



Seagoing Desalination Plant Touts Environmental Benefits

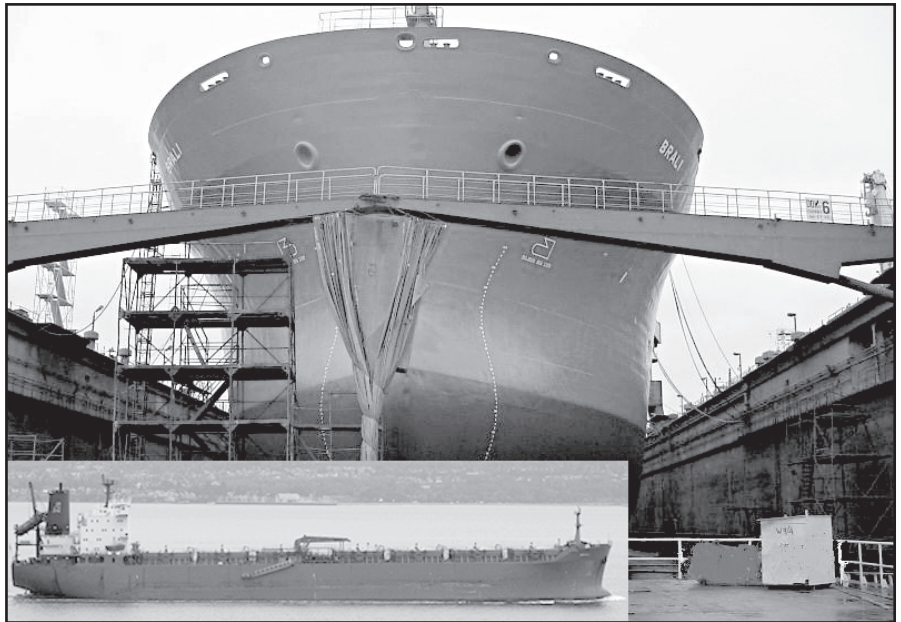
With desalination looming big on the water resource horizon, many water officials are looking at their options. One option Arizona officials are considering is building a desalination plant in Puerto Peñasco that would be a joint Mexican-Arizona project, with both the resort community and the state benefitting from the desalinated water supplies.

With desalination an emerging technology, other kinds of options will be available in the future. One such option is seawater desalination vessels, ships capable of onboard desalination for onshore use. Even land-locked states like Arizona might benefit from such vessels.

(There is something oddly fitting about a seagoing vessel outfitted to desalinate ocean water for inland use. Designed for the sea, the vessel floats on the raw resource to be processed, the ocean in all its abundance, unlike a land-based desalination plant that treats seawater from the shore.)

Water trading would enable Arizona to benefit from a desalination vessel. For example, Arizona could invest in a vessel that would then operate off the coast of California and provide water to the West Coast state. In return, California could agree to Arizona

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Two views of the vessel Bali, in dry dock and afloat on the ocean. The Bali is a vegetable oil tanker that is to be converted into a seawater desalination vessel.

Clean, Green Solar Power Falls Short in Achieving Water Efficiency

by Joe Gelt

Semi-arid Arizona is a mother lode of the raw material needed for solar energy — sunlight.

Despite the impressive advantages of solar power — it converts sunlight into energy and is non-polluting and sustainable — the same concern is being raised about solar facilities that has been raised about coal or nuclear energy plants: water use.

One of the sunniest states in the country, Arizona is poised to become the North American capital of solar power. But does the semi-arid state have adequate water resources for large-scale solar energy production? Further, would producing solar energy largely for export out of state be a wise use of those water resources? (See News Briefs, page 5 for information about state water export through power generation.)

University of Arizona water researcher Gary Woodard appreciates the value of solar energy, but believes more attention should be devoted to the amount of water used to produce solar power. He says, “The water issue is not being squarely addressed.” He believes this is an important but overlooked issue saying, “Solar thermal tends to be the least efficient of all thermal types of power generation.”

Consider water-use information from the 2006 report *Energy Demands on Water Resources, Report to Congress on the Interdependency of Energy and Water* prepared by

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Solar Power...continued from page 1

the U.S. Department of Energy: a coal fired plant uses 110 to 300 gallons per megawatt hour; a nuclear plant uses between 500 and 1100 gallons/MWh; and a solar parabolic trough plant uses 760 -920 gallons/MWh.

Considering the large number of solar plants being proposed for Arizona and the West the question of the amount of water needed to produce solar energy is an important one. The Bureau of Land Management has received 130 applications for large-scale photovoltaic and concentrated-solar projects on 1 million acres of land, most of which are in the West. If all currently proposed plants became actual projects, about 70 billion watts of power could be added to the nation's electrical grid, capable of meeting the electric needs of 20 million homes.

Included in the above are plants proposed for Arizona. Eight solar companies or investment groups have submitted applications to BLM to build 27 solar projects in the state, with the proposed projects having the potential to generate more than 12 billion watts of power.

Concerns overlooked

The high expectations for solar energy tend to overshadow some concerns about this much acclaimed clean, green alternative energy option. Solar facilities require electrical transmission lines, are often located on land providing habitat for plants and animals and, at issue here, consume large quantities of water.

In response to these concerns BLM decided to take a cautious route when approving applications for solar projects. After receiving the above-mentioned 130 applications, the federal agency announced it would accept no other applications for large-scale solar projects on its western lands pending the completion of an Environmental Impact Statement.

According to a press release, the process will "assess the environmental, social, and economic impacts associated with solar energy development on BLM-managed public land in six western States: Arizona, California, Colorado, Nevada, New Mexico, and Utah." Water would be one of the issue addressed by the EIS along with visual impact, effects on species and competing uses of land.

The delay raised the ire of members of Congress and the solar industry; BLM reversed its decision. Many of the proposals already submitted,

however, may be approved through individual National Environmental Policy Act reviews before EIS guidelines are written.

Solar energy and water use

What all thermal-based energy production has in common, whether involving solar concentrators, coal, nuclear or, to some extent, natural gas, is that they all use heat to boil water and produce super heated steam. The steam then rotates a large turbine activating a generator that produces electricity. The steam is then condensed back into water in cooling towers, giving off waste heat in the process. This waste heat is dissipated by evaporating water from another source.

Those who know solar energy only from the photovoltaic systems installed on roofs and that provide electricity for domestic use might wonder about the concern about water use. Photovoltaic systems convert sunlight directly to electricity using the semiconductor materials in solar panels, with no water needed.

The big water users are solar facilities relying on concentrated solar power or CSP projects. As its name suggests CPS uses long parabolic mirrors or Fresnel lenses to concentrate the sun's energy on black tubes carrying molten sodium or high-temperature oil. These fluids are used in turn to boil water, with the steam turning a conventional turbine to produce electricity. CPS systems require a water source and cover large areas of land, up to several square miles, to produce sufficient electricity for export or local use.

All but one of the solar projects proposed for Arizona are CPS projects use parabolic-trough technology. The lone exception is a project proposed on BLM land just south of Eloy that would use photovoltaic panels.

Efforts to increase water efficiency in solar energy operations involve modifying the conventional cooling tower. For example,

Rooftops, a High-Level New Frontier

Roofs are becoming a new frontier in the Green Movement, a region to stake out territory to achieve various energy and water-saving initiatives. A photovoltaic system installed on a house roof shows that the homeowner is committed to solar energy to provide electricity for domestic use. Roofs also figure into larger more grandiose solar energy planning. Southern California Edison has a \$875-million plan to lease commercial rooftop space that would be equal to 2 square miles which would be about 100 or 150 buildings, producing about 250 megawatts of electricity.

Rooftops are also the headwaters for many rainwater harvesting projects, both in domestic and commercial buildings. (See page 7 for information about a Tucson law requiring rainwater harvesting systems in new commercial development.) The roof serves as a catchment area during rainfall, with the rainwater conveyed by gutters and leaders to a cistern for storage or to areas for direct use. At its simplest, a rainwater

harvesting system consists of a container capturing rain dripping from roof or patio.

Roof-top gardens, also called green roofs or eco-roofs, are more evident in Europe than in the United States. Like roofs in rainwater harvesting systems, roof gardens capture rain, with the water then used to irrigate the garden rather than flowing off to be stored in a cistern. Green roofs reduce the need for land-consuming retention ponds in areas where runoff poses a water quality problem. The gardens would be useful in Arizona since they reduce cooling costs for buildings; they also help offset the effects of global warming by converting carbon dioxide to oxygen.

Chicago has the largest number of roof gardens in the country, the result of efforts started by Mayor Richard M. Daley. A few years after a particularly severe heat wave, he had a garden installed on top of 12-story City Hall. About the size of a city block, the rooftop garden was designed to reduce the city's heat island effect.

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Water Vapors

WRRC Web Site to Be Improved

An improved WRRC web site is in the works. The first important step in the WRRC web improvement project was taken when John Dale was hired as application systems analyst to review and improve the site.

