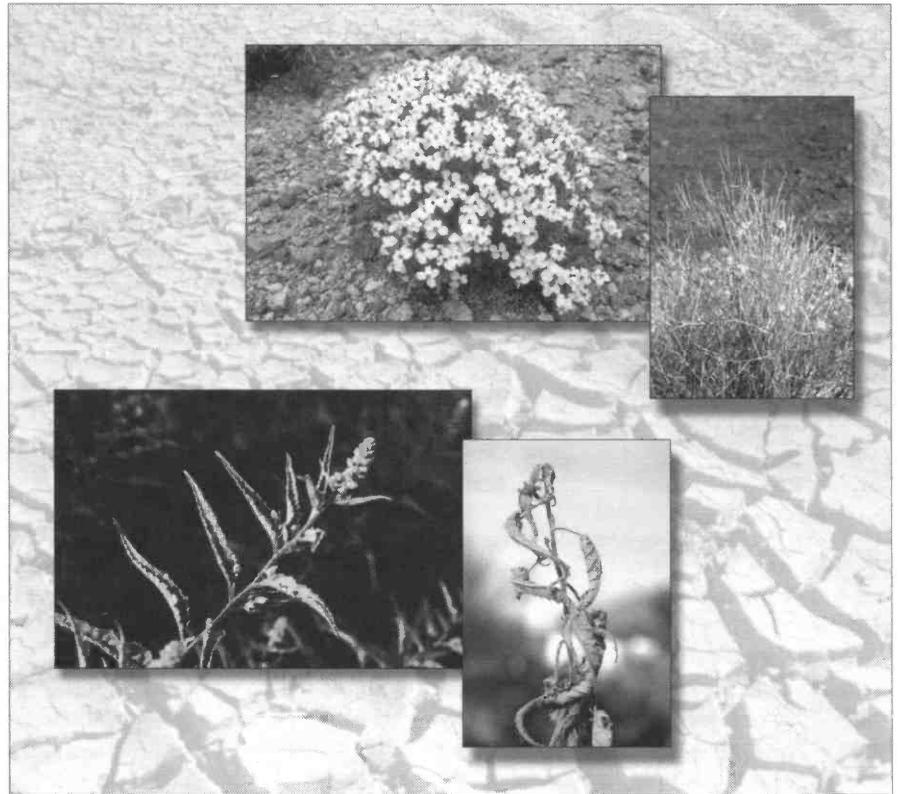




Effects of the prevailing dry conditions are to be seen throughout the state, from depleted reservoirs to increased particulates in the atmosphere. To observe desert plants during this dry season is to move from the big to the little picture. Yet, the photos to the right of desert zinnia (top) and canyon ragweed (bottom), which contrast the effects of wet and dry seasons, may be a more graphic image than depleted reservoirs of the current dry phase of a climatic cycle. Two years ago an explosion of wildflowers occurred. Last year there was sufficient moisture for the well-watered plants to the right to grow. This year's photos show the desert zinnia bristling with dry stalks, and the leaves of canyon ragweed wilting and twisting.

Most of Southern Arizona has not had any significant precipitation since October. Climatologists say La Niña is to blame, a weather pattern causing warm, dry conditions. This lingering La Niña, now into its second year, may be part of a larger, longer-lasting climate shift. Some evidence seems to indicate a shift into a new phase of the Pacific Decadal Oscillation (PDO). PDO is a fairly regular pattern of high and low pressure systems over the northern Pacific Ocean. The PDO operates on a 20- to 30-year time scale – a much longer event than the briefer and more familiar El Niño and La Niña. Although it is too soon to tell if this phenomenon is indeed occurring, the Southwest may be poised at the beginning of a prolonged drought.



Photos: stressed plants, B. Tellman; desert zinnia, M. Dimmett; canyon ragweed, B. Tellman. Design, K. Carpenter

Salty Irrigation Water Raises Groundwater Levels – and Concerns

Managing Rising Groundwater Now an Issue

Dropping groundwater levels are a major concern in Arizona, with laws and policies adopted to control the decline in various areas of the state. Yet where irrigation occurs, and groundwater pumping has either been reduced or stopped, rising groundwater levels can be a problem, in both agricultural and urban areas. Laden with salts and other chemicals, rising groundwater can threaten the productivity of the land and cause other problems as well.

As a result, some officials are urging a more comprehensive understanding of groundwater management, to also address the growing problem of salinization and the rise of groundwater levels. Herman Bouwer, chief engineer of the U.S. Water Conservation Laboratory, shares this view. He says, "You cannot escape the fact. Evaporate the water, and you concentrate the salts which will then end up in the underlying groundwater. Unfortunately salts are not biodegradable. So you have to start managing the groundwater levels and the salt." Bouwer believes serious problems

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Disposing of Salt via the "Brine Line"

Removing salts that accumulate will be a challenge. In an effort to meet the challenge the U.S. Bureau of Reclamation is considering the construction of a "brine line," to remove leach water and/or brine from the state. The proposed conveyance would most likely consist of a pipeline running the reverse direction of the CAP canal, from Tucson north westward, taking advantage of gravity flow. BuRec first thought about using an abandoned pipeline along the railroad tracks but found the pipes to be unsuitable. The agency is now considering laying wider pipes along the railroad right of way. The planned route would be from Tucson north westward, to pick up salt water pumpage from various irrigation districts along the way, in Marana and the Gila River and Ak-Chin Indian communities, and then heading west to pick up reject brines and salt drainages from the Phoenix area, before heading south to Yuma. At Yuma, the flow could be treated in the existing reverse osmosis plant or piped to the Gulf of California. It also could be put to environmental use to dilute the Salton Sea or restore wetlands at the mouth of the Colorado River.

Irrigation Water...continued from page 1

could result if action is not taken to control rising water tables and the accumulation of salt in groundwater in south-central Arizona.

Managing salt can be a major undertaking, considering the amount of salt accumulating in the state. For example, the Salt-Verde and Colorado rivers, important sources of renewable water supplies for south-central Arizona, especially for the Phoenix and Tucson areas, supply about 2 million acre-feet of water per year. This water also delivers 1.5 million tons (dry weight) of salt per year to the land.

(The salt content or salinity of water refers to the quantity of mineral constituents dissolved in the water and is generally reported as "dissolved-solids concentration." It is measured and expressed as milligrams of dissolved salts in one liter of water [mg/L]. Water with less than 500 mg/L — about a quarter of a teaspoon of salts per gallon of water — is considered suitable for drinking and most uses. The Salt-Verde rivers are 400 mg/L; the Colorado River 700 mg/L; and most groundwater is about 300 to 1000 mg/L.)

