# Water Resources Research Institute
# Annual Technical Report
# FY 2007

# Introduction

This program report provides the required information for projects funded with the 2007 base grant and mandatory non−federal matching funds. Please note that there may be some overlap in information with our 2006 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) provides on−line 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. Although most of New Mexico remained in the drought free category based on above−average precipitation for the 2007 summer and the 2007−2008 winter season, the Four Corners area and northeastern New Mexico experienced mild to moderate drought stages through December 2007. Above average precipitation in the Four Corners area alleviated drought conditions at the beginning of 2008, while below average precipitation conditions in the southeastern part of the state resulted in the expansion of advisory drought conditions. Reservoir levels range from a low of 1% capacity at Brantley reservoir in eastern New Mexico to 86% capacity at Navajo reservoir in the northwest. Storage at New Mexico's largest reservoir, Elephant Butte, is at 21% capacity, a slight decrease from last year. 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 Drought Task Force, established in April 2002 by New Mexico's governor after declaring a state of emergency because of the drought, continues to monitor the situation.

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.

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, four projects received joint funding from state appropriations and the 2007 Annual Base Program. These projects include two that fit into the water conservation, planning and management category: “Development of Geospatial Modeling Tools for Watershed−based Water Resources Management in New Mexico” and “Geographic Information System for Water Resources Planning.” One project was funded in the atmospheric, surface and groundwater relationships category: “A Physically Based Parsimonious Approach for Spatial Disaggregation and Recovery of NEXRAD Precipitation Data in Mountainous Terrains” and one project was funded in the utilization of saline and other impaired waters category: “Sustainable Recovery of Potable Water from Saline Waters.” The NMWRRI also received a USGS 104G award categorized in the atmospheric, surface and groundwater relationships category: “Validation, Calibration and Improvement of Remote Sensing ET Algorithms in Mountainous Regions.”

During the reporting period, the NMWRRI administered a total of 44 projects dealing primarily with water quality and conservation issues. The total value of these projects was over $1.43 million, including required cost sharing. Awards were made by various federal and state agencies, a private foundation, and from the institute's annual state appropriations. Dollar amounts per project award ranged from $1,704 to nearly $171,000. During the reporting period, projects were conducted at New Mexico State University, New Mexico Tech, University of New Mexico, New Mexico Highlands University, and Eastern New Mexico University. Faculty members were principal investigators on 36 projects and NMWRRI staff managed 8 projects. The institute maintained frequent contact with its researchers through periodic progress updates, site visits, and expenditure tracking.

Research projects administered by the NMWRRI utilized at least 126 students during the year including undergraduates, masters, Ph.D. candidates, and Post−docs in the disciplines of agricultural economics, biology, chemical engineering, chemistry, civil engineering, computer science, earth and environmental science, economics, engineering technology, environmental engineering, extension education, fishery and wildlife science, general studies, geography, geology, horticulture, hotel and restaurant management, hydrology, industrial engineering, mathematics, mechanical engineering, natural resource management, plant and environmental science, range science, soil science. A water resources summer training program provided a broad understanding of water resources to approximately 13 Native American high school students from across the nation.

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.

The Influence of Larval Culiseta sp. (Diptera: Culicidae) on Behavior and Growth Rate of Tadpole Shrimp Triops longicaudatus (LeConte) (Notostraca: Triopsidae). WRRI Student Research Grant 06 (Nicole M. Harings, Eastern New Mexico University) $1,704

Civil Engineering Graduate Student Support Grant. Hot Springs Falls Foundation. $4,311

The Influence of Predator Detection on Life History Strategies in DAPHNIA. WRRI Student Research Grant 06 (Irene M. Roselli, Eastern New Mexico University) $4,696

Iron(II) Oxidation in New Mexico Waters: Experimental Development of a Molecular−Level Predictive Model. WRRI Student Research Grant 07 (Andrea Higdon, New Mexico Tech) $4,866

Uranium and Heavy Metals in Macroinvertebrates in the Santa Fe River on the Cochiti Reservation. WRRI Student Research Grant 06 (Carlos R. Herrera, New Mexico Highlands University) $4,899

Bioassessment of Arsenic Contamination of the Gallinas River Using Benthic Macroinvertebrates. WRRI Student Research Grant 07 (Bildad Eta Eyong, New Mexico Highlands University) $4,992

Determination of Heavy Metal Distribution in the Gallinas River Using Aquatic Macrophytes. WRRI Student Research Grant 06 (Chemanji Shu−Nyamboli and Joel Lowry, New Mexico Highlands University) $4,996

Land Application of Wastewater Containing Arsenic: Impacts on the Sorption and Mobility of Arsenic in Soil. WRRI Student Research Grant 07 (Sylvia Nemmers, New Mexico State University) $2,325

New Mexico Water Rights Prices Database Development. WRRI Student Research Grant 07 (Shawn Landfair, New Mexico State University) $5,000

Investigating Potential Salt Contamination of Aquifers from Irrigated Landscapes. WRRI Student Research Grant 07 (Elena Sevostianova, New Mexico State University) $5,000

Estimating Evaporation from Elephant Butte Reservoir with the Monin Obukhov Simularity Theory Using Simple Instrumentation. WRRI Student Research Grant 07 (Jimmy Moreno, New Mexico State University) $5,000

Drinking Water Purification for U.S.A.−Mexico Border Region. WRRI Student Research Grant 07 (Arely Torres, New Mexico State University) $5,000

Carbon Nanotube−Based Biosensor for Pathogens Concentration and Detection. WRRI Student Research Grant 07 (Dipendu Saha, New Mexico State University) $5,000

Arsenic Adsorption and Desorption in Storrie Lake Sediments. WRRI Student Research Grant 07 (Celestine Ngam, New Mexico Highlands University) $5,000

Characterization of Heavy Metal Binding by Functional Groups Found in Biomaterials. WRRI Student Research Grant 06 (Jesus Q. Cantu, New Mexico State University) $5,000

The Effects of Acequias and Riparian Evapotranspiration on the Rio Grande Flow Levels. WRRI Student Research Grant 07 (Ciara Cusack, New Mexico State University) $5,000

Feasibility Study of Wastewater Purification by Low Temperature Distillation Method. WRRI Student Research Grant 07 (Veera Gnaneswar Gude, New Mexico State University) $5,000

