New Mexico Water Resources Research Institute
Annual Technical Report
FY 2014

Introduction

This program report provides the required information for projects funded with the 2014 base grant and mandatory non-federal matching funds. Please note that there may be some overlap in information with our 2013 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 (NM WRRI) 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. In 2005, the New Mexico state legislature gave NM WRRI statutory authority. 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 NM WRRI 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 NM WRRI homepage (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. The institute's website is undergoing a major redesign and will launch in the summer of 2015.

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. As of April 2015, 62 percent of New Mexico was in moderate to severe drought status, and 18 percent was in severe drought. Despite a 50-60 percent chance of increased precipitation through the summer months, forecasters see the drought impacts continuing for a significant amount of time with future water supplies not meeting future water demand in the state. According to a recent report prepared in conjunction with the 2012 NM WRRI annual water conference,"Decades of relative water abundance in New Mexico and the region, coupled with large growth in local and regional populations and increased consumption, are leading us to a crisis point for water availability for residential industrial, agricultural and environmental uses." The New Mexico Drought Working Group monitors the situation and current Drought Status Reports are available at http://www.nmdrought.state.nm.us.

Solving the dire and complex water problems facing New Mexico and the Southwest requires the highest quality research and the NM WRRI is dedicated to assisting in this effort.

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, four projects received funding from the 2014 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." One water quality project was supported: "The Transport and Accumulation of Pyrogenic Black Carbon in Fire-prone Watersheds and Implications for Water Quality." A project that focused on saline and other impaired waters was supported: "Self-Sustaining Produced Water Treatment for Concurrent Renewable Energy Production, Desalination, and Organic Removal." In addition, three projects received supplemental funding through the USGS, "Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan," "Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq," and "Groundwater Exploration, Assessment and Monitoring for Humanitarian Assistance in Ethiopia."

During the reporting period, March 1, 2014 through February 28, 2015, the NM WRRI administered a total of 39 projects dealing primarily with water planning and management issues as well as water quality. The total value of these projects was $1,386,733. Dollar amounts per project award ranged from a Student Water Research Grant on water quality of $5,320 to an international project of $421,500. During the reporting period, nine projects were conducted at New Mexico State University, nine at the University of New Mexico, eight at New Mexico Tech, one at New Mexico Highlands University, one at Eastern New Mexico University, one with the USGS, one with a private entity, and two in-house 104B projects. NM WRRI staff managed seven additional projects.

USGS 104B and USGS Supplemental funded projects administered by the NM WRRI utilized 22 students during the year including undergraduates, masters, Ph.D. candidates, and one Post-doc in the diverse disciplines of art, agricultural economics, education, engineering technology, environmental engineering, hydrology, geography, graphics design, computer science, civil engineering, mechanical engineering, social work, water science, and water management.

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 multi-year funding.

Fire ash influences on aquatic primary producers through changes in water quality, NM State appropriation, student grant $5,320

Evaluating the Impacts of Particulate Matter Deposition on Snow Melt Processes in the Upper Rio Grande, NM, NM State appropriation, student grant $5,738

Temporal analysis of non-snow fed streams in New Mexico, NM State appropriation, student grant $5,771

Water Politics and Cultural Difference: Fostering Community Relationships to Promote Environmental Health and Community Wellbeing in Times of Drought, NM State appropriation, student grant $5,815

Evaluation of Impacts of Silvicultural Operations such as Thinning Treatments on Water Quality and Quantity in New Mexico Forests, NM State appropriation, student grant $5,823

Real Time Monitoring of Flood Control Dams for Emergency Action Management, NM State appropriation, student grant $5,932

Effects of turbidity on group cohesion in Sand Shiners and Red Shiners from the Pecos River in New Mexico, NM State appropriation, student grant $5,973

Development of a Bio-indicator to Assess Water Quality in Ephemeral Ponds, NM State appropriation, student grant $5,989

Linking Forests to Faucets: Investigating Alternative Approaches for Securing Long-Term Funding for Watershed Restoration in New Mexico, NM State appropriation, student grant $5,994

Assessment of Water Quality in the Irrigation Drainage Canals as a Source of Reusable Irrigation Water, NM State appropriation, student grant $5,994

Application of HydroGeoSphere to model climate change effects on three-dimensional hydrological processes in the Valles Caldera, New Mexico, NM State appropriation, student grant $5,994

Enhanced Photocatalysis for Water Purification and Disinfection using Optical Fibers Coated with Nanocomposite Thin Films, NM State appropriation, student grant $6,000

