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Reclamation Completes Successful Pilot Run of the Yuma Desalting Plant

by Jennifer McCloskey, U.S. Bureau of Reclamation Yuma Area Office Manager

From May 2010 to March 2011, Reclamation conducted a pilot run of the Yuma Desalting Plant (YDP) and demonstrated its potential to augment lower Colorado River supplies. Over 30,000 acre-feet of irrigation return flow was recycled preserving a like amount of Colorado River water in Lake Mead, approximately the amount of water used by 116,000 people in a year.

The YDP pilot run was accident free for the entire 328 days of

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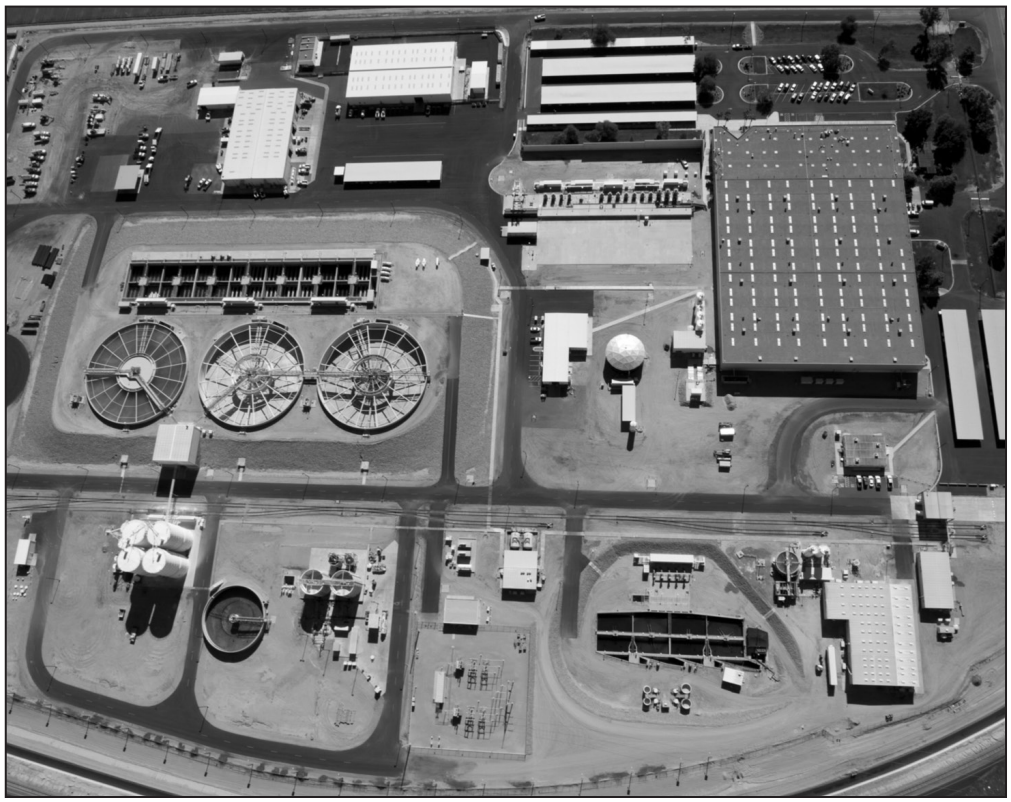

Aerial view of Yuma Desalting Plant in operation during Pilot Run. Photo: U.S. Bureau of Reclamation.

Conference Highlights: The Role of Desalination in Water Supply

Michael Gabaldon Technical Resources Director for the U.S. Bureau of Reclamation (Reclamation) started the conference off strong by describing how Reclamation is involved in water issues from storage to transfer, conservation, and technology. Lorri Gray-Lee, Reclamation's Lower Colorado Regional Director, pointed out the effects of our prolonged drought in Arizona. Since 2000, the Colorado River basin reservoirs have dropped from nearly full to 53 percent of total storage. In April, Lake Mead stood at 43 percent of capacity and was lower than it has been since the 1930s. Projections show that if drought conditions persist, the Lower Basin may be subject to the first ever domestic shortage declaration on the Colorado River as early as 2015.

According to Gray-Lee, there are several potential methods for extending water supplies, including conservation, advanced irrigation techniques, increased storage, imports, water recycling, vegetation management, pricing, alternative landscaping, canal lining, basin study and, of course, desalination. Water supply diversification will be key in the upcoming years.

Shivaji Deshmukh of West Basin Municipal Water District in California encouraged conference participants to think of water supply like a financial investment portfolio. An investment portfolio should maintain a good mix of stocks, bonds, and cash in order to remain stable through time. Similarly, water supply portfolios must contain a mix of the methods mentioned above. In the West Basin, 100 percent of water supply was groundwater in 1947. By 1990, 79 percent of the water supply was imported water. By 2008, it was a mix of imported water

"The last 11 years have been the driest in a century of recorded history."

- Lorri Gray-Lee, Bureau of Reclamation

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SPECIAL DESALINATION CONFERENCE ISSUE

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continuous operation, and came in under budget and ahead of schedule. The dedication and hard work of Reclamation's Yuma Area Office staff contributed to this success. Preparation for the pilot run spanned nearly two years and included a number of one-time plant retrofit projects, environmental compliance and permitting obligations, and development of risk management and safety protocol procedures. In operating the plant over the past year, Reclamation's Yuma Area Office demonstrated the plant's effectiveness and performance capabilities – with the facility performing beyond design expectations, while using over twenty-year-old reverse osmosis membranes.

So what happens next? The plant is being returned to maintenance status. Reclamation conducted the pilot run to gather cost and performance data needed to consider potential future YDP operation. Results from the pilot run will be reviewed for use in future decision making.

The Metropolitan Water District of Southern California, Central Arizona Water Conservation District and Southern Nevada Water Authority are the sponsoring water agencies that funded the pilot run operations. Each agency will receive water credits in proportion to the water produced during the pilot run and each of their funding contributions.

Consultations with Mexico, facilitated through the International Boundary and Water Commission, resulted in an agreement of joint cooperative actions and Minute No. 316 to the 1944 Water Treaty. One of the actions included providing 30,000 acre-feet of water to the Ciénega de Santa Clara, an important wetlands in Mexico. The agreement calls for a coalition of non-governmental organizations, Mexico and the United States each to contribute 10,000 acre-feet, and this effort remains underway. Also an ongoing monitoring program for the Ciénega de Santa Clara is being coordinated through the University of Arizona and funded by the same water agencies that funded pilot run operations.

Solids Contact Reactor in operation during Pilot Run. Photo: U.S. Bureau of Reclamation.

