

**New Mexico Water Resources Research Institute  
Annual Technical Report  
FY 2011**

# Introduction

This program report provides the required information for projects funded with the 2011 base grant and mandatory non-federal matching funds. Please note that there may be some overlap in information with our 2010 report because data collection is based on a July-June fiscal year rather than the March-February USGS Grant Award period.

The New Mexico Water Resources Research Institute (NMWRRI) was established in 1963 by the New Mexico State University Board of Regents, becoming one of the first of the 54 state institutes approved nationwide under the authorization of the 1964 Water Resources Research Act. It is considered to be the statewide nucleus for coordinating water resources research. Using the expertise of researchers in a variety of disciplines at state-supported universities, the institute is able to respond to the critical water needs of New Mexico and the region. It operates under the general advice of a Program Development and Review Board, whose membership includes faculty representatives as well as state and federal agency personnel.

The mission of the NMWRRI is to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems. Specifically, the institute encourages university faculty statewide to pursue critical areas of water resources research while providing training opportunities for students who will become our future water resources scientists, technicians, and managers. It provides an outlet for transferring research findings and other related information to keep water managers and the general public informed about new technology and research advances. In addition, the institute maintains a unique infrastructure that links it with many federal, state, regional, and local entities to provide expertise and specialized assistance.

The institute maintains a dynamic program to transfer technical information from the producer to the user and the public. Technical publications, newsletters, conferences, press announcements, and presentations keep practitioners aware of new technology and research advances. The NMWRRI homepage ([wrri.nmsu.edu](http://wrri.nmsu.edu)) provides online information about the institute, newsletters, technical report series, requests for proposals, upcoming conferences and symposia, links to related entities, and the research reference library.

New Mexico is one of the driest states in the nation, averaging no more than 20 inches of precipitation a year, varying from about 6.5 inches in the Four Corners area to more than 30 inches in the high mountains. The relative humidity is low, resulting in a high rate of evaporation. Summer rain accounts for almost half of the annual precipitation other than in the high mountains. Widely varied precipitation contributes as much to a water allocation problem as water scarcity itself. To compound the situation, New Mexico, like much of the West, continues to suffer from the worst drought in 100 years or longer. Water conservation measures continue to expand in municipalities throughout New Mexico to help ensure adequate public water supplies for residential and industrial use. Drought ordinances are in place in cities across the state, and county and municipal governments are working together to limit water use and reduce demand. The New Mexico Drought Task Force monitors the situation and drought information is updated regularly at <http://www.nmdrought.state.nm.us>.

Currently, about 86 percent of New Mexico is classified with moderate drought conditions or a more severe drought category. Southeastern New Mexico continues to experience the worst conditions, with extreme and exceptional drought persisting for more than a year. Elephant Butte Reservoir, located on the Rio Grande in central New Mexico, is only 18 percent full and is 3 percent lower than it was one year ago. Storage in Navajo Reservoir, another of New Mexico's largest reservoirs, located on the San Juan River in northwest New Mexico, is 77 percent full, similar to a year ago. Because of the latest forecast for inflow into Elephant Butte Reservoir, streamflow is likely to only be about 29 percent of average. If the forecast is correct, very little surface water will be available for farmers in the Elephant Butte Irrigation District. To compensate, farmers

will have to pump more groundwater, which supplies saltier water that can reduce crop quality and is more expensive than using Rio Grande water.

Water problems in New Mexico, like in other western states, continue to revolve around three key issues: quality, quantity, and management. Because water resources are so limited, water quality and water resources management have taken on increasing importance. These concerns are interrelated and sufficiently complex so that the highest quality research is essential to solving them.

## Research Program Introduction

The primary objective of the New Mexico Water Resources Research Institute is to maintain a balanced program of research that addresses water issues and problems critical to New Mexico, the region, and the nation. In administering this program, the institute relies on financial support from state appropriations, federal and state agencies, and the USGS Water Resources Research Institute Annual Base Program (USGS 104B).

To make the best use of limited resources, the institute has targeted four areas as high priority for funding: water conservation, planning and management; atmospheric, surface and groundwater relationships; water quality; and utilization of saline and other impaired waters. During the reporting period, three projects received funding from the 2011 Annual Base Program. Two of these projects fit into the water conservation, planning and management category: "WRRI Information Transfer Program" and "Geographic Information System for Water Resources Planning." A water quality project was also funded: "Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions." In addition, three projects received special funding through the USGS, "Transboundary Aquifer Assessment Program (PL 109-448), "Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan," and "Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq." Also, the USGS awarded a cooperative agreement for the coordination of the conference "New Water New Energy: A Conference Linking Desalination and Renewable Energy," a joint effort between the NMWRRI and the Bureau of Reclamation.

During the reporting period, March 1, 2011 through February 28, 2012, the NMWRRI administered a total of 10 projects dealing primarily with water planning and management issues. The total value of these projects was just over \$1.1 million. Dollar amounts per project award ranged from a small mapping grant of \$5,588 to an international program effort of over \$585,000. During the reporting period, nine projects were conducted at New Mexico State University and one at New Mexico Tech. NMWRRI staff managed nine projects.

Research projects administered by the NMWRRI utilized at least 15 students during the year including undergraduates, masters, and Ph.D. candidates in the disciplines of agricultural economics, civil engineering, engineering technology, hydrology, kinesiology, and mathematics.

Projects administered by the NM Water Resources Research Institute during the reporting period are listed below. Note that total award value is shown and includes both agency and cost sharing when appropriate, and can include multiyear funding.

Information Transfer Program USGS 104B \$35,753

Geographical Information System for Water Resources Planning USGS 104B \$36,105

Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions USGS 104B \$30,000

Transboundary Aquifer Assessment Program - Year 3. USGS \$100,044

Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq USGS \$24,250 (year 2)

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan. USGS \$585,159 (year 4)

## Research Program Introduction

Maintenance and Updates of the PdNWC Website and Web Mapping Applications, Texas A&M University AgriLife Research and Extension Center (TAMU AREC) \$5,588

Physical and Social Drivers of Water Sustainability in a Groundwater-Dependent Agricultural Region on the US-Mexico Border, Southwest Consortium for Environmental Research and Policy (SCERP) \$57,500

Coordination of Conference Entitled "New Water New Energy: A Conference Linking Desalination and Renewable Energy" (cooperative agreement with Bureau of Reclamation through USGS) \$70,462

Chihuahuan Desert Network Administrative Support (National Park Service) \$156,254

## Award No. 08HQAG0146 Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan

### Basic Information

<b>Title:</b>	Award No. 08HQAG0146 Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan
<b>Project Number:</b>	2008NM114S
<b>Start Date:</b>	9/22/2008
<b>End Date:</b>	9/21/2013
<b>Funding Source:</b>	Supplemental
<b>Congressional District:</b>	2
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Category:</b>	None, None, None
<b>Descriptors:</b>	Afghanistan, crop growth, agriculture, economics
<b>Principal Investigators:</b>	Alexander Sam Fernald

### Publications

1. Gregory Torell, 2010, Economic analysis for improved water management, food security, and rural livelihoods in Afghanistan's Balkh Basin, M.S. Thesis, NMSU Department of Agricultural Economics and Agricultural Business.
2. Gregory Torell, Balkh River Canal System, Afghanistan Decision Support (excel spreadsheet), posted on the web at <http://agecon.nmsu.edu/fward/water/>
3. Torell, G. and F.A. Ward, 2010, Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin, International Journal of Water Resources Development, 26,4,613-637.
4. Torell, G. and F.A. Ward, 2010, Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin, International Journal of Water Resources Development, 26,4,613-637.
5. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.

## Description of problem and research objectives

This is the fourth year of a cooperative agreement with NMSU and USGS in support of the development of reducing food poverty through development of improved irrigation institutions in Afghanistan. Activities have focused on the application and development of techniques for monitoring the physical variables governing crop growth, such as timing and level of precipitation, evapotranspiration and temperature, along with human-related factors such as cropped area, agricultural inputs, and economic indicators.

These data have been integrated into an analysis of policy options for improving farm income, rural food security, and improved livelihoods. Recent work has developed and applied a framework to inform farmers, extension personnel, mirabs, and ministry personnel on uses of land and water resources in the Balkh River Basin to improve farm income and reduce food poverty.

A journal article is currently under journal review summarizing connections between irrigation institutions and food poverty in Afghanistan. The research examined the development of irrigation institutions that could contribute to reducing food poverty by improved water allocation among canals.

## Description of methodology

Funding under Agromet has supported the following activities:

Installation of 113 weather observation sites: 1) all 113 observation sites are recording daily rain and snow; 2) 80 of 113 sites are reporting in addition to rain and snow on crops (wheat, rice, barley and maize) and pasture and grazing twice a month (fortnightly forms) including crop condition (all the weather adverse factors, shortage of inputs, weed, pests and diseases infestations) and crop phenological stages (including land preparation) in addition to areas planted (% of the total by agricultural zone), planting and harvesting dates in addition to the expected yields during the agricultural year and final obtained yields after the harvesting; and 3) of 113 sites, 21 sites are complete agrometeorological stations (three observations daily), with 19 classical stations recording 7 weather parameters and 5 automatic stations that can report on up to 20 weather parameters at daily step.