Community and Ecosystem Effects of a Nonnative Fish in Refugia in an Intermittent Stream: Implications for Native Fish Restoration. WRRI Student Research Grant 06 (Ryan McShane, New Mexico State University) $5,000

Relating Fish Abundance and Condition to Environmental Factors in Desert Sinkholes. WRRI Student Research Grant 06 (Kristin Swaim, New Mexico State University) $5,000

The Effects of Eutrophication on the Structure and Function of Stream Biofilms. WRRI Student Research Grant 06 (David J. VanHorn, University of New Mexico) $5,000

Experimental and Numerical Modeling Analysis of Arsenic−sulfide Precipitation in Groundwater Environments. WRRI Student Research Grant 06 (Matthew F. Kirk, University of New Mexico) $5,000

Runoff Processes and the Evolution of Water Chemistry in the Saguache Creek Watershed of the Upper Rio Grande. WRRI Student Research Grant 06 (Marty D. Frisbee, New Mexico Tech) $5,000

Use of Remotely Sensed Observations for Improved Distributed Hydrological Modeling in the Jemez River Basin. WRRI Student Research Grant 06 (Taufique Mahmood, New Mexico Tech) $5,000

Multi−disciplinary Analysis of a New Mexico Cold Water Tufa Spring Mound. WRRI Student Research Grant 06 (Katrina Koski, New Mexico Tech) $5,000

Membrane Testing of Winter Return Flows – Canal Water Treatment Plant. AwwaRF. $17,055

Land Application of Industrial Effluent on a Chihuahuan Desert Ecosystem. Rio Grande Basin Initiative. $29,240

Rio Grande Basin Initiative – Interactive Mapping in New Mexico. Rio Grande Basin Initiative. $24,512

Water Information Websites for the New Mexico/Chihuahua Border Region – Phase 1. SCERP. $24,999

Sustainable Recovery of Potable Water from Saline Waters. New Mexico state appropriations $19,960; 104B program $10,000

A Physically Based Parsimonious Approach for Spatial Disaggregation and Recovery of NEXRAD Precipitation Data in Mountainous Terrains. New Mexico state appropriations $20,000; 104B program $10,000

Solar Desalination of Brackish Water Using Membrane Distillation Process. $30,000

New Mexico Pesticide Management Plan 2006−2007. Memorandum of Agreement with the New Mexico Department of Agriculture $30,000

Predicting Land Use Change and its Effect on Nonpoint Source Pollution. New Mexico state appropriations $30,000

State Science Forums for the Gila Basin Act. New Mexico Interstate Stream Commission $50,000

Development of Geospatial Modeling Tools for Watershed−based Water Resources Management in New Mexico. New Mexico state appropriations $49,789; 104B program $10,000

Geographic Information System for Water Resources Planning. 104B program $74,164

Validation, Calibration and Improvement of Remote Sensing ET Algorithms in Mountainous Regions. USGS 104G $74,795

Water Resources Training Program for Native American Students 2007. US Bureau of Indian Affairs $79,683

Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation. New Mexico state appropriations $60,000; 104B program $30,000

U.S.−Latin American Relations Program – Mapping Project. Hewlett Foundation $101,376

Grand Unified Groundwater Model Development for the Lower Rio Grande. Lower Rio Grande Water Users Association $108,545

Development of a RiverWare Model of the Rio Grande Flow and a Coordinated Database for Water Related Resources in the Rio Grande Watershed. Texas AMUniversity $110,070

U.S.−Latin American Relations Program. Hewlett Foundation $153,925

A Joint Investigation of Evapotranspiration Depletion of Treated and Non−Treated Saltcedar at the Caballo Dam, New Mexico. U.S. Bureau of Reclamation $170,608

# A Physically Based Parsimonious Approach for Spatial Disaggregation and Recovery of NEXRAD Precipitation Data in Mountainous Terrains (Wilson)

## Basic Information

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|---|---|
| **Title:** | A Physically Based Parsimonious Approach for Spatial Disaggregation and Recovery of NEXRAD Precipitation Data in Mountainous Terrains (Wilson) |
| **Project Number:** | 2006NM38B |
| **Start Date:** | 3/1/2006 |
| **End Date:** | 2/28/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | Three |
| **Research Category:** | Climate and Hydrologic Processes |
| **Focus Category:** | Climatological Processes, Hydrology, Models |
| **Descriptors:** | |
| **Principal Investigators:** | John L Wilson |

## Publication


1. Guan, H., J.L. Wilson, and O. Makhnin. 2005. Geostatistical Mapping of Mountain Precipitation Incorporating Autosearched Effects of Terrain and Climatic Characteristics. Journal of Hydrometeorology. 6:6:1018–1031.

## Problem and Research Objectives

The temporal and spatial variability of precipitation controls many terrestrial hydrologic processes and states. Common remotely sensed precipitation products used to estimate precipitation have a spatial resolution that is often too coarse to reveal hydrologically important spatial variability. NEXRAD precipitation fields are one such product. This study is aimed at further developing and testing a physically-based statistical approach to spatial disaggregation using NEXRAD precipitation data.

## Methodology

A parsimonious physically based multivariate-regression algorithm, referred to as multi-level cluster-optimizing ASOADeK regression, is developed for downscaling low-resolution spatial precipitation fields. This algorithm auto-searches precipitation spatial structures (e.g., rain cells), and atmospheric and orographic effects to estimate precipitation distribution without prior knowledge of the atmospheric setting. The only required input data for the downscaling algorithm are a large-pixel precipitation map and the DEM map of the area of interest.

If the proposed algorithm performs well in tests, it will provide a tool to significantly improve existing NEXRAD precipitation estimates in mountains. The spatial disaggregation approach is also applicable to other low resolution remote sensing precipitation products (e.g., TRMM) and modeling precipitation products (e.g., PERSIANN). Based on this, we can generate high-resolution precipitation maps from current remote sensing products. This will significantly improve the atmospheric boundary conditions for near-surface hydrologic modeling, better test the hydrologic models, and improve their predictive capability. The algorithm can also be embedded into hydrologic modeling codes using NEXRAD precipitation an input, or in climate modeling codes to improve the spatial resolution of the output precipitation estimates.