In the world of desalination, and in this time of prolonged drought, the pilot run's success is unprecedented. Through collaboration and continuous commitment to a common goal, many people from various agencies who are concerned about sustaining water supplies in the desert southwest illustrated what happens when we work together.

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(65 percent), groundwater (21 percent), water recycling (7 percent), and conservation (7 percent). In 2020, the portfolio goal is to expand water recycling to 22 percent, conservation to 14 percent, and add ocean desalination to cover 10 percent, leaving only 33 percent of the water supply to be imported. Halla Razak of San Diego County Water Authority also shared a 2020 plan, which includes 10 percent seawater desalination along with recycled water, local surface water, groundwater, transfers and purchases, and conservation.

"Desalination is a local emergency drought-proofing method," said John Balliew, Vice President of El Paso Water Utilities. Drought-proofing is described as having enough available water supply to meet demand during a drought. He described how they were facing an emergency water situation leading up to 2004, after 10 years of drought in the Rio Grande Basin. An accelerated program for wellhead desalination was implemented in 2002 in order to make up for the 8 MGD (million gallons per day) deficit. This was successful, however they are now facing an increase in demand as the Fort Bliss military base looks at expansion, and the population is growing. To be drought-proof, El Paso needs 20 MGD additional water and they believe desalination is the solution. San Diego County Water Authority also describes desalination as their drought-proofing method of choice because it is cost-competitive with other new water supplies and reduces reliance on increasingly constrained imported water supplies.

Jennifer McCloskey, the Yuma Area Manager for Reclamation, reported that the Yuma Desalting Plant's pilot run (running at 30 percent of total capacity) resulted in an estimated 30,496 acre feet added to the Lower Colorado River supply, so important to the Southwest.

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Editor: Susanna Eden
Designer: Lisa Watanabe
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WRRC Website: http://cals.arizona.edu/azwater
WRRC Director: Dr. Sharon Megdal

Arizona Water Resource
Water Resources Research Center
College of Agriculture and Life Sciences
The University of Arizona

350 North Campbell Avenue
Tucson, Arizona 85719 USA

WRRC is a Water Sustainability Program Center

520.621.9591 FAX: 520.792.8518 EMAIL: WRRC@CALS.ARIZONA.EDU

Desalination Opportunities Lead to Binational Cooperation

International Boundary and Water Commission (IBWC) Commissioners Roberto Salmón Castillo (Mexico) and Edward Drusina (U.S.) commemorate signing of Minute 318 to the 1944 treaty dealing with the Colorado River, a result of the on-going dialogue referred to often during the conference in Yuma. Photo: U.S. Bureau of Reclamation

Water does not recognize political boundaries. Therefore, the development of binational partnerships is very important when water resources are shared between countries. Adriana Rodriguez, Project Manager and representative of CONAGUA, the Mexican national water agency, presented an in-depth look at water issues between the United States and Mexico.

The International Treaty of 1944 requires that the United States deliver 1.5 million acre-feet (1850 cubic meters) of Colorado River water to Mexico annually. When there is a surplus on the Colorado River, the U.S. is obligated to deliver additional water to Mexico, up to a total of 1.7 million acre-feet (2097 million cubic meters) per year. In the early 1960s, the Wellton-Mohawk Irrigation and Drainage District (WMIDD) began draining its excess, highly saline groundwater into the Gila River, which in turn carried it into the Colorado. The filling of Lake Powell behind Glen Canyon dam lowered the flows of the Colorado River and reduced the amount of water available for diluting WMIDD's drainage. These two alterations led to a sharp decrease in the quality of the water sent to Mexico, leading the Mexican government to formally complain to the United States that the highly saline water violated the terms of the 1944 Treaty.

In 1973, the two governments reached an agreement, codified as Minute 242 of the International Boundary and Water Commission (IBWC), to resolve these water quality issues. This agreement successfully resolved the transboundary water quality issues for many years. However, of the baseline 1.5 million acre-feet of Mexico's allotment, 140,000 acre-feet (172.7 million cubic meters) of high salinity water was delivered at the Southerly International Boundary (SIB) through the Sanchez Mejorada Canal to water users in Mexico. In late 1995, the Mexican government again complained, taking issue with the variability of flows and with the quality of water sent through the SIB. As a result, a Binational Technical Group was formed in 1997 to ensure that the water Mexico receives is of usable quality.

In 2002, the U.S. installed several devices at the facilities at SIB for better regulation of the water delivered to Mexico. The U.S. also began construction of an interconnecting channel to divert water from Yuma's agricultural drainage to the Wellton-Mohawk Drain during the critical months of October to January, as well as a system to dilute the drainage with well water to maintain moderate salinity levels. This project was completed in 2007; however, Mexico would like to see additional improvements to regulate salinity at an even lower level in order to increase its utility.

Enter desalinization. Though the Yuma Desalting Plant (YDP) was completed in 1992, a flood on the Gila River in 1993 damaged the intake canal that brought feed water to the plant. Since that time the Bureau of Reclamation has maintained the YDP in a state of "ready reserve," while high flows of the Colorado have made its operation unnecessary. Now, with recent lower levels and population growth causing increasing pressure on existing water supplies, the YDP is being looked to again as a way to incorporate the WMIDD drainage as part of the United State's allotment to Mexico. Additionally, in recognition of increasing stress on water resources and uncertainty due to climate change, a group was formed in 2008 within the IBWC to discuss cooperative problem solving in order to effectively manage the shared watershed. In addition to this core group, four working groups were formed to focus on specific issues. One such objective included the identification of sites where binational desalination plants might be constructed at Rosarito and Puerto Peñasco in Mexico.

Mexico is not new to desalination, and continues to build facilities at a high rate. In 2002, there were 171 desalination plants in Mexico and by 2006 there were 435 registered desalination plants. In a potential binational desalination plant agreement, the clean water produced would be shared between the two countries. Two such agreements have been considered: an Arizona-initiated plant in Puerto Peñasco and a California-initiated plant in Rosarito. For the latter, the San Diego Water Authority has financed a feasibility study and preliminary design plan. The first stage of the feasibility study shows the project to be both economical and viable. Now the San Diego Water Authority is in the process of seeking additional funding for the second stage of the feasibility study, which will look more closely at plant operations and agreements for running it. Halla Razak, Director of Colorado River Programs for the San Diego County Water Authority cautioned that after these studies are complete and the project moves forward, there will be a lengthy and complicated permitting process in order to meet both U.S.-Californian and Mexican regulations. Guy Carpenter of Carollo Engineers described similar positive results of a feasibility study he led on the site at Puerto Peñasco.