Cost-efficient detection of endocrine-disrupting compounds in drinking water, NM State appropriation, student grant $6,000

Test of the new LAS MkII Scintillometer for validation of statewide New Mexico evapotranspiration maps, NM State appropriation, student grant $6,000

The Detection of Antibiotic Resistant Bacteria (ARB) in the Gallinas River, NM State appropriation, student grant $6,000

Submerged Aquatic Macrophytes: Ecosystem Engineers in New Mexico Mountain Streams; Effects of Forest Fire, NM State appropriation, student grant $6,000

Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq, USGS Supplemental (extended) $7,208

Geographical Information System for Water Resources Planning, USGS 104B $20,364

The Transport and Accumulation of Pyrogenic Black Carbon in Fire-prone Watersheds and Implications for Water Quality, NM Tech $20,497

Drought, Salinity, and Invasive Plants: A New Model for Sustainable Water Management, NM State Appropriations, $29,070

Doing Hydrology Backwards in New Mexico to Estimate a Statewide Water Budget, NM State Appropriations, $29,904

Policy alternative for controlling nitrate pollution from New Mexico's dairies, NM State Appropriations, $29,978

Assessment of water table and water quality variations with respect to river flow along Rio Grande between Garfield NM and Fabens TX, NM State Appropriations, $29,981

Identification of law and policy options for best water management practices, NM State Appropriation, $29,996

Self-sustaining produced water treatment for concurrent renewable energy production, desalination and organic removal, USGS 104B $30,000

Comparison of operational precipitation and evapotranspiration products for statewide water assessment, NM State Appropriations, $30,000

Assessment of Spatiotemporal Groundwater Level Changes Throughout New Mexico, NM State Appropriations, $30,011

Characterization of produced water in New Mexico, NM State Appropriations, $30,215

Surface-water, inflows, outflow, gains, and losses in New Mexico, NM State Appropriations, $31,550

Information Transfer Program, USGS 104B $38,381

Groundwater level and storage changes: Regions of New Mexico, NM State Appropriations, $38,897

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan, USGS Supplemental $39,308

Recharge data compilation and recharge area identification for the state of New Mexico, NM State Appropriations, $40,915

A dynamic statewide water budget for New Mexico by major river basin, NM State Appropriations, $49,978

Sustaining the Environment at the New Mexico-Chihuahua Border, New Mexico Environment Department, $60,644

Impact of Drought on Household Water Quality in Rural Southern New Mexico, NM Department of Health, $75,000

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan, Phase 2, USGS (non WRRA) $79,290

Chihuahuan Desert Network Administrative Support, National Park Service $99,703

Groundwater Exploration, Assessment and Monitoring for Humanitarian Assistance in Ethiopia USGS Supplemental $421,500

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan

Basic Information

Title:	Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan
Project Number:	2008NM114S
USGS Grant Number:	08HQAG0146
Sponsoring Agency:	None
Start Date:	9/22/2008
End Date:	7/21/2015
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Category:	None, None, None
Descriptors:	Afghanistan, crop growth, agriculture, economics
Principal Investigators:	Alexander G. Fernald, Frank Ward

Publications

1. 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.
2. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
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. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
5. Shahruh Jalilov, Saud Amer, and Frank Ward, "Reducing Conflict in the Development and Allocation of Transboundary Waters," Eurasian Geography and Economics, April 2013.
6. Abdelaziz Gohar, Saud Amer, and Frank Ward, "Economic Performance of Water Storage Capacity Expansion for Food Security," Journal of Hydrology, January 2013.
7. Frank Ward, Saud Amer, and Fahim Ziaee, Water Allocation Rules in Afghanistan for Improved Food Security, Food Security, November 2013.
8. 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.
9. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
10. Jalilov, S-M, S.A. Amer, and F.A. Ward, 2013, Reducing Conflict in the Development and Allocation of Transboundary Rivers, Eurasian Geography and Economics, pp. 1-32.
11. Abdelaziz A.G., F.A. Ward, and S.A. Amer, 2013, Economic Performance of Water Storage Capacity Expansion for Food Security, Journal of Hydrology, Vol. 484, pp. 16-25.
12. Ward, F.A., S. Amer, and F. Ziaee, 2013, Water Allocation Rules in Afghanistan for Improved Food Security, Food Security, November 2013.