Using weather, hydrologic, agronomic, and economic data, several arrangements for allocating water through an existing network of irrigation canals were analyzed for their impacts on land and water use, farm profitability, and food security at both the canal and basin levels.

## Description of principal findings and significance

Findings show that total water supply and institutional arrangements for allocating water during periods of shortages have important influences on farm income and food security. The methods used and results found provide a framework for informing decisions on the sustainable use of land and water for improved food security and rural livelihoods in the developing world's irrigated areas.

One manuscript is currently under review at the journal, Food Security, summarizing recent findings that indicate that a proportional sharing of shortages in periods of drought is the best method for assuring both food security and farm income in the Balkh Basin, Afghanistan.

New work has recently begun that examines potential economic benefits of additional reservoir storage that could be developed in the Balkh Basin.

Review work was also recently completed describing the scope and limits of cost benefit analysis for informing debates on water resources policy.

# Award No. 08HQAG0117 Transboundary Aquifer Assessment Program

## Basic Information

<b>Title:</b>	Award No. 08HQAG0117 Transboundary Aquifer Assessment Program
<b>Project Number:</b>	2008NM115S
<b>Start Date:</b>	4/1/2008
<b>End Date:</b>	3/31/2013
<b>Funding Source:</b>	Supplemental
<b>Congressional District:</b>	2
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Groundwater, None, None
<b>Descriptors:</b>	aquifer assessment, Mesilla Basin, Hueco Bolson, GIS, database,
<b>Principal Investigators:</b>	Alexander Sam Fernald

## Publications

1. Hawley, John W. and Alfredo Granados-Olivas, 2008, Progress Report on Development of an Annotated Bibliography for Transboundary Aquifer Systems of the Mesilla Basin-Paso del Norte Area, New Mexico, Texas (USA), and Chihuahua (MEX), poster presented at the 2008 New Mexico Water Research Symposium, Socorro, NM, August 2008, Symposium Program and Abstracts.
2. Hawley, J.W., B.J. Creel, and B.V.N.P. Kambhammettu, 2009, Digital hydrogeologic-framework model of the San Francisco River basin, west-central New Mexico and east-central Arizona [abstract], Geological Society of America. Abstracts with Programs, 41(7) Session 58-T21 on CD ROM. ISSN 0016-7592.
3. Hawley, J.W., J.F. Kennedy, A. Granados-Olivas, and M.A. Ortiz, 2009, Hydrogeologic framework of the binational western Hueco Bolson-Paso del Norte area, Texas, New Mexico, and Chihuahua. NM Water Resources Research Institute, NM State University, Technical Completion Report 349. 45 p., with 2 plates on CD ROM. <ftp://wrii.nmsu.edu/pub/hueco>
4. Monger, H.C., L.H., Gile, J.W. Hawley, and R.B. Grossman, 2009, The Desert Project: an analysis of aridland soil-geomorphic processes New Mexico State University Agricultural Experiment Station Bulletin 798. 76 p., <http://aces.nmsu.edu/pubs/research/weather-climate/>
5. Creel, B.J., 2010, Research Needs in the U.S. Portion of the Rio Grande Watershed, E.M. Ward and E.A. Barrantes (eds), Journal of Transboundary Water Resources, 01:31-42.
6. Schmid, W., J.P. King, and T. Maddock III, 2010, Conjunctive Surface-Water/Groundwater Model in the Southern Rincon Valley Using Modflow-2005 with the Farm Process, NM Water Resources Research Institute, New Mexico State University, Technical Completion Report No. 351, 65 pp.
7. Servicio Geologico Mexicano, Coordinacion General de Minería, and International Boundary and Water Commission, 2011, Hydrogeological Activities in the Conejos-Medanos/Mesilla Basin Aquifer, Chihuahua, Phase 1. Prepared for the Transboundary Aquifer Assessment Act Project under contract with the New Mexico Water Resources Research Institute and Texas Water Research Institute. Two volumes.
8. Kambhammettu, B.V.N.P., J.P. King and A. Praveena, 2011, Evaluation of mountain-front recharge estimation techniques for Southern New Mexico basins. International Journal of Water Resources and Environmental Engineering, 3(3):66-72.

Award No. 08HQAG0117 Transboundary Aquifer Assessment Program

9. Kambhammettu, B.V.N.P., Chandramouli, S., and King, J.P. 2011. An improved DEM aggregation technique for models with non-uniform resolution. *International Journal of Geomatics and Geosciences*. 1:4:962-970.
10. Kambhammettu, B.V.N.P., Schmid, W., King, J.P., and Creel, B.J. 2011. Effect of elevation resolution on evapotranspiration simulations using MODFLOW. *Ground Water Journal*. doi: 10.1111/j.1745-6584.2011.00852.x.

## Description of problem and research objectives

Rapid population growth in the United States-Mexico border region over the last decade has placed major strains on limited water supplies in the region. Rapid growth rates are expected to continue for at least several more decades. Water quantity and quality issues are likely to be the determining and limiting factors affecting future economic development, population growth, and human health in the border region. Increasing use of groundwater resources in the border region by municipal and other water users has raised serious questions concerning the long-term availability of the water supply.

Cooperation between the United States and Mexico in assessing and understanding transboundary aquifers is necessary for the successful management of shared groundwater resources by state and local authorities in the United States and appropriate authorities in Mexico, including management that avoids conflict between the United States and Mexico. While there have been some studies of binational groundwater resources along the United States-Mexico border, additional data and analyses are needed to develop an accurate understanding of the long-term availability of useable water supplies from transboundary aquifers.

The objectives of the Transboundary Aquifer Assessment Program were to collect and evaluate new and existing data to develop high-quality, comprehensive groundwater quantity and quality information and groundwater flow models for the Mesilla Basin aquifer in New Mexico, Texas, and Mexico.

## Description of methodology

A review of all previously developed groundwater flow models was conducted in 2009. During the past two years field studies were used to develop any additional data that are needed to define aquifer characteristics to the extent necessary to enable the development of groundwater flow models. Additional evaluations of all available data and publications relevant to the aquifer and produce a binational bibliography were conducted. The project utilized the geographic information system database that was created last year to better characterize the spatial and temporal aspects of the aquifer, with emphasis on a digital model of the hydrogeologic framework. The project also continued to expand existing agreements, as appropriate, between the authorities in the United States and Mexico to (1) conduct joint scientific investigations; (2) archive and share relevant data; and (3) carry out any other activities consistent with the program. A basin steering committee of local stakeholders was established to provide review and feedback on tasks and products. One of the major products of this reporting cycle is a report by Mexican hydrologists on the geohydrology and development of the Conejos-Medanos well field immediately across the US border in Mexico. The Conejos-Medanos is one of the chief areas of interest for the TAAP, and the Mexican report was produce with funding from TAAP routed to the Mexican agencies through the US Section of the International Boundary and Water Commission.

## Description of principal findings and significance

A bibliography of previous studies that was compiled in 2008 has been updated and reviewed by the USGS, New Mexico, and Texas team. This is an ongoing process as more literature is found and new literature is written. The basin-scale hydrogeologic framework model that was produced in 2005, including cross sections and model layer maps, was reviewed and updated with recent information and a new compilation of well-control data. Expansion of this model into Mexico has been proposed and is pending finalization of the binational agreement for conducting joint investigations and basic-data sharing. Mesilla Basin groundwater flow models developed in the last 20 years have been reviewed and evaluated for their possible future use and modification. Significant sharing of data between the US participants and Mexican colleagues occurred during the reporting period.

The regional hydrology model of the area released by the New Mexico State Engineer in 2007 has been updated through 2009. The new Farm Module feature of MODFLOW has been added to the model and runs are being done to compare the new version with the OSE version. A mimic model that produces simulations in agreement with the OSE version has been produced and validated.

The basic binational-agreement documents related to conduct of joint investigations and data sharing were signed in August 2009; and specific final arrangements for agreement implementation were completed in March-April 2010. Mexico produced a report on the geohydrology and well field development in the Conejos-Medanos area of the Mesilla Bolson aquifer adjacent to the US-Mexico border, a main focus of the TAAP. The report included maps, geophysical data, well tests, and other relevant information.

# USGS Award No. G10AC00516 Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq

## Basic Information

<b>Title:</b>	USGS Award No. G10AC00516 Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq
<b>Project Number:</b>	2010NM123S
<b>Start Date:</b>	9/1/2010
<b>End Date:</b>	8/31/2015
<b>Funding Source:</b>	Supplemental
<b>Congressional District:</b>	2
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Category:</b>	Drought, Water Use, Management and Planning
<b>Descriptors:</b>	Forecasting, Climate, Water Use, Land Use, Agriculture, Drought
<b>Principal Investigators:</b>	Alexander G. Fernald

## Publications

There are no publications.

## Description of problem and research objectives

This program supports the Iraq Water, Agriculture, Geospatial Data Infrastructure and Technology Transfer Program. Streamflows in the Tigris-Euphrates rivers in Iraq have declined in recent years, and an important policy debate centers in the most economically viable measures for making more economical and business use of those reduced flows in Iraq. The objective of this project is to explore the development of innovative irrigation institutions for allocating water and water rights among water users in Iraq in order to secure more economically productive uses of water in the Tigris-Euphrates basins.

