases in precipitation, natural or human-induced changes in watershed characteristics, and increases in ground-water pumping. Examples of watershed characteristics that can change over time are riparian vegetation, upland vegetation, and stream-channel morphology. Annual precipitation decreased by 13 percent from 1913 to 2002, and the decrease likely resulted in some of the decrease in streamflow; however, statistical analyses provide strong evidence that other factors also contributed to the decrease in streamflow.



**Figure 5.** Trends in streamflow and adjusted streamflow for February and July, San Pedro River at Charleston, Arizona. Lines are LOWESS fit to data.



**Figure 6.** Trends in rainfall-runoff relations for February and July, San Pedro River at Charleston, Arizona, 1913 to 2002.

**Table 4.** Trends in monthly low flow and monthly low flow adjusted for variation in precipitation, San Pedro River at Charleston, Arizona, 1931–2002

[<, less than]

Month	Low flow, 1931–2002			
	Kendall tau trend test			
	Streamflow and time		Adjusted streamflow and time <sup>1</sup>	
	Slope <sup>2</sup>	p-value	Slope <sup>2</sup>	p-value
Jan.	n	0.014	n	0.089
Feb.	n	.292	n	.965
Mar.	p	.527	p	.342
Apr.	n	.139	n	.293
May	n	<.001	n	.007
June	n	<.001	n	.002
July	n	<.001	n	.073
Aug.	n	<.001	n	.002
Sept.	n	<.001	n	<.001
Oct.	n	<.001	n	.003
Nov.	n	.007	n	<.001
Dec.	n	.003	n	<.001

<sup>1</sup>Variation in low flow that was caused by variation in precipitation was removed by LOWESS regression analysis.

<sup>2</sup>Slope of trend: n is negative and p is positive

	p-value
not significant	0.05 to 1.00
n	<0.05

Changes in upland and riparian vegetation were likely major factors in the decreasing trends in total streamflows and low flows. Factors other than precipitation caused significant trends in total flows and low flows in the summer and fall, but those factors did not cause significant trends in late winter flows. The significant trends coincide with high rates of transpiration from vegetation in the summer, and the nonsignificant trends coincide with low rates of transpiration in the late winter. Another piece of evidence that implicates vegetation as a cause of decreased flows is that the upland and riparian vegetation of the San Pedro River Basin changed during the 20th century. The relative proportions of different species changed in upland vegetation (woody plants increased and grasses decreased), and the areal extent and density of riparian vegetation increased substantially (Rojo and others, 1999; Kepner and Edmonds, 2002; as referenced in Thomas and Pool, 2006).

Ground-water pumping in the upper San Pedro watershed in Mexico and the United States had a mixed influence on streamflow trends at Charleston. Pumping increased from less than 2,500 acre-ft/yr before 1940 to about 53,000 acre-ft/yr in 2002 (Thomas and Pool, 2006). Statistical analyses indicate that seasonal pumping from wells near the river for irrigation in the spring and summer was a major factor in the decrease in low flows. The analyses also indicate that year-round pumping from wells in the regional aquifer away from the river was not a major factor in the decrease in low flows. If regional pumping had caused a trend, the pumping should have affected low flows for all months of the year, but factors other than precipitation did not cause significant trends in low flows for January, February, March, and April (table 4). These conclusions are for trends from 1913–2002, and regional pumping in the United States and Mexico could affect streamflow at Charleston in the future, because regional ground-water pumping can have a delayed effect on streamflows (Alley and others, 1999).