One of the first tasks he has undertaken is to provide more direct access to *Arizona Water Resource* articles. As it works now, a search for a particular topic, say the Virgin River, will likely result in various responses including multiple formats (PDF, HTML), multiple versions of the same content or include far more content than requested. The user would then have to search further. Time and energy are wasted.

John says he is “developing a data architecture that decomposes each newsletter into a more search-engine-friendly format.” In other words, he is working out a method to enable a user searching for the Virgin River to get direct access to the appropriate article.

The time savings is obvious. Not as apparent, the energy savings might need some explaining: By providing direct access to the resources on the WRRC web site the amount of electricity required to provide content will be reduced.

John says, “Every page that is served over the Internet requires some amount of electricity to deliver. We can do our part to lower energy consumption if our users load fewer pages to get the content they want and receive only the content they desire.”

John is interested in more energy-efficient Internet operations, a topic getting

increased attention lately.

Measures of web site success

For those who like to keep score — and we like to keep score when it is to our credit — 1298 unique visitors from 68 different countries/territories have accessed the web site’s main page or the WRRC newsletters, *Arroyo* and *AWR* during September. Once direct access is provided through Google to specific articles the number is expected to greatly increase.

Perhaps another way to gauge web success is to consider the attention an *AWR* insert attracted. The *AWR* usually contains an insert, a four-page supplement inserted in the middle of the newsletter.

By paying for an insert an organization or agency is able to publicize its activities and also help support publication of the *AWR*.

The May - June 2006 edition of the newsletter included a supplement by Arizona NEMO (Nonpoint Education for Municipal Officials) titled “Integrated Watershed Management and Planning.” Someone from India who had read the Arizona NEMO supplement on-line contacted project director Kristine Uhlman requesting to

WRRC Director Megdal Receives Award

The Associate Alumnae of Douglass College has named Sharon Megdal to The Douglass Society, honoring her accomplishments as an economist and water resources researcher. Dr. Megdal was one of three alumnae inducted on Sept. 24. The Douglass Society was established in 1973, and comprises nearly 200 previously inducted Douglass College alumnae whose life work embodies exceptional accomplishments and leadership.

Since its inception as the New Jersey College for women in 1918, Douglass College has been devoted to women’s success and leadership. As part of Rutgers University, it is the only women’s college in the nation at a public research university.

use the supplement as a book chapter. It is now in the volume titled *Watershed Management, Concepts and Experiences*, published by The Icfai University Press. This, no doubt, influenced Kristine’s decision to sponsor another supplement, in this newsletter. We thank Kristine and Project NEMO for its support of the *AWR*.

Support the newsletter

We invite other organizations and agencies to help support the *AWR* by sponsoring a newsletter supplement. It may not end up as a chapter in a book, but it will be delivered to over 2500 readers, with others accessing the newsletter on-line.



The Water Resources Research Center celebrated its 50th Anniversary last year. Graphic artist George Wills of the Virginia Water Resources Research Center helped us celebrate the occasion with the above graphic.



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News Briefs

EPA OKs CWA Authority for Hopi Tribe

The U.S. Environmental Protection Agency recently approved the Hopi Tribe's application to administer Clean Water Act programs. With authority to administer the Water Quality Standards and Certification Programs under Sections 303 and 401 of the CWA, the Hopi Tribe can now adopt, review and revise water quality standards for all surface waters within Hopi lands.

The tribe will work with the EPA on a government-to-government basis to develop and adopt water quality standards. Once approved, the standards will form the basis for water quality-based effluent limitations and other requirements for discharges to waters within the tribe's jurisdiction.

The tribe also is authorized to grant or deny certification for federally permitted or licensed activities that might affect waters that lie within the exterior borders of the Hopi lands.

The CWA requires that a tribe can be granted this authority only if it is federally recognized, has a governing body to carry out substantial governmental duties and powers, has jurisdiction to administer the programs within the boundaries of its reservation, and is reasonably capable of administering the program.

Tribes take on the same responsibility to ensure public health as states when they administer drinking water programs. In applying for primacy, the Hopi Tribe had to develop and demonstrate its capability to administer the program, along with adopting appropriate regulations to ensure safe drinking water in public water systems. There are now 43 tribes authorized nationally.

Senator McCain on Water Compacts

It's the political season, and candidates are making the rounds. In making his rounds, Senator McCain commented on two water compacts — contrary to the

Desertification Threatens Las Vegas

Green Economics, a Worldwatch Institute publication, told of a Las Vegas homeowner who was upset about a water district inspector's reprimand about running an illegal sprinkler in the middle of the day. Losing his temper, he said, "You people and all your stupid rules — you're trying to turn this place into a desert!"

view of many western officials, the Colorado River Compact is not the only water compact in the nation — with the senator both disclaiming an unlikely water supply for Arizona and shaking up western water officials.

In an interview with Associate Press during a Detroit campaign stop, McCain voiced support for the Great Lakes Basin Water Resources Compact that would outlaw diversions of Great Lakes water from their natural drainage basin.

Years in the making, the compact is a defensive strategy of the governors of the eight Great Lakes states. They fear that water-needy western states with burgeoning populations and scarce water resources will soon have the political muscle to stake a claim on Great Lakes water.

Playing against this fear, McCain quipped, "I've often had dreams of a giant pipe that ended up in my backyard in Phoenix." He then added, "But the fact is that any decision concerning water should be made by the people who own the water. That's the states."

His comments on the Midwest compact did not raise many eyebrows, except possibly among a few starry-eyed westerners who might really believe that the Great Lakes is a promising future water source. His remarks on the Colorado River Compact, on the other hand, were a different matter. In an interview with *The Pueblo Chieftain*, McCain said that the seven Colorado Basin State should renegotiate the compact to take into account increases in

population and changing water needs.

His statement raised an uproar among many western water officials who view any tinkering with the compact, much less its renegotiation, as threatening to unravel an intricately woven legal fabric made up of state and federal laws and regulations, court decisions, and international treaties. Colorado Sen. Ken Salazar statement that the compact would be reopened "over my dead body" might measure the forcefulness of the response.

McCain later stated that his remarks were misconstrued and that he does not advocate renegotiating the compact.

Bacteria Enlisted in War Against Quagga, Zebra Mussels.

Scientists are testing a new biological weapon for use against the troublesome quagga mussel. On one side of the battle line is the quagga relentlessly spreading through rivers and reservoirs of the West, posing a threat to the operations of hydroelectric plants and water-supply works along the lower Colorado River as well as the ecology of the lower river itself; on the other side is the *Pseudomonas fluorescens*, a bacterial product that has shown in lab tests the ability to knock out quagga and zebra mussels.

Fred Nibbling, an invasive species researcher with the Bureau of Reclamation, says live bacteria would not be released into water. He says, "There is a misunderstanding when you say a release of a bacteria. It is a use of a bacterial product; the bacteria are actually dead." Researchers at New York State Museum found that the bacteria were effective against the mussels.

Commonly used to protect such root crops as potatoes, this particular bacterial strain was found to be lethal to quagga and zebra mussels without posing any adverse effects to other forms of aquatic life.

Nibbling says the only water quality problem he foresees would be the result of mussel die off and decay. The mussels, however, would not die instantly, but

over days and weeks which would help control any impacts on water quality. He adds, "Hopefully we will treat in conditions where we don't have really heavy infestations. We try to anticipate where to treat."

Research is progressing: Nibling says, "We are trying to transition from the bench-scale laboratory scale to more of a field or pilot study stage." The next step would be to test it at one of the dams along the Colorado River. Davis Dam near Laughlin is being looked at where the pipeline has become partially blocked with mussels.

Nibling says, "We have closed plumbing systems in our dams where we can test internally without releasing anything into the water outside the dams. We have several levels of testing before we test in the open waters."

BuRec officials are in the process of meeting with Arizona and Nevada state agricultural officials to obtain approval to test the bacteria in the open waters; the testing would occur in waters bordered by the two states.

Nibling is uncertain when testing in open water will occur, saying it depends upon the regulatory process. "It may be six to ten months; that is a guess."

AZ Builder Joins EPA's WaterSense Home Building Program

An Arizona home builder is one of five companies in the nation to participate in the U.S. Environmental Protection Agency's Water-Efficient Single-Family New Homes Pilot Program. Dorn Homes, located in Tubac, is one of the participating builders who will be constructing residences designed to meet the WaterSense program's draft specification for new homes. Located in different parts of the country, the participating builders have committed to build and certify a total of 35 to 50 homes by 2009.

Certifying homes as part of its WaterSense program is a relatively new EPA venture. The agency had previously focused on certifying products and services in its effort to raise water efficiency awareness. By following testing protocols to spe-

cific categories, products or services could meet EPA criteria for water efficiency and performance. The WaterSense program broke new ground by providing consumers a national reference for water usage efficiency.