Overall Agromet project objectives are:

- Install agro-meteorological stations throughout the country
- Set up an operational agro meteorological database and information system functioning efficiently, including all the relevant data (historical and recent)
- Carry out agro climatic analyses for major agro meteorological parameters
- Provide timely, accurate, and reliable data for decision makers, government agencies, international forces, and national and international NGOs
- Assist the Iraq Government in their efforts to collect and analyze meteorological and agricultural data as it relates to crop production, irrigation, water supply, energy, dust storms, and aviation
- Create a transition plan for future implementation by Iraq government officials
- Play a key role in the institutional capacity building and training of Iraqis in the field of agro- and hydro-meteorology

## Description of methodology

- Collecting agro-meteorological data for water and crop monitoring and forecasting
- Collecting meteorological data for dust storm forecasting
- Development of crop monitoring and production estimating tools
- Temperature and photoperiod inputs to yield estimation
- Development of hydroeconomic policy analytic tools
- Improved rainfall forecasts
- Improved understanding of relations between snowpack and streamflow
- Teach short courses in Iraq on the development and use of hydroeconomic spreadsheet models to support policy analysis of irrigation water management in Iraq.

## Description of principal findings and significance

Historical data have been secured on streamflows, crop production, crop water use, and land in production for the Tigris and Euphrates rivers. An analysis is currently being conducted that will examine opportunities for improving farm income in the face of reduced or unreliable streamflows in both basins.

A prototype watershed policy models has been completed for the Amu Darya basin for which it is hoped that methods can be transferred to address policy debates on the Tigris-Euphrates in Iraq. Two articles are currently under review in connection with this work, one at the journal, Political Geography, and another at Water Resources Management.

# Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions

## Basic Information

<b>Title:</b>	Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions
<b>Project Number:</b>	2011NM126B
<b>Start Date:</b>	3/1/2011
<b>End Date:</b>	2/28/2012
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	2
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Hydrology, Models, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	John L Wilson

## Publications

1. Henry, K., Wilson Karst Hyporheic Exchange below Conduits with Turbulent Flow, Eos Trans., AGU, Fall Meeting Supplement, H23F-1333, 2011.
2. Henry, K., Wilson, J., Kincaid, T. 2011. Instrumentation & Experimental Design for Dye Trace to Observe Water Flow from Conduit to Matrix, Geological Society of America Abstracts with Programs. 43:5:290.
3. Henry, K., Wilson, J., 2011. Conduit Flood Pulses as Drivers of Dynamic Gradients, Geological Society of America Abstracts with Programs. 43:5:291.
4. Wilson, J., Henry, K., 2011. Residence Times of Karst Conduit Hyporheic Flow, Geological Society of America Abstracts with Programs. 43:5:341.

## Brief description of problem and research objectives

Exchanges between karst conduits and surrounding matrix rock are poorly understood. Of particular interest are exchanges from the conduit to the matrix, which occur during conduit flood pulses and, we hypothesize, karst hyporheic flow. This project uses Computational Fluid Dynamics (CFD) modeling to describe these exchanges between conduit and matrix.

Research objectives include:

1. For how long is conduit water sequestered inside the matrix after a flood pulse?
2. What are the differences in flood pulse propagation in the matrix for a confined versus unconfined aquifer?
3. What are the residence time distributions of karst conduit hyporheic flow?
4. What is the effect of flow regime in the conduit on residence times of the hyporheic flow?

## Description of methodology

The flood pulse model was completed in COMSOL Multiphysics, a finite element CFD software program. A model was built using the fundamental physical equations (Navier-Stokes and Darcy's Law) with appropriate boundary conditions and physical parameters. The model was a 2-D cross sectional model showing exchanges from the conduit to the surrounding matrix rock.

The karst hyporheic model was completed in COMSOL Multiphysics, a finite element CFD software program. A model was built using the fundamental physical equations (Navier Stokes and Darcy's Law) with appropriate boundary conditions and physical parameters. The model was a 2-D longitudinal model showing exchanges from the conduit to the surrounding matrix rock caused by small scale pressure gradients in the conduit arising from the topography of the matrix.

## Description of principal findings and significance

Principal findings by research objective are:

- 1) Conduit water is sequestered in the matrix for more than 1 order of magnitude longer than the flood event.
- 2) For the unconfined matrix case the sequestration is even longer, because the water table can bulge over the pressure pulse in the matrix. This results in a lower gradient (because water is distributed over a larger distance) in the matrix, slowing the return of water to the conduit.
- 3) Residence time of the conduit water to the matrix water follows a residence time distribution due to nested scales of the exchange. For an idealized case of individual bedforms, of exactly the same length and height, residence time is shorter than 1 year, for realistic matrix permeabilities and fairly slow conduit velocities.
- 4) For the laminar flow in the conduit, as conduit velocity increases the residence time of the hyporheic flow in the matrix decreases. The turbulent flow case is currently being modeled.

As the COMSOL software has not delivered the promised turbulent flow calculations, we are switching to ANSYS FLUENT to complete the turbulent flow models.

## **Information Transfer Program Introduction**

The New Mexico Water Resources Research Institute maintains an active program to transfer technical information from the producer to the user and the public. Technical publications, newsletters, conferences, symposia, press announcements, and presentations keep practitioners aware of new technology and research advances. The WRRRI homepage ([wrrri.nmsu.edu](http://wrrri.nmsu.edu)) provides online information about the institute's newsletters, technical report series, requests for proposals, upcoming conferences and symposia, and the research reference library. All 56 past annual water conference proceedings have full-text viewing via the institute's homepage. Other federal and state servers, such as the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, USGS, Bureau of Reclamation, and National Weather Service are linked to the WRRRI homepage.

# Geographic Information System for Water Resources Research Planning

## Basic Information

<b>Title:</b>	Geographic Information System for Water Resources Research Planning
<b>Project Number:</b>	2002NM1B
<b>Start Date:</b>	3/1/2011
<b>End Date:</b>	2/28/2012
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	Second
<b>Research Category:</b>	Not Applicable
<b>Focus Category:</b>	Management and Planning, Conservation, Water Quality
<b>Descriptors:</b>	
<b>Principal Investigators:</b>	Alexander Sam Fernald

## Publications

1. Hawley, J.W. and J.F. Kennedy, 2004, Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada del Muerto Basin. New Mexico, Water Resources Research Institute, Technical Completion Report No. 332, New Mexico State University, Las Cruces, New Mexico. 105 p., with 7 plates and appendix on CD ROM.
2. Van Schoik, R., C. Brown, E. Lelea, and A. Conner, 2004, Barriers and Bridges: Managing Water in the U.S.-Mexican Border Region, Environment, 46:1.
3. Connell, S.D., J.W. Hawley, and D.W. Love, 2005, Late Cenozoic drainage development in the southeastern Basin and Range of New Mexico, southeasternmost Arizona, and western Texas, in S.G. Lucas, G. Morgan, K.E. Zeigler, eds., 2005, New Mexico's Ice Ages: New Mexico Museum of Natural History & Science Bulletin No. 28, p. 125-150.
4. Hawley, J.W., 2005, Five million years of landscape evolution in New Mexico: An overview based on two centuries of geomorphic conceptual-model development, in S.G. Lucas, G. Morgan, and K.E. Zeigler, K.E. eds, 2005, New Mexico's Ice Ages: New Mexico Museum of Natural History & Science Bulletin No. 28, p. 9-93.
5. Pazzaglia, F.J. and J.W. Hawley, 2004, Neogene (rift flank) and Quaternary geology and geomorphology, in G.H. Mack, G.H., and K.J. Giles, eds., The Geology of New Mexico: A geologic history: New Mexico Geological Society, Special Publication 11, p. 407-438.
6. Seager, W.R., F.E. Kottlowski, and J.W. Hawley, 2004, Geology of Robledo Mountains and vicinity, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 75, CD-ROM only.
7. Brown, C., Z. Sheng, and M. Bourdon, 2005, Final Project Report for the Paso del Norte Watershed Council (PdNWC) Coordinated Water Resources Database, Phase II. Technical completion report produced on behalf of the PDNWC for the El Paso Water Utilities.
8. Kennedy, J.F., 2004, Application of GIS and Remote Sensing Methods to the Paleohydrogeography of the Paso del Norte Region, Ph.D. Dissertation, Department of Geological Studies, University of Texas at El Paso, El Paso, TX, variously paged.
9. Hawley, J.W. and J.F. Kennedy. 2004 (2005), Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada del Muerto Basin. New Mexico Water Resources Research Institute; prepared for Lower Rio Grande Water Users Organization; Technical Completion Report 332, 105 p., with plates and appendix on CD ROM (including June 2005 Addendum extending model