—Blakemore E. Thomas

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**Table 5.** Results of significance tests for differences among regression relations between precipitation at Tombstone, Arizona, and monthly total streamflow for the San Pedro River at Charleston, Arizona, for three time periods

[---, no data; <, less than]

Month	Months of cumulative precipitation used for explanatory variable <sup>1</sup>	p-values for significance tests of difference among regression relations for three time periods <sup>2</sup>	
		Slope <sup>3</sup>	Intercept <sup>4</sup>
Jan. <sup>5</sup>	---	---	---
Feb.	3	0.213	0.814
Mar.	3	0.663	0.961
Apr.	63	0.302	0.810
May	63	0.188	0.198
June	1	0.451	0.008
July	2	0.002	( <sup>7</sup> )
Aug.	1	0.239	<0.001
Sept.	2	0.889	<0.001
Oct.	2	0.014	( <sup>7</sup> )
Nov.	3	0.731	0.002
Dec.	3	<0.001	( <sup>7</sup> )

<sup>1</sup>Precipitation for same month as streamflow and indicated number of previous months (2 months is the same month and the previous month)

<sup>2</sup>Data were grouped into three time periods (1913–42, 1943–76, and 1977–2002). For each time period, a linear regression analysis was made between precipitation and monthly average streamflow. The difference among regression relations was tested with a nested F-test.

<sup>3</sup>Slope of regression relations.

<sup>4</sup>Intercept of regression relations.

<sup>5</sup>Linear regression relations could not be fit.

<sup>6</sup>Months of cumulative precipitation are January, February, and March.

<sup>7</sup>Significance test for difference among regression intercepts is not valid when the slopes are significantly different.

	p-value
not significant	0.05 to 1.00
significant	<0.05



For further information, contact:

Blakemore E. Thomas  
 U.S. Geological Survey  
 Arizona Water Science Center  
 520 North Park Avenue, Suite 221  
 Tucson, Arizona, 85719-5035  
 Email: [bthomas@usgs.gov](mailto:bthomas@usgs.gov) or visit home page  
<http://az.water.usgs.gov>



## Legislation and Law

### EPA Enforces Water Actions in AZ

Included among the U.S. Environmental Protection Agency's Superfund cleanup highlights of the year are several enforcement actions in Arizona affecting water. Following are brief descriptions of EPA actions taken during 2006.

The EPA and the U.S. Department of Justice reached a settlement with Unidynamics/Phoenix, Inc. and its parent company, Crane Co. requiring parties potentially responsible for soil and groundwater contamination at the Phoenix-Goodyear Airport North Superfund Site to clean up the site at an estimated cost of \$35 million. The settlement also requires the company to pay \$8 million, which includes \$1 million on a Brownfields project in the city of Goodyear, a \$500,000 penalty and \$6.7 million in past costs and future oversight costs.

The EPA reached an agreement with Cyprus Tohono Corporation requiring the company to clean up a 450-acre area of its 10,505-acre mine site responsible for contaminating groundwater on the Tohono O'odham Nation, 32 miles southwest of Casa Grande. Two of the evaporation ponds and the mill tailings impoundment are considered to have contributed to groundwater contamination of an aquifer that was previously the sole source of drinking water for the North Komelik community. Area residents also have reported that in certain wind conditions dust from the mine blows into North Komelik, creating potential inhalation of particulate contamination. Contaminated soil will be excavated, placed on a liner, and covered with a soil cap.

The agency resolved the city of Nogales' long-standing failure to comply with a March 2004 EPA administrative order requiring the city to submit drinking water monitoring and reporting data. The city will pay a \$5,500 fine and spend at least \$50,000 to repair or replace sewer lines that have degraded and are leaking wastewater into the surrounding soil and possibly into groundwater supplies.

The EPA reached an agreement with Tucson developer Whetstone Development Corp. and its general contractor K.E. & G. Development to pay penalties totaling \$110,000 to settle Clean Water Act violations. Whetstone Development Corp. also agreed to donate 40 acres of open space, which contains approximately 2.5 acres of desert wash riparian habitat, to the city of Benson. The EPA's agreement with Whetstone Development Corp. compensates for the permanent loss of approximately 0.25 acres of desert streams, or ephemeral washes, which were filled without a permit during construction activities at The Canyons at Whetstone Ranch residential development in Benson. The affected area is part of the San Pedro River watershed, a vital ecological resource in Arizona.