The 1.5 million tons of salt represent about 785 lbs. per person per year for the current population of the area which is about 4 million. If instead of river flow, pickup trucks delivered the salt, it would take one fully loaded truck arriving every 10 seconds, 24 hours per day, 365 days per year to deliver 1.5 million tons of salt in a year. Needless to say this is a lot of salt, What happens to

all this salt since the imported salt does not leave the region?

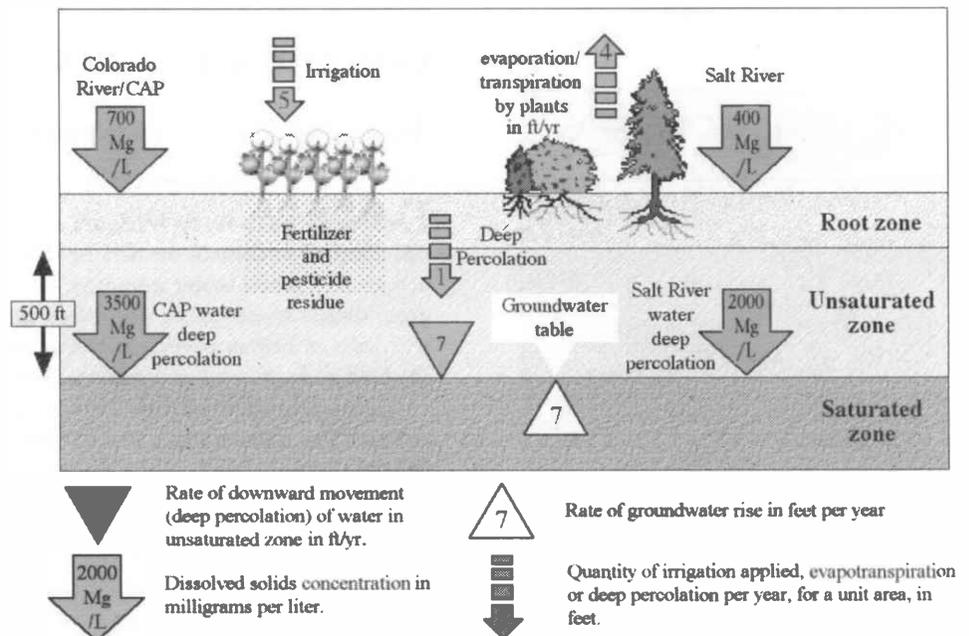
The salts flow with irrigation water and enter the soil. Where evapotranspiration (combined evaporation from soils and transpiration by plants) exceeds combined precipitation and irrigation, salts accumulate in the root zone. The water returning to the atmosphere is essentially distilled water, with salts remaining in surficial soils and in the root zones of plants.

The salt accumulating near the surface of irrigated areas can damage and even kill vegetation. The remedy is to leach the salts from the root zone by applying more irrigation water than evaporates. Excess water percolating through the root zone removes salts, and this deep percolation water, now carrying an increased salt load, continues downward toward the groundwater table. Along with salts, the deep percolation water also might carry residues of fertilizers and pesticides applied by farmers, grounds keepers and homeowners. This deep percolation water poses a threat to the groundwater quality beneath irrigated lands. Groundwater contaminated by deep-percolation water will eventually be too salty to drink or to irrigate crops or landscape vegetation.

Bouwer emphasizes that this is not a problem limited to agricultural areas. "A Landsat picture of the greater Phoenix area shows the surrounding agricultural land as bright red indicating green crops. The desert is brown, and the metro area is pink, with pixels showing irrigated yards, golf courses, parks and so forth," he says. "In the Valley there are about 150 golf courses, and that is about 15,000 acres of irrigated land." Rising groundwater in urban areas could damage basements, sewers and storm drains and threaten cemeteries and land fills.

Bouwer says a building in downtown Phoenix already is showing the effects of a rising groundwater level. "The building has a deep parking garage, and groundwater levels have risen about one foot a year since 1980. The level 5 parking garage would have about eight feet of water if a drainage system wasn't installed to pump the water."

...Irrigation Water continued on page 12





Water Vapors

Good News

There is good news and bad news to report. First the good news: In its evaluation of the University of Arizona's Water Resources Research Center, a USGS team noted that, "The Arizona center is among the strongest institutes nationally. Its overall program is strengthened by the presence of an interdisciplinary research program and a policy analysis program. ... The educational and information transfer components of its program are also excellent."

Bad News

Now the bad news: In the last several months, several WRRC staff members have left the center to pursue new career paths. Lin Stevens-More, who had been Project WET director for seven years, has taken a science coordinator position at the Casa Grande School District. Ken Seasholes left WRRC after eight years to take a water resource specialist position with the Arizona Department of Water Resources in Tucson. After nine years as the WRRC associate director, Gary Woodard left to become assistant director for knowledge transfer at the Science and Technology Center, within the University of Arizona's Hydrology and Water Resources Department.

(Reporting the above as the "bad news" of a "good-news/bad-news paradigm" gives away our understandable bias. The departure of the WRRC personnel is indeed bad news for the center; they and their considerable talents will be missed. It is, however, good news as well, for them as they take on the challenge of new positions.)

At present, one of the positions has been filled. Kerry Schwartz is the new Project WET coordinator. She has a masters degree in geohydrology from the University of Arizona. Along with a technical background, Kerry has experience working with adults and children, interpreting and teaching environmental and water issues.

Visitors

In January, WRRC hosted visitors from India on a 2-week study tour of the western United States. They are senior level managers in a World Bank-financed project to implement a data acquisition and manage-



Above are visitors from India with WRRC staff members. The Indians visited the center for a briefing on Arizona water issues and WRRC programs. (Photo: Dan Crockett)

ment program for eight Southern India states. The project involves remote monitoring of a network of 36,000 wells in hard-rock conditions. They came to the U.S. to observe new technologies, methodologies and policies in groundwater management.

AZ Water Community News

A new section has been added to the Arizona Water Resource newsletter, "AZ Water Community News." This section will provide incidental news and information of interest to the members of the Arizona water community. Promotions, job changes, received honors, changes of address, all are suitable material for "AZ Water Community News." Please submit such

news and information for publication.

