Diving Rod
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New Research Describes Subterranean Water Flow, Chemistry

By Thomas Guengerich, New Mexico Tech

New research by New Mexico Tech professor Dr. John Wilson and doctoral student Katrina Koski sheds further light on the transfer of groundwater between very fast flow paths within karst rock formations and the much larger volume of karst rock with slow flow, with implications for water chemistry and contaminant behavior.

Using funding from the New Mexico Water Resource Research Institute, Wilson and Koski conducted two-dimensional computer modeling to predict how water

New Mexico Tech Professor John Wilson suits up for a dive in Eagles Nest Cave, Chassahowitzka Wildlife Management Area, Florida (photo by K. Koski). Doctoral student Katrina Koski prepares to scuba dive into a karst formation (photo by Tanja Pietrass). Their research will help describe how groundwater is transported through subterranean systems.

Diving Rod

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is transported through subterranean systems and what factors influence the rate and direction of flow.

This project, titled "Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions," has laid the groundwork for future field studies, which recently received funding from the National Science Foundation (NSF) and the U.S. Environmental Protection Agency (EPA).

Karst is a geological term that refers to underground formations that resemble Swiss cheese. On a large scale, we refer to karst features as caves or caverns. Generally speaking, karst refers to regions where rock has begun to dissolve chemically or "undergone chemical dissolution." Karst aquifers are important water sources; they supply water to 25 percent of the United States, and some regions rely almost entirely on such formations; Florida, as an example, gets 90 percent of its water from karst. Also, much of the southern New Mexico Pecos Watershed is karst.

Wilson's work examines the "hyporheic zone," which is the area where water flows back and forth from the cave – or conduit – to the karstic rock formations – or matrix. Hyporheic zones and hyporheic flow was first characterized by biologists studying streams where surface water descends underground and later reappears in the stream.

Chemists soon started examining surface hyporheic zones to explain what happens to dissolved solid organics (and other chemicals) as they move through hyporheic zones, as well as looking at how aquifer water mixes with surface water. Now, hydrologists like Wilson and Koski are breaking ground on subterranean hyporheic zones. In fact, Wilson was the first hydrologist to suggest that hyporheic zones could exist at the margin of a karst conduit.

"If water stays only a short time, it's hyporheic flow," Wilson said. "Through modeling, we are showing the propensity for deep flow. One interesting finding is how the variation in the karst wall topography impacts hyporheic flow."

Scallops – or patterned undulations in the cave walls – create eddies in the flow, and hyporheic flows. Many karst conduits are air-filled with a river-like flow at the bottom. This project specifically examines conduits that are completely filled with water. In some cases, given the right pressure, water can even flow upward through the cave roof into the matrix.

Karst conduits typically have porous and permeable walls. Conduits range in size from building-sized to conduits too small for a diver. Water follows flowlines from high pressure to low pressure. For instance, a flooding event creates high-pressure in the conduit, forcing flow into the matrix. Water tends to flow quickly through the karst conduit and slowly through the matrix – or the aquifer. Conduits respond quickly to precipitation, while aquifers respond – or recharge – very slowly in response to rainfall.

In their modeling, Wilson and Koski accounted for the various characteristics of the karst conduit and the rock matrix, varying water pressures, conduit geometries and flow rates. They also applied standard physics models that describe flow rate – like Darcy's Law and the Navier Stokes Equations.

The resulting models show water flow paths in conduit and matrix, as well as the travel time through the hyporheic zone.

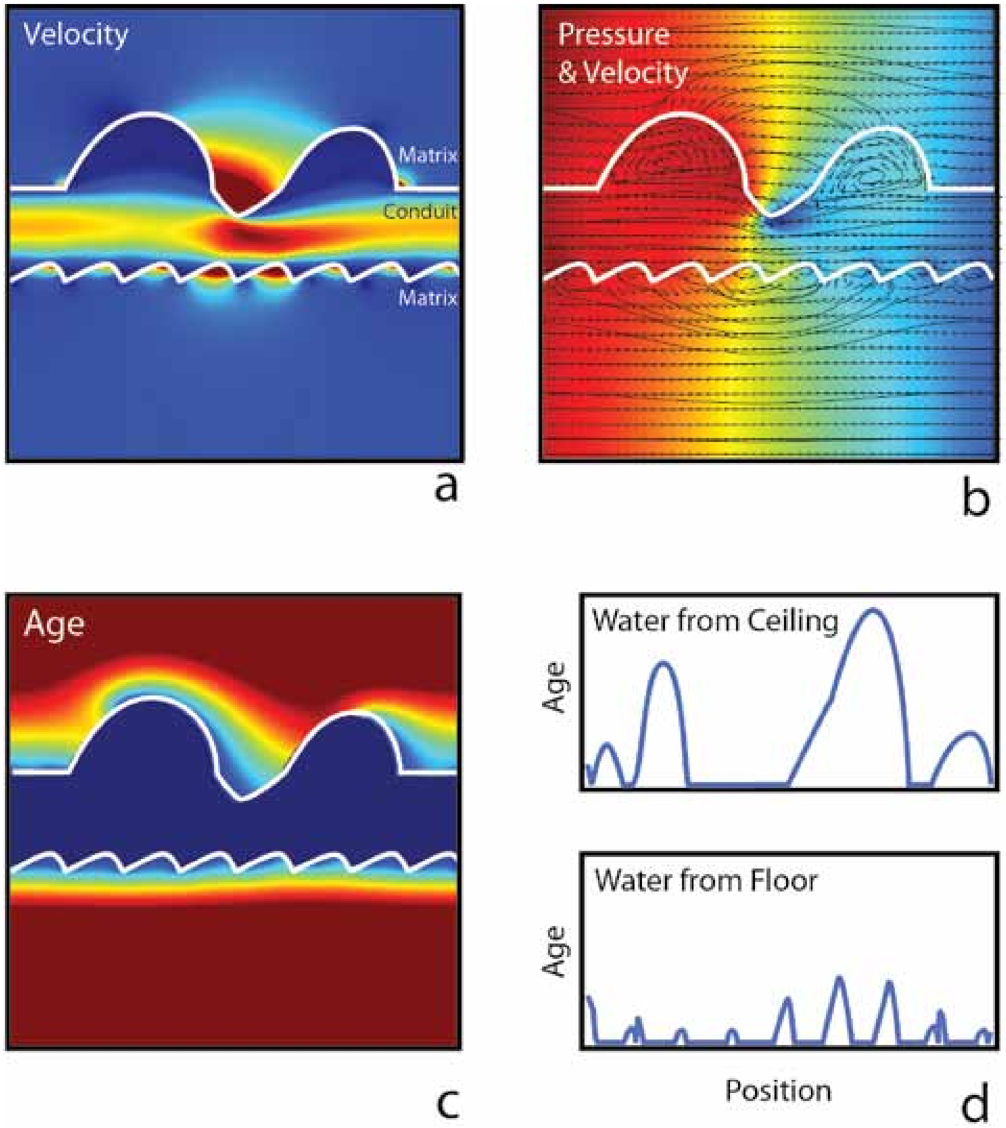
As the project's title suggests, Wilson's NM WRRI research examines water chemistry and the transport of contaminants. They considered how groundwater in the karst aquifers changes chemically as it is transported through conduits and matrix.