The EPA took an enforcement action against construction company Triumph Builders and its subcontractor D. Fenn Enterprises, Inc. after they transported solid waste materials — including broken concrete, asphalt, metal re-bar, soil, metal and PVC pipes, and vegetative debris — from a construction project to the San Pedro River in Pomerene, and illegally dumped the waste into the river

without consultation or authorization from state or federal regulatory agencies. The companies were ordered to remove the demolition waste from the San Pedro River.

The EPA and the Navajo Tribal Utility Authority agreed on actions the utility will take to comply with wastewater discharge, monitoring and maintenance regulations at its Window Rock and Tuba City Wastewater Treatment Plants on the Navajo Nation. The utility violated its pollutant discharge permits by exceeding the effluent limitations for biochemical oxygen demand, total suspended solids, fecal coliform and/or E. coli, and residual chlorine.

Check [www.epa.gov/region09/enforcement/results/](http://www.epa.gov/region09/enforcement/results/) for a full description of the EPA's enforcement cases throughout California, Arizona, Nevada, Hawaii and the Pacific Islands in 2006. 🏗️

### Rural Water Supply Bill Passes

At the end of last session the U.S. Senate passed the Rural Water Supply Bill to assist western rural communities in the 17 reclamation states improve and maintain their water infrastructure.

According to S. 895 the U.S. Department of Interior, through the Bureau of Reclamation, is to establish a program to plan, design, and construct rural water supply projects. The bill authorizes \$15 million a year for planning new water delivery infrastructure.

Further, a loan guarantee program would be established within Reclamation to assist communities finance new water projects as well as pay for maintenance on existing water systems. Communities with less than 50,000 residents would be eligible.

The federal loan guarantee program would allow rural communities and Reclamation project beneficiaries to obtain loans at interest rates far lower than loans not guaranteed by the federal government.

The legislation also expedites the appraisal and feasibility study process to allow communities to find the best approach to meet their needs.

Sen. Pete V. Domenici sponsored the bill. Sen. Jeff Bingaman, one of the bill's cosponsors, said, "Rural communities in New Mexico and across the West face many challenges in meeting their future water demands and sustaining their economies. This legislation gives the Bureau of Reclamation new authority to take a proactive approach in working with communities to assess and meet their long-term needs."

The Senate first passed the bill in November. Since the language was slightly altered in the House, however, another Senate vote was necessary.

Endorsing the Rural Water Supply were the National Rural Water Association, the Western Governors' Association, the Western States Water Council, the National Water Resources Association, and the Family Farm Alliance.



## Publications & On-Line Resources

### The Broad Cultural View of Water Management

**PRECOLUMBIAN  
WATER MANAGEMENT**  
Ideology, Ritual, and Power  
EDITED BY LISA J. LUCERO AND  
BARBARA W. FASH



**Precolumbian Water Management Ideology, Ritual, and Power**

*Edited by Lisa J. Lucero and Barbara W. Fash. University of Arizona Press at <http://www.uapress.arizona.edu>, 296 pp., \$55, cloth.*

Most people consider water management as a relatively recent development. Yet, cultures have been managing their water throughout history, albeit without active management areas and management plans. "Precolumbian Water Management" discusses how

the control of water shaped the political, economic and religious landscape of the ancient Americas, examining water manage-

ment from both economic and symbolic perspectives.

Water management facilities, settlement patterns, shrines, and water-related imagery associated with civic-ceremonial and residential architecture provide evidence that water systems pervaded all aspects of ancient society. Through analysis of such factors, the contributors seek to combine an understanding of imagery and the religious aspects of water with its functional components, thereby presenting a unified perspective of how water was conceived, used, and represented in ancient greater Mesoamerica. The collection provides broad chronological and geographical coverage—from the irrigation networks of Teotihuacan to the use of ritual water technology at Casas Grandes—that shows how procurement and storage systems were adapted to local conditions. The articles consider the mechanisms that were used to build upon the sacredness of water to enhance political authority through time and space and show that water was not merely an essential natural resource but an important spiritual one as well, and that its manipulation was socially far more complex than might appear at first glance.