Also, the invitation to submit materials is further extended to include the Guest View section. Readers are invited to submit a guest view discussing some aspect of water affairs. In this issue, Sharon Megdal discusses the Groundwater Management Act. The Guest View section is intended to serve as a forum for interested persons to discuss ideas and issues of significance to the Arizona water community.

Finally, the WRRC is planning a spring conference on Arizona's Groundwater Management Act., now marking its 20th anniversary. See page 6 for additional conference information.



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Arizona Water Resource Staff

Editor: Joe Gelt
 Editorial Assistant: Joel Spezeski
 Reporters: Val Little
 Barbara Tellman

Arizona Water Resource

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

WRRC Director: Dr. Peter Wierenga

520-792-9592; FAX 520-792-8518
 Email: wrrc@ag.arizona.edu



News Briefs

Sunset Committee Says "Yes" to ADEQ

A sunset committee has recommended continuation of the Arizona Department of Environmental Quality. Business groups urged the favorable action, while an environmental group criticized aspects of the agency's operations.

Support came from officials of the Arizona Chamber of Commerce, the Arizona Association of Industries as well as various businesses regulated by the state environmental agency. A consensus among business groups was that ADEQ has improved, although it still needs help retaining trained employees. Business representatives also gave high marks to the agency for including business interests in the rule-making process.

Sandy Bahr, conservation outreach coordinator with the Sierra Club's Grand Canyon Chapter, gave the department a low score in the protection category. She said that company lawyers are too involved in the rule-making process for regulating their industries.

"I do disagree with the industry folks on the stakeholder process. I don't think it is working for the public," Bahr said. Lawyers for big business and municipalities dominate the stake holder groups, she said.

According to ADEQ Director Jacqueline Schafer, that Arizona's business community supports the agency demonstrates that it is doing a good job. "The reason that they are able to attract employees and grow in the state of Arizona is because of our good environmental quality, and it is in the interest of future growth in jobs that we have a strong ADEQ," she said.

The sunset committee recommended a five-year continuation of the agency, with the extension to include further review and the development of performance guidelines.

U.S., Mexico to Disclose Hazardous Waste Sites

The United States and Mexico have agreed to begin publicly disclosing all existing and proposed hazardous waste sites located

within 100 kilometers (62 miles) of their joint border. This will mark the first time that government officials and residents of both countries will have access to such information.

"This new arrangement is a major leap forward in the level of openness and environmental cooperation between the United States and Mexico," said Felicia Marcus, administrator of EPA's regional office in San Francisco.

Called "consultative mechanism," the arrangement covers hazardous and radioactive waste disposal sites as well as recycling, treatment and incineration facilities. It was worked out by the binational Hazardous and Solid Waste Workgroup, an organization of representatives from environmental agencies of both countries and the ten U.S. and Mexican border states.

Each country will still decide locations for its waste dumps, but it would have to notify its neighboring country of its decisions. Concerned interests on both sides of the border would then have been alerted about planned facilities. The pact is in line with ongoing efforts for greater openness between the two countries in deciding environmental and health matters

The Texas Center for Policy Studies in Austin issued a report on border waste issues that says 42 waste facilities are located in the six Mexican states. EPA spokesman David Schmidt, however, said many more might exist that are not mentioned by the report. "You can have a hazardous site built on the Mexican side of the border, and no one on the U.S. side would know about it," he said.

Schmidt hails the agreement as a major step toward better environmental protection on both sides of the border. He says the agreement will be enable them to track down the source of contaminated air or water that may come from across the border.

A skeptical note was sounded by Vera Kornylak, staff attorney at the Tucson office of the Arizona Center for Law in the Public Interest. "The EPA doesn't have a great implementation record for border agreements. What we need is to see the agreement actually implemented," she said.

Project to Improve Nogales Area Wastewater Treatment

Plans are under way to improve wastewater treatment along the international border between Arizona and Mexico. The goal of the Ambos Nogales Wastewater Infrastructure Improvement Program is to help resolve the wastewater pollution and public health problems along the border.

The program modifies the existing Nogales International Wastewater Treatment Plant (NIWTP) in Nogales, Arizona, to treat wastewater more effectively and efficiently. The modified plant will continue to treat a combined flow of 17.2 million gallons per day (mgd), with Mexico allocated 9.9 mgd and Nogales, Arizona 7.3 mgd. The upgrade will enable the NIWTP facility to comply with new regulatory requirements and to protect exposed aquatic biota from acute or chronic effects.

The NIWTP releases treated water into the Santa Cruz River, and an important benefit of this project is it will improve surface water quality of the river. Improving the treatment process will result in effluent with reduced ammonia concentrations, a toxic to some aquatic species. Existing aquatic and riparian habitats downstream of NIWTP will be preserved, and additional habitats will be created at discharge locations in Arizona and Sonora.

Also, the plan includes expanding NIWTP by 5 mgd to accommodate additional flows that could come from Mexico because of storm events, system failures or while later phases of the Mexican wastewater system are being implemented.

Wastewater flows generated in Mexico beyond its allocated amount to NIWTP will eventually be treated at a new facility in Sonora, near the Los Alisos River. A new raw wastewater pumping system to be built in Nogales, Sonora would convey wastewater to the new facility.

A new International Outfall Interceptor pipeline is to be built from the border to the NIWTP, and the wastewater collection system pipes in both countries are to be rehabilitated. The estimated cost for the project is \$72 million, not including operation and maintenance cost.

New AZ Wetlands to be Large Restoration Project

One of the largest wetland restoration projects ever attempted in Arizona may result from recent land purchases. The U.S. Forest Service has purchased 6,500 acres of privately held land in northern Arizona to create the Hay Lake Project. The Natural Resources Conservation Service simultaneously purchased a 30-year easement on more than 1,500 acres under its Wetland Reserve Program. Officials say the two actions will protect the land from development and allow the restoration of 750 acres to wetland habitat

The wetland is located about 40 miles southeast of Flagstaff. Restoration strategies include creating portholes to collect standing water in an area that has been dried through agriculture and ranching. Native vegetation also will be planted.

Restoring wetlands improves the quality of surface and groundwater, promotes aquatic species and attracts animals such as egrets, hawks, deer and geese. The Natural Resources Conservation Service along with the Nature Conservancy and the Arizona Game and Fish Department are among the groups restoring the wetland. The Forest Service seeks funds from Congress to buy an additional 3,600 acres in the area.