Groundwater contains varying levels of organic and inorganic chemicals – both natural and anthropogenic. As water moves through a hyporheic zone, dissolved chemicals undergo reduction-oxidation – or redox reactions. Water will enter the matrix in one chemical state, travel through the hyporheic zone and return to the conduit in a different state. Wilson and Koski's models show that water entering the matrix at Point A may stay sequestered longer than water entering at Point B. The longer water is sequestered, the more redox reactions take place.

"We know the chemical reactions taking place," Wilson said. "There's a cascade of reactions as the water moves through the matrix. We are looking at how water gets sequestered, and how it is transformed into something less mobile and less toxic."

In the absence of sunlight and biological factors found on the surface, water becomes anaerobic and then begins to lose other elements. At some locations where long-sequestered water re-enters the conduit, researchers are even finding mineral deposits.

Wilson and Koski are examining these chemical changes that occur in the water.



This simulation depicts a cross-section of flow in a karst conduit and induced hyporheic flow in the surrounding rock matrix that is located both above and below the conduit. The ceiling above the conduit has two large cupolas while the floor is lined with regularly-spaced features called scallops. The upper left (a) depicts relative flow speed (red = fast, blue = slow) with different color scales in conduit and matrix. The upper right depicts the distribution of fluid pressure (color, red = high, blue = low), fluid velocity (arrows), and flow paths in the matrix. The ceiling morphology drives the hyporheic flow deeper into the matrix ceiling above the conduit than the smaller scallops drive flow into the matrix below the floor. With a porous and morphologically complex ceiling and floor, there is an interaction between the floor and ceiling morphology that creates nested hyporheic flow paths in the matrix on the other side of the conduit. The relative age of hyporheic flow is shown in the lower left (color: red = old, blue = new) while in the lower right is the highly variable spatial pattern of relative residence time for the returning hyporheic floor to the conduit from the ceiling (top) and floor (bottom). The illustrated domain is 2m wide and 2.5m tall.

Additionally, the researchers also look at speleogenesis – or cave formation. They are looking at the chemical reactions that cause the karst rock, which can be almost spongy, to disintegrate over time.

“Rock will basically dissolve from the inside-out,” Wilson said. “It’s rotting at depth. We can see the reactions and the enlargement of karst features.”

The next step in the research of karst hyporheic flow and water chemistry will be field studies. Wilson and Koski are working on a field study in Wakulla, Florida, near Tallahassee. Using a $387,000 grant from the NSF, they will scuba dive into the karst terrain. (Actually, they will hire NSF-approved divers because the target location is both deep and difficult to dive.) They will take core samples and install sondes that will measure and transmit data on water pressure, temperature and chemistry. The array of instruments will be the first such observatory dedicated to the study of hyporheic flow and chemistry. Koski, who earned her master’s at New Mexico Tech in 2000, will use that field work for her doctoral dissertation.

“We were selecting an important scientific question for the dissertation, one that had not been answered before,” Wilson said. “Katrina wanted to do her Ph.D. in flowing caves. I’d been doing research in air-filled caves and how gasses exchange. I thought her proposal was interesting.”

Koski also landed an EPA Star Fellowship to support her work. The Fellowship, which includes a stipend for Koski, allowed Koski’s salary from the NSF grant to fund another graduate student, Kenneth Salaz, who originally earned his bachelor’s at New Mexico Tech in 1998 and was Tech’s top undergraduate student that year, earning him the coveted Brown Medal.

“That’s the really nice thing about this NM WRRI grant,” Wilson said. “It has seeded two new sources of funding that are continuing today.”

Global Perspectives

SYMPOSIUM & WORKSHOP

Acequias and the Future of Resilience in Global Perspective

Symposium & Workshop

March 2 - 3, 2013
Las Cruces Convention Center
Las Cruces, NM

Acequias and the Future of Resilience in Global Perspective

This symposium pursues a holistic understanding of acequia irrigation in the upper Rio Grande Valley as made up of interactive, interdependent biophysical, economic, ecological, and sociocultural systems. It brings together scholars whose perspectives on comparable social-ecological systems in other parts of the world can shed light on the particular and shared features of New Mexican acequias as well as on the challenges they face. Of special interest are questions about whether and how local common resource pool management can maintain or regain resilience under conditions of accelerating integration into a global economy and climate change.

