57th Annual New Mexico Water Conference

Hard Choices

Adapting Policy and Management to Water Scarcity

Proceedings

August 28, 2012

Corbett Center, New Mexico State University

57th Annual
New Mexico Water Conference

NM WRRI Report No. 361

Hard Choices:

Adapting Policy and Management to Water Scarcity

co-hosted by

Senator Tom Udall
and
New Mexico State University President Barbara Couture

August 28, 2012
NMSU Corbett Center Ballroom
Las Cruces, New Mexico

TOM UDALL
SENATOR FOR NEW MEXICO

NM STATE UNIVERSITY

New Mexico
Water Resources Research Institute

HARD CHOICES:
Adapting Policy and Management to Water Scarcity

A record crowd of over 470 people registered for the conference and another 50 students attended sessions as their class schedule allowed. The conference was available via a live webcast and is archived for viewing at http://2012.wrri.nmsu.edu/webcast. The webcast is divided into sections for convenient viewing. Photos by Will Keener unless otherwise noted.

USDA Rural Development State Director Terry Brunner and Deputy Undersecretary for Rural Development Judy Canales presented plaques at the luncheon funding award ceremony to Brazito, La Union, and Lake Roberts projects.

Thirty posters were presented on a wide variety of water related research, many by students.

Current New Mexico State Engineer Scott Verhines confers with his predecessor, John D'Antonio.

The first panel focused on where and how much water we have in New Mexico. Panelists included (from left) Sam Fernald, Dagmar Llewellyn, Del Archuleta, Mike Darr, and Steve Vandiver.

Co-hosted by Senator Tom Udall and NMSU President Barbara Couture

57th Annual New Mexico Water Conference

August 28, 2012, Corbett Center, New Mexico State University

Different perspectives on the state's water issues were voiced by panelists (from left), Paula Garcia, Richard Sayre, Denise Fort, and Larry Webb.

Conference participants networked throughout the day.

A highlight of the conference was the "Straight Talk" panel of experienced officials from the New Mexico Office of the State Engineer, moderated by Senator Udall. Seated next to Senator Udall are John Hernandez, Eluid Martinez, Tom Turney, and John D'Antonio.

NMSU professor and conference moderator Phil King took this photo of (from left) Herman Settemeyer (Texas Commission on Environmental Quality), Estevan Lopez (NM Interstate Stream Commission), Gary Esslinger (Elephant Butte Irrigation District), and Mike Gabaldon (Bureau of Reclamation). "It illustrates the power of the annual water conference. These gentlemen have been among the players in many past, current, and pending litigation actions, each against the others. The WRRI meeting brings us all together and reminds us (fleetingly, perhaps) that we have commonality and community, even in the depths of drought," said Dr. King.

Co-sponsors:

- **Los Alamos National Laboratory**
- **Elephant Butte Irrigation District**
- **Rio Grande Basin Initiative**
- **Hazel & Ulysses McElyea Endowment**
- **Sandia National Laboratories**

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DIRECTOR'S STATEMENT

Alexander "Sam" Fernald, NM Water Resources Research Institute

In Spring 2011, Xochitl Torres-Small of Senator Tom Udall's Las Cruces office approached NM WRRI regarding a potential conference on water conservation that the Senator wanted to hold in cooperation with New Mexico State University. A conference planning committee, with input from the Senator's staff, decided to broaden the topic to look at water scarcity in New Mexico, especially as it relates to the ongoing drought. And it became clear that WRRI should host the conference as its 57th Annual New Mexico Water Conference. New Mexico State University President Barbara Couture was eager to co-chair the conference on the NMSU campus.

During the summer, I met with Senator Udall in his Washington D.C. office to discuss the conference and came away with several ideas for the planning committee, including a panel of former New Mexico State Engineers to provide the "straight talk" on water in New Mexico. The Senator was keen to hear lessons from the past and how we can apply those lessons to the future. A transcription of that panel discussion is including in these proceedings.

The conference was held at Corbett Center on the NMSU campus and drew a record crowd of over 500 participants, including more than 50 students. Farmers, ranchers, engineers, experts and community members addressed the impact of water scarcity and explored possible solutions to help New Mexico adapt to the drought. Conference participants were encouraged to ask questions of the speakers as well as to propose their own actions on strategies and policy proposals.

The day following the conference, a diverse group of water policy experts met to discuss and organize the proposals and recommendations that were made at the conference. A Water Conference Report was issued the following April, a product of months of hard work following the conference. We are very appreciative of the effort by this workshop group. The report also includes recommendations by audience members from the conference. The full report is contained herein.

As Senator Udall said, the Water Conference Report represents a continuation of the conversation on water scarcity. The upcoming NM WRRI annual water conference will highlight proposals to deal with the issue. I hope you'll join us for the 58th Annual New Mexico Water Conference, *New Water Realities: Proposals for Meaningful Change*.

I would like to thank the sponsors of the 2012 water conference. Their generosity allowed us to offer a registration fee of only $25. New Mexico State University, Los Alamos National Laboratory, Sandia National Laboratories, Elephant Butte Irrigation District, Rio Grande Basin Initiative, Hazel & Ulysses McElyea Endowment, and Senator Tom Udall made this successful event possible.

Also, thank you to the workshop participants who gave willingly of their time and were respectful and thoughtful while discussing controversial issues:

- Beth Bardwell, Audubon New Mexico
- Greg Daviet, New Mexico Pecan Growers
- Jorge Garcia, City of Las Cruces Utilities
- J. Phillip King, New Mexico State University
- Julie Maitland, New Mexico Department of Agriculture
- Olga Morales, Rural Community Assistance Corporation
- Howard Passell, Sandia National Laboratories
- Fred Phillips, New Mexico Tech

- Blane Sanchez, Pueblo of Isleta/New Mexico Interstate Stream Commission
- Bruce Thomson, University of New Mexico
- Talia Lapid, Senator Udall's Las Cruces Office
- Marco Grajeda, Senator Udall's Las Cruces Office
- Andrew Wallace, Senator Udall's Washington DC Office
- Jeanette Lyman, Senator Udall's Washington DC Office

And lastly, thank you to the conference planning committee members who met many times over the months leading up to the conference and whose insight and suggestions were invaluable:

- Greg Daviet, New Mexico Pecan Growers
- Elizabeth Driggers, Senator Tom Udall's Office
- Gary Esslinger, Elephant Butte Irrigation District
- Sam Fernald, NM Water Resources Research Institute
- J. Phillip King, New Mexico State University
- Julie Maitland, New Mexico Department of Agriculture
- Catherine Ortega Klett, NM Water Resources Research Institute
- Fred Phillips, New Mexico Tech
- Jeanette Lyman, Senator Tom Udall's Office
- Aggie Saltman, NMSU Government Relations Office
- Bruce Thomson, University of New Mexico
- Xochitl Torres-Small, Senator Tom Udall's Office
- Andrew Wallace, Senator Tom Udall's Office
- Frank Ward, New Mexico State University

See you in Albuquerque on November 21-22 at the 2013 NM WRRI annual water conference.

Alexander "Sam" Fernald
Director, NM WRRI

New Mexico Water Resources Research Institute
presents
57th Annual New Mexico Water Conference

HARD CHOICES:
Adapting Policy and Management to Water Scarcity

co-hosted by

Senator Tom Udall and NMSU President Barbara Couture

New Mexico State University Corbett Center Ballroom
August 28, 2012

WELCOME: 8:00 a.m.

- New Mexico Water Resources Research Institute
  Interim Director Alexander "Sam" Fernald
- New Mexico State University *President Barbara Couture*
- U.S. *Senator Tom Udall*

SESSION 1: 8:45 a.m.

Setting the Stage: Where is the Water and How Much Do We Have?
Moderated by *J. Phillip King*, New Mexico State University

- New Mexico's Water Budget, *Alexander "Sam"Fernald*, NM Water Resources Research Institute
- Climate Change, Dagmar Llewellyn, Bureau of Reclamation
- Deteriorating Water Infrastructure and Impact on Supply, *Del Archuleta*, Molzen-Corbin
- The Transboundary Aquifer Assessment Project, *Mike Darr*, U.S. Geological Survey
- Status Quo of Water Rights in Times of Shortage: Legal and Environmental Constraints
  Steve Vandiver, Rio Grande Water Conservation District, Alamosa, CO
- Facilitated discussion

SESSION 2: 10:15 a.m.

Water Users Perspectives: Agriculture, Municipal, Energy, and Environmental Moderated by *Jeff Witte*, New Mexico Department of Agriculture

- Scarcity Impact on Acequias, *Paula Garcia*, New Mexico Acequia Association
- Municipal Water Reuse, *Larry Webb*, City of Rio Rancho
- Algae Water Use, *Richard Sayre*, Los Alamos National Laboratory
- Protecting Our Natural Environment, *Denise Fort*, Utton Transboundary Resources Center
- Discussion with audience on other best practices and policy ideas

BREAK AND POSTER VIEWING: 11:35–12:30 p.m.
(Dona Aña Room and West Lobby)

LUNCHEON: 12:30–1:45 p.m.

- U.S. Department of Agriculture Funding Award Ceremony
- Keynote address by Bureau of Reclamation *Commissioner Michael L. Connor*
- Update by New Mexico *State Engineer Scott Verhines*

BREAK AND POSTER VIEWING: 1:45–2:15 p.m.
(Doña Ana Room and West Lobby)

PANEL DISCUSSION: 2:15 p.m.

Straight Talk: Voices of Experience from the Office of the State Engineer
Moderated by *Senator Tom Udall*
Panelists: *John Hernandez, Eluid Martinez, Tom Turney, John D'Antonio*

SESSION 3: 3:00 p.m.

Building a Plan: Best Practices
Moderated by *Commissioner Michael L. Connor*, **Bureau of Reclamation**

- Environmental Water Transactions, *David Yardas*, National Fish and Wildlife Foundation
- Water Leasing Market Experiments, *David Brookshire*, University of New Mexico
- Rio Grande Basin Opportunities, *Lee Peters*, Peters Law Firm
- Bridging the Gap Between Future Projected Water Demand and Supply in the Middle Rio Grande *Howard Passell*, Sandia National Laboratories
- NSF Water Infrastructure Engineering Research Center, *Nirmala Khandan*, New Mexico State University
- Questions and answers

SESSION 4: 4:00 p.m.

Can We Grow the Pie? Conservation and Supply Opportunities
Moderated by *Bruce Thomson*, **University of New Mexico**

- Working Toward Net Zero, *Benny J. Tomlinson*, Fort Bliss Public Works
- Desalination Update, *Michael Gabaldon*, Bureau of Reclamation
- Watershed Restoration, *Jack Chatfield*, Canadian River Riparian Restoration Project
- Multiple Benefits of Pecos River Restoration, *Paul Tashjian*, U.S. Fish and Wildlife Service
- Salinity Control, *Fred Phillips*, New Mexico Tech
- Discussion with audience on other best practices and policy ideas

FINAL THOUGHTS: 5:25 p.m.

POSTER PRESENTATIONS AND RECEPTION: 5:30-6:30 p.m.
(Dona Aña Room)

TOM UDALL
SENATOR FOR NEW MEXICO

Conference Report

Policy Options from the New Mexico Water Resources Research Institute's
57th Annual New Mexico Water Conference

Hard Choices: Adapting Policy and Management to Water Scarcity

Co-hosted by New Mexico State University and United States Senator Tom Udall

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This conference report is a discussion of a variety of policy options proposed by participants and attendees of the New Mexico Water Resources Research Institute's 57th Annual Water Conference titled *Hard Choices: Adapting Policy and Management to Water Scarcity*. The conference in August 2012 featured five panel discussions and solicited input from all attendees to submit policy ideas for discussion. Following the conference, I directed my staff to work with a diverse group of water policy experts to put this document together to record the policy options for consideration by the public and policy makers.

As we adapt to our ongoing drought and a future where drought may become more frequent in New Mexico and the Southwest, I will look to this conference report as a resource, and I encourage further engagement and feedback from New Mexicans. I would like to thank the New Mexico Water Resources Research Institute Interim Director Sam Fernald and his staff for their tremendous assistance, along with other experts representing agricultural, municipal, environmental, state, federal and tribal stakeholders.

I feel strongly that working collaboratively is the key to overcoming our collective water challenges. I will strive to carry on the Western tradition of leadership on water issues to best serve New Mexico and the United States.

Tom Udall
United States Senator

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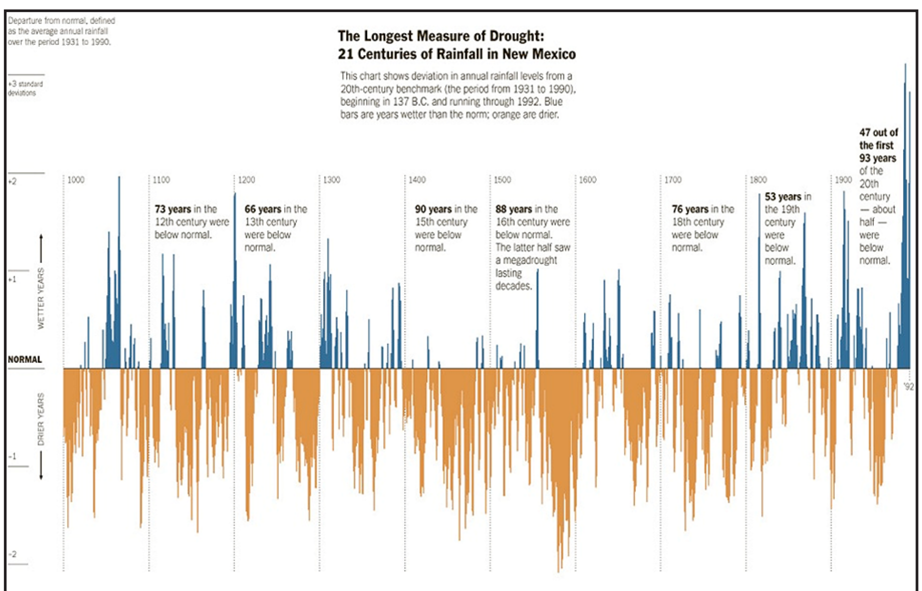
PROLOGUE

The information and proposed actions in this document represent a comprehensive discussion of current and near-future water issues as articulated by regional experts and the public during the 2012 WRRI NM Water Conference. Although the issues range widely over supply, demand, conservation, technology and policy, a relatively simple reality emerges. It is likely to be drier in New Mexico in the decades to come than it has been in recent decades past, as the chart below suggests. By almost any measure, under current trends and trajectories, future water supply will not meet future water demand in New Mexico. Although supply can clearly be augmented in the future by conservation, improved policy and management, and new technologies, the evidence that emerges from the best New Mexico water science is that significant reduction in demand will be essential to meeting the constraints placed by smaller future supplies. Decades of relative water abundance in New Mexico and the region, coupled with large growth in local and regional populations and increased consumption, are leading us to a crisis point for water availability for residential, industrial, agricultural and environmental uses.



Sources: Henri D. Grissino-Mayer, University of Tennessee, "A 2,129-Year Reconstruction of Precipitation for Northwestern New Mexico, USA," 1996; David M. Anderson, National Oceanic and Atmospheric Administration National Climatic Data Center; Graph, Bill Marsh/NYTimes; August 12, 2012

We cannot predict the future, but we can see clearly where robust, long-term trajectories are taking us. We must lay the groundwork now for long-term adaptation strategies while we have the relative luxury of still sufficient but declining water resources. It is crucial that we have strong and visionary leadership, good science, collaboration across sectors and disciplines, and cooperation among stakeholders in order to succeed.

I. RESEARCH, DATA, AND MONITORING

The Secure Water Act

The Secure Water Act authorizes a national water census to determine the quantity of the nation's water resources, particularly in western areas where demand threatens supply and historical supply estimates may be inaccurate. The Act further includes study of lesser known groundwater resources. The Act was approved by Congress in 2009 as part of the Public Lands Omnibus package and authorized over $500 million in federal funds.

- **Proposed Action**: At the current pace, the Secure Water Act is behind schedule on funding. Current and future Administrations and Congresses should be continually educated on the importance of funding the Secure Water Act. This knowledge will help regions, states, and localities better plan for growth and water uses when they have a better understanding of the real limits to supply.

Energy and Water Nexus

New Mexico and the West are major sources of energy production, primarily oil, gas and coal mining. Energy resource extraction is a consumer of water as it is a power generator. The current extreme drought has adversely affected water resources needed for both purposes in various areas, creating potential conflicts with other uses. A range of new technologies and practices promise to increase recycling water in the energy sector which may reduce its water footprint. Further research on how water and energy resources are interconnected and the development of recycling technologies is needed.

- **Proposed Action:** Ongoing federal research efforts into this field are taking place, including at New Mexico's national laboratories. Sandia National Laboratories maintains a research program in this area, and the Department of Energy supports research as well. These efforts should be continued and Congress should consider reintroducing Senator Bingaman's Energy and Water Integration Act of 2011. That legislation would direct the Secretary of Energy to enter into an arrangement with the National Academy of Sciences to conduct an in-depth analysis of the impact of energy development and production on U.S. water resources, including reauthorizing the Water Desalination Act of 1996 through FY 2016. The legislation has been subject to hearings, but no further action. Senator Udall will ensure that this proposed legislative effort continues past Senator Bingaman's retirement.

Federal Water Monitoring Assets

The United States has the largest, most advanced water monitoring network in the world, from satellites orbiting in space to thousands of stream gauges in waterways large and small throughout the nation. Data collected through National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS) are both a very valuable research tool and extremely beneficial to water users in the agricultural, municipal, and industrial sectors.

Unfortunately, recent fiscal pressures on federal spending have led to reductions in funding and the existing monitoring network is eroding. Long-term stream flow data are essential for good future water planning but now, as water is in decline, so too is our ability to collect the long-term data we need to better understand current dynamics and to better forecast future ones. USGS stream gauges in particular are being lost due to lack of operations and maintenance funding, threatening the integrity of historical records going back for many decades. Lack of USGS funding is leading the agency to enter into more and more private consulting contracts with water users and parties to existing water litigation, which may lead to a reduction in their independence going forward.

Several weather and climate monitoring satellites are aging and replacement capabilities are costly to develop and launch. NOAA and the National Aeronautics and Space Administration (NASA) are seeking to maintain their research and development capabilities, but data gaps are possible and future funding uncertain with both agencies facing cuts in the current fiscal environment.

- **Proposed Action:** restore funding priority for federal water monitoring assets, particularly high value and low cost assets like USGS stream gauges. Maintain U.S. weather and climate satellite monitoring capabilities. To underscore the importance of monitoring assets, more research should be applied directly to how they inform management decisions and policy. Funding for the National Integrated Drought Information System (NIDIS) should be reauthorized. NIDIS provides easily accessible drought information; it developed and currently operates the U.S. Drought Portal.

Transboundary Aquifer Assessment Program

The United States-Mexico Transboundary Aquifer Assessment Act authorizes $50 million for the period of FY 2007 through FY 2016 to assess priority transboundary aquifers systematically. Through this program, scientists from multiple universities, the USGS, state agencies, and Mexican counterparts have worked in partnership to collect and evaluate new and existing data to develop high-quality, comprehensive, groundwater data and flow models for bi-national aquifers. The program has developed new collaborations and data exchange between Mexican and U.S. collaborators that have provided an entirely new understanding of the aquifers that straddle the border, including enhanced appreciation of challenges to aquifer sustainability. The goal is to understand availability and water use and to evaluate strategies through sound, scientific analysis in order to protect water quality and enhance water supplies for sustainable economic development on the U.S.-Mexico border.

- **Proposed Action:** Funding for the ten-year program ended two years ago with only a small portion of the legislative funding being appropriated. With the interim report from USGS ready to be submitted to Congress soon, additional efforts should be explored to fund the program, either in standalone legislation or included in existing legislation.

Additional Water Research Priorities

Participants at the 2012 NM WRRI NMSU – Udall Water Conference identified a variety of other high priority research topics. The likely support agencies for this research include the Department of the Interior and its bureaus such as the USGS, Department of Energy, and National Science Foundation. Important topics include:

- *Watershed and forestry research:* analysis of how forestry and forest management practices will impact water supply in local watersheds and regions, including modeling research on relationships between fire, forest thinning, and the resultant impacts on water supply.
- *Watershed supply modeling:* this has been an increasingly useful management tool for government authorities and water users in order to understand connections and trade-offs of watershed practices and water supply management strategies.
- *Southwest climate research:* regional climate studies help predict local impacts of climate change on Southwest water supplies, including Long Term Ecological Research Sites, such as the Jornada Basin and the Sevilleta in New Mexico, which are funded by the National Science Foundation.
    - **Proposed Action:** re-prioritization of agency resources and support for existing, unfunded programs like the Rio Grande Environmental Management Program to address these three research areas.
- *Water supply and growth:* the assumption of continued economic growth and resource consumption may be constrained by scarcity of water and other resources, and water conserved through greater efficiencies may encourage further growth. As water users become more efficient and their conserved water is applied elsewhere, all users have less excess water that could be conserved later, and so can be more vulnerable to natural, wide variations in the availability of the resource. This is called hardening of demand, and, just as it sounds, it can make a region more brittle, and more prone to fracture.
    - **Proposed Action:** encourage National Science Foundation: supported research into the potential limits to growth in regions with constrained water resources, dynamics associated with hardening of demand, and potentially useful adaptation strategies.
- *Water Resources Research Act (WRRA):* continued support of funding for the state-based Water Resources Research Institutes, including the New Mexico WRRI housed at NMSU. These institutes provide independent, basic and applied water research that is useful in their regional watersheds.

- **Proposed Action:** Senator Udall will continue to be one of the bipartisan coordinators of the annual budget requests under the WRRA, and support legislation to reauthorize the program and fund through the USGS.

- *Climate Adaptation Strategies:* the U.S. Department of Interior (DOI), U.S. Department of Agriculture (USDA), U.S. Environmental Protection Agency (EPA), and other federal agencies are cooperating in adaptation strategy planning for federal lands. They are also providing assistance to state and local government for water infrastructure adaptation planning. These efforts are in a relatively early stage, and comprehensive strategies to plan for water resources management have not yet been implemented.
    - **Proposed Action:** Federal efforts should be hastened along with increased coordination with regional, state, and local governments and water users affected by federal water projects.
- *Desalination:* the federal government has supported research into desalination technology for many years, and while progress has been made, the key issues of energy use and infrastructure costs remain significant obstacles at current prices for water in most areas. Desalination has applications for marine, brackish and produced water from oil and gas operations. New Mexico and the Southwest continue to see increasing interest in using desalination for the large brackish groundwater reserves in the state and its produced water, but not at significant volumes. It is difficult for cities and other users to count on desalination technology at its current level of development. If water supplies face greater stress, prices may support greater use of desalination, which is currently providing significant supplies to areas like El Paso, Texas. Combining desalination with solar energy or waste heat has promise, especially in remote locations with oil and gas operations.
    - **Proposed Action:** continue to support progress on desalination research and development, including the Bureau of Reclamation's test facility in Alamogordo, New Mexico. Improved assessment of existing brackish groundwater quantity and quality would aid adoption of desalination where feasible. More uniformity in regulatory frameworks could improve disposal efficiency of concentrate, which is the salt solution remaining after production of treated water, and could ease adoption of desalination technology.

II. WATER SECTOR INFRASTRUCTURE

Municipal and Regional Water Utility Infrastructure Funding

Water utilities in cities, small towns and rural areas are responsible for providing drinking water for the majority of New Mexicans. Drinking water infrastructure uses freshwater resources, either surface or groundwater, and treats it to meet the federal Safe Drinking Water Act and state standards using a variety of water treatment technologies and facilities. Water utilities then supply it to residential and commercial customers via pumping and piping infrastructure. In the smaller communities of New Mexico, drinking water is widely provided by mutual domestic water providers and private water companies. These providers receive little state assistance with their infrastructure.

Utilities are also responsible for wastewater treatment, though coverage is less than for drinking water service in small communities and sparsely populated rural areas. Wastewater infrastructure consists of sewer pipes that collect wastewater from customers, and returns it to a central location for sanitary treatment before discharging it back to the environment, usually as surface water flows. The Clean Water Act and state laws set standards for any such discharges of wastewater into the environment. Local authorities also maintain stormwater infrastructure that channels runoff from rain back to surface-water bodies to minimize flooding.

Water utility infrastructure costs are primarily covered by the water rates that customers pay, which are set by utility boards or local governments. With the enactment of federal standards for drinking water and wastewater, Congress has also provided a variety of federal funding programs over the past several decades to assist water utilities with funding, especially in rural and low-income areas. The EPA, USDA, U.S. Army Corps of Engineers (USACE), and the Indian Health Service have all provided such assistance over the years, some through congressionally directed funds for specific local projects.

With existing federal budget challenges, and congressional spending reform, direct grant funding is very limited at the current time. USDA may still provide modest grants in rural areas for projects with urgent needs, and the Indian Health Service provides grants for Tribal governments. The vast majority of funding is low-interest loan financing. EPA provides funds to the states to capitalize State Revolving Funds and USDA offers direct grants and loans through state Rural Development offices.

- **Proposed Action:** encourage recognition that the federal government is unlikely to provide large grants to construct or rehabilitate water utility infrastructure in the future and encourage local utilities to budget for the long-term.

- **Proposed Action:** enhance effectiveness of existing federal low-cost loan programs, including modest grant portions for low-income areas with limited resources. Effectiveness of loan programs include better cross-agency coordination with USDA, streamlining paperwork to prevent delays and increased costs, and encouraging EPA-state cooperation to ensure federal funds are turned around quickly to local utility recipients.

- **Proposed Action:** update the federal funding formulas to account for shifts in population since the most recent amendments of 1986 and 1996 are out of date. This should lead to increases in funding for many western states that have seen population increases, including New Mexico. For example, legislation considered in the Senate in 2009 would have increased New Mexico's share from 0.5% to 0.75%.

- **Proposed Action:** while reducing loan and project preparation periods, federal loan programs can be used to ensure improvements in local utility practices and regional collaboration for developing sustainable systems. Without large federal grant funding, water utilities and communities will face the actual cost of their water infrastructure in the future. For example, utilities should conduct sound asset management, and only construct assets that they will maintain through their rate base. Utilities should also have long-term planning on rates and conservation actions when accessing federal loans or funds to reduce waste and reflect the value of this essential resource. A long-term business plan tied to the growth level of their community is also important, where their rates support the operation, maintenance and replacement of assets. In addition, some water utility infrastructure projects are local projects chosen and built without taking other regional infrastructure and plans into account. Regionalization can provide an opportunity to improve infrastructure, achieve economy of scale to lower overall costs, and implement conservation and best management practices.

Water Quality Standards

As a result of the passage of the Clean Water Act and the Safe Drinking Water Act, with the last major amendments in 1986 and 1996, respectively, the nation's wastewater and drinking water quality has improved. Treating wastewater before discharging it to the environment and treating water before sending it to customers for consumption is essential to public health. The costs of treatment to utilities, however, are increasing due to higher energy costs, population growth, and increasingly strict standards for contaminants. Some local private utilities and governmental utilities feel burdened by "unfunded mandates" to meet updated federal standards without federal funding to cover the costs. These effects are especially felt by small private non-profit and for-profit water and wastewater companies with limited access to funds to pay for compliance and with a limited customer base from which to collect the cost of compliance through utility rates.

- **Proposed Action:** improve the link of federal funding opportunities to federal water quality standards. In New Mexico in particular, many utilities are struggling to comply with arsenic contaminant standards, given that arsenic is a naturally occurring contaminant in many areas. The reverse osmosis treatment technology used can be very expensive and energy intensive, and recent treatment investments have had mixed success.

New Water Utility Infrastructure Technologies

Much of the water infrastructure currently used to supply, treat, pipe, collect, and discharge water and wastewater is the same technology that has been used for many decades. The focus has been on steel and concrete infrastructure during the post-WWII period where the unit price of both the water supply and the electric power needed for pumping was quite low. In the Southwest, water is becoming scarcer due to climate variability, population growth, pollution, waste, and other factors, and the cost of energy has risen significantly over the past decade. As a result, southwestern and New Mexico water utilities must seriously examine new technologies and practices to adapt to this current environment.

- *Smart Water Technology:* There is significant promise in technologies that will reduce leakage from municipal water delivery systems. EPA estimates leakage rates average around 14%, with some utilities experiencing significantly higher rates. Leak detection and system management can reduce the water consumption needed by utilities and these technologies may have promising applications in agricultural settings. The Bureau of Reclamation has an existing WaterSmart program that provides grants for system improvements and EPA is encouraging utilities to address these issues to improve sustainability.

- **Proposed Action:** further enhancement and funding focus on these programs could advance these goals, as well as federal agency outreach, education, and procurement. Issues to be addressed include: consumer acceptance of better monitoring technology, and a life-cycle understanding and accounting of water "savings."

- *Desalination:* In desert areas with access to salt water either from the ocean or from underground non-potable aquifers, such as in New Mexico, desalination has been a tantalizing proposition for many years. If desalination technology could overcome its high energy costs and waste production issues it could become a very popular solution in many areas. Desalination technology is in operation in several locations in the Southwest, including El Paso's water utility and the Bureau of Reclamation's Brackish Groundwater National Desalination Research Facility in Alamogordo, NM.

    - **Proposed Action:** at large scales, the energy and waste issues associated with desalination remain obstacles in today's environment, when compared to costs of various efficiency measures in meeting municipal needs. Long-term sustainability needs to be further discussed for landlocked operations that are mining a brackish, non-renewable aquifer. Development of modular projects that can use renewable solar or geothermal energy should continue as they are the most promising outlets for desalination development.

- *Reuse:* Another growing trend in water infrastructure is reuse of wastewater for potable or grey water purposes, such as for watering parks. The reality is that almost all areas that rely on surface flows are reusing water that has been treated upstream. Water reuse includes re-injection of treated wastewater into aquifers to further store and treat it, which is starting to occur in places like Rio Rancho, NM. In other cases, treated wastewater is then turned into a product and further marketed for industrial, agricultural or greenspace use. As other supply sources face limited availability and rising cost in the Southwest, more and more utilities are turning to reuse technologies. Reuse increases availability to the reuser, but not necessarily to the system. If reuse can replace aquifer withdrawals, it is more sustainable, but may reduce overall near-term flows into a system. A certain type of reuse may degrade (or upgrade) the quality of ultimate discharges. Reuse is relatively under-utilized, and many aspects of reuse implementation are poorly documented; these include impacts on receiving aquifers, regulations governing quality and quantity of reuse, and policy implications of reuse.

- **Proposed Action:** while reuse should be encouraged at various governmental levels, it is important to distinguish between consumptive and non-consumptive uses. More information will improve local decision-making, particularly documentation of impacts, regulations, and policy implications.

- *Alternative Energy:* One of the major costs associated with providing water is the associated energy costs involved in pumping and treating. Utilities in the Southwest are increasingly using solar energy to limit power costs. Various water infrastructure entities, including Elephant Butte Irrigation District (EBID), are pursuing the use of low-head hydropower in existing channels. Unlike other renewable energy, hydropower faces a relatively stringent licensing process, designed to protect natural waterways.

    - **Proposed Action:** Senator Udall has co-sponsored legislation in Congress, S.629, the Hydropower Improvement Act of 2011, which would create an easier process for licensing in man-made irrigation channels and water pipes.

- *Green Infrastructure:* Stormwater infrastructure makes up a significant part of local government water infrastructure. This infrastructure collects stormwater runoff and channels it through pipes and ditches to water bodies, preventing flooding. Pavement and concrete conveyances, however, reduce absorption and speed up discharges, creating flooding when too much water hits in a shorter time frame than designed. Increasing the amount of green space, porous pavement, green roofs, and vegetation in key areas increases aquifer recharge and slows flows to levels that can be handled by the existing stormwater infrastructure, thus reducing flooding risk. Green infrastructure cannot increase overall water supply, but it can increase local supplies via recharge and retention, and thus opportunities for reuse. Green infrastructure can also improve water quality for eventual discharges through actions of vegetation, and has promise in the wastewater and drinking water sectors.

    - **Proposed Action:** at the federal level, Congress has required 20% and 10% set-asides for green infrastructure in EPA's Water State Revolving Funds in various years since 2009. Senator Udall is the sponsor of the Green Infrastructure for Clean Water Act to require EPA to conduct outreach and incorporate green infrastructure into permitting actions. These initiatives can be continued and enhanced.

Water Supply Infrastructure

Water supply infrastructure is used to refer to the dams, levees, irrigation district systems, and pipelines that manage the flow of surface water. Much of this infrastructure was designed to store and distribute water in a regular, reliable way for the benefit of agricultural production in the arid lands of the American West. On the federal level, infrastructure constructed for agricultural water is constructed and managed by the U.S. Department of the Interior's Bureau of Reclamation (BoR). The U.S. Army Corps of Engineers

(USACE) constructs and is responsible for numerous dams and levees, as part of their primary mission of flood control. New Mexico and other states also have constructed dams, and growers' organizations such as EBID, Middle Rio Grande Conservancy District (MRGCD), and Navajo Agricultural Products Industry (NAPI) take responsibility for water supply infrastructure. Along the U.S.-Mexico border, the International Boundary and Water Commission (IBWC) is responsible for the water supply infrastructure of the Rio Grande.

These water supply infrastructure systems are managed on the Rio Grande and Colorado River according to interstate compacts and the 1944 Treaty with Mexico, which divides water rights among the states and Mexico. Each year allocations are determined based on precipitation and reservoir levels, and then allocated further within states according to state laws. The federal and bi-national agencies are required to coordinate their actions in carrying out the allocations.

In the first half of the 20th century, the federal government authorized and constructed numerous water supply projects throughout the West and several in New Mexico. Since then and in the foreseeable future, new federally funded water supply projects are expected to be much more limited. The majority of current and future projects, both in New Mexico and nationally, are those that meet tribal water settlement responsibilities.[1] Future water supply policy will thus likely focus on maintaining and optimizing the use of existing infrastructure, limited new projects, and more flexible use of existing assets for shared purposes of agricultural water and ecosystem health.

- **Proposed Action:** continue the federal government's progress in meeting its trust responsibility to Tribes and Pueblos by finalizing water settlements and funding necessary infrastructure. Ensure that infrastructure associated with such projects does not degrade the environment and alternative infrastructure supply options are considered. Continue to encourage Congress and the Administration to fund New Mexico settlements in future budgets and appropriations legislation as they have done in the past.

- **Proposed Action:** better manage existing dams and reservoirs in order to maximize both agricultural and environmental water needs. The two purposes are not mutually exclusive – water in the river is used for environmental purposes and it will eventually be used as agricultural water downstream; water used for agriculture (especially through flood irrigation) makes its way back to the river system where it can meet environmental needs downstream. Further study is needed to determine whether and how these federal reservoirs might be managed independently or as a single system; specifically, to provide optimal conservation of water for the several beneficiaries, a drought reserve for the system, and enhanced water availability for consumptive users, agriculture and the environment. Existing project authorizations and state law may provide authority for such operational changes, but amendments to existing authorizations to these projects could be considered if statutory obstacles prevent greater coordination.

[1] These include the Aamodt and Abeyta Settlements, the Animas-La Plata Project, the Jicarilla Apache Rural Water Systems Act, the Navajo Indian Irrigation Project, the Navajo Water Settlement and Eastern New Mexico Rural Water Project.

- **Proposed Action:** encourage better coordination with agricultural water releases among the U.S. states as part of river compacts with IBWC, which handles water releases for Mexico. In 2012, early releases of water for Mexico, due to drought conditions, led to greater losses of water through bed seepage, than when the releases for Mexico, Texas, and EBID are combined. A lack of communication and coordination resulted in controversy that should not be repeated.

- **Proposed Action:** encourage greater scrutiny from the scientific community, water planners, and the public of the large water projects that involve intra- and inter-basin transfers. This will better serve communities as well as provide more opportunities for rigorous technical assessment by the scientists, engineers, water planners and economists in the planning and evaluation, especially when such large projects are subsidized by federal and state taxpayer dollars. Some future projects are still potentially possible in New Mexico, such as within the Arizona Water Settlement Act (AWSA) and Ute Pipeline Project. The Ute project has been funded and is proceeding. However, completion is many years away. It has local support, but ongoing concerns and issues remain.

While the Ute project, now underway, will likely continue, the trajectory of the AWSA is uncertain. A transfer project under the Arizona Water Settlement involving the Gila River has experienced halting progress. Locally preferred options for watershed and river management to meet AWSA goals are being promoted, yet larger scale water transfer projects have faced significant controversy. While some funding is guaranteed for the Gila River water projects, tens of millions of additional federal appropriations would be needed for a large-scale transfer project, and such funding is unlikely to be forthcoming in the near term. Any Arizona Settlement project should not move forward without cost/benefit analysis, feasibility studies, full exploration of economic need, ecological study and full consideration of all proposed alternatives for use of settlement funds and water.

III. WATER TRANFERS AND WATER MARKETS

One of the most promising but controversial ways to better meet competing water needs in the Southwest in the context of increased drought and greater scarcity is the use of water transfers and water markets. For the vast majority of commodities—oil, gas, timber, metals, foodstuffs—market prices drive allocations of resources to the highest economic value user. In many agricultural settings in New Mexico, water is considered a public good or community resource. However, with increasing demand and competition, water is being transformed into more of a commodity.

In the Southwest today, surface water is allocated to agriculture according to long-standing precedents and laws governing water rights. In most municipalities, water is provided to consumers on an equal access basis at regulated prices by governmental or quasi-governmental agencies, or private contractors in some areas. Many rural residents use their own groundwater wells. Groundwater laws and rights are more recent, but access and transfers are fully regulated by state law in New Mexico and other western states.

As the cities in the Southwest have grown, they have acquired significant water rights over the years from agricultural interests, reducing the amount of irrigated land and increasing urban areas in the process. Most of these transfers have been permanent, and are the result of unique, one-time negotiated deals, the terms of which are often not fully transparent to other parties. These transfers are often of surface water rights, but groundwater rights may be transferred as well. Proposed water transfers of groundwater outside a basin are currently the subject of great interest in New Mexico and elsewhere, as the ultimate users and purchasers of the water are yet unknown. Local rural areas are concerned about transfers of groundwater out of their areas and the potential impact to their own wells.

While in the past, the most common water transfer has been from agriculture to municipal, there is growing interest in water transfers for environmental benefits. These transfers are different in that the environmental purpose—instream flow—is not entirely consumptive, and thus water remains for use downstream (though water for riparian habitat may be similar to agricultural water use). They also differ in that they may be most useful on a temporary, rather than permanent basis, such as during droughts or seasonal periods. The federal government has a strong interest in both temporary and permanent transfers under the Endangered Species Act (ESA), where water is needed to preserve at-risk aquatic and dependent bird species that are particularly stressed in times of drought.

Water transfers are controversial for several reasons. In many basins, water rights are not fully "adjudicated" so it is more difficult to make a transfer of title work when not all water rights are fully determined under the law. Full adjudication is not likely to be practical in a reasonable time frame so provisional arrangements may be needed. Contested tribal water rights in particular represent an obstacle to such transfers, if they conflict with the federal government's trust responsibilities to settle their rights. However, they can also serve as a critical tool for helping to settle longstanding conflicts over such rights on a voluntary basis. Additionally, in areas where water rights are held by a large number of agricultural users, each with a small share (such as an acequia), individual sales by willing sellers may undermine the community base of support necessary to maintain agriculture in the area for the water right holders that remain, unless those concerns are affirmatively addressed. This loss of irrigation system viability is particularly acute for acequia systems where ditch-wide sharing of water can be undermined when (1) not enough water is available to move irrigation flows to the end of the ditch; or (2) when water transfers lead to residential developments that physically block or remove connecting sections of ditch.

Many rural residents are also concerned that water transfers and markets will irrevocably lead to the further erosion of sustainable, rural, agricultural communities.

Since water transfers exist, albeit often in poorly operating markets, it is worthwhile to pursue policies which can maximize their benefits of sustainability for all users while minimizing negative, irreversible impacts.

- **Proposed Action:** promote temporary water transfers for instream flows in order to preserve agricultural water rights while maximizing the potential for transfers for environmental use. Pilot transfer programs are a logical way to develop best practices that can help to shape more permanent transfer arrangements on a voluntary basis.

- **Proposed Action:** promote transparency and facilitation of transfers for water rights that are adjudicated. Temporary transfers are especially important where existing rights are not fully adjudicated. Voluntary water transfers are preferable as local, collaborative efforts can achieve desired outcomes while minimizing impacts to users. All water transfers must be voluntary. The state government is primarily responsible for reducing bureaucratic barriers to transactions, although the federal government can also play an instrumental role in facilitating and funding transfers in federal projects.