WaterSense labeled new homes will combine WaterSense labeled products with other water-efficient fixtures and practices to reduce water use by approximately 20 percent. Owners of the new homes will save more than 10,000 gallons of water per year, with further significant energy and financial savings due to reduced hot water

use. Homes must meet criteria in three areas: indoor water use, outdoor water use and homeowner education.

EPA is taking on a big-ticket item by granting WaterSense certification to homes and is looking to the cooperating builders to assist the agency to test the process for inspecting and certifying the residences. The agency expects builders to complete homes to the draft specification and report on the results of the WaterSense New Homes Pilot Program in early 2009. Results will shape the final Water-Efficient Single-Family New Homes Program.

Water Figures Into Power Export, Import

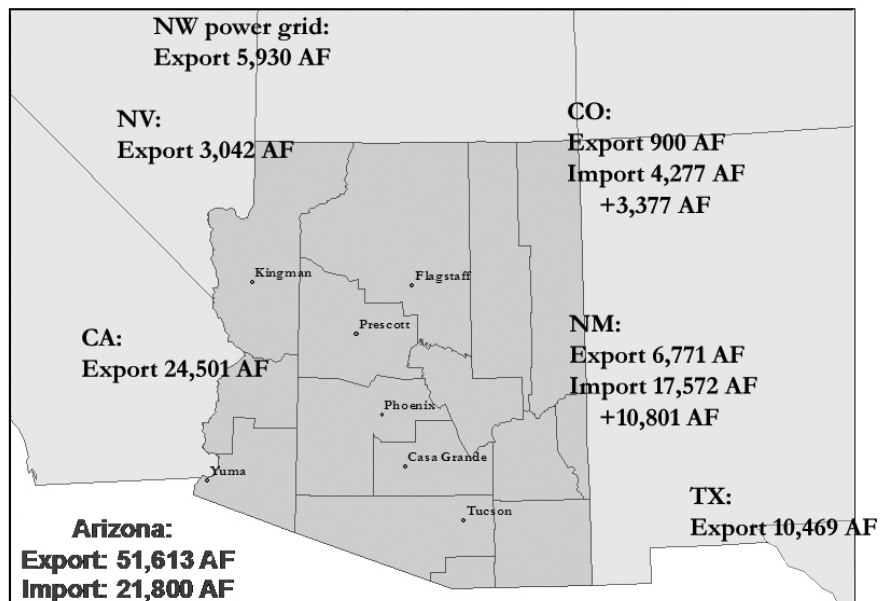
Water used by Arizona power generating facilities to produce electricity for other states is water unavailable for in-state use. This concern prompted Arizona State University researcher Mike Pasqualetti, professor in the School of Geographical Sciences, to investigate the amount of water such facilities are using in Arizona for in-state and out-of-state power production.

In gathering data showing the amount of water used at power plants in Arizona, Pasqualetti found that 150,350 acre feet were used for electricity production in 2007. Of that amount, 98,732 acre feet were used to generate power for use in Arizona. The difference between the two figures is the amount of virtual water Arizona is exporting to other states by generating power for their use.

At the same time, however, Arizona is importing energy from other states and benefitting from the water used in those states to generate the electricity.

The graphic below shows the amount of virtual water Arizona exports and imports with energy transactions, as well the destination of exports and the source of imports. Figuring net water consumption shows Arizona in the hole for 29,813 acre feet.

Net Water Consumption - 29,813 AF





Guest View

Needed: US Water Commission to Find Ways to Increase Water Supply

Twenty-First Century Water Commission bill awaits congressional action

Robert S. Lynch, an attorney with Robert S. Lynch & Associates, contributed this Guest View. Mr. Lynch devotes most of his practice to water, electricity and environmental law issues.

Two Congresses ago, Congressman John Linder of Georgia introduced H.R. 135, the Twenty-First Century Water Commission bill. The bill sets up a national commission to study ways to increase water supply throughout the United States similar to the last national study of this nature put forth by the National Water Commission in 1973. The bill passed the House in both the 108th and 109th Congresses, only to die in the Senate Environment and Public Works Committee. It was reintroduced in this Congress and has passed both House Committees (Natural Resources and Transportation and Infrastructure). The T&I Committee amended it from its original introductory form to emphasize climate change as an area of inquiry for the commission. The House bill has been languishing on Calendar No. 429 since June 4, 2008.

The companion bill in the Senate, S. 2728, was reported by the Senate Environment and Public Works Committee on August 22 of this year. It currently resides on Calendar No. 941 but a hold has been placed on the bill by Senator Coburn of Oklahoma. Apparently Oklahoma has no water problems worthy of national consideration. The hold places the bill in good company, at least, since Senator Coburn has seen fit to place holds on a great number of bills. As I dictate this, and Congress is about to adjourn having theoretically remedied the mess on Wall Street, the likelihood for this bill passing in this Congress devolves around whether and to what extent a lame duck session will occur.

What does the bill do? First, it declares as a national concern that we must find ways to increase our water supplies. Second, it creates a nine-member commission. The appointments to the commission vary slightly between the House and Senate versions of the bill as do the directions to the commission as to what to emphasize in its deliberations. For the most part, however, both versions direct the commission to focus on the supply side aspect of water supply in contrast to the numerous bills that have been considered by Congress lately on drought management and conservation, the demand side of the equation. And, most importantly for water lawyers like me, both versions respect the primary role of the States in managing and adjudicating water rights.

You might ask why a Congressman from Georgia (the Atlanta suburbs) would care about water. This is a Western is-

sue, isn't it? Well, Atlanta is the largest city in the United States without a major river running through it. It is more or less dependent on Lake Lanier, a nearby Corps of Engineers project that is subject of litigation with Florida and Alabama and has been for some years. To make matters worse, Georgia just lost a decision in federal court over operation of Lake Lanier.

Water rights, infrastructure financing, environmental impacts and mitigation, species habitat, river basin ecology, scientific developments and, yes, even climate change, must figure in any national discussion of increasing water supply. The only certainty is that not starting that dialogue only postpones addressing solutions to our increasingly stressed water supplies.

There have been a number of bills introduced in this Congress and the last several focusing on specific solutions to specific problems, some of them in particular states and some of them regional in application. Perhaps the most notable of these is the bill authorizing a new interstate compact for the Great Lakes - St. Lawrence River Basin (S.J.Res. 45; H.R. 6577). However, none of the legislation looks at water supply from a nationwide perspective except the Twenty-First Century Wa-

Georgia (and a number of other Eastern states) are now learning the lesson former Congressman Jay Rhodes has turned into a catchphrase for this bill: "Drought, it's not just for the West anymore."

ter Commission bill. National policy and programs emanated from the National Water Commission report in 1973. Without a national look again, it will be difficult to adjust current policies and programs to the needs of the Twenty-First Century.

I had the pleasure of working with Congressman Linder to fashion H.R. 135 and have worked with him and his office and water organizations and attorneys throughout the West and the United States since then attempting to produce a bill that could accomplish some good. We made great progress in the House during a period of time in which many of the Eastern states were in severe drought. We may have to wait for a similar unfortunate set of circumstances in order to get this commission approved by the Senate. That is unfortunate but it may be political reality. In the meantime, I will continue to do what I can to help this legislation along because I believe we will never get to a place where we can talk about outside-the-box solutions until we have a bully pulpit from which to speak. 🗣️



Legislation and Law

Laws Inconsistent in Their Support of Rainwater Harvesting

Tucson Breaks New Ground With Proposed Water Harvesting Law

Due to the complexity of water law, seemingly simple solutions often end up not being so simple after all. A case in point is rainwater harvesting, a method to concentrate and collect rain falling on house and grounds for direct use and storage. Free, literally falling from the sky, rainwater can augment domestic water supplies.

The law of gravity, however, is not the only law affecting the harvesting of rainwater. Other laws also apply. For example, laws from two different locations, one in effect in Colorado and the other proposed in Tucson, take much different approaches to rainwater harvesting, one essentially forbidding the practice and the other requiring it. Together, the two laws provide an interesting case study of different views of water harvesting.

A person wanting to harvest rainwater in Colorado faces a rather formidable barrier in state law. The doctrine of prior appropriations with its mantra of “First in time, first in right” rules and determines surface water rights. This means that senior water right holders, those who first put water to beneficial use, have priority water rights in the now overly appropriated rivers. In the event of shortages on the river, their rights are satisfied before junior water right holders.

Prior appropriation does not disallow water harvesting; nor does the Colorado state constitution which allows the right to divert the “unappropriated waters of any natural stream.” Problems arise, however, with the Colorado Supreme Court’s rather broad interpretation of the term “natural stream.” That, along with the presumption that the flow of all diffused water ends up in groundwater or streams, complicates rainwater harvesting efforts in the state. A person harvesting rainwater is, in effect, diverting water from those with more senior rights to it.

(Other states have definitions more accommodating to rainwater harvesting. Also a prior appropriations state, New Mexico, for example, considers roofs as an artificial surface while water running downstream flows on a natural surface.)