## Geographic Information System for Water Resources Research Planning

- into Rincon Valley and adjacent areas).
10. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of saved-water and the costs of alternative methods of reducing carriage losses from district canals. New Mexico Water Resources Research Institute, Technical Completion Report No. 335, with plates and appendices on CD ROM.
  11. Hawley, J.W., J.F. Kennedy, and M. Ortiz. 2005. Digital hydrogeologic-framework model of the western Hueco Bolson area, Texas and Chihuahua. New Mexico Water Resources Research Institute, New Mexico State University. Project Completion Report, prepared for California State University-Los Angeles (CSULA Purchase Order CGA46120/NMSU Acct # 20050644), 45 p., 2 plates.
  12. Creel, B.J., J.W. Hawley, J.F. Kennedy, and A. Granados-Olivas. 2006. Groundwater resources of the New Mexico-Texas-Chihuahua border region. *New Mexico Journal of Science*. 46:11-29.
  13. Granados-Olivas, A., C. Brown, J. Greenlee, B. Creel, J.W. Hawley, J.F. Kennedy, O. Dena-Ornelas, and B. Hurd. 2006. Geographic information systems at the Paso del Norte region: The academic accomplishments and challenges for a transboundary water resources GIS cooperation. *New Mexico Journal of Science*. 46:45-56.
  14. Kennedy, J.F., R.P. Langford, and J.W. Hawley. 2006. Using GIS and Remote Sensing to Reconstruct Late Quaternary and Early Holocene Paleo-Hydrography Using Climate Data and Modern Topography: An example from the Southwestern US. *Computers and Geosciences*. In press.
  15. Kennedy, J.F., R.P. Langford, and J.W. Hawley. 2006. Estimating a Water-Balance Equation for a Playa in the Tularosa Basin of Southern New Mexico. *Computers and Geosciences*. In press.
  16. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy, and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project, Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of water that may be saved, and the costs of alternative methods of reducing carriage losses from district canals. New Mexico Water Resources Research Institute Technical Completion Report 335, with plates and appendices on CD ROM, New Mexico State University, Las Cruces, New Mexico.
  17. Ortiz, Marquita. 2007. The Impacts of Land Use Change on Water Resources and Traditional Acequia Culture in Northcentral New Mexico. Master's thesis, Department of Geography, New Mexico State University, Las Cruces, NM.
  18. Alfredo Granados-Olivas, Erick Sanchez-Flores, Antonio De la Mora-Covarrubias, Servio Tulio De la Cruz, Gerardo Reyes-Macías, Francisco Llera-Pacheco, Javier Chavez, Bobby Creel, and Christopher Brown, 2008, Roadmap of Geospatial Education in Mexico, ASPRS 2008 Annual Conference Portland, Oregon, April 28-May 2, 2008.
  19. Glaze, Susanna, Bobby J. Creel, Casey Gomez and Royce Stevens, 2008, Rio Grande Basin Initiative Interactive Mapping for New Mexico, In Proceedings of the 2008 AWRA Spring Specialty Conference, San Mateo, CA, March 17-19, 2008.
  20. Zhuping Sheng, Christopher Brown, Bobby Creel, Raghavan Srinivasan, Ari Michelsen, and Michael P. Fahy, 2008, Installation of River and Drain Instrumentation Stations to Monitor Flow and Water Quality and Internet Data Sharing, New Mexico Water Resources Research Institute Technical Completion Report 344 and Texas Water Resources Institute Technical Report 320, August 2008, 38 p.
  21. Hawley, J.W. and Kernodle, J.M., 2008, Early contributions to arid-zone hydrogeology in the eastern Basin and Range region Historical Note: *Ground Water*, 46(3), 510-516.
  22. Eastoe C.J., Hibbs, B.J., Granados-Olivas, A., Hogan, J.F., Hawley, J., and Hutchison, W.R., 2008, Isotopes in the Hueco Bolson Aquifer, Texas (USA) and Chihuahua (Mexico): Local and general implications for recharge sources in alluvial basins, *Hydrogeology Jour.*, 16(4), 737-747.
  23. Sandor, J.A., Hawley, J. W., Schiowitz, R.H., and Gersper, P.L., 2008, Soil-geomorphic setting and change in prehistoric agricultural terraces in the Mimbres area, New Mexico, *New Mexico Geological Society Guidebook* 59, 167-175.

## Geographic Information System for Water Resources Research Planning

24. Hawley, J.W., and Granados-Olivas, A., 2008, Progress report on development of an annotated bibliography for transboundary aquifer systems of Mesilla Basin-Paso del Norte area, New Mexico, Texas, and Chihuahua: 2008 New Mexico Water Research Symposium (N.M. Tech-8/12/2008), N.M. Water Resources Research Institute, NMSU, Symposium Program and Abstracts, p. E-14.
25. Hawley, J.W., and Kennedy, J.F., 2008, Digital hydrogeologic models of basin-fill aquifer systems in the southwestern New Mexico border region A powerful tool for binational water-resources management: American Institute of Professional Geologists 45th Annual Meeting AIPG-AHS-3rd IPGC Symposium, Flagstaff, AZ, Program-Poster Abstract, p. 48.
26. Monger, H. C., Gile, L.H., Hawley, J.W., and Grossman, R.B., 2008, The Desert Project An analysis of arid land soil-geomorphic processes, in Topical Session T17. Integration of soils and geomorphology in deserts: A tribute to the 50 years of soils research of Dan Yaalon: Geological Society of America/Soil Science Society of America-Joint Meeting, GSA Abstract with Programs, 40(6).
27. Creel, B.J., J.W. Hawley, J.F. Kennedy, and A. Granados-Olivas. 2006. Groundwater resources of the New Mexico-Texas-Chihuahua border region. *New Mexico Journal of Science*. 46:11-29.
28. Granados-Olivas, A., C. Brown, J. Greenlee, B. Creel, J.W. Hawley, J.F. Kennedy, O. Dena-Ornelas, and B. Hurd. 2006. Geographic information systems at the Paso del Norte region: The academic accomplishments and challenges for a transboundary water resources GIS cooperation. *New Mexico Journal of Science*. 46:45-56.
29. Kennedy, J.F., R.P. Langford, and J.W. Hawley. 2006. Using GIS and Remote Sensing to Reconstruct Late Quaternary and Early Holocene Paleo-Hydrography Using Climate Data and Modern Topography: An example from the Southwestern US. *Computers and Geosciences*. In press.
30. Kennedy, J.F., R.P. Langford, and J.W. Hawley. 2006. Estimating a Water-Balance Equation for a Playa in the Tularosa Basin of Southern New Mexico. *Computers and Geosciences*. In press.
31. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy, and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project, Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of water that may be saved, and the costs of alternative methods of reducing carriage losses from district canals. *New Mexico Water Resources Research Institute Technical Completion Report 335*, with plates and appendices on CD ROM, New Mexico State University, Las Cruces, New Mexico.
32. Ortiz, Marquita. 2007. The Impacts of Land Use Change on Water Resources and Traditional Acequia Culture in Northcentral New Mexico. Master's thesis, Department of Geography, New Mexico State University, Las Cruces, NM.
33. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen, R. Srinivasan, and A. Granados. 2009. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed (Phase III) Part I Lower Rio Grande Flood Control Model RiverWare Model Development. *New Mexico Water Resources Research Institute Technical Completion Report No. 348, Part I (Texas Water Resources Institute Technical Report No. 359, Part I)*, New Mexico State University, Las Cruces, NM.
34. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen, R. Srinivasan, and A. Granados. 2009. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed (Phase III) Part II Availability of Flow and Water Quality Data for the Grio Grande Project Area. *New Mexico Water Resources Research Institute Technical Completion Report No. 348, Part II (Texas Water Resources Institute Technical Report No. 359, Part II)*, New Mexico State University, Las Cruces, NM.
35. Hawley, J.W., B.J. Creel, and B.V.N.P. Kambhammettu. 2009. Digital hydrogeologic-framework model of the San Francisco River basin, west-central New Mexico and east-central Arizona. Contract report for New Mexico Interstate-Stream Commission, NM Water Resources Research Institute, New Mexico State University, with CD ROM. In preparation as NMWRRRI Technical Completion Report.
36. Brookshire, D., B.J. Creel, S.L. Piper. 2009. Final Report: Gila Planning Economic Forum. Western New Mexico University, Silver City, NM. Submitted to the New Mexico Interstate Stream