#### Draft Volume III of Arizona Water Atlas Issued

The Arizona Department of Water Resources has completed draft Volume III of a nine-volume set comprising the *Arizona Water Atlas*. The new volume covers the Southeastern Arizona Planning Area, from near Globe to Arizona's southeastern boundary with New Mexico and Mexico, and includes all of Cochise and parts of seven other counties. The atlas series is divided into seven planning areas, with each planning area discussed in a separate volume. Volume 1, Introduction, and Volume 2, Eastern Plateau Planning Area, have already been issued. The first three volumes are available on the ADWR website: [www.azwater.gov](http://www.azwater.gov). As each volume is completed ADWR solicits comments from the public and water professionals. Check website for information about submitting comments.

#### Water in the Urban Southwest — An Updated Analysis of Water Use in Albuquerque, Las Vegas Valley, and Tucson. Western Resource Advocates

This publication provides a comparative analysis of water use in Albuquerque, the Las Vegas Valley and Tucson. The report notes that despite similarities among these communities, they manage and use water quite differently. All three communities have demand-side management programs that are successfully reducing per-capita water use within their service areas, although, at the same time, taking very different approaches. Despite progress that is being made, the report concludes there still is room for improvement. The publication is available at [www.westernresources.org/media/pdf/FINAL%203%20City.pdf](http://www.westernresources.org/media/pdf/FINAL%203%20City.pdf). Western Resource Advocates is a non-profit environmental law and policy organization dedicated to restoring and protecting the natural environment of the West.

#### The World's Water 2006-2007: The Biennial Report on Freshwater Resources.

*Author/Editor: Peter H. Gleick, Heather Cooley. Island Press at [www.islandpress.org](http://www.islandpress.org) or call 1-800-621-2736, 388 pp., \$70.*

Produced biennially, *The World's Water* provides a timely examination of the key issues surrounding freshwater resources and their use. Each new volume identifies and explains the most significant current trends worldwide, and offers the best data available on a variety of water-related topics.

The 2006-2007 volume features overview chapters on: water and terrorism; business risks of water; water and ecosystems; floods and droughts; desalination; and environmental justice and water. The book contains an updated chronology of global conflicts associated with water as well as an assessment of recent water conferences, including the 4th World Water Forum. It also offers a brief review of issues surrounding the use of bottled water and the possible existence of water on Mars.

#### New Website: AZ Section, WateReuse Assoc.

The Arizona Section of the WateReuse Association has launched a new and improved website to better serve the state's water reuse and desalination communities. The organization is made up of Arizona water professionals working together to encourage and assist communities to achieve sustainable water supplies through reclamation and reuse. Its mission is to promote the responsible stewardship of Arizona's water resources through the beneficial and efficient use of water reclamation and reuse. The website is available at [www.wateruse.org/az/](http://www.wateruse.org/az/).



## Special Projects

### WRRC Announces 104B Water Research Awards

The Water Resources Research Center, in its role as administrator of the Section 104B program of the Water Resources Research Act, has selected five programs for funding. Funded by the U.S. Geological Survey, the 104B program, available only to faculty members at Arizona state universities, supports small research projects investigating water issues of state and regional importance.

Following are 104B projects for 2007:

— *Compound Specific Isotope Analysis of Natural Attenuation Activity in Chlorinated-Solvent Contaminated Aquifers*; PI: Mark Brusseau, [brusseau@ag.arizona.edu](mailto:brusseau@ag.arizona.edu) University of Arizona. \$10,000. Remediation of polluted soil and groundwater at chlorinated-solvent contaminated sites is of immediate importance in protecting Arizona groundwater resources. Recently, monitored natural attenuation has garnered increasing interest as a low cost, effective solution for remediation of contaminated groundwater. The goal of this project is to provide a simple and broadly applicable method to assess the feasibility of using MNA at chlorinated-solvent contaminated sites in Arizona. One potential low-cost, rapid method for directly identifying the presence of biological natural attenuation processes is Compound Specific Isotope analysis. The specific objective of this project is the development of CSI analysis methods that will permit rapid and accurate screening of the suitability of Arizona sites for MNA.