Soroosh Sorooshian, University of Arizona professor of hydrology and water resources, was named regents professor, the highest rank given to faculty in Arizona. He was recognized for his work in various areas, including flood forecasting and control, watershed modeling and climate research in the American Southwest and Mexico.

Jacqueline Schafer, director of the Arizona Department of Environmental Quality, announced the appointment of **David Esposito**, who has been director of the Pima County Department of Environmental Quality for 10 years, as the new director of the waste programs division at the state DEQ.

Sid Wilson, general manager of the Central Arizona Project, has been elected to a two-year term representing Arizona on the Colorado River Water Users Association board of directors.

American Rivers announces its intention to close its Southwest Regional Office in Phoenix on June 30, 2000. In making the announcement, the organization noted, "Our decision is driven largely by a combination of funding challenges and a desire to bring greater focus while increasing the effectiveness of our program work in other areas."

After retiring as chief hydrologist of the water rights unit of the Arizona Attorney General's Office, **Don W. Young, Ph.D.** established WESTWATER, LLC which specializes in water resource project development, water rights and stream restoration. He also retains an adjunct faculty position within the University of Arizona's Department of Hydrology and Water Resources.



World Water Cost Survey

In the United States the cost of water has fallen for the second consecutive year. There was an average of 0.5 percent drop in the price of water to just under 51 cents per cubic meter over the 12-month period ending July 1, 1999

	Country	Cost US cents per m ³	% Change from last year	12 year change
1	Germany	182	0.7	95%
2	Denmark	162	4.5	N/A
3	Belgium	122	0.1	54%
4	Netherlands	119	-0.2	75%
5	France	118	1.3	75%
6	United Kingdom	115	3.2	166%
7	Italy	73	2.1	119%
8	Finland	64	-2.3	N/A
9	Ireland	62	5.0	50%
10	Sweden	56	2.5	6%
11	Australia	55	3.1	-35%
12	Spain	54	1.3	N/A
13	United States	51	-0.5	39%
14	South Africa	50	9.8	N/A
15	Canada	41	3.9	100%

The above information is from the National Utility Service's International Water Cost Survey. Survey highlights include the following: German consumers pay the most for their water; South Africa posted the greatest price increase; the greatest drop in prices was in Finland; French consumers have started to see prices rise; and Canada remains the cheapest country surveyed. NUS also publishes a table comparing water prices of selected U.S. cities. The table and additional information can be obtained from National Utility Service, Inc. Guy McKanna, 1-800-888-2190; email: GMcKanna@nusinc.com



Guest View

After 20 Years GMA is Due for “Comprehensive Conversation”

Sharon B. Megdal, Ph.D. of MegEcon Consulting contributed this Guest View

Since the 1980 passage of the Groundwater Management Act (Act), Arizona's population has almost doubled, growing from 2.7 million to about five million people, with increased urbanization. We have made great strides in managing groundwater supplies in the five designated Active Management Areas. Rules requiring use of renewable water supplies for new residential development are in place. The CAP is complete and efforts to increase utilization of Arizona's allocation have been successful. A series of sometimes complex amendments to the Act, including regulations for storage and recovery of renewable water supplies and the 1996 formation of the Arizona Water Banking Authority, have introduced flexibility and foresight into water planning. Twenty years later, we should both congratulate ourselves on our successes and ask the question: Can we manage our State's precious water resources even better?

Governor Hull recognized the need to “engage in another comprehensive conversation about water management” in the “Issues of Interest” portion of her January 10, 2000 State of the State address. Why do we need to do this? For many reasons. Let's start with a simple one. Millions of people who currently live in Arizona have no knowledge of the rationale for and performance of the Act. While many know that water is an essential resource for a rapidly growing, desert state, I would suggest few understand just how we are attempting to ensure sufficient water supplies to sustain our current and growing population and economic activities. Therefore, education of the public as to why we regulate ground-

water use as we do and why some changes may be needed is an important reason to engage in a comprehensive conversation.

This more comprehensive conversation will quickly reveal a somewhat disconcerting picture:

- There are serious questions about the ability of certain populated regions to meet what is understood to be their state mandated safe-yield goal. Although the Act requires the Phoenix, Tucson and Prescott Active Management Areas only to “attempt to achieve and thereafter maintain a long-term [groundwater] balance...” (emphasis added), many are not satisfied with a prognosis of failure to actually achieve balance by 2025.
- Significant growth is predicated on replenishment of groundwater use by the Central Arizona Groundwater Replenishment District (CAGR), but the CAGR currently has no long-term contracts for renewable water supplies and is not required to replenish where the groundwater pumping occurs — even if the pumping is in an area of critical groundwater decline.
- There are significant concerns about the increase in localized groundwater declines and land subsidence.
- Much CAP water is being stored for future use, and now storage on behalf of other states has been approved, but recovery plans for stored water can at best be characterized as incomplete.
- Wildcat subdivisions continue and the drilling and operation of exempt wells are a problem.
- Assumptions about the rate at which groundwater use by mining companies would decline over time have not been accurate. New permits for industrial uses of groundwater can place additional demands on already overdrafted aquifers.

GMA... continued on page 8

Conference Celebrates GMA's 20th Anniversary – and Beyond

“Arizona's Groundwater Management Act, Twenty Years of Progress: What Comes Next?” is the title of a statewide conference celebrating the 20th anniversary of the law. The conference will be held May 1-2 at the Tempe Mission Palms Hotel. On May 1, a joint meeting of the five Groundwater Users' Advisory Councils will be conducted from 1:30-5:30 pm. Joint GUAC agenda topics include an up-to-the-minute report on the status of CAP repayment negotiations, major Indian water rights settlements and other key western water issues; a report from the Water Management Task Forces in each Active Management Area; and a policy discussion of future water management needs and objectives oriented towards a review of the GMA by the Governor's Water Commission. A 20th GMA anniversary reception will follow the GUAC meeting, from 6:30-8:30 p.m.

The main program will begin the next day, May 2, at 8:30 a.m. Included as part of the program will be discussions of major water issues still in need of solutions. Conference speakers include: Governor Jane Hull, Kathy Ferris, Rita Pearson, Robert Glennon, Steve Weatherspoon and many others. The luncheon speaker will be Fitzsimmons, Arizona Daily Star political cartoonist. Panelists will offer contrasting views on such hot topics as: Are safe-yield and assured water supply really safe and assured? Is CAP water banking a good long-term solution? Do we have enough water for projected population growth? Are new approaches needed in some parts of the state without AMAs. As a finale an invitation is extended to visit the New Tempe Town Lake after the conference.