NSF · WRRI · New Mexico EPSCoR · UNM · New Mexico Acequia Association · Sandia National Laboratories · New Mexico Tech · NM State University

Black carbon impact on water quality focus of USGS 104B research grant

In response to the NM WRRI's Request for Proposals in November 2012 for a seed grant project to be funded through the U.S. Geological Survey's 104B program, a water quality study has been selected. "The transport and accumulation of pyrogenic black carbon in fire-prone watersheds and implications for water quality" is under the direction of New Mexico Tech Assistant Professor of Hydrology Daniel Cadol. Co-investigators Fred Phillips and Michael Heagy, also from NM Tech, will join the effort.

Dan Cadol, with daughter Abby, examining black carbon-rich deposit in tributary of Mineral Creek, Gila National Forest.

With a record-setting wildfire season behind us, with the intensity and frequency of forest fires predicted to increase as a result of climate change and shifts in land use, and with its relianance on forested catchments for much of its drinking water, New Mexico must make well-informed post-fire management decisions.

This work will identify the relative importance of mass movement and river flow in transporting pyrogenic black carbon through recently burned semi-arid watersheds by identifying the dominant depositional zones—floodplains, river banks, or depositional debris fans. The potential for long-distance transport of debris to downstream reservoirs represents a threat to drinking water and irrigation supplies that is highly dependent on transport mechanisms. By determining the likely black carbon transport mechanisms, this study will assist managers in prioritizing treatment areas for infrastructure protection.

The mission of the NM WRRI includes the training of the state's future water experts. Principal investigators are strongly encouraged to include students in their projects. This one-year, approximately $30,000 project includes financial support for a graduate research assistant.

USGS 104G Water Resources Research National Competitive Grants Program RFP

The U.S. Geological Survey in cooperation with the National Institutes for Water Resources requests proposals for matching grants to support research on the topic of improving and enhancing the nation's water supply, including the following specific areas of inquiry:

- Evaluation of innovative approaches to water treatment, infrastructure design, retrofitting, maintenance, management and replacement.
- Exploration and model development of the dynamics of extreme hydro-meteorological events and associated economic, environmental, social, and or infrastructure costs.
- Development of methods for better estimation of water supply, both surface and groundwater, at gaged and ungaged sites, including estimation of the physical supply and of the economic supply of water.
- Development and evaluation of alternative approaches and governance mechanisms for integrated surface/ground water management.
- Evaluation/assessment of the effects of water conservation practices, as well as adoption, penetration and permanence.

This program provides university researchers with up to $250,000 for projects of 1 to 3 years in duration. It requires a 1:1 non-federal match. The intent of the program is to encourage projects with collaboration between universities and the USGS. Funds have not been appropriated for this program but the USGS is proceeding with the proposal solicitation process in case an appropriation is received. The RFP at https://niwr.net/competitive_grants/RFP gives information on past year funding including award amounts and funding success rates.

Researchers must submit their proposal online at the NIWR website. The deadline is February 21, 2013, by 2pm MST. If you are interested in submitting a proposal, please contact NM WRRI Director Sam Fernald (575-646-4337; afernald@ad.nmsu.edu as soon as possible. Proposal and budget should be reviewed by NM WRRI no later than February 14, 2013.

NM WRRI annual water conference presented "Straight Talk"

Needed: Visionary leadership, streamlined policies, and respect for New Mexico's unique traditions

story and photos by Will Keener

Eluid Martinez, who served as New Mexico's state engineer from 1991 to 1994, calls himself the "last of the water buffaloes." As an engineer principally involved in the development of water infrastructure, including dam building, his work has been criticized in intervening years. "Conservation meant using every drop we could in beneficial uses," he recalled during a special panel presentation, called "Straight Talk." Martinez, who also served as Bureau of Reclamation commissioner from 1995 to 2001, was joined by two other past state engineers, Tom Turney and John D'Antonio as well as a long-time state engineer assistant, John W. Hernandez, on the panel.

"Then things began to change," Martinez said, pointing to the public perception of using water for environmental purposes and concerns about population growth and how to meet its demands. Now, in a water-short era, "People who once criticized the dam building are saying, if it weren't for those reservoirs, where would we be?"

Martinez's story puts the cyclical nature of the state engineer's job into perspective. Not everything changed, he hastened to add. The key problem facing the NM WRRI conference he attended 40 years ago "is the same issue sitting before us today. How do you meet increasing demand with limited resources?"

"The pressures on the Rio Grande now and other rivers of the state in the future are great," said Sen. Tom Udall, who moderated the panel. If we didn't have the storage in northern New Mexico reservoirs and the San Juan-Chama project, the Rio Grande would be dry right now. That's a pretty shocking thing . . . Where are we going to get the water?"

Straight Talk Panel: Sen. Tom Udall, John Hernandez, Eluid Martinez, Tom Turney, John D'Antonio

New Mexico can be considered "the poster child of water users in the U.S.," John D'Antonio said. "We've got every water user and interest group that any other state has and more." D'Antonio served as state engineer from 2003 to 2011. "New Mexico water issues are "polarizing at times," he told the audience, "but they are also rewarding. The water community is here in this room and no matter the differences and the contentiousness, I still consider it as a family." Now in times of extreme drought, "we all know what Scott [Verhines present state engineer] is going to be facing. We aren't going to be able to get anywhere unless we collaborate."

Eluid Martinez

An obvious choice for bringing water to growing municipalities is to transfer it from agricultural use. About 75 percent of the state's water use is for agriculture. Steve Reynolds, an often-quoted state engineer who served in the post for 35 years until his death in 1990, estimated that a 10 or 15 percent cut in irrigation water would allow New Mexico municipalities to double their population. "The problem is," Martinez said, "that right now we are attempting to meet existing demands and future demands. You cannot accomplish both objectives."

Tom Turney

New Mexico's water priority system, the makings of which reach back to the 1500s, calls for all users to be treated equally. Some western states have changed to a priority system that recognizes the needs of municipalities in times of water shortages and diverts available waters to them first. "We see these priorities argued in the courts," said Tom Turney, state engineer between 1995 and 2003. "Every user wants the number one priority and the maximum amount of water they can get." Changing the priority system would not change that and would be "a terrible mistake," he said.