— *Geospatial Analysis of Urban Thermal Gradients: Application to Tucson Arizona's Projected Water Demand*; PI: Christopher Scott, [cascott@email.arizona.edu](mailto:cascott@email.arizona.edu), University of Arizona. \$12,000. The water budgets of urban and urbanizing areas are hypothetically affected in a significant manner by rising regional temperatures, shown to result from urban heat island effects and broader warming across the Southwest. Both urban and regional warming are projected to increase even further with city growth and climate change. This project proposes to conduct geospatial analysis of Landsat TM thermal infrared data (x, y, t) and DEM (z), thereby generating surfaces of heat source-sink gradients, signatures of the persistence of thermal threshold exceedances, and identifying features or episodes of thermal reset, e.g., [micro-] topographic cooling corridors, vegetation buffers, or precipitation events. Thermal gradients will be mapped in the Tucson basin over the period 1984 to the present and spatially correlated to urban growth, urban heat island effects, and water supply. Indoor vs. outdoor water use will be estimated from supply data using temporal disaggregation techniques. Results will be assessed with reference to the growth and water demand scenarios in the Tucson Water Plan 2000-2050.

— *Riparian Vegetation Response to Cessation of Groundwater Pumping, Lower San Pedro River, Arizona*; PI: Julie Stromberg, [email:jstrom@asu.edu](mailto:email:jstrom@asu.edu), Arizona State University. \$11,990. Hundreds of millions of dollars are being spent on the restoration of riparian ecosystems throughout the Southwest, often without sufficient scientific background to ensure success. A novel restoration approach has been pioneered along

the lower San Pedro River by the Nature Conservancy of Arizona and other collaborating groups, to purchase farms that pumped large quantities of alluvial groundwater and reduce the pumpage to negligible levels. The assumption is that biotic components of the riparian ecosystems will then establish on their own accord, thereby obviating the need for restoration plantings. The results of this hydrologic restoration strategy need to be documented to assess its effectiveness on the San Pedro River as well as its applicability in other settings. In 2002 and 2003, baseline monitoring was initiated at seven restoration research sites and five reference sites on the Lower San Pedro. Project funds will support another year of data collection and data analysis and synthesis.

— *Sources of Nitrate in Groundwaters of the Tucson Basin*; PI: Thomas Meixner, [tmeixner@hwr.arizona.edu](mailto:tmeixner@hwr.arizona.edu) Thomas, University of Arizona. \$9,121. The assumption that high nitrate levels in groundwater are associated with human activities is not always true in arid states like Arizona. Understanding the sources and mechanisms of nitrate contamination in groundwater is important since this is the first step to understanding how to solve any contamination problem. This project will utilize two differing flow path transects within the Tucson basin to investigate the sources of nitrate to groundwater in the Tucson basin. The research has three objectives: 1) use geochemical and isotopic techniques to quantify groundwater sources; 2) quantify nitrate isotopes to connect groundwater nitrate to various nitrate sources and sinks; 3) develop conceptual model of nitrate sources and processes along the two flowpaths using results of



San Pedro River © Paul Hardy/The Nature Conservancy

first two objectives and existing nitrate and groundwater geochemical data.