A June 6 article in the Denver Post provided a case study of the state’s regulatory approach to water harvesting. A woman living in a solar-powered home in rural Colorado makes ends meet by growing organic food for sale. She applied for a water right to collect rain running off the roof of her house and greenhouse to

water her crops. The state engineer opposed her application arguing that her roofs were “tributary” to the San Miguel River and that her water gain from roof runoff could result in a water loss to senior water right holders on the river. The state water court agreed.

She could harvest rainwater for her garden, however, if she developed an augmentation plan and provided proof to the state engineer and water court that she would release to the stream the same amount of water she captured to grow her vegetables. Further, an engineering analysis would need to be done — she would pay for it — to demonstrate that her augmentation water would be released to the river consistent with the natural cycle.

Washington state appears to have an ambivalent attitude about rainwater harvesting. Technically harvesting runoff from a roof is illegal since the collected rainfall is considered a resource of the

Graywater Plumbing to be Required in New Tucson Homes

The Tucson City Council unanimously voted that graywater plumbing will be a required feature in houses built within city limits after 2010. Per the new ordinance, builders will have to install plumbing that could be connected to a graywater system for landscape irrigation.

The ordinance only requires the installation of special plumbing in a new house to collect graywater, along with a separate set of pipes to drain water from a washing machine to landscape areas. The homeowner would then decide when and if to install a graywater-pumping system, the more expen-

sive component of the graywater unit. This would include additional pipes, underground tanks for storage and a pump.

The law pertains only to newly constructed homes. Existing houses will be affected only if an addition is constructed with a bedroom, kitchen and bathroom. Also affected would be newly constructed guesthouses on existing property.

The Southern Arizona Home Builders Association figures installing such a system will cost about \$500, although builders are allowed a \$200 tax credit for installing such a graywater component.

state and is regulated as public waters. Despite the legal restrictions, however, state officials have allowed homeowners to harvest small amounts of rainfall.

State officials are more concerned when large amounts of rainwater might be harvested, although the threshold between acceptable and illegal amounts has not been defined. This uncertainty has discouraged collection projects in the state. To reassure potential rainwater harvesters, Seattle obtained a citywide water-right permit enabling its citizens to legally collect roof runoff in most areas of the city.

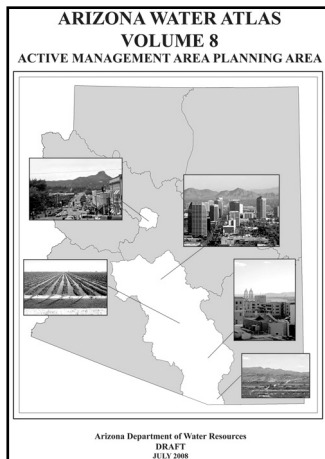
Compared to the above states, Tucson is taking a more determined approach for encouraging rainwater harvesting. Up for an Oct. 14 vote by the City Council, a proposed law would mandate water harvesting for landscaping on commercial properties including most apartment complexes. Per the proposed law, beginning June 1, 2010, when the law would go into effect, new business premises must have plans to install systems to harvest rainfall. Further, within three years of legally occupying the premises, at least 75



Publications & On-Line Resources

ADWR issues Draft Volume 8 of Arizona Water Atlas

The Arizona Department of Water Resources has completed draft Volume 8 of a nine-volume set comprising the *Arizona Water Atlas*. Volume 8 covers the five active management areas: Phoenix, Pinal, Prescott, Santa Cruz and Tucson.



For study purposes, ADWR divided Arizona into seven planning areas, with a separate Atlas volume for each of planning area, an introductory volume composed of background information and a water resource evaluation volume.

Volume 8 is the first document of a larger AMA planning effort that includes the AMA Assessment and the fourth management plan for each AMA. The assessment

will provide detailed information on each AMA and an analytical foundation for the fourth management plans.

Draft Atlas volumes 1-8 are available on the ADWR website: www.azwater.gov Containing considerable numbers of high-quality maps, the volumes are extremely large. ADWR recommends users download each item, rather than attempt to view them on line.

Department staff is seeking substantive public and professional comment on the work in progress. Comments on all draft volumes are due by Oct. 31. Staff plans to revise the *Atlas* based on comments received. An electronic comment form is available on the website.

The final volume of the *Arizona Water Atlas*, Volume 9, Arizona Water Sustainability Evaluation, will attempt to answer the public's most common question: Does my community have enough water? To answer this question Volume 9 will describe the sustainability of water supplies for planning areas, basins, and selected communities using water resources information from Volumes 2-8 of the *Arizona Water Atlas*.

For additional information, contact Sandra Fabritz-Whitney, ADWR assistant director for water management: safabritz@azwater.gov, 602-770-8589 & Statewide Conservation and Strategic Planning Division 602-771-8523

USGS Report on Groundwater Availability

Scientists proposed a strategy to study the nation's groundwater supply as part of the federal government's effort to help address the nation's increasing competition for water. The report, *Ground-Water Availability in the United States*, examines what is known about the nation's groundwater availability and outlines a strategy for future national and regional studies to provide information to help state and local agencies make informed water-availability decisions. The approach outlined in the report is designed to provide useful regional information for state and local agencies who manage groundwater resources, while providing the building blocks for a national assessment. View the report on-line at <http://pubs.usgs.gov/circ/1323/>.

Rainwater harvesting...continued from page 7

percent of the water used for landscaping must be water harvested by the system.

The proposed law has raised concerns among developers. In response to such concerns, a July 22 meeting conducted at Tucson Councilman Rodney Glassman's office provided an opportunity for developers and others with questions and concerns about the law to meet with city staff. About 60 people attended the meeting.

Concerns raised at the meeting included cost: some feared that installing a rainwater harvesting system will add significantly to the cost of a building. Aesthetics also was a concern with some questioning whether rainwater harvesting systems with cisterns and large basins could be attractively worked into a building design. Questions also were raised about having to meet the 75 percent quota of harvested water on landscaping during times of drought.

If the lively exchange did not end with the issues decidedly settled, it did demonstrate that the proposed law has attracted broad community interest.

Val Little, director of the Water Conservation Alliance of Southern Arizona (Water CASA), believes the proposed Tucson

law is taking an innovative approach to rainwater harvesting. She says, "It is setting performance-based goals by saying you will get 75 percent of your landscaping irrigation from rain. ... This is a very creative way to set up requirements because it offers landscape architects, designers and engineers the opportunity to come up with unique solutions that match the site. So you could say [the proposed law] is very forward looking and unique in the nation."

But, at the same time, Little says Tucson's action is not particularly unique in that efforts are underway all over the country to remove obstacles to the harvesting of rainfall. Tucson is taking a prominent place in that growing movement.

The state of Arizona also has a rainwater harvesting strategy, its approach differing, however, from Tucson's efforts at the local level. Rather than a legal mandate, the state relies on economic incentives, offering taxpayers a one-time tax credit of 25 percent of the cost of a rainwater or graywater system, up to \$1,000. Builders plumbing new residences to capture all graywater sources are also eligible for an income tax credit up to \$200 per residence.



Special Projects

Study Looks at Wastewater Treatment Methods of Removing Estrogen

by Susanna Eden

Celebrity projects such as the Phoenix Mars mission grab headlines. The value of small-scale research, however, should not be underestimated, such as the work of David Quanrud and his colleagues at the University of Arizona's Office of Arid Land Studies and the Department of Chemical and Environmental Engineering. They are working to identify the best methods for removing a group of new and troubling contaminants from wastewater.

There has been a great deal of interest in recent years on wastewater contamination by pharmaceuticals, personal care products, and other substances in everyday use. A major concern is the tendency of these substances to disrupt the normal activity of the endocrine system — the hormones that regulate important biological processes in organisms, including humans. Although impacts on human health are uncertain and much debated, laboratory and field studies have shown that endocrine disrupters produce birth defects and sex reversal in fish.

Very little is known about these substances — how prevalent they are in the environment; how they interact with each other and the environment; what sort of effects they may have on humans and other animals. It is widely acknowledged, however, that trace levels of these compounds are ubiquitous in municipal wastewater. The molecular diversity of these contaminants makes developing treatment technologies to eliminate them difficult.

No regulations for endocrine-disrupting compounds in wastewater exist because much is unknown about these substances. Further, measuring the trace levels of these compounds is extremely difficult and expensive. Tools and methods for precise measurement have yet to be developed. According to Quanrud, "There aren't very many commercial labs that can even measure those levels...so if you set that regulatory limit, how do you measure it?"