Construction of binational desalination plants could help supply both the U.S. and Mexico with potable water. Moreover, such cooperative development would ensure that the highly saline concentrate will not negatively affect either country. If successful, the National Water Commission of Mexico hopes that this collaboration will be used globally as an example for other binational integrated water management partnerships.

Public-Private Partnerships Recommended for Desalination Financing

One of the major factors in considering desalination technology is cost: the cost of building the plant, the cost of running the plant, and the cost of the water produced by the plant. The owners of the plant want production costs to be lower than the income produced, so that they can continue to operate. Municipalities want the cost of desalinated water to be less than other forms of water acquisition in order to resell it to the user. Users also want the final product to be as inexpensive as possible.

One way to reduce costs may be to combine the advantages of the public and private sectors in public-private partnerships (PPP) to build and operate desalination plants. Michael Irlbeck of Befesa Water explained PPP simply as "private financing of public infrastructure." In more depth, a PPP is "a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. In addition to sharing resources, each party also shares the risks and potential rewards."

The State of Israel's three major plants (Ashkelon, Palmachim, and Hadera) cost $30 million, $8 million, and $85 million, respectively. The State of Israel currently charges between $0.52 and $0.70 per cubic meter (cubic meter = 264.2 gallons) of desalinated water (taxes not included). Some plants operate on a BOT (Build, Operate, Transfer) tender where the State owns the land, but the plant is run by a private company. Other plants use a BOO (Build, Operate, Own) structure where the entire operation is privately owned, but the final desalinated water goes to the Israeli government.

The cost of the Yuma Desalting Plant (YDP) pilot run was approximately $23.2 million ($6.6 million for preparation and $16.6 million for operations and maintenance). The YDP is a project of the United States Bureau of Reclamation, but required cost-sharing. Of the $23.2 million project, $14 million was contributed by the Central Arizona Project, Salt River Project and Metropolitan Water District of Southern California. The backers received proportional shares of the desalinated water.

For El Paso Water Utilities, desalination is not the cheapest option, but it does provide needed supplemental water supply. Among the types of water utilized by El Paso, imported water is the most expensive at about $1400 per acre-foot and groundwater is the least expensive at about $164 per acre-foot. Desalination is in the middle at approximately $419 per acre-foot. The plant originally cost about $91 million and the proposed shift to solar power would push it over the $100 million mark but presumably reduce long-term operating costs. The plant is a joint venture of El Paso Water Utilities and the U.S. Army's Fort Bliss.

Several desalination facilities are being proposed in California. The Camp Pendleton project, on the U.S. Marine Corps base, is undergoing additional feasibility studies and expects that ocean intake and discharge facilities will account for up to 15 percent of the final project cost. After passing its first feasibility investigation, the concept of a desalination plant at Rosarito Beach in Mexico is being evaluated as part of a binational feasibility and design study funded by Central Arizona Water Conservation District, Metropolitan Water District, San Diego County Water Authority, Southern Nevada Water Authority, and the Republic of Mexico. Additional funding of $600,000 is still being negotiated for the second phase of the study. The country of Australia is also conducting a feasibility study of a new plant in conjunction with a Coal Seam Gas project.

Conference participants enjoyed a morning tour along the Yuma East Wetlands Restoration Area, stopping at the Herb Guenther Scenic Overlook. Sid Wilson, former General Manager of the Central Arizona Project took the opportunity to telephone Herb Guenther, former Director of the Arizona Department of Water Resources, to congratulate him on the overlook named for him. Photo: Stephan Przybylowicz, WRRC Graduate Assistant Outreach.

West Basin Municipal District in California estimates desalination costs of $1273 per acre-foot for brackish water and $1700 per acre-foot for seawater. CH2M Hill estimates desalination operation and maintenance costs at around $488-$977 per acre-foot for brackish reverse osmosis and $977-$2688 per acre-foot for seawater reverse osmosis.

As technology has improved over time, the total cost of desalination has decreased. The cost of RO membranes, for instance, has been steadily declining. A membrane element in 1978 cost $950 or $6.33 per square foot, while in 2006 this cost went down to $550 or $1.38 per square foot.

This trend is likely to continue, but the cost of membranes now make up a relatively small portion of desalination's total cost. More cost savings are likely to come by discovering and commercializing technologies relating to energy use and management of the saline

waste water. For example, researchers at the University of Arizona are evaluating halophyte (plants that thrive in salty water) farming as a viable disposal method for the concentrate from large scale reverse osmosis water treatment facilities. This would not only reduce disposal costs, but also potentially improve the environment.

Because desalination is very costly, even with technological improvements, it becomes important to identify stakeholders early and work together to find funding solutions to avoid potential water shortages. Public-private partnerships and other cost-sharing methods help get results through sharing capabilities, risks, and rewards.

Education & Outreach Are Vital Parts of Desalination Projects

Drought in the western U.S. has raised public awareness and concern. Shivaji Deshmukh from the West Basin Municipal Water District shared the results of a survey given to the customers in the district in 2008 and repeated in 2009. In the 2008 survey, water ranked dead last on the list of important issues, but by 2009 water had rocketed up to 2nd place, led only by the economy. In addition, ocean-water desalination made the top three ways the public would like California to move in the future, along with voluntary conservation and water recycling.

Promising so much good, proposed desalination plants would seem to have no opponents; but that is not the case. There are economic and environmental concerns to be addressed, and in many instances a lack of knowledge on the part of the public can interfere with a balanced appraisal of the pros and cons.

Water education and outreach on desalination and its role in water supply and conservation are arguably the most important factors in changing the knowledge base of the general public.

Several conference speakers raised the issue of education and outreach in their presentations. Desalination proponents can look to organizations and agencies already integrating outreach and education into their programs. Environmentalists have been doing this work successfully for some time. In his conference presentation, "Environmental Monitoring of the Ciénega de Santa Clara," Karl Flessa showed several examples of bilingual signage in different areas of the Ciénega where the public passes. These signs give information about the body of water, its connections to the surrounding community, and information regarding endangered species habitats that it contains. The signs then go even further in providing guidelines about how visitors should behave in terms of fishing practices, camping rules, and trash removal in order to keep the area safe for wildlife.

Similar programs provide education to visitors to Sweetwater Wetlands in Tucson, Arizona. The Sweetwater Wetlands is a water treatment facility, an urban wildlife habitat, and an outdoor classroom. As a water treatment facility, the wetland filters and transforms pollutants; then the treated water flows into recharge basins for later use in the reclaimed water system. As an urban wildlife habitat, this water-rich streamside riparian zone supports a huge variety of wildlife including dragonflies, raccoons, hawks, bobcats and dozens of other species. As an outdoor classroom, the Sweetwater Wetlands provides an environmental, educational experience in natural settings for teaching about ecology and water resource management.