# Development of Geospatial Modeling Tools for Watershed−based Water Resources Management in New Mexico (Vivoni)

## Basic Information

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| **Title:** | Development of Geospatial Modeling Tools for Watershed−based Water Resources Management in New Mexico (Vivoni) |
| **Project Number:** | 2006NM44B |
| **Start Date:** | 3/1/2006 |
| **End Date:** | 2/28/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | Three |
| **Research Category:** | Climate and Hydrologic Processes |
| **Focus Category:** | Climatological Processes, Hydrology, Management and Planning |
| **Descriptors:** | |
| **Principal Investigators:** | Enrique Vivoni |

## Publication


1. Aragon, C.A., E.R. Vivoni, L.A. Malczynski, and V.C. Tidwell. 2008. Ungauged tributary contributions in large ephemeral river basins through dynamical simulation. Hydrological Processes. In preparation.

## Problem and Research Objectives

The project is developing new geospatial modeling tools for managing water resources in New Mexico using scientific knowledge on climate, surface and groundwater relations. The new technology will be designed to provide decision makers with probabilistic forecasts of water supply using ensemble techniques and address the potential for climate and land cover changes on hydrological quantities. While sophisticated, the modeling results will be made amenable to water managers through monthly web products in a similar fashion to existing drought maps. The specific objectives of the project are to:
a. Identify the hydrologic processes and feedbacks to be simulated in a system dynamics framework.
b. Design and implement watershed model in PowerSim (a system dynamics framework) with the linkages to a GIS and mathematical software (MATLAB).
c. Develop ensemble forcing and parameter estimation code in MATLAB to generate alternative climate and land-use scenarios.
d. Utilize existing data for Río Grande (topography, land/soils, rainfall, atmospheric observations) to obtain retrospective model simulations as a proof-of-concept.

## Methodology

The project will integrate various technologies for the purpose of hydrological forecasting in regional basins. The hydrological simulation code is being developed in a system dynamics (SD) modeling environment known as PowerSim; the geospatial products are stored, queried, displayed and archived in a geographical information system (ArcGIS); the ensemble generator and uncertainty estimator for climate/land-use changes will be developed in a mathematical software (MATLAB). We will spend considerable effort in integrating the three components to provide the user with seamless operation. The project will result in a semi-distributed hydrologic model to address the spatial and temporal dynamics of watershed processes, applied initially to the Río Grande from headwaters to the NM/TX state line. Through coupling to a GIS, the model will incorporate remote sensing observations of rainfall, topography, vegetation cover and soils to provide maps of hydrologic states (e.g., soil moisture, water table depth) and fluxes (e.g., evapotranspiration, runoff, recharge).

## Principal Findings

Over the course of the project, the system dynamics-based watershed model in Powersim has been completed and tested in the Rio Salado, a major ungauged tributary in the Rio Grande. The model development has been carried out using both Powersim coding and Visual Basic. In addition, tools have been developed in Excel, GIS and MATLAB to visualize model input and output. In addition to the model development efforts, we have also focused on collecting watershed data necessary to run the model for the Río Grande over the time period of interest. We have selected the Río Salado as our prototype case study and focused on the relevant data sets for this model application. Model testing has

been completed and will be summarized in a M.S. thesis by Carlos A. Aragon (defense date June 9, 2008). The thesis includes:

1. Description of watershed model equations, parameters and forcing.
2. Description of model testing at the Sevilleta Deep Well site and Rio Salado basin.
3. Description of rainfall uncertainty propagation and climate change scenarios using the watershed model.

# Sustainable Recovery of Potable Water from Saline Waters (Khandan)

## Basic Information

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| **Title:** | Sustainable Recovery of Potable Water from Saline Waters (Khandan) |
| **Project Number:** | 2006NM51B |
| **Start Date:** | 3/1/2006 |
| **End Date:** | 2/28/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | Second |
| **Research Category:** | Engineering |
| **Focus Category:** | Treatment, Water Quality, Conservation |
| **Descriptors:** | |
| **Principal Investigators:** | Nirmala Khandan |

## Publication


1. Veera Gnaneswar Gude and NirmalaKhandan. Desalination Using Low Grade Heat Sources. Submitted to ASCE Journal of Energy Engineering.
2. Veera Gude, 2008. Desalination Using Low Grade Heat Sources, Ph.D. Dissertation, New Mexico State University, Department of Civil Engineering, Las Cruces, NM.
3. Veera Gude and N. Nirmala Khandan. 2008. Combined Desalination and Solar−assisted Air−conditioning System. Accepted for publication in Energy Conversion and Management.
4. Veera Gude and N. Nirmala Khandan. 2008. Desalination Using Low Grade Heat Sources. Accepted for publication in ASCE Journal of Energy Engineering.
5. Veera Gude and N. Nirmala Khandan. 2007. Desalination at Low Temperatures and Low Pressures. Submitted to Desalination.

## Problem and Research Objectives

Due to increasing energy costs and declining energy sources, interest in the use of low grade heat sources and recovery of waste heat is growing. The goal of this study is to evaluate the feasibility of utilizing low grade heat to run a new desalination process. Traditional desalination processes such as reverse osmosis, electrodialysis, mechanical vapor compression, and multi-effect flash distillation require electrical energy derived from nonrenewable sources the cost of which has increased by 10 times over past 20 years. Recently, a new desalination process has been proposed by Al-Kharabsheh & Goswami (2004), which has the potential to run solely on low grade heat at around 50$^{o}$C. We propose a modification to that process, whereby it can be run round the clock using a thermal energy storage (TES) system. The TES system can be maintained at the desired temperature using waste heat from any available source. In this study, we evaluated the feasibility of utilizing the heat rejected by a solar-powered absorption refrigeration system (ARS) to provide the energy for the TES.

## Methodology

An integrated process model has been developed using Extend® and EES® software to simulate the desalination- Absorption refrigeration system (ARS) process. Process parameters have been established to evaluate process performance and economical feasibility of the combined desalination/air conditioning system. Operating parameters have been identified. Design values of solar panels and TES volumes have been calculated for different desalination/air-conditioning rates.