- **Proposed Action:** utilize facilitated, temporary water transfers as a solution under the ESA and for Tribal water settlements, to avoid the need for more onerous "command and control" regulation to protect threatened and endangered species or to resolve other longstanding conflicts. Such transfers from irrigation districts to address the needs of listed or candidate species should include "safe harbor" type assurances, similar to voluntary Candidate Conservation Agreements with the Fish and Wildlife Service (FWS). These transfers should, however, focus on ecosystem benefits (such as river and riparian health), rather than on a single species.

- **Proposed Action:** enhance safeguards for water transfers with irreversible, potentially negative impacts on rural communities, agriculture, and the environment. Water transfers may need regulation or authority at the irrigation district or acequia level to ensure system integrity. Prohibitions on out of state transfers should be maintained and inter-basin transfer should continue to receive a high level of scrutiny.

- **Proposed Action:** use of federal funds for water transfers can increase achievement of federal environmental goals, and also drive improvements in the transparency and functioning of water transfers, by offering funding as a reward for voluntary participation. Water transfer authority and support of qualified local entities to facilitate transactions should be considered for inclusion in the budgets of BoR, the USACE and IBWC and authorizing legislation. Local issues, local expertise and local control remain very important and it is equally important for federal agencies to understand them in detail.

- **Proposed Action:** pursue methods for streamlining water rights adjudication at the state level. This could include state legislation that places limitations on adjudication options or creates special state district courts or processes for adjudication cases.

IV. ENVIRONMENTAL RESTORATION AND WATER QUALITY

In addition to concerns regarding existing and future surface water supplies and infrastructure, it is also important to maintain and restore healthy river ecosystems and instream water quality. In the late 19th and early 20th centuries, western rivers were almost exclusively managed for their agricultural purposes, flood control, and human development. In recent decades, society has also valued maintaining living rivers, and there have been ongoing efforts to restore riparian habitat and water quality necessary to support diverse aquatic and land-based species—plants, fish, birds, and mammals such as elk. In concert with treatment and riparian conservation, greater scientific understanding of watersheds is leading to forest headwaters restoration projects to improve habitat and water quality within the basin.

- *Instream water quality:* The Clean Water Act sets safety and environmental standards for the composition of surface waters that fall under the Act, interstate waters and those waters with a "significant nexus" to interstate waters. This includes some wetlands and intermittent waters, according to the most recent Supreme Court decisions on the topic. Major point sources of pollution, such as industrial, municipal, and some large agricultural producers are directly regulated by permits from the state or federal government. Diffuse "non-point" sources are covered in less direct and more diverse ways, including public outreach, design standards and local ordinances. Instream water quality—the number and amount of potentially harmful contaminants—has obvious importance for drinking water sources, agricultural irrigation, biodiversity, and ecosystem health.

- *Water quality impairment:* Almost one-third of New Mexico's assessed stream miles have water quality impairment. Watershed restoration and protection have the potential to mitigate and prevent water pollution. Funding of Clean Water Act authorities can assist communities in implementing restoration.

- *Salinity control:* One of the major water quality challenges in the Southwest is the high levels of salts or dissolved solids in instream water. Elevated salinity reduces water's suitability for agricultural uses and increases the amount of treatment necessary for drinking water. Salinity levels are influenced by both man-made and natural factors that vary depending on the area, with pasture and cultivation significant contributors in some areas, according to the USGS. Research from the New Mexico Environment Department (NMED), the New Mexico Interstate Stream Commission (NMISC) and universities indicate that natural causes are the principal factor along the Rio Grande in New Mexico.

  Salinity levels can be reduced by water supply management actions and salinity-control projects that improve irrigation or limit high salinity discharges into waters. Different mitigation efforts may be more or less appropriate in different areas. The Colorado River basin has a well-organized salinity program under the Colorado River Basin Salinity Control Act of 1974, involving the BoR, USDA and Bureau of Land Management (BLM) and the multi-state Colorado River Salinity Control Forum. In 2007, the USGS found that salinity control projects had made progress in reducing salinity in many areas downstream in the Colorado Basin. The Rio Grande Compact

Commission has formed a Rio Grande Salinity Management Coalition, with the Lower Rio Grande as a reach of particular concern. The USACE has begun a Rio Grande Salinity Management Program under the 2007 Water Resources Development Act. The Pecos River also faces acute salinity management challenges.

- **Proposed Action:** continued research is needed on the causes and nature of Rio Grande and Pecos salinity issues, focusing primarily on the link to cost-effective salinity control projects so that growing coordination and management efforts know where to focus resources. Additionally, funding the USACE's program should continue beyond the first phases for the Rio Grande and Pecos River assessment and control projects from a variety of funding sources.

  While the natural causes may not be reversed, agricultural practices upstream may improve the quality of water for downstream agricultural and other uses. Other approaches, such as interception of saline tributary flows, may improve downstream water quality but reduce the volume of available water. Measures should be taken to ensure that water rights are not impaired in quantity to make downstream improvements in quality.

- *Watershed health:* At a broader level, instream water quality is affected by any major landscape change inherent to large urban or agricultural areas, such as through major timber, mining, or energy development. Other factors that determine the runoff rate as a percentage of precipitation in a watershed include: the amount and type of vegetation cover, agricultural use, structures and pavement with impervious surfaces, and the type of substances on the surface, storage in depressions and reservoirs, riparian buffers that impact flow, and groundwater aquifer characteristics, including connections to streams. Standards on these activities are primarily set by local zoning or conservation districts. A narrower or indirect impact is influenced by larger state or federal government decisions, such as industrial permitting or endangered species actions. Any effort to manage or improve water quality and environmental restoration must account for a variety of factors, including erosion and sediment management, salinity control, invasive species, and the relationship between federal and state water quality standards and conservation efforts.

- *Invasive Species:* When it comes to water supply, the primary invasive species of concern are the tamarisk/salt cedar, Russian Olive, and other phreatophytes that thrive in salty, dry soils by tapping groundwater. Many private landowners, non-profits, and government agencies at all levels are conducting removal and control actions using mechanical and chemical methods. There are concerns that the water savings of tamarisk removal are unknown, and if that could be determined it could be weighed along with other conservation or water supply efforts. In addition, the tamarisk beetle, which feeds on tamarisk, has been introduced in neighboring states to control the trees and preserve water for other beneficial uses. The beetle has now been found in New Mexico along both the

San Juan River and in the Rio Grande Basin north of Albuquerque. The final impact of this release is unknown, with some areas seeing success, but others voicing concern of fire risk, lack of certainty on native re-colonization, and the potential of endangering willow fly-catcher habitat.

- **Proposed Action:** balance invasive removal efforts with an emphasis on restoration of native plants and the river processes that sustain them. Increase coordination of tamarisk and other invasive removal efforts and river restoration among agencies and private landowners in manageable watershed units.
- **Proposed Action:** with the beetle acting as an uncontrolled experiment in New Mexico, further research into the potential negative side effects is urgently needed, in order to plan further mitigation activities. Interstate planned introduction of invasive species should also receive greater federal scrutiny.
- **Proposed Action:** support the efforts of the Sevilleta Long-Term Ecological Research (LTER) Program that is currently measuring long-term patterns of tamarisk water use under varying climates and hydrology.
- **Proposed Action:** expansion of research into water consumption by non-native and native phreatophytes should be supported to improve the understanding of effects of vegetation management on river basin hydrologic budgets.

- *Integrated river basin management:* Diverse government bodies and jurisdictions within river basins in New Mexico make coordinated planning and implementation challenging. Various organizations and forums exist to discuss these issues but most have a specific focus, such as protection of endangered species or water delivery among states and not overall planning. Nationwide, large watersheds have developed formalized programs, such as the Great Lakes and the Chesapeake Bay, to address the coordination issue and seek and use limited conservation funds more effectively. These programs incorporate various river basin commissions that plan and manage deliveries, but also incorporate land use and conservation projects.
    - **Proposed Action:** enhance collaboration between states, different agencies, and water users within basins such as the Rio Grande and Pecos River basins. Build upon and tie together existing efforts, such as the Compact Commissions, Endangered Species Collaborative, state water agencies and plans, and conservation efforts like the Rio Grande Environmental Management Program. A federally chartered program for these basins could be authorized via legislation, on a consensus basis among the state delegations. This is an ambitious effort and should start with voluntary and coordinating efforts to build trust, which is especially important in the current environment. Use integrated river

basin computer simulation modeling developed with multiple stakeholder involvement to evaluate consequences of various future water management strategies.

- **Proposed Action:** continue implementing the Secure Water Act's Basin Study Program. Even with existing divided management of water resources in major basins, integration can be improved with better information. The Secure Water Act, enacted in 2009, has funding for basin studies and water assessments to give planners and stakeholders better information about how much water is available. The Lower and Upper Rio Grande studies were initially funded in 2011 and the Pecos in 2012, with federal and state/local cost-shares.

- *Riparian and watershed restoration projects:* A diverse group of governmental and non-profit organizations and private companies are funding and implementing riparian and watershed preservation and restoration projects. There appears to be much more demand than funding in the current environment, especially following the recent catastrophic wildfires in the West. These efforts are not necessarily coordinated or part of a broader plan for watersheds. The Rio Grande Environmental Management Program is a recent attempt at coordinating and funding these efforts, but it has not yet been funded.

    - **Proposed Action:** protect federal funding for river/ecosystem restoration in the budget process. Federal funding is available for land acquisition through the Land and Water Conservation Fund (LWCF), which can include associated water rights. Other land conservation funding comes from federal agencies such as the BLM and USDA, the National Fish and Wildlife Foundation (a non-profit chartered by Congress), and a variety of other sources. Most of these organizations focus on land conservation, but for southwestern rivers in drought, more conservation resources could be focused towards water acquisition or temporary transfers for environmental flows and conservation. One option that could be pursued would be to use state legal provisions such as those found in instream flow laws. These provisions allow water rights owners to temporarily release their water for instream uses as a beneficial use, or to abandon their water right and dedicate that water to instream use. However, New Mexico does not have an instream flow law and therefore has fewer options for temporary transfers than surrounding Western states.

    - **Proposed Action:** provide non-structural green infrastructure approaches for flood control along with traditional levee-based protections. Restoring the natural channels for rivers increases riparian habitat. Many riparian habitats have been significantly altered by the channelization for flood control purposes. Under USACE reforms enacted by Congress in 2007, more analysis is now used to ensure that non-structural options are considered and implemented where appropriate. Several stretches of levees in New Mexico will need reconstruction in coming years. Amendments to existing authorizations for these flood control projects could be considered if statutory obstacles prevent adequate consideration and construction of non-structural green infrastructure.

- **Proposed Action:** flood control can, in some areas of the state, be coupled with storm water capture and re-use, thereby adding to the benefits and economic performance of infrastructure investments. Institutional barriers, such as some requirements of the Clean Water Act, may need to be relaxed in order to support and encourage creative storm water management to best fit hydrologic conditions and user opportunities.

V. AGRICULTURAL PRACTICES

As late as the 1950s New Mexico was largely self-sufficient in terms of food production for human consumption. The development of the interstate highway system, expanding food production in California and other states, and the increasing centralization of food distribution across the United States made the importation of food to New Mexico economically viable. Since then, much of the agriculture in the state has transitioned to forage crops for livestock. This makes an important economic contribution throughout the state. However, future energy prices and overall economic conditions may one day make cultivation of human food crops in New Mexico much more important than it is today. Maintaining agriculture in the state for the future could one day mean greater food security for New Mexico citizens.

Agriculture is the largest user of water in the Southwest and New Mexico by a wide margin. If water supplies become scarcer—and/or population and economic growth lead to greater demands for water in other sectors—improvements in agricultural efficiency or changes in regional agricultural practices may provide a promising solution. However, the place of agricultural water in the overall water cycle is complex, and the ultimate impacts of proposed changes should be understood beforehand.

- *Crop changes:* Different crops use different amounts of water and produce different values. In the West, one of the more common, relatively high consumptive use crops is alfalfa hay. Making changes to different crops is challenging when feed crops like this are low-risk, easy to produce and have ready nearby markets in local cattle and dairy producers. Furthermore, farmers producing these crops often have senior water rights and little incentive to reduce use by switching to a higher value, but riskier crop, which can lead to loss of water rights over time. It is also important to realize that while water is a significant factor in a farmer's crop choice, it is one factor among many that is considered.

    - **Proposed Action:** agricultural producers are good at adapting over time to new developments, including changes in water supplies and climates. These producers often prefer not to have to adapt to changes in policy. In the U.S. agricultural economy, crop-specific mandates are unsuitable and should be avoided. Better market signals to the agricultural economy could produce better value-based decision making on behalf of individual producers. Existing regulations and incentives should be re-examined to ensure that they do not needlessly encourage or subsidize such crops at the expense of others that may provide higher value.

As discussed in other sections, water is not clearly valued in a market and doing so across the agricultural, municipal, and industrial sectors could have far reaching, permanent impacts that eliminate long standing rural communities. This would reduce rural representation in political decision-making, creating a negative feedback loop for agricultural communities. In contrast, encouraging optimization of water management for multiple purposes and temporary water transfers within agricultural and environmental sectors is a promising alternative. This could introduce better market signals while keeping water available for agriculture and the environment, in potentially mutually beneficial arrangements.

- *Irrigation Practice Changes:* Many arid areas have seen a shift from flood irrigation to drip irrigation systems to reduce the amount of water needed to produce the same value of crops. These systems require an upfront cost, which can be recouped based on improved yield and quality. Additionally, in some areas where absolute scarcity is reducing the deliveries to irrigators, a shift to drip irrigation systems can allow them to maintain higher yields. However, local evidence indicates that current flood irrigation practices along the Rio Grande reduce salinity and recharge aquifers. If irrigators withdraw the same amount of water from a river, but use it more efficiently, they will return less water, with higher salinity concentrations. There is an efficiency conundrum, because using more water for consumptive plant use leaves less water for hydrologic and environmental services of percolation and seepage.

    - **Proposed Action:** improve and expand current instream flow opportunities that allow water users to lease, loan, or permanently release unused or unneeded water for dedicated use as instream flow.

    - **Proposed Action:** drip irrigation may be appropriate for some growers who are not receiving the necessary water for flood irrigation on the same yields. But in a "use it or lose it" water rights context, greater efficiency means more yield, and greater consumptive use. Promoters of drip irrigation must focus on where water savings from irrigation practices go, and how to implement the practices for what purpose. Policies and regulations to enhance conjunctive use of surface water and groundwater could help ease the conflict between irrigation efficiency and ecosystem benefits of unconsumed water.

    - **Proposed Action:** New Mexico and irrigation systems in the West have also seen some upgrades in infrastructure to avoid leakages in ditches. Covered ditches can reduce evaporation and increase the amount of water available for irrigators, all things being equal. But, again, more efficient irrigation systems are likely to increase consumptive use but may reduce return flows. Additionally, they may increase salinity if they also reduce seepage back into riverine aquifers and no "savings" are applied for transfers to environmental or other agricultural uses. State and federal programs aimed at improving irrigation efficiencies, such as those implemented by the Natural Resources Conservation Service, should be maintained and broadened.

- *Water market changes:* When the full agricultural hydrologic cycle is taken into account, along with the water rights rules that drive the incentives of individual users, it becomes clear that large-scale changes in crops and irrigation should be part of a broader water reform effort. This ensures that water savings are applied in a beneficial way. Without a way to temporarily transfer water savings to other users, irrigators have little to gain from reducing absolute consumption. In times of drought, these potential savings represent real opportunities to address scarcity for other agricultural users, as well as instream environmental flows (which are sometimes mutually reinforcing). Mechanisms for instream environmental flows are rudimentary in New Mexico and may limit aquatic ecosystem management options.

- *Intersectoral transfers of conserved irrigation water:* Most agricultural water conservation practices do not aim to reduce the depletion of water by crops, but rather to reduce the non-consumptive losses such as canal seepage and deep percolation. The reduction of applied water through reduced non-consumptive losses may interrupt recharge processes if the "conserved" water is moved to another use or location. The effect can be masked for a time by reduction in groundwater storage, but longer term negative consequences must be considered.

    - **Proposed Action:** any federal efforts to incentivize more water-efficient crops or irrigation systems should take these factors into account. Funding then may provide an incentive for states to provide avenues for transfers that are acceptable to irrigators and communities—especially temporary transfers during times of drought. As noted elsewhere, water transfers can be highly controversial when water rights are withdrawn from agricultural use or transferred from one basin to another.

VI. WATER CONSERVATION

"Do more with less" is a common sense response to scarcity of any resource, and water conservation is an ongoing goal especially in the municipal and commercial sectors. Federal agencies such as the EPA, state agencies like the New Mexico Office of State Engineer, local water utilities large and small, non-profit organizations, businesses, and many individual citizens view using less water as both the smart thing to do to save money and the right thing to do with a scarce resource needed by all to survive. Much progress on water conservation is underway in the U.S. broadly, and in New Mexico in particular, with some success in terms of lowering per capita use of water. However, water conservation efforts need to be considered holistically for all their effects since water conservation and efficiency can be either absolute—less water used—or relative—less water used in one instance leading to equal or greater water use overall. One consequence to water conservation is that it can allow for new and other uses of the conserved water leading to a "hardening of demand," where users learn to adapt to less water by using less. The problem arises when periodic scarcities occur, but there is no longer any room for any greater conservation or greater reduction in demand. This can create a human system that is more fragile and more prone to fracture and collapse of one kind or another.

- *Municipal water efficiency:* Arid and developed areas in the United States have higher per capita municipal use rates than similarly situated developed areas elsewhere in the world (such as in Israel or Australia). In addition to fixing leaky infrastructure, municipal efficiency can be increased through more climate appropriate landscaping, more efficient appliances, and behavioral changes. Utility water pricing will also drive conservation by commercial and residential users. Conservation of municipal water use allows for extension of existing infrastructure, reducing local costs. Conservation also allows for continued growth in areas with limited water rights and availability. It is unlikely that major municipal water efficiency efforts will meaningfully increase water supplies for other users in the system, however. Municipal use makes up 6% of the water use in New Mexico, so municipal conservation does not provide huge supply benefits long-term.
    - Proposed Action: consideration should be given to using aquifer injection or other storage to set aside conserved water for times of scarcity, rather than always allowing conserved water to be allocated to further growth in water consumption by default.
    - Proposed Action: all arid municipalities should improve efficiency in order to prudently prepare for future shortages in times of drought and climate change. In an emergency, where there are no "savings" and the response is rationing of existing supply, citizens tend to support strong efficiency measures.

In times of adequate supply, local water managers must show that conservation has a purpose. Users will want to know where the "saved" water is going. For municipalities that wish to grow, conservation already is a cost-effective option in many cases and will likely improve its relative future costs compared to obtaining new water rights or drilling new groundwater wells. As an additional benefit, conservation does help preserve agricultural uses at the margin. Conservation of groundwater pumping extends the life of wells. Environmental flows are a benefit but require public acceptance and/or funding to drive municipal conservation.

Overall, the linkages and beneficiaries should be clearly understood, and value allocated accordingly. For example, if a city wishes to expand and provide water to a new development, the developers may compensate existing water users' conservation efforts to more directly link the costs and benefits. As with irrigation efficiency, there is a conundrum with conservation. Conservation does not create new water supplies to address supply variation and scarcity. Conserved irrigation water is used for more crop production and conserved municipal water is used for more house construction, largely because of the use-it-or-lose-it legal backdrop. Current efforts often simply cite conservation as a virtue, not an incentive, which may limit mass adoption and effectiveness.

Fewer concerns exist regarding the scarcity in arid areas at the national level. Improving appliances through mandatory and voluntary standards like the WaterSense label will limit costs of sustaining a growing population with finite water flows. Limiting leakage from water systems through smart water efforts and water reuse efforts will be driven by local concerns, but the federal development and standardization efforts will help those who want to access them.

VII. WATER RESOURCE PLANNING

The institutions for managing water infrastructure, supply, and planning for future water scenarios become even more important in times of scarcity. Persistent drought, whether through natural cycles or human-induced climate change, may severely test these institutions and organizations in the years to come.

As many have observed, the distribution of the major surface waters in the Southwest—Rio Grande, Colorado, Pecos—was determined during a time of plenty and in areas with much different populations, economies, values and distributions than exist today. Federal agencies are responsible for managing their infrastructure in a way that spans watersheds, but local management and policy is determined by states and units of local government, including water districts, which do not match up with watersheds.

These existing water management organizations are primarily focused on managing within sub-basins, for the current and upcoming water year, and on the long process of determining rights and responsibilities based on the past. Planning for the medium and long-term future at a regional or basin level is a lower priority, especially when budgets are tight and water tensions are high. Management and planning also typically occur within certain stakeholder jurisdictions—agricultural water supply organizations plan, cities and towns plan, and large industrial users plan, but not necessarily as part of the same process. As a result, conflict can often arise during scarcity as managers and planners look outside their jurisdiction to make up shortfalls.

- *Water Storage:* The historical way to manage water scarcity in the West has been the numerous dams and reservoirs to store water during wet times and release it during dry times. At this point, the major focus is on maintaining the existing water storage system. No major new water storage projects are likely on western U.S. rivers due to cost and environmental concerns. There are no other feasible ways to store large volumes of surface water, and reservoir evaporation is a significant problem in extended dry times, with large loss factors.

  The only other option in more local contexts is aquifer storage, where water (often re-used wastewater or other resource) is injected into the groundwater aquifer for later withdrawal. The City of Rio Rancho is conducting injection storage of treated wastewater, as is the Albuquerque-Bernalillo water utility, and NMED expects future projects in New Mexico.

- **Proposed Action:** maintain federal and state reservoir capacity through operations and maintenance of aging infrastructure. Improve the effectiveness of this storage capacity by ongoing improvement of water operations, such as the recent agreement to improve water management in the Colorado River Compact. Different schedule and delivery plans will have different water losses and environmental trade-offs. If the human and environmental benefits of minimizing the losses can be realized then the overall pie can increase, within limits.

  Aquifer storage activities will be pursued where cost appropriate, especially as a way to increase public acceptance of re-use. State and federal permitting standards seem to be adequate at this time but may need revision if receding groundwater and water rights issues drive a major increase in the activities. Aquifer storage may reduce surface flows in some places at times and increase them in others. These water supply and environmental impacts need to be understood before undertaking the actions.

- *Intrastate Regional Planning:* Different regions of New Mexico do not always communicate on their individual water plans, and several stakeholders questioned whether the New Mexico State Water Plans are effective. This plan was first produced in 2003, updated in 2008 and will be updated again in 2013. While much progress has been made, there are many areas where the state plan can provide greater benefit, such as better coordinating regional plans that use the same water from a closed basin. One important consideration that will undoubtedly be addressed is the fact that we are experiencing significantly different water availability than in 2003.

  - **Proposed Action:** update the State Water Plan to provide: greater clarity on the state's water budget; ongoing areas of water rights adjudication and settlement; greater coordination among regions, especially within watersheds and basins; and a platform for greater state participation in interstate water organizations. A water development board distinct from but complementary to the Office of the State Engineer could help coordinate solutions by planning across multiple water sectors. Planning efforts should be paired with new field investigations to identify potential systems for aquifer storage and recovery.

- *Regional Watershed Planning:* It is a common refrain in water policy, but there is truth to the belief that greater regional watershed planning will be beneficial. First, the act of planning and negotiating can be consensus building, or at least clarifying. Repeated rounds of planning meetings with little strategic implementation, however, can quickly become irrelevant and frustrating. At the local levels planning tends to be focused on tangible topics with authorities able to implement them, but the greatest need is with larger intrastate and basin planning. This planning is challenging, especially given the Rio Grande Compact where the effects of drought disproportionally impact downstream users. States are going to be disproportionally impacted, so the incentives for cooperation in planning are limited.

- **Proposed Action:** stakeholder-driven planning will focus on the key issues of the day and keep implementation processes in mind. It is difficult to plan when water rights are uncertain and stakeholders are at direct odds. Nevertheless, with New Mexico facing its worst drought in decades, stakeholders in the state need to come together at the various planning forums with an open mind and commitment to flexibility in pursuit of their interests.

  Strategic implementation of this planning ensures its benefit. A major example is the future commitments of water users and management groups, along with municipal and environmental interests, to provide flows to secure river ecosystem health and for endangered species such as the silvery minnow. In the absence of such planning, the Fish and Wildlife Service will likely implement what it finds necessary under the Act without as much local input.

  One way to encourage planning and cooperation is the joint development of a watershed model in stakeholder groups. When the underlying assumptions are agreed upon, different interests can view the impacts of various actions and changes, such as different water operation plans for the Rio Grande Compact. Sandia National Laboratories and others have experience developing these models and walking groups of users through them in a learning process, and this could be done for the Rio Grande.

  There is significant ongoing federal funding for operations and maintenance of water infrastructure in the Southwest. In the future, this funding could be used to encourage greater regional planning by prioritizing funding towards areas with successful planning operations.

- *River Compacts:* Three major river Compacts affect New Mexico—the Colorado Compact, the Rio Grande Compact, and the Pecos Compact. All have been the subject of litigation over the years. Conflict is seemingly increasing in many areas as projected supplies under the Compacts are failing to materialize. These Compacts were negotiated and signed in an era with vastly different population, water use, economies, values and climate characteristics, and implementing them is challenging. As noted elsewhere, a major update was recently made to the Colorado Treaty between the U.S. and Mexico. The update included new ways to share shortages among the U.S. and Mexico, transfer water from Mexico to the U.S. in the near term (in exchange for infrastructure funding), and enhance delivery of water to the Colorado River Delta ecosystem along with expanded environmental restoration efforts.

- **Proposed Action:** the federal government could sponsor initiatives that focus on revisiting the seven or eight inter-state Compacts to update them based on current understandings of water budgets and future climate projections. This is obviously a large, complex, and likely controversial undertaking. The status quo, however, is also large, complex and controversial, as the underlying reality is changing in the river basins. The Compacts were signed when the purpose of water management was to "green the desert" for agriculture, whereas now the preservation of agriculture is one goal among many others. The Rio Grande Treaty and Convention of 1906 may be next in line for a similar attempt to update between the United States and Mexico, which could benefit water users and the environment in both nations. Short of major changes to existing compacts states, federal agencies, and water users should explore ways to update and change practices under the existing rules.

VIII. ADDITIONAL SUGGESTIONS FROM AUDIENCE

Session 1

- Use cisterns upstream to catch rainfall to reduce flooding and recharge aquifers.
- Regarding agriculture use - take great care with water rights transfer; moving agricultural water to Mexico and elsewhere is extremely risky; regulated deficit irrigation can save significant amounts of water – agriculture must consume most water.
- Promote conservation - invest in efficient irrigation systems to market the water that is conserved for ex moving from gravity systems to center pivots.
- Restrict development - development must be accompanied by new regulations regarding water use recycling conservation. Development must be accompanied by advances in water sustainability regulations research technology. "Smart" development may mean a moratorium on development until we have a plan for the future!
- Implement wastewater treatment on Indian lands for economic development for these tribes; make agreements with tribes and support reuse.
- Conservation – Involve youth by creating sponsorships with federal, state and tribal agencies to sponsor water conferences that address water conservation strategies and help teach kids at an early age to conserve.
- Create water abuse laws and have water cops (i.e. Albuquerque Water Authority fines users for using sprinklers at certain times of days).
- Compacts from 100 years ago no longer work and we need to revisit them.

- Need a study to control the damage done to the Pecos River by Golden Algae.
- Educate the public on the value of water and increase water rates to reflect the true cost of water and the cost in providing it.
- Make link between water and other resources scarcity and population growth.
- Redo all water laws – Need water laws that are nationwide policies and those that look at whole cycle without separating surface and groundwater; we need to eliminate the rule of capture that allows landowners to take their neighbor's water; and stop policies that encourage maximum water consumption.
- Balance impacts to local, rural communities with the needs of larger cities' industrial uses of water - or more specifically, what policies could secure a balance of impacts across the landscape to assure rural water uses, environmental water is not impacted to a greater degree?
- Texas has right of capture philosophy, there needs to be consideration at a national level to end such philosophies.
- Currently water laws deal with surface and ground water separately. But surface and ground waters are interrelated. We need to look at the possibility of a total makeover of water laws based on total water cycle.
- New Mexicans have been leaders in the areas of water conservation, new technology and collaborative decision making and we need to export our knowledge skills to the many arid regions of our country.
- What percentage of New Mexico's water basin aquifers are considered mined - that is, current and future water rights are based on an "acceptable" but constantly declining water table.
- We need more enforcement mechanisms for water conservation and infrastructure improvements - there is a gap between what water distribution systems pump and what they bill.

Session 2

- We need to find out what local and regional efforts are now underway that brings diverse stakeholders together; learn from these efforts about what has worked; utilize existing stakeholder collaborative efforts and make clear goals and timelines for those goals transparent to participants.
- Look at storm water for passive aquifer recharge and figure out how to streamline the EPA policies which are cumbersome at permitting such activities. The U.S. Forest Service needs to manage forests to meet at least one of the 1897 mandates to provide favorable supplies of water. This can be mandated to implement best watershed management policies as described in many USDA publications.

- Tax each user on acre foot usage and let the State Engineer's office administer the taxation since they have the data. No exemption to cities and community wells.
- Make funding available through FEMA and the National Flood Insurance Program for watershed floodplain management for maintenance of infrastructure and flood mitigation.
- Communities that are contributing funds through the CRS program should be benefitting from some of the millions of dollars that are given through flood insurance policies.
- More cross agency cooperation to manage watersheds and regulations. EPA-FEMA; NMED- NMFMA; Industry/MS4 communities.
- Our Compacts are based on uncharacteristically wet years and our paper water obligations exceed wet water more often than not. We need to renegotiate the Compacts.
- Regarding the FSA Programs – we need programs for drought assistance to help producers in irrigation districts. In Southern NM many of the canals and laterals could be "piped" that run through producers' farms. We know that "piping" a canal can save hundreds of acre feet as well as allow producers to pump irrigation water into the pipelines that can cut fuel cost and ground water losses.
- Along the lines of Del Archuleta's talk, the state should develop methods of allocating more funding to water conservation and maintenance of systems. This funding should focus on conservation and not more bureaucracy because water and money are so scarce and both must be used effectively.
- Adopt water user fees. Use revenues to subsidize large agricultural user conversion to drip irrigation or other water conservation technologies.
- If water is the limiting resource for many proposed new business projects then more emphasis should be spent determining if the project is viable based on water needs at the onset. Businesses spend effort on other aspects of the development of the project and the public is involved in public comment but emphasis needs to shift to water availability and the impact of the proposed project as the initial step to assessing a new business development.
- Aquifer storage should be considered under Compacts as well as reservoir storage. Reconsider use of reservoirs given the high evaporation rates. Encourage crops that are lower water users to allow restoration of mined aquifers.
- The Office of the State Engineer uses unrealistic regulations to deny farmers access to their ground water rights. If you do not have an operational well on your farm you are prohibited access to your water rights. Your neighbor is prohibited from pumping for you, although this metering is available to report this pumping. There needs to be discussion about what recourses are available to the agriculture industry to work around this problem.

- The prior appropriations doctrine is the law in NM. How is it that farmers "share the shortage" rather than first in time first in right?
- Limit growth to a specific percentage per year similar to Davis, California which is at 1%.
- Resume water banks allowing those to sell their water rather than grow crops with it.
- Short term water transfers are a huge mistake. A short term expedited transfer policy is an easy and quick route to avoiding the issue of growth versus agriculture and environment.
- Green meeting practices would be appropriate to be the example of sustainable behavior (i.e. asking people to bring their own drinking cup; not using or providing water bottles).
- We should accelerate the adoption to treat household grey and black waste water so it can be reused. It's cheaper to retrofit rural residences with sewer systems than it is to build rural semi-rural region waste water treatment systems.
- There should be more transparency in whether there are any foreign interests in NM water.
- There is concern in the lower Rio Grande about how farmers can have confidence that the Office of the State Engineer has their best interests in mind if they are considered Texas as far as the compact.
- More transparency about how much ground water NM has and how long it will last.

Transcription of Water Conference Opening Remarks by New Mexico Senator Tom Udall

Tom Udall became New Mexico's 17th United States Senator on January 6, 2009, after two decades of public service as U.S. Representative and New Mexico's State Attorney General.

Born to Stewart and Lee Udall in Tucson, Arizona, on May 18, 1948, Tom's roots in New Mexico are deep. His grandmother, Louise Lee, was born in Luna, New Mexico, during territorial days and was part of a ranching family in what is now Catron County. Her family used to drive cattle down the White Mountains to the railroad in Magdalena.

In the Senate, he serves on five committees: the Appropriations Committee, specifically the Subcommittee on Energy and Water Development; the Committee on Foreign Relations; the Committee on Environment and Public Works (EPW); the Committee on Indian Affairs; and the Committee on Rules and Administration.

As a member of the Environment and Public Works Committee, Tom works on important environmental and infrastructure issues, including water policy. That Committee's jurisdiction includes the Army Corps of Engineers Civil Works Program, the Clean Water Act, the Safe Drinking Water Act, and the Endangered Species Act. On the Indian Affairs Committee, he continues his longtime mission of helping shape the unique matters concerning Native Americans, including water settlements, economic development, trust responsibilities, land management, Indian education and health programs.

Tom is married to Jill Cooper and they have one grown daughter. In Tom's spare time he enjoys tennis, fly-fishing, mountain climbing, and staying involved in his community.

New Mexico Water Resources Research Institute Director Sam Fernald, thank you for that kind introduction. The water resources research institutes, I believe, across the nation are very valuable. Congress authorized these institutes in every state in 1964 and New Mexico's was one of the first in the nation and I believe it is one of the very, very best. I also would like to thank President Barbara Couture. New Mexico State University is a tremendous asset for Las Cruces, Doña Ana County, New Mexico, and the Southwest as a whole, and especially for our state's important water resources and agricultural economy.

> As the famous Irish writer Oscar Wilde once said, "A cynic knows the price of everything and the value of nothing." In New Mexico, we cannot afford to be cynical about the value of water.

We have a full program today packed with a great amount of insight for our state's water challenges. I want to thank everyone who is participating as a moderator, speaker, and panelist. And finally I want to thank everyone who is attending today or watching our webcast online. We need everyone's help to ensure sustainable—and we need to make that word mean something—water for New Mexico.

What we are trying to do here today was very powerfully brought to me when I walked in. One of our participants said in a very frank way, "We want to get to the truth about water in New Mexico; we don't want to hear a lot of lies." He gave it to me straight as you can see. And that's how I've felt for a long time, so I have joined with Barbara Couture to bring people together today.

Secondly, we want to look at the big picture. I'm going to try to lay out the big picture before we move to our panelists. Part of this was exemplified this morning on the front page of the *Albuquerque Journal* where drought was discussed and the Mayan culture of a thousand years ago. The article said we need to look at what happened there and see if there is anything to learn. The article referred to an archeologist by the name of Jerry Sabloff, and I want to read just a couple of sentences summarizing his thoughts. These are the questions we should be asking as we get into our panels. Sabloff thinks we need to look across the Southwest and ask serious questions about where we are headed given our vulnerability to drought and the changing climate. Sabloff asked, “Are we going to allow unfettered growth? How resilient do we want to be? What sort of steps are we willing to take to get there?” These questions are really what I want this conference to be about. I want you to participate in finding those steps that we are willing to take, build that consensus, and move forward on collaboration so we can come together on water.

Let me start first with the value of water. Adam Smith, one of the creators of modern economics, called water an example of the paradox of value. A diamond is very beautiful, but it has a limited function and it’s very expensive. Fresh water is essential to human life and yet it is very inexpensive. The average American uses about 100 gallons of water per day, costing about 20 cents, total. A one-carat diamond can be worth $3,000, that’s worth 1.5 million gallons of tap water, enough to keep 100 people alive for over 80 years for each of them. A simple answer to the paradox is that diamonds are rare and water is plentiful. But Adam Smith’s point was that the price does not always equal value. As the famous Irish writer Oscar Wilde once said, “A cynic knows the price of everything and the value of nothing.” In New Mexico, we cannot afford to be cynical about the value of water.

Indian tribes and pueblos have a deep spiritual connection to their water sources. Farmers, ranchers, conservationists, city dwellers, and small business people all have some kind of special relationship with water. New Mexicans are very conscious compared to many others Americans about water and about the impacts of water. I believe we face a critical time and need to redouble our efforts when it comes to the preciousness of water and how we think about it.

Figure 1 gives you the big picture. This is the picture of drought in America today. Over 50 percent of the United States is in drought. The agricultural losses have been stunning with the highest corn prices on record. The drought in the Midwest is so bad that parts of the Mississippi are impassable for barges, over 100 are stranded. High feed prices are devastating for New Mexico ranchers and dairies. I joined other Senators in calling for a reduction in corn ethanol this year to ease prices. This year the Senate passed an updated, bipartisan farm bill with my support. We’re hoping the House will act on that bill or at least a drought disaster bill. Our farm policy needs to adapt to an era of high commodity prices and more drought disasters. Producers will likely need fewer subsidies but more emergency assistance.

Figure 2 is a close-up look of drought in New Mexico. All New Mexico counties have been declared drought disaster areas by the USDA and are eligible for assistance. Unlike many areas in the country in drought, these dry conditions in New Mexico have been going on for several years. The current stretch of drought is the worst since the 1950s and we are not through it yet. Handouts on your tables provide drought assistance information for farmers and ranchers. Of course, our farmers and ranchers would prefer not to need that assistance. Like our rivers, our cities, and towns, and our industry, they need water. Times of drought and shortage lead to short tempers and

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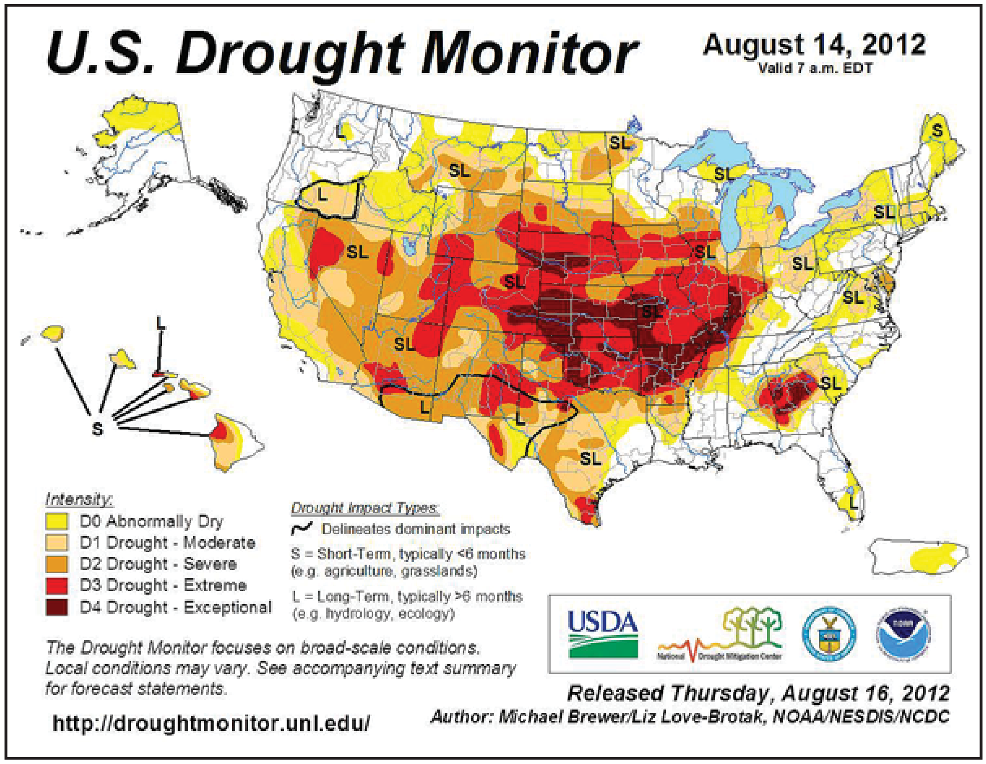


Figure 1. Drought in America as of August 2012

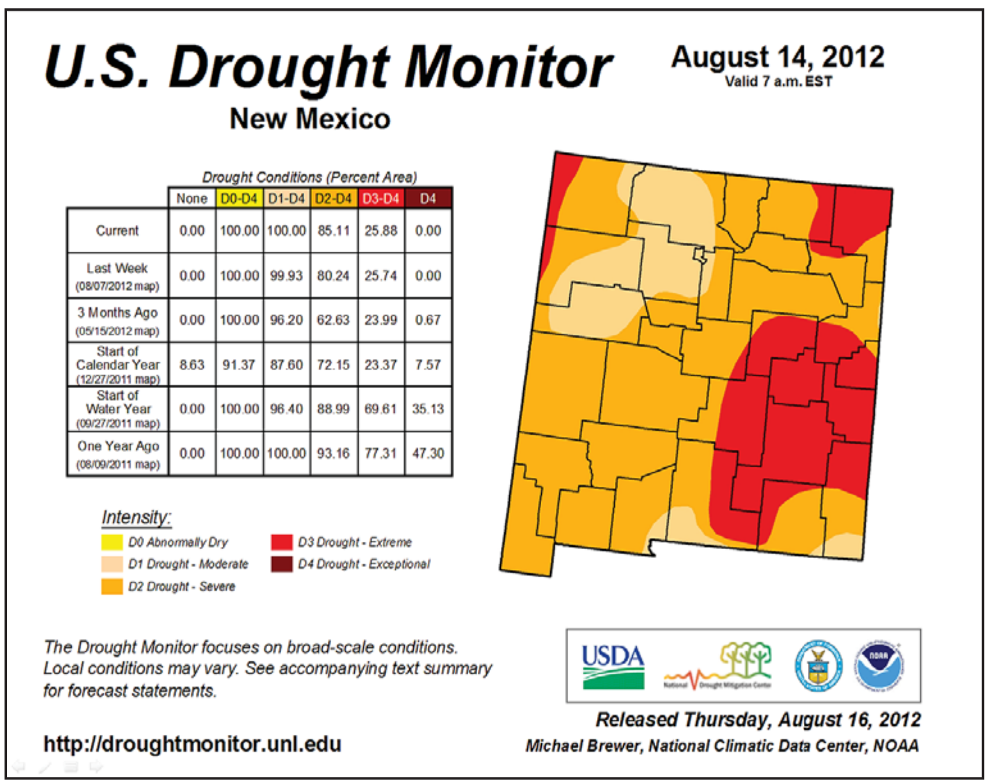


Figure 2. Close-up of drought in New Mexico, August 2012

litigation. I'm sure all of you have heard the old saw many times: in most places in the country, water is for drinking and whiskey is for fighting. But in the West, that is reversed, water is for fighting, whiskey is for drinking. Determining who has rights to what water is a story that is as old as the West.