— *Modification of conventional wastewater treatment processes for estrogen removal*; PI: David Matson Quanrud, [quanrud@email.arizona.edu](mailto:quanrud@email.arizona.edu), University of Arizona. \$11,454. The fate of trace organics during wastewater treatment or, from another perspective, facilities design/operation for control of trace organics should be an important factor in water supply and wastewater treatment planning. This project is designed to provide data in that critical area. The project is a full-scale investigation of wastewater treatment processes likely to significantly reduce the activities of estrogenic and androgenic compounds in wastewater. The processes of interest are membrane biological treatment and activated sludge treatment. Both will be studied under nitrifying conditions likely to produce biochemical transformations of aromatic trace contaminants such as those that contribute to estrogenic and androgenic activities. All procedures to be used in the study were previously developed or adapted for use in the UA environmental engineering laboratory. ■



## Announcements

### UA, ASU Offer Water Workshops

#### Emerging Contaminants Workshop

The University of Arizona Water Sustainability Program in collaboration with the Arizona Water Institute and the University of Arizona Superfund Hazardous Waste Program is offering a one-day workshop addressing "Trace chemical contaminants in water and wastewater — semiarid perspectives." Scheduled March 2 in Phoenix, the workshop is geared to the needs of water managers and decision makers and will provide the latest on emerging water contaminants of concern in the state.

Ed Furlong of the U.S. Geological Survey and co-author of the 2002 report on pharmaceuticals, hormones and organic contaminants in U.S. streams will lead off the morning session, followed by Gail Cordy (formerly of the USGS) reviewing the Arizona situation. Experts from Arizona's state universities and the private sector will discuss the most recent research findings of occurrence, environmental impacts, health effects, fate and treatment for an array of emerging chemical contaminants in state waterways including estrogens, PBDEs, new disinfection byproducts, nanoparticles and heavy metals. Perspectives from the Arizona Department of Environmental Quality and Arizona Water Institute will wrap up the day. The workshop will be held at the Maricopa County Cooperative Extension Office, 4341 E. Broadway Road, Phoenix.

Registration information and the agenda will be posted on the Water Sustainability Program web site <http://www.uawater.arizona.edu/programs/workshops.html> as plans are finalized. For further information contact Jackie Moxley [jmoxley@cals.arizona.edu](mailto:jmoxley@cals.arizona.edu)

#### ASU Water Quality Seminar

Scheduled Feb. 15, the 8-hour Water Quality Laws & Requirements Seminar will provide participants with an understanding of all major water quality laws affecting Arizona, including the Federal Clean Water Act, state water quality requirements as well as offering an illustrative overview of local requirements in the major metropolitan areas. Also included will be information about what activities are regulated under water quality laws in Arizona, the processes for either obtaining permit or other required approval and how to qualify for general permits or applicable exemptions. In addition, newly enacted regulatory and statutory provisions will be reviewed, and discussion of key regulatory guidance documents will be provided. Seminar cost is \$195; the event will be held at the ASU Polytechnic Campus. To register and for additional information, contact Denise Kolar at ASU Office of Environmental Technology 480-727-1825, fax 480-727-1684 or check web site: <http://www.poly.asu.edu/seminars/>

#### Rainwater Harvesting – Call for Papers

A call for papers has been issued for the American Rainwater Catchment Systems Association Conference to be conducted Aug. 14 - 17 on the Island of Hawaii. Papers are due Feb. 15; information about submitting papers is available at [www.arcsa07.com](http://www.arcsa07.com)

Rainwater harvesting enthusiasts, practitioners, and experts are invited to attend the event to discuss a broad range of rainwater catchment topics. This conference will present information valuable to users, public health officials, academics, designers, installers, architects, builders, product vendors, students, planners, and water utility staff.

#### AZ Riparian Council Issues Call for Abstracts

The Arizona Riparian Council is conducting a joint meeting with the University of Arizona's Cooperative Extension Service and CLIMAS (Climate Assessment for the Southwest) to address issues relating to climate and riparian areas. Titled "Connecting the Dots – Climate Change/Variability and Ecosystem Impacts in Southwestern Riparian Areas," the conferences will be held at the Hotel Casa Grande in Casa Grande on April 11-13. The call-for-abstracts deadline is March 7. Presentations about climate and riparian areas are requested, but all riparian-related abstracts will be considered. Submission can be done online at <http://azriparian.asu.edu/2007/>

[AbstractSubmittalForm.pdf](#) For additional information contact Cindy Zisner; email: [Cindy.Zisner@asu.edu](mailto:Cindy.Zisner@asu.edu).