13. Shokhrukh-Mirzo, J., S.A. Amer, and F.A. Ward, 2013, Water, Food, and Energy Security: An Elusive Search for Balance in Central Asia, Water Resources Management, Vol. 27, pp. 3959-3979.
14. 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.
15. Ward, F.A., 2012. Cost benefit and water resources policy: A survey. Water Policy. 14:250-280.
16. Jalilov, S-M, S.A. Amer, and F.A. Ward, 2013, Reducing Conflict in the Development and Allocation of Transboundary Rivers, Eurasian Geography and Economics, pp. 1-32.
17. Abdelaziz A.G., F.A. Ward, and S.A. Amer, 2013, Economic Performance of Water Storage Capacity Expansion for Food Security, Journal of Hydrology, Vol. 484, pp. 16-25.
18. Ward, F.A., S. Amer, and F. Ziaee, 2013, Water Allocation Rules in Afghanistan for Improved Food Security, Food Security, November 2013.
19. Shokhrukh-Mirzo, J., S.A. Amer, and F.A. Ward, 2013, Water, Food, and Energy Security: An Elusive Search for Balance in Central Asia, Water Resources Management, Vol. 27, pp. 3959-3979.
20. Abdelaziz A. Gohar, S.A. Amer, and F.A. Ward, 2015, Irrigation Infrastructure and Water Appropriation Rules for Food Security, Journal of Hydrology, 520, 85-100.

Description of problem and research objectives

This is the seventh year of a cooperative agreement with NMSU and the US Geological Survey in support of the development of reducing food poverty through analysis of improved irrigation systems and institutions in Afghanistan. Activities have focused on the application and development of techniques for monitoring the physical factors 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 infrastructure development.

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.

Five journal articles have been published since the year 2008 that examine 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.

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 phonological 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.

Data on weather patterns and crop water use were assembled and integrated to perform a policy assessment of alternative institutional and infrastructure interventions for adapting to long term patterns of flood and drought. Results are described below.

Ongoing work is underway to expand these findings to a national level in Afghanistan, for all 18 river basins in the country. Results will likely be used to provide information to assess alternative transboundary water sharing arrangements between Afghanistan and its downstream neighbors.

Principal findings and significance

In the developing world's irrigated areas, water management and planning is often motivated by the need for lasting food security. Two important policy measures to address this need are improving the flexibility of water appropriation rules and developing irrigation storage infrastructure. Little research to

date has investigated the performance of these two policy measures in a single analysis while maintaining a basin wide water balance. This research examined impacts of storage capacity and water appropriation rules on total economic welfare in irrigated agriculture, while maintaining a water balance. The application is to a river basin in northern Afghanistan. A constrained optimization framework is developed to examine economic consequences on food security and farm income resulting from each policy measure. Results show that significant improvements in both policy aims can be achieved through expanding existing storage capacity to capture up to 150 percent of long-term average annual water supplies when added capacity is combined with either a proportional sharing of water shortages or unrestricted water trading. An important contribution of the research is to show how the benefits of storage and a changed water appropriation system operate under a variable climate. Results show that the hardship of droughts can be substantially lessened, with the largest rewards taking place in the most difficult periods. Findings provide a comprehensive framework for addressing future water scarcity, rural livelihoods, and food security in the developing world's irrigated regions.

Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq

Basic Information

Title:	Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq
Project Number:	2010NM123S
USGS Grant Number:	G10AC00516
Sponsoring Agency:	None
Start Date:	9/1/2010
End Date:	8/31/2015
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, Water Use, Management and Planning
Descriptors:	Forecasting, Climate, Water Use, Land Use, Agriculture, Drought
Principal Investigators:	Alexander G. Fernald, Frank Ward

Publications

1. Water Rights Systems for Adapting to Shortage (under review, Journal of the American Water Resources Association)
2. Salman, D.A., S.A. Amer, and F.A. Ward, 2014, Water Appropriation Systems for Adapting to Water Shortages in Iraq, Journal of the American Water Resources Association, pp. 1-18.
3. Salman, D.A., S.A. Amer, and F.A. Ward, 2014, Water Appropriation Systems for Adapting to Water Shortages in Iraq, Journal of the American Water Resources Association, pp. 1-18.
4. Salman, D.A., S.A. Amer, and F.A. Ward, 2015, Water Right Systems to Protect Food Security in the Lower Tigris-Euphrates. Under journal review: Water Policy, April, 2015.

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. Important policy debates centers in the most economically sustainable interventions for making more economical 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.