In the background of the current drought is global climate change. Federal, academic, and international scientific bodies are all warning us of the increasing risk of greenhouse gas emissions. Projections for the Southwest indicate hotter and dryer conditions with the potential for both greater fires and greater floods when water comes. Sandia National Laboratories recently published a peer-reviewed study of the economic impacts of hotter and dryer conditions, focusing on impacts to water. I quote from that study, "The average risk of damage to the U.S. economy from climate change at the national level is on the order of $1 trillion over the next 40 years.

Figure 3 shows that New Mexico is at particular risk. This map shows state by state impacts. Sandia estimated losses of $25 billion for New Mexico and over 200,000 jobs lost over that 40-year period from now until 2050. Most of those 200,000 jobs are losses in terms of agriculture. Climate scientists say that climate change loads the dice in favor of drought.

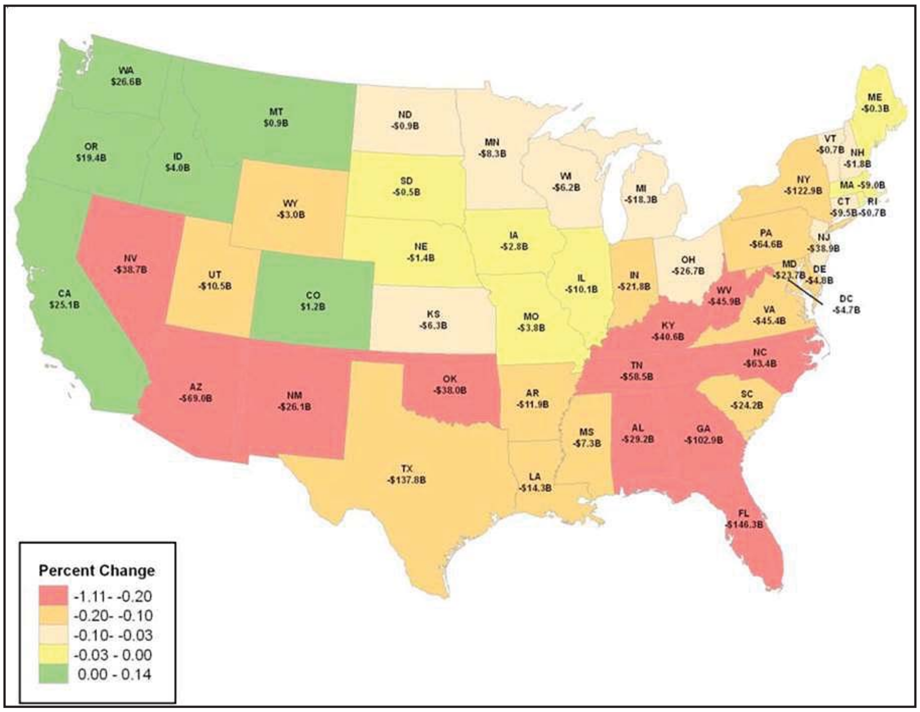


Figure 3. Possible economic state impacts due to climate change

Now how much water do we have? Given the climate risks, New Mexico and other regional watersheds need to ask a basic question—how much water do we realistically have? First, how much surface water can we expect, taking into account historical conditions, current drought conditions, and potential future conditions. We will look to our first panel to help answer this question.

Figure 4 shows that the early 20th century had historically high flows in watersheds that future years might not match. This chart appeared two weeks ago in the *New York Times*. It was based on studies of tree rings from northern New Mexico. It shows dry and wet years going back over 1,000 years. On the far right we can see the early 20th century and that in recent years, we have experienced historically high rainfall. The Colorado River Compact was signed in 1922, and the Rio Grande Compact was signed in 1938. I believe this kind of data shows that we need to plan for potentially drier times. I want to point out that when looking at this graph, we see that at the time when we were entering into the Compacts, we were experiencing wetter periods. We have been experiencing wetter periods than we've seen in the last 1,000 years. What is striking is to see over 1,000 years is how many more drier times we've had than wetter. It's something we need to realize and deal with, talk about, and understand.

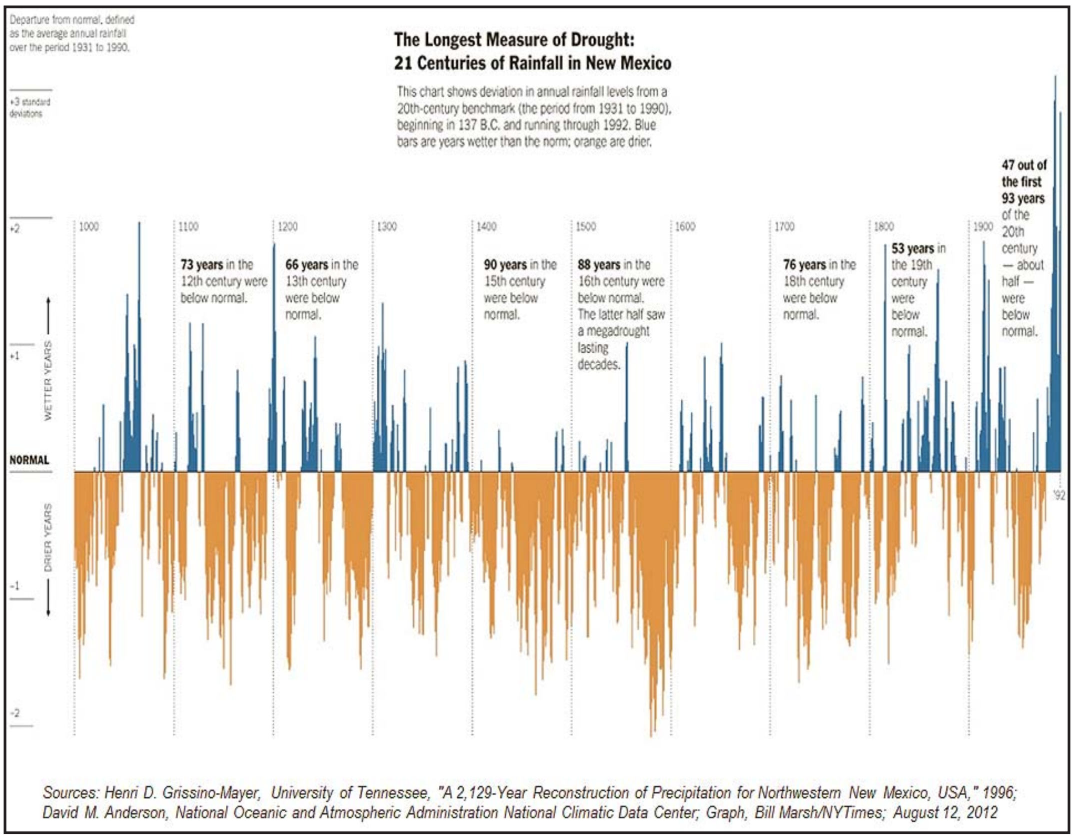


Figure 4. Measuring drought in New Mexico over 21 centuries

New Mexico's surface waters have been completely allocated for decades. Paper water often exceeds wet water and conflict can result. As shown in a 2004 water supply study of the Middle Rio Grande, New Mexico would not meet Compact obligations over 50 percent of the time under drought condition (Fig. 5). If conservation actions were taken, we could almost meet our obligations as seen by the blue bars in the chart, an average deficit of 7,100 acre-feet. Under drought conditions, New Mexico would be out of balance even with conservation measures. It would fail obligations more than 50 percent of the time. This is shown by the maroon bar, an average deficit of 41,000 acre-feet.

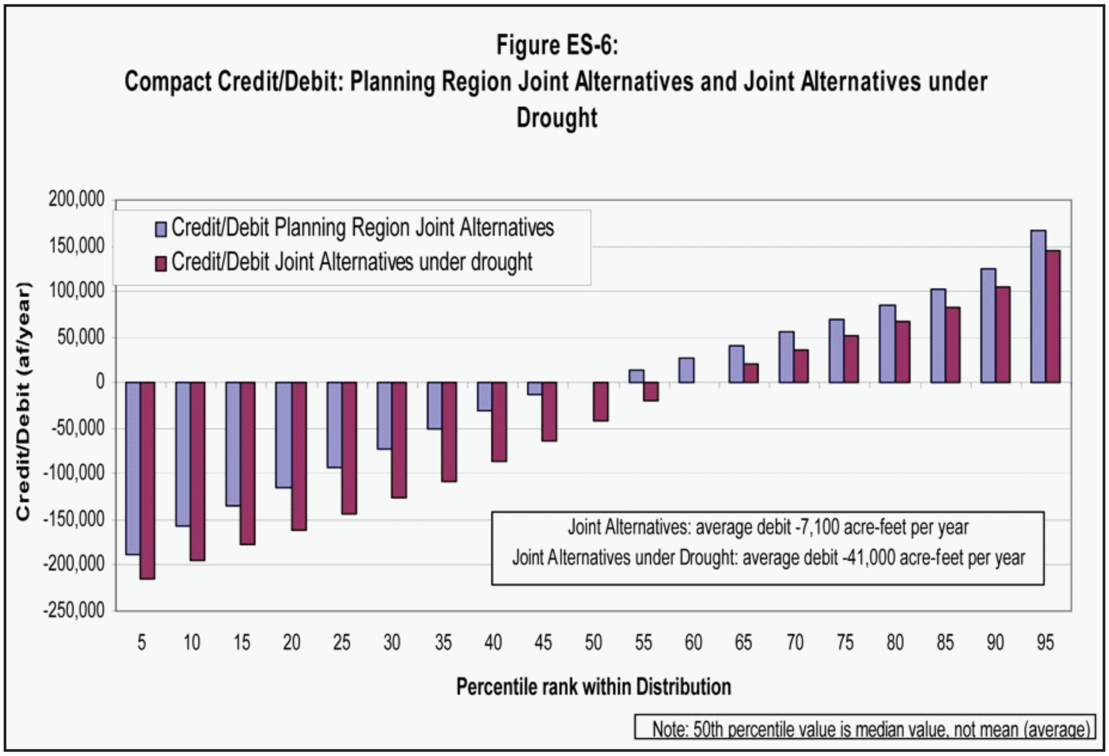


Figure 5. Meeting Compact obligations in the Middle Rio Grande under drought conditions (2004)

Sandia National Laboratories recently published a peer-reviewed study of the economic impacts of [hotter and drier conditions], focusing on impacts to water. I quote from that study, "The average risk of damage to the U.S. economy from climate change at the national level is on the order of $1 trillion over the next 40 years.

In addition to Compact obligations, surface water is also affected by the Endangered Species Act (ESA). A new biological opinion is due this year. The ESA can be a blunt instrument, but seemingly insignificant species can be the canaries in the coal mine. If our rivers cannot support their traditional life, how long can we live off it?

As with surface water, New Mexico's water supply is uncertain since groundwater is out of sight. There is a natural tendency to be optimistic, but in eastern New Mexico, the Ogallala aquifer is dropping. Pumping in the Albuquerque area has had to be curtailed to allow the aquifer to recover. Here in the southern New Mexico, drought and unregulated pumping in Mexico are having a major impact.

Figure 6 is an image from a recent report from the scientific journal, *Nature*. The color scale represents their estimate of groundwater stress that is going on around the world. As you can see, the U.S./Mexico border region from Texas to Arizona is seeing heavy stress. Areas with similar stress are in the Ogallala and areas around the world like the Middle East, Iran, India, and China. A U.S. intelligence agency report recently predicted this situation could cause political instability in these areas overseas, and of course we want to avoid that.

I believe we are at a crossroads where we will have to make hard choices. The hardest choice is between conflict and cooperation. I realize how difficult this is. In this room, we have organizations that are actively suing each other over water. Municipalities and agriculture have had disputes in several New Mexico areas. Texas and New Mexico have a long history of litigation over the Rio Grande. The U.S. and Mexico disputed the Treaty of 1944 for many

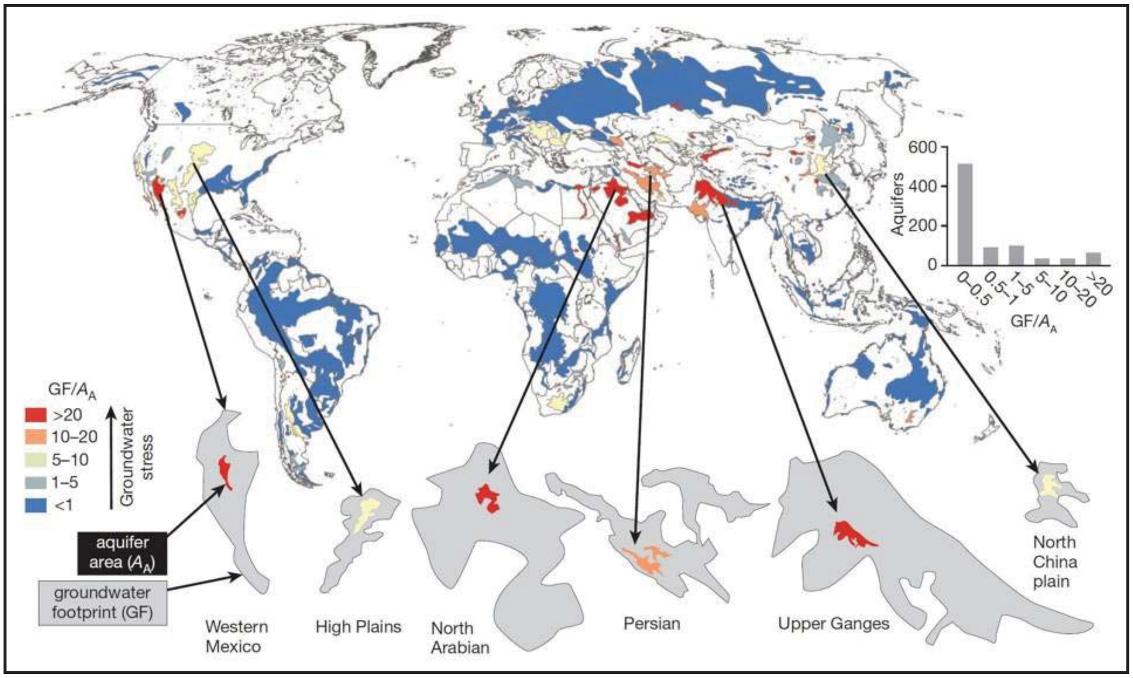


Figure 6. Groundwater stress across the world

years. This spring we had a dispute when the International Boundary and Water Commission sent water to Mexico early in the irrigation season with little coordination with other relevant agencies. New Mexico is involved in litigation with the Bureau of Reclamation. Developers are filing controversial plans to transfer water outside regions. Recently the federal government brought litigation to claim groundwater rights associated with our surface water flows.

Some people may think it is a little ironic for a member of Congress to offer their thoughts on cooperation versus conflict. One poll has the Congress's generic approval rate as low as 12 percent. As John McCain has said, we're down to staffers and blood relatives at this point. But I hope you will bear with me for a minute. I do not believe that most members of Congress are bad people. Most of us have a higher individual approval rating than 12 percent. I sure hope I do. But the wrong rules and process can lead good people to unproductive conflicts—our campaign finance system for most special interests and fund raising over the public interest and legislation is an example. Rules in the Senate like holes and filibusters allow one senator or a small minority to block the process of voting on nominations or legislative ideas. I proposed a number of ideas to improve Congress by reforming these kinds of rules and at the very least we need to discuss and debate which rules are best.

Figure 7. John Wesley Powell's suggested state boundaries based on watershed boundaries

Like Congress and the federal government as a whole, western water policy has arcane rules and overlapping agencies and jurisdictions. When John Wesley Powell first surveyed the American West , he traveled western rivers (Fig. 7). Most famously he led the first European expedition down the Colorado River through the Grand Canyon—and he only had one arm. He realized the importance of river basins and watersheds as shown on his land-marked maps. You can see by this figure how he thought the West should be organized. In fact, he made recommendations and a big fight ensued in the Congress. He recommended that western state lines be drawn according to watersheds to promote the best management of the most valuable resource. He felt the most precious resource in the West is water, and the states should be organized around watersheds.

Well, you know what can happen to a good idea. Figure 8 shows current state lines. The rivers are all on there but little square boundaries were drawn to create states.

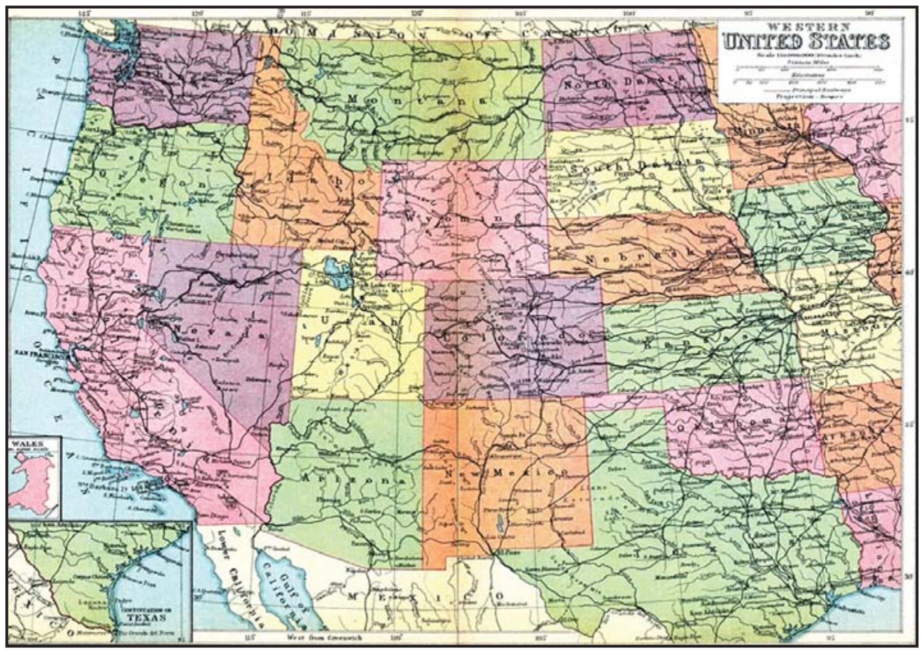


Figure 8. State boundaries

By one count, there are at least a dozen federal agencies with some authority over water. States also have multiple interested agencies involved with water and local governments do as well. All of these factors can make conflict more likely than cooperation.

Our conference is focused on water policy in the context of drought, but I do not have a specific policy agenda I'm trying to promote. My agenda for today's conference is to improve our process and to try to build some consensus. NMSU and the WRRI have brought together some of the best and brightest in a collaborative format. We are also seeking audience input both during and after the conference. Following the conference, my staff and the water institute are going to get together and produce a compilation of options from what we hear today. We are going to post that report on our websites and solicit further input. Any specific policy options may or may not have broad consensus or be fleshed out in complete detail, but they will be available for anyone to use as a resource, whether as a citizen, an advocate, or a local, state, or federal official.

I want to be the first to tell you, I don't have all of the answers. I know there are many of you in this room who worry every day about water—from farmers and ranchers to engineers. There are some goals that I would like to lay out for us today in terms of water policy: focus on the reality of supply and on the future, not past disagreements; maintain sustainable New Mexico agriculture—once again the keyword is "sustainable," let's make that mean something; enable sustainable municipal and industrial growth; restore living river systems and streams in New Mexico for fishing, recreation and wildlife; avoid litigation when possible; understand surface and groundwater supply through monitoring and data; adapt to the new era of federal policy and earmark moratorium resulting in fewer projects, tighter budgets; create opportunities for regional planning and coordination especially for drought conditions; and improve communication and coordination among numerous agencies.

Drought is not the most uplifting topic as we all know, but I think there are reasons for optimism. I will list just a few here: slow but steady progress toward an accommodation between agricultural water use and urban use and between acequia use and city use; combining interests of agriculture and the environment to encourage greater instream flows; progress in recycling water in municipalities and in the oil and gas industry; progress in the desalinization of brackish aquifers using solar power; the development of algae biofuel projects in New Mexico, which can utilize brackish water for an agricultural and energy enterprise; smart water technology that can reduce the massive amounts of leakage from our aging infrastructure; a new federal role of technology leadership with assistance and facilitation building on past successes of regional watershed planning both locally and among western states. We will hear more about these and other ideas from our panelists today.

As I wrap up, I would like to talk specifically about the federal role in water. Figure 9 is a list of the active major water supply construction projects to be built in the coming years. As you can see, the 21st century will still see some new major water supply projects in New Mexico. Almost all of these result from tribal settlements.

TOM UDALL
SENATOR FOR NEW MEXICO

MAJOR FEDERAL ONGOING WATER SUPPLY PROJECTS IN NEW MEXICO

Aamodt Settlement—San Ildefonso, Nambe, Pojoaque, and Tesuque Pueblos and surrounding communities. Regional Water System cost - $106.4 million. Claims Resolution Act of 2010.

Abeyta Settlement—Water projects for Taos Pueblo and local water users including acequias. Cost $144 million. Claims Resolution Act of 2010.

Animas-La Plata Project – includes the Navajo Nation Municipal Pipeline in NM. Cost estimate $586 million. Colorado Ute Settlement Act of 2000.

Jicarilla Apache Rural Water Systems Act –$45 million authorized for water infrastructure. Jicarilla Apache Rural Water Systems Act in 2002.

Navajo Indian Irrigation Project –Part of the Colorado River Storage Project, irrigation for the Navajo Agricultural Products Industry (NAPI).

Navajo Water Settlement - Navajo Gallup Pipeline to supply the Navajo Nation, Gallup, and Jicarilla Apache Nation. Total cost estimated at $995 million. Omnibus Public Land Management Act of 2009.

Eastern New Mexico Rural Water Project –Ute Reservoir pipeline to Curry and Roosevelt counties to replace Ogallala water. Estimated cost is $500 million. Omnibus Public Land Management Act of 2009.

Figure 9. Major ongoing federal water supply projects in New Mexico

The 20th century federal water policy was defined by big projects and big laws. Think of Hoover Dam and all the dams and reservoirs in New Mexico and across the West that were authorized and funded by Congress. Congress also passed the Clean Water Act, the Endangered Species Act, National Flood Insurance Act, and the Agricultural Assistance Program.

Much of recent decades has been spent maintaining, implementing, and litigating these projects and laws. Outside of tribal settlements, future funding is unlikely except for a few major projects. Major new water laws are also unlikely in the current climate. So if the era of major federal water projects and legislation is coming to an end, what can we expect in the future? My vision is for a more flexible, adaptive, and collaborative federal role. The federal government is in a great position to do pilot projects with new technology. For example, I think the federal government can lead with smart water pilot projects that reduce leakages and losses using information technology. The federal government can also act as an information and best practices clearinghouse. I proposed legislation for EPA to promote, but not mandate, the use of more natural green infrastructure for stormwater management that can help recharge groundwater, reduce flooding, and save on construction costs. The federal government must continue to lead on research, monitoring, and data collection. Funding cuts to these functions are dangerous and it's like flying blind.

My vision is for a more flexible, adaptive, and collaborative federal role. . .The federal government must continue to lead on research, monitoring, and data collection.

Finally, I hope the federal government can facilitate regional water planning. As we saw on John Wesley Powell's map, our state boundaries and our watershed boundaries do not match up. Back in the 1960s and 70s, river basin commissions and interstate compacts agreed to by states with a federal role were quite popular. They still exist in some places, mostly in the eastern half of the U.S. We need not revive them exactly, but regional and interstate planning is a must. To improve the federal role we must also look to reforming and coordinating federal water agencies. After 9/11, Congress quickly reformed many different security agencies. Secretary Salazar did the same after the BP Deepwater Horizon Spill. Drought is a natural disaster with contribution by climate change, and it may acquire a similar response.

I want to thank you all for being here. Let's get started with the conference.

SESSION ONE

Setting the Stage: Where is the Water and How Much Do We Have?

Moderated by Phil King, New Mexico State University

Phil King is a Professor and Associate Department Head in the Civil Engineering Department at New Mexico State University, where he has been since 1990. He specializes in water resources engineering, and in addition to teaching, research, and service, he works as a consultant with Elephant Butte Irrigation District. Phil has PhD and MS degrees in agricultural engineering from Colorado State University, a BS in civil engineering is from Berkeley, and an MBA from NMSU. He served in the Peace Corps, as a Science and Technology Policy Fellow with AAAS at the National Science Foundation, and he is currently a Bill Daniels Fellow for Ethics.

New Mexico's Water Budget

Sam Fernald, NM Water Resources Research Institute

Sam Fernald was appointed interim director of the New Mexico Water Resources Research Institute (NM WRRI) in January 2011. As interim director, he will lead the institute in its mission to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems.

The NM WRRI, one of 54 water institutes in the nation, encourages university faculty statewide to pursue critical areas of water resources research while providing training opportunities for students, and transfers research findings to the academic community, water managers and the general public. Professor Fernald also is a faculty member in the Department of Animal and Range Sciences at New Mexico State University.

Dr. Fernald's earned degrees include a 1987 B.A. in international relations from Stanford University, an M.E.M. in 1993 in water and air resources from Duke University, and a

I will start this morning with the drier part of my talk: water budgets. Figure 1 shows New Mexico's water budget—water coming into and water going out of the state. This diagram was produced by Bobby Creel of NM WRRI in 2005. In a typical year, we have 85.3 million acre-feet of precipitation, with most of that, 82 million acre-feet, going back to the atmosphere through evaporation from water, soil, and plants and transpiration—water that goes through plant roots up to the atmosphere. New Mexico receives 2.4 million acre-feet river inflow annually, and 3.4 million acre-feet on an average annual basis goes to downstream neighbors for compact deliveries. The state also loses another million acre-feet in deep percolation and other losses. An acre-foot is defined as the volume of water that would cover one acre to a depth of one foot. When it's all said and done, on average we have 1.2 million usable acre-feet of surface water in New Mexico.

One of my key points is that we have multiple perspectives concerning water and all are valid. If you look at the state's water withdrawals, we have about 2 million acre-feet of surface water withdrawals. Given that I just said we have 1.2 million acre-feet of usable water, how can that be? This is due to reuse of water. For example, we have studies of acequia irrigation in northern New Mexico where water is diverted from the Rio Grande, put into fields, with water seeping through fields and ditches, and in some of the wettest situations, only 7 percent of the diverted water is actually used and eventually goes back to the atmosphere. In other extremely efficient cases, we have nearly 100 percent consumptive use. So even though we have 1.2 million acre-feet of surface water hydrologically, in terms of withdrawals, we can have up to 2 million acre-feet, more or less, of surface withdrawals for the whole state.

Ph.D. in watershed science from Colorado State University in 1997. His primary research interests include water quality hydrology; land use effects on infiltration, runoff, sediment yield, and nonpoint source pollution; and effects of surface water/ groundwater exchange on water availability and water quality. Dr. Fernald received a Fulbright Scholarship to Patagonian National University, Trelew, Argentina in 2008, and another Fulbright Scholarship to the University of Concepcion, Concepcion, Chile in 2000.

Dr. Fernald currently is leading a multi-institutional, five year, $1.4 million water research project funded by the National Science Foundation. In addition to NMSU, partners in the study include the University of New Mexico, New Mexico Tech, Sandia National Laboratories, the New Mexico Acequia Association, and the Maxwell Museum.

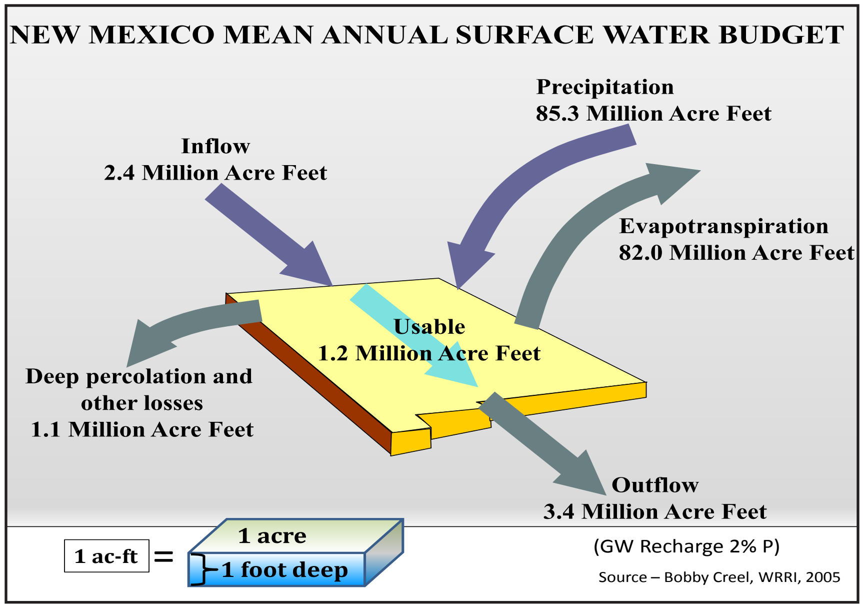


Figure 1. New Mexico mean annual surface water budget

Figure 2 shows New Mexico's water withdrawals for 2005 with agriculture using about 78 percent, public water supplies accounting for a little over 8 percent, and 1 percent for commercial/industrial, mining, power, domestic wells each. How do we get close to 4 million acre-feet of withdrawals with only 1.2 million usable acre-feet available? Groundwater makes up that difference. Groundwater is like a savings account or trust fund that we're drawing on and not saving for a rainy day. Groundwater has become part of our regular water withdrawals and represents about 47 percent of New Mexico's annual withdrawals. Thus different perspectives that are seemingly at odds, if looked at hydrologically, they can be compatibilized, if that's a word.

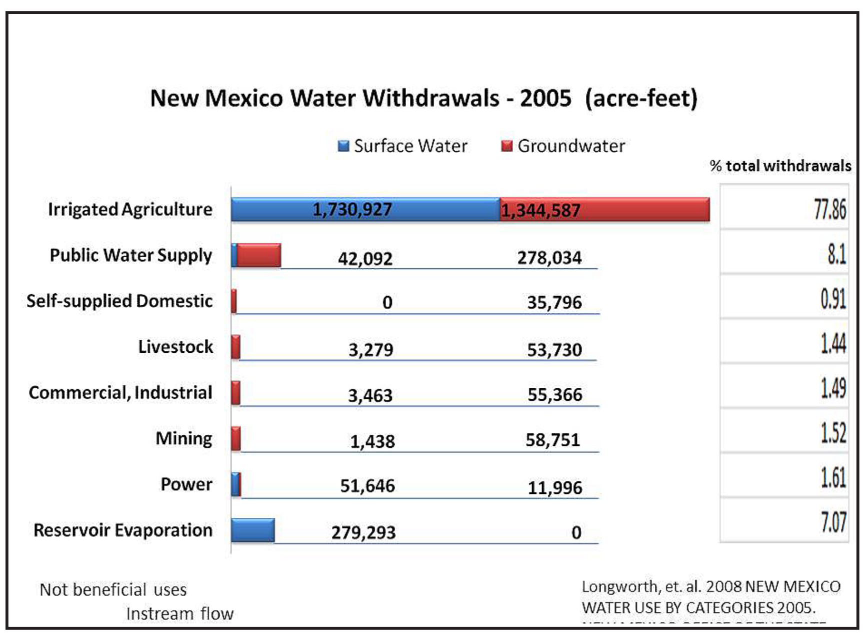


Figure 2. New Mexico water withdrawals - 2005 (acre-feet)

We have a groundwater sustainability story here in the Mesilla Valley—Burn Lake was formed when the water table was perforated during freeway construction and the excavation pit turned into a lake. During the drought in the 1950s, water levels in the Mesilla Valley dropped, and then came up in the 60s. After recovery in the 80s and 90s, the 2000s have seen water levels in the Mesilla Valley drop, and just this spring, Burn Lake dried up. We lost our visible, daily connection to the groundwater, to the water table—an indicator of sustainability.

If we maintain a connection between groundwater and surface water in our rivers, on an annual or multi-year basis, it's an indicator that we have sustainable groundwater use (Fig. 3). If we go over that into groundwater mining, we've lost our connection to the groundwater. Are we going to use our groundwater like a savings account that we want to build up and keep about the same balance, or do we want to spend it? This is a big part of our water management.

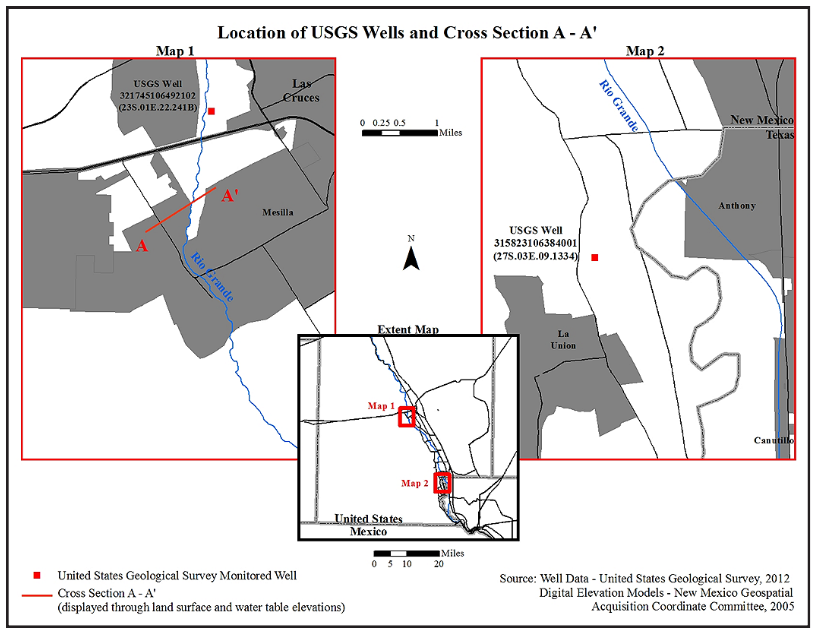


Figure 3. Location of USGS wells and cross section A - A′

To manage New Mexico's water, we must have all perspectives represented, and it's why this conference is so important. We really need to have all of the perspectives in this room. Consider examples in Roswell or the Taos valley where we have settlements after many years of negotiations, but are the solutions reflecting all the perspectives? I appreciate Senator Udall's perspective on this: instead of going to court, I'm going to the workshop room and bringing these perspectives together.

When we talk about solutions, a couple things come to mind that the Water Resources Research Institute is interested in—of course, research. We don't have a good map or quantification of our state's aquifers and our groundwater availability. How do we plan without having a good tabulation of what groundwater is available, both brackish and fresh?

We also don't have a good handle on variability. There is no normal year concerning our water sources; we have river flow that varies dramatically, precipitation that varies spatially and temporally, and our groundwater availability and use varies spatially. We need to document that variability. We need to come together just like we're doing today and get these perfectly-valid-at-the-same-time perspectives together to confront water management.

Climate Change

Dagmar Llewellyn, Bureau of Reclamation

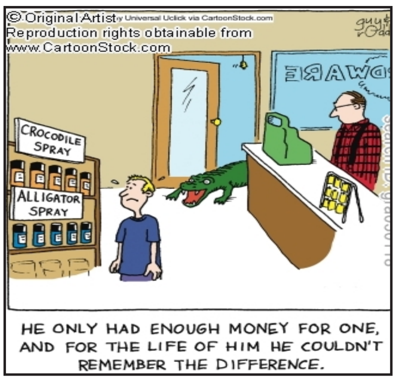
Dagmar Llewellyn is a hydrologist, with an educational background in geosciences and civil engineering, and post-graduate studies in climate dynamics, paleo-climatology, river restoration, GIS, and water law and management. For the past 12 years, her work has focused on water-management and endangered-species issues in the Middle Rio Grande of New Mexico. Her work has involved water supply and demand evaluation, groundwater/surface-water interaction, irrigation efficiency, habitat and hydrologic requirements of endangered species, and accounting under the Rio Grande Compact. After 25 years in environmental and water-resource consulting, her interest in working for the federal government was sparked by the passage of the SECURE Water Act, which assigned to the Bureau of Reclamation a west-wide evaluation of the potential hydrologic implications of climate change. Since 2010, she has worked at the Bureau of Reclamation on programs authorized under the SECURE Water Act, as well as on Middle Rio Grande water management and endangered species issues. Dagmar is a member of the West-Wide Climate Risk Assessment (WWCRA) Implementation Team and a listed author on the SECURE report to Congress. She currently serves on the WWCRA Ecological Resources Team, which seeks to

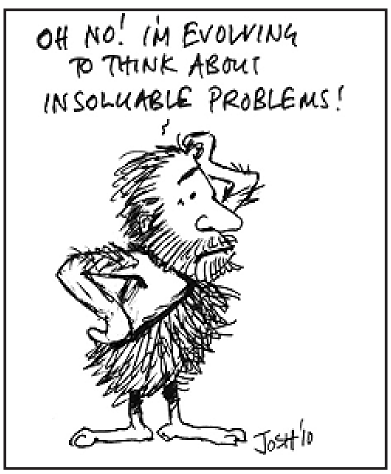
Good morning, everyone. I have some highly technical slides that I think Sam's daughter would approve of. Climate change is a topic that we like to find ways to avoid talking about but to some degree it is why we are all here today. It's incumbent upon us as scientists, engineers, and water managers to tackle the problems the climate change presents for our water supply.

I'd like to introduce a particular work by Reclamation that came out of the passage of the SECURE Water Act by Congress in 2009, the Upper Rio Grande Impacts Assessment, which is a component of the West Wide Climate Risk Assessment, and a WaterSMART program. In the West Wide Climate Risk Assessment, we are trying to assess the hydrologic impacts of climate change, in major Western river basins, and in the Upper Rio Grande Impacts Assessment, we are doing so specifically on the Rio Grande in Colorado and New Mexico. Our report will be coming out within the year, and we are looking for partners amongst all of you to work with Reclamation to develop adaptation strategies to the hydrologic impacts that it projects.

This afternoon, Howard Passell will talk about some specifics of this study and present some ideas we have developed for possible adaptation strategies. Also, poster number 31 in the hallway presents some details of our analyses.