#### WaterReuse Foundation to Fund Research

The WaterReuse Foundation is seeking preproposals under its 2007 Unsolicited Research Program. The foundation seeks preproposals that involve original concepts, novel techniques, and other scientific research needs related to water reuse and desalination. The foundation anticipates funding between two and four projects with a maximum funding level for any single project of \$175,000. Preproposals are due by February 20. For more information check [http://www.watereuse.org/Foundation/rfp\\_unsolicited.htm](http://www.watereuse.org/Foundation/rfp_unsolicited.htm)

#### Water Quality RFA Issued

The National Integrated Water Quality Program has issued a Request for Applications from National Facilitation Projects, Extension Education Projects, and Integrated Research, Education, and Extension projects. The closing date for the RFA is April 04. Priority areas or interests for each of the projects, along with other information pertaining to the RFA, are available at: <http://www.csrees.usda.gov/fo/fundview.cfm?fnum=1134>. Questions regarding the content of the RFA should be directed to Mike O'Neill ([moneill@csrees.usda.gov](mailto:moneill@csrees.usda.gov); 202-205-5952).



## Public Policy Review

by Sharon Megdal

### Front-Row View of Federal Water Lawmaking Shows Process Works

*U.S.-Mexico Transboundary Aquifer Assessment Act pondered, passed and signed*



Otto von Bismarck reportedly once said, "Laws are like sausages, it is better not to see them being made." I am not sure what to make of this remark since lawmaking, not sausage making, is my interest. It is an interest that recently broadened when I had the privilege of testifying before the Water and Power Subcommittee of the House Resources Committee on the United States-Mexico

Transboundary Aquifer Assessment Act. This bill, numbered S 214 in the Senate and HR 469 in the House, gained final approval in the wee hours of the 109th Congress and was signed by the President on December 22. My previous involvement in lawmaking had been at the state level.

The program's purpose is to provide state, national and local officials with information to address pressing water resource challenges in the U.S.-Mexico border region. As finalized, the act authorizes the Secretary of the Interior, through the U.S. Geologic Survey, to collaborate with the states of Arizona, New Mexico and Texas, the country of Mexico, and others to conduct hydrologic characterization, mapping and assessments of priority transboundary aquifers. For Arizona, the two priority transboundary aquifers established in the legislation are the Santa Cruz River Valley and San Pedro aquifers. The program is authorized for ten years.

Working on obtaining Congressional approval of this bill was a learning experience. I had once provided written testimony to a Congressional subcommittee, but I had not previously had the opportunity to provide oral testimony.

The acting USGS director and I were the only witnesses. Some unexpected, tough questions came up at the hearing regarding the bill's connection to the Colorado River and the treaty with Mexico. The Subcommittee chairman held the bill to allow additional comments. Through the assistance of staff to Senators Kyl and Bingaman, respectively, amendments to address multiple concerns with the bill's language were developed.

In contrast to sausage making, which must be a very messy business, I was participating in a carefully crafted lawmaking process involving compromise and clarification to achieve agreement and support.

As a witness on the bill, I first provided written testimony and then was given a few minutes to present oral remarks at the hearing. The oral remarks were not expected to be the same as the written testimony. I emphasized the importance of the bill by making the following points.

I testified that the transboundary aquifer assessment program will assist federal, state and local officials address critical water resource challenges in the U.S.-Mexico border region. The act will build the scientific foundation for addressing daunting and acute

water resource issues. The program also will serve as a catalyst bringing together the human capital and financial resources necessary to characterize transboundary aquifers. The resulting increased understanding should help resolve many of the currently unquantified — and therefore unresolved — water resource issues.

I emphasized the importance of water to the growing, arid Southwest, especially along the border where population continues to grow rapidly on both sides. Water resource issues become more complex and acute along the shared border where understanding aquifer characteristics is critical to the human health and economic vitality of this region. Along the border many and varied interests need to cooperate and participate to address water issues.