Methodology

1) Secure agro-meteorological data for water and crop monitoring and forecasting
2) Secure meteorological data for dust storm forecasting
3) Development of crop monitoring and production estimating tools
4) Temperature and photoperiod inputs to yield estimation
5) Development of hydroeconomic policy analytic tools
6) Improved rainfall forecasts
7) Improved understanding of relations between snowpack and streamflow
8) Formulate empirical analysis examining economic impacts of alternative methods to address food security in Iraq in the face of falling or unreliable surface water supplies.

Description of principal findings and significance

Much research has examined climate-related impacts on food security, but little has systematically examined flexible water right systems for protecting food security. This research addresses that gap by examining the performance of alternative water right systems that could protect food security while adapting to ongoing water supply fluctuations. It examines three alternative water allocation rules for adapting to drought while protecting food grain security in the Lower Tigris-Euphrates Basin, Iraq. The most widespread method for sharing water shortages when they occur in Iraq is an upstream priority water allocation system. Two alternative method for adapting to reduced supplies are a proportional sharing of shortages and a market system for trading water. It formulates a national scale farm income maximization framework to assess the performance of three water shortage sharing methods under each of two potential food subsidy programs based on how each contributes to protecting national food security. A proportional sharing of shortages and unrestricted water trading both outperform an upstream priority system. Results point to the importance of carefully designed rules for allocating water shortages to ensure food grain security in the world's irrigated regions where drought and climate warming pose growing challenges.

The transport and accumulation of pyrogenic black carbon in fire-prone watersheds and implications for water quality

Basic Information

Title:	The transport and accumulation of pyrogenic black carbon in fire-prone watersheds and implications for water quality
Project Number:	2013NM160B
Start Date:	6/1/2013
End Date:	5/31/2014
Funding Source:	104B
Congressional District:	NM-2
Research Category:	Water Quality
Focus Category:	Geomorphological Processes, Hydrogeochemistry, Surface Water
Descriptors:	None
Principal Investigators:	Daniel Cadol, Michael Heagy, Fred Phillips

Publications

There are no publications.

Description of problem and research objectives

Problem: Post-wildfire debris flows and flooding deliver abnormally high loads of sediment to downstream waterways. In addition to the mineral sediment, black carbon (BC) in the form of soot and char generated by incomplete combustion of organic matter is transported and redeposited throughout the watershed. Black carbon has the potential for both negative impacts on water quality, for example fouling of drinking water supplies and generation of anoxic conditions, and positive impacts, such as sequestration of hydrophobic contaminants through sorption. An improved understanding of the transport and accumulation of BC following wildfire will be beneficial to managers implementing post-fire emergency treatments and preparing for impacts to downstream resources and infrastructure. The intensity and frequency of forest fires are predicted to increase as a result of climate change and shifts in land use, and New Mexico is reliant on forested catchments for much of its drinking water, making well-informed post-fire management ever more important.

This research measured the black carbon concentration in depositional zones of two recently burned watersheds in Valles Caldera National Preserve, New Mexico. We tested for the presence of certain contaminants found by previous researchers to be associated with wildfires. We measured the arsenic partitioning characteristics of a subset of our depositional zone soil samples.

Objectives: The primary objective of this work was to quantify the relative abundance of black carbon in two potential depositional zones – channel margins/floodplains and depositional fans. There were two secondary objectives: 1) Quantify the capacity of depositional zone soil samples from recently burned watersheds to absorb the heavy metals arsenic and chromium; and 2) Document the presence or absence of Cr, As, and Pb in depositional zone samples from recently burned watersheds, noting the partitioning of these constituents between the black carbon fraction of the soil and the remainder of the matrix. The primary objective is given greater attention because it is of interest from three perspectives: 1) Contaminant filtration (as addressed in the secondary objectives), 2) global carbon cycling and sequestration, and 3) soil fertility and pedogenesis.

Description of methodology

Sampling/Field Methods: We selected two field areas in New Mexico with recent fires: the Las Conchas fire (2011) and the Thompson Ridge fire (2013). An unburned control site was selected in the Cebolla Creek watershed. Moderate-resolution DEMs (30 m cells) and high-resolution stereophotogrammetry analyses (meter-accuracy) were used to characterize the morphology of the study basins and streams (relief, valley confinement, valley gradient, hillslope steepness) and to map geomorphic features of interest (debris fans, floodplains, active channel banks, and hillslopes of various steepness and aspect). Soil sampling was stratified by geomorphic context. Soil was collected systematically from hill slopes, river banks, floodplains, and alluvial fans, with sample locations marked by GPS and imported into a GIS.