Deshmukh wants to take this concept and apply it alongside desalination plants. The blueprint for their proposed full-scale desalination facility includes a large education building that will provide information for visitors about the desalination process and benefits to wildlife and the community.

While this passive education influences the people who take the time to read signs, others may only be reachable by active teaching. Abraham Tenne, who

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AZ Legislature Authorizes Salinity Study

The Arizona State Legislature's House Bill 2593 was signed on April 19, 2011. This bill establishes a joint legislative study committee on water salinity issues. The committee will examine the relationship between salinity and its various effects. Salinity can affect water conservation in multiple ways, as well as wastewater reclamation and groundwater quality, and these are topics the study will address. The study will also examine how salinity affects the uses of water and reclaimed water, such as on golf courses, with an eye toward the potential effects on tourism. The study will be taking a special look at water softeners and their high usage in Arizona. The financial impacts, including the potential costs for water and wastewater treatment that address salinity will also be examined. The committee is tasked to report its findings, including recommendations on any further action, to the governor, the president of the senate and the speaker of the House of Representatives no later than December 31, 2011.

The Water Resources Research Center's 2011 Annual Conference Salinity and Desalination in the Southwest: Challenges and Solutions, was the product of collaboration between the WRRC and the U.S. Bureau of Reclamation, particularly with the Yuma Area Office. The success of the conference would not have been possible without them and the support of our sponsors: Befesa which sponsored the reception; Carollo Engineers, which sponsored the ice cream break; and APS, BKW Farms, CAP, CH2MHill, Montgomery & Associates, SAWUA, SRP, USGS, Arizona Cooperative Extension, The University of Arizona College of Agriculture & Life Sciences, and WSP.

Announcements

AHS September Symposium

The Arizona Hydrological Society will hold its annual symposium in Flagstaff on September 18-20, 2011. The symposium theme this year is "Watersheds Near and Far: Response to Changes in Climate and Landscape" and will be a collaboration of watershed scientists (near!), planetary hydrologists (far!) and many others. Symposium highlights include a field trip to the Schultz fire and flood areas hosted by representatives from the Forest Service and Arizona Geological Survey and a workshop presented by Dr. Dennis Helsel on Making Sense of Nondetects in Analytical Data. For more information and registration: http://www.azhydrosoc.org/2011_symposium.html

UA Student Wins Schusterman Israel Scholars Award

The WRRC would like to congratulate Marissa Isaak, a graduate research assistant at the WRRC and a PhD candidate in the School of Geography and Development, for winning the prestigious Schusterman Israel Scholars Award, for her dissertation work on desalination in Israel. The $15,000 award by the American-Israeli Cooperative Enterprise (AICE) is highly competitive and her selection speaks to the timeliness of her topic. The funds will allow Marissa to travel to Israel this summer and support her research for the next academic year. The grant is renewable for up to three years.

Conference Poster winners accept maps. Photo: Stephan Pryzbylowicz, WRRC Graduate Assistant Outreach.

Best Desalination Conference Poster Presenters Win Arizona Water Maps

Desalination was the topic of the WRRC's 2011 Annual Conference, "Salinity and Desalination in the Southwest: Challenges and Solutions," which featured a poster session and reception. Posters presented at the session received prizes in three categories: presentation of research, ability to communicate and overall quality. Brian Moravec, a UA graduate student in the department of Chemical and Environmental Engineering won the best overall quality prize for his poster, "Solar Membrane Distillation." This poster discussed the development of a desalination prevaporation reactor designed as the core unit in a solar-driven, membrane distillation process. The concept is being developed for use at remote locations and will be piloted on the Navajo Reservation. The students from Jisan Research Institute in Alhambra, California, were awarded the prize for the best presentation of research for their

Kerry Schwartz, Arizona Project WET Director, explains the APW School Water Audit Program Poster at the Conference Poster Session. APW also conducted a workshop for 19 Yuma area teachers on the second day of the Conference, where they learned the basic issues surrounding desalination. These 19 teachers shared their new knowledge to more than 2,600 K-12 students.

poster, "Desalination Powered by Entropy." Their faculty advisor and mentor, Dr. Sanza Kazadi, said that his students at this unique research program for high school students have produced research on a par with work done at universities. As proof, he reported that he and his students have published over 50 papers, collectively. Jamie McEvoy, a UA graduate student in the School of Geography and Development, took the prize for best ability to communicate for her poster, "Desalination and Development: The Technological Transformation of the Gulf of California." Her research is examining the potential for social impacts in vulnerable communities due to desalination in Baja California using semi-structured interviews, focus groups, household surveys, and a time-series analysis of secondary data. The prizes, newly updated Arizona Water Map posters, were presented at the Conference dinner on April 26, 2011.

WRRC Names New Montgomery & Associates Writing Intern

The WRRC is pleased to announce the addition of Josue Sanchez Esqueda as our summer intern selected this year from an outstanding group of applicants. Created to provide opportunities for writing about environmental and water issues, the internship is open to students from all three of Arizona's state universities. Josue is a student in the department of Soil, Water, and Environmental Science at the University of Arizona and he looks forward to sharpening his writing skills and increasing his understanding of complex water issues. The internship is supported by Montgomery & Associates, an Arizona-based consulting firm specializing in hydrology and water resource issues. The Montgomery & Associates Intern contributes to research and writing for the Arroyo, the annual WRRC publication that focuses on a critical Arizona water issue. The upcoming Arroyo, to be published in the spring of 2012, will cover Arizona – Mexico border water issues. Born and reared in Hermosillo, Sonora, Josue will be able to approach these issues from experience on both sides of the border.

Education & Outreach... continued from page 5

leads the desalination efforts of the Israel Water Authority, discussed how Israel is taking water education to the next level by incorporating water into elementary and high school programs of study. Conferences and lectures about water are encouraged in schools and scholarship programs are available for students pursuing water studies in higher education. Their desalination plants also include water research and studies centers. The Water Quality Improvement Center located at the Yuma Desalting Plant is a similar center. In addition, professional technicians and engineers at Israeli facilities are encouraged to take continuing education programs in water technologies. This hands-on approach to water education, which starts with very young children, has been called the key ingredient in water sustainability for the future.