## Geographic Information System for Water Resources Research Planning

- Commission and Southwestern New Mexico Stakeholder Group.  
<ftp://water.nmsu.edu/pub/gila/hydrogeologic>.
37. Hawley, J.W., J.F. Kennedy, A. Granados-Olivas, and M.A. Ortiz. 2009. Hydrogeologic framework of the binational western Hueco Bolson-Paso del Norte area, Texas, New Mexico, and Chihuahua. NM Water Resources Research Institute, New Mexico State University, Technical Completion Report 349. 45 p., with 2 plates on CD ROM. <ftp://wri.nmsu.edu/pub/hueco>
  38. Monger, H.C., L.H., Gile, J.W. Hawley, and R.B. Grossman. 2009. The Desert Project an analysis of aridland soil-geomorphic processes New Mexico State University Agricultural Experiment Station Bulletin 798. 76 p., [http://aces.nmsu.edu/pubs/research/weather\\_climate/](http://aces.nmsu.edu/pubs/research/weather_climate/)
  39. Kambhammettu, B.V.N.P., J.P. King and A. Praveena. 2011. Evaluation of mountain-front recharge estimation techniques for Southern New Mexico basins. *International Journal of Water Resources and Environmental Engineering*, 3(3): 66-72.
  40. Sandor, J., Minnis, P, and Hawley, J., 2010, On Mimbres farms and terraces: 16th Biennial Mogollon Archaeology Conference, October 14-16, 2010; Department of Anthropology, New Mexico State University-Las Cruces; Abstracts, p. 19-20.
  41. Schmid, W., J.P. King, and T. Maddock III. 2010 Conjunctive Surface-Water / Groundwater Model in the Southern Rincon Valley Using Modflow-2005 with the Farm Process. NM Water Resources Research Institute, NM State University, Technical Completion Report No. 351. 65 pp.
  42. Servicio Geologico Mexicano, Coordinacion General de Minería, and International Boundary and Water Commission, 2011. Hydrogeological Activities in the Conejos-Medanos/Mesilla Basin Aquifer, Chihuahua, Phase 1. Prepared for the Transboundary Aquifer Assessment Act Project under contract with the New Mexico Water Resources Research Institute and Texas Water Research Institute. Two volumes.
  43. Kambhammettu, B.V.N.P., W. Schmid, J.P. King, and B.J. Creel. 2011. Effect of Elevation Resolution on Evapotranspiration Simulations using MODFLOW. *Ground Water*.
  44. Granados-Olivas, A., Creel, B., Sánchez-Flores, E., Chávez, J., and Hawley, J.W., 2012, Thirty years of groundwater evolution: Challenges and opportunities for binational planning and sustainable management of the Paso del Norte watersheds, in Lee, E., and Ganster, P., *The U.S.-Mexican border environment: Progress and challenges for sustainability: Southwest Consortium for Environmental Research and Policy, SCERP Monograph Series, no. 16, p. 201-217.*

## Problem and Research Objectives

The New Mexico Water Resources Research Institute has become the focal point for geographic information system (GIS) data and information concerning water resources in New Mexico. It combines database management with digital mapping into spatial-tabular data models. These models are powerful tools for representing and manipulating earth science information.

As use of geographic information systems has grown and presented new opportunities, it also has raised a number of new issues and problems. Of increasing concern is the management of a growing collection of spatial data sets and applications programs. These data sets and programs are very expensive to produce but relatively easy to share, so there is a great incentive to avoid duplicating production efforts. The trend clearly is toward managing these elements in distributed spatial libraries.

The primary objective of the project is to increase availability and accessibility of water resource information to support water resource planning and management in the state. The first task provides spatial data library accessibility. This task maintains arrangements and establishes those necessary to provide access to spatial data maintained by other agencies and organizations. The second task, spatial data development, evaluates needs, establishes priorities, and undertakes development of spatial data that is otherwise unavailable. These efforts will be coordinated with cooperating agencies and organizations to ensure no duplication of effort and to establish guidelines for coverages and priorities. The principal investigators maintain, update as necessary, and make the data available to cooperating agencies and organizations through both formal and informal arrangements to facilitate water resource planning activities.

## Methodology

A number of cooperative data sharing agreements have been entered into with state, federal, and local agencies and organizations to facilitate access and to develop spatial data. Others will be pursued as necessary. Research funded by the NMWRRI in many cases results in the development of data that can be represented in a spatial form and thus can contribute to the state data pool. Projects that have such a potential are adjusted as necessary to meet this secondary purpose.

The NMWRRI maintains a GIS laboratory consisting of computer workstations; data storage devices; input/output devices; software for mapping and analysis (ARC/Info); database development and visualization; and network systems. The laboratory is connected via fiber to the New Mexico State University computer network and thereby to the Internet. The NMWRRI also maintains an Internet web server site through which both spatial and tabular water resource data can be provided.

## Principal Findings

Various research activities are supported by the system for water resources planning in the state. The New Mexico Interstate Stream Commission provides grants to regional groups to support water resources planning. NMWRRI has assisted the NM Interstate Stream Commission and many regional groups with GIS mapping products for use in their plans and in public outreach efforts.

Additionally, support has been given to the New Mexico/Texas Water Commission and various public entities of southern New Mexico for their planning activities. GIS mapping support is also provided to the Lower Rio Grande Water Users Organization. This sophisticated mapping and geo-spatial database management system, originally designed to support NMWRRI-funded research activities, is now being used for external research grants (e.g., Creation of a Digital Hydrogeologic Framework Model of the

Mesilla Basin and Southern Jornada del Muerto Basin; creation of maps for the purpose of water planning funded by the New Mexico Interstate Stream Commission; and pesticide management planning in the state funded by the New Mexico Department of Agriculture) by water resources management and planning agencies in the state. A research grant resulted in the creation of a regional geographic information system to support water planning in the Paso del Norte borderland area of the southwestern United States. A current grant provides funding to maintain and update the Paso del Norte website and web mapping application.

During the reporting period, projects funded through the GIS lab were sponsored by the USGS, the Southwest Consortium for Environmental Research & Policy, the National Park Service, and the Texas A&M University AgriLife Research and Extension Center.

This is an ongoing project with new data continually being added to the database and assistance being given to produce specific GIS products upon request. Continued funding is anticipated from annual state appropriations as well as pending agency awards.

# Information Transfer Program

## Basic Information

<b>Title:</b>	Information Transfer Program
<b>Project Number:</b>	2002NM3B
<b>Start Date:</b>	3/1/2011
<b>End Date:</b>	2/28/2012
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	Second
<b>Research Category:</b>	Not Applicable
<b>Focus Category:</b>	Education, None, None
<b>Descriptors:</b>	
<b>Principal Investigators:</b>	Cathy T. Ortega Klett

## Publications

1. Smith, G.B. and K.H. Oshima, 2004, Development of a Laser-Based Detection System for Water-Borne Pathogens. New Mexico Water Resources Research Institute, Technical Completion Report No. 331, New Mexico State University, Las Cruces, New Mexico, 10 pp.
2. Hawley, J.W. and J.F. Kennedy, 2004, Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada del Muerto Basin. New Mexico Water Resources Research Institute, Technical Completion Report No. 332, New Mexico State University, Las Cruces, New Mexico, 105 pp.
3. Boren, J., T. Baker, D. Cowley, G. Mason, S. Eaton, and B. Hurd, 2005, Terrestrial Vegetation Inventory of Water Delivery Systems Between San Acacia Diversion and the Bosque del Apache National Wildlife Refuge. New Mexico Water Resources Research Institute, Technical Completion Report No. 333, New Mexico State University, Las Cruces, New Mexico, 6 pp.
4. Ortega Klett, C.T., 2004, Proceedings of the 48th Annual New Mexico Water Conference, New Mexico Water Planning 2003. New Mexico Water Resources Research Institute, Technical Completion Report No. 329, New Mexico State University, Las Cruces, New Mexico, 149 pp.
5. Cowley, D.E., J. Alleman, R.R. McShane, and P.D. Shirey, and R. Sallenave. 2005. Effects of Salinity and Suspended Sediment on Physical Properties of the Egg of the Rio Grande Silvery Minnow (*Hybognathus amarus*). New Mexico Water Resources Research Institute, Technical Completion Report No. 334, New Mexico State University, Las Cruces, New Mexico.
6. Ortega Klett, C.T., 2005, Proceedings of the 49th Annual New Mexico Water Conference, Water Desalination and Reuse Strategies for New Mexico. New Mexico Water Resources Research Institute, Technical Completion Report No. 336, New Mexico State University, Las Cruces, New Mexico.
7. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen, R. Srinivasan, and A. Granados. 2006. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed. New Mexico Water Resources Research Institute, Technical Completion Report No. 337, New Mexico State University, Las Cruces, New Mexico.
8. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy, and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of saved-water and the costs of alternative methods of reducing carriage losses from district canals. New Mexico Water Resources Research Institute, Technical Completion Report No. 335, with plates and appendices on CD ROM, New Mexico State University, Las Cruces, New Mexico.