## Principal Findings

A variety of near-full scale experiments have been completed with different process configurations with (1) direct solar collector and (2) direct solar energy + photovoltaic (PV) panels. Using direct solar collectors, 4.9 L/day of desalinated water was produced using a collector area of 1 m$^2$. Using direct solar energy during daylight hours and photovoltaic energy during non-sunlight hours (with a 6 m$^2$ PV module) the production was 12 L/d. The specific energy requirements in the two cases were 4,157 kJ/kg 2,926 kJ/kg of desalinated water, respectively. The system was evaluated at various evaporation temperatures and brine withdrawal rates to calibrate and validate the process model developed during the first year. In addition, the feasibility of reclaiming potable quality water from the effluent of the Las Cruces Wastewater Treatment plant by the system was evaluated. The results of these studies showed that the quality of the product water exceeded the US Drinking Water Standards.

# Validation, Calibration, and Improvement of Remote Sensing ET Algorithms in Mountainous Regions

## Basic Information

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| **Title:** | Validation, Calibration, and Improvement of Remote Sensing ET Algorithms in Mountainous Regions |
| **Project Number:** | 2006NM63G |
| **Start Date:** | 9/1/2006 |
| **End Date:** | 8/31/2008 |
| **Funding Source:** | 104G |
| **Congressional District:** | Second |
| **Research Category:** | Climate and Hydrologic Processes |
| **Focus Category:** | Hydrology, Water Quantity, Models |
| **Descriptors:** | |
| **Principal Investigators:** | Jan M.H. Hendrickx, Jan Kleissl |

## Publication


1. Hendrickx, J.M.H., J. Kleissl, J.D. Gomez−Velez, S.−h Hong, J.R. Fabrega−Duque, D. Vega, H.A. Moreno−Ramirez, and F.L. Ogden. 2007. Scintillometer networks for calibration and validation of energy balance and soil moisture remote sensing algorithms. Proc International Society for Optical Engineering (SPIE). 6565:65650W.
2. Gomez, J.D., J. Kleissl, J.M.H. Hendrickx, and O.K. Hartogensis. 2008. Large aperture scintillometers for hydrology. Water Res. Res.submitted.
3. Hong, S.−h., J. Kleissl, J.M.H. Hendrickx, R.G. Allen, W.G.M. Bastiaanssen, R.L. Scott, and A.L. Steinwand. 2008. Validation of SEBAL for mapping sensible and latent heat fluxes in arid riparian areas from remotely sensed optical imagery. Water Res. Res. In preparation.
4. Kleissl, J., S.−h. Hong, and J.M.H. Hendrickx. 2008. New Mexico scintillometer network in support of remote sensing, and hydrologic and meteorological models. Bulletin American Meteorological Society. In press.
5. Kleissl, J., J. Gomez, S.−H. Hong, J.M.H. Hendrickx, T. Rahn, and W.L. Defoor. 2008. Large aperture scintillometer intercomparison study. Boundary Layer Meteorol. 128:133–150, DOI 10.1007/s10546−008−9274−1.

## Problem and Research Objectives

Accounting of key reservoirs and fluxes associated with the global water cycle, including their spatial and temporal variability, are crucial goals of water resource managers. Advancements in satellite optical remote sensing have resulted in the development of several operational remote sensing evapotranspiration (ET) algorithms. While these algorithms typically give accurate ET predictions over flat terrain, significant difficulties have been encountered in mountainous regions which are characterized by heterogeneous soil and topography and high elevation changes. However, mountain runoff represents more than 90% of the total runoff in the semi-arid basins of the Rio Grande, Oranje, Colorado, and Rio Negro rivers. Thus improving ET estimates in the mountains is crucial for determining the regional water balance in the southwestern U.S. and in many mountainous regions worldwide. The following objectives will be pursued:

Objective One: We will validate sensible and latent heat fluxes estimated from SEBAL$^{NM}$ using ground measurements over mountainous landscapes in New Mexico.

Objective Two: We will calibrate SEBAL$^{NM}$ satellite ET maps using ET measurements over scintillometer transects in near real time.

Objective Three: We will develop improvements for SEBAL$^{NM}$ and other remote sensing ET algorithms for better ET estimates in mountainous areas. To achieve this we will incorporate shade effects, lapse rates, advection, and air flow effects into SEBAL$^{NM}$.

## Methodology

Most remote sensing algorithms obtain ET as the residual of the energy balance after measuring and/or modeling net radiation, ground heat flux, and sensible heat flux H. Among these fluxes, H is the most complex to estimate and its value is associated with the greatest uncertainty. We will use novel measurement techniques, such as scintillometers, together with spatially dense meteorological measurements and archived ETA numerical weather model data to measure H and determine how it is related to temperature lapse rate, wind speed, water vapor deficit, and boundary layer height. Two protected sites with idealized topographical shape will be considered in the field study: the Magdalena Ridge and the Valles Caldera National Park in New Mexico. First, the measured H will be used to validate estimates derived from the Surface Energy Balance over Land (SEBAL) algorithm applied on data from synchronous ASTER and MODIS satellite overpasses. Second, techniques for calibration of the SEBAL algorithm in near-real time using surface measurements of H will be developed. Third, parameterizations in the SEBAL algorithm for mountain lapse rates, wind speeds, and surface roughnesses will be critically reviewed and improved by considering meteorological measurements and archived numerical weather model data. Through this work we will make a lasting contribution to ET estimation from SEBAL and other remote sensing algorithms for current and future satellite missions.

Principal Findings

The support of this USGS/NMWRRI project together with support of other sponsors has allowed us to investigate and develop procedures for the validation and calibration of remote sensing ET algorithms in mountainous regions in New Mexico. Our research work on ET algorithms started well over eight years ago. However, due to the extremely complex nature of combining the physics of momentum, mass, and energy transport in the atmospheric boundary layer with the radiation physics of remote sensing imagery, it took over five years to prepare our first publications. The USGS/NMWRRI support is critical to complement our progress to date and to develop new knowledge to expand our remote sensing algorithms to more challenging conditions.

For the validation of SEBAL$^{NM}$ we have used the new technology of scintillometry. Since no other research group had established a network of six scintillometers over an area of 315,000 km$^2$ we have spent considerable effort to test the performance of scintillometers under the mountainous conditions of New Mexico.