Climate change is, by definition, highly uncertain and what we need to do in environmental and water resource work is move forward anyway, embracing that uncertainty. As *determine ways to systematically evaluate climate-change impacts on ecological resources in the western US. She is co-lead of the Rio Grande Climate Impact Assessment, and Reclamation's project manager for the Santa Fe Basin Study. She is also Reclamation's project manager for an effort to enhance operations modeling for the Middle Rio Grande to support climate-change analysis.*





a community, we have embraced the idea of adaptive management as a way of moving forward with our work in the face of uncertainty. As adaptive management is defined currently, it is not quite applicable to climate change because of the timescales involved. However, we need to develop some variant of that process that allows us to step forward in the face of uncertainty to begin to develop solutions to the challenges posed by climate change.

Taking action under uncertainty involves risk, whether we do something, or do nothing, or act on all of our options. We need to find a way to move forward to solve unsolvable problems. Discussions about climate change are very often about attribution...who is at fault...who believes...and who denies. I am not here to talk about those things. I'd like instead to look at some of the things that are common to all of the projections of our future climate and water supply, including Reclamation's current study, to help us move forward based on that common ground.

The first of these commonalities is that our usable, manageable life supply of water is going to decline or is declining already. We count on snowpack and the storage of that snowpack, both in the mountains and in our reservoirs, to provide us with our water supply for summer irrigation and recreation. That decline in our water supply and our ability to store it is occurring at the same time as our demand is increasing—so there is a growing gap between water supply and demand. As Sam pointed out, we respond to such gaps with an increased reliance on our nonrenewable groundwater resources. The use of those resources, in turn, will impact our surface water supply.

Further, it is projected that our state's water supply is going to be subject to increased uncertainty and increased variability, and it is a highly variable system to start with. Senator Udall referenced the graph on historical drought that recently appeared in the *New York Times*. The graph showed the drought and heat we've been experiencing over the last couple of years and how we are already outside of the historic norms for drought frequency.

A recent paper by Craig 2010 put it this way: "We are entering a world of continual, unpredictable, and nonlinear transformations of complex ecosystems." We are dealing with an already highly variable system that is stepping into even more variability and uncertainty. We must plan for those challenges as well as for changes in the spatial and temporal distribution of our water. The global models that we used for our projections don't really show this, but there's been some speculation about potential strengthening of our summer monsoons. We are not currently capable of making use of this possibility because our storage is upstream expecting snowpack. But this could present an opportunity for management changes that help us adapt to the future.

Another finding in our Upper Rio Grande Impacts Assessment is that San Juan-Chama project water is looking to be more reliable than our native Rio Grande water. This would have real socioeconomic implications in our basin. But again, this understanding is something that we can work with in our planning, as we try to distribute our water as fairly as we can.

Finally, feedbacks can lead to cascading impacts, and we've seen this sort of thing recently in New Mexico. More intense droughts and higher temperatures can lead to moisture deficit in our trees. These trees are then susceptible to beetle infestations. And the weakened and dead trees are susceptible to catastrophic wildfires. Thunderstorms tend to build up over the fire scars because they're black and they heat up. Then we have large rainstorms on top of the fire scars, which can lead to debris flows and to the flow of ash and debris into the river. The ash in the river can decrease the oxygen supply and lead to fish kills. Debris flows can dam tributaries and decrease our available supply downstream. In our management, we have to be cognizant that every action, everything that we change, has potential cascading consequences. Finally, everything impacted by climate change is compounded by all of the other changes that we're making to our landscape.

It is time to develop our plan.

Deteriorating Water Infrastructure and Impact on Supply

Del Archuleta, Molzen-Corbin Associates

Del Archuleta is a native New Mexican, raised in Clayton. He began his professional engineering career 36 years ago after completing his master's degree in civil (environmental) engineering at New Mexico State University in 1975. In 1990, he received NMSU's Emeritus Faculty Distinguished Alumni Award; in 1995 he was inducted into the Honorary Academy of Civil, Agricultural, and Geological Engineering; in 2004 he was named NMSU's Distinguished Alumni for the College of Engineering ; and in 2010 he received an honorary doctorate. He also served on the NMSU Board of Regents from 1996-2002, serving as president for two years. Del has been with Molzen-Corbin since 1975 and within 10 years, he became CEO and majority stockholder. Among other honors, Molzen-Corbin has been consecutively named one of the "500 Largest Hispanic-Owned Companies" by Hispanic Business Magazine for 19 years.

Thank you, Dr. King, for that introduction. My name is Del Archuleta, CEO of Molzen-Corbin Associates, and graduate of New Mexico State University. For the last 37 years, I've had the best job in the world getting to work with New Mexico's municipalities and local water systems all over the state, from little villages up to our largest cities. Hopefully I've added some value in managing and planning their water systems.

My topic concerns how we get water to the consumer in these communities and the status of the state's water supply infrastructure. A recent report by the New Mexico Section of the American Society of Civil Engineers presented the results of a survey conducted by a group of 50 professional engineers. Some interesting findings include the fact that 95 percent of community drinking water systems utilized a groundwater source, but 43 percent of the actual consumers served also consumed surface water. That's due, of course, to the larger systems in Albuquerque, Santa Fe, and other larger cities. Also, the report noted that a substantial portion New Mexico's infrastructure is over 60 years old and it was never intended to last that long. Thirteen percent of groundwater and surface water is allocated to drinking water and 70 percent or so goes to agriculture.

The survey looked at work categories such as capacity, condition, funding, operation and maintenance, public safety, and resilience. Overall they gave the entire system that they surveyed a C-. But with regard to the condition, capacity, and the safety and resilience categories, they gave it a C, or average grade. Regarding condition, funding, and operation maintenance—and operation maintenance in this case is really a category of funding, having the money to be able to operate and maintaining systems—the score given was a D, or poor. That doesn't come as a surprise to many of us because we could find similar sorts of grades for other systems. The C grade for capacity, safety, and resilience doesn't really surprise me because what that's really about is making sure that we supply water to the consumer on a day-to-day basis and if that's not happening, if well or line goes out to particular user, elected officials hear about it. And we find the way to fix the problem.

But what is really concerning to me is the poor grade when it comes to preventative maintenance, the investment in infrastructure that is worth millions and millions of dollars that is being swept under the rug. One day this is going to catch up with us in New Mexico. Our infrastructure is in poor condition and it's not going to get better because in most places preventative maintenance is the last thing that we fund. We are not set up to fund maintenance and grants and other monies do not encourage budgeting for preventative maintenance. We have some of the lowest water user rates in the country in New Mexico, but we need to understand that we must start investing in maintaining our infrastructure.

Can we improve that situation? Certainly, and I want to offer three or four additional thoughts. First, we need to stress water conservation. Local governments are starting to do a pretty good job of requiring graywater, for example. But beyond that I think we need to have, perhaps at the federal or state level, more emphasis on leak surveys to make sure we have an accounting of what is going on with the water once we pump it or we take from the surface water or groundwater and it ends up with the consumer. We need more leak surveys, better watershed management, and funding should be done in a way that encourages better management. We need a data-driven system.

We need to do a better job with regard to planning and strategic execution. We have this silo mentality that's pretty common in lots of areas not just in this particular area. The federal government does a great job with the USGS and other agencies getting good data. The state has a state water plan and is running its programs, and local governments are working very hard within their own areas. But if we ran things as a business, we would do things very differently. We would cooperate if we really valued water as the senator pointed out earlier. Municipalities are required to have a 40-year water master plan and local governments do ICIP (infrastructure of capital improvement plans). Too often that's done as a check-the-box at the last minute deal as opposed to being data-driven or coming from the water master plans and appropriately signifying the highest priorities in local government.

If we were doing things more as a business, we would work together and understand where we should emphasize reuse in our state, where we should emphasize recharge, and where we should use surface water. We would understand our groundwater resources a lot better. And the funding mechanisms to help these communities would be geared in a way to encourage strategies that work in various parts of the state.

We need better coordination of funding. Currently the established programs are pretty good about requiring master plans and federal and state money. But when it comes to capital outlay, as you know, we are a poor state and we have low water rates. We cannot afford to waste the little money we have. The way that capital outlay works in the state has been debated by the last administration and the current administration. We all understand that it's wasteful because instead of funding full projects that these communities need, they get a little bit of funding and then they can't use it, so it sits there for a long time. We have the same project requests year in and year out because we don't have enough money to fund the full project. I think we could do a lot better job of organizing and funding the needed projects.

Today we are going to hear about the need to use brackish water resources and we need to continue to encourage that use.

Lastly, let me say that the greatest recommendation I have is that as a state, as communities, and as individuals, we must face up to the true cost of water. We must understand the value of water. We need to allow our elected officials to budget adequately to run sustainable programs. The public must become educated in the true costs associated with these systems. We cannot continue to not budget for preventative maintenance, not allowing ourselves to have great systems. The people who are involved in these efforts do a great job with what they've got. They need more money and we need to allow them that money to do outstanding programs.

Thank you.

The Transboundary Aquifer Assessment Project

Mike Darr, U.S. Geological Survey

Mike Darr is a hydrologist with the USGS New Mexico Water Science Service Center, where he has served as Project Chief for the Trans-Boundary Aquifer Assessment Program (TAAP), helping to coordinate the efforts of research teams in Mexico, New Mexico, and Texas in the Mesilla Basin (U.S.) and Acuífero Conejos-Médanos (Mexico), as part of an international program to investigate hydrogeology and water resources in the border region. He earned his MS and BS degrees in geology from Northern Arizona University and the University of Texas. Mike has additional graduate coursework in biology from UNM and is proficient in Spanish and involved with cross-border initiatives in Latin America and the Caribbean. Most recently

My first figure shows that there are many aquifers that cross the United States/Mexico border. These aquifers occur in a similar way and are juxtaposed with political boundaries. Congress recognizes the critical nature of these transboundary resources and passed the Transboundary Aquifer Assessment Act in 2006. The goal of this Act is to provide sound scientific basis for appropriate management of these resources. The U.S. Geological Survey (USGS) was tasked as the lead agency to implement

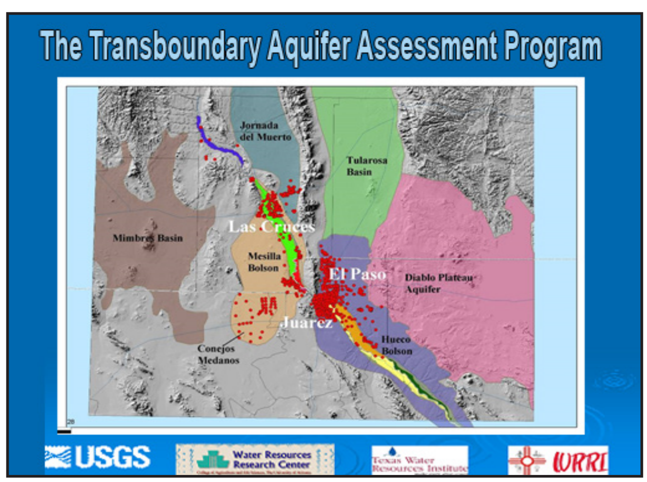


Figure 1. U.S./Mexico transboundary aquifers

he assisted with evaluating stream water quality effects from wildfire. Mike has applied debris-flow models to evaluate potential hazards from wildfire burn-scar areas in northern New Mexico.

the Act in association with the water resources research institutes here in New Mexico and also in Arizona and Texas. It was funded in coordination with the International Boundary and Water Commission (IBWC).

In New Mexico, we focused on the Mesilla Basin and its correlative in Mexico, the Conejos-Médanos aquifer. We recognize the numerous treaties that deal with surface water, which are closely watched and guarded. But we also recognize at the same time that there is very little in the way of groundwater understanding across these aquifers. We know through conjunctive use problems throughout our state and elsewhere that surface water and groundwater are intimately interrelated. The Transboundary Aquifer Assessment Program (TAAP) is focused on understanding those groundwater resources; to really get at the groundwater quantity questions and to help answer the questions of how much water we have and how we share it fairly.

Basically, in Arizona there were two basins analyzed, the San Pedro and the Santa Cruz and in New Mexico we focused on the Mesilla Basin and Conejos-Médanos. Figure 2 shows the Mesilla Basin on the left and the Conejos-Médanos on the right. What always astounds me about these diagrams is that there is always a blank spot on the map wherever the borders occur. It's the same aquifer and it is quite extensive as you can see from the diagram. The Mesilla (left) is shown on a model grid that has been developed by a number of researchers in the U.S. They worked on getting down to the minutia of the surface water/groundwater interactions and the aquifer characteristics on the U.S. side.

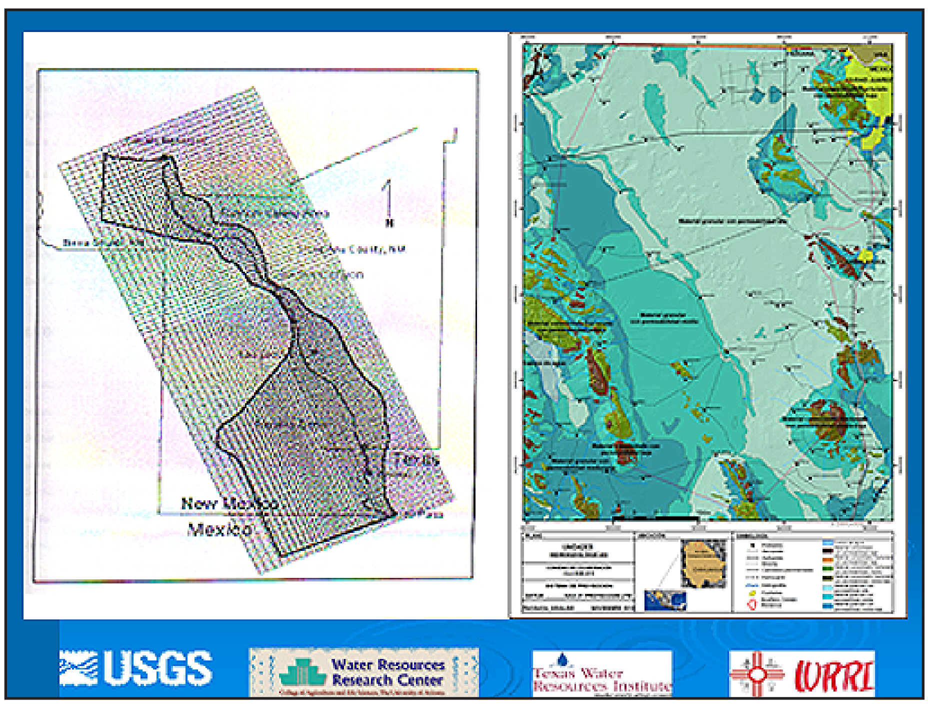


Figure 2. Study areas: Mesilla Basin (left), Conejos-Médanos aquifer (right)

As part of the transboundary program we were able to fund a regional hydrogeologic study through the Mexican geological service of the Conejos-Médanos Basin, which you can see in the figure with Juárez on the upper right. The basin is massive and extends quite a bit off to the south. This is a pioneer area in which both sides are trying to better understand the transboundary resource and to get a sound scientific basis on which to manage the resource.

The accomplishments of the transboundary work were limited by funding. Originally, there was a ten-year program that had an ambitious funding level. But at the end, only a couple million dollars were dedicated out of $50 million or so planned. We were still able to get quite a lot done with those limited resources and one of the main accomplishments was the regional hydrogeologic study on the south side of the Conejos-Médanos.

Another accomplishment was work done on a modeling study that helped to create a new tool for conjunctive water use management, which is integrated hydrologic modeling. The model accounts for all of the water all of the time, both surface and groundwater together rather than trying to partition them. Advances made in developing these new modeling tools were accomplished through the efforts of Randy Hanson and Wolfgang Schmidt.

Through the IBWC, the door has been opened to work with Mexico for data exchange, due in large part to the efforts of NM WRRI's previous director, Bobby Creel. Dr. Creel did so much to create an annotated bibliography and a shared database with Mexico. This has allowed people to share information that is being developed on both sides of the border. He also worked on updating the hydrogeologic work with John Hawley.

Another major accomplishment was an isotopic sampling study in much of Mesilla Park that we would have liked to have extended into Mexico. The study was done by John Bumgarner from USGS/Texas and involved environmental tracers, age, and surface water relationship definitions.

There is a lot of potential for additional advancements. In terms of next steps, an interim report to Congress is being prepared. Our wish list for future work involves continued work on the Mesilla and the Conejos-Médanos as part of the binational technical committees that were established. There is a lot of momentum there; there were a lot of contacts, and a lot of energy in the group that could be capitalized on. And in the next five years, if the program continues, we would like to begin work on the Mimbres and the Puerco.

Thank you.

Status Quo of Water Rights in Times of Shortage: Legal and Environmental Constraints

Steve Vandiver, Rio Grande Water Conservation District, Alamosa, CO

Steve Vandiver is a graduate of La Junta, Colorado High School and the University of Colorado with a BS degree in Civil Engineering (1972).

Steve worked for the Colorado Division of Water Resources as a hydrographer and dam safety engineer for 9 years, then 24 years as the Division Engineer for the Rio Grande Basin in Colorado for CDWR before retiring from the State. (1973-2005) He was on the initial Recovery team for the Rio Grande Silvery Minnow while serving as the Engineer Adviser for Colorado for the Rio Grande Compact for 14 years.

From 2005 to the present, Steve has been the General Manager for the Rio Grande Water Conservation District responsible for the Closed Basin Project local sponsorship. He is active in the Colorado Water Congress, the Intrastate Basin Compact Commission as well as a sponsor of the Groundwater Subdistrict formation and administration, the Habitat Conservation Plan for Southwestern Willow Flycatcher, and Natural Area administration with BLM on the river corridor along the RG from the Alamosa National Wildlife Refuge to the stateline. He is involved in Land Trust and River Restoration Projects throughout the basin.

Thank you and I appreciate very much being invited to speak today. I feel a little bit like the Lone Ranger as I look around the room and don't see any of my counterparts in the audience, but I do have a lot of friends here. I have a history here in New Mexico with my work as a Rio Grande Compact Engineer Advisor. I share your concerns and certainly understand a lot of the issues that are happening here. Unfortunately, Colorado is in the same situation as New Mexico as our dependence on surface supplies and groundwater supplies is incredible, and we are certainly outstripped in many instances in our ability to sustain our current system.

My topic here is to speak about the status quo of water rights in times of drought. I will suggest that there is no such thing as a status quo and you must have some kind of water rights system on which you can depend. Colorado is fortunate enough to have an adjudication system that goes back to the late 1800s, and we've been fortunate enough to keep that system going since that time. We not only have all of our surface water adjudicated but all of our groundwater adjudicated as well. We have a system in place and it provides a base from which we can operate. It is there day to day and from year to year and it's not something we have to guess about.

In Colorado we have is a very strong state engineer system that has division engineers and water commissioners in each of the drainage basins. They actually go out and administer water rights in priority; they have a hydrographic staff that keeps track of hundreds of gauging stations around the state and many in the San Luis Valley. We've also been fortunate to have put in a satellite monitoring system that records and monitors virtually all of the main diversions on the Rio Grande. We have the ability, on a day to day basis, to know where the water is in the system and who is diverting it. Plus we have a very strong system of allocation under our priority system to serve those water rights and priority.

The problem comes obviously in times of drought. I've been in the San Luis Valley since the early 70s and we've been in drought much more than we've been in ample years. Our priority system is first and foremost our allocation system. I've seen an open river where all water rights were being served, or when everyone was satisfied, only twice in forty years. Our priority system never goes away. It starts the first day of the irrigation season and continues throughout the entire year.

Throwing in Compact obligations on top of that, Colorado actively administers and curtails even pre-Compact surface rights in order to meet our Compact obligations to New Mexico and Texas. We physically shut off pre-Compact rights on a daily basis to ensure that water gets to New Mexico. That is obviously a result of many years of turmoil and in some cases conflict with New Mexico and Texas. But we learned our lesson well, and from the late 60s to now, we have maintained our obligations on an annual basis. I am quite proud of that and it's taken a lot of work dealing with the water users in the San Luis Valley to help them understand that obligation and to be able to live with the consequences. About a third of our water generated in Colorado comes to New Mexico on an annual basis. When you already have an over-appropriated system and you take a third of that water and send it downstream, it doesn't play well with the water users and the water rights holders in the San Luis Valley.

One thing that I want to stress is that there is no status quo except for some institutional aspects. Things are changing everyday as we know. Climate change isn't new. We are arrogant to think that this is the first time there has been climate change. Senator Udall put up a chart showing that climate change has been going on forever and certainly with a lot worse conditions than we are seeing today. The problem is that all of us grew up in a time when there was a fairly ample water supply and so we think that's the norm. That's just arrogance and ignorance.

We have many examples of much more extreme situations than we are facing today. The problem is that we've added a whole bunch of people and a whole bunch of irrigation to the system that wasn't here before. Trying to adapt to that is our challenge today. Now we have new problems like dust-on-snow that I'm sure many of you have heard about where we get a new snowpack, it gets covered with dirt, and we wonder why it melts so quickly.

Also, there are general changes in hydrology. In the last three years we've had significant changes. In fact, since 1988, the headwaters on the Rio Grande have been down about 20 percent of the long-term average. As time goes on, that's getting worse and worse.

We are seeing changes in the law. You think critical habitats are in place. But what happens? We have to revisit them again. All of these changes are difficult to adapt to. Unlimited growth was mentioned earlier. We have a finite resource and we wonder why we are running out of water at the same time we are encouraging unlimited growth. It is the same all over the Southwest and at some point we have to face the fact that we can't continue to depend on a finite resource with an unlimited demand.

Budgets have also changed. The Water Conservation Board has had $175 million taken away from its water project funding in the last three years by the legislature, simply because it was an easy pot of money—it was seen as simply a severance tax that was laying around not doing anything except funding water projects, and it was needed for other things. Priorities change. We have some significant challenges ahead of us and we are trying desperately in Colorado to keep up with those challenges.

SESSION TWO

Water Users Perspectives: Agriculture, Municipal, Energy, and Environmental Sectors

Moderated by Jeff Witte, New Mexico Department of Agriculture

Jeff Witte is the director/secretary of New Mexico Department of Agriculture (NMDA) and the cabinet secretary of agriculture for NMDA under Governor Susana Martinez. He served as the assistant director of NMDA from 1994 to 2003 then the director for the Office of Agricultural Biosecurity for NMDA and New Mexico State University (NMSU) until 2011. Jeff codirected the Southwest Border Food Safety and Defense Center at NMSU, working on agriculture issues related to homeland security. He is an adjunct instructor with Louisiana State University; the National Center for Biomedical Research and Training; and the University of Tennessee, College of Veterinary Medicine. Jeff is a member of Infragard New Mexico; New Mexico Biosecurity Work Group; founding member of AgriGard, a national workgroup that brings together industry and law enforcement; and is also a member of the Association of Food and Drug Officials Food Protection and Defense Committee. Jeff comes from a ranching family in northern New Mexico. He is a graduate of New Mexico State University with a bachelor's degree in Agricultural Business Management and a master's degree in Agricultural Economics and Economics.

Scarcity Impact on Acequias

Paula Garcia, New Mexico Acequia Association

Paula Garcia is the Chair of the Mora County Commission, an office for which she was elected on a platform of ethics in government, revitalization of the land-based economy, and protection of land and water resources. Paula is also Executive Director of the New Mexico Acequia Association, a grassroots, statewide organization of acequias which are centuries-old, community-based irrigation systems. In her years of service to the Association, acequias have built a movement around the principle that "el agua es la vida – water is life" and have achieved major policy changes locally and statewide to protect rural water rights. The Association also created a project entitled Sembrando Semillas (Growing Seeds) to promote revitalization of agriculture and to cultivate the next generation of farmers and ranchers. NMAA also co-

My name is Paula Garcia and I am Executive Director the New Mexico Acequia Association. It is a tremendous honor to be here this morning before a very impressive group of people who are devoted to water. A special thank you to President Couture for her leadership as well as the NMSU faculty and researchers devoted to the study of water. Also thank you, Professor Fernald, for involving the New Mexico Acequia Association in some of your research that helps us understand better the relationship between surface water and groundwater, and very importantly for the acequia community, the importance of community resiliency. Resiliency is going to be an important characteristic for all of our communities as we move into the future.

Water scarcity, the topic of this conference, is very timely but we also know that water scarcity is nothing new in New Mexico. Water scarcity is deeply rooted in our past in the land and its people, and we have a long memory of water scarcity New Mexico. We saw the diagram earlier based on tree rings research, but there's also a long memory of water scarcity in oral history from an ancient peoples of our state, mainly the Native Americans, who have a tremendous amount of knowledge and wisdom about water scarcity and how water scarcity was dealt with historically. Part of this history of water scarcity is also embodied in the acequias that have centuries-old customs for sharing water scarcity. These traditions have been in place and have evolved and adapted for hundreds of years. Their idea of sharing in times of scarcity is based on a sense of mutuality; our shared future, our shared *founded the New Mexico Food and Seed Sovereignty Alliance which promotes the seedsaving traditions of traditional acequia and Native American communities.*

Paula is a board member of La Asociacion de las Acequias del Valle de Mora, a council of acequias in the Mora Valley, and President of La Merced de Santa Gertrudis de lo de Mora. She is a strong advocate for the cultural heritage and the historic land and water rights associated with community land grants and acequias.

Paula's views on land, water, and community have been published and referenced in various op-ed pieces, articles, and book chapters. She has also spoken at numerous conferences at the local, state, and national level including being featured as a plenary speaker at the W.K. Kellogg Foundation Food and Society Conference and at a conference of the National Water Resources Association. Her experience on land and water issues was a valuable asset when she served on policy making boards including the New Mexico Water Trust Board, the Utton Transboundary Resources Center at the UNM Law School, and the Governor's Blue Ribbon Task Force on Water. She was recently appointed by USDA Secretary Tom Vilsack to the Minority Farmer Advisory Committee.

survival is dependent upon finding that mutual benefit in sharing water. The whole concept of sharing and having customs and traditions for sharing water is deeply rooted in a place-based knowledge about the river and about the acequia system. It comes from observation and years of empirical knowledge. We have a lot to learn from that type of knowledge about water systems.

We also have a framework in our state for water allocations, which in this state like Colorado, is a prior appropriation system. Some of the trends we are seeing are that even with this system of prior appropriation, water sharing customs have endured. They not only have endured, but in some ways they are adapting to new conditions. While we've seen water stream sharing between acequias in a very small region, we are starting to see discussion on how to share water in the whole basin, for example, between the upper and the lower Chama. We are trying to figure out how to deal with sharing between entities. We see cities and towns that have surface water diversions and are attempting to share the same stream system with irrigators who have senior water rights. There still must be an allocation system in place by priority administration and it is the law in New Mexico. It is still a factor particularly for agricultural water users because seniority can be a type of leverage senior water right owners have at the negotiating table. Within this context, you also have parties willing to come together to figure how to share water so that everyone benefits.

Something that is exacerbating the need for water sharing is climate change and drought. There is a high importance on reaffirming where there are customs for sharing in place, but also to reinvent those. We have an interest in acequia water sharing, but we also want to bring more entities to the table. State and federal water managers would benefit greatly from the knowledge of local water managers, like the mayordomos and other officials in managing their stream systems. There should be a complementary relationship between those who are in charge with administering our state water and those at the local level who have the day-to-day knowledge for managing the system. This is true not just for acequias but for irrigation in general. We need more negotiation, collaboration, and cooperation within the framework of our laws on prior appropriation with the flexibility to recognize customary or emerging water sharing arrangements.

A big factor for agriculture in New Mexico is water markets. Water markets are in place regardless of whether there is increasing scarcity, and they are increasingly viewed as a remedy for future water supply problems. We need to keep in mind that water markets tend to focus only on one value of water, the economic value, when water really has many values to our communities. We must be very mindful of the impact to rural communities especially to small-scale agriculture, which is more vulnerable to market forces. For the future, we should look at some type of adaptive regulatory framework for water transfers that allows for changing needs while also protecting what we find valuable to our communities. Some of the adaptations we might look at include rather than having large-scale or permanent water transfers, shorter term leases could allow water to stay in agriculture for the long-term while also having short-term ways to address short-term shortages. There are ways to rotate lands so that no land is left fallow for too long. There are some adaptations that we can look at concerning water transfers where we don't look at it as a zero sum game where agriculture loses and other wealthier regions with more resources wins.

Lastly, an important adaptation for the future is to look at the way we make investments and expand our view not only to make infrastructure investments, but also restoration investments. Restoration infrastructure investments should be cross-sector. In other words, if we are going to make a big investment in either infrastructure or watershed restoration, the various entities in that same region should all be part of the planning process and all benefit equally. You can imagine a scenario in which a town might get a huge investment for infrastructure but not necessarily the nearby agricultural users, and thus you've built in a structural inequity to access that water unless you're mindful about how the planning takes place. We want to be mindful about investments so that they are a win-win situation for all the water users. Some incentives must be built into the funding so that everyone comes to the table and develops voluntary water sharing agreements.

There are reasons for optimism in our state about our future, despite the daunting challenges facing water. Some of the reasons to be optimistic are that in our state, we have a lot of lessons to draw upon concerning water and how we've dealt with water shortages. We also have a framework for allocation that we need to improve upon in order to adapt to changing conditions. We have a spirit of cooperation, and as we face these tough times what we are seeing is a broader view of not only looking at our own water rights by those of us who are defending water rights for our respective communities, but also looking at water as a collective responsibility for which we need to take good care. We must view ourselves as caretakers of the water for future generations.

Thank you for the opportunity to speak at this conference.

Municipal Water Reuse

Larry Webb, City of Rio Rancho, Public Works Department

Larry Webb was raised in Hobbs, New Mexico and after graduating from Hobbs High School, he spent four years in the United States Air Force. After finishing his military service, Larry attended New Mexico State University and received an associate degree in Water Utility Operations and Management. Larry then worked two years as the Wastewater Systems Manager in Silver City, New Mexico. He moved to Texas in 1980 where he worked for 17 years with the City

I'm glad to be here today and as I look at the crowd, I see familiar faces that I've worked with over the past 35 years. My topic today is water reuse. Senator Udall set the stage with water issues that we are all facing. Like his reference to diamonds, this is a multifaceted problem that we have.

Rio Rancho is a city of 87,000 people and the third largest city the state (Fig. 1). It was planned at a time when it was thought that there was an abundance of water throughout the Rio Grande. Newspaper articles noted how vivacious the Rio Grande was and how extensive the aquifer below the Albuquerque area was. The city was chartered 31 years ago, which means it's starting to mature a bit. It was stated at one time that it was the fastest growing city in the state. I'm not sure that is still the case with our current economy.

of League City, Texas as Director of Utilities. Larry received his bachelor's degree in Environmental Management from University of Houston-Clear Lake. He was the American Water Works Association, Texas Section Chairman in 1996-97. Larry moved back to New Mexico in 1997 and started working for the City of Rio Rancho as the City's Utilities Director. In 2005, the City of Rio Rancho went through a re-organization of departments absorbing the Utilities Department into the Public Works Department and Larry was named the Utilities Operations and Resources Manager.

He is a Past President of the New Mexico Environmental Quality Association and has served on many environment committees with the New Mexico Municipal League. He is also an active member of the Rocky Mountain Section of American Water Works Association and the Rocky Mountain Section of Water Environment Association. Larry is a lifetime member of the New Mexico Water and Wastewater Association and instructs management classes. He is also a lifetime member of the American Water Works Association. Larry holds a Class IV Water and Class IV Wastewater Certification in New Mexico.

Like the Middle Rio Grande valley, Rio Rancho has seen an increase in municipal and industrial water demands with a population projection of over two million people by the year 2060. And that's what we are working on today—how we are going to meet that demand for water. The water supply, as has been stated many times, has been fully allocated. The water source for most cities, and certainly for Rio Rancho, is the aquifer from which we are pumping and which is tied to the river and which requires us to have water rights. Eleven or twelve years ago, we started looking at water quality issues, particularly arsenic, and how we treat the water before we discharge it to the river or whether we would just do away with discharges. In some of our initial studies, we found that it was very helpful for us to talk about water reuse and conjunctive management of our aquifer itself.

The Incentive

Timeframe	Population	Demand (ac-ft/yr)
Present	90,000	14,000
Future	300,000	50,000

- **Surface & groundwater supplies fully appropriated**
- **City water rights allow diversion of ~27,000 ac-ft/yr**
- **Must secure additional water to meet future demands**

Figure 1. Rio Rancho now and in the future

The other thing that has come into play for us in the last couple years is conservation. We reduced from about 180 gallons per person per day in Rio Rancho to about 140 system-wide. For residential use, we are down to about 80 gallons per day per person. Rio Rancho has a problem in that it did not exist when the San Juan- Chama river project was being put together in the 1960s and when it came forth in the 1970s. So we've looked at the fact that we have to commit to water reuse and how to manage that reuse.

Most water is reused as part of the natural hydrological cycle that takes care of a lot of the cleaning up process. Water in river systems is used many many times by stream users. I was struck many years ago when I was in New Orleans drinking a glass of water at a water conference like this, and someone stated the fact that every gallon of water in New Orleans was used 400 times either for industrial or agriculture or city use—so I switched to Coca-Cola.

Wastewater effluent has been used for irrigation for number of years—in fact some of the water used was not of very good quality, but the State of New Mexico has increased water quality regulations. There is a stigma that's attached to water reuse and the notion that your drinking water used to be somebody's wastewater. It's the micro-constituents, the contaminants that worry us—the personal care products, hormones, and pharmaceuticals. On the other hand, the reality of reuse is that we all go to restaurants each day and that plate, that glass, those forks have all been used and treated and disinfected and washed many times. And that's what we do when we talk but water reuse; it's a treatment prior to you using it again. As I was sitting in my hotel room last night, I was thinking about how many people have slept in that same bed and used the same shower. It's not a foreign notion to us to reuse as long as we have treatments to safeguard us.

There are multiple terms used interchangeably when talking about reuse, whether it's reclaimed water, recycled water, or potable reuse. The new buzzword in water reuse is the Water Reuse Association's new term "purified water," and it does make a little difference in the connotation and the way we think about it and what we're about to do with it. Treatment technologies have proven that you can remove contaminants or reduce them to a protection limit. There are physical barriers, environmental buffers such as ponds and aquifers that help. Rio Rancho is currently piloting a recharge project that we think will work for us. We put a lot of work into the pretreatment of that water; we have not used effluent yet, we've used potable water to trace and track down contaminants as they travel across the aquifer.

Before I leave today, I want to say that there are already a number of communities throughout the world that have done these projects. El Paso, our neighbor to the south, certainly has been reusing water since the early 1980s and very successfully. I think you'll see more reuse of the future. Reuse will be needed to meet Rio Rancho's 50,000 acre-feet ultimate build-out. So we've got quite bit to go. We've got to plan for the future if we are going to grow. I don't know that we are growing any faster than anywhere else in the world. Dallas, California, and Las Vegas are having economic difficulties, but they are still going to grow. New Mexico may not grow as fast, but it will still grow.

Thank you.

Algae Water Use

Richard Sayre, Los Alamos National Laboratory

Dr. Richard Sayre is a senior research scientist at Los Alamos Nationals Laboratory (LANL) and Director of the Biolabs at the New Mexico Consortium (NMC). The primary focus of his research is on renewable biomass production systems. Prior to coming to LANL/NMC, Dr. Sayre was the Director of the Enterprise Rent-A-Car Institute for Renewable Fuels at the Donald Danforth Plant Science Center in St Louis and a faculty member and Chairman of the Department of Plant Cellular and Molecular Biology at Ohio State University. Dr. Sayre is currently the Scientific Director of the Center for Advanced Biofuel Systems, a DOE-Energy Frontier Research Center, and the National Alliance for Advanced Biofuels, the DOE algal biomass program. From 2005-2010, Dr. Sayre directed the BioCassava Plus Program funded by the Bill and Melinda Gates Foundation. Biocassava Plus developed biofortified cassava for subsistence farmers in Africa. Dr. Sayre is a co-founder and CTO of Phycal Inc, an algal biofuels company.

Dr. Sayre has received several honors including being named College of Biological Sciences Distinguished Professor, Ohio State University (2005-2008); Honorary member, Phi Beta Kappa (2006); Fulbright Scholar, Inst. Quimica, University Sao Paulo, Sao Paulo, Brazil (2007); and selected by "Nature" as one of "Five Crop Researchers Who Could Change the World" (Nature 456: 563-569, 2008). He is co-editor in chief of "Algal Research."

Thank you for the opportunity to speak at this conference. I'm perhaps the newest resident of New Mexico attending and speaking a this conference although my family has deep roots in New Mexico. My grandmother grew up on the Mescalero Apache Indian Reservation outside Roswell and my brother-in-law has been an attorney in Santa Fe for 25 years. I am very happy to be back to the Southwest.

I want to start off with the caveat that I'm going to read a prepared statement because I've been on the road for the last three weeks and I apologize for not being more interactive. We've heard from a number of people at the conference this morning about a variety of factors that contribute to setting policy for the most productive use of New Mexico's water resources. For the agricultural systems, which I'll be speaking more directly to, factors will include economics, crop yields per unit water use, the mitigation of evaporative water use, use of wastewater, impacts of other resources and energy inputs on that water use, and finally, environmental impacts.

Among the emerging cropping systems potentially requiring large amounts of water is the algal biofuels industry. New Mexico is now the home of the largest early-stage algal biofuel production systems in the United States. This includes operations under construction by Sapphire, Jewell, and El Dorado biofuels among others. The primary factors that drew this emerging industry to New Mexico were climate and economics. The mild winter temperatures with virtually uninterrupted solar radiation in southern New Mexico as well as the availability of relatively flat low-cost terrain are the major factors that contributed to the emergence of New Mexico as a center for algal biofuels commercialization.

Significantly, two of the aforementioned companies have chosen to utilize saline or recycled water. Sapphire has proposed to use saline water pumped from aquifers to grow marine algal species, and El Dorado is using produced water from oil wells. In each case, the issue of salts or solids mitigation due to evaporative water losses could present challenges, both in terms of cost and freshwater use. Significantly the high demand for water use in open ponds is counterbalanced by the very high biomass productivity of algae relative to terrestrial crop systems. Due to their high photosynthetic efficiency and the lack of non-photosynthetic organs, algae are capable of producing three to ten times more biomass per acre than the best terrestrial crops systems in the world. Ironically, open pond systems also lose approximately 30% less water per unit surface area than terrestrial crop systems and this is due to the fact that crop systems have very large plant leaf surface areas relative to the land surface.

Currently algal production systems are producing between 30 to 60% oil per unit biomass. Importantly, these algal oils are directly compatible with current and emerging refinery and energy distribution and engine combustion technologies and could substantially reduce our dependency on foreign oil as well as create jobs in the United States. Furthermore, algae can directly capture carbon dioxide injected into ponds from point sources such as power plants or cement kilns helping reduce greenhouse gas emissions. Finally, oil extracted algal biomass is protein rich and has recently been shown by NMSU researchers to be an excellent substitute for plant proteins in a variety of animal feeds.

Thus the biofuel production from algae is likely to have limited impact on food production, but there's room for improvement. Research members of the National Alliance for Advanced Biofuels and Bioproducts, based at Los Alamos National Laboratory, have made significant advances in improving yields, reducing inputs, enhancing production stability, and addressing environmental concerns. Some of those accomplishments include the identification and engineering of new algal strains with the potential for a twofold increase in yield; identification of lab-scale energy efficient algal harvesting technologies that have less than 1% parasitic energy losses and can harvest algae at a cost of five cents a gallon; development of efficient wet lipid extraction technologies, which will eliminate the need to dry the algae and the associated water and energy losses; the development of efficient hydrothermal processing technologies for direct fuel conversion from algal biomass; demonstration that lipids extracted from algal meal can replace soybean meal in cattle, chicken, and fish feed; and development of complete lifecycle analysis models for algal biofuel systems indicate the potential to produce on the order of $7,000 gross income per acre per year in algal biomass production systems.

Additional research efforts have led to the development of engineered algae with improved light utilization efficiencies, a very important aspect in New Mexico that can increase yields by an additional 30%. More improvements in water use recycling and efficiency are expected. The use of municipal wastewater runoff from animal feedlots for algal ponds is a win-win partnership. The algae benefit from the rich source of nutrients in the wastewater and wastewater treatment facilities reduce the release of environmentally damaging nutrients. To further reduce water demand, semi-closed systems utilizing heat tolerant algae are being developed that have reduced evaporative cooling demands. In addition, micro encapsulated algae grown as super high cell densities will further reduce water requirements. Hybrid oil production systems that utilize sugars produce another biomass crop that boost the oil production in algae and will reduce demands for water to algal biomass.

In conclusion, as we develop policy impacting the use of water, it will be critical to provide opportunities for emerging technologies that utilize water resources more efficiently for biomass production while mitigating the release of climate changing greenhouse gas emissions, thus addressing both the immediate and long-term needs of water resources.