A number of significant studies suggest that the primary estrogens in wastewater can be efficiently removed during wastewater treatment. However, detailed relationships between estrogenic activity in effluent and treatment plant design and/or operational characteristics remain to be established. Research establishing these relationships will be useful in guiding future selection of treatment technologies and processes for control of trace organic contaminants

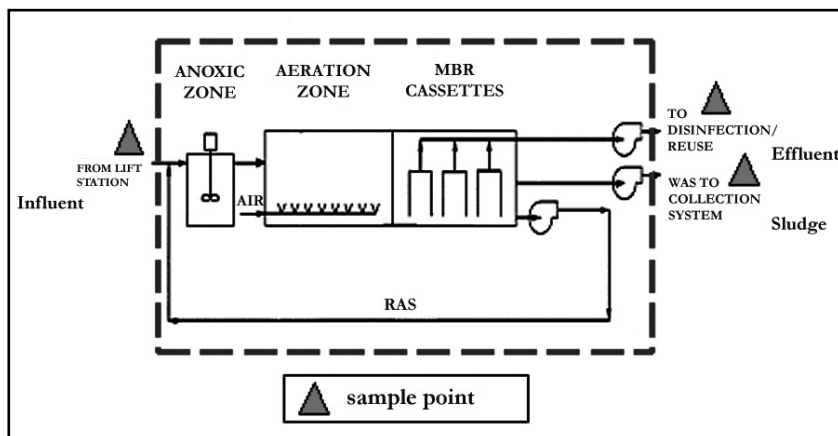


The Randolph Park Wastewater Reclamation Facility

in wastewater. Results will be particularly useful for dischargers to effluent-dependent streams such as the Santa Cruz River and situations in which a community is considering potable water reuse.

The project, recently completed by Quanrud and his colleagues, compared the

efficiency of two full-scale municipal wastewater treatment plants in the Tucson area, a membrane bioreactor at the Randolph Park



The Randolph Park Wastewater Reclamation Facility uses membrane bioreactor technology which is more efficient at removing estrogenic activity than an activated sludge plant.

Wastewater Reclamation Facility and an activated sludge treatment system at the Ina Road Water Pollution Control Facility. Membrane bioreactors represent a technological advance over more traditional forms of wastewater treatment, including activated sludge processes. Randolph Park is operated for biological control of effluent nitrogen levels through nitrification and partial denitrification using membrane bioreactor technology. The plant is designed to facilitate accumulation of biomass and increase solids retention times during biological treatment of wastewater.

Not surprisingly, removal of estrogenic activity was more efficient in the membrane bioreactor than at the activated sludge plant. In fact, the plant that best removed other undesirable components of wastewater, including biochemical oxygen demand and suspended solids, also removed more estrogenic activity. Of the estrogenic activity in the wastewater entering the plants, the amount left in the effluent was 2 percent for the membrane bioreactor and 30 percent for the activated sludge plant.

Among the advantages of the Randolph Park facility was its nitrification/de-nitrification capability. Nitrogen transformation efficiency was correlated with loss of estrogenic activity. Further investigation is needed in this area. There are plans for the Ina Road plant to be upgraded for nitrogen control in the near future, which is expected to improve its removal of estrogenic activity. This expectation will be tested in future research.

This project was supported by a Water Resources Research Act grant. The Water Resources Research Center provides small grants to investigators at all three Arizona universities for research on water and related topics through the WRRR Section 104(b) Research Grant Program. More information about the program and program-supported research in Arizona can be found on the WRRC web page. ■



Announcements



WRRC Invites Research Proposals

The University of Arizona's Water Resources Research Center is accepting proposals for research grants under the Water Resources Research Act, Section 104(b). Funded by the U.S. Geological Survey, the Section 104(b) program supports small research projects of state and regional importance. WRRC expects to fund three small grants of approximately \$10,000. Projects are funded for 12 months, with projects starting March 1, 2009, contingent on federal budget approval.

Faculty members at the three Arizona state universities may submit proposals in the social, biological, physical and engineering sciences, as well as such fields as water management, water law, economics and public health.

Research proposals are requested that explore new ideas to address water problems in Arizona and expand understanding of water and related phenomena. A primary 104(b) program goal is to foster the entry of new research scientists, engineers and technicians in the water resources field. Successful proposals will include significant student involvement.

Proposals must be submitted electronically via the National Institutes for Water Resources web site. An electronic copy and 15 hard copies must be submitted to the WRRC as well. Guidelines are available on the WRRC web site: <http://cals.arizona.edu/azwater/> Proposals are due by 5:00 p.m., November 12th, 2008.

For additional information contact Susanna Eden. 520-792-9591 Ext. 6; fax: 520-792-8518 or seden@cals.arizona.edu

Colorado River Basin Symposium,

The Colorado River Basin Science and Resource Management Symposium, scheduled Nov. 18-20 in Scottsdale, will promote the ex-

change of information on research and management activities related to the restoration/conservation of the Colorado River and its major tributaries from the headwaters to the U.S./Mexico border. Multiple programs to restore and conserve the Colorado River's native species and habitat have evolved independently, with many sharing common goals and objectives. This basin-wide symposium will provide scientists, stakeholders, land and resource managers, and decision-makers the opportunity to learn about these various programs and exchange ideas and data enhancing the effectiveness of these programs. For more information about the symposium check the Water Education Foundation website: <http://watereducation.org>.

Call for Abstracts

Call for abstracts has been issued for the 2009 Tamarisk & Russian Olive Research Conference to be conducted Feb. 18 - 19, 2009 in Reno, NV. The purpose of this conference is to bring tamarisk and Russian olive researchers together at a single venue to share their results with other

scientists and western land managers so that future management efforts can be guided by the state-of-the-science. This conference will promote dialogue between researchers and managers to identify future research needs for the development of effective policy and management decisions. Presentation

submissions are welcome from all areas of tamarisk and Russian olive biology and management. Deadline for Submission is Nov. 15; for more information about the conference and abstract submittals check www.tamarisk.colostate.edu.



Tamarisk along the Colorado River.

Seagoing Desal...continued from page 1

taking a share of its allotted Colorado River water. Desalinated water would be swapped for Colorado River water. This is a simplified version of what would be a very complicated agreement.

Water Standard, a Texas-based company, has developed the seawater desalination vessel as an alternative to land-based systems. The company is converting existing tanker vessels into desalination vessels by adapting proven processes used on military and cruise ships and installing proprietary technologies. The company says the result will be an environmentally friendly desalination process that can be designed for different capacities, to deliver from 5 to 75 million gallons of desalinated water per day.

Able to move about, the vessels will be able to seek areas of the ocean with the best quality water for desalination. Since the vessels will be processing better quality water with less suspended solids, there will be reduced pre-treatment costs associated with power, chemicals, and waste disposal. The low-velocity pumps that draw seawater through the intake water system mean less impact on sea life. Further, the passive screen on the intake will minimize entrain-

ment and entrapment.

The vessels could deliver desalinated water onshore through seabed pipelines or by employing shuttle tankers similar to those in use for bulk transport of orange juice concentrate or wine. If operating within a harbor, the vessels could pump water directly ashore.

Water Standard considers that two prime advantages of the vessels are their distance from shore — they will typically operate two to five kilometers from the coast — and their mobility. This enables the vessels to confront a range of possible future scenarios from bad weather and natural catastrophes to geopolitical and socio-economic instability. Mobility also ensures that if objections arise that the desalination operation is visually unattractive, the vessels could move over the horizon, out of sight of land.

According to Gayle Collins, Water Standard spokesperson, the company's seawater desalination vessel is a relatively new concept. She says, "There are no such vessels operating in the world right now. All eyes are kind of on us to get that first one out." ■



Public Policy Review

by Sharon Megdal

WRRC Soldiers On In Face of Bittersweet News and Budget Woes



This column is a bittersweet one. I say this because this issue of the newsletter marks the end of an era: Joe Gelt is retiring as Water Resources Research Center editor/writer after working tirelessly at the center for over 20 years. A key accomplishment during those years has been his involvement in launching this newsletter, the *Arizona Water Resource*.

The newsletter bears his personality, and its success must be attributed to him. Along with the *AWR*, Joe's other writing assignments included the *Arroyo*, WRRC's other newsletter, which Joe also helped establish, as well as the myriad reports the WRRC has submitted over the years.

I knew Joe would retire someday, and the someday is now. That's the bitter part of the news. There is, however, a positive side to sweeten and lighten bitterness. Along with Joe having more time to work on personal writing projects and to indulge in personal interests, he will continue working at WRRC part-time. Over the next several months, we'll be figuring how this will be reflected in the frequency, format and length of the newsletter. I hope to hire a part-time associate editor, but with recent and looming budget cuts, this may not be possible with existing revenue streams. Although the WRRC has done a lot with limited resources, the current budgetary realities are of sufficient concern that I feel a need to inform you, our readership, about our efforts to continue to meet your expectations and our own aspirations.

When I was preparing to become WRRC director in 2004, I convened meetings of stakeholders to ask what they liked about the WRRC and what they would like to see more of. Their most common positive comment had to do with the quality of this newsletter. Many indicated that they look forward to reading it and appreciated receiving a paper version.

The WRRC has always sought funding to cover the production costs of the newsletter, including layout. The newsletter serves an important information transfer and outreach function. Further, through this column, it enables me to communicate with readers, providing information about water policy and WRRC matters.