In the United States, the "No Child Left Inside" legislation (still pending in Congress) gives each state the opportunity to develop an Environmental Literacy Plan. The Arizona plan is being led by the Arizona Association for Environmental Education (http://www.arizonaee.org/) and the California plan has already been implemented by the Association for Environmental and Outdoor Education (http://aeoe.org/). Planned water education would not only highlight the importance of water, but also expose young people to water-related technologies, such as desalination, so that they may become the future innovators of the field.

UA Salinity Research Is Wide and Varied

Researchers at the University of Arizona are tackling the problems associated with salinity and desalination from various perspectives. From small to large, projects range from investigating point-of-use technologies to examining desalination's social impact at a regional scale. Across the university, such research is providing information to improve efficiency, decrease waste, understand social impacts, develop useful technologies and protect the environment. A few of the projects and programs currently active at UA show the range and depth of on-going research.

The Inland Salinity Management Research Program

A research consortium consisting of University of Arizona researchers, the U.S. Bureau of Reclamation (Reclamation) and the Northwest Water Partners (NWWP) has conducted research over the past six years at a regional pilot-scale desalination facility known as the Tangerine Road Field Site, north of Tucson. The challenge has been to manage the salt load coming into the Tucson basin from the Colorado River via the Central Arizona Project (CAP). CAP water has a higher concentration of total dissolved solids (TDS) in the range of 700 - 800 mg/l compared to EPA's Secondary (non-enforceable) Standard advising a maximum contaminant level (MCL) of 500 mg/l for TDS. Research is ongoing to improve the efficiency, water recovery and cost-effectiveness of using reverse osmosis (RO) to reduce the salinity for potable use. The researchers also are looking for economically feasible and safe ways to dispose of the RO concentrate and residuals at the end of the process. This has involved testing new technologies to pretreat water and improve membrane performance, and investingating methods for post-treatment of the saline concentrate stream.

Additional efforts are aimed at finding commercial uses for the byproducts of RO waste. The concentrate or brine has been used in trials to test different irrigation regimes on varieties of salt tolerant plants called halophytes that have potential to be used as a feed source for cattle. The concentrate is also being used to raise tilapia in tanks.

Water Quality Improvement Research

Concurrent with the Yuma Desalting Plant pilot run, Reclamation and partnering agencies including University of Arizona researchers are conducting a comprehensive research project at Reclamation's Water Quality Improvement Center to evaluate alternative pretreatment technologies and reverse osmosis membranes for potential plant upgrades. The research uses both water from the Wellton-Mohawk drainage diversion and the Yuma Mesa Conduit, which collects groundwater-derived agricultural drainage.

The Water Quality Improvement Center at the Yuma Desalting Plant houses research on desalination technology. Photo: U.S. Bureau of Reclamation.

Research Projects in the Ciénega de Santa Clara

The Ciénega de Santa Clara (Ciénega) is the largest wetland in the Colorado River Delta and is maintained mainly by agricultural runoff from the Wellton-Mohawk Irrigation and Drainage District in Arizona. The Ciénega provides critical habitat for the Yuma Clapper Rail, an endangered species in the U.S, and 28 migrating and shore bird species. Monitoring studies were conducted in order to predict how water quality, in particular salinity, affects the density and distribution of marsh vegetation. Critical bird habitat could be affected if the Yuma Desalting Plant (YDP) is re-started. Baseline water quality data were collected prior to and during the YDP test run to evaluate the possible effects of re-starting the YDP. Other studies include: remote imaging techniques to map vegetation dynamics in the Ciénega; effects of the El Mayor Cucapah, April 4th 2010, earthquake and water management decisions on the Colorado River Delta tidal inundation patterns — implications for shorebird habitat; and salinity tolerance and productivity of *T. domingensis, S. americanus* and *P. australis* in the Ciénega.

Study of Social Impacts of Desalination in Baja California

The provision of potable water in urbanizing arid regions, facing a projected reduction in precipitation and reduced water sup-

ply due to climate change, is a critical challenge worldwide. The state of Baja California Sur (BCS) is located in Mexico's most arid region. Desalination offers a potentially "limitless" supply of water and is becoming the preferred augmentation strategy in BCS. While desalination can reduce some vulnerabilities (e.g., future water supply), it may increase others (e.g., equity, affordability, environmental impacts, and energy demands). This research project is using semi-structured interviews, focus groups, household surveys, and a time-series analysis of secondary data to look at potential impacts.

Solar Desalination Pilot

A team of UA faculty and students working with U.S. Bureau of Reclamation engineers have developed a low-cost solar desalination system using membrane distillation that has the potential for application in remote areas to treat poor quality water for potable use. A simple system, the membrane distillation process uses solar energy to heat poor quality water. The steam then passes through a membrane and condenses as pure water free of salts and contaminants. The team hopes to locate a system on the Navajo Nation once testing of the prototype at the Tangerine Road Field Site is complete.

Chemical-Free Water Softening Pilot

Industrial and residential water softening contributes about 26 percent of the salts in domestic wastewater and engineers at UA are conducting a pilot on a process to eliminate the need for added salt. Called rapid electrochemical crystallization softening (RECS), the process removes scale-forming compounds from water without the addition of chemicals. The researchers will also be examining the possibility of using this process to remove silica from reverse osmosis (RO) brine.

Alejandra Calvo uses a locating device to monitor activities of elusive marsh bird species at the Ciénega de Santa Clara. Photo: Pablo Valle, Pronatura Noroeste

Desalination Permitting Can Be Tortuous

Permitting and regulation is a necessary, but often frustrating, part of building and operating desalination plants. Michele Robertson of Montgomery & Associates pointed out that almost every aspect of the plant requires permits: the original sources of water, the technology used to remove the salt, concentrate disposal, and building. While regulation is necessary to ensure the feasibility of the project and that it will cause minimal harm to others, most people involved in the process agree there should be a more streamlined permitting process.

San Diego County Water Authority is experiencing permitting frustrations firsthand. The Carlsbad Desalination Project, still in development by Poseidon, took 10 years of planning and 5 years of permitting through the State of California. The project is now fully certified and the last permitting challenge was dropped as of May 27, 2011. Phase I construction began in 2009; however, it will be 2015/2016 before the plant is fully operational. The Camp Pendleton Desalination Project in Northern San Diego County recently completed a feasibility study and expects a decision on proceeding with the permitting process by the end of 2012, with the date for coming on line set for 2020.

The Rosarito Beach Desalination Project is still conducting its feasibility study, but the permitting process and construction can be expected to take 10 years or more. This is problematic because water shortages are imminent in the area.