Additionally, 28 soil pits in the vicinity of Redondo Peak that had been sampled in 2009, prior to the Thompson Ridge fire, were resampled. The archived pre-fire soils and the resampled post-fire soils were analyzed for black carbon content, and the geomorphic context of the pit locations were described.

Black Carbon Quantification Methods: The Chemo-thermal oxidation method (CTO-375) is a well-established procedure known for its reliable results for soil samples (Hammes, et al., 2007) and for its capability to measure the amount of soot in a soil sample. This method oxidizes organic carbon at 375ºC,

acidifies inorganic carbon and converts it to CO_2, and finally quantifies the remaining carbon in the sample as black carbon. We modified this method to combust at 340ºC in order to increase the amount of char quantified in the analysis.

Contaminant Sequestration Analysis: Selected samples were tested for the presence of arsenic (As), chromium (Cr), mercury (Hg), and lead (Pb) using ICP-MS analysis methods (Moor et al., 2001; Melaku et al., 2005). Selected samples were also analyzed for As sorption using isotherm batch equilibrium experiments, performed at concentrations ranging from 0.001 to 0.1 mg/L. For the sorbents, two soils were tested, as well as a soil spiked with additional black carbon and a commercially available black carbon sample.

Principal findings and significance

In the broad geomorphic sampling of two burns and a control site we found evidence for enhanced local deposition following fire. Significant amounts of soot were also found in the control site, indicating either long-lived (>70 years) retention in the soil, or deposition of windblown ash in areas far from active fires. In the years following a fire, we found evidence of decreasing black carbon in soils, which may either be the result of biochemical breakdown or of erosion and transport downstream.

In the pre- and post-fire soil pit samples we found minimal changes in mean black carbon content. However BC content tended to increase in geomorphic positions low on slopes and near streams, while BC content tended to decrease in positions high on hillslopes. This suggests post-fire erosion on hillslopes, and deposition at the foot of slopes and on floodplains. There is also the possibility that pre-existing soil black carbon was combusted during the fire.

Arsenic sorption did not vary greatly between the hillslope and the floodplain soil that we analyzed. Adding black carbon to the samples did not increase equilibrium sorption for low concentrations (0.001 mg/L) but did increase capacity and rate for higher concentrations (0.1 mg/L).

Geographic Information Systems for Water Resources Research Planning

Basic Information

Title:	Geographic Information Systems for Water Resources Research Planning
Project Number:	2013NM162B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	NM ALL
Research Category:	Not Applicable
Focus Category:	Drought, Hydrology, Models
Descriptors:	None
Principal Investigators:	Alexander G. Fernald

Publication

1. Walker, J.S, J. Hawley, C. Brown, and A. Fernald, 2014, Examination of Mesilla Basin Aquifer Pollution Sensitivity Using the DRASTIC System, New Mexico Water Resources Research Institute Technical Completion Report, in preparation.

Description of problem and research objectives

The New Mexico Water Resources Research Institute has become a 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 grows and presents new opportunities, it also raises 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 moves 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, and make the data available to cooperating agencies and organizations through both formal and informal arrangements to facilitate water resource planning activities.

Description of 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 NM WRRI, 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 NM WRRI maintains a GIS laboratory consisting of computer workstations; data storage devices; input/output devices; software for mapping and analysis (ArcGIS, ENVI); 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 NM WRRI also maintains an Internet web server site through which both spatial and tabular water resource data can be provided.

Description of principal findings and significance

Various research activities are supported by the system for water resources planning in the state. The New Mexico Interstate Stream Commission has utilized GIS mapping products for use in their regional plans and in public outreach. 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.

The sophisticated GIS mapping and geo-spatial database management system, originally designed to support NM WRRI-funded research activities, has been used for external research grants by water resources management and planning agencies in the state (e.g., New Mexico Office of the State Engineer, New Mexico Environment Department, New Mexico Department of Agriculture, Paso del Norte Water Task Force, and New Mexico State University).

During the reporting period, projects supported by the GIS lab included the National Science Foundation: New Mexico Experimental Program to Stimulate Competitive Research (NM EPSCoR) project, the Statewide Water Assessment, and acequia projects.

The EPSCoR statewide water assessment for New Mexico 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.