Thank you.

Protecting Our Natural Environment

Denise Fort, Utton Transboundary Resources Center

Denise Fort is a Professor of Law at the University of New Mexico School of Law and Director of the School's Utton Center. She writes about environmental law, water policy, river restoration, and climate policy. She chaired the Western Water Policy Review Advisory Commission, by appointment of President Clinton, which prepared a seminal report on western water policy.

Fort also served as Director of New Mexico's Environmental Improvement Division, as an attorney with New Mexico PIRG and Southwest Research and Information Center, and as Executive Director of Citizens for a Better Environment (CA). She was a member of the National Research Council's Water, Science, and Technology Board and participates in NRC reports. She has worked in public finance as the Secretary of Finance and Administration for New Mexico and an assistant Attorney General in the Taxation and Revenue Department of the state.

I'm very happy to be here. I've been coming to NMSU for many years to talk about water and environmental issues and it's great to see a growing number of people, including students who have graduated from UNM Law School here. So thank you very much for inviting me to give an environmental perspective. I confess that giving any environmental perspective is a little daunting when many of you consider yourselves environmentalists who take some stewardship responsibility for the natural environment. I'm just going to give one perspective and give only two points about things that matter for the environment.

A question earlier was asked about water quality in New Mexico and that of course is an important part of our environmental protection of water within the state. We have a framework to protect water quality in the state. Indeed, we've had it since before the passage of the federal Clean Water Act. We have groundwater laws to protect groundwater quality. There are loopholes in both of these statutory schemes to protect certain industries, but we do have a framework for protecting water quality.

We don't have a framework for protecting the ecological aspects of rivers and streams and that's what I want to talk about today. We have failed to protect these natural values in our rivers, and my concern as we look toward the future is what sorts of steps Congress should take to stem further damage and to help us restore our rivers and streams.

So my first point is that New Mexico should manage water demand rather than investing in large-scale water projects. I don't want to give a break-off on how big is big, but let's say that we do still have half a billion dollars in water projects on the drawing boards (see Fig. 1, page 62) These projects to which the state has committed monies under the Water Trust Board are far from having the entire amount of money available. With respect to the tribal water projects, some of the issues are different there because of the federal trust responsibility towards tribes. But in some instances, the solutions we have identified have a high environmental cost both in terms of the rivers from which the water is taken and the cost of the energy that is being used to pump the water to different places.

Let me give you a few examples that may raise a few hackles. The Arizona Water Settlement Act is an instance in which Congress said that we had an opportunity to get additional water out of the Gila River, water for which New Mexico doesn't necessarily have a need, and we would get that water out at a pretty high cost. Some of the costs would be paid for by the federal government, but not necessarily the entire cost. Why would the Congress make a commitment to provide "new" water for New Mexico rather than looking for cheaper solutions, which might be available closer at hand? The communities involved are looking for cheaper solutions in terms of lining leaking water systems and so on. But we have $66 million in free federal money if we go the route of a diversion project to take extra water out of the Gila River. Once we remove that water, we perhaps have pipeline costs, energy costs, and other costs in delivering that water to a place where it could be used.

The Ute Lake Project is another controversial example of this. Congress has committed about $400 million for a pipeline project to deliver water to different parts of eastern New Mexico. The question has to be asked as to whether there were cheaper alternatives that could have been used, including demand management, to address those water needs. In general, demand management will be a better alternative for the state unless we have large federal money that intervenes and makes a difference.

I appreciated Paula Garcia's comments earlier on water markets. I did know how controversial this panel would be. Water markets and water transfers are probably how we are going to address these water needs in the future in New Mexico. I'm not sure exactly what she'd propose in terms of the more nuanced and adaptive approach, but that's what we should be doing.

Let me turn quickly to my second recommendation and that is restoration. Restoration of the state's rivers is something we had begun to a limited degree using state funds under a WRRI program, but the program did not have statutory authorization and there is a question as to whether or not we can continue it. I believe that there is a role for the federal government in protecting and restoring our state's rivers, especially where federal projects have degraded these rivers.

Thank you.

Figure 2: Projects in the Pipeline

Flaming Gorge, WY and CO
- Communities Served: The Front Range of Colorado, and Wyoming
- Water Source: Green River
- Federal Funding: Funding not yet identified

Lake Powell Project, AZ and UT
- Communities Served: Utah
- Water Source: Colorado River
- Federal Funding: No

Yampa River Pumpback, CO
- Communities Served: The Front Range of Colorado
- Water Source: Yampa River
- Federal Funding: No

Navajo-Gallup Project, NM
- Communities Served: Eastern section of the Navajo Nation, the southwestern part of the Jicarilla Apache Nation, and the City of Gallup
- Water Source: San Juan River
- Federal Funding: Yes (100%)

Southern Delivery System, CO
- Communities Served: Colorado Springs and surrounding communities
- Water Source: Arkansas River
- Federal Funding: No

Cadiz Valley Water Conservation, Recovery and Storage Project, CA
- Communities Served: Southern California Water Districts
- Water Source: Groundwater from Bristol, Fenner, and Cadiz Watersheds
- Federal Funding: No

Peripheral Canal/Tunnel, CA
- Communities Served: Central California, Southern California, and some Northern California water agencies
- Water Source: Sacramento River
- Federal Funding: No

Weber Siphon, WA
- Communities Served: Agricultural land in the Odessa Subregion in Washington State
- Water Source: Columbia River
- Federal Funding: Yes (100%)

Lewis and Clark Regional Water System, SD, IA, and MN
- Communities Served: South Dakota, Iowa, Minnesota
- Water Source: Aquifer adjacent to the Missouri River near Vermillion, SD
- Federal Funding: Yes (80%)

Mississippi River/Ogallala Aquifer, Various States
- Communities Served: Colorado River Basin communities, including Las Vegas, and western irrigation
- Water Source: Mississippi River
- Federal Funding: No

Narrows Project, UT
- Communities Served: Sanpete County in Utah
- Water Source: Price River, a tributary of the Green River
- Federal Funding: The applicants propose funding from the Small Reclamation Projects Act

Ute Lake Project, NM
- Communities Served: Eight Eastern New Mexico communities
- Water Source: Canadian River
- Federal Funding: Yes (75%)

Santa Fe-Pecos, NM
- Communities Served: Santa Fe and other communities in the Rio Grande Basin
- Water Source: Transfer of Pecos River water rights used for agriculture
- Federal Funding: No

Eastern Nevada to Las Vegas, NV
- Communities Served: Las Vegas and surrounding communities
- Water Source: Groundwater from 5 Basins: Snake Valley, Spring Valley, Cave Valley, Dry Lake Valley, and Delamar Valley
- Federal Funding: No

Northern Integrated Supply Project, CO
- Communities Served: 15 Northern Front Range water providers
- Water Source: Cache la Poudre River
- Federal Funding: No

Uvalde County - San Antonio Pipeline Project, TX
- Communities Served: San Antonio, Texas
- Water Source: Groundwater from Edwards Aquifer
- Federal Funding: No

Figure 1. Projects in the Pipeline. Pipe Dreams Report, NRDC; available at: http://www.nrdc.org/water/management/pipelines-project asp

STRAIGHT TALK: Voices of Experience from the New Mexico Office of the State Engineer

Moderated by: Senator Tom Udall (see Senator Udall's Opening Remarks on page 31)

Panel Members: John Hernandez, Eluid Martinez, Tom Turney, and John D'Antonio

John Hernandez was involved with and at the Office of the State Engineer (OSE) for almost all of the 50 plus years of his engineering career, joining the OSE a few months before Steve Reynolds became the State Engineer. He had a major hand in developing the State's Water Quality Act and the Water Quality Control Commission. In 1984-85, John worked at the OSE overseeing the case involving the City of El Paso well-permits in New Mexico. From 1990 to 1994, he worked on a three-day-a-week NMSU contract to help solve the problem of water deliveries to Texas on the Pecos River. In 1995 John worked under State Engineer Tom Turney on the Taos water plan.

John, NMSU Professor Emeritus, received a BS in civil engineering from UNM, an MS in sanitary engineering from Purdue University, an MS in environmental engineering from Harvard University, and a PhD in 1965 in water resources also from Harvard. He began his career with NMSU as an associate professor in 1965. In 1981, President Reagan named John deputy administrator of the Environmental Protection Agency. Also that year, he retired as a captain from the Navy Civil Engineering Corps Reserve. Two years later, John became the EPA's acting administrator. In 1984, he returned to NMSU after a brief post with the U.S. Department of Energy. John received many awards throughout his career including the prestigious Donald C. Roush Excellence in Teaching Award from New Mexico State University in 1990, and the Civil Engineering building at NMSU is now named Hernandez Hall in his honor. John is an honorary member of the oldest national engineering society in the U.S., the American Society of Civil Engineering, or ASCE.

Eluid Martinez served as the Commission for the Bureau of Reclamation from 1995 to 2001. He was nominated by President Clinton and confirmed unanimously by the U.S. Senate. A distinguished engineer with extensive experience in water resource planning and flood protection programs, Martinez served in the New Mexico Office of the State Engineer for 23 years, working as the State Engineer and the Secretary of the New Mexico Interstate Council on Water Policy, among *other positions. He was the first Hispanic American to serve as commissioner in Reclamation's 90+ year history, and is a native of Rio Arriba County, New Mexico. Martinez received an undergraduate degree in engineering at New Mexico State University and is a licensed Professional Engineer and Land Surveyor. He currently is with Water Resources Management Consultants LLC in Santa Fe, NM.*

Tom Turney P.E. was New Mexico State Engineer from April 1995 to February 2003, responsible for the measurement, apportionment, and distribution of the waters of the State of New Mexico. During his tenure, among other accomplishments, he oversaw development of administrative guidelines for water management within the state and developed the process to begin to deny or approve protested water right applications, which had been backlogged for nearly three decades. Currently, Tom is a consulting engineer on water rights, water administration and policy, and water supply within New Mexico. He earned bachelor's and master's degrees from New Mexico State University in civil engineering and is a registered Professional Engineer in New Mexico.

John D'Antonio is a registered professional engineer in New Mexico and Colorado, former New Mexico State Engineer, and became the Deputy District Engineer for the U.S. Army Corps of Engineers Albuquerque District in November 2011. He has experience in hydraulic design, acequia rehabilitation, water resource management, water policy development and project management for both civil works and military construction projects. Before he was appointed by Governor Bill Richardson to the state's chief water post, John served as the Cabinet Secretary of the New Mexico Environment Department. He served as the Director of the Water Resource Allocation Program for the Office of the State Engineer from 2001 to 2002 and as the District 1 Supervisor in Albuquerque from 1998 to 2001.

John previously worked for 15 years with the U.S. Army Corps of Engineers as a hydraulic design engineer and was the project manager for Cannon Air Force Base and for the Acequia Rehabilitation Program. A native New Mexican, D'Antonio received a bachelor's degree in civil engineering from the University of New Mexico in 1979. He was a member of the Governor's Blue Ribbon Task Force on Water Issues from 1998 to 2011. During his nine year tenure as State Engineer, John was Secretary of the Interstate Stream Commission, Chairman of the Water Trust Board; Governor's Water Infrastructure Investment Team; and the Governor's Drought Task Force. He also served as the New Mexico Commissioner to the Rio Grande, Costilla, and Upper Colorado River Compacts.

[The following conference panel discussion was transcribed and edited for these proceedings. If you would like to listen to the original webcast, please go to the NM WRRI website at: http://wrri.nmsu.edu, click on the 57th Annual New Mexico Water Conference – August 28, 2012 and click on "Webcast."]

Senator Udall: This is one of the most exciting panels that I think we are going to hear today. While sitting in Washington doing a bit of planning for this conference, I thought we should have a panel with former engineers and call it "Straight Talk: Voices of Experience from the New Mexico Office of the State Engineer." I really believe that these guys have the ability to give us the straight talk on water in New Mexico. Before I start, I want to thank our current State Engineer, Scott Verhines, for his remarks during lunch. He is a dedicated public servant with a tough job.

I personally wanted to get this group of former State Engineers together so we could hear lessons from the past that we can apply to the future. Let me make some brief introductions and then we'll begin the discussion. First, on my left, is John Hernandez, who spent almost 50 years in and out of the Office of the State Engineer under several administrations. He is professor emeritus here at New Mexico State University and is a tremendous resource for our conference. Next to him is Eluid Martinez, who was State Engineer from 1991 to 1994, and who also served as Commissioner of the Bureau of Reclamation from 1995 to 2001 as its first Hispanic Commissioner in its history and is also a graduate of New Mexico State University and a consulting professional engineer. Next to him is Tom Turney who served as State Engineer from 1995 to 2003 and was a leader on water management issues. He, too, is an NMSU graduate and consulting professional engineer on water issues. And lastly, John D'Antonio is our most recent past State Engineer serving from 2003 to 2011 and is currently the Deputy District Engineer for the U.S. Army Corps of Engineers in the Albuquerque District. Welcome everyone.

To add a little diversity to our panel, John Hernandez received his engineering degree from UNM, so it's not exclusively a New Mexico State University panel. I want to thank all of you for traveling here from Santa Fe and Albuquerque to participate. My goal is to stop talking and facilitate a great discussion. As former Engineers, you are able to come to this conference and be truth tellers. As State Attorney General, I became very familiar with the process of being appointed by the New Mexico Senate, and once you are appointed, you can only be removed for "cause." Appointees, like the State Engineer, should be independent and these guys are independent. They are going to tell us the truth about water. We'll let them start by commenting on anything that they have heard today.

John Hernandez: I like the title of this panel—straight talk on difficult decisions. I'm going to talk principally about one concerning the Pecos River, which I'll talk about in a bit.

Eluid Martinez: I want to take a few moments to acknowledge Dr. John Hernandez. If it weren't for the fact that Bruce King was elected governor in 1994 instead of Frank Bond, John would have been State Engineer instead of me. He has taught former State Engineers and advised them and I have a certificate here making him an honorary State Engineer for the purposes of this discussion. I think the State of New Mexico owes John a lot. Thank you, John.

Let me leave you with some starting thoughts. New Mexico water rights administration cannot be compared to water rights administration in other western states because New Mexico is unique in its problems and its water uses. When I was State Engineer, I recall attending a meeting with other western engineers and one of the state engineers, I believe from Montana or Wyoming, told me he was quite proud of the fact that the earliest water priority in his state was from the late 1880s. I looked at him and said, "Is that early?" In New Mexico, inhabitants were using water prior to 1000 and by the 1700s, some of the rivers were fully appropriated. We are dealing with a completely different kind of use—by Indian tribes, Hispanic acequias, and Bureau of Reclamation projects. When Colorado and other states say they have taken care of their adjudications, they have been adjudicating Reclamation projects, but they have not dealt with many Indian water issues and surely not some Hispanic acequia issues. New Mexico issues are completely different than other western states. Another recollection I have from my days as Commission of Reclamation was visiting Hoover Dam. The Dam's staff took great pride in showing me the generators at Hoover Dam. They showed me the penstock pipes that come into the generators and they were approximately 15 feet in diameter and flowing full of water. You could probably put all of New Mexico's water flowing in its rivers into one or two of those pipes. But the other interesting thing was that when I went up to Grand Coulee Dam, they showed me their generators and reminded me of the penstocks at Hoover Dam that were 15 feet in diameter and the spillway tunnels that you could drive a semi-truck through—and those tunnels were the size of the penstocks into *their* generators. When you talk about the Columbia River, all the water in New Mexico I administered over ten years could probably flow through one of those penstocks in a few seconds. I'm not saying they don't have their water issues on the Columbia River or on the Colorado River. But what we have in New Mexico is unique in terms of how it administers water. When somebody says that experience in Australia should teach us something about New Mexico, it might, but it might not.

Tom Turney: Thank you, Senator, for organizing this conference on water scarcity, which is a very important subject. We saw a graph earlier this morning that included the last couple thousand years of precipitation. Figure 1 is basically the same graphic the Senator showed earlier this morning; this one was developed by the Office of the State Engineer. It shows average precipitation over the last 2100 years. The graph was prepared from research on trees near the Bandara ice cage near Grants. The startling thing to me about this graph, and I studied it for years, is that if you look to the years prior to the 1950s, it shows that there were a whole lot worse conditions that have occurred in the past. History tells us that drought is going to happen again and what we are experiencing now will probably continue and it may get worse before it gets better. This kind of conference is totally appropriate as there are hard decisions that are going to have to be made in the future. This graph speaks to the necessity for establishing policies, whether they concern conjunctive management, priority of use, or issues of that nature.

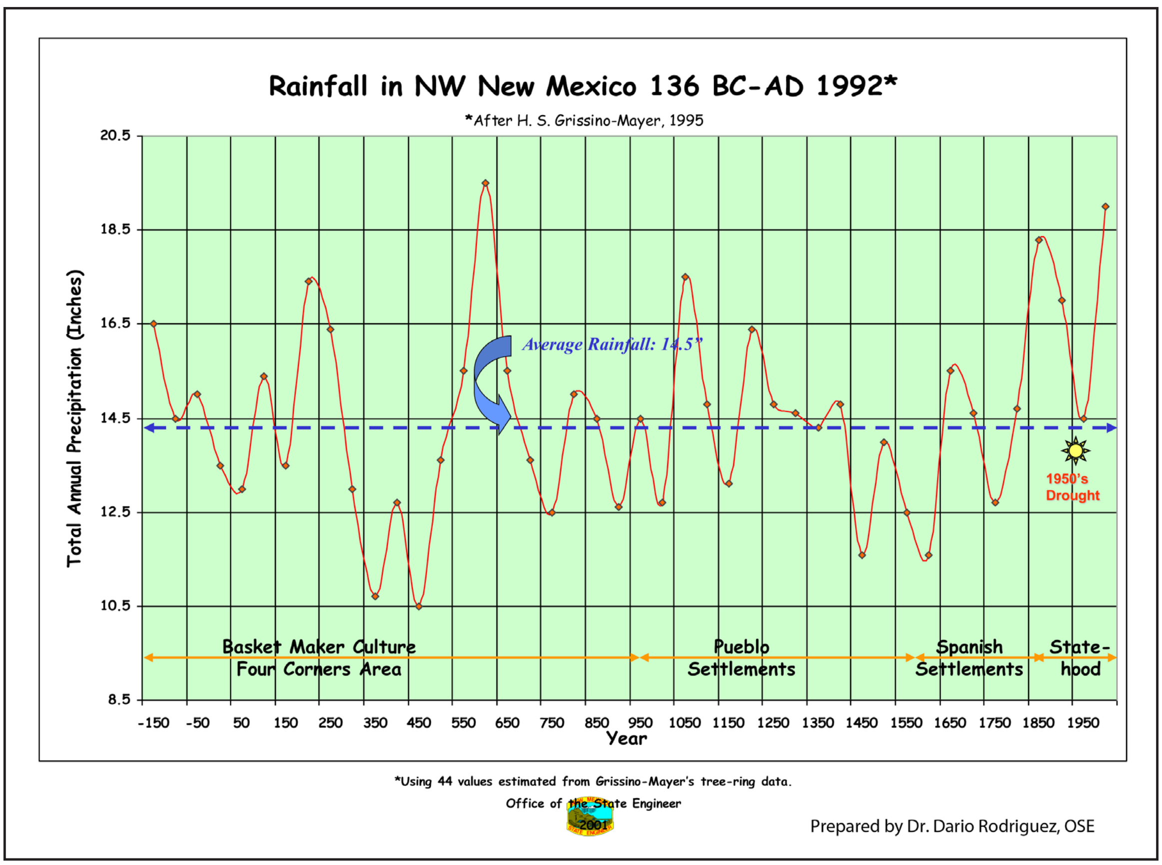


Figure 1. Rainfall in NW New Mexico, 136 BC-AD 1992

John D'Antonio: Good afternoon everybody. It's great being here back at the annual water conference. What's so great about New Mexico and about water is that although it can be polarizing the times, it's also rewarding when we can sit here in a group like this to discuss the issues. I see many people in the audience with whom I've dealt: water managers, mayors, city councilors, technical people, former staff and colleagues at the Corps, from in and out of state. The water community is here sitting in this room and no matter the differences that we've had over the years, the contentiousness that we've had, I still can consider it somewhat of a family. I want to thank Senator Udall for laying some of the groundwork on what I inherited when I became State Engineer. It is really about people—we have two million people in the State of New Mexico and we have very diverse water uses. We are the poster child of water use within the United States. Beside the acequias and the historical water use by 22 Native American tribal entities, we have rural folks all over the state, growing municipalities, environmental groups, and on and on and on. We have various power and energy folks coming to New Mexico now. We have every single water user, interest groups, and stakeholder groups that any other state has and more. What I would like to impart at this point is that it is a tough job being State Engineer. I think we all know what current State Engineer Scott Verhines is going to be going through in the next few years. It also is about people and working together for collaborative solutions. We can't get anywhere unless we collaborate.

Senator Udall: One of the big issues that I hear about from people like you in the audience and when I do Townhall Meetings around New Mexico, is that people are concerned about the pressures on the Rio Grande. I know we have a number of other rivers in the state, but let's stick with the Rio Grande as an example. Some people say we are inevitably going to keep growing New Mexico; we are two million now, we are going to be four million soon, and we will continue to grow beyond that. So the pressures on the Rio Grande are going to be enormous as well as on our other rivers. It was pointed out to me that given the current drought, if we didn't have water stored in the reservoirs in northern New Mexico, and if we didn't have the water from the San Juan-Chama Project, the Rio Grande would be dry right now. That is a pretty shocking situation, but that is where we would be. How do we address this? Do we ask ourselves whether we are going to have unfettered growth? Where are we going to get the water from? Are we going to go out and raid agriculture? We've heard many of our speakers talk about acequias and agriculture and how they are a vital part of New Mexico. So where are we going to get that water and how are we going to get it? John D'Antonio says we need to cooperate and work with each other. But what are the changes that need to be made?

John Hernandez: Years ago, I sat in on an Intel Corp. hearing on water that required the State Engineer Eluid Martinez to make a tough decision. The question concerned whether Intel's water use was in the public interest.

Eluid Martinez: I have the distinction of being tagged as one of New Mexico's last water buffalo State Engineers. The old State Engineers who were called water buffaloes were principally engineers whose main activity was developing water infrastructure. There has been some controversy since then that Reclamation and state water officials/buffaloes dammed every river in the West and dammed the environment. It is interesting how things turn 360° and now we are wondering if it were not for those reservoirs, where would we be? At any rate, earlier State Engineers—and New Mexico was fortunate to have had one State Engineer for 35 years, Steve Reynolds—were principally involved in making sure that New Mexico was able to exercise all the waters that have been apportioned to New Mexico through its compacts. Conservation of water meant using every drop that you could put to beneficial use. Then things started to change: the public perception of the use of water for environmental purposes and the concern about growth and how water supplies would meet new demand. I recall the first meeting of this group that I attended as a student at New Mexico State University over 40 years ago. And the last time I addressed this group was as Commissioner for the Bureau of Reclamation. The issues discussed 40 years ago or 13 years ago are the same issues sitting before us today. How do we meet increasing water demand with limited resources? I subscribe to the old buffalo theory that you have water, but you do not have enough water to meet all existing demands and all future demands. Former State Engineer Steve Reynolds used to say that if you had a reduction of 10 to 15 percent of agricultural demand, you would double the amount of water available for nonagricultural or municipal uses. The problem is that in New Mexico, as well as throughout the United States, we are attempting to meet existing demand as well as additional demand. I think that is where the hard decisions are to be made: in times of shortages, where does the water flow? Some states have priority of water use. In other words, in times of water shortages, by statute, municipal and domestic uses take first precedence. New Mexico does not have this under its water law. All beneficial uses share equally. The point I try to make is that we are in a water-short era and will continue to be in water-short situations as long as we try to meet existing demand as well as future demand. You cannot accomplish both objectives.

Tom Turney: What Eluid says is very true. There is not enough water to meet all existing demands and all future demands. In the future, there will have to be administrative changes. The decisions the State Engineer makes are unpopular a lot of times. Everyone who sits up here knows that—you make a decision and 50 percent of the people like it and 50 percent of the people hate it. Some get on the phone and even threaten you physically because you decided a certain way. The State Engineer has some really tough decisions ahead. Concerning the concept of priority of water use in New Mexico, I have noticed that people will argue in court that every use of water—whether industrial, municipal, agricultural, Indian use—everybody wants to have the number one priority and the maximum amount of water they can get. That is just the way the system works. I think it is a terrible mistake to try to change today's priority system or to change the priority of some special user/special interest group. I do not think that will be any better than what we have now. There will be controversies over the priority system no matter what you have. When the New Mexico Constitution was formed—and John Hernandez's grandfather actually sat in on this meeting—it created the priority in time clause and I think it ought to be given a chance to work and we are lucky that we have it. The State Engineer is going to face some very hard decisions ahead on the usage of water. It is easy to say that if we take a lot of water from agriculture, we can double the population of the state. I do not think it is that easy. I personally think it would be a terrible mistake if we do away with the state's historical heritage of agricultural use of water and steps need to be taken to protect New Mexico's roots.

John D'Antonio: The big question is: Where is the visionary leadership? Where is the next San Juan-Chama Project? If it weren't for the visionary leadership 40 and 50 years ago, we would not have that transmountain water coming into Albuquerque and Santa Fe today, or the drinking water project, or the Buckman direct diversion. Those projects had their beginnings decades ago and the really good thing about those projects is that they are from a renewable source of supply. That has taken pressure off our groundwater. I heard this morning discussion about the Ute Pipeline Project and how that may not be a good idea. That project has been fully vetted; it provides a renewable source of supply. The investment was made in the 1960s to build Ute Reservoir. That reservoir can bring a pipeline of water down to New Mexico's eastern communities. Similarly with the Gila project. The Gila is coined as the last free-flowing river within the state of New Mexico, although it is not really. The point being that we certainly need more water in the State of New Mexico. A comment was made that we don't need that water in New Mexico; we can let it flow down to Arizona. That is not the visionary leadership we need for New Mexico. We need more water. I want to point out the leadership at the Interstate Stream Commission and the leadership of Commissioner Jim Dunlap who has been very courageous over the last few years. A lot of work has been done under his leadership and Director Estevan Lopez. They have been talking about new supplies of water. How do we get new water infrastructure built within the state? How do we augment supplies to the state? We need to look for the next San Juan-Chama Project for the State of New Mexico. It is about having that visionary leadership. We cannot do it alone; we'll partner with local entities, other states, and certainly our federal counterparts and that is where the Bureau of Reclamation comes in. Reclamation is a great partner as is the Corps of Engineers.

Senator Udall: There seems to be some sympathy on the panel for the idea that you do not necessarily deal with population growth by raiding agriculture or acequias. But what can folks do to protect our agriculture? As former State Engineers and advisors to the State Engineer, what would you tell them they should be doing in order to try to protect rural areas, acequias, and agriculture? Is this something that is decided within the Office of the State Engineer or is there something that can be done outside?

John D'Antonio: Certainly the State Engineer is the arbiter of all applications that come forward. There is no new water in the State of New Mexico. You must file an application if you are going to request a change in place or purpose of use. We are fully appropriated in just about every basin. There are a few areas where we can consider new appropriations but very few. Four million acre-feet of water is diverted every year in New Mexico. In round numbers, three million acre-feet or 75 to 78 percent is used by agriculture. We could look at taking out a bit from agricultural to fund that growth, but where is that water and how do we do it? Growth in New Mexico is occurring in the Rio Grande corridor. Half the state's population, about two million people, lives from Cochiti down to Las Cruces. There is high demand there and not enough farmland within the Middle Rio Grande Conservancy District and elsewhere to execute change in place and purpose of use permits to allow for consumptive use of water for the growing cities and municipalities. So where do we get the water? It is through conservation, reuse, or new supplies, which could be brackish water, deep groundwater sources, desalination, or actually going into old water transfers. That has been tested a couple of times. During my tenure, an application for a Fort Sumner pipeline was denied because it was too speculative. Another was filed from the San Augustine Plains. You are going to see those types of applications continue. The economic engine for the State of New Mexico is the Middle Rio Grande and that is where the jobs are going to be. That is where we need additional water resources. Hopefully at some point, we will have that balance. We must have agriculture, we must maintain an agricultural community that allows us in drought years to make short-term transfers out to augment other supplies. But the water needs to stay in agriculture to a certain extent although a small part could be transferred out for permanent use.

Tom Turney: I'm glad John brought up water conservation. It is important and will continue to be very important for cities, municipalities, and water associations to practice conserving water to decrease their demand. The Middle Rio Grande Conservancy District has dramatically increased their efficiency. I think they have cut their diversions close to 50 percent in the last few years. This transfer of water from ag to municipal and industrial (M&I) will continue. The State Engineer could create a mechanism for moving water from agriculture to M&I purposes on a short-term basis. The transfers could be done for just a few months, which is not the way transfers happen now. Currently you come in and take the water rights from the agricultural land and dry up that land. Some new transfer mechanism could be created that is different from what has been done historically. Another example of the demand on agricultural uses is a situation occurring right here between the city of Las Cruces and the Jornada. There is a small separate underground water basin that is not connected to the Rio Grande. It exists as an isolated little basin. There are proposals to develop a community of several hundred thousand people on this underground water supply that we know won't last forever. Purely from a planning perspective, it is a terrible mistake as eventually those communities will run out of water. Meanwhile, they'll look over here and see all the water that is being used for agricultural purposes. It is going to be very hard to tell 100,000 or 200,000 people, "Sorry, you are going to have to leave." But they will get their way. I think the legislature will be persuaded to encourage a water transfer. But for now, you cannot have a policy that will dramatically impact agriculture the future.

Eluid Martinez: Let me pick up where Tom was headed. The current transfer process is so cumbersome that if a city begins a request to transfer water for municipal purposes on a short-term basis, the city could disappear before the Supreme Court enters a decision as to whether your permit will be approved or not. It needs to be advertised, it is subject to protest, subject to District Court appeal, and so on. What that does is to force municipalities or water users to look and acquire water rights long-term so that they are in a position to be able to use the water when they need it without having to go through a transfer process that might not get them water. So perhaps legislation could be put in place that allows transfers in times of drought from ag to M&I purposes short-term and quickly. That way a farmer, instead of farming in a particular year, would provide his water to others short-term. That accomplishes two objectives: municipalities get some short-term water and the farmer continues to farm while leasing his water short-term.

The State Engineer has been viewed in the last 10 to 15 years by some groups as being the last avenue of hope to prevent growth or to use water as a tool to prevent certain activities. To go back to the Intel application that John Hernandez mentioned earlier, Intel Corporation wanted to expand their business and protesters' biggest objection was not water issues but growth issues. The protesters asked the State Engineer to use his authority over water to manage growth. My order in that decision, which was not appealed to the District Court and therefore there is no precedence, took the position that the role of the State Engineer should not supplant the role of the local planning and zoning officials. If the State in New Mexico had gone out and recruited business to New Mexico and the local county had zoned property or had provided bonding authorities, and the local planning commission had done their zoning, I did not believe that it was the place of the State Engineer through a water issue to say that growth was not a good thing. I think that goes with what Paula Garcia was saying this morning. There is not enough case law or State Engineer decisions on the issue of public welfare, but I will subscribe to you that there is the beginning there.

John D'Antonio: When I became State Engineer, the legislature recognized that the adjudication process was slow, drought and water challenges were imminent, and we could not wait for full adjudications. They directed us to put in an expedited transfer process, promulgate rules and regulations, and do what was necessary to actively manage our water resources. From 2003 to 2011, we diligently went on that path. We established 17 basins within the state, we put in project management plans for all those basins, and we put meters in place as best we could. When I left the office, we had in excess of 90 percent of meters in place and 100 percent of water masters out in the field. We promulgated a general set of rules and regulations that went through a legal barrage of challenges. We have been trying to do what is necessary. You cannot manage water if you do not measure it. Once you measure it, you have to put things in place and follow through. From my perspective, I got the hand-off from Tom Turney and Eluid Martinez who started this process. I needed to get water management into the next century to do managing and expedited transfers as Eluid mentioned. That is one way I think we were on the cutting edge with respect to other states within the West as we were trying to put the process into place. A couple Supreme Court cases are still pending with one of them on active water resource management and that has challenged our ability to continue. Good or bad, there are checks and balances. It seems like whenever there is any change to the status quo, it gets challenged and the legal community tends to muddy it up just because they can. I wanted to add that it has not been for a lack of trying.

Senator Udall: An important point has been made on this question a couple of times. As Eluid said, the Office of the State Engineer should not be the place where the position is taken that growth is not a good thing. I think the question people wonder about when you ask about growth is where do we make that decision? It seems to me that short-term water transfers allow communities to have that discussion on growth. In a democracy, if you're going to make choices on growth and where the water for that growth will come from, it should be the community as a whole that takes part in the discussion. I think short-term water transfers would allow a city or a village to have that discussion themselves. People in those communities can come in and say that their water rights are being taken away and the full community can have that discussion. They can discuss whether they want to go with conservation, or with additional infrastructure, or where they want to head. That is a very worthy discussion to have. It should not be put on the State Engineer. It should be a decision made by the whole community.

John Hernandez: I am going to talk about a hard decision made around 1991-92. I was working for Eluid and he asked me to help him solve the issue on the Pecos River. We were faced with a Supreme Court decree that said we had to deliver water to Texas on the Pecos. Steve Reynolds always said, "The Supreme Court is not always right, but they are always supreme." We were faced with two hard decisions. One was to call priority: that means you cut off all junior water rights. On the Pecos, we would have had to cut it off to 1932 water rights in order to come up with about 18,000 acre-feet of water for delivery in Texas. I went around southern New Mexico asking what people thought about declaring priorities and cutting off these guys. I found amongst the bankers, farmers, and others that they did not want that to happen because they would go bankrupt and the banks would go under. The other alternative was that we look for state funding to buy rights from some of the water users in the basin because about 18,000 acre-feet of water would have a marked effect on the flow on the Pecos. It was not hard to sell that idea to the governor. King was the governor at that time and we asked him if he knew he was going to be faced with a Supreme Court decree and faced with contempt of court if he did not somehow manage to send the water down to Texas on the Pecos. He looked around and said, "Waterman, are we talking about one term or two terms of office?" I told him we were talking about two terms, but this was a serious problem. He opted for the buyout plan. It was a hard decision and it was made.

Eluid Martinez: If you listened carefully this morning, there was discussion about the priority system. But whenever this issue has come to a head, it has evolved into an acquisition program. Commissioner Connor said this morning that Reclamation is buying water and retiring water to meet needs. A priority enforcement system in New Mexico—unlike Colorado, which is different—as I visualize it, would cause chaos. My advice is that it is a good hammer but it is a hammer that does not work. We need to make sure that we never force a priority call in the State of New Mexico because it will cause economic chaos. The alternative will cost money, but I understand the federal government has a lot of money for water projects. Congress and the administration found close to three quarters of a trillion dollars to keep some Wall Street bankers from going under. I am sure that $50 billion, which is a drop in the bucket, could be found to assist the western states with their water problems.

Senator Udall: I would like to give each of you a couple of minutes for your final thoughts. We are fortunate to still have Commission Connor and State Engineer Verhines in the audience. Any final thoughts and advice in terms of where we go from here?

John Hernandez: When I left the State Engineers office to come to NMSU, Tom Turney was State Engineer and I remember one of his staff members coming to me and giving me this bottle of water. The label reads: *New Mexico's share of the Pecos River water as decreed in Texas vs. New Mexico, No 65; entrusted to John Hernandez—in case of a shortfall, drive to the stateline and deliver this to Texas*.

Eluid Martinez: I tend to not give advice to State Engineers because having walked in those footsteps, they need to their own job. I would leave it at this: I have been in the water business for 40 years, both at the state and national level, and while the past has taught us experiences and has set criteria for how things should be done, do not depend too much in the past. Look to the future and look out-of-the-box because decisions in the past were made on past information. If you have new information, new ways of addressing problems, look to address problems using the new status and not the past.

John Hernandez and I come from the past and we can share our experience, but it is the future where our problems will be solved.

Tom Turney: My advice is to keep the lines of communication open. Do not move immediately into court. The court route takes a long, long time and you may not like the outcome. Keep discussions alive among all the water users. Everybody has their own particular demand whether it is endangered species, municipal and industrial use, and so on. I think better solutions come out of dialogue and discussion. Going through the court system is sometimes necessary, but it should be the last resort.

John D'Antonio: I think we might have heard a bit of revisionary history this morning and afternoon on a couple of items. But one of the things that I think is so very important is to recognize good data and how imperative it is. We need good science and good data. A lot of smart folks are out there; the state can get involved in a lot of collaborative efforts with the federal agencies. We can look to NASA, NOAA, USGS, NRCS and they are all involved with water in some form. One of the things I am going to try to do is to take some of what I learned while working for the state and participate a bit more in the WestFAST program, which is a western federal action support team that works with the Western States Water Council and the Western Governors Association on western water issues. If we are going to get anywhere in water, we are at the point where we need regional solutions. We need big and regional answers to a lot of our problems. We tend to look too small sometimes at what the answer might be. We need to be able to leverage federal and state monies, and we've had some projects with severance tax monies going to the Water Trust Board and through the Finance Authority to get projects built. We need to better leverage that money and bring in federal programs as many of these projects are too large to build on their own. We need to collectively base decisions and solutions on good sound scientific data information and on a collaborative approach. I think New Mexico is getting there. The knowledge in this room is tremendous. Thanks to all of you for your patience and listening to us ramble up here. It has been a pleasure.

Senator Udall: Thank you panelists.

I want to take a minute to thank the members of my staff and staff here at New Mexico State University who have worked very hard on this conference. My staff, Elizabeth Driggers and Marco Grijalva have helped. We had a former staff member, Xochitl Torres-Small who started the early organizing of this conference. The University of New Mexico Law School stole her away from me. My two policy people out of Washington D.C., Drew Wallace and Jeanette Lukens are here and there many others who contributed including Dave, Beverly, Sarah, Bianca and Marisa—thank you for all of your work. Let's give one last round of applause for the Straight Talk former State Engineers and advisors.

SESSION THREE

Building a Plan: Best Practices

Moderated by Commissioner Michael L. Connor, Bureau of Reclamation

Michael L. Connor was confirmed Commissioner of the Bureau of Reclamation by the U.S. Senate on May 21, 2009. Connor has more than 15 years of experience in the public sector, including having served as Counsel to the U.S. Senate and Natural Resources Committee since May 2001. At the committee, Connor has managed legislation for both the Bureau of Reclamation and the U.S. Geological Survey, developed water resources legislation and handled Native American issues that are within the Energy Committee's jurisdiction.

From 1993 to 2001, Connor served in the Department of the Interior, including as deputy director and then director of the Secretary's Indian Water Rights Office from 1998 to 2001. In this capacity, Connor represented the Secretary of the Interior in negotiations with Indian tribes, state representatives, and private water users to secure water rights settlements consistent with the federal trust responsibility to tribes.

Before joining the Secretary's Office, he was employed with the Interior Solicitor's Office in Washington, DC and in Albuquerque, New Mexico. He began his Interior career in the Solicitor's Honors Program in 1993.

Connor received his J.D. from the University Of Colorado School of Law, and is admitted to the bars of Colorado and New Mexico. He previously received a bachelor's degree in chemical engineering from New Mexico State University and worked for General Electric.

The Bureau of Reclamation is a contemporary water management agency and the largest wholesale provider of water in the country. It brings water to more than 31 million people, and provides one out of five western farmers with irrigation water for farmland that produces much of the nation's produce. Reclamation is also the second largest producer of hydroelectric power in the western United States with 58 power plants.

Environmental Water Transactions

David Yardas, National Fish and Wildlife Foundation

David Yardas directs the National Fish and Wildlife Foundation's Southwest and Interior Water Programs. David has a 26-year track record building transactional, collaborative, and legislative initiatives to help restore at-risk rivers, lakes, and wetlands, reduce water conflicts among competing sectors, and settle Native American water claims. His past work covers an expansive western geography that includes the Truckee, Carson and Walker River basins in Nevada and California; the Sierra

Good afternoon everyone. I want to thank Senator Udall, his staff, New Mexico State University, all the organizers, fellow panelists, and all the attendees for your attention today. It's a pleasure to be here representing the National Fish and Wildlife Foundation (NFWF).