"It's easy to say we can take water from agriculture to double the state population, but it's a mistake to do away with the heritage of agricultural use of water in New Mexico," Turney said.

John D'Antonio

Priority calls may be a thing of the past, said John Hernandez, a 50-year veteran of the state engineer's office and professor emeritus at NMSU. A 1991 court decision requiring New Mexico to find and deliver 18,000 additional acre-feet annually to Texas resulted in a state acquisition of the water rather than a priority call, he noted. Asking people with water rights obtained after 1932 to give them up would have created a difficult and chaotic situation, he said. Then-Governor Bruce King was easily persuaded to take the acquisition approach.

"Making a priority call is a good hammer but a hammer that does not work," Martinez said.

Also a question with agricultural transfers is "where and how do we take water out of agriculture?" D'Antonio said. Some two million people live between Cochiti Pueblo and Las Cruces in the Middle Rio Grande Valley and there is not enough farmland to provide needed water use permits. "So where do we get it?" Conservation, reuse of water, and new (non-renewable) supplies through desalination technologies, may provide part of the solution. Interbasin water transfers, bringing water from outside the valley, have been proposed twice in recent years, but denied by the state engineer's office. "This valley is the economic engine for state. The jobs are going to be there." Short-term transfers in drought years, may help provide some flexibility, D'Antonio said.

Once identified, moving water from agriculture to cities and industrial uses under the current rules and regulations is a difficult process. "The transfer process is so cumbersome, a city could disappear before you could get through the process and get a Supreme Court decision," said Martinez. As a result, municipal users tend to acquire long-term water rights to avoid the transfer process.

A short-term transfer process would allow for quick action, "where the municipalities get the water, but the farmer can continue to farm," Martinez said. It has the added advantage of allowing communities to discuss water needs instead of asking the state to decide, noted Udall. "A village can talk about their water rights and decide if conservation or infrastructure improvements are needed, or where the community should head. It should be a community decision."

The legislature recognized the slow process involved in transfers and directed that an expedited process be developed a decade ago, D'Antonio said. The state engineer established basins, put in place project plans, and set up water masters to meter use. "We have been at the cutting edge with respect to other states in the West, trying to put this into place. You can't manage unless you measure the water," he said. The hold-up to the process has come largely as a result of legal challenges, he said, "not for lack of trying."

Both Martinez and D'Antonio harkened to the "water buffalo" approach to water. "The big question is "where's the next San Juan-Chama project?" said D'Antonio, who is now deputy district engineer in the Army Corps of Engineers' Albuquerque office. "There is no new water. We are fully appropriated for the most part." The last large-scale projects had their beginnings decades ago, he noted. To take pressure off of the state's groundwater, New Mexico should be addressing the building of new water infrastructure and augmenting supplies. "We've got to look for next San Juan-Chama project. We can't do it alone, we need to partner with other state and fed agencies. We need to work together in a lot of different areas," he said.

In closing, Martinez urged present leaders to value New Mexico's unique past, but not to depend on old ways too much. "Begin to look out of the box based on new information," he urged.

"Don't go immediately to court," Turney advised. "Keep discussions between water users alive. Better solutions come from dialog and discussion," he said.

Use science-based decisions, collaborate with the many experts available to the state, and seek regional solutions, suggested D'Antonio. "We tend to look too small sometimes. If we can leverage federal and state programs, we can build systems that are too large to build on our own," he said.

U.S. ranks third in annual consumption of water

A study conducted by two engineers at the University of Twente in the Netherlands calculated how much water is used around the world and what countries have the highest consumption rates. According to their research, more than 9 billion cubic meters of water are used around the world each year. The countries with the greatest annual consumption of water are:

China, 1,207 billion cubic meters

India, 1,182 billion cubic meters

U.S., 1,053 billion cubic meters

After the U.S., the amount of water consumed per country drops of significantly," says Klaus Reichardt, CEO and founder of Waterless Co. "For instance, Brazil, which is next on the list, uses less than half of what is consumed in the U.S."

However, the study shows the amount of water consumed on a per capita basis can vary significantly. Even though it is number three on the top ten list, the U.S. has the highest per capita water footprint at 2,842 cubic meters per person.

Top ten water consuming countries in the world are:

1. China
2. India
3. U.S.
4. Brazil
5. Russia
6. Indonesia
7. Pakistan
8. Mexico
9. Japan
10. Nigeria

The long view

Bridging the gap between future projected water demand and supply in the Middle Rio Grande

conference stories and photos by Will Keener

Howard Passell, Sandia National Laboratories

New Mexico is likely to face a significant gap between supplies of water, energy, and food by the next century. That's the conclusion of Howard Passell, a Sandia National Laboratory scientist, and a group of colleagues, working to assess the impacts of climate change and population in the years ahead.

Careful not to call the conclusions "predictions," Passell said the modeling results do offer a point of departure for discussions of the future. Speaking on a panel at the 57th Annual New Mexico Water Conference titled "Building a Plan," Passell told the audience that state residents will face hard choices including severe measures "not yet on the table" should the model scenarios become reality.

An examination of technologies now being investigated to bridge the supply-demand gap shows that most are "incremental," Passell said. But increasing capacity with sure, but small steps, won't be enough. "We're not on track to get us where we need to be," he said. "We need transformational solutions." Most current solutions simply shift the gap, but do not eliminate it.

In one case study, researchers from Sandia and the Bureau of Reclamation looked at climate change impacts in the upper and middle Rio Grande valleys on stream flows, reservoir levels, and meeting downstream treaty obligations. The team used several climate variables and 112 computer runs with 16 different general circulation models to arrive at a conclusion.

The average model run suggests that on the basis of climate change alone—without increases to population, added water conservation, or any changes to current water operations factored in—New Mexico could end up running two million acre-feet short of its obligations to the Rio Grande Compact by 2100. "That will never fly, of course, so something has to be done," Passell said.