Groundwater Exploration, Assessment and Monitoring for Humanitarian Assistance in Ethiopia

Basic Information

Title:	Groundwater Exploration, Assessment and Monitoring for Humanitarian Assistance in Ethiopia
Project Number:	2013NM171S
USGS Grant Number:	G13AC00037
Sponsoring Agency:	USGS
Start Date:	3/1/2013
End Date:	2/28/2015
Funding Source:	104S
Congressional District:	
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Alexander G. Fernald

Publications

1. Jalilov, S-M, S.A. Amer, and F.A. Ward, 2013, Reducing Conflict in the Development and Allocation of Transboundary Rivers, Eurasian Geography and Economics, pp. 1-32.
2. Jalilov, S-M, S.A. Amer, and F.A. Ward, 2013, Reducing Conflict in the Development and Allocation of Transboundary Rivers, Eurasian Geography and Economics, pp. 1-32.
3. Befekadu Goraw Habteyes, 2015, Mutually Beneficial and Sustainable Management of Ethiopian and Egyptian Dams in the Nile Basin, unpublished MS thesis, New Mexico State University, Summer, 2015.

Description of problem and research objectives

New Mexico State University, Las Cruces, has established a program of cooperative activities with the U.S. Geological Survey in support of the drought mitigation project for humanitarian assistance in part of Ethiopia funded by the USAID, Ethiopia mission.

The economy of Ethiopia is largely dependent on agriculture which accounts for approximately 41% of GDP and about 85% of the total employment. The average annual rainfall is 1,200 mm (The World Fact Book, CIA and Ethiopia-Wikipedia, 2012). Even though the highlands of Ethiopia are the sources and headwater of the Blue Nile, but due to the lack of well-developed hydrologic infrastructure in the country, agriculture is mainly dependent on rain and groundwater resources. Given the wide annual variation in rainfall and less developed groundwater resources management and planning, the country faces frequent droughts and major food insecurity, Figure 2 (A-C), rainfall estimates (RFE), FEWS Net Data Portal, USGS and USAID, 2012.

Activities at NMSU are focusing on the application and development of techniques for monitoring the physical variables governing crop growth, such as the timing and amount of precipitation, evapotranspiration and temperature, along with human-related factors such as cropped area, agricultural inputs, and economic indicators. We will combine university-based research in the modeling, monitoring and analysis of remotely sensed estimates of environmental variables with science advisory, training, and development activities in Ethiopia. We plan to bring together field scientists from Ethiopia with research scientists at New Mexico State University, Las Cruces in a single team of the New Mexico Water Resources Research Institute, assembled to take on the activities needed to deal with threats to food security in Ethiopia.

Methodology

NMSU's strengths in statistical climatology, hydrology, GIS, remote sensing, water resource economics, modeling, and policy analysis, match up well with the goals of the proposed activities. The university is using these strengths to improve the scientific research, capacity building, and applications of the USGS component Water Resources Studies in Ethiopia.

The university's scientific focus will be on estimating timed crop water relationships, with emphasis on monitoring and forecasting the natural and human inputs to food production and economics of water allocation. Scientific research will address improved monitoring of rainfall, crop modeling, and quantifying the connection between water, irrigated land rehabilitation, development of reservoir storage, crop prices, farm production costs, and farm net income. Better techniques, algorithms, and modeling applications, involving exploitation of remote sensing and other geospatial data, will emerge.

Integration of data from a variety of sources can result in a product that exploits the positive characteristics of all the input datasets. This is especially true for precipitation where satellite derived estimates can be merged with station values to create a rainfall field that is superior to either of these sources individually. The team at NMSU has developed a series of tools and techniques that allow the analysis and integration of points and raster rainfall datasets. The NMSU team also has been working on the development of water allocation models and decision support tools that enable professionals in the

field and decision makers for more informed decisions regarding agriculture and economics of water uses and best practices.

The work for this proposal is to integrate remotely-sensed, observed and ancillary data into the existing tools and models, develop new ones as necessary, to help the Government of Ethiopia (GoE) to explore new sources of groundwater, increase drilling success of water wells, develop a sustainable water use plan, and to study economics of water use and water allocations. Also, the proposed activities include capacity building to Ethiopian professionals and NGOs working in the water sector.