We performed first two field studies with six large aperture scintillometers (LASs) using horizontal and slant paths. The accuracy of this novel and increasingly popular technique for measuring sensible heat fluxes was quantified by comparing measurements from different instruments over nearly identical transects. Random errors in LAS measurements were small, since correlation coefficients between adjacent measurements were greater than 0.995. However, for an ideal set-up differences in linear regression slopes of up to 21% were observed with typical inter-instrument differences of 6%. Differences of 10% are typical in more realistic measurement scenarios over homogeneous natural vegetation and different transect heights and locations. Inaccuracies in the optics, which affect the effective aperture diameter, are the most likely explanation for the observed differences (Kleissl et al., 2008b). The quantification of the instrument error of large aperture Kipp & Zonen scintillometers is critical information for all hydrologists using scintillometer worldwide. These results are relevant for Objective One.

We also established in New Mexico a first-of-its-kind network of seven Large Aperture Scintillometer (LAS) sites to measure sensible heat fluxes over irrigated fields, riparian areas, deserts, lava flows, and mountain highlands. Wireless networking infrastructure and auxiliary meteorological measurements facilitate real-time data assimilation. LAS measurements are advantageous in that they vastly exceed the footprint size of commonly used ground measurements of sensible and latent heat fluxes (~100 m2), matching the pixel-size of satellite images or grid cells of hydrologic and meteorological models (~0.1-5 km2). Consequently, the LAS measurements can be used to validate, calibrate, and force hydrologic, remote sensing, and weather forecast models. We have published initial results for: (1) variability and error of sensible heat flux measurements by scintillometers over heterogeneous terrain and (2) the validation of the Surface Energy Balance Algorithm for Land (SEBAL) applied to MODIS satellite imagery (Hendrickx et al., 2007; Kleissl et al., 2008a). The findings from this study are relevant for Objectives One and Two.

In another recently submitted publication, we present our experiences with the emerging method of scintillometry for hydrologic studies include the use of SEBAL$^{NM}$. Large aperture scintillometers are employed to derive the sensible heat flux over irrigated fields, riparian areas, deserts, lava flows, and mountain highlands in New Mexico. The theory and technical aspects of the setup, operation, and analysis of LAS data are discussed. The advantages of a larger flux footprint, compared with other measurement techniques for the sensible heat flux, are explained, particularly in the context of the calibration and validation of remote sensing surface energy balance algorithms, and hydrologic and meteorological models. The scintillometer transects were used to explore this measurement technique as a potentially useful tool in hydrological applications. Evapotranspiration rates for hydrologic applications can be obtained at scales of the pixel-size of satellite images or grid cells of hydrologic and meteorological models (0.1-10 km$^2$) (Gomez et al., 2008). The findings from this study are relevant for Objectives One and Two.

Finally, in another recent publication we discuss why scintillometer measurements cannot be used directly for the calibration and validation of SEBAL$^{NM}$ since the sensible heat flux determined by SEBAL$^{NM}$ absorbs biases caused by its assumptions and atmospheric conditions (Hong et al., 2008). This was somewhat of a surprise to us and is very relevant for practitioners worldwide; it is relevant for Objective Two.

We have already taken many measurements relevant for Objective Three such as air temperature and humidity measurements along elevation gradients and scintillometer measurements over snow in the Valles Caldera (Figures 1 and 2). These measurements still need to be analyzed. Since a new PhD student withdrew from the project in the fall semester of 2007 this work has been delayed and, therefore, we will request a no-cost extension of one year.

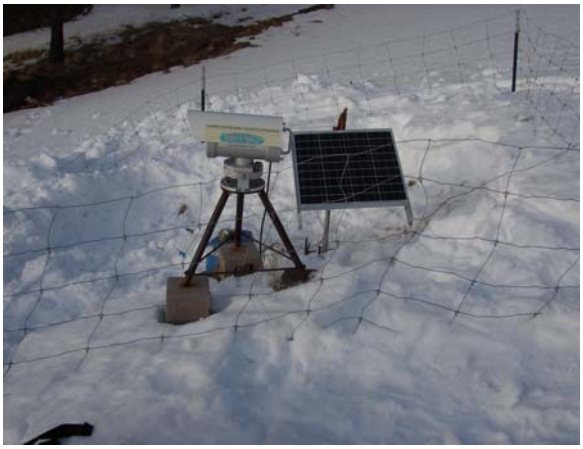

**Figure 1.** Transmitter in Valles Caldera transect in January 2008. The tough field work makes the project less attractive for some graduate students.


**Figure 2.** Waist-deep snow posed severe access problems. After one failed attempt on snow shoes the Valles Caldera National Park made their snowmobiles available to access the scintillometer.

# Geographic Information System for Water Resources Research Planning

## Basic Information

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| **Title:** | Geographic Information System for Water Resources Research Planning |
| **Project Number:** | 2007NM102B |
| **Start Date:** | 3/1/2007 |
| **End Date:** | 2/28/2008 |
| **Funding Source:** | 104B |
| **Congressional District:** | 2 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Management and Planning, Water Quality, Models |
| **Descriptors:** | GIS, digital mapping |
| **Principal Investigators:** | Bobby J. Creel |

## Publication


1. Granados−Olivas, Alfredo, E. Sanchez−Flores, A. De la Mora−Covarrubias, S.T. De la Cruz, G. Reyes−MacÃ-as, F. Llera−Pacheco, J. ChÃ¡vez, B. Creel, and C. Brown. 2008. Roadmap of Geospatial Education in Mexico. ASPRS 2008 Annual Conference Portland, Oregon, April 28−May 2, 2008. ISBN 1−57083−087−8
2. 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 Report 341, October 2007, 85p
3. Hawley, J.W., J.F. Kennedy, A. Granados−Olivas, and M.A. Ortiz. 2007. Hydrogeologic framework of the western Hueco Bolson area of the Rio Grande rift, Texas, New Mexico, and Chihuahua: Progress report on digital−model development: Geological Society of America, Abstract with Programs, v. 39, no. 6, ISSN 0016−7592, Session 34−3 on CD ROM.

## 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 (color plotter, digitizer, etc.); 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 continues to be utilized by the NM Interstate Stream Commission to provide GIS mapping products for use in their plans and in public outreach. NMWRRI has helped 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 WRRI-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.