First, a few brief words about NFWF: we are a congressionally-chartered nonprofit foundation established in 1984. Like any nonprofit we can accept tax-deductible charitable contributions; but we are also authorized to receive federal appropriations directly, and to manage federal monies in partnership with various federal agencies. We focus on partnerships and collaboration with grantees, agencies, benefactors, corporate partners, and others. In 2011 we granted a total of approximately $130 million for on the ground investments; about a third of that was federal money, with about two-thirds coming from philanthropic dollars and grantee match. The whole idea is to use partnerships to put money on the ground, and to leverage the federal investment.

Nevada/Central Valley/Bay-Delta watershed in California; and the multi-state and bi-national Rio Grande/Rio Bravo and Lower Colorado River systems.

Prior to joining NFWF, David held staff positions at Environmental Defense Fund, Independent Power Corporation, Resources for the Future, and the U.S. Department of Health and Human Services. He was also a founding member of Great Basin Land and Water, a research assistant at the World Bank, and an independent consultant to the U.S. Bureau of Reclamation, University of Nevada, ICF International, and The Nature Conservancy. David holds a B.A. in economics from UC Davis and an M.S. in energy and resources from UC Berkeley.

The Foundation's Western Water Program specializes in environmental water transactions, and the definition here is a pretty broad one: using voluntary agreements to benefit freshwater species and habitats while addressing the needs and interests of willing sellers and other stakeholders. We do this work within the boundaries of the prior appropriation system, and we work almost exclusively within systems that are fully appropriated. Thus, we grapple with many of the challenges that are being faced here in New Mexico today.

The objectives of our program include the restoration of freshwater flows to rivers and streams, riparian and wetland habitats, desert terminal lakes, degraded delta estuary systems, and natural processes like sediment movement and floodplain connectivity. In addition, an important theme of our work is to use transactional initiatives to solve problems and resolve conflicts over water.

Many of our programs interface with some kind of regulatory precedent—for example, the "Reasonable and Prudent Alternative" in the Pacific Northwest which led to establishment of the Columbia Basin Water Transaction Program, and attempting to forestall a critical habitat designation here in the Lower Rio Grande by working with the Elephant Butte Irrigation District to establish a collaborative water transactions program. Our work also involves facilitating water rights litigation settlements; helping to modernize irrigation systems; and bringing flexibility into historically inflexible systems in order to deal with all of the realities of climate change, growth, and hydrologic uncertainty.

Our primary transactional tools include purchase and sale agreements, water lease agreements, and forbearance agreements, all with willing sellers. There is a wide array of tools in the toolkit (Table 1) that we rely on and that form the basis for the kinds of programs in which we get involved. It takes a lot of different pieces of the puzzle to pull these programs together and make things work.

Table 1. Water transaction toolkit

Water Transaction Toolkit

- Annual and Term Lease
- Purchase and Sale
- Partial Season Irrigation
- Source Switch
- Forbearance
- Diversion Reduction
- Land Fallowing
- Stewardship/Revegetation

- Assessment/Deed of Trust
- System Improvements
- Water Banking
- Conveyance/Wheeling
- Standard Offer
- Procurement Auction
- MOUs/Framework Docs
- Monitoring & Assessment

Given the comments in the last panel, I should have prefaced my comments on the Columbia Basin Program by noting that although the Columbia Basin is a very different place, the common theme of this program is that tributary streams, not the main stems, are typically over-appropriated and often run dry in the summer. They do share some common characteristics with admittedly different landscapes. Indeed, all of the western basins are different, and tools have to be tailored to the realities of each situation. But there are also common themes, such as trying to work on a partnership basis by moving transactional activities out to local entities whenever possible.

Another of our existing programs is the Walker Basin Restoration Program, a large-scale restoration initiative in Nevada and California. It uses a variety of authorized tools established by Congress and funded through the Bureau of Reclamation including willing seller acquisitions, water leasing, conservation and stewardship, research, evaluation, and implementation support.

In the Lower Rio Grande, we are working with the Elephant Butte Irrigation District and with Audubon New Mexico, our local on-the-ground partner, with sponsorship from and in partnership with the U.S. International Boundary and Water Commission and the U.S. Fish and Wildlife Service. The goal of the Lower Rio Grande Water Transactions Program is to restore 30 riparian sites along a 105-mile reach of the river to meet the commitments under USIBWC's 2009 Record of Decision, to avoid a critical habitat listing for the Southwest Willow Flycatcher, and to deal with Endangered Species Act assurances related to uncertain water supplies.

Let me conclude by talking briefly about common themes and best practices in all of our transactional work. To invest in local transactions capacity, NFWF generally acts as a fund administrator and tries to push transactions capacity know-how and knowledge out to the ground to local transactors, who know their communities best and who can work directly with local irrigation districts and with tribes. We work closely with landowners, water managers, and other local stakeholders to understand and address their needs. Stewardship programs are a big part of such efforts, whether for revegetation of affected farmlands; restructuring of the water-rights portfolio in order to work with landowners to grow high-value crops that can help to preserve jobs; negotiating water conveyance agreements; or whatever else it takes to get the job done. We utilize independent expertise to establish strategic priorities, business plans, and review annual funding proposals to get the most bang for our buck whenever possible. We help to evaluate program performance; conduct critical due diligence with respect to the full array of property acquisition activities so that you know what you're buying and can put it to beneficial use; and we assist with the water rights change approval process, whether at the local, state, or federal levels. We help define critical outcome metrics, monitor and track performance, and adapt and adjust where needed. And finally, we relentlessly pursue funding in a variety of forums, both public and private, to develop new initiatives such as regulatory flow credits and water restoration certificates, and to partner with other funders to expand the funding available for this important restoration work.

I'm afraid I'm out of time, thank you very much!

Water Leasing Market Experiments

David Brookshire, University of New Mexico

David S. Brookshire is a Distinguished Professor and Director of the Science Impact Laboratory for Policy and Economics (SILPE) within the Department of Economics at the University of New Mexico (UNM). After completing his B.A. in economics at California State University at San Diego in 1970, David earned his Ph.D. in economics at the University of New Mexico in 1976. He was on the faculty at the University of Wyoming from 1976 to 1990. He returned to UNM in 1990 and served as department chair from 1993-2000. David specializes in environmental and resource economics. Among his many appointments, he has served as Policy Sciences Editor of Water Resources Research (published by the American Geophysical Union), served on the Executive Board of the Sustainability of Semi-Arid Hydrologic and Riparian Areas (SAHRA) Science and Technology Center at the University of Arizona, served on three National Research Council panels and worked as an economist for the National Water Commission, the U.S. Department of Commerce, and the U.S. Geological Survey.

David specializes in public policy issues in the natural resource, environmental and natural hazards areas. In particular, he has completed studies pertaining to seismic building codes, earthquake prediction impacts, environmental regulations, endangered species, air pollution, the effects of seismic zoning and the value of geologic information and water allocation. His current research interests include ecosystem valuation, natural hazards issues, endangered species protection, field and laboratory experiments for the estimation of disaggregated

It is a pleasure to be here. I will tell you right up front my comments have morphed a bit as I have listened to the very interesting conversation that we have had throughout the day. The focus of my conversation is going to be on flexibility issues and water reallocation. More specifically, I want to talk about some ideas about water leasing.

Let me suggest that currently in terms of water allocation, we do not have best practices. We have current practices and part of the theme of my talk is that we need to move beyond the status quo and redesign the institutions that we have for water transfers. You've heard quite a bit about this especially from the last panel. In fact, my take-away point from the last panel was that everybody hates markets right up until the moment they love markets.

What I'm going to talk about here is embodied, in some sense, in a book that recently came out, *Water Policy in New Mexico: Addressing the Challenge of an Uncertain Future* edited by myself and Hoshin Gupta and Paul Matthews. I caution you, if you read Chapter 14 of the book you will find that as one colleague has suggested: you didn't try to go from "a" to "b" to "c"—you wanted to go directly to "z." In the book we tried to stir the pot. I'm going to give you a few brief thoughts on that. Now obviously we've heard a lot about the need for more flexible institutions: in the amount of time that it takes to do a water transfer whether it is a lease or a permanent trade. The time is really quite long and is well documented. Those that entered into this process have found it costly.

The need for expedited transfers is fully recognized in the State Water Plan, but this is not fully implemented. In Section C2 and 6-9, words such as "efficient transfers of water that consider economic, cultural, and other custom norms, and water banks" are all talked about. Notice all those words are bundled together. They are not bundled together as: let's do a water market and ignore everything but just the value of the transfer water. It says this market must be, in fact, be constrained in some fashion, and if you think about it for a moment, there are almost no markets in our country that are not constrained in some fashion. So the task at hand in designing an efficient water leasing market that respects cultural norms.

Let me talk about some things that we have tried to do to address this issue. There needs to be, I would suggest, at a minimum, two advances if we are going to move towards what I would call a real-time leasing market. First, we need a "coupled model framework" that integrates the best knowledge from scientists, engineers, lawyers, Native Americans, stakeholders, environmentalists—I probably have forgot someone, forgive me—but everybody basically has to be at the table. We need that model, fully integrated, and fully coupled, so that when one piece kicks the other piece, they all know about it. Second, you need to tie that model to a **voluntary** leasing market. If you don't want to be in the market, you are not in the market. If you go into Smith's and you don't want tomato paste, don't buy tomato paste. It's that simple.

demand of consumer water users, the value of water in non-market settings, and integrated hydrological/biological/economic modeling of alternative institutional and behavioral characteristics of water banking/leasing markets.

You need these two components linked together so that as trades are initiated, it's tracked, and you know what's happening in terms of various kinds of things. By constraining these markets in some fashion, you know that, in fact, for some trades, it will be said, "no, can't do that one—it violates this or that." Essentially, you are giving the policymakers a framework that allows them to stand back and, with low transactions costs, and watch an efficient, adaptive management tool evolve as people interact in these markets. Can this be done? We think so. In fact, we've developed a stylized market based on the Middle Rio Grande where we had these coupled integrated models. After a presentation and at the encouragement of John D'Antonio, former state engineer, he asked us to go do some of this work on the Mimbres River Basin. We have been working down there with stakeholders. Let me say one thing very quickly about that—is this easy? No. We've been at this for a couple of years and it's a very slow process. There's a necessary process for building trust and communication. Will this be a complete success? I can't tell you that, but we will again have learned some lessons in terms of developing this market.

So the idea here is that if you have a real-time market coupled to the physical, engineering, environmental situation at hand, this might imply that all water leasing markets might be specific markets to specific places designed by specific stakeholders. One shoe does not fit all. This will facilitate the transfer process and remember, a market is only going to be as good as a stakeholder's involvement in the design of that market. You can design any kind of market. The poster child of a bad market is the California electricity market. The idea is to avoid that kind of situation.

This conference is about hard choices. My hard choice would be: Are we going to sit with the existing institutions for allocation that soon will be inappropriate in the 21st century, or are we going to move beyond the status quo and begin to try to develop these institutions.

Thank you.

Rio Grande Basin Opportunities

Lee Peters, Peters Law Firm, LLC

Lee E. Peters is the owner of a water and natural resources law firm, Peters Law Firm, LLC. From 1989 to 2010, he handled cases regarding water rights, public lands, grazing rights, wilderness, environmental law and endangered species, as well as general civil law for Hubert & Hernandez, P.A. From 1984 to

Thank you, Commissioner Connor. I'm very honored to be here with Senator Udall. Senator Udall and I have known each other since we were young and struggling attorneys back in the old days in Santa Fe. You haven't heard any jokes today, usually speakers come out and tell jokes, but water law and water issues are just not that funny. We know it's not funny because in New Mexico we are very amenable to our neighbors, but the old saying is modifiable a little bit here where we say "mi casa es su casa, pero mi agua es mi agua." You don't come in and use our water in New Mexico.

1987, Lee was Special Assistant Attorney General, New Mexico State Land Office, primarily responsible for the Land Office's water policies.

He was the lead counsel for the State Land Office in administrative proceedings before the State Engineer filed by the City of El Paso for massive groundwater rights within New Mexico. Since 1987, Lee has been counsel for clients such as the Elephant Butte Irrigation District and the Carlsbad Irrigation District. He received a B.A. in economics and political science from UNM and received a juris doctor from UNM's School of Law in May 1980.

I'm going to talk about New Mexico's Lower Rio Grande area. We have a situation here where we are urbanizing with the City of Las Cruces and other areas like the City of El Paso area, which gets the other part of Rio Grande Project Water, and is highly urbanized as is Albuquerque. All of these cities are surrounded by irrigation or conservancy districts that control the bulk of the surface water in those areas. So there's a need for methods to get that agricultural water into other uses. We've talked about markets and other things, but there are institutional barriers present. You can't just go buy an agricultural water right in these areas and move it to where you want it for whatever purpose you want.

In the Lower Rio Grande, we have the federal Rio Grande Project that runs from Elephant Butte Reservoir to Ft. Quitman in Texas. It's a single-purpose project, authorized in 1906. That single purpose is agriculture. Elephant Butte Irrigation District (EBID) within the New Mexico portion controls virtually all of the surface water. There's a lot of pressure—economic, legal, and otherwise for those ag water rights to be moved into other uses. I'm going to talk about two methods for this. One is in place, and one we are working on.

The first one is special water users associations, which are authorized by state law since the year 2000. Municipal entities, universities, and other kinds of water providers can become a special water user association and apply to an irrigation district and to the state engineer to become such an entity. They can then lease water rights from within an irrigation district and use them within or without the district for municipal and industrial purposes. Thus we have a mechanism to get agricultural water into these other two kinds of uses, which is where much of the demand is coming from.

In this area, nobody is actually diverting surface water for municipal uses. The Doña Ana Mutual Domestic Water Consumers Association will likely be the first. They have plans underway to build a surface water treatment plant near the Leasburg Dam. I understand the City of Las Cruces has some plans to divert surface water. No water has actually been diverted for these purposes, but we will see this happen in the near future. This is a fairly unique statute and authorization because it allows agricultural water to be used within or outside the irrigation district boundaries for these nonagricultural uses.

Another thing EBID is working on in partnership and collaboration with the International Boundary and Water Commission, the Audubon Society, National Fish and Wildlife Foundation, and through the offices of Senator Udall and Senator Bingaman is what we have tentatively called an environmental water transaction program. The program would allow EBID agricultural water to go into habitat restoration and other types of environmental uses. EBID is developing this on the basis that this is another kind of agricultural use: it's a human use of water to grow plants for human benefits, it provides habitat for endangered and threatened species. U.S. Fish and Wildlife and the Bureau of Reclamation are also involved. We have a tentative thumbs-up from Reclamation Commissioner Connor on this approach. This would allow the sale or lease of EBID water for use within the district for wildlife habitat, restoration, and maintenance. It is still within the single purpose of the Rio Grande Project, it's still an agricultural use, although it's a different kind of agricultural use. What we are developing now are protections for this water against sanctions that might be imposed under the Endangered Species Act that would force the use of that water if it's diverted into an endangered species purpose. We don't have a lot of threatened or endangered species down here—not a lot of habitat is being developed, so we are starting basically from the ground up. As these rights are developed, they will be protected so that the only water that can be used is limited to the regular allotment that any other water right owner within the district has. It's kind of funny to be talking about this at this point because we don't have much surface water. The idea is to keep those depletions for this kind of agricultural use in balance. They would not be allowed any increase in depletions over agricultural use, and the deliveries would be made within the irrigation system.

In conclusion, this is a program to create flexibility and to provide other methods to allow the free market to function within an irrigation district. Farmers have the option to sell or lease or even donate water for these other uses. It opens the market for nonagricultural uses—for urban and municipal uses or for environmental uses. The water remains under the administration of EBID and keeps the EBID viable because the assessments for the water would still be paid and allows EBID to continue to maintain the system. This addresses the same concern that Paula Garcia had for the acequias. Thank you very much.

Bridging the Gap—Transformational Solutions for a More Sustainable Water Future

Howard Passell[1], Jesse Roach[1], Dagmar Llewellyn[2]
[1]Sandia National Labs
[2]U.S. Bureau of Reclamation

Howard Passell works in the Earth Systems Analysis Department at Sandia National Laboratories, in Albuquerque. His work focuses on sustainability and resource management projects associated with water, energy, and food resources, with an emphasis on the links between those and other systems, including ecosystems, demographics, economics, public health, governance, and security.

His work has involved resource monitoring, modeling, management, capacity-building, and policy-related projects at various scales in the U.S., Central Asia, the Middle East, and North Africa. Of special

I'd like to thank my co-authors, Dr. Jesse Roach from Sandia National Labs and Dagmar Llewellyn from the U.S. Bureau of Reclamation, both in Albuquerque, and the WRRI and Senator Udall and his staff for making this important event possible.

I'm going to report on one case study from a set of three we examined as a way of better understanding future water supply and demand dynamics in the western U.S. The other case studies include work from Dr. Vince Tidwell and Katie Zemlick, both from SNL, and Dr. Cliff Dahm from UNM biology.

Data from regions around the world suggest that humans are facing a considerable gap between projected supply and projected demand for water in many regions, with New Mexico in particular, and the U.S. Southwest in general, as prime examples. It is also becoming apparent that the advantage gained by current supply augmentation and conservation technologies being applied around the world are incremental at the margins, and linear, and not adequate for bridging the future gap between projected supply and demand. We set out to examine what we thought might be transformational solutions that would bridge the gap by creating non-linear advantages. We

Sandia National Laboratories is a multiprogram laboratory managed and operated by Sandia Corporation, a wholly-owned subsidiary of Lockheed Martin Corporation, for the US Department of Energy's National Nuclear Security Administration under contract DEAC04-94AL85000.

interest is the relationship between resources, population, ecosystems, and human security. His undergraduate studies were in classical literature and the liberal arts. He earned master's and doctorate degrees in conservation biology and hydrogeoecology at the University of New Mexico.

found solutions that appeared to bridge the gap, but upon closer inspection it became clear that they really shifted the gap from one sector—water—to others, including economics, ecology, and culture. We demonstrate today with one of three case studies.

This case study focuses on work being presented in a poster at the conference entitled "URGSiM Analysis of Climate Risk in the Upper Rio Grande Basin" by Dr. Jesse Roach from SNL, and Dagmar Llewellyn and Warren Sharp from the Bureau of Reclamation. The authors present the final results from a complex sequence of computer modeling approaches used to evaluate how climate change might affect water supply and demand in the upper and middle Rio Grande basin, and how those effects might impact legally binding downstream delivery obligations. This work was part of the Bureau of Reclamation's West Wide Climate Risk Assessment Program. The analyses performed by the West Wide Climate Risk Assessment used 16 different general circulation models and 112 different model runs to simulate and analyze future climate scenarios and their impacts to water deliveries, river flows, and reservoir levels in the upper and middle Rio Grande (Fig. 1). Much more information on the model and the analysis is available on the poster, and from the co-authors.

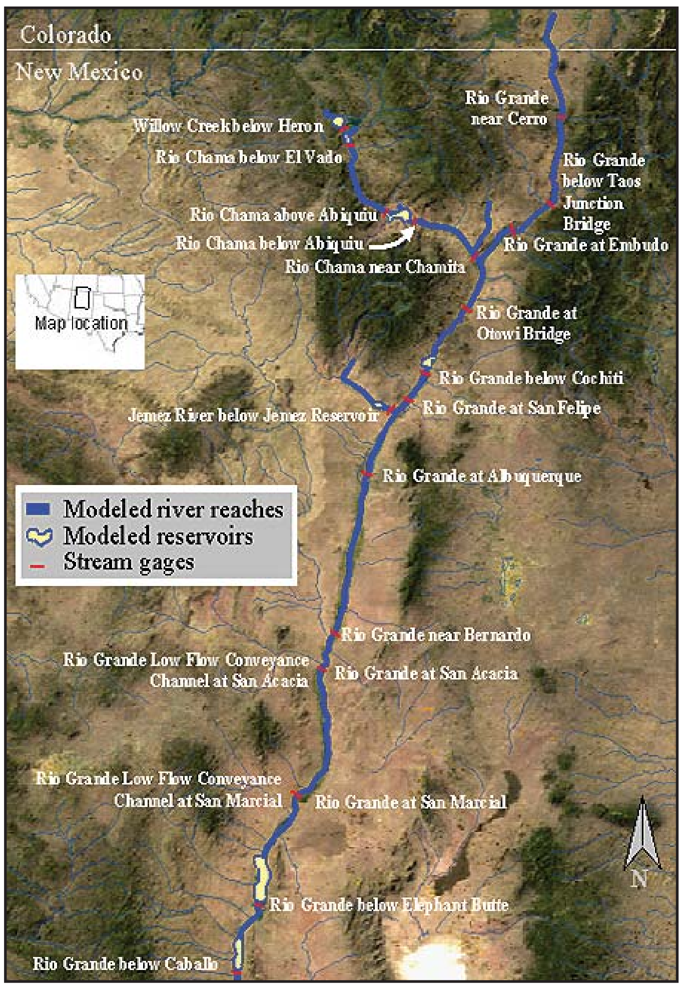


Figure 1. Map of the Upper and Middle Rio Grande

Figure 2 shows surface water supply in the study area out to 2100. These results are not predictions, according to the authors, but rather are a starting point for dialogue and increased awareness of potential impacts. These simulations account for climate change, but not population growth or any kind of water conservation. Declines in surface water supply are evident at Rio Grande at Lobatos, Rio Chama near La Puente, and Azotea Tunnel. These declines are occurring in a region already suffering from surface water shortages relative to current demand.

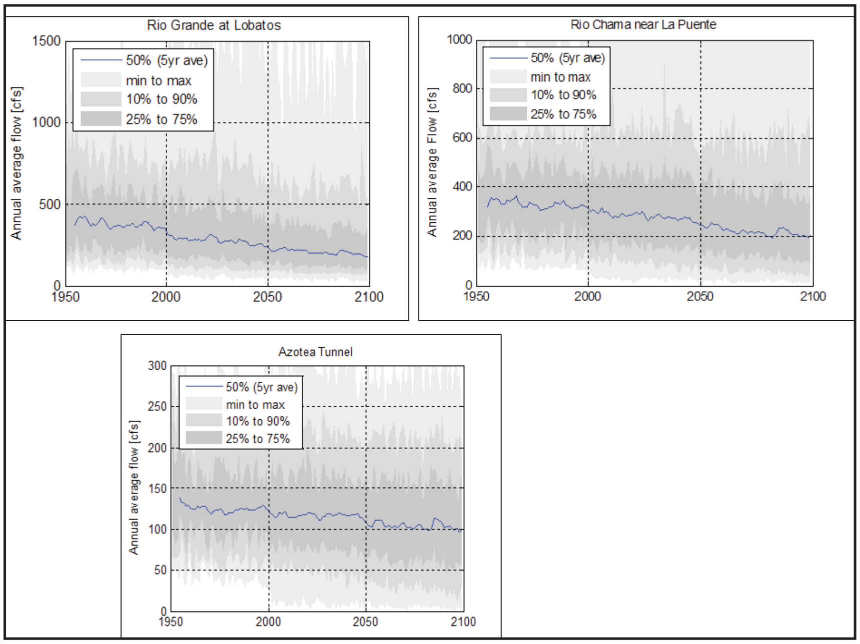


Figure 2. Surface water supply

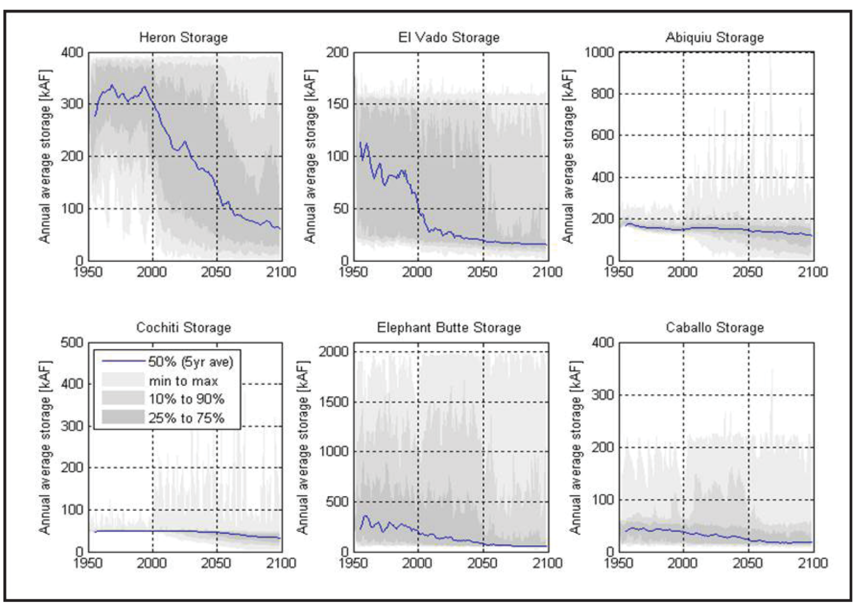


Figure 3. Reservoir storage

Reservoir levels are shown decreasing over time in Fig. 3 for Heron, El Vado, Abiquiu, Cochiti, Elephant Butte, and Caballo. Fig. 4 shows irrigated agriculture, riparian vegetation, and municipal demand all increasing. What's the impact on the Rio Grande Compact? Fig. 5 shows that by 2100, without any sort of proactive or reactive water management policy changes, New Mexico is projected to amass a Compact deficit of over a million acre-feet in more than half of the simulations, which would represent flagrant non-compliance with the Compact and would never be allowed to occur under the current Compact agreement.

The researchers used their operations model to evaluate different scenarios for what might be done to reduce the simulated Compact deficit—or to bridge that gap. Figure 6 shows how the model reduces agriculture to solve the Compact problem. By the year 2100, the model simulates cutting agriculture in the Middle Rio Grande Basin by about 21 percent, from about 58,000 acres down to about 46,000 acres. In other words, the Compact deficit in the Middle Rio Grande Basin is relieved by significantly cutting the agricultural area. Figure 7 shows the result on the Compact when those agriculture reductions take place: we go from an over 1,000,000 acre-foot deficit in Fig. 6 to significantly less than a 200,000 acre-foot deficit in Fig. 7, which is the maximum deficit allowed under the Compact. So cutting agriculture helps bridge the Compact gap, but it creates another gap represented by the loss of agriculture, which would have economic, ecological, and cultural implications. It could create an important future gap in regional food security if those agricultural lands are lost for good, and fossil fuel prices increase such that it is no longer economical to import food from other states or other countries.

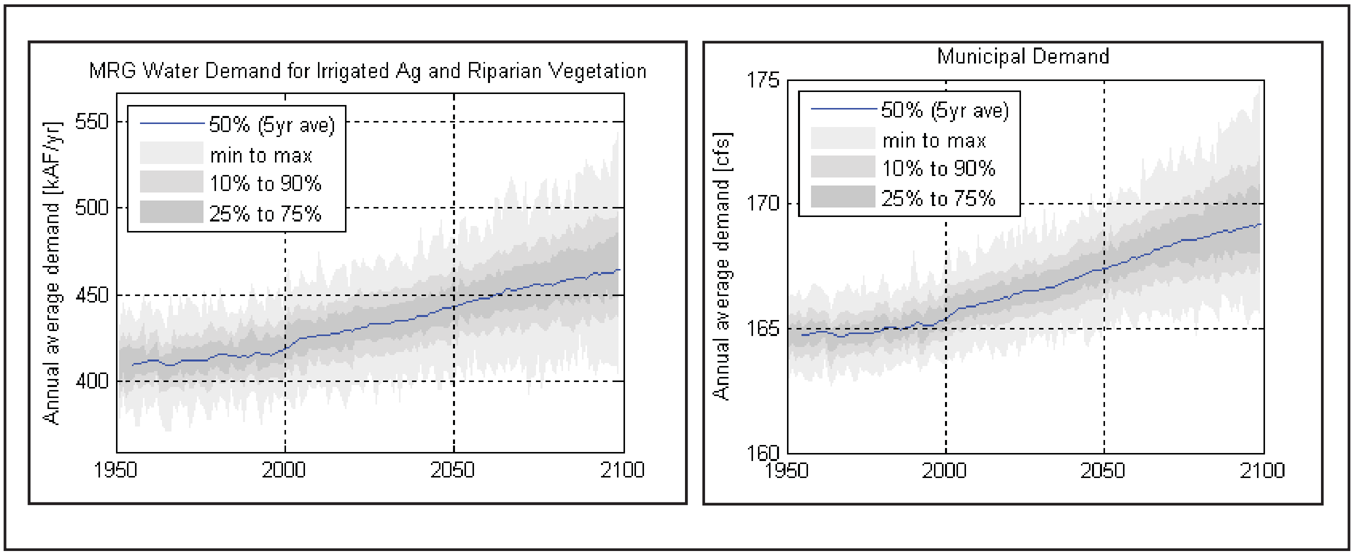


Figure 4. Agricultural, riparian, and municipal demand

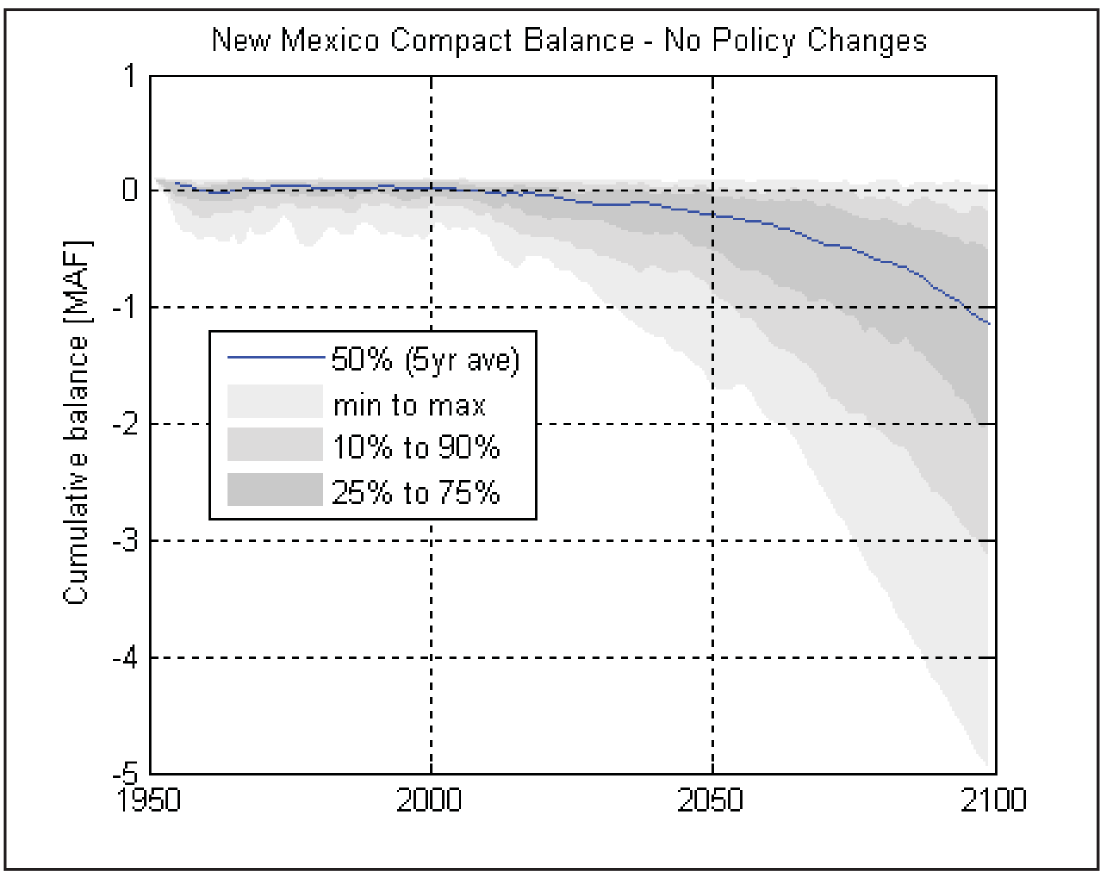


Figure 5. The Gap in the Rio Grande Compact

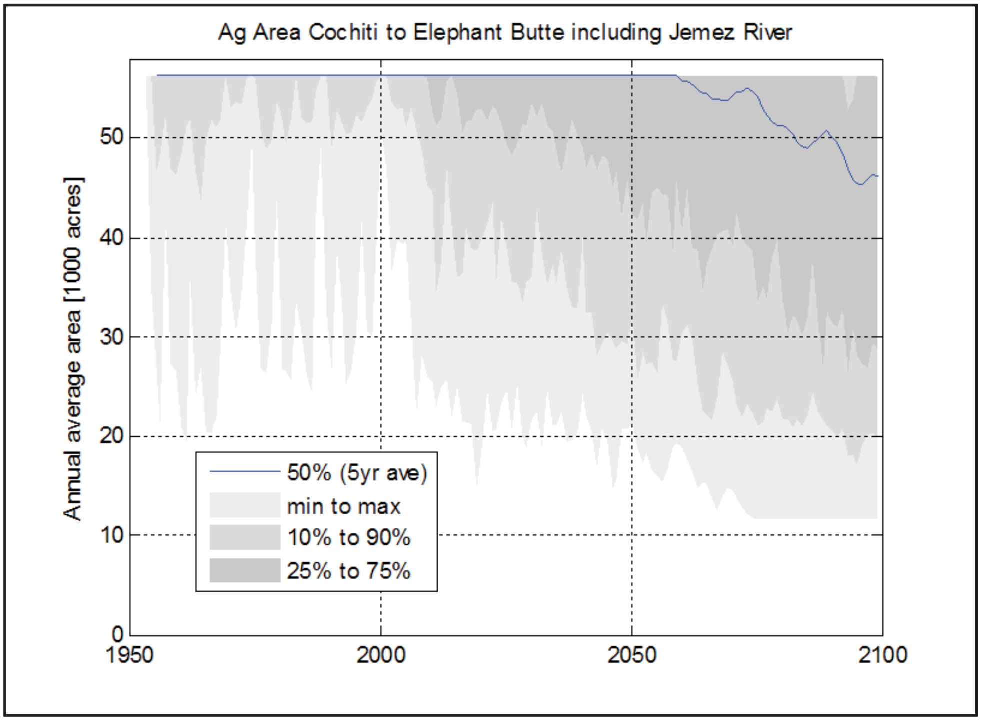


Figure 6. Agriculture reductions as a possible strategy

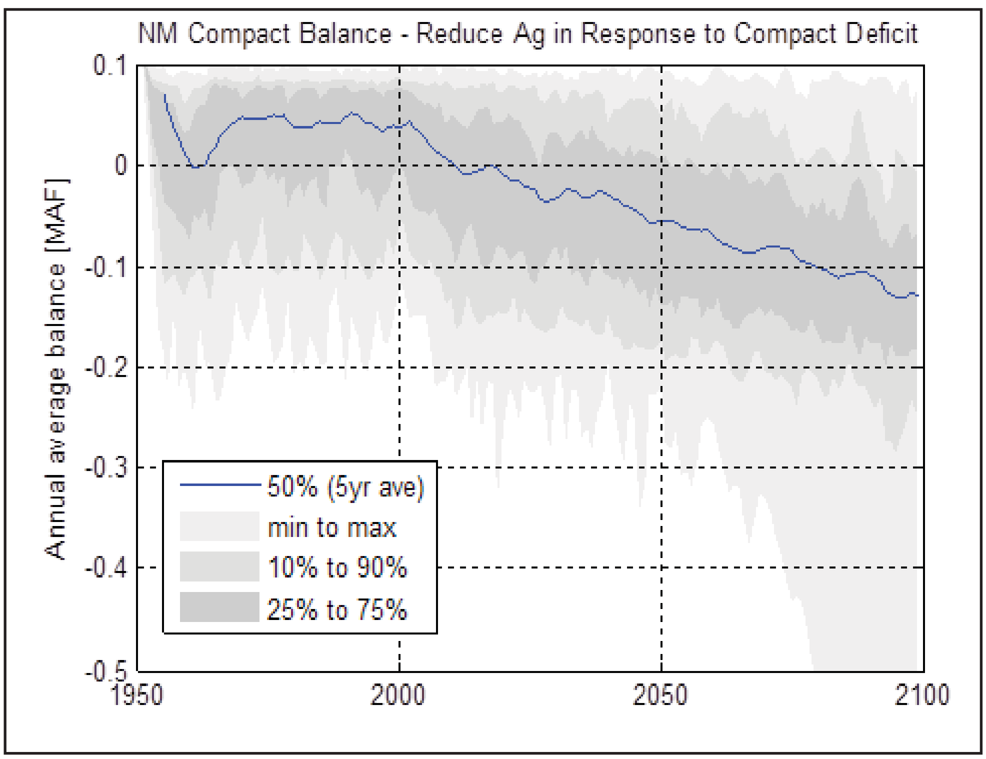


Figure 7. Compact response to Agriculture reductions

Another scenario aimed at reducing the Compact deficit reduces our riparian area, the bosque, in the Middle Rio Grande Valley by about 40 percent, from a little under 55,000 acres down to about 33,000 acres (Fig. 8). That reduction helps bridge the Compact gap, leaving a roughly 100,000 acre-foot deficit instead of an over one million acre-foot deficit in the base-case scenario (Fig. 9). However, it shifts the gap to the bosque, which would have broad ecological and cultural impacts.

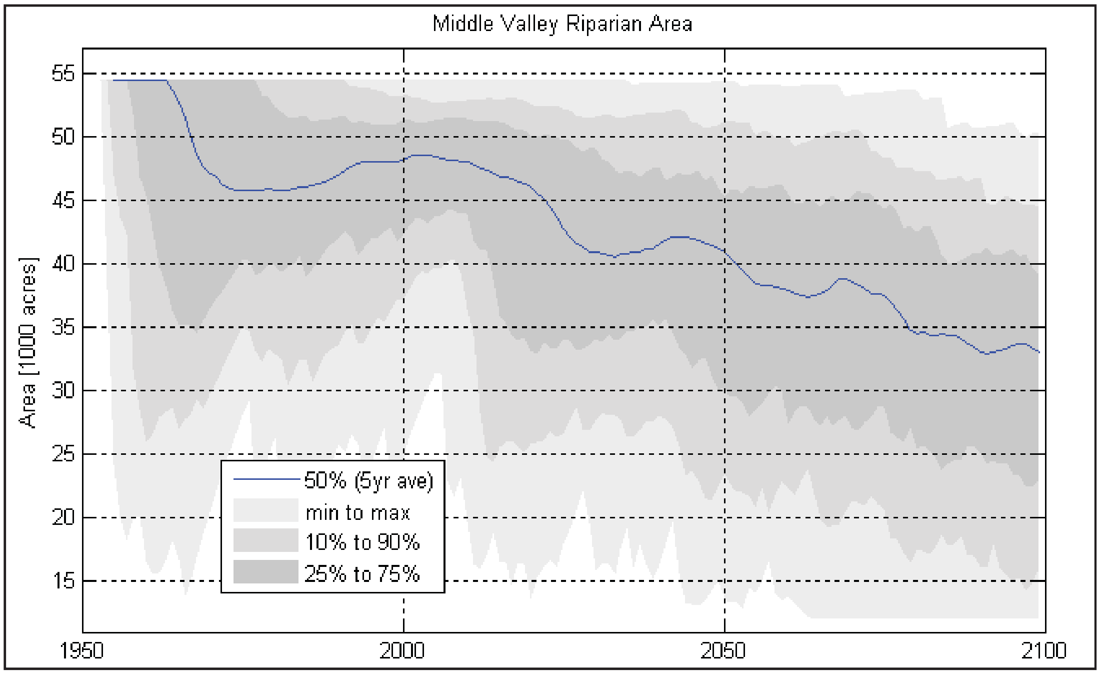


Figure 8. Bosque reduction as a possible strategy

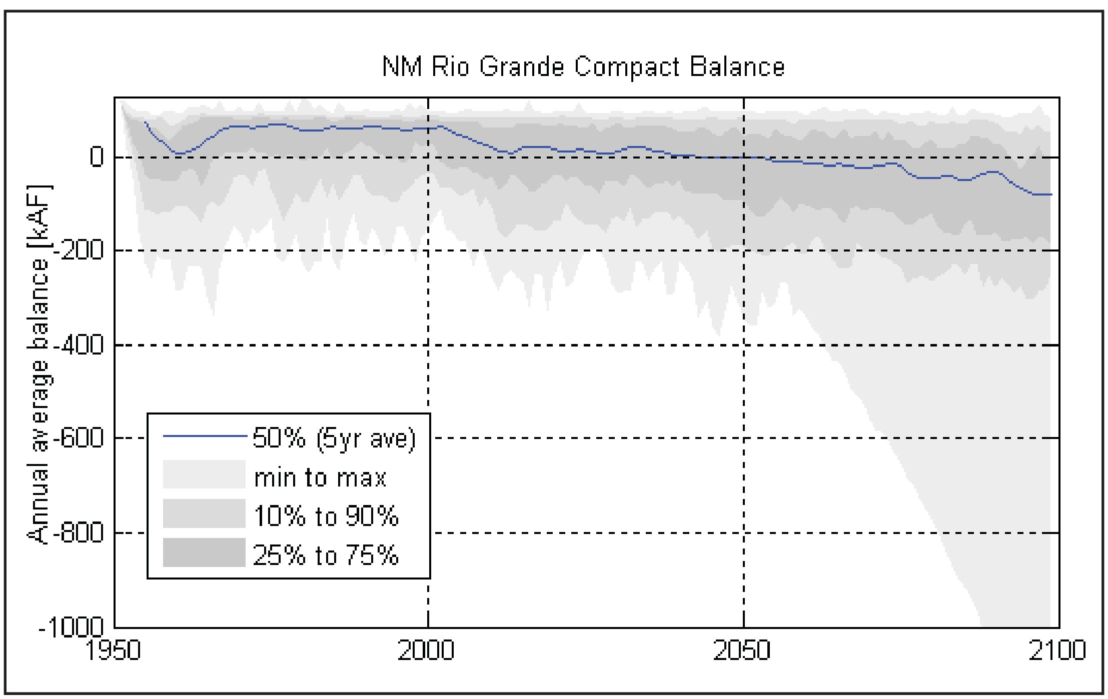


Figure 9. Compact response to bosque reduction

Yet another scenario examined lining the river with cement as a possible strategy for bridging the Compact gap (Fig. 10). Lining about 60 percent of the river between Cochiti and Elephant Butte by 2100 bridges the Compact gap (Fig. 11). However, cementing the river would have the important impact of preventing infiltration to the deep aquifer, which is a primary source of recharge to that aquifer. It would also contribute to drying out the bosque, which receives some of its water from river leakage, it would have impacts on endangered species such as the silvery minnow, and it would have other economic, ecological, and cultural impacts.