The conference is sponsored by the Water Resources Research Center, University of Arizona, with many co-sponsors. For more information, contact WRRC at 520-792-9591 or check either the WRRC web site: <http://ag.arizona.edu/AZWATER> or the Arizona Department of Water Resources's web site: www.adwr.state.az.us. The joint GUAC meeting and reception is sponsored by the ADWR. For additional information about the joint GUAC meeting, contact Kathy Jacobs at 520-770-3800.



Legislation and Law

Proposed Rules Allow Less Restricted Graywater Use

The Arizona Department of Environmental Quality is in the process of revising its regulations relating to reclaimed water use. Although much of the proposed regulations have to do with reclaimed water from wastewater treatment plants, new rules also are being considered for regulating domestic graywater use. Graywater is water resulting from residential use of bathtub, shower, washing machine and bathroom sink.

The proposed rules add fodder to an ongoing debate about the appropriate regulation of graywater. The crux of the issue is whether domestic graywater use poses a public health hazard. Some health officials contend that it does indeed. Others disagree, believing graywater is in fact safe to use for domestic landscaping. They are likely to view current rules as unduly restrictive; thus discouraging use of this valuable water resource.

Present rules permit single and multi-family residences to use graywater for surface irrigation under certain conditions. These conditions include DEQ approval of the design and construction of the system. The system must include a settling or holding tank to settle out the grit and heavier material from the graywater. A filtration device also is required. If the graywater is to be applied to the surface, a means of disinfecting the graywater also is necessary.

Also, graywater used for surface irrigation must meet allowable water quality and monitoring specifications. Allowable limits are set for fecal coliform and chlorine residuals. A sampling schedule also is established.

Critics of present graywater regulations claim the above rules are sufficiently onerous to serve as a deterrent to actually getting a permit. Further, even if a householder dutifully attempted to follow the regulations, graywater use would not be cost effective due to the cost incurred meeting such regulations. With the proposed rules, some graywater users will have less of these permitting requirements to meet.

The proposed rules establish two categories of graywater users. Private graywater irrigation systems with a flow of less than 400 gallons per day would be allowed "a general permit without notification." In other words, a householder in this category would be able to set up and operate a graywater system without needing to seek official review or approval. They would, however, need to meet specific conditions or performance standards. These include rules on graywater use, quality and application, the operation of the graywater system and mosquito control.

Enforcement to ensure that the above conditions are being met will be "complaint driven." In other words, health officials will respond if a neighbor complains about a graywater irrigation system. An official will then check to be sure that the system is in compliance with performance standards.

(An evaluation of the results of a graywater study involving ADEQ, Arizona Department of Water Resources, Pima County DEQ and the University of Arizona will be a factor in deciding the final requirements for a general permit without notification. The

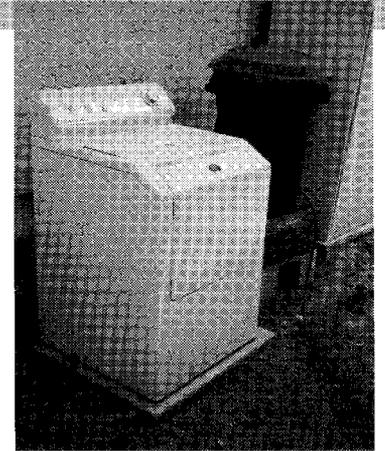
study is underway, with data collected, and final analysis and evaluation of the findings in process.)

The proposed rules differ for residential graywater irrigation systems with a flow between 400 gallons and 3,000 gallons per day. In this situation, a general permit with verification would be issued providing the system satisfies design and installation criteria contained in Appendix G of the Arizona Uniform Plumbing Code.

The proposed regulations, however, go on to state, "The Department may issue a general permit for a graywater system that differs in design and installation details if the system provides equivalent performance and protection of health and water quality."

The proposed rules do not intend to have the final say on regulating residential graywater irrigation. Local government has recourse to modify or change provisions. The proposed regulations state: "Towns, cities, or counties may further limit the use of general permits for irrigation reuse of graywater ... through passage of a rule or ordinance."

Thus, within the state, varied graywater regulations may be in effect, some restrictive of its use, others supportive, with some in between. For example, Pima County has a more tolerant attitude toward graywater use than Maricopa County; ordinances from the two counties would no doubt reflect this difference.



Standard domestic graywater system—washing machine and surge tank.

Arizona Water Resource is financed in part by sponsoring agencies, including:

Arizona Department of Environmental Quality
 Arizona Department of Water Resources
 Arizona Hydrological Society
 Arizona Municipal Water Users Association
 Central Arizona Water Conservation District
 Geraghty & Miller
 Metro Water District
 Salt River Project
 Tucson Water
 USGS Water Resources Division
 Water Conservation Alliance Of Arizona



Publications

Environmental Restoration Symposium Issue

Arizona Law Review

This special issue of the *Law Review* steps away from the traditional legal focus and includes numerous perspectives from a wide variety of academic disciplines and applied contexts. The articles and essays published in this issue relate to materials presented at the Environmental Restoration Symposium hosted by the James E. Rogers College of Law this past November. In discussing environmental restoration, the focus of this interdisciplinary issue is the interrelationship of science and law with a particular subfocus on watershed restoration. Copies will be available in May, 2000 for \$14 each. To order a copy call 520-621-1289 or email arizlrev@info.law.arizona.edu

Environmental Biology

Chuck Gerba, Raina M. Maier, Ian Pepper, et al.

This text offers a comprehensive discussion of environmental biology as a discipline. The authors define environmental biology as the study of microbial fate and activity in air, water and soil, as well as the resulting impact on human health and welfare. This book is designed for use in courses at the senior undergraduate and graduate levels, and to serve as a reference to those interested in the field. Soon to be published, the volume is tentatively priced between \$89 and \$99. For more information contact David Packer at Academic Press; email: david.packer@acad.com

Hydrogeological Investigations of the Sierra Vista Subwatershed of the Upper San Pedro River Basin, Cochise County, Southeast Arizona

Don Pool, Alissa Coes

The flow of the San Pedro River and the health of the San Pedro National Riparian Area are threatened by groundwater pumping, but climate and vegetation changes have also effected recent changes in river flow. These are the findings of a U.S. Geological Survey study conducted from 1995 through 1998 with Cochise County and the Arizona Department of Water Resources. The

study examined the interrelation between streamflow and the groundwater system that feeds the stream. A report with study results may be purchased from the U.S. Geological Survey, Branch of Information Services, Box 25286, MS517, Denver, Colorado 80225-0286; call 303-202-4210 for ordering information.