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 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 WRRI homepage (wrri.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 52 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, and National Weather Service are linked to the WRRI homepage.

# Information Transfer Program

## Basic Information

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|---|---|
| **Title:** | Information Transfer Program |
| **Project Number:** | 2002NM3B |
| **Start Date:** | 3/1/2002 |
| **End Date:** | 2/28/2009 |
| **Funding Source:** | 104B |
| **Congressional District:** | Second |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Education, None, None |
| **Descriptors:** | publications, conferences, press releases, presentations, website |
| **Principal Investigators:** | Bobby J. Creel, Cathy T. Ortega Klett |

## Publication


1. 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.

9. 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.

**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 available information on the institute's website. For the past 52 years, the NMWRRI has sponsored the Annual New Mexico Water Conference focusing on a topic of importance to the New Mexico water community. The annual conference is held in different locations around the state, usually 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 200 and 350 people, depending on the location and topic of the conference.

Publications include technical completion reports resulting from NMWRRI-sponsored projects, special in-house publications, and conference proceedings. The institute has published more than 370 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. WRRI water conference proceedings for the past 52 years are also available online in full text.

A quarterly newsletter, *The Divining Rod,* focuses on research and current water issues. It is distributed to approximately 2,300 readers and is available on the WRRI homepage.

A reference room, housed at the institute, contains over 11,000 documents and is used frequently by faculty, students, and others. A complete catalog of holdings can be searched through the NMWRRI home page on the Internet, along with an extensive water resources and information system database and other information about the institute.

The institute director and associate director are 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 52$^{nd}$ Annual New Mexico Water Conference was held in late November in Santa Fe,

New Mexico. The conference was entitled, “Beyond the Year of Water: Living within Our Water Limitations.” The conference was well attended and was described by several participants who attend yearly as one of the most informative conference in years, mainly do to the high quality of speakers including the Lt. Gov. of New Mexico, the New Mexico State Engineer, the New Mexico Congressional Staff, and experts in the area of climate change. A full proceedings of the conference was produced and is available on the WRRI website. All conference participants received a copy on CD.

The NMWRRI coordinated the 2007 Water Research Symposium held on the campus of New Mexico Tech, in Socorro, New Mexico. The one-day “2007 New Mexico Water Research Symposium” was co-sponsored by 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. Twenty-two oral presentations were given and 28 posters displayed. Over 100 participants including 45 students from throughout New Mexico, Arizona, and west Texas attended.

The WRRI co-sponsored the Spring 2007 New Mexico State University Water Lecture Series, a monthly seminar with attendance averaging about 100.

Institute staff judged water-related projects at the New Mexico Science and Engineering Fair for high school and middle school students and presented awards to students with water-related projects. The institute director participated as a judge in New Mexico State University’s Research Fair.

The institute’s publications for the period included three technical reports: “Phase II Final Project Report Paso del Norte Watershed Council Coordinated Water Resources Database and GIS Project”; “Solar Desalination of Brackish Water Using Membrane Distillation Process”; and “Mitigation of Membrane Biofouling by Harnessing Bacterial Cannibalism.” The 52$^{nd}$ Annual New Mexico Water Conference proceedings was 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 averages over 45,000 webpage hits each month and averages 146 online requests for publications from its technical report series each month. Because of the ability to view and print all institute publications online, the WRRI is averaging only about 8 requests for hard copies of specific publications each month via the postal mail or visits to the institute. Requests online have more than quadrupled in the past three years.

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. The layout of the newsletter was redesigned during the summer of 2007, its first revision in ten years. Each issue is available on the NMWRRI’s homepage. Hard copies of the

newsletter are distributed to approximately 2,300 readers. During the reporting period, the institute published one 8-page issue and three 12-page issues of *The Divining Rod*.

Online usage of the WRRI's reference room averages 400 requests per month. During the reporting period, approximately 30 publications were checked out of the library.

The institute's director and assistant director participate in local, state, and national conferences and workshops and speak before many groups. For example, during the reporting period, Director Karl Wood spoke before an audience of 50 at the Las Cruces Rotary Club; spoke before 30 people at the Tularosa Rotary Club; and about 50 people at the New Mexico League of Women Voters. The theme for these presentations was "Futuristic Ways to Increase New Mexico's Water Supplies."

The institute director is currently the past-president of the national organization, Universities Council of Water Resources, and is an active member of the National Institute of Water Resources. 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.

# Student Support

| Student Support | | | | | |
|---|---|---|---|---|---|
| **Category** | **Section 104 Base Grant** | **Section 104 NCGP Award** | **NIWR−USGS Internship** | **Supplemental Awards** | **Total** |
| **Undergraduate** | 5 | 4 | 0 | 0 | 9 |
| **Masters** | 5 | 1 | 0 | 0 | 6 |
| **Ph.D.** | 1 | 2 | 0 | 0 | 3 |
| **Post−Doc.** | 1 | 1 | 0 | 0 | 2 |
| **Total** | 12 | 8 | 0 | 0 | 20 |

# Notable Awards and Achievements

Sri H.Valluri, a master's student in Chemical Engineering at New Mexico State University received an award for the best poster presentation at the NMSU Research Council Fair in October 2006 for his poster presentation “Direct Contact Membrane Distillation for Brackish Water Desalination: Comparison of Flat−Sheet Membrane and Hollow Fiber Membrane Modules.”

Ryan McShane, a master's student in the Department of Fishery and Wildlife Sciences at New Mexico State University received the Best Oral Presentation Award at NMSU's Graduate Research and Arts Symposium in April 2007. He presented research results for his WRRI funded project, “Ecological Effects of an Invasive Fish in an Arid−Land Stream,” at various national and international meetings including the North American Benthological Society and the American Society of Limnology and Oceanography.

Research by New Mexico State University Civil Engineer Nirmala Khandan and Ph.D. student Veera Gude on “Sustainable Recovery of Potable Water from Saline Waters” was featured by numerous media outlets including national, state, and local publications such as the ASCE Civil Engineering magazine in August 2007 as well as being covered by two national radio programs, “Earth and Sky” and “A Moment of Science.” The research has a patent application pending and World Wide Water Inc. has secured exclusive licensing of the technology developed from this project from NMSU. Many presentations were made in the past year including at the 3rd International Conference on Thermal Engineering: Theory and Applications, in Amman, Jordan in May 2007.