## Information Transfer Program

9. Bawazir, A.S., J.P. King, S. Kidambi, B. Tanzy, F. Nibling, N.H. Troxel Stowe, and M.J. Fahl. 2006. A Joint Investigation of Evapotranspiration Depletion of Treated and Non-Treated Saltcedar at the Elephant Butte Delta, New Mexico. New Mexico Water Resources Research Institute, Technical Completion Report No. 328, New Mexico State University, Las Cruces, New Mexico.
10. Ortega Klett, C.T. 2006. Proceedings of the 50th Annual New Mexico Water Conference, New Mexico Water: Past, Present, and Future or Guns, Lawyers, and Money. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 339, New Mexico State University, Las Cruces, New Mexico.
11. Ortega Klett, C.T. 2006. Proceedings of the 51st Annual New Mexico Water Conference, Water Quality for the 21st Century. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 340, New Mexico State University, Las Cruces, New Mexico.
12. Deng, S. 2008. Solar Desalination of Brackish Water using Membrane Distillation Process. New Mexico Water Resources Research Institute, Technical Completion Report No. 342, New Mexico State University, Las Cruces, New Mexico. 31 pp.
13. Brown, C., Z. Sheng, and M. Bourdon. 2007. Phase II Final Project Report Paso del Norte Watershed Council Coordinated Water Resources Database and GIS Project. New Mexico Water Resources Research Institute, Technical Completion Report No. 341, New Mexico State University, Las Cruces, New Mexico (co-published as Texas Water Resources Institute Technical Report No. 307). 85 pp.
14. Huang, F. and S. Rogelj. 2007. Mitigation of Membrane Biogouling by Harnessing Bacterial Cannibalism. New Mexico Water Resources Research Institute, Technical Completion Report No. 338, New Mexico State University, Las Cruces, New Mexico. 14 pp.
15. Ortega Klett, C.T. 2008. Proceedings of the 52nd Annual New Mexico Water Conference, Beyond the Year of Water: Living within Our Water Limitations. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 343, New Mexico State University, Las Cruces, New Mexico. 158 pp.
16. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen, R. Srinivasan, and A. Granados. 2006. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed. New Mexico Water Resources Research Institute, Technical Completion Report No. 337, New Mexico State University, Las Cruces, New Mexico.
17. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy, and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of saved-water and the costs of alternative methods of reducing carriage losses from district canals. New Mexico Water Resources Research Institute, Technical Completion Report No. 335, with plates and appendices on CD ROM, New Mexico State University, Las Cruces, New Mexico.
18. Bawazir, A.S., J.P. King, S. Kidambi, B. Tanzy, F. Nibling, N.H. Troxel Stowe, and M.J. Fahl. 2006. A Joint Investigation of Evapotranspiration Depletion of Treated and Non-Treated Saltcedar at the Elephant Butte Delta, New Mexico. New Mexico Water Resources Research Institute, Technical Completion Report No. 328, New Mexico State University, Las Cruces, New Mexico.
19. Ortega Klett, C.T. 2006. Proceedings of the 50th Annual New Mexico Water Conference, New Mexico Water: Past, Present, and Future or Guns, Lawyers, and Money. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 339, New Mexico State University, Las Cruces, New Mexico.
20. Ortega Klett, C.T. 2006. Proceedings of the 51st Annual New Mexico Water Conference, Water Quality for the 21st Century. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 340, New Mexico State University, Las Cruces, New Mexico.
21. Sheng, Z., C. Brown, B. Creel, R. Srinivasan, A. Michelsen, and M.P. Fahy. 2008. Installation of River and Drain Instrumentation Stations to Monitor Flow and Water Quality and Internet Data Sharing. New Mexico Water Resources Research Institute, Technical Completion Report No. 344, New Mexico State University, Las Cruces, New Mexico. 47 pp. (co-published as Texas Water Resources Institute Technical Report No. 320)

## Information Transfer Program

22. Aragón, C.A. and E.R. Vivoni. 2008. Development and Testing of a Semi-Distributed Watershed Model: Case Studies Exploring the Impact of Climate Variability and Change in the Rio Salado. New Mexico Water Resources Research Institute, Technical Completion Report No. 345, New Mexico State University, Las Cruces, New Mexico. 155 pp.
23. Aldrich, G.A., J. Chermak, and J.A. Thacher. 2008. Water Quality and Land Use: Implications for Regulation and Urban Planning. New Mexico Water Resources Research Institute, Technical Completion Report No. 346, New Mexico State University, Las Cruces, New Mexico. 70 pp.
24. Ortega Klett, C.T. 2009. Proceedings of the 53rd Annual New Mexico Water Conference, Surface Water Opportunities in New Mexico. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 347, New Mexico State University, Las Cruces, New Mexico. 134 pp.
25. Lucas, R.W., T.T. Baker, M.K. Wood, C.D. Allison, and D.M. VanLeeuwen. 2008. Response of Streambanks to Different Intensities and Seasons of Cattle Grazing in Two Montane Riparian Areas in Western New Mexico. New Mexico Water Resources Research Institute, Miscellaneous Report No. 29, New Mexico State University, Las Cruces, New Mexico. 28 pp.
26. Wood, Karl, 2008, El Agua es Vida or Water is Life, Society of Range Management, 30(5), 6-10.
27. Shukla, M.K., J.G. Mexal, G.A. Picchioni, T. Sammis, D. Daniel, P. Adhikari, and M. Babcock. 2010. Land Application of Industrial Effluent on a Chihuahuan Desert Ecosystem: Impact on Soil Physical and Hydraulic Properties. New Mexico Water Resources Research Institute, Technical Completion Report No. 351, NMSU, Las Cruces, New Mexico. 75 pp.
28. Schmid, W., J.P. King, and T. Maddock, III. 2009. Conjunctive Surface-Water/Groundwater Model in the Southern Rincon Valley Using Modflow-2005 with the Farm Process. New Mexico Water Resources Research Institute, Technical Completion Report No. 350, NMSU, Las Cruces, New Mexico. 65 pp.
29. Hawley, J.W., J.F. Kennedy, A. Granados-Olivas, M.A. Ortiz. 2009. Hydrogeologic Framework of the Binational Western Hueco Bolson-Paso del Norte Area, Texas, New Mexico, and Chihuahua: Overview and Progress Report on Digital-Model Development. New Mexico Water Resources Research Institute, Technical Completion Report No. 351, NMSU, Las Cruces, New Mexico. 55 pp. with map and 11 plates.
30. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen and R. Srinivasan, and A. Granados. 2009. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed (Phase III) Part I Lower Rio Grande Flood Control Model [LRGFCM] RiverWare Model Development. New Mexico Water Resources Research Institute, Technical Completion Report No. 348 Part I, NMSU, Las Cruces, NM. 48 pp. (co-published as Texas Water Resources Institute Technical Report No. 359, Part I)
31. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen and R. Srinivasan, and A. Granados. 2009. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed (Phase III) Part II Availability of Flow and Water Quality Data for the Rio Grande Project Area. New Mexico Water Resources Research Institute, Technical Completion Report No. 348 Part II, NMSU, Las Cruces, NM. 24 pp. (co-published as Texas Water Resources Institute Technical Report No. 359, Part II)
32. Granados-Olivas, A. 2009. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed (Phase III) Part III GIS Coverage for the Valle de Juárez Irrigation District 009 (ID-009) (Distrito de Riego 009) Chihuahua, México. New Mexico Water Resources Research Institute, Technical Completion Report No. 348 Part III, NMSU, Las Cruces, NM. 31 pp. (co-published as Texas Water Resources Institute Technical Report No. 359, Part III)
33. Piñón-Villarreal, A.R. Z.A. Samani, A.S. Bawazir, M.P. Bleiweiss, R. Skaggs, and T. Vien. 2010. Estimating Water Use Through Satellite Remote Sensing. New Mexico Water Resources Research Institute, Technical Completion Report No. 357, NMSU, Las Cruces, New Mexico. 72 pp.
34. DeMouche, L., S. Landfair, and F.A. Ward. 2010. Analysis of Water Rights Prices in New Mexico's Lower Rio Grande Basin. New Mexico Water Resources Research Institute, Technical Completion Report No. 356, New Mexico State University, Las Cruces, New Mexico. 23 pp.

## Information Transfer Program

35. Khandan, N.N. and V.G. Gude. 2010. Sustainable Recovery of Potable Water from Saline Waters. New Mexico Water Resources Research Institute, Technical Completion Report No. 355, NMSU, Las Cruces, New Mexico. 20 pp.
36. Hawley, J.W., B.V.N.P. Kambhammettu, and B.J. Creel. 2010. Digital Hydrogeologic-Framework Model of the San Francisco River Basin, West-Central New Mexico and East-Central Arizona. New Mexico Water Resources Research Institute, Technical Completion Report No. 354, NMSU, Las Cruces, New Mexico. 52 pp.
37. Kambhammettu, B.V.N.P., A. Praveen, and J.P. King. 2010. Simulation of Groundwater Flow in the Southern Jornada Del Muerto Basin, Dona Ana County, New Mexico. New Mexico Water Resources Research Institute, Technical Completion Report No. 352, New Mexico State University, Las Cruces, New Mexico. 63 pp.
38. Wood, M.K., and J. Mosely. 2010. Hydrologic and Vegetal Responses to Prescribed Burning and Herbicidal Treatment of Broom Snakeweed on Blue Grama Rangeland in New Mexico. New Mexico Resources Research Institute, Miscellaneous Report No. M31, NMSU, Las Cruces, New Mexico. 20 pp.
39. Wood, M.K., and B. Racher. 2010. Recovery of Habitat for Gila Trout and Livestock Grazing Following Wildfire in Main Diamond Creek in the Black Range of Southwestern New Mexico. New Mexico Resources Research Institute, Miscellaneous Report No. M30, NMSU, Las Cruces, New Mexico. 20 pp.
40. Kambhammettu, B.V.N.P. 2010. Effect of Elevation Resolution on Evapotranspiration Simulations Using MODFLOW. Doctoral dissertation, Department of Civil Engineering, NMSU, Las Cruces, NM. 154 pp.
41. Tillery, S., Z. Sheng, J.P. King, B. Creel, C. Brown, A. Michelsen, R. Srinivasan, and A. Granados. 2006. The Development of a Coordinated Database for Water Resources and Flow Model in the Paso del Norte Watershed. New Mexico Water Resources Research Institute, Technical Completion Report No. 337, New Mexico State University, Las Cruces, New Mexico.
42. King, J.P., J.W. Hawley, J.W. Hernandez, J.F. Kennedy, and E.L. Martinez. 2006. Study of Potential Water Salvage on the Tucumcari Project Arch Hurley Conservancy District: Phase I. A pre-appraisal-level study of the potential amount of saved-water and the costs of alternative methods of reducing carriage losses from district canals. New Mexico Water Resources Research Institute, Technical Completion Report No. 335, with plates and appendices on CD ROM, New Mexico State University, Las Cruces, New Mexico.
43. Bawazir, A.S., J.P. King, S. Kidambi, B. Tanzy, F. Nibling, N.H. Troxel Stowe, and M.J. Fahl. 2006. A Joint Investigation of Evapotranspiration Depletion of Treated and Non-Treated Saltcedar at the Elephant Butte Delta, New Mexico. New Mexico Water Resources Research Institute, Technical Completion Report No. 328, New Mexico State University, Las Cruces, New Mexico.
44. Ortega Klett, C.T. 2006. Proceedings of the 50th Annual New Mexico Water Conference, New Mexico Water: Past, Present, and Future or Guns, Lawyers, and Money. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 339, New Mexico State University, Las Cruces, New Mexico.
45. Ortega Klett, C.T. 2006. Proceedings of the 51st Annual New Mexico Water Conference, Water Quality for the 21st Century. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 340, New Mexico State University, Las Cruces, New Mexico.
46. Leinauer, B., E. Sevostianova, and C. Johnson. 2012. Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation. New Mexico Water Resources Research Institute, Technical Completion Report No. 358, New Mexico State University, Las Cruces, New Mexico. 66 pp.
47. Ortega Klett, C.T. 2011. Proceedings of the 56th Annual New Mexico Water Conference, New Water New Energy: A Conference Linking Desalination and Renewable Energy. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 360, New Mexico State University, Las Cruces, New Mexico. In press.