Riparian Ecosystem Restoration in the Gila River Basin: Opportunities and Constraints

Patrick B. Shafroth, Barbara Tellman, Mark K. Briggs

This publication of the Water Resources Research Center documents the content of a workshop held in April 1999 on riparian ecosystem restoration in the Gila River Basin. It is intended to help those interested and/or involved in riparian restoration to more effectively plan, implement, and manage riparian restoration projects. Topics include: lessons gained from past recovery efforts; considerations of the problems and possibilities for restoration efforts; monitoring and assessment methods; restoration of native vegetation; watershed improvement; and case studies. Since limited copies are available, this publication is not for sale; however, it can be obtained free on the web at <http://ag.arizona.edu/AZWATER/>

Water Conservation, Yesterday and Today: A Story of History, Culture, and Politics

Joe Gelt. Vol.10 No. 4 of *Arroyo*, a quarterly publication of the Water Resources Research Center. Defined as the careful use of water to maintain current supplies, water conservation has gained new importance as technological attempts to circumvent the arid conditions of the desert have fallen short, and water managers try to meet growing demand with insufficient supplies. This edition chronicles the culture, politics, history, and necessity of water conservation in the arid Southwest, from ancient times to the present. Individual copies – also subscriptions to *Arroyo* – are available without charge from the Water Resources Research Center, University of Arizona, 350 N. Campbell Avenue, Tucson, AZ 85721; phone 520-792-9591; fax 520-792-8518

GMA... continued from page 6

- Legal rights to pump groundwater far exceed actual pumping, which means groundwater mining could be worse than we are currently experiencing.

- Farming interests, which are currently using significant quantities of CAP water, could return to reliance on groundwater in future years, prolonging agriculture's use of groundwater beyond earlier projections.

- Conservation programs are complex, and frequently water conservation targets are not being met or are subject to challenge.

- Areas outside of Active Management Areas are growing rapidly and are facing water availability and management challenges.

In the near term, it is expected that some significant Indian water rights claims and the dispute between the CAP Board and the federal government regarding CAP repayment and other issues will be settled. These settlements will reduce or eliminate some significant uncertainties that have impeded long-term water planning in certain parts of the State.

Many challenges to achieving state water goals, however, will not go away. Since its inception, the framers of the Act have argued that in 1980 a delicate balance of competing interests was achieved and, consequently, that efforts to amend the Act should be avoided. Yet the Act has been amended frequently, with the amendments often times being substantial and complex.

It is time to take stock of where we are, where we are likely to head under current law, and where we believe some changes in course are desirable. If we wish to maintain and enhance our vibrant, growing economy as well as the property values of all property owners, a comprehensive conversation on the Groundwater Management Act is the only prudent thing to do.



Special Projects

Photos Show Verde River Changes Over Time

Researchers from Northern Arizona University's Geology Department are interpreting historic photos to document changes in riparian conditions along a stretch of the Verde River, from 1946 to the present. They will examine historical aerial photos of about 13,000 acres, from three miles below Oak Creek to seven miles above Clarkdale, to document vegetation changes. Professor Abe Springer is the project's primary investigator, and Sharon Masek Lopez is the research assistant.

The goal of the project is to determine the causes of vegetation changes, whether due to human activities in the watershed or the result of natural causes such as flood or drought. Information about past and changing river conditions will guide decisions about the future management of the Verde Valley riparian system. Areas suitable for future revegetation will be better identified.

The researchers at first searched literature and data relevant to the study. For example, histories of the Verde Valley were examined to determine land use practices that may have affected riparian areas. They also examined existing hydrologic information for the Verde Valley, including reports, water level data for wells, climate data and stream gauging data. This information helps explain the interaction between the hydrologic system and the riparian system. Remote sensing riparian studies also were reviewed to ensure methodological compatibility.

To interpret the aerial photos (scale range 1:12,000 to 1:30,000) researchers are viewing the photos using a stereoscope and then digitizing tree stand polygons directly onto the scanned photographs using ArcView. Two classes of vegetation will be mapped. These are Fremont cottonwood/Goodding willow (*Populus fremontii*/*Salix gooddingi*) and velvet mesquite (*Prosopis velutina*).



The study area near Cottonwood in 1968

The researchers found that it is not practical to map individual willow stands since they are usually not distinguishable from cottonwood stands.

Along with vegetation coverage, the researchers also are interpreting land use by digitizing land use types by decade on separate GIS covers. Land use types include forest, agriculture, residential

and industrial/commercial, with others designated if necessary. The river channel will also be mapped as well as bare sediment along the channel.



The study area near Cottonwood in 1995

Work began with the most recent set of photos. (e.g. 1995). After interpreting photos the researchers ground-truthed samples. Ground-truthing involves taking photos and completed photo interpretation print outs into the field to check for accuracy in interpretation of tree species and extent of tree stands.

ArcView will be used for the GIS analysis. Digital spatial data sets will be created that can be made available in ArcView shapefile format or ArcInfo coverage format. Attributes will be assigned to each polygon. For the tree stands, attributes include species, density and water use. Various analyses of the data will be performed.

Kyle Bohnstiehl of North American Geographical Information Systems is serving as the project's GIS analyst. He will conduct a time series analysis comparing the six different layers (decades) of data. The analyses will be useful to compare vegetation from decade to decade and quantitatively show shifts or trends. Tables and graphs will be generated to display this information in an understandable format to the public.

The project also will develop An Assessment of Human Influence report to discuss changes in riparian vegetation in the Verde Valley, between the 1940s and 1990s as influenced by human activity in the watershed. Much vegetation change is natural, associated with climate cycles over time. Human activity in the watershed, however, also can have a significant effect on the distribution and density of riparian tree species.

Additional information about the project can be found on the web site (<http://vishnu.glg.nau.edu/verde>) or by contacting Sharon Masek Lopez, research assistant, Upper Verde Valley Riparian Area Historical Analysis: email, smasek@infomagic.com or phone, 520-525-1980.

This project is funded by the Arizona Water Protection Fund. The Arizona Legislature created the fund in 1994 to support projects to enhance riparian areas of the state.