More recently, we've offered organizations that help pay production costs the opportunity to include an insert in the newsletter. Fortunately many have taken advantage of this opportunity over the years to work with us. We thank all of you who have done so, and I invite others to contact me about newsletter sponsorship and support.

We hope to continue our recent tradition of publishing an *Arroyo* each winter. The *Arroyo* is our single-issue newsletter, now back on track after an hiatus from 2002 until 2007. The 2007 issue focused on recharge, and the 2008 issue was on river restora-

tion. In early 2009, we plan to publish an *Arroyo* focused on water re-use. Claire Landowski, the E.L. Montgomery & Associates summer intern, continues to work with us on this upcoming issue.

As Joe and the WRRC move through this transition, we hope to maintain the quality you expect of us. Please do not hesitate to contact me with any feedback you might have and join me in wishing Joe well.

All of our publications are posted on our web site. We were able to secure grant funds through the US Geological Survey 104b program to hire a part-time applications systems analyst. John Dale joined us in August and is helping us maintain and improve our web site. (See Vapors, page 3, for more information about work on the WRRC web site.) The WRRC has administered the 104b grant program, authorized by the Water Resources Research Act, since 1964. For years now, this federal funding has been zeroed out each year. Securing continued federal funding, even for an established program such as this one, can be challenging. The funding has remained flat for many years, with the real purchasing power of the grants program diminishing over time. Nevertheless, this funding is critical to the WRRC, and I will again visit Washington this winter, along with water institute directors from other states, to request continued funding of this important national program.

Along with the water institutes in Texas and New Mexico, the WRRC is seeking federal support for the recently inaugurated U.S.-Mexico Transboundary Aquifer Assessment Program. This federally authorized program, signed by President Bush in late 2006, is carried out in partnership with the U.S. Geological Survey. Work in progress includes an inventory of investigations and reports pertaining to the Santa Cruz shared aquifer; we expect similar work on the San Pedro to follow in the very near future. The authorizing legislation allows U.S. funds to be expended in Mexico for binationally prioritized assessment studies pending a 50 percent cost share (cash or in-kind) from Mexican resources. We are actively working with stakeholders from each binational aquifer, including representatives from Sonora, Mexico and the Mexican federal government. We recently had the two Arizona aquifers accepted for case study by the UNESCO Internationally Shared Aquifer Resources Management Initiative.

Space constraints prevent me from providing more of an overview, but please visit our web site and those of our affiliated programs, such as Arizona Project WET and Arizona NEMO, to obtain more information. More than ever, partnerships are essential to fulfilling our mission of promoting an understanding of critical state and regional water management and policy issues through research, community outreach and public education. We look forward to working with you! 🏠

Solar power...continued from page 2

dry desert air could be used instead of water to cool the operation. This, however, would greatly increase building costs because enormous cooling towers would need to be constructed. Also relying on air to cool would not cool the water circulating through the plant to a low enough temperature for peak performance, decreasing the efficiency of the plant.

Woodard says hybrid cooling towers have been designed and built that are both dry and wet. In winter or in the middle of the night, with temperatures in the cool range, dry cooling is effective. When temperatures rise to a certain degree, water is then used, with devices Woodard describes as "outdoor misting systems on steroids" activated in the cooling towers.

Woodard says, "They can be operated either as dry cooling or wet cooling towers. You get a compromise. You still use some water but not nearly as much if you were always using water, and you still have to build somewhat larger and more expensive cooling towers."

Joseph Simmons, co-director of the Arizona Research Institute for Solar Energy at the University of Arizona, says that solar processes are being developed that will not use any water. One process will use hydrogen heating fluid and another will rely on hot acid. Simmons expects the former will likely be available in about a year.

In the meantime, while these innovative solar processes are being developed, Simmons says, "The work horses of the utilities

are solar thermal systems using parabolic-trough technology ... They use quite a bit of water"

Reallocating water for solar power

The Sierra Club has varied concerns about the proposed solar power plants including water use. Its primary concern, however, has more to do with location, whether, for example, a plant proposed for a particular area may pose a threat to environmental values. Sandy Bahr, spokesperson for the Sierra Club, says, "We support solar power, but it is an industrial activity and putting it next to a wilderness area just is not a good idea."

Bahr says, "Water use is one of the things to consider. If

they are proposing to place [solar power plants] on undisturbed desert lands and pump groundwater where currently no groundwater pumping is occurring, we will give it more of a critical eye."

The issue that concerns the Sierra Club is not just the amount of water a proposed plant would use but also the source of that water, whether new wells would be drilled or an existing water source reallocated to the new use. The one solar plant in Arizona the Sierra Club is supporting is the Solana plant, a 280-megawatts plant proposed for the Gila Bend area. Bahr says, "It is on private land, not public land, and

is currently agricultural land. Depending on how you calculate it [the power plant] will use 75 to 85 percent less water than the current agricultural use. It is still a fair amount of water but it is much less than it takes to grow alfalfa." 🏠



Parabolic trough power plants use a large field of parabolic trough collectors that track the sun and concentrate the solar radiation on a receiver tube located at the focus of the parabolic shaped mirrors.



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Arizona NEMO: Watershed Projects and Programs

To assure the sustainability of water resources, community character, and long-term economic health of Arizona, the Arizona Nonpoint Education for Municipal Officials (NEMO) Program supports volunteer efforts across the state to restore watershed health by reducing nonpoint source pollution. Nonpoint source water pollution results from a variety of human land uses that mobilize pollutants and impact the water quality of streams and lakes. These include increased sediment due to construction and road building, degraded stormwater runoff due to urbanization, and the introduction of fecal pathogens due to overgrazing in riparian areas. Arizona NEMO provides

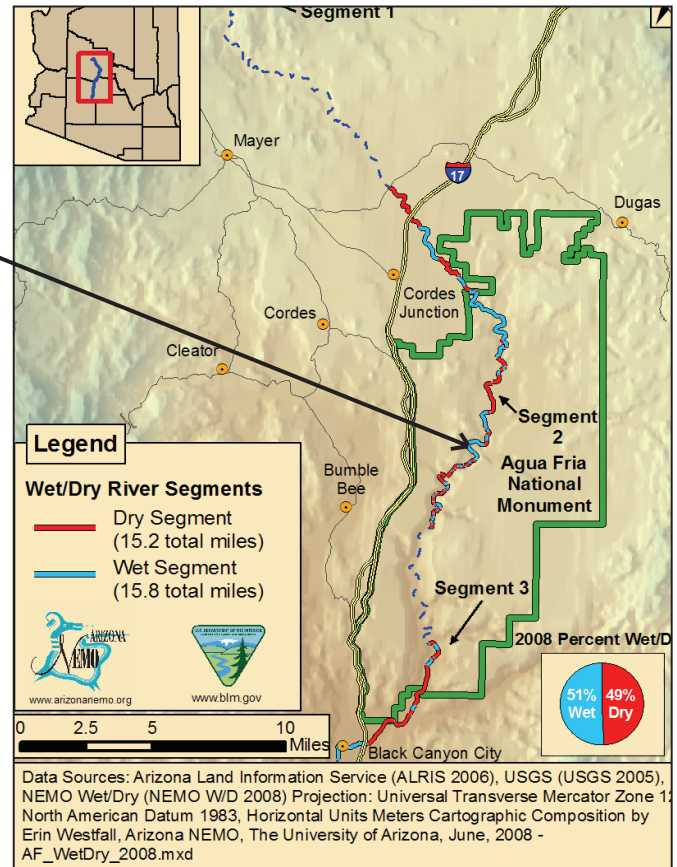
education in order to engage stakeholders and foster better land-use decisions to protect our water resources. Emphasis is on the linkages between water quality and land use, as well as water quantity and supply.

NEMO Wet/Dry Mapping

In response to community interest in developing a volunteer river monitoring program, Arizona NEMO has developed a mapping protocol and GIS data management and processing methodology to record the perennial reaches of Arizona rivers. Built on a Nature Conservancy and Bureau of Land Management volunteer monitoring program on the San Pedro Riparian



The Agua Fria River



Perennial reaches of the Agua Fria River were mapped in June of 2009

Arizona NEMO is tasked with educating land-use decision makers to make choices and take actions to lessen nonpoint source pollution and protect natural resources. A program of the University of Arizona, Cooperative Extension and housed in the Water Resources Research Center, NEMO is a non-regulatory, research-based educational program using geospatial information and other advanced technologies for outreach education, analysis, and research addressing water quality and sustainability concerns in Arizona

educational outreach to an adult audience of policy makers, planners, and land use decision makers facing water management decisions.