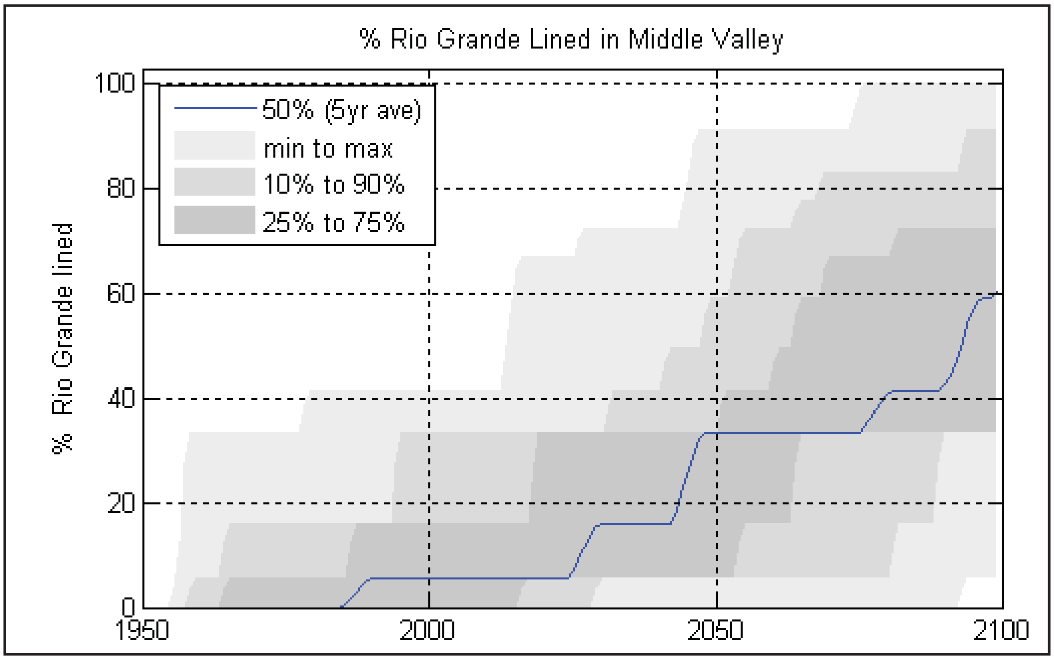


Figure 10. Lining the river as a possible strategy

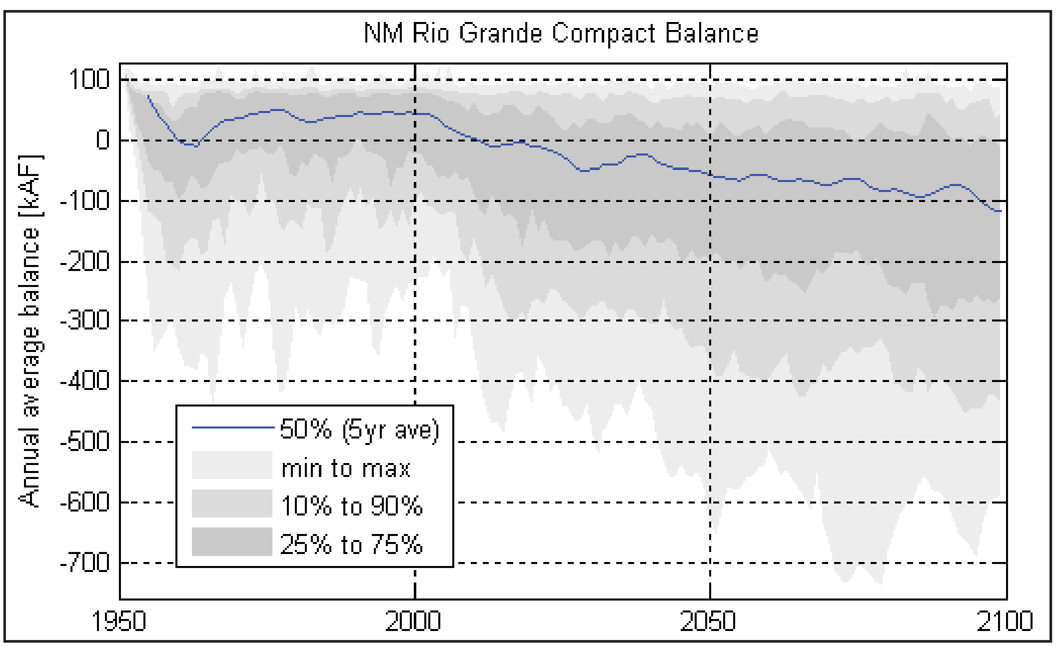


Figure 11. Compact response to lining the river

All of these model results allow us to improve our mental models of what measures might be taken, and at what levels, to relieve Compact gaps that might occur in the future. In fact, some combination of all these measures could be taken, and the operational modeling would allow those kinds of mixed scenarios to be evaluated as well. All these possible solutions, taken individually or mixed, would leave the valley with various kinds of deleterious impacts, and all of these scenarios include the loss of natural capital—agricultural land, the bosque, or the river itself. It's important to remember that these scenarios account only for the effects of climate change on water supply and demand and do not simulate population increase or increasing demand for any other reason, or future conservation. However, the same measures simulated in the work described here could be used to bridge gaps driven by population growth or other factors.

This case study shows that many of the solutions that we currently imagine might help us bridge the gap between supply and demand only shift the gap to other sectors. In other words, we can meet projected demand, but only if we are willing to give up what some may consider to be important values. If this is correct, then what other measures might be taken that do not simply shift the gap? There are many ways we could reduce water demand in New Mexico and the West in general. We can use a mix of the alternatives simulated above. We can reduce agriculture in some places (which is already happening in response to population growth and rising property values), reduce evapotranspiration from the bosque in various ways, or line irrigation canals and ditches (although cutting leakage from the system will also dry out parts of the valley that are now green). The cities can continue with what have been effective water conservation measures.

But the modeling suggests that unless we are willing to see the gap shifted to our regional natural capital, then we must take bolder measures. It is noteworthy that instead of cutting agriculture or the bosque, other modeling done at SNL suggests that the same amount of water savings could be achieved by changing cropping patterns and irrigation technologies, without reducing agricultural acreage itself.

Maybe one of the most important measures we could take in the upper and middle Rio Grande valley would be to start moving away from a 'constant growth' economic paradigm to something closer to a steady state economy. A reduction in population growth rates (with continued reduction in per capita consumption) could help relieve regional water scarcity, although with an impact to the construction industry, and maybe to property values. We do seem to be playing what some call a zero-sum game, in which gains in one sector are mirrored by losses in another. The challenge we face now is to decide where those gains and losses will occur.

I mention some of these bolder alternatives because they have generally not been put on the table as possible solutions. The modeling described today suggests that significant demand reduction is required, probably using means that have not been considered before. None of these solutions, by the way, need to be implemented by some kind of government mandate dictating which crops could be grown or products brought to market, or how people could migrate into NM, but could be achieved gradually and maybe even somewhat painlessly through tax incentives. The great challenge facing us now is to what extent we can manage our own future, and to what extent we will simply be carried into it by currents beyond our control.

Some might say that some of these solutions are so far out of the main stream that they are preposterous. But I would suggest that degrading and eliminating our natural capital and impairing the ecosystem services that allow us to be here in the first place, all in exchange for constantly increasing consumption of resources, is what is actually preposterous. What is the gap that we most want to prevent from opening up? We might argue that it would be a gap in "quality of life." That gap will almost certainly open up if we continue increasing our consumption of resources at the expense of the systems that provide those resources. We need to be looking out of the box for new sets of solutions. If we do not have enough water in the basin to meet projected demand, and that's where the evidence is pointing, then one of the things we need to do is reduce that projected demand in the future—and stop dreaming that all the water we need will just fall from the sky.

NSF Water Infrastructure Engineering Research Center

Nirmala Khandan, New Mexico State University

Nirmala Khandan (Khandan) holds the Ed & Harold Foreman Endowed Professorship in the Civil Engineering Department at New Mexico State University (NMSU). During his 22 year-tenure at NMSU, he has taught several undergraduate and graduate courses in the environmental engineering area. His research has covered areas of renewable and sustainable technologies in the energy/water nexus, including biohydrogen, microbial fuel cells, biodiesel, and desalination. His research projects have been funded by the Department of Energy, National Science Foundation, Department of Agriculture, and Environmental Protection Agency etc. Currently he is the lead investigator at NMSU of the NSF-funded Engineering Research Center on Reinventing the Nation's Urban Water Infrastructure (ReNUWIt), a collaboration between NMSU, Stanford, Berkeley, and CO School of Mines.

Outcomes of his research projects include 12 PhD degrees, and over 100 ISI journal papers with over 1100 peer citations.

Thank you all and WRRI for this opportunity to talk about the Re-inventing America's Urban Water Infrastructure project that was funded at New Mexico State University recently as a National Science Foundation Engineering Research Center. You may recall this morning that President Couture referred to this project as a collaborative project with Stanford University, UC–Berkeley, Colorado School of Mines, and NMSU. The lead university is Stanford University. The theme of the project is reinventing the nation's urban water infrastructure. As President Couture mentioned, our water infrastructure is almost 50 years old. The designs were done perhaps 50 or 60 years ago when energy was very cheap and CO_2 emissions were not considered at all. The liability and sustainability of the systems were not major considerations at that time. Today, those factors are very important. We want to reinvent the system and we pretty much want a clean slate.

This project went through a two-year review process with pre-proposals, proposals, site visits, reverse site visits, and so on. It was a very tough competitive process, but I'm happy to say that out of the four projects that were granted last year, this was one of the projects selected. We just completed the first year and are into the second year now. Figure 1 gives some details as what we are trying to do. The project is illustrated using a three-plane diagram. We are trying to do fundamental research in the laboratory at the first level, then taking it to the next level of prototype testing, and then to be demonstrated at field scale.

As you can see, it's a multidisciplinary project with biologists, process engineers, chemists, economists, and lawyers involved in this project. Currently, at New Mexico State University we have four projects already in place, two of them in engineered systems and two of them in natural systems. We are supporting four new PhD students, graduate students, and several undergraduates.

He has received several awards for his teaching and research accomplishments. One of his research projects on desalination, funded by NM WRRI, has been selected as one of the 28 "Best & Brightest" projects in the Genius Issue of Esquire Magazine in 2008. This project resulted in a process that has been patented recently.

As part of this research center, education and outreach are very important, as requested by NSF as part of all these large-scale projects. During this past summer we had several activities as part of our education and outreach component. We had a program called the Research Experience for Undergraduates where we recruited two undergraduates from outside the consortium, from UTEP, to work with us at NMSU. We had a program called Research Experience for Teachers where we brought in three teachers from area middle schools and gave them opportunities to work with researchers in water-related areas. We had summer K-12 programs for the Hatch Valley School District. Participants came to NMSU to spend about ten weeks working on various parts of the research. We also had four community college participants working closely with the center's researchers in water-related projects.

Ongoing activities include new courses that are being developed for undergraduate and graduate level programs. Thank you very much.

Figure 1. Re-inventing America's urban water infrastructure

SESSION FOUR

Can We Grow the Pie? Conservation and Supply Opportunities

Moderated by Bruce Thomson, University of New Mexico

Bruce Thomson is a Regent's Professor in the Department of Civil Engineering at the University of New Mexico and is Director of the UNM Water Resources Program. He has a BS degree in civil engineering from the University of California at Davis, and MS and PhD degrees in environmental science and engineering from Rice University. Bruce teaches in the areas of water chemistry and treatment, groundwater hydrology and remediation, and water resources management. Recent research has included projects on water resources of New Mexico, the impact of energy and mineral development on water resources, and water reuse and treatment. He has served on many federal, state and local committees involved with management and protection of water resources. Bruce was recently elected to the Board of Directors of the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA). He is a licensed Professional Engineer in New Mexico.

Working Toward Net Zero

Benny J. "BJ" Tomlinson, Fort Bliss Public Works

BJ Tomlinson is the Renewable Energy and Sustainability Program Manager for the Fort Bliss Garrison, Directorate of Public Works. He has bachelor's and master's degrees in mechanical engineering from the University of Texas at El Paso. He has over 17 years of government experience in program management, research and development, and systems engineering including military service as an officer in the United States Air Force, research engineering at the Air Force Research Laboratory specializing in space vehicle cryogenic cooling, energy generation and storage, and thermal management, and as the Operations Manager for the High Energy Laser System Test Facility and other test and evaluation activities at White Sands Missile Range.

I came to Fort Bliss about three years ago, hired as a person to come in, shepherd, and provide overall management to an initiative called "The Road to Net Zero" at Fort Bliss. "Net zero" is the term they came up with concerning the objectives that the Army wants to achieve on all their installations. The Army may have picked me for this job because of my systems engineering background. Basically I've done a whole lot of different things: dual spacecrafts, lasers, energy conservation, facility management, and so on. The Army wanted me to come in and help bridge the gaps among the various different groups within the garrison to achieve these very difficult objectives.

In April 2010, we self nominated to become a triple-net zero installation for the Army. This is a pilot program and there were only two installations selected to participate in the triple-net zero: Fort Bliss and Fort Carson. The current net zero focus is on: concept development/planning; energy initiatives task force development of the current near term project; ongoing conservation (energy, water, waste); and systems engineering/integration. The Army provided us with these focus areas. The net zero energy goal is to produce as much renewable energy as we consume, both electrical energy and thermal energy.

Dealing with water is a bit more difficult. There is talk about how to return the water back to the aquifer from which it came. We are looking at strict conservation and wastewater reclamation—but the definition gets very foggy on how to achieve that measure. Net zero waste is very simple: no waste actually makes it to a landfill. We reuse, reduce, and recycle. At the very tail-end, with whatever is left, we want to look at a waste energy process for disposal so it does not go into a landfill.

Several efforts are ongoing at Fort Bliss where we are looking at how plans could be implemented to meet net zero including how it would impact the environment, our mission, and everything else. Meanwhile, we are looking at concepts; we are looking at ways to do things better along with continuing all the other ongoing Army programs. The Army has always been involved with conservation, using less energy and water, and reducing waste. All of these efforts cost money so every time we do something smarter and are able to conserve, the Army saves money and that's a big deal. There are many places within the Army that are very wasteful, and we are trying to improve in those areas every day. Conservation has always been key to the Army.

Concerning energy and waste, we have many ongoing energy conservation projects. Most of these projects involve photovoltaics—panels on top of buildings and ground-mounted panels. These projects are an attempt to reduce the footprint of buildings or facilities that surround our renewable energy assets.

We also are studying large-scale waste-to-energy. This is an idea that partners with the City of El Paso. We are looking at the entire waste-stream for the City of El Paso, which amounts to about 1,000,000 tons of waste a year. The Army, the City, and the electric company are trying to come up with a project where the Army could achieve net zero through the energy that is produced with that project. The City could then solve its long-term problem with landfills filling up. All of this is in the conceptual stage; many of legal issues need to be overcome. I think everybody is willing to do these kinds of projects, the problem is nobody knows how to do it yet, and it's very difficult when you are the first one trying to figure it out for yourself.

Our efforts include an Energy Savings Performance Contract (ESPC). This contract with the Army allows a contractor to help us with energy conservation measures. They then get paid back with the savings generated by implementing those conservation measures. The Energy Initiatives Task Force is a group out of the Pentagon that is helping us with program development for these very large-scale renewable energy projects.

As far as waste goes, right now we are focusing on recycling and reduction of waste that we generate because of the way we buy things. In the future, we want to move to a waste management type of scheme where we look at everything, all the way down to how we actually collect the waste, separate it, and recycle it. This is in order to maximize that fraction of the waste-stream that is recycled and minimize the amount that actually goes out the door, which we call unusable waste.

This conference, of course, is focused on water. Net zero water is arguably the most difficult to achieve of all three of the net zero aspects. One of the reasons is because it just doesn't make economic sense if you look at it from a strict financial viewpoint. From a business perspective, you would say, "I pay this much for water right now. If I implement this project, it saves a lot of water. How long does it take to pay back my investment?" Our problem is that water infrastructure is so expensive that these paybacks are in terms of centuries instead of five- and six-year periods.

We looked at our water use and found that about 50 percent of our water goes to irrigation—that includes parade fields, golf courses, housing areas, and so on. We can work on those areas by applying reclaimed water, but we need the water infrastructure to do so.

One of the many things we want to do is to develop solutions that not only include Fort Bliss but also the surrounding community. That will allow us to achieve our goals but not at the expense of the community. Thank you and please feel free to contact me if you have any questions.

Desalination Update

Michael Gabaldon, Bureau of Reclamation

Michael Gabaldon is the Director of Technical Resources for the Bureau of Reclamation located in Denver, Colorado. He oversees Reclamation's Technical Service Center, the Research and Development Office, the Power Resources Office, and the Design, Estimating, and Construction/ Dam Safety Office. A native of New Mexico, Mike earned a Bachelor of Science degree in civil engineering from the University of New Mexico, holds a degree in water technology/ utilities from New Mexico State University, and completed the Executive Leadership Program at Harvard University's Kennedy School of Government. He is a registered Professional Engineer in New Mexico and Colorado.

Thank you Dr. Thomson. Bruce was my fluid mechanics professor when I was in college in the late 70s. Bruce was a very young professor at that time; either that or I've aged a lot faster than he did.

I grew up in New Mexico in the middle Rio Grande valley, in Belen, and it's always great to be back in the Land of Enchantment. I was Reclamation's area manager in Albuquerque that covered this area for a few years in the mid-90s. We dealt with some difficult issues; in fact I was named in the silvery minnow lawsuit on the Rio Grande. It was a lot of fun in those days and I've worked with a lot of people in this room. I'm currently in Denver as part of the Commissioner's Office.

During the mid-50s there was a severe drought in this area—we've all seen the charts, one of the worst droughts on record. My father farmed in the middle valley and relied on farming for his livelihood. In those particular drought years, there was no water, therefore no farming. My mother also helped on the farm. They weren't farming much in those days so out of boredom they conceived a child. Here I am 56 years later, a direct product of the drought. And, I do have six brothers and six sisters so it was a pretty bad drought.

I would like to talk about a little niche with the Bureau of Reclamation, a niche that some of you may not be aware of, and that's advanced water treatment—desalination. We are very involved in desalination these days. "How do we grow the pie?" is what this panel is about and this is one way that we see as a means to grow that pie. We all need to get more and more involved in advanced water treatment.

We are and have been involved in it and we have an incredible facility in Alamogordo, New Mexico that we call the Brackish Groundwater National Desalination Research Facility. Reclamation partners with New Mexico State University to conduct research on brackish groundwater. The facility was the brainchild by Senator Pete Domenici back when he was a senator in Congress and after he retired, Senator Bingaman lead the charge to keep that facility running. Several others from this area, including NMSU, have put a great deal of effort into the facility.

A lot of research is being conducted at the facility in partnership with New Mexico State University—they do the research and we run the facility. We opened its doors a couple years ago and it is a very busy place with six bays inside, which are always active with desalination research. The facility also includes three outside, larger bays that are also pretty tied up with research efforts. We can produce about any concentration of desal water to accommodate research—and it's great for researchers. We've performed research work with Veolia Engineering, along with UTEP, on a zero discharge project. The University of Nevada is also conducting a pressure retard osmosis pilot project. New Mexico State University teamed with GE on a reverse osmosis/nano filtration study. Suns River Solar is doing research on how to bring down the cost of implementing and incorporating renewable energy to the desalination process. We are very proud of that facility and the partnerships we have working with us at the facility.

Reclamation's mission; you heard the Commissioner talk about it, is to deliver water, we generate power—that's what we are about. Developing agriculture infrastructure was our primary purpose back in 1902 and we continue to be about agriculture. We built dams, we built facilities—we have 450 dams throughout the West including Hoover Dam and Elephant Butte Dam. Again, our main purpose was agriculture, but those facilities that we built also afforded hydropower development opportunities.

So that secondary part of our mission is hydropower production and there is definitely a nexus between hydro, water, and energy. When you have a drought, it affects everything, not only agriculture but also hydropower production. We are very involved with what is going on in water management, especially in trying to find new sources of water. Water is finite—I'm preaching to the choir—you all know that, there's not a whole lot of new water out there. But maybe, the next opportunity out there is brackish groundwater desalination. Certainly the Middle East and other places around the world are ahead of us in that area because they had to be—they had absolutely no other water source. We will continue working with all of you towards those goals that we share: to manage a finite resource in the most effective and efficient manner. To make that drop of water go as far as it can—to grow the pie! Thank you.

Water Restoration

Jack Chatfield, Canadian River Riparian Restoration Project

Jack Chatfield is a 5th generation rancher, husband, and father of three. He has managed the Canadian River Riparian Restoration Project since its creation in 2004.

I'm excited to be here today to talk about something very dear to my heart and that's watershed restoration. How many people out there, other than me, does it bother to see a picture of New Mexico without our little family farms? How can we keep those farms? How can we have a little more water? We can't force more rainfall, but we can do a better job of taking care of the water that we have.

We put together a project in northeastern New Mexico that will help us take care of our water. The Canadian River Riparian Restoration Project's goal is to restore the riparian corridors of the Canadian River, both on the mainstem and on its tributaries, to a healthy productive state that will provide native habitat for a variety of wildlife and water for communities, agriculture, and recreation throughout the course of the watershed. We have treated about 24,000 acres so far. We know how to do it—we know how to treat the watershed and help protect the water in it.

One of the main causes of degradation of New Mexico's riparian corridors is infestation of salt cedar, Siberian Elm, Russian Olive, and other non-native invasive species. Those 30-foot tall trees not only use water, but nothing can grow underneath them, you lose the rushes and sedges that fold over and armor the banks of the streams, and they cause down-cutting. The streams draw the water out of the riparian area and the water level in the aquifer is never any higher than the bottom of that stream. You lose the meadows on the banks on both sides of the stream that provide food and habitat for elk, deer, cottontail rabbits, and all the animals that live there.

Our project is guided by a steering committee made up of eight Soil and Water Conservation Districts and the New Mexico Association of Conservation Districts. We receive technical advice and funding from a variety of state and federal agencies including Cooperative Extension Services, Natural Resources Conservation Service, New Mexico Department of Agriculture, New Mexico State Land Office, NMSU Range Improvement Task Force, U.S. Forest Service, U.S. Geological Survey, Resource Conservation & Development Councils, National Wild Turkey Federation, Bureau of Land Management, and a good number of others. Something that I am proud of is the cooperation we receive from state and federal agencies—they've got some skin in the game. We didn't just put their names down on the cooperator's list. They fund us, they provide technical expertise, and they actively participate in the project. These entities work together through a Joint Powers Agreement that allows for the sharing of funding and personnel.

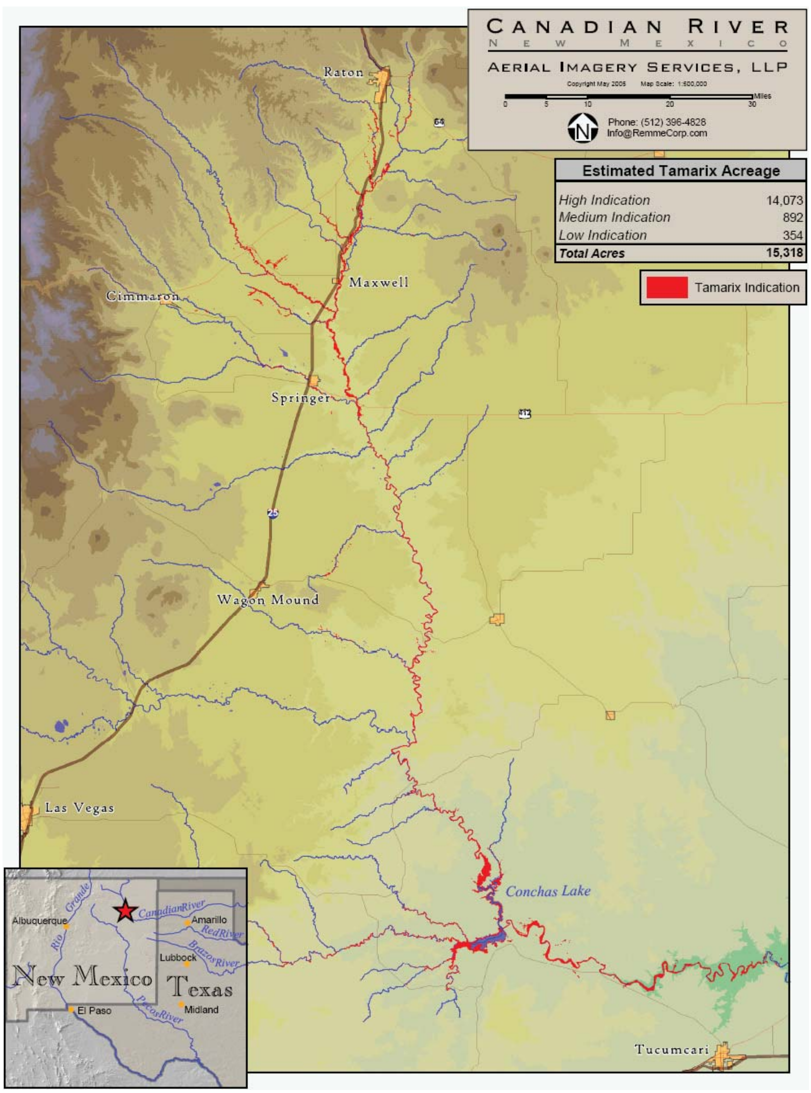


Figure 1. Canadian River Watershed map

One of the first things we did on the project was to map the Canadian River watershed (Figure 1) from the top near Raton down to Ute Reservoir. The map includes well over 2,000 miles of riparian corridor and is available in electronic GIS format. You can click on any spot on the map and it will tell you who owns that particular piece of property. It will tell you how much salt cedar is on that property as well as its density.

Figure 2 shows a Bell Jet Ranger hard at work in the Box Canyon of the Canadian River eradicating salt cedar. We use a new type of herbicide; it's not a poison like the old type herbicide. It is an enzyme blocker that blocks an enzyme in the plant that causes the plant to produce a leaf. Without a leaf, the plant basically starves to death. The herbicide is harmless to humans, animals, fish, macro-invertebrates, and so on. We conducted scientific studies to monitor the macro-invertebrates before and after treatment in an area and we found no negative impacts.

Figure 3 shows one of our mulching machines hard at work on a good-sized stand of the 30-foot tall salt cedar. It does a good job, although we didn't get quite as good a kill as we got with the helicopter. We went back and treated the re-sprouts and Figure 4 shows what the area looked like after we finished.

Our rehabilitation efforts include pole planting, reseeding, mechanical clearing, chipping, biological renovation, encouraging individual landowner monitoring, and educating landowners to alter their management practices. Figure 5 shows us not only planting some major vegetation, but also teaching landowners how to restore their property with native vegetation. Thank you.


Figure 2. Bell Jet Ranger eradicating salt cedar in Box Canyon of the Canadian River


Figure 3. Mulching machine working on a 30-foot tall salt cedar


Figure 4. After treating for salt cedar


Figure 5. Educating landowners on restoring native vegetation

Multiple Benefits of Pecos River Restoration

Paul Tashjian, U.S. Fish and Wildlife Service

Paul Tashjian has worked as a hydrologist for the U.S. Fish and Wildlife Service since 1991. With over 20 years of professional experience in New Mexico, Paul's expertise includes water management and water protection for wildlife, river restoration, water law, and water monitoring. His current work focus includes quantifying and protecting National Wildlife Refuge water rights, conducting studies and workshops to improve wetland management through historic emulation, and monitoring river restoration responses on the Pecos River.

Lately I've been spending a lot of time looking at river systems historically in order to understand how these systems used to function. We try to emulate those functions in the modern, and possibly restore what processes we can. Through this work I have seen a loss of ecologic systems that is staggering. I want to start with this premise: Our rivers have been dramatically transformed by water development and this transformation is nothing short of a large-scale ecological disaster. What we have left are fragments of historical river systems.

The Endangered Species Act has been the most common voice for the conservation of these remnants. Where some sort of historic function remains there are remnants of historic ecology remaining. In these places the ecology is very commonly in a perilous state and often has endangered species associated with it. Beyond this ecologic loss, there are human costs to river engineering. There is a natural mathematical wisdom in a river system. Rivers move both water and sediment and when we dramatically alter how water and sediment move through these corridors, there are unintended economic consequences. These include river maintenance costs, flood maintenance costs, dangerous fires, and an increasing dependency on snowpack within our arid region.

Today we discuss how to grow the water pie in an overtaxed system. I think there is a false idea out there that when we start talking about water efficiency and water conservation, that it equates to an improvement for the environment. Water efficiency improvements without environmental safeguards can be death to an ecosystem. The tighter we get with water, the less water there is for these ecosystem islands.

There are two primary components to restoration: 1) flow modification and, 2) physical restoration. I am going to talk primarily about physical restoration on the Pecos, but I want to give a shout out to the importance of the flow modifications—you can't have one without the other. If you go out and do a lot of restoration and you have a big drought that dries the river channel, all your work can be for not.

The middle Pecos River between Fort Sumner and Carlsbad is a system that is close to working. This is largely because of work that has been done through the New Mexico Strategic Water Reserve to ensure minimum flows and the physical restoration work we have done with federal agencies. The restoration of the Pecos River at Bitter Lake National Wildlife Refuge has occurred since 2008 and encompasses over 12 river miles. The project includes 1,700 acres of salt cedar removal, removal of bank-lined levees along the 12 river miles resulting in a connection of the floodplain at the annual flood recurrence, connection of 1½ miles of former river channel, active planting of native vegetation including shrubs and grasses, and an annual treatment of salt cedar re-sprouts. Salt cedar must be kept at bay before you can get the natives established.

We have completed the bulk of the heavy lifting and continue to monitor and actively manage the river on the refuge. Partnerships have been key to this effort and the primary partners include the New Mexico Interstate Stream Commission, the World Wildlife Fund, the Bureau of Reclamation, and the New Mexico Environment Department. The project was also helped by letters of support from the Carlsbad Irrigation District and Chavez County; both saw benefits from the project.

What are the benefits of his restoration effort? One, there's help with the Endangered Species Act. If you have better habitat for endangered species, there's greater resiliency and population dynamics when a drought comes and a better ability to make it through droughts. Second is ecotourism. Bitter Lake National Refuge has a fantastic, relatively new, visitor center named in honor of the late Congressman Joseph Skeen who was a strong advocate for the refuge. People want to see the Pecos River when they come to the refuge. It's a river of great historic lore and if people see it in a restored state this generates additional tourism. Third is fire threat reduction. Reduction of fire threat during dry years is done by removing salt cedar thickets. These fires not only threaten human infrastructure but also promote salt cedar growth, which comes in thicker after a fire. Fourth is flood control. By reconnecting the floodplain we have returned the natural functioning of the floodplain to put the brakes on flows during flood events. The farmland in Chavez County, below the refuge, abuts directly against the Pecos River. The historic floodplain has largely been eliminated in this area. By connecting 12 river miles of floodplain directly upstream of these farmlands, we are helping to take the punch out of flash floods.

Finally the water budget. Riparian evapotranspiration studies of the University of New Mexico have demonstrated that riparian plants consume water roughly equivalent to their leaf area. Where salt cedar control occurs with no follow-through, salt cedar often returns. When this happens, there is little benefit to the water budget. But at wildlife refuges and other places where we actively manage the landscape and have goals for returning grasslands to the riparian system, it means a dramatic reduction in leaf area. This is true in the Bosque del Apache, Sevilleta, and Bitter Lake National Wildlife Refuge. On the Pecos, at Bitter Lake, we removed 1,700 acres of salt cedar from floodplain and if you assume that two-thirds of the salt cedar will return, you still have an estimated reduction in water consumption of several thousand acre-feet a year. The water is not necessarily returning to the river, but it's returning to the system. We are doing much better than this, and we estimate at least 75 percent of the cleared areas have come back in non ground-water consuming grasslands and shrubs.

In conclusion, my policy recommendation is to further empower New Mexico's Strategic Water Reserve and the New Mexico River Ecosystem Restoration Initiative. Both these programs are state-based initiatives and lay the groundwork for long-term river ecosystem protection. Both programs are in need of funding. The state could have better coordination between the two programs and establish a proactive river restoration state-based program. We need these programs now more than ever to help preserve the ecosystem islands that remain. By doing so, we will see benefits that reach beyond wildlife and demonstrate our interconnectedness with healthy river corridors.

Thank you.

Salinity Control

Fred Phillips, New Mexico Tech

Fred Phillips is a professor of hydrology and director of the Hydrology Program at New Mexico Tech. He joined the university in 1981 after completing a PhD in hydrology from the University of Arizona. Fred also has an MS in hydrology from UA as well as a BA in history from the University of Santa Cruz. His scientific interest lies within the area where hydrology, geochemistry, and geology overlap. Fred has focused on the effects of climate change on the hydrologic cycle and the influence of the hydrologic properties of geologic materials on the transport of solutes in groundwater and soil water. His favorite tools for these investigations are stable and radioactive isotope techniques. Fred was elected into the American Geophysical Union in 2008 and in 2007, he was elected as a Fellow of the American Association for the Advancement of Science.

I'm going to take advantage of being the last speaker of the day and in addition to talking specifically about the issue of salinity on the Rio Grande, I'm also going to talk about some of the things I've heard throughout the day in relation to the issue of salinity—the bigger picture and the hard choices that are the theme of this conference. In terms of Rio Grande salinity, the biggest message I have to deliver is that unlike the weather where everybody talks about it but nobody does something, there is actually a plan to do something about salinity on the Rio Grande.

The salinity of the river goes from about 30 ppm at the headwaters near Creede, Colorado to 3,000 ppm down by Fort Quitman. That's a two orders of magnitude increase in the salinity, which is very impressive. The plan that has been formulated has been put together by the Rio Grande Salinity Management Coalition, which has 18 members and includes the Rio Grande Compact commissioners from Colorado, New Mexico, and Texas, the state environment departments and boards, municipal utilities, and practically every player on the basin. The goal is to reduce and manage salinity along the Lower Rio Grande.

Phase 1 of that project involved assessing salinity causes and the report that was issued in 2000 identified the six major sources of salinity on the river. The report recommendations were to monitor so we would have data to base decisions on, focus studies at sites of saline inflows, and follow that with modeling to show how it could be reduced. Phase 2 started with a management alternatives analysis that was published in 2011 and it performed semi-quantitative evaluation of the effectiveness of management alternatives at specific sites. Based on that analysis, three sites were selected. The highest priority was the distal Mesilla Basin, the second was the saline discharges at Truth or Consequences, and the third was near Fabens, Texas. The current phase involves detailed site investigations and modeling to show how mitigation alternatives might specifically affect salinity and that should lead to, within the next year or two, specific recommendations for projects at those sites or possibly recommendations that a project wouldn't be worthwhile. In fact, tomorrow there will be on meeting on that here on the New Mexico State campus.

Our moderator, Bruce Thomson, asked us to formulate our thoughts in terms of a couple of challenges and policy changes. Suppose we tackle those salinity sources. What are the kinds of challenges that we might be looking at in the future that we are only beginning to see now? I'm going to propose that a major challenge is going to be managing the effects of increased groundwater pumping during periods of drought. Almost every day you can open the newspaper or watch TV and see some-body talking about the drought and how terrible it is, all the bad effects, and so on. I think that very likely the reality is that what we are seeing today is the new normal. What we have seen in the studies that we've done at New Mexico Tech on groundwater and irrigation districts during drought is that the salinity of the water everywhere in the system goes up up up as the drought goes on. Farmers cope with the drought by pumping groundwater, which itself is more saline than the surface water supply. They then reduce the flow in the drains and they recycle that pumped water through what ultimately ends up going out to the river, which is much more saline than water during normal conditions. If we are, in fact, going to experience long severe droughts—much worse than during the historical record as all the climate projections would seem to indicate—then we are going to effectively have a new source of salinity in the system that is going to have to be actively managed.

We were also asked to consider policy changes that might affect the situation. The policy that I am going to suggest here would involve officially recognizing the interconnection of water use and water quality in the legal and institutional framework within which we manage water in the state. We can't separate them. The example that I just gave you shows that in the old days even during a drought, the river would go down, but without this groundwater recycling you wouldn't get the kind of ramping up of salinity that happens today. The two are interconnected and the general usage affects water quality, especially during periods of low water supply.

We do have an extensive water infrastructure in the state and on the Rio Grande in particular, which gives us the flexibility to potentially manage that kind of situation. But the potential flexibility and the actual flexibility are two very different things because the usage of the water is actually governed by two institutions: the legal doctrine of prior appropriation and the Rio Grande Compact. Both of these are early twentieth century institutions, they are 100 years old now. How well do they really work in the modern environment? We heard a very frank assessment of that right after lunch in the former state engineer panel. Former state engineer Eluid Martinez said something I never thought a state engineer would say: that priority administration of water delivery, under the prior appropriation doctrine, really does not work and to try and implement it would be a disaster.

So how do we manage the water then? The answer is that we have a lot of ad hoc workarounds that work around the pro forma legal system and enable us to kind of do the job that we want to. How long will it continue to work? I don't think it is going to continue to work for very long and the reason is that nature has been relatively kind to us so far in terms of the water supply. But I think the changes that humans are producing in the climate system are going to make the water supply go down and when that happens, this sort of ad hoc system is not going to be the answer. I think we are going to have a three-way train wreck between the Rio Grande Compact, attempts to force priority administration, and salinity. You saw some of that in Howard Passell's presentation. My modest proposal here is maybe it's time to actually say—you know, the nominal system that we have isn't working very well, we really use another system, why don't we institutionalize the system we really use? Doing so would give us the opportunity to recognize salinity and management of salinity as one of the aspects of the system that we would like to deal with under the new regulations.

To wrap up, in terms of the big picture, we are still operating with early twentieth century institutions because the people back then had a vision for what they wanted to do with water. That vision can be summed up in four words: make the desert bloom. That doesn't correspond to the vision modern society has for the use of water in New Mexico. Maybe it's time to say, let's institutionalize the way that we do it now and incorporate the goals we have today. Perhaps in doing so, it would enable us to address some of the hard choices we are facing.

Thank you.

POSTER ABSTRACTS

Concentrate Stream as a New Potential Media for Growing Algae

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Poster Abstract 1

The scarcity of drinking water is an ever-increasing quandary, and there is a need to desalinate different sources of water such as saline and inland brackish water. There are different desalination methods that can be applied in combination with available local energy sources to treat water in dry places. EDR technology system, in which electrical current is utilized to reduce the ionic content of water, has significantly increased over the past two decades. By using this method, the salinity of concentrate stream increases with each subsequent separation stage. As a consequence, reject water is disposed which is costly, while there still remains a precious water resource. Any attempt to minimize the cost of disposal and make beneficial use of concentrate can have great benefits in terms of water usage and impact on the environment.