Regulatory issues are further complicated when the project is binational, such as in the case of Rosarito, requiring binational agreement on permit requirements. Adriana Rodriguez, of CONAGUA, pointed out that it is crucial to have clear rules on operations and management of the facilities and the quality to be met by both the product water and waste.

The State of Israel currently has three desalination plants open and two more under construction, all since 2005. Approximately five years (as opposed to ten in the United States) are required from the time that a governmental decision is made to construct a new desalination facility, to initiating supply of desalinated water to the national grid. This estimate includes time for international negotiations with surrounding desert countries. This is primarily because the Israeli Government in 1998 declared sea water desalination a "National Priority" and allows such projects to be "fast-tracked" through the permitting process by the Minister of National Infrastructure.

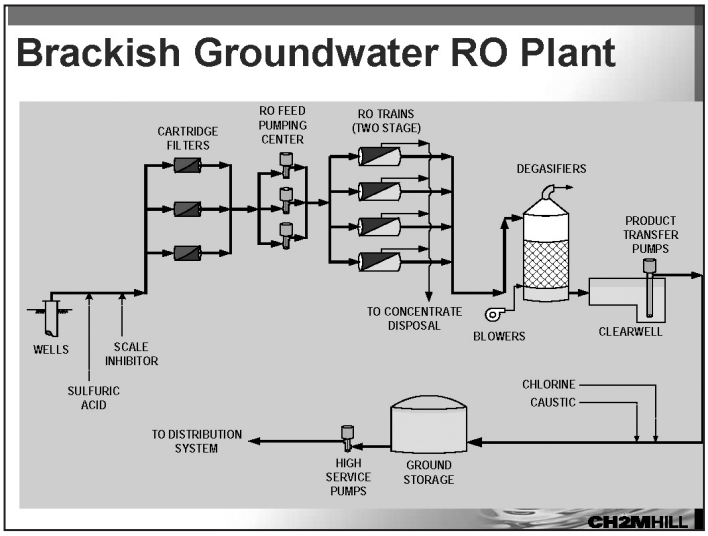
"If Noah needed a permit to build the Ark, none of us would be here today."

- Abraham Tenne, Head of Desalination Division and Water Technologies, Israel Water Authority

Desalination Technology 101

James Lozier, of CH2MHill, provided an overview of the present and future of desalination technologies (http://cals.arizona.edu/azwater/programs/conf2011/pdf/Lozier.pdf). Desalination is the process of removing salt (dissolved solids) from an impaired water supply (brackish water, seawater, or wastewater) in order to put the water to beneficial use (drinking, irrigation, industrial needs, etc). The entire process is quite complex. Since a picture is worth a thousand words, the following diagram shows a typical desalination cycle at a brackish groundwater RO plant.

The source water from wells is treated with chemicals to protect the system from corrosion and scaling and then pumped through a series of filters that take out the larger contaminants. The filtered water is pumped through a series of reverse osmosis



Schematic diagram traces desalination by reverse osmosis (RO) for brackish groundwater. Source: CH2MHill.

membranes that separate the product water from the concentrate. The product water is further treated and stored before it is distributed.

Fresh water has the lowest salinity (<1,000 mg/L of dissolved solids). When this water is desalinated, it is primarily treated with filtration technology. Brackish water has moderate salinity (1,000-20,000 mg/L) and is primarily treated using electrodialysis and/or reverse osmosis technology. Seawater has the highest salinity (20,000-50,000 mg/L) and can be treated by reverse osmosis or thermal processes that turn the water into steam and condense the steam back into water minus most of the impurities.

Nanofiltration, electrodialysis, and reverse osmosis are all membrane technologies, meaning they work by pushing water through a semi-permeable barrier (the membrane) in order to remove dissolved solids. The greater the salinity, the more pressure is needed to move water through the membranes. Therefore, seawater desalination requires more pressure. It also is more expensive, generally requires more pretreatment, may require more cleaning, and may cause a shorter membrane life. For a more detailed explanation of desalination processes see the 2011 Arroyo at http://ag.arizona.edu/azwater/arroyo/Arroyo_2011.pdf

Reverse osmosis is the most prevalent technology among desalination plants in the U.S., so a lot of study has gone into making these membranes more effective and less costly over the years.

What does desalination technology research hold for the future? Scientists and engineers are now looking to several renewable energy sources (wind, solar, and geothermal) in order to power existing desalination technologies. In addition, forward osmosis and biomimetic membranes will help make desalination more efficient.

Forward osmosis uses the osmotic pressure created by a draw solution to pull water through a membrane instead of pushing it using hydraulic pressure, as with reverse osmosis. The water is drawn through the membrane to the side with the draw solution leaving most of the dissolved salts behind. All that is left to do is to separate the water from the draw solution. The advantages of forward osmosis include high rejection of a wide range of contaminants and simple equipment requirements.

Biomimetic membranes are meant to emulate natural water purification by using aquaporins, proteins embedded in the cell membrane that control the flow of water into and out of the cell. Aquaporins have complete selectivity to move water molecules in and out of cells while preventing the passage of solutes. This technology illustrates a growing field of research into using nature to solve human problems.

Water & Energy Concerns Intersect in Desalination

Water production issues cannot be separated from the issue of energy. The water-energy nexus is an important consideration for providing both water and energy sustainability. New technologies and improvements to older technologies have significantly reduced the energy requirement of desalination, but energy remains the single largest operational cost for a desalination plant, representing between one-third and one-half of operational costs. Communities contemplating desalination must face the issue of energy availability and cost from the very beginning. Bob Lotts of APS spelled out the need to think about water and energy sustainability together. "Conserving one can conserve the other," he said. New technology is needed to improve the energy efficiency of water treatment including desalination and also to improve the water efficiency of power production.

The cost of energy represents not only the energy consumed for water desalination; the environmental impact of generating the energy is also a consideration. The San Diego County Water Authority considers greenhouse gas emissions resulting from energy consumption as one of the criteria used in evaluating future desalination projects. This concern about greenhouse gas emissions has many communities looking into renewable energy resources for desalination plants. James Lozier of CH2MHill mentioned the possibility of using geothermal energy to run desalination plants, in addition to solar and wind methods.

Brian Moravec, whose poster on solar desalination won the best of conference poster prize, showed how solar energy can be used effectively for desalination. "The idea is that you run hot water through one side of the membrane," says Moravec. "It passes through the membrane, evaporates and is carried as water vapor through heat exchangers. Finally, the water cools back to a liquid form." By converting water to its vapor form via energy from the sun, the solar desalination process uses less energy to turn contaminated water into clean water.