I told how the modeling and data base developed as part of the program will address important water quantity questions including those associated with salinity and toxins. Further complicating border water issues are the different water quality standards and the physical relationship between surface water and subsurface flows associated with transboundary aquifers that raise special challenges.

I also told the subcommittee that the program authorized by this bill will meet a critical need by establishing a partnership of federal, state and local governments, university researchers and others to provide scientific information on transboundary aquifers.

I informed the committee that the need for additional scientific information on water resources is well recognized. For example, in fall 2004, the 85th Arizona Town Hall concluded that "[to] avoid crisis management, Arizona must engage in long-term planning based on good science and data collection that should be made widely available throughout the state." Town Hall participants were calling for sound science and data as well as the dissemination of the information to avoid crisis. The program authorized by the bill envisions the partnerships necessary to accomplish these tasks.

I noted the widespread support for the bill from governmental and non-governmental entities. In addition, a 2005 United States-Mexico Border Governors Conference declaration emphasized the importance of the program by calling for a collaborative work program that includes "the permanent exchange of data and information regarding surface and ground water along the border..."

Passage of the act demonstrated once again that water policy making is a bi-partisan exercise. All recognize the need for sound information to develop good water policies to ensure needed water supplies to accommodate the rapid growth of the border regions. Funding for this newly authorized program is needed, and the hard work of obtaining federal appropriations now begins.

The University of Arizona's Water Resources Research Center and its sister centers in New Mexico and Texas are expected to work closely with USGS and collaborators on developing this program. I thank those who helped us get this far and look forward to working on implementing this legislation. 🏗️

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by drowning. Prior to the sacrifice, the victims' tears would be collected in a ceremonial bowl as an offering.

Tlaloc lived in a place the Aztecs called Tlalocan, where all people who had drowned resided. He lived there with his companion, Chalchiuhtlicue, the goddess of freshwater lakes and streams. Theirs was a compatible relationship, with Tlaloc controlling the waters of the sky and Chalchiuhtlicue the terrestrial waters.

Even when considered an important element in Aztec water management, Tlaloc now holds more anthropological interest to us than hydrological.

Science rules the day, and even if a few still might attribute hydrological powers to supernatural powers, Tlaloc would not likely be the role model.

Yet some commonality exists between Aztec water management and our own efforts to plan for and cope with the uncertainties of supplies. Throughout the ages availability of water has been a hit-and-miss goal, with supplies plentiful at times, sometimes too plentiful, and at other times unavailable and scarce. In their efforts to manage water supplies, whether by sacrificing to Tlaloc or other water lords or staking out active management areas, societies have come to share an understanding that human ingenuity and inspiration are essential to cope with the uncertainties of water supplies.

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working out of cost estimates. Once a feasibility study is completed Congress then must approve the project and its funding.

The advisory committee knows that a federal project would be a down-the-road solution to a now pressing problem. Liz Archuleta, chair of the advisory committee and member of the Coconino County Board of Supervisors, says, "If we get congressional authority for a feasibility study we are talking about a study that will take quite a few years to complete. Then we would have to actually get funding for a pipeline. This is 20 or 30 years down the road.

"So we are trying to address (the issue) right now. We know there will be a shortage of water to meet our needs in 50 years, and we are trying to address the projected need. The pipeline is the re-

ally long-term solution; the shorter-term solution is going to have to be education and water conservation and legislation that promotes good land use planning."

Conservation and water education, however, will likely get the region only so far in meeting its future water needs. What most agree is needed is a pipeline delivering a new water source into the region.

Archuleta is optimistic that the federal government will support such a project. She says, "I don't see why not. Some people thought that the CAP would never be a reality."

The Reclamation report titled, North Central Arizona Water Supply Study, is available at the agency's website: <http://www.usbr.gov/lc/phoenix/>. ■



Arizona Water  
Resource

Water Resources Research Center  
College of Agriculture and Life Sciences  
The University of Arizona  
350 N. Campbell Ave  
Tucson, AZ 85721

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