Algae have been considered a renewable and sustainable feedstock for the production of biofuels from non-food sources which can lessen our dependence on fossil fuels. Algae can utilize water from concentrate for its growth by using nutrients and salts available in the concentrate.

In this research, concentrate stream of EDR with TDS of 5.54 g/L was used to grow microalgae, Chlorella sorokiniana (UTEX 1230). A factorial design statistical experiment with CRD arrangement was conducted to grow algae in five different media (concentrate, BBM, three levels of concentrate (25%, 50% and 75%)) under 16-8 light cycle at 25oC. It was found that the algae grown in 50% concentrate resulted in the highest increase of biomass production. The biomass derived from 75% concentrate was considerable as well.

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Progress Report on Development of an Annotated Bibliography for Transboundary Aquifer Systems of the Mesilla Basin-Paso Del Norte

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Poster Abstract 2

The goal of the 2007 United States-Mexico Transboundary Aquifer Assessment Act is to characterize, map, and model priority transboundary aquifer systems along the United States-Mexico border at appropriate levels of detail. Mandated studies include assessment of aquifer systems of the Mesilla Basin-Paso del Norte region (pop. about 2 million) by the New Mexico and Texas offices of the U.S. Geological Survey (USGS) and Water Resources Research Institutes at NMSU (NM WRRI) and TAMU AgriLife Research Center-El Paso (TAMU-EP). Work involves collaboration with a binational group of organizations who share interests in the western Texas, southern New Mexico, and northern Chihuahua region. An initial task involved compiling a bibliography on transboundary aquifers of the study area, with the NM WRRI leading this effort in collaboration with the Departamento de Ingeniería Civil y Ambiental at the Universidad Autónoma de Ciudad Juárez, the USGS, and TAMU-EP. A preliminary annotated reference list, with provisional alphanumeric cross-referencing codes for almost 750 items, has now been created. Major topics include: bibliographies and reviews; historical documents; environmental and geologic settings; basic hydrogeologic concepts; GIS/remote sensing and land-use planning; regional geohydrology; basin to local-scale aquifer systems (hydrogeology, hydrochemistry, geophysics, and groundwater-flow models); and paleohydrology. Short summary statements (English/Spanish) are being prepared for specific references as needed; with EndNote® software being used to facilitate bibliography, reference-list and foot-note word processing. After peer review, the NM WRRI plans to create a bilingual (online) publication for internet-site posting in collaboration with USGS Water Science Centers in New Mexico and Texas, and TAMU-EP.

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Effects of Seasonal Well Operation on Hydrologic Conditions and Public-Supply Well Vulnerability

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Poster Abstract 3

As part of the National Water-Quality Assessment Program, the U.S. Geological Survey investigated the effects of seasonal variability in pumping stress on the vulnerability of public-supply wells in two deep basin-fill aquifers to contamination with constituents of natural and anthropogenic origin. Historical water-quality data for multiple public-supply wells in Modesto, California (117 wells) and Albuquerque, New Mexico (95 wells) indicate that seasonal variation in the concentrations of contaminants of concern (nitrate and uranium in Modesto and arsenic in Albuquerque) is relatively common. In Modesto, groundwater from supply wells is more likely to be younger and have higher nitrate and uranium concentrations during the summer (high) pumping season than during the winter (low) pumping season. In Albuquerque, groundwater from supply wells is more likely to be older and have higher arsenic concentrations during the winter (low) pumping season than during the summer (high) pumping season. Seasonal variability in contaminant concentrations in both study areas is driven by the effects of well operations on vertical hydraulic gradients in the aquifer and on the period of time that a supply well is idle, allowing its well bore to act as a conduit for vertical groundwater flow. The length and (or) depth of the screened interval influence the magnitude and chemical characteristics of flow through the well bore. Results of this investigation show that supply-well vulnerability can be dependent on seasonal pumping stress and suggest that even in aquifers dominated by old groundwater, changes in well design and operation could help reduce vulnerability to selected contaminants.

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Drought Management Planning at Ute Reservoir, Quay County, NM

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Poster Abstract 4

A mass-balance reservoir model has been developed and employed to define appropriate drought recurrence intervals and manage competing interests at a multi-use reservoir in New Mexico. Ute Reservoir was constructed on the Canadian River by the State of New Mexico to provide a sustainable, municipal and industrial (M&I), water supply of 24,000 acre-ft/year to eastern New Mexico. The Eastern New Mexico Water Utility Authority (Authority) is building the Ute Pipeline Project under authorization and funding by US Bureau of Reclamation. The project will divert 16,450 acre-feet of water annually from the reservoir for the Authority's use.

The model was developed to examine changes in reservoir elevation due to withdrawal of the full 24,000 acre-ft/year contracted to NM communities. This model assessed the impacts of various drought management strategies, with the goal of maximizing reservoir yield, preserving reservoir storage and conserving water elevations. Scenarios were examined that address a range of potential drought trigger elevations and curtailments. These scenarios were developed utilizing the concept of a 'prudent reserve' – defined as the quantity of water in storage required to meet prescribed low-flow events. Based on this concept a scenario whereby reductions in demand of 10, 20, and 30% are achieved at elevations corresponding to 8, 7, and 6 years of storage required to meet a 5 consecutive year low flow event appears to achieve favorable results (maintain a high project yield, reservoir elevations, and minimizing spills, and supply deficits). Future work could evaluate out-of-basin aquifer storage and the impacts of climate change.

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Six Decades of Water Levels in the Albuquerque Area (1950 – 2008)

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Poster Abstract 5

The Albuquerque area is the major population center in New Mexico and experienced more than a five-fold population increase between 1950 and 2010. Before 2008, groundwater was the primary source of Albuquerque's public water supply, but since that time the city has started to divert San Juan/Chama river water transported via the Rio Grande to augment municipal water supplies. Consequently, there is interest in understanding how groundwater levels changed from 1950 to the present in response to groundwater pumping, surface-water diversions and conservation measures. Previous studies have described water-level declines in the production zone from pre-development to the present (2002 and 2008) using measured water levels. To give a more detailed history of water-level changes, maps were created by contouring water-table elevations and water levels in the production zone that were simulated with a recently updated transient groundwater-flow model at 10-year intervals between 1950 and 2008. The maps also compare the simulated decline of the water-table and water levels in the production zone to their estimated pre-development levels. Both the water table and production zone water levels decline over time with the largest change occurring between 1970 and 1980, which was a period of rapid population growth. Declines in the water table and production zone water levels occur around major pumping centers, and are largest in the production zone. A comparison of simulated hydrographs to observed water levels at selected locations indicates that simulated water levels are generally within 5 meters of measured water levels.

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Using Household Graywater on Bermudagrass (Cynodon dactylon)

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Poster Abstract 6

Water is becoming a rare resource. The conservation and reuse of water is becoming increasingly more important; worldwide consumption of fresh water has more than doubled since World War II and is expected to rise another 25 percent by 2030. However, aesthetic residential landscapes provide numerous homeowner benefits; including dust abatement, moderation of temperatures, reduced air condition requirements, increased home value and increased use of home landscapes. In order to maintain our desired residential landscapes, alternative conservation strategies will be required to minimize the impact to potable water sources. The reuse of graywater collected from individual households may provide this additional water resource. Graywater is wastewater from clothes washers, bathtubs, showers, and sinks, but not from kitchen sinks, dishwashing machines, and toilets. The use of graywater on turfgrass and landscape plants will reduce the average consumption of potable water. The objectives of this study are to determine the potential water savings with the use of graywater on residential lawns, and to monitor the potential soil chemical property changes. The results to date show no detrimental effects to using graywater on turfgrass. The increased levels of both sodium as well as nitrate levels from the graywater source could change the soil chemistry as the research progresses. Proper irrigation and the leaching of sodium and nitrate will validate the use of graywater as an alternative irrigation source for home lawns.

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Real Time Measurement Site on the OSE Website

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Poster Abstract 7

On the website of the Office of the State Engineer and Interstate Stream Commission: www.ose.state.nm.us we have a page called "Real-Time Water Measurement Information System". The OSE/ISC are the State agencies responsible for the administration of water rights. As such we have installed water measurement stations that through satellite or radio telemetry can be accessed through this page. As the title implies, diversions in cubic feet per second or gallons per minute from OSE/ISC installed water measurement stations in fifteen-minute interval data points can be viewed in real time with only a few hours of lag time. The quantity of water diverted by the major water users in several river basins around the State of New Mexico can be downloaded from this site. Links to the gages that the United States Geological Service or other agencies manage in these same basins can be accessed through this page.

This page was first made available to the public during the 2011 Irrigation Season. The OSE/ISC uses the site to generate water use reports and for management purposes. Most of the data in the 2011 Gallinas River basin annual water use tables was compiled from data obtained from this page.

A reason for this site is to help the major water users manage their water resources. It also helps the OSE/ISC Water-Masters identify if there is any problem with the stations they are responsible for maintaining. The interested public can see how the water is being used in these basins.

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Potential Groundwater Recharge from a Domestic Sewage Disposal Field in Eastern Bernalillo County, New Mexico

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Poster Abstract 8

In semi-arid regions, the infiltration of effluent from domestic sewage disposal fields (disposal fields) can be a significant contribution to groundwater recharge; however, limited data exist to quantify recharge from disposal fields. Eastern Bernalillo County, New Mexico is part of the rapidly growing Albuquerque metropolitan area. Increasing water use in this semi-arid area has raised concerns about the effect of development on the availability of water resources. Quantifying the amount of recharge from disposal fields is critical to water resource planning and management. Information from this study will provide a better understanding of the importance of recharge from disposal fields to hydrologic budgets in semi-arid climates.

A water-balance approach was used to estimate the amount of potential groundwater recharge occurring from a disposal field in Eastern Bernalillo County during 2011. Potential groundwater recharge due to effluent was estimated as the volume of effluent dosed to the disposal field in excess of the volume of effluent lost through evapotranspiration (ET) from the disposal field. The amount of effluent lost through ET from the disposal field was estimated as the amount of potential ET loss on the disposal field in excess of potential ET loss off the disposal field in the surrounding terrain. Model calculations of potential ET were calibrated with actual ET measurements collected using a portable ET chamber. Preliminary results indicate that potential recharge from disposal-field effluent during 2011 was 75 to 87 percent of the volume of effluent dosed to the disposal field.

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Santa Fe Watershed Investment Program - Water Customers Protecting Their Water Source

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Poster Abstract 9

Santa Fe's watershed investment program was born in the ashes of the 2000 Cerro Grande Fire, which cost $970 million in compensation, suppression and rehabilitation, and made national headlines for several weeks. The fire prompted Santa Fe to assess the vulnerability of its 17,000 acre Santa Fe River municipal watershed, which supplies up to 40% of the city's water, to a similar event. From 2002 to 2007, the USFS treated 5,500 acres of ponderosa pine forest in the lower, non-wilderness portion of the municipal watershed, where pre-treatment tree density was between 1,000-2,000 trees per acre, while historic density was between 20-50 trees per acre. In 2007, the City of Santa Fe and partner groups including the USFS, the Nature Conservancy and the Santa Fe Watershed Association, completed a 20-year watershed management plan which guides forest maintenance work and new treatments. The plan proposed paying for ongoing project costs through a Payment for Ecosystem Services finance model, which passes costs along to the beneficiaries of the healthy watershed: Santa Fe's water customers. In 2008, the city and the USFS established a financial collection agreement, allowing the city to cost-share half of the ongoing project costs. In 2009 the City instituted a rate increase which will be used to cover future project costs once state funds expire. The project has drawn interest from other communities in the west, whose drinking water systems face similar wildfire risks, yet lack the financial resources to treat their watersheds to reduce critical fuel loads.

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Historic and Predicted Hydrographs for the Gila Basin: Assessing Gila Water Projects in New Mexico

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Poster Abstract 10

The Arizona Water Settlements Act of 2004 ("AWSA") provides New Mexico an additional annual average of 14,000 acre-feet of water in the Gila Basin, and authorizes the New Mexico Interstate Stream Commission (ISC) in consultation with the Southwest New Mexico Water Study Group or its successor, to determine how the water will be used. The AWSA also requires that any such decision be subject to the requirements of the National Environmental Policy Act and the Endangered Species Act – in other words, the ecological systems of the Gila Basin must be evaluated and considered before any project may go forward. The ISC has adopted a policy that requires full consideration of both the environment and water demands, now and into the future.

A crucial component of this evaluation is an understanding how the Gila and its tributaries behave under base flow conditions, seasonal variations, and runoff events. This is particularly important for predictive modeling, as climate change, potential stream diversions, and fire effects will have a significant imprint on any conclusions that may be drawn. With a robust stakeholder involvement process, the ISC has launched these hydrologic studies, and – combined with other studies on Gila Basin hydrology, geomorphology, water needs, and ecosystems – will use the results to inform its decisions on which, if any, AWSA projects should go forward.

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Using Geothermal Water and Cow Manure for Growing Chlorella Sorokiniana

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Poster Abstract 11

In near future the demand for energy could double or even triple as the global population grows and developing countries expand their economies. Fresh water is also going to be a major limitation for energy production. Using alternative sources of water and energy can be solution for combating shortage of these two resources. Microalgae are promising source for clean, sustainable, and renewable, energy. Geothermal water is a source of water rich in dissolved CO2 and different nutrient content. However, it is lacking nitrogen, the major source of nutrient for the growth of algae. In this study, geothermal water from the A-mountain site of New Mexico State University is used in the laboratory of the Institute for Energy and the Environment (IEE) for growing chlorella species of microalgae (UTEX-1230), using different concentrations of manure (0.4% to 8%, by vol., in various concentrations) as a source of nutrient. The results indicated high amount of manure, 3.2% by vol., can change the color of media and block the light which is highly needed for algae growth. However lower amount, 1.6% by vol., can boost the growth of algae, but it is not comparable to BBM, the widely used nutrient to grow algae.

Using relatively inexpensive sources for water and nutrients can lower the cost of producing biofuels from algae.

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Groundwater Hydrology and Estimation of Horizontal Groundwater Flux from the Rio Grande in Albuquerque, New Mexico

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Poster Abstract 12

In 2003, the U.S. Geological Survey, in cooperation with the Bureau of Reclamation and the U.S. Army Corps of Engineers, began a detailed hydrologic characterization of the Rio Grande riparian corridor in Albuquerque, New Mexico, to provide hydrologic data to enhance the understanding of hydraulic interactions among the river, riverside drains, and shallow alluvial aquifer.

Throughout the Albuquerque Rio Grande riparian corridor, groundwater flows away from the Rio Grande towards riverside drains. Results of slug tests indicate that shallow (less than 50 feet) alluvial hydraulic conductivities range from 3 to 240 feet per day (ft/d) with a median of 50 ft/d. Based on groundwater-level measurements, the average of median daily horizontal hydraulic gradients ranged from 0.002 to 0.011.

Groundwater fluxes calculated using hydraulic conductivities and Darcy's law ranged from about 1.2 to 32.4 cubic feet per day per linear foot of river (ft3/d/ft), and those calculated using temperature and the Suzuki-Stallman method ranged from 6.9 to 15.6 ft3/d/ft. While the calculated Darcy's law and Suzuki-Stallman fluxes are similar, comparisons to measured fluxes derived from seepage surveys of riverside drains near the Montaño Bridge indicate that the calculated flux of water from the Rio Grande at the Montaño Bridge accounts for only 18 to 50 percent of the measured drain fluxes.

The results of this study indicate that groundwater flux rates within the Rio Grande riparian corridor are highly variable and scale dependent and that seepage from the Rio Grande is not the only source contributing water to the riverside drains.

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Desalination in a Pilot-Scale Electrodialysis Process: Selective Removal of Divalent Ions in Comparison with Monovalent Ions

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Poster Abstract 13

Desalination as an artificial process by which saline/brackish water is converted to fresh water is considered as a solution to global drinking water crisis. Electrodialysis (ED) is a membrane based separation process in which the partial separation of the components of an electrolyte solution occurs due to applied electrical voltage. Although Electrodialysis Reversal (EDR) technology has been commercially used since the early 1960s, the fundamental understanding of this technology is not fully developed. Groundwater resources, which are very important sources of drinking water in many parts of the world as well as southwest region of the United States, have various water chemistries. Therefore, ions with higher levels preferentially should be removed selectively, since most of the other ions exist within acceptable range based on drinking water standards. In this study, selective removal of different divalent cations and anions using pilot-scale EDR has been studied. The experiments were done at different levels of temperature, linear velocity, feed water conductivity and applied voltage. The EDR pilot scale set up has been installed in Brackish Ground Water Desalination Research Facility, BGNDRF, located in Alamogordo, New Mexico. The EDR stack was composed of 40 cell pairs in which CR67 and AR204 were used as cation and anion exchange membrane, respectively. The obtained results show that the CR67 and AR908 membranes remove divalent cations (such as calcium) and anions (such as sulfate) better than monovalent ions at various operating conditions, respectively. However, the selectivity values of the EDR process depend on the experiment operating condition.

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Efficient Irrigation Technologies: Helping to Meet Public Policy Goals In Landscape Water Conservation

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Poster Abstract 14

Landscape irrigation in residential and industrial areas has been identified as a major source of high potable water use during the summer months. Consequently, water utilities and municipal ordinances encourage strategies aimed at conserving potable water use in landscape irrigation. There are several options to reduce or eliminate the amount of potable water used for irrigation. First, potable water could be eliminated completely and replaced by recycled or low quality ground water that does not meet standards for human consumption. This strategy has been applied by numerous communities for parks, athletic fields, and golf courses and is also being considered for residential developments. In order to make the use of recycled water a successful long term strategy, salinity tolerance needs to be included as a criterion for plant recommendations. Second, the planting of low water use and/or drought tolerant plants has been suggested and communities have published lists with low water-use plants. However, consumptive water use of plants is the result of the amount of water available in the rootzone and plants often exhibit luxury consumption (high water use) when abundant water is available. Recommending certain plants must be accompanied by education measures on sufficient irrigation and/or the installation of scheduling technology that enables irrigation in adequate amounts at the appropriate intervals. Third, adopting the most efficient method of irrigation available reduces water losses significantly and can have a significant impact on water conservation efforts. Subsurface irrigation systems and micro or streaming sprinkler technology have been shown to irrigate uniformly and keep losses to a minimum. The presentation will use water conservation goals set forth by municipalities or water utilities and discuss the impact of the aforementioned strategies on meeting these goals in urban landscape irrigation.

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Existing Models for Membrane Desalination

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Poster Abstract 15

Technologies that were originally developed to desalinate water are widely applied remove salt from water supplies. Of the several available desalination technologies, two membrane processes (reverse osmosis and electrodialysis) are most widely used in the United States. Membrane distillation is another separation method that is a thermally driven in which separation is enabled due to phase change.

This study reviews the existing transport models of membrane desalination. Transport models relate fluxes through the active layers to driving forces and provide mechanistic descriptions of how material water molecules or mineral ions depend on the feed; travels from one side of the membrane to another side. Many mechanistic and mathematical models have been proposed to describe reverse osmosis membranes and one of the models proposed for describing electrodialysis is an irreversible thermodynamics model by Kedem and Katchalsky (Tanaka, 2007).

Mechanistic transport models may also be used to predict how a particular membrane will perform in a new process, or may help development of new membranes. Reverse osmosis models can be divided into three types; irreversible thermodynamics models (Kedem-Katchalsky and Spiegler-Kedem) (Kedem & Katchalsky, 1958); nonporous or homogeneous membrane models (solution-diffusion, solution-diffusion-imperfection, and extended solution-diffusion) (Wijmans & Baker, 1995); and pore models (finely-porous, preferential sorption capillary flow, and surface force-pore flow) (Sourirajan, 1970; Merten, 1966; Matsuura & Sourlrajan, 1981; Sourirajan & Matsuura, 1985). A hydrophobic membrane displays a barrier for the liquid phase, letting the vapor phase pass through the membrane's pores in membrane distillation. The driving force of the process is given by a partial vapor pressure difference commonly caused by a temperature difference (http://en.wikipedia.org).

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Overview of Desalination Technologies

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Poster Abstract 16

The objective of this work is to present an overview of current and future technologies applied in the desalination of brackish and seawater to produce fresh water for supplementing drinking water supplies. The three basic categories of water desalination are membrane technologies, thermal technologies, and chemical approaches (Younos & Tulou, 2005). Membrane technologies are the most common technology of desalination in the United States, while thermal technologies are commonly practiced in areas with abundant fossil fuel with low cost such as Middle East (Watson et al., 2003). Chemical approaches include processes such as ion exchange, which is considered impractical for treating waters with high levels of dissolved solids. Chemical approaches have the potential of implementation in future and currently are mostly under research and development for possible applications to desalination.

Membrane treatment processes can be categorized to pressure-driven and electrical-driven technologies. Pressure-driven membrane technologies include reverse osmosis, nano-filtration, ultrafiltration, and microfiltration (Duranceau, 2001). Electrical-driven membrane technologies that are effective with salt removal include Electrodialysis, Electrodialysis Reversal and Electro-deionization (Brunner, 1990). Thermal technologies are based on the concept of evaporation/distillation physical processes. These technologies are applied to desalination of seawater. Some common processes include multi-stage flush, vapor compression and some variation of those technologies. The ion exchange technologies for water treatment are often used for water softening among other applications. The ion-exchange system can best be described as the interchange of ions between a solid phase and a liquid phase surrounding the solid (Arden, 1968; Wachinski, 1997; Sengupta, 1995). Several new technologies are being researched with potential for future applications to desalination. New technologies include Membrane Distillation, Freeze Separation, Freezing with Hydrates, Vacuum Distillation are also based on thermal technology (http://en.wikipedia.org/wiki/Desalination). All of these technologies are applied as a desalination method to increase the availability of potable water.

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More Water for New Mexico

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Poster Abstract 17

The North America Water and Power Authority (NAWAPA) can provide water solutions for the North American Continent and New Mexico. NAWAPA is a North American Continent Plan for more water. NAWAPA takes fresh water that flows into the Arctic and Pacific Oceans that people don't use and transports it south to continental locations where people can use the fresh water. The project is large in scope and creates an estimated 4 million jobs that can't be exported to lower priced labor market countries overseas, because the NAWAPA creates water related infrastructure and jobs in North America. New Mexico gets jobs in the design, financing, construction, agriculture and operation of the system plus the Rio Grande River flowing full, possibly all year, and expanded agriculture and lower cost hydroelectric power. New Mexico information and the NAWAPA XXI Project are downloadable below:

The overall NAWAPA Plan, NAWAPA XXI report 93p is at
http://larouchepac.com/files/20120403-nawapaxxi-forweb_0.pdf
http://larouchepac.com/node/22218

For SW NM details see video minute 16:14 to minute 17:53 within
http://larouchepac.com/nawapaxxi/feature

The 30 million acre feet of water per year enters NM from AZ via a tunnel west of Truth or Consequences, NM crossing northwest over the NM, creating new and expanding exiting water storage, then exits NM into Colorado under Raton Pass and two places south. New Mexico gains 186 miles of water tunnels, over 400 miles of water canals including a tripling of our NM irrigated land plus hydroelectric power to NM customers that currently import expensive power from Arizona.

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A Two-City Case Study in Transboundary Aquifer Management

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Poster Abstract 18

The Middle Rio Grande (MRG) basin has been identified by the Bureau of Reclamation as an area of potential future conflict because of inadequate water supplies. Climatic changes, increased populations, and increased demands for water may exacerbate the problem. Improved management of these scarce water resources, which is necessary in reducing the stress on this system, may require novel approaches. This work focuses on the potential for coordinated management between cities situated along the MRG. Following Chermak, Patrick and Brookshire (2005) we develop a dynamic game theoretic model that considers not only the benefits of the individual agents under non-cooperative and cooperative management scenarios, but also the impacts on ground and surface water resources. This model will provide the theoretical basis for a systems dynamics model (SD) for Albuquerque, which relies on surface water augmented by ground water and Rio Rancho, which relies on groundwater. From this model we will be able to consider the impact of coordinated or cooperative management, compared to the status quo of individual management plans, under various scenarios of population growth, drought, and incentives and consider the impact on the groundwater levels as well as impacts on the Compact.

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Using Electrodialysis Reversal Concentrate as Medium for Algal Biomass Production

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Poster Abstract 19

Currently, research efforts in microalgae as a feedstock for biofuel production are focused on making the process cost effective. By utilizing waste from other systems, the cost of all processes involved can be minimized. Membrane processes such as Electrodialysis Reversal (EDR) have proven to be practical and effective methods for the treatment of low quality water. For this reason, the number and scale of desalination plants are increasing to meet water remediation demand. Although EDR systems are efficient with high water recovery rates, the process does produce a waste concentrate that requires disposal. Disposal options can be costly and have negative environmental effects. Similarly, cow manure is plentiful waste product and an inexpensive nutrient source.

In this experiment, microalgae was grown in a medium of EDR concentrate and cow manure. Chlorella sorokiniana was cultured in EDR concentrate and deionized water for comparisons among different media for biomass production. The results indicate highly significant biomass increase when low amounts of manure, 1mg/l, were used in concentrate media.

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Reusing Anaerobic Digested Sludge and Desalination Concentrate as Water Media and Nutrient for Growing *D. salina* and *S. platensis*

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Poster Abstract 20

Renewable energy, microalgae is one of the world recognized oldest life forms and one of the future green energy source that will may solve issues such as energy security and CO_2 emissions. Algae are well known for their high growth rate when given the correct nutrient combination light, carbohydrate, CO_2, N, P and K and warm water. Algae can produce lipids and proteins in large amounts over short periods of time. The simple structure of Algae allows efficient converting solar energy into chemical energy.

Algae use nutrients from wastewater (such as anaerobic digested sludge) and are capable to growing in low quality land this alleviates competition with lands that are specifically used to grow food. Therefore, oil productivity from microalgae culture exceeds other oilseeds crops. For sustainable, pollution control, and cost-effectiveness, wastes need to be reuse in microalgae production.

In this study, microalgae were grown by reusing concentrate from desalination. Two species (D. salina and S. platensis) and two levels of conductivities of concentrate were used in our studies. Most of our data show longer culturing times are required for *D. salina* and *S. platensis* to reach the maximal growth due to the higher conductivities (31,800 and 25,442 µS/cm for *D. salina*; 35,900 and 21,500 µS/cm for *S. platensis*). The dry weight productions from our studies are comparable to that of the literature data where seawater and pretreated seawater; $NaNO_3$, and Zarrouk's nutrients were used.

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The Economics of Drought in the Middle Rio Grande

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Poster Abstract 21

The timing and severity of drought may severely impact water availability, especially in semi-arid climates like the American Southwest. Utilizing a Systems Dynamics model, we consider the residential water use for the cities of Albuquerque and Rio Rancho, New Mexico over a 50-year time horizon.

These two cities comprise about 30% of the state's total population and the majority of the population along the Middle Rio Grande. While they are adjacent to each other they are very different in terms of population and sources for water supply. Both cities see increasing water scarcity in the future, but are considering different ways of coping. Rio Rancho is experimenting with injection of reclaimed water into the aquifer. Albuquerque is focusing on a number of plans, including reliance on surface water with groundwater being a drought reserve. Specifically, we consider the impact of water usage in these cities under varying drought scenarios on the physical system. In our preliminary results, we find that droughts that occur in later periods when we have larger populations have larger impacts and the duration of the drought is important. This impacts not only human consumption, but also the flows in the river and the aquifer level. While alternative policies can provide some relief, the type of policy, the severity of that policy, and the timing of drought are important - as may be the form of economic growth in an area. We estimate economic impacts of the alternative scenarios.

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Estimated Probability of Postwildfire Debris Flows in the 2012 Whitewater-Baldy Fire Burn Area, Southwestern New Mexico

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Poster Abstract 22

In May and June of 2012, the Whitewater–Baldy Fire burned approximately 300,000 acres of the Gila National Forest, in southwestern New Mexico. The burned landscape is now at risk of damage from post-wildfire erosion, such as that caused by debris flows and flash floods. A pair of empirical hazard-assessment models developed using data from recently burned basins throughout the intermountain western United States was used to estimate the probability of debris-flow occurrence and volume of debris flows along the burned area drainage network and for selected drainage basins within the burned area. The models incorporate measures of burn severity, topography, soils, and storm rainfall intensity to estimate the probability and volume of debris flows following the fire. A combined hazard ranking was also developed for selected drainage basins incorporating the predicted probability and estimated volume for those basins.

In response to the 25-year-recurrence, 30-minute-duration rainfall, modeling indicated that 24 basins, 19 percent of the total, have high probabilities of debris-flow occurrence. High probability basins were concentrated in the west and central part of the burned area, including tributaries to Whitewater Creek, Mineral Creek, and Willow Creek. Estimated debris-flow volumes ranged from about 3,000–4,000 cubic meters (m^3) to greater than 500,000 m^3 for all design storms modeled (including the 2-year and 10-year recurrence storms). Basins with the highest combined probability and volume Relative Hazard Ranking include tributaries to Whitewater Creek, Mineral Creek, Willow Creek, West Fork Gila River, West Fork Mogollon Creek, and Turkey Creek.

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Surface Water and Groundwater Interactions in Semiarid Irrigated Floodplains of Northern New Mexico

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Poster Abstract 23

Deep percolation from irrigation can provide a significant amount of aquifer recharge in alluvial floodplains. A better understanding of surface water and groundwater interactions in irrigated floodplains is needed for properly assessing the mechanisms of water transport through the vadose zone and for estimating potential aquifer recharge from deep percolation in these systems. Primarily based at the NMSU-Alcalde Science Center in Alcalde, NM, we are conducting a study aimed to quantify different components of the water budget in different crop fields with alluvial soils. We are conducting several studies on different crops (alfalfa, grass hay, strawberry, and jujube) with different irrigation techniques (flood, sprinkler, and drip) to characterize changes in soil water storage, water movement through the vadose zone, and shallow groundwater level rise in response to deep percolation from irrigation. We have instrumented these crop fields to measure total amount of water applied, changes in soil moisture, and drainage below the root zone. In addition, we have installed and instrumented different monitoring wells to track water table fluctuations in response to irrigation deep percolation. Climate data from nearby, previously installed, weather stations are being used to calculate evapotranspiration. Preliminary results show a relatively rapid movement of water through the upper 50 cm of the vadose zone for crops irrigated under flood and under sprinkler conditions. Results from this study can contribute to the better understanding of the surface water and groundwater interactions in floodplain irrigated valleys of northern New Mexico under different irrigation techniques.

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Concentrate Management Strategies for Inland Desalination

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Poster Abstract 24

Ninety-six percent of municipal desalination plants in the United States are located inland[1], where increasing challenges to concentrate management have resulted in high-recovery and zero liquid discharge (ZLD) systems recently being considered for many municipal applications[2]. In various inland locations in the United States, conventional concentrate management options are not cost-effective and thus, desalination plants are not being built[2]. This is particularly problematic in the inland arid southwestern portion of the United States, where both surface water disposal and disposal to publicly owned treatment works are limited[2].

However, the economic future of the arid Southwest will demand some combination of water conservation, recycling, and the creation of "new water" from the extensive brackish water resources available in the area[3]. It is estimated that 75% of the groundwater in New Mexico is too saline for most uses without treatment[4], and that these large volumes of once-ignored saline/brackish water could provide much needed relief to existing fresh water supplies[5]. As the costs associated with concentrate disposal may be the biggest roadblock to widespread inland desalination[3], [6], it is necessary to investigate the best practices for concentrate management. Conventional options for inland concentrate management include:

- Disposal into surface water bodies
- Disposal to municipal sewers
- Evaporation ponds
- Deep well injection
- Irrigation of plants tolerant to high salinities (halophytes)

Where the main factors that influence the selection of a disposal method are:

- Volume of concentrate
- Quality of concentrate (especially considering heavy metals and chemical additives)
- Physical and geographical considerations
- Capital and operating costs
- Possible future expansion/reduction of the facility
- Public acceptance

A systematic approach to determine the best practices for concentrate management, while simultaneously pursuing technologies with high-recovery capabilities, will enable arid inland regions to explore the potential for desalinating their brackish water supplies.

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Comparison of Optimization Methods for Multipurpose Reservoir Management

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Poster Abstract 25

Water resources projects in arid regions are critical to the health, safety, economic development, and environment in which project beneficiaries live. Such projects consist of physical infrastructure and operations, which can lead to very complex and competing management decision criteria. Various methods for identifying optimum management strategies and decisions have been developed over the years, with Linear Programming (LP) making early inroads, and more sophisticated approaches such as Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) allow more complex and realistic objective functions and constraints to be implemented.

This poster examines the application of GAs and PSO to the Zyandeh Rood River in central Iran. A major multipurpose reservoir on the river controls water for municipal/industrial purposes, irrigation, and hydropower generation. Optimizing the total economic benefits to the system users using GAs and PSO allows for comparison of the performance and optimum solutions for the two methods, and demonstrates their utility. Such methods may be applicable to river/reservoir systems in the United States, including the Rio Grande.

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Can Clinoptilolite Zeolite Conserve Nitrogen Fertilizer in Agricultural Loamy Sand Soils?

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Poster Abstract 26

In southern New Mexico, large agricultural areas composed of sand and sandy loams require numerous nitrogen fertilizations per season to meet crop nutrient needs. However these areas are prone to leach large amounts of nitrogen to shallow groundwater. The objective of this study was to investigate the effects of applying CZ to sandy soils to the retention and transport of nitrate-nitrogen (NO_3—N) and ammonium-nitrogen (NH_4+–N). Adsorption and leaching experiments were carried out by applying a nitrogen fertilizer solution (Urea-ammonium-nitrate, UAN®32) to four soil treatments to simulate crop irrigation. The treatments were composed of 100% CZ, 100% loamy sand (LS), a mixture of 80%:20% (LS:CZ), and a mixture 60%:40% (LS:CZ) by mass, respectively. Results from the experiments showed an inverse relationship between NO_3–N adsorption and the amount of CZ added to soil caused by anion exclusion, and a direct relationship between NH_4+–N adsorption and the amount of CZ mixed with LS due to ion entrapment by the CZ molecules. Except at the highest nitrogen solution concentration used in the experiments, there was no significant difference in NO_3–N and NH_4+–N adsorption between the two soil mixtures; 80%:20% and 60%:40% (LS:CZ). It is recommended that other types of fertilizers that do not include NO_3–, such as ammonium sulfate ($(NH_4)_2SO_4$), be used in LS soils amended with CZ to reduce the risk of leaching. Otherwise, fertilizers containing ammonium nitrate could be applied to LS soils amended with CZ at reduced rates but at higher frequencies to meet plant demands.

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Restoration of Riparian Vegetation Using Geo-Engineering Material

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Poster Abstract 27

Hydrologic alteration and operation of the Rio Grande have contributed to unsuccessful riparian vegetation restoration attempts by local, state and federal organizations. These alterations have allowed exotic invasive species such as saltcedar (Tamarix spp.) to spread and dominate riparian plant communities in the southwestern United States. A pilot study was conducted at a saltcedar-managed area near Caballo, New Mexico to investigate the use of geo-engineering, clinoptilolite zeolite (CZ), as a wicking material to restore native vegetation. In January 2012, a total of 104 CZ boreholes were drilled and installed in two 60 ft x 60 ft plots at Caballo Test Bed site. In March of the same year selected native riparian plants were transplanted into the CZ cores, and control individuals were transplanted into in-situ riparian soil (RS). During June and July of 2012, vegetation survival and growth, groundwater levels, water and soil chemistry, soil moisture, and climate data were collected and analyzed to evaluate the success of the restoration. The climate was dry and hot, precipitation was low (0.34 in), and depth to groundwater (DGW) was about 2.6 m. Plant survival for the CZ cores in Plot 1 was 37.5% versus 50% in the RS cores while Plot 2 had a survival percentage of 66% in the CZ cores compared to 59% in RS cores. In Plot 1, the decrease in the groundwater and moisture levels caused low unexpected survival rates for CZ. The study is still in progress to determine the final establishment rates for transplanted vegetation.

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Managed Riparian Zones to Conserve and Improve Water Quality and Improve Habitat

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Poster Abstract 28

Managing natural systems has always been a challenge to water resource managers and decision makers in an effort to conserve water, improve water quality, and improve habitat. However, there are no current predictive management techniques that quantify the economic and ecosystem benefits of utilizing native vegetation to conserve water, improve water quality, and restore habitat from high water consuming invasive and non-native vegetation. Extensive restoration efforts in fully-appropriated stream systems suffer from an inability to demonstrate a decrease in depletions resulting from the restoration efforts. This research investigates the use of low water consuming native vegetation and geo-engineering technique to reinvent current storm water conveyance and detention systems in urban settings however it is in its preliminary stage. The following is in progress: i) measurement of evapotranspiration depletion by invasive non-native vegetation (*Tamarix spp*.) and native saltgrass (*distichlis spicata*), ii) monitoring of depth to groundwater table using a network of piezometers, iii) regular measurement of groundwater, river water, and soil quality, iv) testing of riparian restoration using geo-engineering material, and v) monitoring of micro-climate.

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Water Use by Managed Saltcedar Area at the Caballo Reservoir, New Mexico

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Poster Abstract 29

Evapotranspiration (ET) of saltcedar managed by mowing at a riparian region near Caballo Reservoir in New Mexico was measured during the peak of the growing season in June and July of 2012. Saltcedar was mowed in July of 2011 and allowed to grow during the 2012 season. Saltcedar grew vigorously from about 30 cm, when it was mowed, to about 183 cm. Using the energy budget method and utilizing eddy covariance technique, net radiation (Q), soil heat flux (G) and sensible heat (H) were measured. Latent heat (LE) was determined as a residual. Then LE was converted to equivalent depth of water (or ET) using the latent heat of vaporization of water (2.45 MJ/kg). ET measured from June 21 through July 19, 2012 (29 days) was 150 mm (LE = 367 MJ/m^2). The groundwater table was about 1.83 m deep from ground surface. The electrical conductivity (EC) and Total Dissolved Solids (TDS) of saturated soil paste extract (1 soil: 5 distilled water) measured at the site varied with depth. The highest EC of 4,523 μS/cm and TDS of 2,426 mg/L were observed at 15.2 cm depth. The average ambient temperature was 27°C with the highest temperature reaching 39°C. The average relative humidity was 38% during the 29 days with lowest observed humidity of 6% and a maximum of 93%.

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RO / NF Applications in Brackish Water Desalination: Membrane Characterization and Hybridization with EDR

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Poster Abstract 30

The fresh water supply is a source of great concern due to the increase in earth's population and maybe the cause of future conflicts over the rights to bodies of water. Water shortage and scarcity pose significant threats for developing countries since desalination technologies are expensive. As a result, there is much interest in reducing the costs of water desalination. In all around the world, waters sources include oceans, brackish waters, and wastewaters. But, brackish water is used as the most common source in New Mexico. The most common brackish water quality problems are caused by suspended solids and hardness. Both problems respond to inexpensive treatment methods.

Reverse osmosis (RO) is one of the technologies used for desalinating brackish and saline waters to provide drinking water. RO treatment plants use semipermeable membranes and pressure to separate salts from water. With the progress of membrane science, RO overtook multi stage distillation as the leading desalination technology. In the last two decades, RO processes had significant progress, allowing new brackish groundwater desalination facilities to use RO technology much more economically than distillation. These systems typically use less energy than thermal distillation, leading to a reduction in overall desalination costs.

The focus of this study is in two parts. First is, studying the characterization of different types of membranes used in RO systems. The objectives are accomplished by utilizing pilot plant experiments. The experiments are designed to test the effect of Recovery, Permeate Flow, Inlet pH, and Inlet Conductivity on Permeate and Concentrate Conductivity, Primary Pressure, and Bank one Permeate Flow. A huge database collected from a full pilot-scale system, located at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, NM, and operated by New Mexico State University, are going to be analyzed.

Second part is to combine pressure driven systems, like RO/NF, with electric driven ones, like EDR, find out the stability of hybrid systems, and try to develop a cost model for them. In order to get to this approach we are running such systems in a pilot plant for about 300 hrs. Then, to model the hybrid system, we use WinFlows for RO and WATSYS for EDR. At the end of modeling, applying mass balance, we can get to the product and concentrate blowdown streams specifications. Of course, there are different scenarios of hybridization. We choose couple of these scenarios worthwhile to examine to do the experiments.

This study improves the benefits of using RO by reducing the cost, time, and energy spending to find the best approach for different conditions.

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