In his presentation to conference participants, Abraham Tenne, spoke at length about how the State of Israel is combining renewable energy with water desalination. According to Tenne, all new desalination plants in Israel will be equipped with solar

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panels and two solar power plants have been built in conjunction with desalination plants, one using solar thermal technology and one using photovoltaics. He also spoke about a wind turbine farm and three pumped-storage energy projects that have completed the approval process and will be used to help run desalination plants. In the meantime, as more renewable power generation facilities are built, Israel is turning to natural gas instead of coal fired power plants.

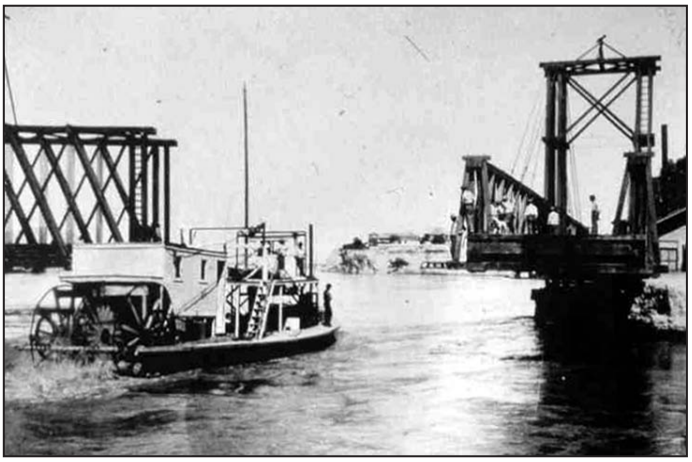
Guy Carpenter of Carollo Engineers described the results of several feasibility studies they have undertaken regarding energy use in different scenarios. In a brackish groundwater study in Buckeye Sink, the total power required was 1,349-2,887 kWh per acre-foot, depending on type of facility and percentage of water recovery. In a seawater desalination study at Puerto Peñasco on the Sea of Cortez, the energy costs were significantly greater, making the project more expensive overall. The study looked at a plant that would likely be built in stages. The first stage could operate using power from the existing electrical grid, but at full operation it would need additional sources. Clean, renewable technologies are currently under investigation.

Environmental Concerns Temper Enthusiasm for Desalination

Environmental interests and desalination intersect in sometimes surprising ways. Take for example the Ciénega de Santa Clara, a wetland in Mexico that is an ecologically important wetland, habitat for endangered species, home to migratory birds and shorebirds, and a source of ecotourism. The Ciénega is also the natural resource that will be most affected by operation of the Yuma Desalting Plant (YDP). Karl Flessa, professor of Geosciences at UA, focused on this intersection in his presentation "Environmental Monitoring of the Ciénega de Santa Clara." During its recently completed pilot run, YDP diverted up to 30 percent of the water that would normally flow to the Ciénega and instead flushed the processed effluent, much saltier water, into the Ciénega. Flessa's team has been monitoring the inflows to the wetland, water quality, vegetation, and marshbirds to see if the YDP run will significantly affect the Ciénega habitat. Jennifer Pitt of the Environmental Defense Fund reported that the YDP pilot run at one-third capacity resulted in a 20 percent increase in salinity and a 25 percent decrease in flow to the Ciénega. So far, research has shown that the area is accustomed to some variation in water supply and is fairly resilient, but the full effect of the YDP run is unknown. More long-term monitoring is necessary.

The more common environmental concerns are about ocean desalination, both from sucking the seawater into the facility and returning the concentrated brine waste to the ocean. Care must be taken to avoid harming both large and small organisms by trapping them in the intake screens. New designs for ocean water intake specifically address this issue. Passive intake screens can withdraw a large amount of water at a low, uniform velocity with no moving parts, which leaves aquatic life and debris in the water source.

Concentrate, the highly saline effluent produced, must be dispersed in a way that minimizes ecosystem harm. Remedies for ocean outfalls to date depend on site specific designs for rapid diffusion of the brine, but more research is needed into impacts on the marine environment and methods for preventing damage. Issues concerning the ocean environment were mentioned in the Yuma conference presentations, including "San Diego Water Authority's Seawater Desalination Program Update" and "The Master Plan for Desalination in Israel." In both of these talks, speakers identified major environmental issues, which include ocean intake and outfall concerns and the need for monitoring impacts on coastal ecosystems. One speaker also mentioned the importance of using local recycled materials and environmentally-friendly design guidelines in building desalination plants.



Conference participants were treated to a luncheon talk on the history of the Colorado River in Yuma, where less than a hundred years ago paddle boats carried cargo and passengers up and down the river. In this photograph the pivot bridge across the river, at the site of the Pivot Point Convention Center where the conference was held, is opening for a vessel. Photo: Arizona Historical Society

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Campus Water Sustainability Community Elects Advisors to UA President

Congratulations to Sabrina Helm of the Norton School of Family and Consumer Sciences and Jackie Moxley at the Water Resources Research Center, who were elected to represent the employee community on President Shelton's Advisory Council on Environmental Sustainability.

President Shelton established the President's Advisory Council on Environmental Sustainability in October 2010 as part of a larger reorganization of UA Campus Sustainability. The Council provides comprehensive guidance and advice to the President on high-level issues regarding the University of Arizona's leadership in environmental sustainability as it pertains to campus design, student engagement, operations, education, research, and outreach. The Council membership is composed of representatives from the university administration, academic units, students, and community representatives, with two seats reserved for university employees.

EcoOps, an organization of volunteers from the university community, with support from the Office of Sustainability, provided 'bottom-up' grassroots mechanism through which these two representatives were identified and selected. Jackie and Sabrina were elected by a vote of the EcoOps membership, which reflects the diversity of employee interests, expertise and positions across UA.

Conference Covers the Five Es of Desalination

By Sharon Megdal, Director

By all accounts, the Water Resources Research Center's 2011 conference on Salinity and Desalination in the Southwest was a success. Over the course of the conference, the excellent speakers did a phenomenal job of covering the challenges and opportunities associated with using desalination technology to address pressing water supply challenges in Arizona, the broader region, and worldwide. Holding the conference at the Pivot Point Conference Center on the Colorado River in Yuma allowed us to see restoration efforts and visit the Yuma Desalting Plant. The conference benefitted immensely from our collaboration with the U.S. Bureau of Reclamation.

The pages of this newsletter cover some of the information shared, which included technological, environmental, financial, regulatory, environmental, educational, historical, international, and political perspectives. I am going to summarize some of my take-away messages in the context of the framework presented by Shivaji Deshmukh, Assistant General Manager of the West Basin Municipal Water District, which serves several communities in the Los Angeles area. He underscored the importance of four Es to the incorporation of desalination technology, whether for recycling treated wastewater or desalinating seawater: Energy, Environment, Education, and Economics.