In partnership with and funded by the Arizona Department of Environmental Quality (ADEQ), Arizona NEMO is also supported by the University of Arizona, Technology and Research Initiative Fund (TRIF), Water Sustainability Program through the

Water Resources Research Center, and is a program of Arizona Cooperative Extension. Arizona NEMO integrates watershed management and planning with research-based, professional

National Conservation Area, this project records where water flows in the San Pedro River. NEMO formalized the volunteer monitoring program and expanded the activity across Arizona. The main objective of the monitoring program is to create a map that shows where water is present, and where it is not, in the driest time of the year immediately prior to the Monsoon rains of summer. By mapping during the 'dry' season, information as to river base-flow and the interrelationship between surface

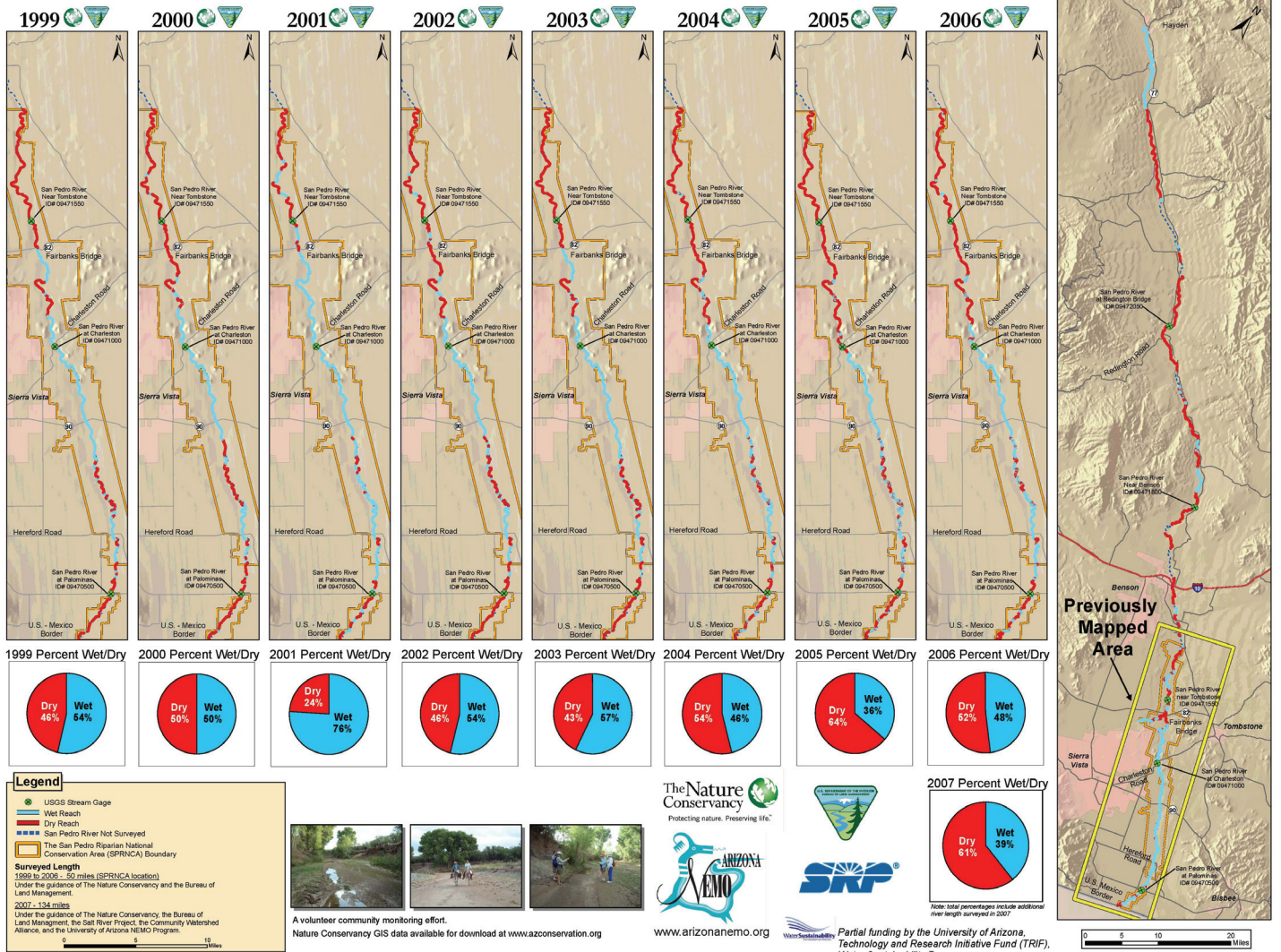
water and ground water is documented and better understood.

The goal of annual monitoring is to create a long-term record of changes in that flow; while the record of any single year is interesting it is a record for multiple years that may show what is really happening to the flow in the river. In addition, the goal of Wet/Dry is to build community participation, provide outreach education on the importance of long-term monitoring of our natural environment, and foster understanding of and responsibility for the health of Arizona watersheds. Global Positioning System (GPS) technology is used to record where

ing the June 2007 mapping effort, Arizona NEMO then initiated a mapping program on the Agua Fria River in June 2008.

The Agua Fria Wet/Dry mapping project brought together local citizens and representatives from governmental and non-profit organizations including the Bureau of Land Management, the Upper Agua Fria Watershed Partnership, Friends of the Agua Fria National Monument, the community of Arcosanti, and the Arizona Riparian Council. Roughly 24 miles of the 82 mile long Agua Fria River that flows through the rugged Agua Fria National Monument were mapped, along with various

Wet/Dry Mapping of the San Pedro River



The Nature Conservancy and the Bureau of Land Management had originally designed the volunteer monitoring program for the San Pedro Riparian National Conservation Area. Arizona NEMO is taking the program state-wide.

the water starts and stops, and Geographic Information System (GIS) technology is used to produce the final maps. Re-mapping the river each year at the same time can provide valuable data on long-term trends and changes to base flows.

After contributing to the expansion of the Wet/Dry mapping of the San Pedro River from 50 miles to a total of 134 miles dur-

reaches north and south of the Monument.

Arizona NEMO trained the volunteer groups, some walking and others on horseback, to map the Agua Fria River. Starting early in the morning to avoid the heat, 34 volunteers were provided with GPS units and data sheets to accurately record their observations. Data sheets included entries for the starting and

stopping points of the water (in the form of GPS coordinates) and whether the water was flowing or pooled. Volunteers also included observations such as the existence of fish, wildlife, illegal dumping and vehicle tracks in the river. The June mapping date was chosen to get a snapshot of the river because it is typically one of the driest days of the year, before the start of the monsoon storms. Any water in the river at that time is unlikely to be the result of a rain event but rather part of the perennial flows.

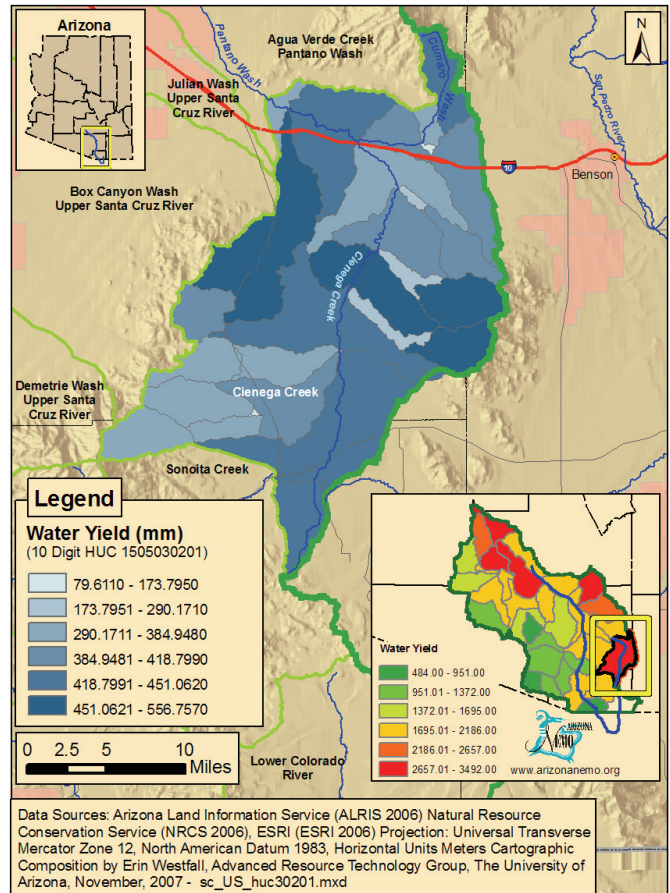
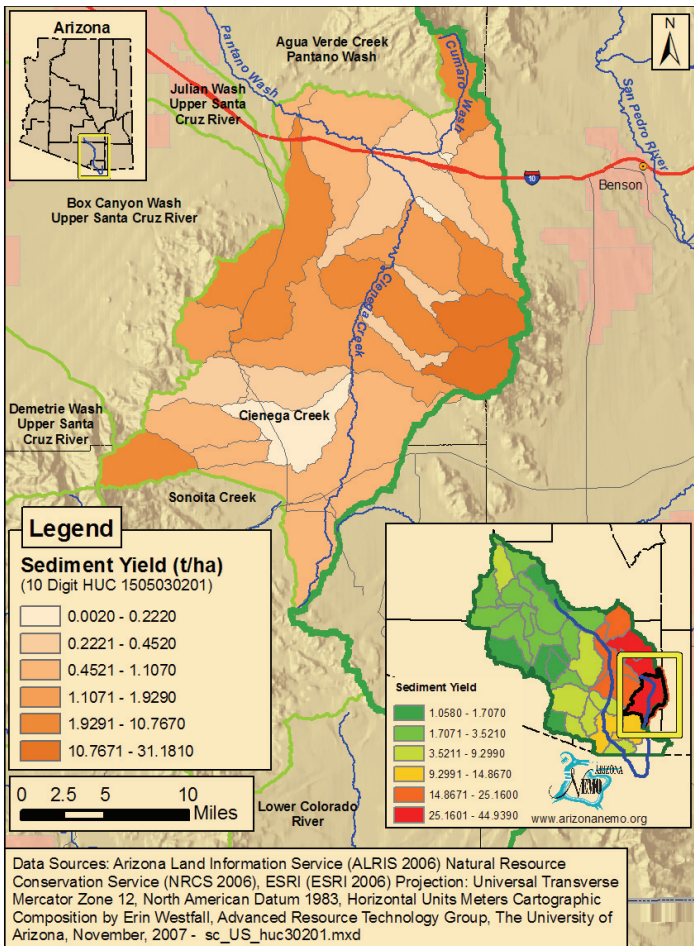
NEMO Watershed Modeling