Description of principal findings and significance

Ongoing pressures from population growth, recurrent drought, climate, urbanization and industrialization in the Nile Basin raise the importance of finding viable methods to adapt to these pressures. Four tributaries of the Eastern Nile Basin contribute to supplies of the Nile. These include the Blue Nile (55%), White Nile-Albert (15%), Atbara (10%), and Sobat (10%). Several existing studies have been published and programs have been enacted addressing the need to equitably share the Nile's waters among the basin riparians. Despite this, no peer reviewed studies to date have quantitatively examined opportunities for a greater economic benefits of the whole basin that could be achieved through the development and management of new storage infrastructure on the Nile. Moreover, the risk of growing future scarcity of water motivates the search for alternative benefit sharing arrangements that could reduce impacts on downstream water users resulting from new upstream water developments. Therefore, this research examines the potential for mutually beneficial and sustainable benefit sharing management from the operation of the Ethiopian Grand Renaissance and the Egyptian High Aswan Dams. An integrated approach is formulated to bring the hydrology, economics and institutions of the region into a unified framework for policy analysis. A nonlinear optimization model is developed to identify the potential for Pareto improving operation to minimize impacts of these two dams for the four Eastern Nile countries: Ethiopia, South-Sudan, Sudan and Egypt. Results indicate that it is possible for all four countries to be better off with careful operation of both dams. Despite these results, considerable diplomatic negotiation among the four riparian will be required to turn potential gains into actual on-the-ground welfare improvements.

Self-Sustaining Produced Water Treatment for Concurrent Renewable Energy Production, Desalination and Organic Removal

Basic Information

Title:	Self-Sustaining Produced Water Treatment for Concurrent Renewable Energy Production, Desalination and Organic Removal
Project Number:	2014NM166B
Start Date:	5/1/2014
End Date:	4/30/2015
Funding Source:	104B
Congressional District:	Dona Ana
Research Category:	Water Quality
Focus Category:	Treatment, Wastewater, Water Use
Descriptors:	None
Principal Investigators:	Pei Xu

Publications

1. Stoll A.Z., C. Forrestal, Z. Ren, and P. Xu, 2015, Shale Gas Produced Water Treatment Using Innovative Microbial Capacitive Desalination Cell. Journal of Hazardous Materials, Vol. 283, pp. 847-855.
2. Stoll, Z.A, J. Dolfing, Z. Ren, and P.Xu, 2015, Interplay of anode, cathode and current in microbial fuel cells: implications for wastewater treatment. In preparation, to be submitted to Bioresources Technology.

Brief description of problem and research objectives

The oil & gas exploration and production plays a critical role in national energy security and economic development. Management of produced water is a significant challenge to oil & gas producers and operators. Produced water contains contaminants such as suspended and colloidal solids, petroleum hydrocarbons, salts, and chemical additives. The water is considered hazardous waste and must be treated or disposed safely. The common disposal method - deep well injection is costly and waste of valuable water resources. Conventional thermal evaporation and membrane-based water treatment technologies such as reverse osmosis are cost and energy intensive.

In this study, we propose to develop an innovative microbial capacitive deionization cell (MCDC) to simultaneously remove organic substances and salts from produced water so it can be recycled and reused. Moreover, compared to other energy intensive systems, MCDC uses bacteria to convert biodegradable pollutants into direct electricity, which offsets operation energy use or supplies additional energy for other systems.

Therefore the objectives of the research are threefold: 1) develop modular MCDC to substantially increase system performance in produced water treatment and energy production; 2) optimize the systems with novel electrode materials to make the technology more efficient; 3) evaluate the MCDC process at system level for treating produced water.

Description of methodology

MCDC is the latest application of bioelectrochemical systems (BESs). BESs use microorganisms as biocatalysts to oxidize biodegradable electron donors and generate electricity (microbial fuel cell, MFC) or value-added chemicals (microbial electrolysis cells, MEC). For example, in a two-chamber MFC reactor, bacteria oxidize organic compounds in the anode chamber to acquire energy for metabolisms. Some of the electrons derived from this oxidization are transferred from the bacteria to the anode and then flow to the cathode through an external circuit, where they are harvested for direct current generation. In the mean time, equal amount of protons are released into the anolyte. If a pair of anion exchange membrane (AEM) and cation exchange membrane (CEM) is installed in the MFC reactor, with the AEM next to the anode and the CEM by the cathode, the two-chamber MFC becomes a three-chamber microbial desalination cell (MDC), which is able to desalinate salty water, such as seawater, brackish water, and produced water.