While sound engineering (a fifth E) is a prerequisite to utilization of any technology, engineering itself is not the determinant of our ability to deploy desalination technology. Engineering, as well as research and development, influences the economics or cost of technology. The full costs of technology depend on a host of factors, including the energy used and environmental impacts. The dynamic relationship between energy and water is well recognized, if not always well understood. The type and cost of energy required for desalination are quickly mentioned in discussions of desalination plants. Is the energy carbon-intensive? Does production of the energy itself require a lot of water? The other item quickly mentioned is brine disposal. What happens to the brine stream from the desalination plant? What are the economics and environmental implications of discharging it? Examples discussed at the conference included: conveying it 22 miles to a well site for deep injection, as is done by El Paso Water Utilities; discharging it back into the source water, as is done at seawater plant sites; and transporting it to the Ciénega de Santa Clara, as is done with the Yuma Desalting Plant brine stream.

In addition to the panel addressing the environmental implications of operating the Yuma Desalting Plant, there was considerable mention of environmental implications of desalination. Adriana Rodriguez of the Mexican national water agency CONAGUA, spoke about Mexico's desalination program. When I asked her about the potential to build a desalination plant in the Sea of Cortez, something that Arizona water entities have studied, she cited concerns about the environment. When discussing the possibility of building a plant at Rosarita, Baja California, she noted the environmental impact of brine discharge. This plant has potential to serve some of San Diego's needs. While some seem to see the partnership with Mexico as a way for Californians to export the environmental impacts of desalination, I do not see it that way. Mexico is a very sophisticated partner on water matters. Binational arrangements will have to incorporate sufficient benefits for all partners and address environmental impacts. The recently completed test run of the Yuma Desalting Plant provides an example.

Education is a critical piece of the puzzle. Educating policy makers and the public is key to moving forward with long-term investments. We heard about Israel's desalination strategy, as well as that of Australia, where conditions associated with severe drought spurred action. California's cutbacks of water deliveries from the State Water Project were a wake-up call to residents of Southern California. We also heard about the efforts of the West Basin Municipal Water District, where the public has accepted investment in high-level treatment of wastewater for use by industry as well as general municipal customers. West Basin has also invested in a sophisticated education center for its customers. Education efforts require resources, too, but the payoff can be great. Teachers from the Yuma area attended part of the conference and participated in a workshop conducted by Arizona Project WET. They heard about the complex considerations and costs associated with desalination and toured the water quality center operated by Reclamation at the YDP site. They will surely take what they learned back to the classroom. The conference, however, was just a very small part of the education efforts that are needed by our communities and the State.

Economic considerations permeate all decision making. Understanding the trade-offs associated with alternative policies is critical. The test run of the Yuma Desalting Plant was a conference focus. Now that it is complete, what will the future of this plant be? Will it return to its dormant status? Will the investment be made in re-piping the plant, something we heard was necessary? Should it be made? When the Bureau of Reclamation's reports and other analyses, including the results of the environmental studies being led by Karl Flessa of the University of Arizona, are completed, they will serve as the foundation of much discussion. Other discussions will ensue in Arizona regarding desalination of brackish groundwater and treated wastewater. It is important that we consider carefully the economic implications of alternative courses of action.

We have our work cut out for us. As noted by Deputy Reclamation Commissioner Kira Finkler, in her talk at dinner, we are experiencing long-term drought conditions at a time of severe budget limitations at all levels of government. Michael Galbadon of Reclamation likewise underscored the importance of ensuring long-term access to water for all water using sectors. For many, desalination is or will become an important component in making water supply portfolios sustainable and resilient. I thank all those who attended, spoke, sponsored or contributed to the conference in other ways. Thanks for participating in our joint exploration of the challenges and opportunities associated with desalination in the Southwest.

ARIZONA WATER RESOURCES

WATER RESOURCES RESEARCH CENTER
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
THE UNIVERSITY OF ARIZONA
350 N. CAMPBELL AVENUE
TUCSON, AZ 85719

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Inland desalination is not without its environmental concerns. Of first importance is what to do with the concentrated brine. Currently, many methods exist for concentrate management: disposal to surface water, disposal to sewers, land application, deep-well injection, and evaporation ponds. Disposal to surface water is most common because it is relatively inexpensive and convenient. However, the increase in salinity may be detrimental to freshwater habitats. Disposal to sewers requires wastewater treatment plants to be able to handle the increase in salinity, possibly requiring more advanced treatment such as reverse osmosis. Land application can be beneficial when used to water landscaping; however, vegetation must be salt-tolerant. Deep-well injection puts the concentrate deep underground, so it is necessary to monitor the effects on groundwater, and it cannot be used in areas prone to earthquake and other ground instability. Evaporation ponds work well in arid climates where solar energy is abundant; however, ponds typically require large land area and impervious lining to protect the groundwater, which increase costs significantly. Blending with wastewater treatment plant effluent or power plant cooling water may facilitate concentrate disposal and be used in conjunction with above methods. Concentrate has also been used for dust suppression, roadbed stabilization, and soil remediation in small quantities.

In addition to these common concentrate management strategies, there are several newer technologies that fall under the category of "zero liquid discharge." Thermal brine concentrators, crystallizers, and spray dryers reduce concentrate to a solid product for landfill disposal. However, the costs for these technologies are currently too high for most plants. Because every ecosystem is different, planning for proposed desalination plants must include adequate research about the area in order to find the most environmentally benign solution for that particular facility.

On the other hand, desalination can also have environmental benefits. Desalination plants can provide a secure source of water, albeit salty water, for environmental purposes. Salt tolerant wetlands plants can thrive on concentrate from inland desalination and provide an ecosystem supporting marsh birds and other wildlife. James Lozier, of CH2MHill, reported that the Oxnard, California Concentrate Treatment Wetlands demonstrates the ability of an engineered natural treatment system to utilize concentrate for environmental benefit. This is accomplished by employing salt-tolerant, brackish marsh species to remove nutrients and heavy metals and to provide volume reduction. With appropriate methods, it may be possible to restore or create new wetlands habitat using concentrate as a sustainable water source.

SAVE THE DATE

The WRRC's 2012 Annual Conference is scheduled for **Tuesday, January 24**, in Tucson. The WRRC is teaming up with the Morrison Institute for Public Policy, Arizona State University, to present the latest thinking on the "Sun Corridor", the megalopolis predicted to cover a swath down the middle of Arizona from north to south, andthe implications for water policy and management.