One possible solution would be to cut agriculture by 50 percent in the middle Rio Grande Valley, to about 25,000 acres. Using the models to evaluate this approach reveals that such a measure will make up the deficit. "We can fix the compact problem, but it creates another problem," Passell said. "That is, we lose a lot of agriculture."

Another possible solution is to use water dedicated for the bosque, or wetlands along the river. By cutting the bosque in the Middle Rio Grande from 60,000 acres to 20,000 acres, the compact demands can be met, according to the computer models. "We no longer have a gap in terms of the compact, but we've created another gap because we've lost the bosque," Passell said.

Another possibility looked at was lining about 80 percent of the Rio Grande between Cochiti Reservoir and Elephant Butte Reservoir by 2100. "That will solve the deficit, but we are just moving the gap because by lining the river with concrete we don't have leakage from the river to the shallow or deep aquifer, we lose the bosque, or part of it, and reduce aquifer recharge, and so on," Passell said.

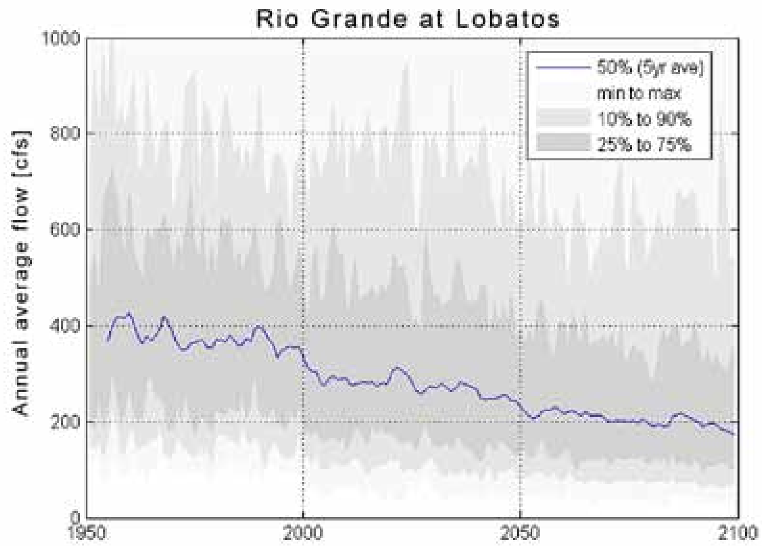
Preliminary conclusions of the case study show that these measures, reducing agriculture or wetlands, or lining the river channel can solve the compact deficit problem. "But they lead to many other kinds of gaps and we end up with many shortages and problems," he said.

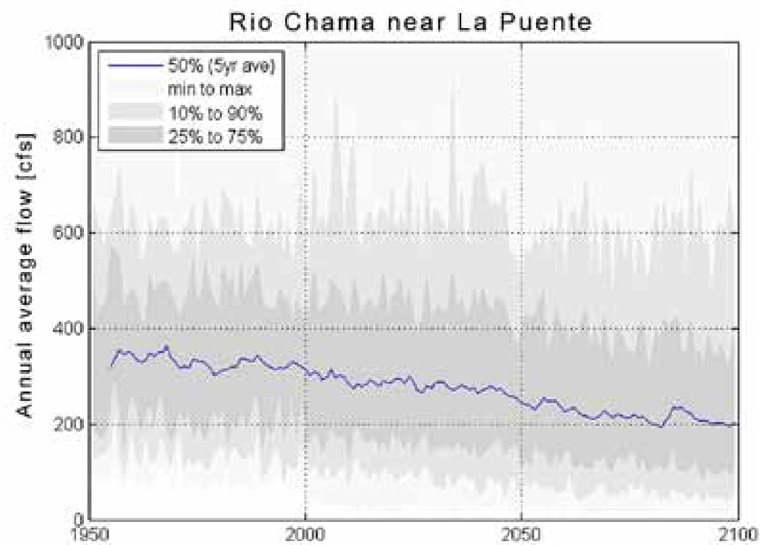
Another scenario examined by others at Sandia as part of other projects was changing cropping patterns and irrigation methods instead of eliminating agriculture. If drip irrigation and production of vegetables replace flood irrigation and alfalfa and grass cultivation, almost as much water could be saved as by eliminating agriculture all together—although Passell points out that this just shifts the gap again to those who grow and use alfalfa and grass hay. "There is a virtue in maintaining agriculture in the basin because it addresses food security issues. Right now we import a lot of food from thousands of miles away. Instead of that we might cultivate our food in our own basin," he said.

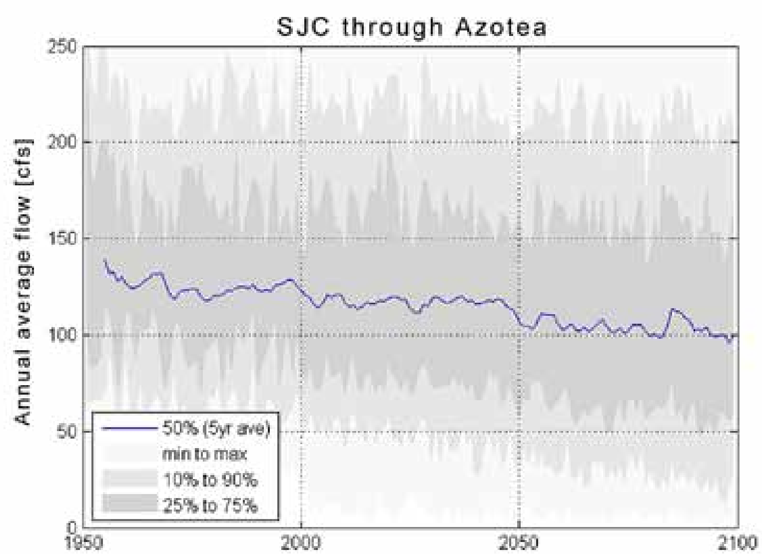
"Demand reduction in the end may be the only sensible solution that doesn't shift the gap," Passell said. To accomplish that, population growth control and dramatic changes in New Mexico's water, energy, and food consumption would be in order, he said. Examples include more judicious agriculture, smaller and much more efficient homes and buildings and turning the thermostats down in winter and up in summer, changes in diet like less dairy and beef, fewer electronic gadgets and appliances. "Generally these topics have not been put on the table as possible solutions," Passell said. "Too often these kinds of solutions are marginalized in favor of efforts to simply meet the ever increasing projected demand."