## Information Transfer Program

48. Ortega Klett, C.T. (ed). 2012. One Hundred Years of Water Wars: 1912 - 2012. Sunstone Press, Santa Fe, New Mexico. In press.
49. Granados-Olivas, A., B. Creel, E. Sánchez-Flores, J. Chávez, and J.W. Hawley. 2012. Thirty years of groundwater evolution: Challenges and opportunities for binational planning and sustainable management of the Paso del Norte watersheds, in Lee, E., and Ganster, P., The U.S.-Mexican border environment: Progress and challenges for sustainability: Southwest Consortium for Environmental Research and Policy, SCERP Monograph Series, no. 16, p. 201-217.
50. Kambhammettu, B.V.N.P., W. Schmid, J.P. King, and B.J. Creel. 2011. Effect of Elevation Resolution of Evapotranspiration Simulations using MODFLOW. Ground Water. NGWA.org. 9 pp.

## Statement of Critical Water Problem

The New Mexico Water Resources Research Institute's Information Transfer Program is designed to bring the results of its research projects to the public and to educate New Mexicans on the critical water issues of the state, region, and nation. Different sectors of the public are targeted for each of its activities.

## Statement of Results and Benefits

The program goal is to provide people with water information appropriate to their level of training and interest. Information transfer activities are funded primarily from non-federal sources. Responsibilities for different segments of the program have been assigned to various professional and support staff at the institute.

## Nature, Scope, and Objectives

The primary methods for information transfer are conferences, publications, audio/visual presentations, and information posted on the institute's website. For the past 56 years, the NMWRRI has sponsored the Annual New Mexico Water Conference focusing on a topic of importance to the New Mexico water community, usually policy oriented. The annual conference is held in different locations around the state in the fall. Most of the conference participants are water resources practitioners working for state, federal, or local agencies, although some members of the general public and of academia also attend. Average attendance ranges between 150 and 200 people, depending on the location and topic of the conference. A few years ago, the New Mexico State Engineer called the NMWRRI annual conference the premier water meeting in the state. The NMWRRI began hosting a technical research symposium in 2002 and the annual event has become the focal meeting for researchers from around the state and region to share their water-related research and demonstration projects. Many students attend the symposium and present posters and oral presentations.

Publications include technical completion reports resulting from NMWRRI-sponsored projects, special in-house publications, and conference proceedings. The institute has published more than 386 technical and miscellaneous reports. The peer reviewed technical completion reports are directed toward water professionals working in disciplines related to the research projects. All technical reports are now available via the NMWRRI website in full text. Those interested in a particular report are able to print off the Internet instead of ordering a hard copy of the report. NMWRRI water conference proceedings for the past 56 years are also available online in full text.

A quarterly newsletter, *The Divining Rod*, focuses on research and current water issues. It is emailed to approximately 1,600 readers and hard copies are sent to about 200 readers. The newsletter is available on the NMWRRI homepage.

A reference room, housed at the institute, contains over 11,000 documents and is used by faculty, students, and the general public. A complete catalog of holdings can be searched through the

NMWRRI homepage on the Internet, along with an extensive water resources and information system database.

NMWRRI's homepage (<http://wrrri.nmsu.edu>) provides online information about the institute's newsletters, technical report series, requests for proposals, upcoming programs, and the research reference library. All NMWRRI reports are available for viewing online via the institute's website. The website, created in 1995, is updated on a regular basis and continues to be a focal point of information on New Mexico's water resources with many links to other related sites such as the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, USGS, Bureau of Reclamation and National Weather Service. In recent years, the NMWRRI website received an average of over 6,000 inquiries per month.

NMWRRI has developed a state-of-the-art geographic information system on water resources in New Mexico and has become the focal point for GIS data and information concerning water resources in the state. It combines database management with digital mapping into spatial-tabular data models. These models are powerful tools for representing and manipulating earth-science information. The primary objective of the system is to increase availability and accessibility of water resource information to support water resource planning and management in the state. Efforts are coordinated with cooperating agencies and organizations to ensure no duplication of effort and to establish guidelines for map coverages and priorities. The staff maintains, updates as necessary, and makes the data available to cooperating agencies and organizations through both formal and informal arrangements to facilitate water resource planning activities.

The institute director is invited frequently to speak at local, regional, and national conferences and workshops in addition to serving on a number of committees that focus on water resources.

#### Accomplishments

The 56<sup>th</sup> Annual New Mexico Water Conference was held in Alamogordo, New Mexico and was co-hosted by the Bureau of Reclamation. The conference theme was, "New Water New Energy: A Conference Linking Desalination and Renewable Energy" and was attended by about 150 participants. The conference included tours of the Brackish Groundwater National Desalination Research Facility. In attendance were international experts on desalination and renewable energy representing Europe, Australia, the Middle East, Northern Africa, Canada, and Singapore. A full proceedings of the conference is in production and will be available on the Reclamation's and NMWRRI's websites. All conference participants will receive a copy on CD.

This year, the annual technical symposium was combined with the annual water conference. The conference provided a unique opportunity for researchers and students to learn about desalination and renewable energy from some of the world's leading experts in the area. Researchers were given the opportunity to present oral and poster presentations at the meeting. The symposium continued to receive sponsorship from Sandia National Laboratories, Los Alamos National Laboratory, New Mexico's three state universities, the Office of the State Engineer, New Mexico Interstate Stream Commission, and the AWRA-New Mexico section. A total of 14 oral presentations were given and 14 posters displayed. Ten students presented oral or poster presentations and 22 students attended the conference.

The institute's publications for the period included one technical report: "Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation" by NMSU researchers. The 56<sup>th</sup> Annual New Mexico Water Conference proceedings is being produced in hardcopy and on CD. NMWRRI technical completion reports are available at no charge while supplies last. A copy charge is assessed if the report is out of print or has been reprinted.

The institute's website averages over 10,500 unique online visits each month. It averages nearly 4,300 online unique visits for publications from its technical and miscellaneous report series and an average of about 10,868 unique visits and pdf downloads per month of its proceedings series. Because of the ability to view and print all institute publications online, the WRRI is averaging only a few requests for hard copies of specific publications each month via postal mail or visits to the institute. Requests online have continued to increase each year.

The institute's quarterly newsletter, *The Divining Rod*, is an eight- to sixteen-page newsletter that focuses on research projects administered by the NMWRRI and on current water issues in New Mexico. It provides information on upcoming conferences, seminars, and workshops; describes new grants and newly released publications; and provides general information on new developments in water resources research and management. Each issue is available on the NMWRRI's homepage. Hard copies of the newsletter are distributed to approximately 200 readers and about 1,600 readers receive it via email with a pdf of the newsletter attached. To become more cost-effective and to save resources, the institute is now distributing the newsletter primarily via email. During the reporting period, the institute published three newsletters, one 12-page issue and two 8-page issues of *The Divining Rod*. The newsletter received an average of 450 downloads per month online during the past year. Online unique visits per month of the WRRI's reference room averaged about 160 for the reporting period.

The institute's director participates in local, state, and national conferences and workshops and speaks before many groups. The institute's director is an active member of the National Institutes for Water Resources and the Universities Council on Water Resources and has helped in the planning of their 2012 national meeting to be held in Santa Fe, New Mexico. The NMWRRI staff also regularly provides expertise for solving specific problems and general concerns. They play a central role in planning for the water future of the region by cooperating with a host of water resources entities throughout the state and region, particularly in the Paso del Norte area.