Announcements

National Watershed Outreach Conference

The National Watershed Outreach Conference in San Diego, April 17-19, 2000 is an opportunity to share new and innovative ideas to involve citizens in watershed protection activities. Sponsors include the U.S. Environmental Protection Agency and the University of California Cooperative Extension. Topics include Communicating Technical Information, Innovative Approaches to Reaching Nontraditional Audiences, Tools for Evaluating Outreach Successes, Creating Partnerships to Meet Outreach Goals, and Reaching Across Political Boundaries. For more information, visit the conference web site at <http://www.epa.gov/OWOW/watershed/outreach/events/aprilconf.html> or contact Stacie Craddock (craddock.stacie@epa.gov), U.S. EPA Headquarters, at 202-260-3788 or Melissa Bowen (bowenme@tetrattech-ffx.com), Contractor, Tetra Tech, Inc., at 703-385-6000.

AZ Riparian and Stream Restoration Forum

The Arizona Water Protection Fund Commission presents its First Annual Information Transfer Forum on Riparian and Stream Restoration in Arizona March 22-23, 2000 at the Crowne Plaza North Hotel in Phoenix. This forum will provide an opportunity for individuals involved or interested in restoration of our streams and watersheds to share information about restoration techniques. Forum topics include Revegetation Planning, Range Management, Stream Channel and Erosion Control Structures, and Enhancing Natural Fish Habitat. Registration fees are \$45 before March 10 and \$55 after March 10. For more information about this forum, contact: Irmalisa Horton 602-417-2400 x 7016, or Ruth Valencia 520-523-6613.

Water Quality Improvement Grant Program

Through the Water Quality Improvement Grant Program the Arizona Department Of Environmental Quality (ADEQ) distributes grant funds from the Environmental Protection Agency, provided under the Clean Water Act. Workshops are to be offered to provide information about the granting process and to answer questions. A manual detailing the grant program and all necessary information to apply for grants is undergoing development and will be available after January 2000. For additional information contact Deborah Patton, Grant Coordinator, AZ Department of Environmental Quality, 3033 North Central Avenue, Phoenix, AZ 85012; phone: 602-207-4635; fax: 602-207-4634; email: patton.deborah@ev.state.az.us

Nonstructural River Management and Restoration Conference

Southwest rivers, streams and washes have been extensively modified through traditional approaches to convey flood flows. A shift is occurring in the understanding of the importance of these natural systems and the value and role they play within a community.

This conference will explore the scientific, economic, and policy basis for a shift in management approach that balances flood protection with other management objectives. Examples of these objectives include, riparian zone enhancement and restoration, recreation, ground water recharge, water quality improvements, fluvial processes, and conserving native biodiversity of aquatic ecosystems. This conference is intended for floodplain managers, engineers, planners, geomorphologists, ecologists, landscape architects, natural resource managers and decision makers interested in integrated approaches and their application to watercourse management and restoration in the Southwest. The conference takes place April 3 - 5, 2000 at the Crowne Plaza North hotel in Phoenix. For more information, contact: Valerie Swick; phone: 602-506-4872; email: vas@mail.maricopa.gov

Tucson AMA Provides Funding

The Arizona Department of Water Resources is now accepting applications for funding for conservation assistance and augmentation projects in the Tucson Active Management Area. The object of the programs is to assist water users within the Tucson AMA in meeting the conservation requirements contained in the management plan and to promote the use and storage of renewable sources of water. Between \$150,000 and \$250,000 will be available for grants this cycle; the deadline for applications is 5 p.m. Friday, March 31. Application packets may be obtained from the Tucson AMA by contacting Nancy Holland 520-770-3800, or may be downloaded from the ADWR web site, www.adwr.state.az.us

USGS Issues Request For Grant Proposals

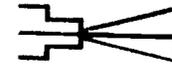
A request for proposals (RFP) for matching grants to support research on non-point source water pollution and water use has been issued by the U.S. Geological Survey, in cooperation with the National Institutes for Water Resources and the Kentucky Water Resources Research Institute. The RFP is only available electronically and can be read and/or downloaded from the web site:

<http://www.uky.edu/waterresources/pdf/RFP6.pdf> A total of \$1-million is being made available for research under this program. Any investigator at an institution of higher learning in the United States is eligible to apply for a grant through a Water Research Institute or Center established under the provisions of the Water Resources Research Act. Proposals must be filed on the Internet at <http://www.niwr.org/> by March 24, 2000 and must be approved for submission to the National Competitive Grants Program not later April 3, 2000 by the Institute or Center through which they were submitted. Questions concerning this RFP and the proposal review and selection process should be addressed to: Bob Volk, Director Kentucky Water Resources Research Institute, 233 Mining & Minerals Resources Building, University of Kentucky Lexington, KY 40506-0107; phone: 606-257-1299; fax: 606-323-1049 email: bvolk@pop.uky.edu





Calendar of Events



RECURRING



Arizona Hydrological Society (Flagstaff). 2nd Tuesday of the month (during the school year). Meeting times and locations may vary, NAU, Southwest Forest and Science Complex, 2500 S. Pine Knoll Dr., Room 136, Flagstaff. Contact: Abe Springer 520-523-7198, email: abe.springer@nau.edu

Arizona Hydrological Society (Phoenix). Usually 2nd Tuesday of the month. Contact: Christie O'Day 602-379-3087, ext 224.

Arizona Hydrological Society (Tucson). Usually 2nd Tuesday of the month. Contact: Laura Davis 520-326-1898.

Arizona Water Banking Authority (Phoenix). Next quarterly meeting will be held on Mar. 15th at the ADWR in Phoenix. Contact: Nan Flores 602-417-2418.

Arizona Water for People Committee, Phoenix, meets on the 2nd Thursday of even-numbered months at City of Phoenix Squaw Peak Facilities, 6202 N. 24th St., Phoenix at 6 p.m. Contact Dave Christiana 602-417-2400, ext 7339; Tucson, meets the 3rd Thursday of even-numbered months. Time and place varies. Contact Sheila Bowen, 520-625-8409 or sbowen@communitywater.com

Arizona Water Protection Fund Commission. Contact: Irma Lisa Horton 602-417-2400 ext. 7016.

Arizona Water Resources Advisory Board. Contact: Kathy Donoghue 602-417-2410.

Central Arizona Water Conservation District. Usually 1st and 3rd Thursdays of the month, time to be determined one week in advance. CAP Board Room, 23636 N. 7th St., Phoenix. Contact: Ardis McBee 602-869-2210.