"If we can't meet demand, we are going to have to do other things. If we can reduce population growth, then we can move toward a steady state economy—one that doesn't depend on constant growth.

Some of these things are pie in the sky and some might even say that these things are preposterous, but I would suggest that eliminating our natural capital, impairing the ecosystem services that have allowed us all to be here is equally preposterous," he said. "We need to be looking outside the box for new sets of solutions. If we don't have enough water to meet projected demand, maybe one of the things we have to do is reduce that demand in the future."







Model results show river deliveries going down over time as a result of climate change alone, not including consumption from increasing population, and not including efforts at conservation or demand reduction. The authors of the study indicate that "Results are not predictions, but rather a starting point for dialogue and increased awareness of potential impacts of climate change."

Environmental perspective

Time to invest in demand management instead of large-scale water projects

Denise Fort, Utton Transboundary Resources Institute

Two water projects under development in New Mexico came in for criticism by Denise Fort, professor of law at University of New Mexico and director of the Utton Transboundary Resources Center in Albuquerque. Fort is taking the side of the river and the fish in a state that has "no legal framework for protecting the ecological aspects of rivers and streams and has failed to protect the natural values in our rivers," she said.

"Right now in New Mexico, the fish lie between agricultural and municipal interests," Fort told the 57th Annual New Mexico Water Conference. "Water flows to cities and there is not always necessarily a benefit in that." Environmentalists in the state are working "to make sure not just cities and rural people but our natural systems as well are protected," she said.

"Looking to the future, New Mexico should manage water demands rather than investing in large scale water projects, Fort said. "These projects have high environmental costs, such as energy costs to pump the water to different places other than the river, from which water is taken." She excluded most tribal projects, where issues are different.

Fort said that although the Arizona Water Settlements Act of 2004 "gave us the opportunity to get additional water for New Mexico," the additional supply comes at a high cost. She said the state "doesn't necessarily have a need for the water." Part of the project would be paid for with federal funds, but not all. "I would ask why would the federal government make a commitment to provide 'new water' for New Mexico, rather than looking for cheaper solutions, which might be available closer at hand?"

Local communities are looking at lining leaking water systems and other measures, she said, but the lure of $66 million in "free federal money" is strong. "Once we remove the water from the river, we have pipeline, energy, and other projected costs to move the water to a place where it can be used," she said.

She also criticized the Ute Lake project where Congress has committed $400 million for a pipeline to deliver water to eastern New Mexico. "Were there cheaper alternatives, including demand management to address those needs?" she asked. Unless the federal government can pay for the bulk of the project, demand management seems a better alternative, she said.

Among the hard choices the state must begin to wrestle with are programs to reuse water and actions to help determine what crops are appropriate to an arid state, she said. "From an environmental perspective, reuse is a direction the state should be going when it makes economic sense." In the cases where reuse projects are underway, the environmental standards have been quite high and "should be reassuring to citizens," she said.

In Australia, when a major river system was severely degraded, officials invested in buying back water rights and dedicated water to the environment, she said. In light of state population growth and expected climate change impacts, New Mexico "should look to Australia about what hard questions to ask about what we would like the next century to be like," she said. "Let's shape the future ourselves."

Coupled to the Australian approach is the question of what crops and what lands are appropriate for agriculture, she said. In Australia, some crops were moved to more productive locations to make agriculture more efficient.

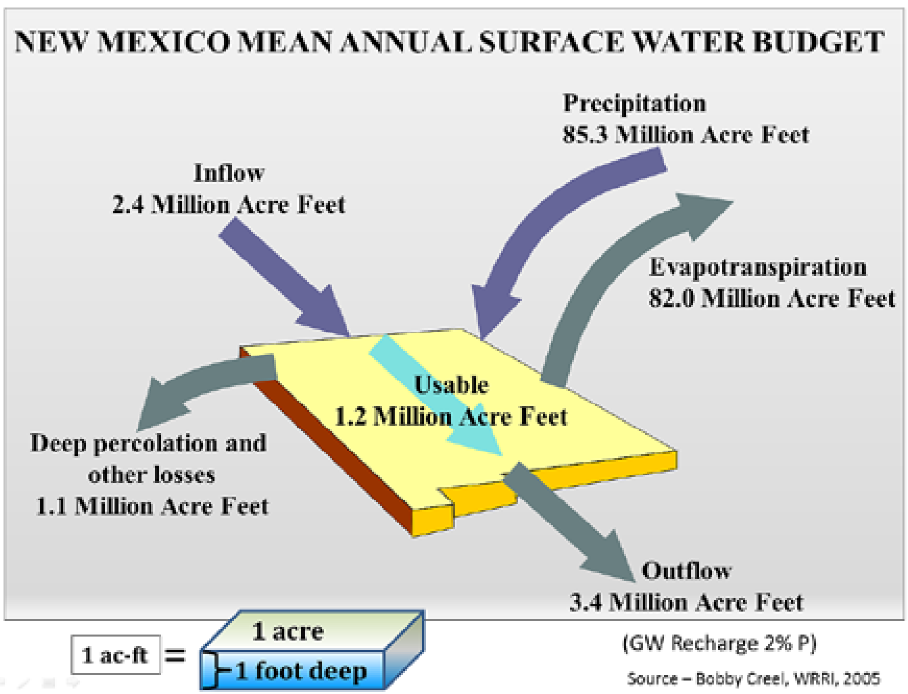
Responding to an audience comment about the Rio Grande being dry at some locations, Fort said, "It has to be our aspiration to actually have a living Rio Grande up and down the river. . . . State law does not provide protection for the ecological health of the river. The time has come to change the law and more explicitly recognize these other values or we will move to a commoditized version of water management."