For each watershed across the state, the NEMO program has simulated watershed response to rainfall in a series of numerical models. Model results are reported in a Watershed-Based Plan identifying locations susceptible to nonpoint source pollution. The Plans also advocate land management practices designed to protect, restore, and manage the watershed.

The models compute runoff and erosion for each watershed, and are able to address varying soils, land use, and management conditions. GIS provides the framework within which spatially-

distributed data are collected and used to prepare model input files and evaluate model results. GIS-based tools, such as the Automated Geospatial Watershed Assessment – Soil and Water Assessment Tool (AGWA – SWAT), are used to illustrate the effects of land use practices on runoff and erosion, and to support watershed-wide land use management decisions.

The USDA-ARS Southwest Watershed Research Center and



Nonpoint source pollutant transport by overland flow is simulated here in the Santa Cruz River Watershed south of Tucson. Pathogens and nutrients originating from grazing or agricultural practices may be transported to the water body by overland flow.

the UA Advanced Resource Technology Group (ART), in cooperation with the US EPA Office of Research and Development, have developed AGWA to facilitate simulation of the impact of land management practices on water and sediment yields on a watershed scale. AGWA-SWAT is a component of the AGWA tool-box of hydrologic simulation. Based in Tucson, the Southwest Watershed Research Center conducts research with a focus on the unique hydrology of our semi-arid climate and topography. In developing AGWA, research was supported by field experiment at the USDA Walnut Gulch Experimental Watershed, near Tombstone, Arizona (<http://www.epa.gov/esd/land-sci/agwa/>).

A program within the School of Natural Resources, ART provides leadership in such areas as GIS environmental database design and development, application of cartographic and

Excessive sediment is a principal nonpoint source pollutant in 28 percent of the 409 stream miles classified as impaired by ADEQ in 2006. GIS AGWA modeling identifies where in the Santa Cruz River watershed nonpoint source pollutants may be originating and if transport to the water body is by sediment.

spatial analysis, as well as AGWA modeling support. The ART Group provides the primary focus for research and extension in cartographic and spatial analysis for the College of Agriculture and Life Sciences at the University of Arizona.

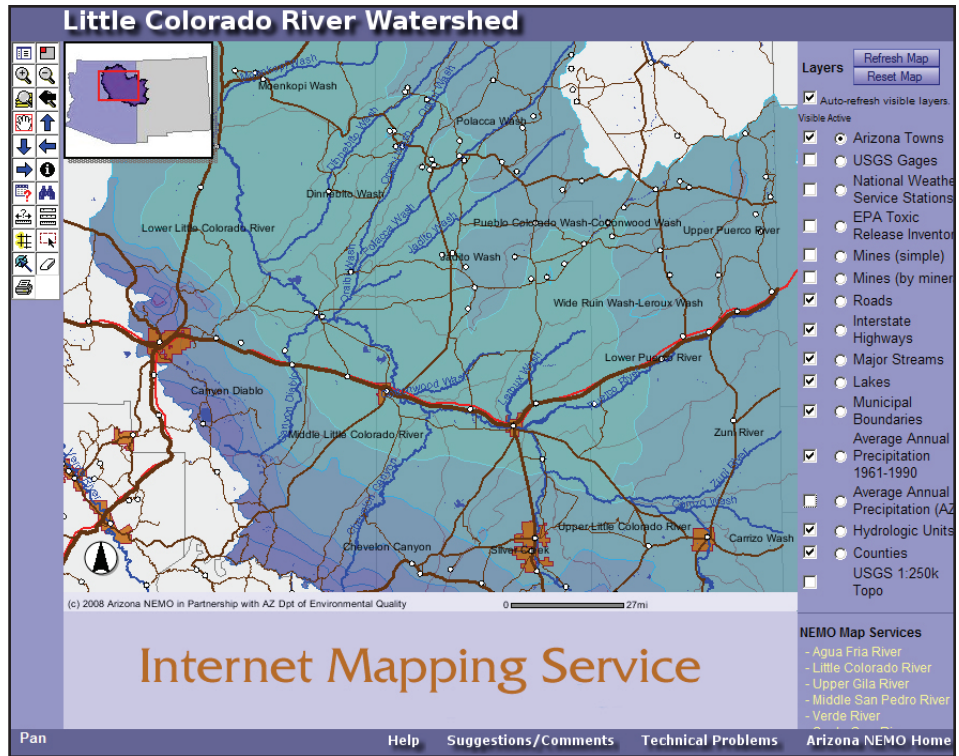
The NEMO Watershed-Based plans include watershed characterization in addition to the AGWA-SWAT modeling results. Characterization includes physical, biological, and social/economic data in a GIS database format, as both mapped and tabulated data. The characterizations represent an inventory of natural resources and environmental conditions that affect primarily surface water quality. In addition, the characterizations provide mapping and educational outreach material to stakeholders and watershed partnerships.

The NEMO Watershed-Based Plans follow guidance based on EPA's 2003 Guideline for the award of Section 319 Nonpoint Source Grants. The United States Congress amended the Clean Water Act (CWA) in 1987 to establish the Section 319 Nonpoint Source Management Program because it recognized the need for greater federal leadership to help focus State and local nonpoint source efforts.

Under Section 319 of the CWA, states, territories, and Indian tribes receive grant money which supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. Consistency of the NEMO plans with the key elements of the EPA Guidelines allows ADEQ to prioritize funding to stakeholders and watershed partnerships implementing projects across the state.

NEMO IMS Mapping

As part of the effort to empower rural communities and local watershed partnerships in their grant-writing efforts and overall watershed management activities, Arizona NEMO incorporated an Internet Mapping Service (IMS) in the tool box of land-use planning resources. Watershed stakeholders and community members are being taught how to access the NEMO web page to locate features in their watershed and customize their map at the scale defined by the map-



Screen shot of the www.arizonanemo.org web page Internet Mapping Service showing mapping tools for the Little Colorado River watershed.

maker. Included in the map coverage are the USGS topographical maps and live-links to USGS gaging stations with stream gage data. Hikers learn how to design and print maps featuring their next hikes—maps that show geology, vegetation types, and soils. Maps that show precipitation, average annual temperature, or stream water quality can be created and printed on home or office computers. Grant writers learn to create maps to attach to their next grant applications.

Nonpoint Education for Municipal Officials: NEMO



Avanyu, the NEMO Logo

Kristine Uhlman, R.G., NEMO Program Coordinator and Area Extension Agent
D. Phillip Guertin, Ph.D., Chair Watershed Management and EcoHydrology Program
Channah Rock, Ph.D., Water Quality Extension Specialist Soil, Water, and Environmental Science Department
Erin Westfall, GIS Analyst
Terry Sprouse, Ph.D., Senior Research Specialists

The University of Arizona
 School of Renewable Natural Resources
 College of Agriculture and Life Science

Found in the spiritual mythology of the ancient Zuni, Hopi and Pueblo cultures, Avanyu is the name for the water serpent, "one who lives in the water below the earth, and one who carries us through the water of change."

Avanyu is a mythical sea-serpent, the guardian of the mountain springs across the Pueblo cultures of the American Southwest. The Avanyu petroglyph was created long before Europeans set foot on this continent, and is believed to date back to the Anazazi, the "Ancient Ones." According to tribal wisdom, those who poison the water must face Avanyu's fiery revenge.