The Information Transfer Program is an ongoing program with no particular timelines.

# USGS Summer Intern Program

None.

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 NCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	3	0	0	5	8
<b>Masters</b>	1	0	0	3	4
<b>Ph.D.</b>	1	0	0	2	3
<b>Post-Doc.</b>	0	0	0	0	0
<b>Total</b>	5	0	0	10	15

## Notable Awards and Achievements

NMWRRI nominated New Mexico State University researcher, Dr. Bernd Leinauer for this year's NIWR Impact Awards. Dr. Leinauer received a 42-month USGS 104B award (2005-2009) for his project entitled, "Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation." Dr. Leinauer is widely considered an expert in urban water conservation and has given numerous talks and presentations nationally and internationally on the subject of turfgrass and landscape water conservation and on the impact of salinity on plant performance. He has published over 50 articles and has co-authored a book and a book chapter on efficient irrigation and turfgrass water conservation. Professor Leinauer has mentored many students and has co-authored papers with his students on subject matters such as germination, seed emergence, and plant establishment in saline soils.

Dr. Nirmala Khandan, professor of civil engineering at New Mexico State University, and his Ph.D. student and subsequent post-doc, Gude Veera Ganeswar have published twelve articles in peer-reviewed scientific journals as a result of their USGS 104B project entitled, "Sustainable Recovery of Potable Water from Saline Waters." Khandan and Ganeswar also have a U.S. Patent pending related to the seed grant project. Professor Khandan was named the first holder of the Ed and Harold Foreman Endowed Chair in Civil Engineering at NMSU in 2010. Gude Veera Ganeswar is now an assistant professor of civil and environmental engineering at Mississippi State University.

New Mexico Tech Professor John Wilson is currently the PI on a 104B seed grant, "Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance in Contaminant Transport, and Chemical Reactions." Recently he was awarded an NSF grant to continue the modeling work accomplished as part of this NMWRRI grant, and attempt to observe hyporheic flow at the margin of karst conduits. NSF Award Number 1141768 has a start date of March 1, 2012 and the total award was for \$261,540. Also, a graduate student supported on the NMWRRI grant has been awarded an EPA STAR Fellowship. Her application included modeling results produced during a NMWRRI Student Research Award Modeling of Karst Conduit Floods. The total award value, which includes stipend, tuition, and travel is \$119,007. Another graduate student participating on the project received a Cave Conservation Fellowship. His application includes modeling results produced during the NMWRRI grant. The total award value, which will be used for field travel and supplies is \$15,000. And finally, a student working on the project received a CUAHSI \$5,000 travel grant fellowship.

New Mexico State University College of Agricultural, Consumer, and Environmental Sciences Deans Award for Research Excellence, 2010, was awarded to Gregory Torell, a master's degree student working on the supplemental award entitled "Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan." Principal investigator, Professor Frank Ward, taught a related course in Valencia, Spain in May-June 2010 entitled, "Water Policy Analysis through Hydroeconomic Models."

New material from the Transboundary Aquifer Assessment Program (TAAP), a special USGS award, will be added to two existing courses at New Mexico State University, Department of Civil Engineering: CE 452, Geohydrology (undergraduate) and CE 581, Groundwater Hydrology and Modeling. The TAAP was the subject of a special session at the American Water Resources Association Annual Conference in Albuquerque on November 8, 2011. Speakers included Dr. Phil King of NMSU and Mr. Michael Darr of the USGS. The session was moderated by Dr. Ari Mickelson of TAMU Agrilife Center, El Paso.

## Publications from Prior Years

1. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Tang, Q., E.R. Vivoni, F. Muñoz-Arriola, and D.P. Lettenmaier. 2012. Predictability of Evapotranspiration Patterns Using Remotely Sensed Vegetation Dynamics during the North American Monsoon. *Journal of Hydrometeorology*. 13:1:103-121.
2. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Forzieri, G., F. Castelli, and E.R. Vivoni. 2011. Vegetation Dynamics within the North American Monsoon Region. *Journal of Climate*. 24:6:1763-1783.
3. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Liuzzo, L., L.V. Noto, E.R. Vivoni, and G. La Loggia. 2010. Basin-Scale Water Resources Assessment in Oklahoma under Synthetic Climate Change Scenarios Using a Fully Distributed Hydrologic Model. *Journal of Hydrologic Engineering*. 15:2:16 pp.
4. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Forzieri, G., G. Moser, E.R. Vivoni, F. Castelli, F. Canovaro. 2010. Riparian Vegetation Mapping for Hydraulic Roughness Estimation Using Very High Resolution Remote Sensing Data Fusion. *J. Hydraul. Eng.* 136:855.
5. 2006NM38B ("A Physically-based Parsimonious Approach for Spatial Disaggregation and Recovery of NEXRAD Precipitation Data in Mountainous Terrains (Wilson)") - Articles in Refereed Scientific Journals - Frisbee, M.D., F.M. Phillips, G.S. Weissmann, P.D. Brooks, J.L. Wilson; A.R. Campbell, F. Liu. 2012. Unraveling the mysteries of the large watershed black box: Implications for the streamflow response to climate and landscape perturbations. *Geophys. Res. Lett.* 39:1.
6. 2008NM89B ("Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation (Leinauer)") - Articles in Refereed Scientific Journals - Rimi, F., S. Macolino, B. Leinauer. 2012. Winter-applied Glyphosate Effects on Spring Green-up of Zoysiagrasses and 'Yukon' Bermudagrass in a Transition Zone. *HortTechnology*. 22:1:131.
7. 2008NM89B ("Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation (Leinauer)") - Articles in Refereed Scientific Journals - Serena, M., B. Leinauer, R. Sallenave, M. Schiavon, and B. Maier. 2012. Media Selection and Seed Coating Influence Germination of Turfgrasses under Salinity. *HortScience*. 47:1:116.
8. 2008NM89B ("Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation (Leinauer)") - Articles in Refereed Scientific Journals - Rimi, F., S. Macolino, B. Leinauer, U. Ziliotto. 2011. Green-up of Seeded Bermudagrass Cultivars as Influenced by Spring Scalping. *HortTechnology*. 21:2:230.
9. 2008NM89B ("Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation (Leinauer)") - Articles in Refereed Scientific Journals - Macolino, S. M. Serena, B. Leinauer, and U. Ziliotto. 2010. Preliminary Findings on the Correlation between Water-soluble Carbohydrate Content in Stolons and First Year Green-up of Seeded Bermudagrass Cultivars. *HortTechnology*. 20:4:758.
10. 2008NM90B ("Estimating Water Use through Satellite Remote Sensing (Bleiweiss)") - Articles in Refereed Scientific Journals - Bawazir, A.S., M. Bleiweiss, Z. Samani, and R. Skaggs. 2011. The convergence of water rights, structural change, technology, and hydrology: A case study of New Mexico's Lower Rio Grande. *Natural Resources Journal*. 51:1:95-117.
11. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gneswar, G.V., N. Nirmalakhanda, S. Deng, and others. 2012. Feasibility study of a new two-stage low temperature desalination process. *Energy Conversion and Management*. 56:192-198.

12. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, S. Deng, and others. 2012. Low temperature desalination using solar collectors augmented by thermal energy storage. *Applied Energy*. 91:1:466-474.
13. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, S. Deng, and others. 2012. Desalination at low temperatures: an energy analysis. *Desalination and Water Treatment*. 40:1-3:272-281.
14. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, and S. Deng. 2011. Integrated PV-thermal system for desalination and power production. *Desalination and Water Treatment*. 36:1-3:129-140.
15. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, and S. Deng. 2011. Sustainable low temperature desalination: A case for renewable energy. *Journal of Renewable and Sustainable Energy*. 3:4:Article Number 043108.
16. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, and S. Deng. 2011. Desalination using solar energy: Towards sustainability. *Energy*. 36:1:78-85.
17. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, and S. Deng. 2010. Renewable and sustainable approaches for desalination. *Renewable & Sustainable Energy Reviews*. 14:9:2641-2654.
18. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V. and N. Nirmalakhandan. 2010. Sustainable desalination using solar energy. *Energy Conversion and Management*. 51:11:2245-2251.
19. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V., N. Nirmalakhandan, and S. Deng. 2010. Low temperature process to recover impaired waters. *Desalination and Water Treatment*. 20:1-3:281-290.
20. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V. and N. Nirmalakhandan. 2009. Desalination at low temperatures and low pressures. *Desalination*. 244:1-3:239-247.
21. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V. and N. Nirmalakhandan. 2008. Combined desalination and solar-assisted air-conditioning system. *Energy Conversion & Management*. 49:11:Special Issue:3326-3330.
22. 2006NM51B ("Sustainable Recovery of Potable Water from Saline Waters (Khandan)") - Articles in Refereed Scientific Journals - Gnanaswar, G.V. and N. Nirmalakhandan. 2008. Desalination using low-grade heat sources. *Journal of Energy Engineering-ASCE*. 134:3:95-101.