Refining the answer to ‘how much?’

Climate change, infrastructure, hydrogeology studies help determine how much water New Mexico has

How much water does New Mexico have? The answer depends on a variety of factors that remain little understood, high variable, and in need of better definition. At least that was the answer of a panel of experts at the 57th Annual NM WRRI Conference held Aug. 28 in Las Cruces. Although there are general answers to the question, research is needed to refine the numbers, they say.

Sam Fernald, director of NM WRRI and an NMSU faculty member, said understanding how much water is available to the state depends on “bringing a number of different perspectives” together to deal with water management issues. “We need more research,” Fernald said, adding that a better understanding of the quality and extent of groundwater, groundwater-surface water interactions, and the kinds of supply variability that the state will be facing in coming years are all needed to better piece the puzzle together.



Current figures suggest New Mexico’s average yearly “water budget” is about 1.2 million acre-feet of usable water, Fernald said.Yet there are two million acre-feet of surface water withdrawals and four million acre-feet of total withdrawals in the whole state. Part of the reason this is possible is that water for agriculture is reused as it flows downstream, he said. The balance of the withdrawals are made by tapping groundwater. Fernald referred to the state’s groundwater as “our trust fund. We are not saving it for a rainy day.”

Dagmar Llewellyn, hydrologist with the Bureau of Reclamation, said an assessment of climate change must also be factored into water estimates. She said most water users agree that usable and manageable water “is going to be or already is in decline.” At the same time, demand is increasing, causing a gap between supply and demand. “We try to avoid talking about climate change, but it’s incumbent upon us to tackle the problems of future supply,” she said.

Llewellyn said a study of climate change impacts on the Rio Grande is beginning this fall and the Bureau of Reclamation will be looking for partners to participate. Chaining of events connected with climate change creates highly variable water scenarios for New Mexico, Llewellyn said. “We have to embrace the uncertainty and concentrate on adaptive management.”

Although climate models do not necessarily predict less precipitation for New Mexico, where and when that water will be available may change with new conditions, she said. Heat and drought in the past two years have already pushed the state outside its normal envelope in temperature measurements.

Another factor to be considered is the ability of the state’s water infrastructure to work in an effective way to preserve water and deliver it where it is needed. “A substantial portion of the New Mexico infrastructure is more than 60

Mike Darr

Dagmar Llewellyn

Del Archuleta

Sam Fernald

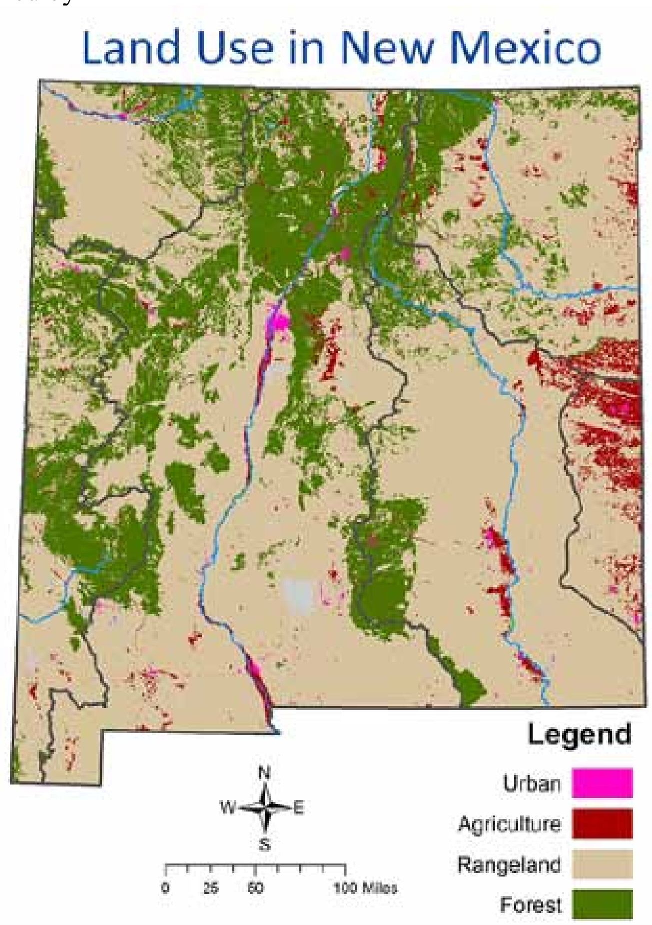
years old," said Del Archuleta, CEO of Molzen Corbin and Associates, an Albuquerque-based planning, engineering, and architectural firm.

A group of 50 engineers studying the systems statewide gave it a grade of "C minus," he said. The system scored a "C" (average) for reliability on a daily basis, but earned a "D" (poor) in the areas of operation and maintenance, Archuleta said. "Preventive maintenance is the last thing we fund in most places," he said, noting that much of the state's infrastructure is in "poor condition and not going to get better." He called for better accounting of existing systems, with leak surveys and other measures and better planning for improvements.

"If we valued water, we would do things very differently," Archuleta said. New Mexico is a state with low capital outlays and low water rates, he said. "We have to face up as a state, every one of us, to the true costs of water and allow our elected officials to build and run sustainable programs."