Susanna H. Glaze, a graduate student in geography at New Mexico State University received the GREG Award from the Office of the Vice President for Research. This two−year graduate assistantship provides funding for Suzanna's project, which is to develop planning models that can be used to evaluate the impact and sustainability of cities water supplies that are experiencing pressures of high growth and the effect that climate change may have on their water supply in the Rio Grande Basin of New Mexico. The New Mexico WRRI sponsored the project proposal and Suzanna conducts her research at the institute's GIS laboratory.

In June 2007, the Senate of the State of Texas named the top 20 Rio Grande Water Studies. The list included several by WRRI−funded researchers and projects including: 1) Hibbs, B., B.J. Creel, et al. 1997. Transboundary Aquifers of the El Paso/Ciudad Juarez/Las Cruces Region: U.S. Environmental Protection Agency, Region 6. Technical Contract Report prepared by the Texas Water Development Board and the New Mexico Water Resources Research Institute. 2) Phillips, F.M., J.F. Hogan, S.K. Mills, and J.M.G. Hendrickx. 2002. Environmental tracers applied to quantifying causes of salinity in arid region rivers: Preliminary results from the Rio Grande, southwestern USA, in Alsharhan, A.S., and Wood, W.W., eds., Water resources perspectives: Evaluation management and policy: Amsterdam, Elsevier. 3) Ward, F.A., J.F. Booker, and A.M. Michelsen. 2006. “Sustainable Policy Design through Integrated Basin Models: Findings from the Rio Grande.” Increasing Fresh Water Supplies, Universities Council on Water Resources, Santa Fe, NM. July 18−20

The results of the project entitled “Development of Geospatial Modeling Tools for Watershed−based Water Resources Management in New Mexico” has been incorporated into the revised undergraduate and M.S. curriculum in the hydrology program at New Mexico Tech. Examples and modeling exercises from the work will form part of ERTH 440 Hydrologic Theory and Field Methods, an upper level undergraduate and first year graduate course taught by the principal investigator, Dr. Enrique Vivoni.

New Mexico State University graduate students Prajwal Vikram and Amlan Chakraborty will use the experimental apparatus, a solar collector, as teaching equipment for a new renewable energy course at NMSU. The equipment was originally used for research involving solar desalination of brackish water.

Arely Torres, an undergraduate in the Department of Chemical Engineering at New Mexico State University, received the Spring 2008 Center for International Programs award for the Outstanding Graduates. Torres earned a 4.0 GPA, is on the National Dean's List and has also received the Rotary Youth Leadership Award. She has received the AIChE Minority Affairs Committee Scholarship, the AIChE Donald F. and Mildred Topp Othmer National Scholarship and the Dr. Edward Groth Jr. Endowed Memorial Scholarship. Arely received a WRRI student grant for her project entitled “Drinking Water Purification for U.S.A.−Mexico Border Region.”

# Publications from Prior Years

1. 2000NM10B ("Soil Moisture−Rainfall Feedbacks in New Mexico") − Articles in Refereed Scientific Journals − Gutmann, E.D., and E.E. Small. 2007. A comparison of land surface model soil hydraulic properties estimated by inverse modeling and pedotransfer functions. Water Resources Research. 43:W05418. doi:10.1029/2006WR005135
2. 2000NM10B ("Soil Moisture−Rainfall Feedbacks in New Mexico") − Articles in Refereed Scientific Journals − Larson, K.M., E.E. Small, E.D. Gutmann, A. Bilich, P. Axelrad, and J. Braum. 2007. Using GPS multipath to measure soil moisture fluctuations: initial results. GPS Solutions. http://xenon.colorado.edu/Larson2007_soil.pdf, doi:10.10007/s10291−007−0076−6
3. 2000NM10B ("Soil Moisture−Rainfall Feedbacks in New Mexico") − Articles in Refereed Scientific Journals − Kurc, S.A., and E.E. Small. 2007. Soil moisture variations and ecosystem−scale fluxes of water and carbon in semiarid grassland and shrubland. Water Resources Research. 43:W06416. doi:10.1029/2006WR005011
4. 2000NM10B ("Soil Moisture−Rainfall Feedbacks in New Mexico") − Articles in Refereed Scientific Journals − Bedford, D.R., and E.E. Small. 2008. Spatial patterns of ecohydrologic properties on a hillslope−alluvial fan transect, central New Mexico. Catena. 73:1:34−48
5. 2000NM10B ("Soil Moisture−Rainfall Feedbacks in New Mexico") − Articles in Refereed Scientific Journals − Hong, S., V. Lakshmi, and E.E. Small. 2007. Relationship between Vegetation Biophysical Properties and Surface Temperature Using Multisensor Satellite Data. Journal of Climate. 20.22:5593−5606. doi: 10.1175/2007JCLI1294.1
6. 2000NM7G ("Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin") − Articles in Refereed Scientific Journals − Ward, F.A., A.M. Michelsen, and L. DeMouche. 2007. Barriers to water conservation in the Rio Grande basin. Journal of the American Water Resources Association. 43:1:237–253. doi:10.1111/j.1752−1688.2007.00019.x
7. 2000NM7G ("Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin") − Articles in Refereed Scientific Journals − Ward, F. A. 2007. Decision support for water policy: a review of economic concepts and tools. Water Policy. 9:1−31
8. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Chalus, O., and J−C Diels. 2007. Lifetime of fluorocarbon for high−energy stimulated Brillouin scattering. JOSA B. 24:3:606−608
9. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Conference Proceedings − Schmitt−Sody, A., J−C Diels, and L. Arissian. 2007. Ultra−slow dynamics of an ultra−fast laser. Quantum Electronics and Laser Science Conference QELS ‘07, 1−2. doi:10.1109/QELS.2007.4431799
10. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Zavadilova, A., V. Kubecek, and J−C Diels. 2007. Picosecond optical parametric oscillator synchronously intracavity pumped by mode−locked Nd:YVO4 laser. Proceedings of SPIE, 6610. doi:10.1117/12.740027
11. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Conference Proceedings − Zendzian, W., J.K. Jabczynski, J. Kwiatkowski, V. Kubecek, H. Jelinkova, A. Stinkz, and J−C Diels. 2007. Quasi CW laser diode side pumped Nd:YAG slab laser passively mode−locked using multiple quantum well saturable adsorbers. Lasers and electro−optics. CLEO 2007, 1−2. doi:10.1109/CLEO.2007.4452341
12. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Jabcyznski, J.K., W. Zendzian, J. Kwiatkowski, V. Kubecek, H. Jelinkova, A Stintz, and J−C Diels. 2007. Picosecond Nd:YAG slab laser passively Q−switched and mode−locked using multiple quantum well saturable adsorbers. Proceedings of SPIE, 6731. doi:10.1117/12.752920

13. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Bourdier, A., A. Binet, O. Chalus, J−C Diels, P. Guimbal, and V. LeFlanchec. 2007. Long UV pulse propagation in the atmosphere. Pulsed Power Plasma Science. PPPS 2007, 138, doi:10.1109/PPPS.2007.4345444
14. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Arissian, L., J−C Diels, and A. Velten. 2007. Group velocity control by atomic nonlinear response in laser cavity. Lasers and Electro−Optics. CLEO 2007, 1−2. doi:10.1109/CLEO.2007.4452467
15. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Kubecek, V., M. Drahokoupil, H. Jelinkova, A. Stintz, and J−C Diels. 2008. Pulsed passively mode locked operation of diode pumped Nd:GdVO4 and Nd:YVO4 in a bounce geometry. Proceedings of SPIE, 6871. doi:10.1117/12.763231
16. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Chalus, O., A. Sukhinin, A. Bourdier, D. Mirell, A. Aceves, and J−C Diels. 2007. Simulation of the propagation of a UV filament in the air. Quantum Electronics and Laser Science. QELS 07, 1−2. doi:10.1109/QELS.2007.4431460
17. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Zavadilova, A., V. Kubecek, J−C Diels, and A. Velten. 2007. Intracavity pumped picosecond Optical Parametric Oscillator for intracavity interferometry. Lasers and Electro−Optics. CLEO 2007, 1—2. doi:10.1109/CLEO.2007.4453038
18. 1999NM102B ("Detection of Groundwater through Ultra−Sensitive Magnetic Measurements with Ultra−short Pulse Lasers") − Articles in Refereed Scientific Journals − Zavadilova, A., V. Kubecek, and J−C Diels. 2007. Ring picosecond optical parametric oscillator pumped synchronously, intracavity, by a mode−locked Nd:YVO4 laser. Proceedings of SPIE, 6582. doi:10.1117/12.722774
19. 2006NM41B ("Mitigation of Membane Biofouling by Harnessing Bacterial Cannibalism (Huang)") − Articles in Refereed Scientific Journals − Magedov I.V., M. Manpadi, S.V. Slambrouck, W.F. Steelant, E. Rozhkova, N.M. Przheval'skii, S. Rogelj, and A. Kornienko. 2007. “Discovery and investigation of antiproliferative and apoptosis−inducing properties of new heterocyclic podophyllotoxin analogues accessible by a one−step multicomponent synthesis.” J Med Chem. 50.12:5183−92
20. 2006NM41B ("Mitigation of Membane Biofouling by Harnessing Bacterial Cannibalism (Huang)") − Articles in Refereed Scientific Journals − Magedov, I.V., M. Manpadi, E. Rozhkova, N.M. Przheval’skii, S. Rogelj, S.T. Shors, W.F.A. Steelant, S. Van slambrouck, and A. Kornienko. 2007. “Structural simplification of bioactive natural products with multicomponent synthesis: Dihydropyridopyrazole analogues of podophyllotoxin.” Bioorganic &Medicinal Chemistry Letters. 17.5:1381−1385. doi:10.1016/j.bmcl.2006.11
21. 2006NM41B ("Mitigation of Membane Biofouling by Harnessing Bacterial Cannibalism (Huang)") − Articles in Refereed Scientific Journals − Magedov, I.V., M. Manpadi, N.M. Evdokimov, E.M. Elias, E. Rozhkova, M.A. Ogasawara, J.D. Bettale, N.M. Przheval’skii, S. Rogelj, and A. Kornienko. 2007. “Antiproliferative and apoptosis inducing properties of pyrano[3,2−c]pyridones accessible by a one−step multicomponent synthesis”. Bioorganic &Medicinal Chemistry Letters. 17.14:3872−3876. doi:10.1016/j.bmcl.2007.05.004
22. 2006NM41B ("Mitigation of Membane Biofouling by Harnessing Bacterial Cannibalism (Huang)") − Articles in Refereed Scientific Journals − Manpadi, M., P.Y. Uglinskii, S.K. Rastogi, K.M. Cotter, Y−S C. Wong, L.A. Anderson, A.J. Ortega, S. Van slambrouck, W.F.A. Steelant, S. Rogelj, P. Tongwa, M.Y. Antipin, I.V. Magedov, and A. Kornienko. 2007. “Three−component synthesis and anticancer evaluation of polycyclic indenopyridines lead to the discovery of a novel indenoheterocycle with potent apoptosis inducing properties.” Org. Biomol. Chem. 5:3865−3872. doi: 10.1039/b713820b

23. 2006NM60G ("Impacts of Land Use Change on Water Resources, Water Quality, and Acequia Culture in Northern New Mexico/Southern Colorado") − Book Chapters − Chermak, J. and D. Brookshire. 2007. Conceptual Issues of Benefit Transfers and Integrated Modeling. In Environmental Value Transfer: Issues and Methods. In the Kluwer Academic Publishers series entitled The Economics of Non−Market Goods and Resources, S. Navrud, R.C. Ready, and O. Olvar (eds).
24. 2006NM60G ("Impacts of Land Use Change on Water Resources, Water Quality, and Acequia Culture in Northern New Mexico/Southern Colorado") − Book Chapters − Chermak, J., D. Brookshire, and R. DeSimone. 2007. Uncertainty, Benefit Transfers, and Physical Models: A Middle Rio Grande Valley Focus. In Environmental Value Transfer: Issues and Methods. In the Kluwer Academic Publishers series entitled The Economics of Non−Market Goods and Resources, S. Navrud, R.C. Ready, and O. Olvar (eds).