City of Tucson Citizens Water Advisory Committee. Usually 1st Tuesday of the month, 7:00-9:00 a.m., 310 W. Alameda, Tucson. Contact: John O'Hara 520-791-5080 ext. 1446.

Maricopa Association of Governments/Water Quality Advisory Committee. Contact: Lindy Bauer 602-254-6308.

Maricopa County Flood Control Advisory Board. Usually 4th Wednesday of the month, 2:00 p.m., 2801 W. Durango, Phoenix. Contact: Kathy Smith 602-506-1501.

Phoenix AMA, GUAC. Scheduled monthly, please call. Conference Room A, 500 N. 3rd St. Phoenix. Contact: Mark Frank 602-417-2465.

Pima Assoc. of Governments Water Quality Subcommittee. Usually 3rd Thursday of the month, 9:00 a.m., 177 N. Church St., Suite 405, Tucson. Contact: Gregg Hess 520-792-1093.

Pinal AMA, GUAC. Usually 3rd Thursday of the month, 2:00 pm. Pinal AMA Conference Room, 1000 E. Racine, Casa Grande. Contact: Randy Edmond 520-836-4857

Prescott AMA, GUAC. 2200 E. Hillsdale Rd., Prescott. Contact: Phil Foster 520-778-7202.

Santa Cruz AMA, GUAC. Usually 3rd Wednesday of the month, 9:00 am, Santa Cruz AMA Conference Room, 857 W. Bell Rd, Suite 3, Nogales. Contact: Kay Garrett 520-761-1814.

Tucson AMA, GUAC. Usually 3rd or 4th Friday of the month, 9:00 a.m., Tucson AMA Conference Room, 400 W. Congress, Suite 518, Tucson. Contact: Kathy Jacobs 520-770-3800.

Tucson AMA, Safe Yield Task Force. Every Wednesday. Contact Kathy Jacobs 520-770-3800.

Verde Watershed Association. Contact: John Parsons and Tom Bonomo, VWA Newsletter Editors, Verde Watershed Association, P.O. Box 4595, Camp Verde, AZ, 86322. 520-567-2496. Message phone: 520-649-9978, email: obarc@sedona.net; web site: <http://www.vwa.org>

Water Users Association of Arizona, 2nd Friday of the month at noon (except in September). Call for reservations and exact location. Contact: Paul Gardner, 480-987-3240.

Yavapai County Flood Control District Board of Directors. Contact: Ken Spedding, 520-771-3197.

UPCOMING



May 12-13, 2000 The Arizona Riparian Council' 14th Annual Meeting will be held at Eastern Arizona College, Safford. On May 12, a plenary session will be held, followed by a general session of technical papers. The following day field trips will be conducted to various locations in the Flagstaff area. For additional information contact: Cindy Zisner, Arizona Riparian Council, phone: 480-965-2490; fax: 480-965-8087; email: Cindy.Zisner@asu.edu

June 2, 2000 A one-day symposium devoted to the natural recharge of groundwater will be hosted by the U.S. Soil Conservation Lab, the U.S. Geological Survey, and the Arizona Department of Water Resources, to be held at the Embassy Suites in Tempe. Invited speakers will present the latest research on natural recharge with a focus on the desert regions of the Southwest. For additional information, contact Doug Bartlett, phone: 602-294-9600; email: dbartlet@clearcreekassociates.com

Submit calendar, announcement, or publication information to Joel Spezeski, WRRRC; phone: 520-792-9591 x56; fax 520-792-8518; email botmc31415@aol.com

Irrigation Water...continued from page 1

If groundwater tables are dropping — this was the situation in south-central Arizona during much of this century — the slow moving deep-percolation water from agricultural fields and urban areas does not reach the retreating groundwater. The lowering groundwater level thus acts to preserve water quality from the salty deep-percolation water.

With less groundwater pumped and more CAP water used, especially in agricultural areas, groundwater levels are declining more slowly and in fact may even be rising. This might also occur in urban areas when pumping is stopped because of salt, nitrate or industrial chemicals in the groundwater. Deep percolation water is then more likely to reach the groundwater, degrading water quality and causing a further rise in the groundwater level.

Bouwer says this is the scenario in the southeastern part of the Salt River Valley, in South Mesa, Gilbert and Chandler. "There is a lot of irrigation in these areas, and they have turned off the pumps because of an abundant supply of surface water. The groundwater levels have risen an average of about 4 feet per year since the 1980s so they have come up about 60 feet." If this rate were applied to other south-central Arizona areas, groundwater now at a depth of 300 feet could rise to the land surface in about 70 years. This would be contingent upon pumping being discontinued, with surface water used for irrigation.

"If you are going to prevent rising levels of salty groundwater you will eventually have to start pumping again," Bouwer says. "You then have to decide what to do with the salts that come out of the wells." Water levels remaining at or near land surfaces could result in salt marshes and salt flats.

The salty water from wells can be disposed of in evaporation ponds or be desalted by reverse osmosis (RO) for reuse, including drinking. RO, however, produces a reject brine that must be disposed of. The salty groundwater and brine could be put in evaporation ponds. These ponds, however, not only require a lot of land but they eventually become environmental hazards. The volume of salty groundwater can be reduced by using the water to sequentially irrigate increasingly salt-tolerant crops, applying deep percolation water from one crop to irrigate the next more salt-tolerant crop, until it is used to irrigate halophytes that can grow in sea water. Salt is thus concentrated in a much smaller volume of water, for evaporation in smaller ponds. Plans also are being considered to construct a "brine line" to convey the leach water and/or reverse osmosis brine to the Yuma area for desalinization or further transport. (See sidebar, page 2)

Whatever solution is adopted must cope with special conditions. Bouwer explains: "Salinization and excessive rise of groundwater levels will not occur everywhere at the same time. Their occurrence depends upon irrigation intensity and local groundwater pumping." Bouwer believes, however, a solution to the problem requires a coordinated effort and cannot be left to the efforts of individual cities, irrigation districts and Indian reservations.

Bouwer says the problem has not attracted the notice it deserves, partly because its effects are mostly evident in the long-term. As a first step toward recognizing the problem a salt forum was held in Phoenix in July to bring water officials and stakeholders together to discuss possible future developments. Another step in the right direction is to consider groundwater management not only as strategy to protect against undue depletion of groundwater but also against its undue rise.



Arizona Water
Resource

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College of Agriculture
The University of Arizona
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Tucson, AZ 85721

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