Mike Darr, a hydrologist with the U.S. Geological Survey in Albuquerque reviewed his work to better understand groundwater in the major basins that cross the border between the U.S. and Mexico. Working with the water resources and research institutes in Texas, New Mexico and Arizona, the Survey has been hampered by funding cutbacks, but is continuing to get results, he said. Much of the effort to date has focused on the Mesilla Basin, in southern New Mexico, and the corresponding Conejos Medanos Basin in Mexico. Las Cruces, El Paso, and Juarez all draw drinking water from this aquifer.

Officials in Mexico are sharing pumping data with their U.S. counterparts to help get a better picture of basin supplies, Darr said. "We want to get at the groundwater quantity and how to share it fairly," he said. Also under way is a project to use surface and groundwater monitoring data to model the interaction and relationships between the two water sources. Darr praised the work of the late Bobby Creel, associate director of NM WRRI, "opening the door for data exchanges with Mexico."



Acequia view

Water-sharing traditions adaptable to 21st Century

New Mexico acequia (photo by Will Keener)

For smaller agriculture users in New Mexico, answers to the water shortage are found in the wisdom of the early Native Americans and Spanish settlers, as well as in the language of prior appropriation. “Water scarcity is nothing new in New Mexico,” said Paula Garcia, director of the New Mexico Acequia Association. “Scarcity is deeply rooted in the land and the people.”

Early state societies have long memories, preserved in oral histories, of dealing with water scarcity “based on a sense of mutuality,” she said. “We have a lot to learn from that type of knowledge as a framework for water sharing.” Garcia’s remarks came during a panel discussion at the 57th Annual New Mexico Water Conference on August 28, 2012. Garcia, who is also a Mora County commissioner, urged state and federal water managers to work with local majordomos and other community leaders to establish a relationship of negotiation and collaboration within the prior appropriation framework.

Prior appropriation is a legal framework used in most Western states to settle water disputes. The system awards water rights based on the dates of filing, with “senior” or early water users having the priority over “junior” rights holders. The acequia systems hold relatively senior water rights, which is a blessing, Garcia said. Farmers understand that “the bigger numbers are going to prevail” and that communities must have water. “We all have a stake in having a viable agriculture system, where we can produce our food locally and it doesn’t always have to come to conflict,” Garcia said.

“From a custom of sharing water between acequias, we are starting to see discussions of sharing water across entire basins, or cities and towns sharing with irrigators. Prior appropriation is a factor, but now we are seeing parties willingly coming together to share water,” she told the audience.

Water markets are in place in New Mexico for buying and selling of water rights and they are "increasingly viewed as a remedy for supply problems." The problem with these markets, she said, is that they focus only on the economic value of water and are not "mindful of impacts on rural communities. . . . Unfettered, water markets could end our agricultural future."

A system that "allows for changing needs, but also protects what we find valuable for our communities," is needed, she said. "We need an adaptive regulatory format for water transfers rather than permanent transfers. We need to allow water to stay in agriculture over the long-term, but still use it to address short-term shortages," Garcia said. The state engineer has proposed alternative water administration tools for the state to administer by priority, with the flexibility to say that if the parties can come together and work out an agreement that will be a viable approach, she said.

She called for users' incentives to negotiate rather than fall back on the appropriations system, when considering new projects. Planning can ensure that access to water is equitable for all users, she said. "This is not a zero sum game, where agriculture loses and some other user with more resources tends to use the water."

Paula Garcia, New Mexico Acequia Association

Despite daunting challenges, New Mexico can improve and adapt to changing conditions, she said. "We have a spirit of cooperation and a broader view of not only looking at our own rights and defending the rights for our communities, but also looking at the water and taking care of it for future generations."

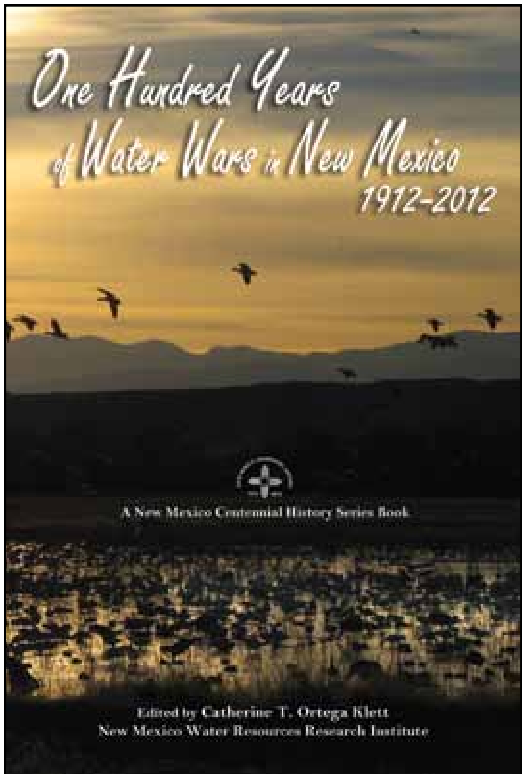
James Witcher inducted to Geology Hall of Fame

Dr. Nancy McMillan, NMSU Geosciences Department Head, presents James Witcher with a certificate commemorating his induction into the Geology Hall of Fame.

Congratulations to James Witcher who was added to the Geology Hall of Fame this year to honor his contributions in the field of geothermal energy. A celebration of Witcher's career was held on Friday, October 26, 2012 at the Geology Hall of Fame Luncheon, at the Farm and Ranch Heritage Museum in Las Cruces.

Jim owns Witcher and Associates of Las Cruces, a geothermal consulting company, and was honored as the preeminent researcher on geothermal energy in New Mexico in 2009 by the New Mexico Energy, Minerals and Natural Resources Department, and the New Mexico Bureau of Geology and Mineral Resources.

Having graduated with a BS in 1977 and an MS in 1993 from NMSU, Jim has had a long association with the NM WRRI. He is the first author of a 2004 NM WRRI technical report entitled, "Sources of Salinity in the Rio Grande and Mesilla Basin Groundwater" and presented a talk at NM WRRI's 2011 annual water conference, "Geothermal Resources Suitability for Desalination in New Mexico."



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