MCDC, which integrates capacitive deionization (CDI) into the MDC design, has the advantages of using electrodes to electrically adsorb ions while overcoming the challenges of pH imbalance and preventing salt transport to anode and cathode. A schematic of the MCDC is illustrated in Figure 1. Modular MCDC reactors were built treating a produced water from shale gas production. Produced water was deionized through electrochemical ion adsorption driven by the electrical field generated by microorganisms. Activated carbon cloth (ACC) – membrane assemblies were designed to connect with the anode and cathode and adsorb ions from water. During desalination, the ions are stored in the electrical double layer capacitors between the solution and the ACC assembly interfaces, thus preventing the salinity increase in treated wastewater. After the ACC is saturated with adsorbed ions, the assembly can be

regenerated by removing the electrical potential and the retained salts can be fully recovered in situ for disposal or further salt recovery.

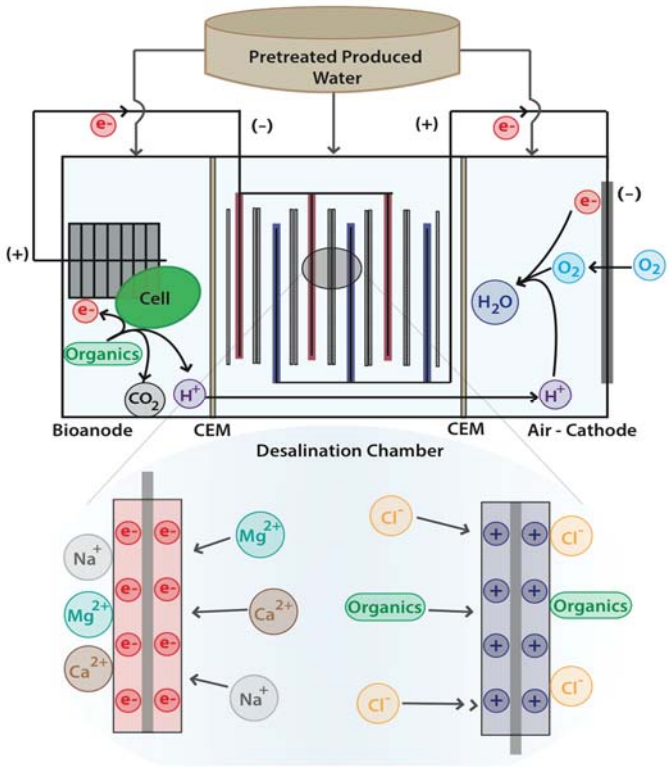

Figure 1. Schematic of the MCDC treatment process

Principal findings and significance

In this study we investigated the removal capabilities and mechanisms of a microbial powered system that harnesses the energy stored in the organic compounds to power the treatment of produced water. This proof-of-concept study demonstrated that the shale gas produced water contained sufficient biodegradable organic matter to run the MCDC, generating an electrical potential of 0.25-0.28 V for desalination. In the anode, removal of DOC and aromatics was due to biodegradation and sorption, and the microbial community was able to generate a consistent potential over the life of the experiment. Salt was mostly removed by electrosorption, a reversible processes, in the MCDC. Over 36 mg TDS/g ACC was removed from the desalination chamber in one hour, demonstrating the desalination efficiency of MCDC is much higher than conventional MDC and CDI.

The ongoing research is focused on understanding the interplay of anode, cathode and current in microbial fuel cells for wastewater treatment. In addition, inexpensive and innovative materials such as carbon felt and Fe-EDTA activated carbon were synthesized and used as electrodes in order to reduce the costs of MFC and MCDC.

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 58 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 NM WRRI homepage.

Information Transfer Program

Basic Information

Title:	Information Transfer Program
Project Number:	2013NM161B
Start Date:	3/1/2013
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	NM ALL
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	Cathy T. Ortega Klett

Publications

1. Ortega Klett, C.T., 2013, Proceedings of the 57th Annual New Mexico Water Conference, Hard Choices: Adapting Policy and Management to Water Scarcity. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 361, New Mexico State University, Las Cruces, New Mexico.
2. Ortega Klett, C.T., 2014, Proceedings of the 58th Annual New Mexico Water Conference, New Water Realities, Proposals for Meaningful Change. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 364, New Mexico State University, Las Cruces, New Mexico. In preparation.
3. Hawley, J.W., 2014, Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP). New Mexico Water Resources Research Institute, Technical Completion Report. In preparation.
4. Wilson, J.L., and K. Henry, 2014, Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance to Contaminant Transport and Chemical Reactions. New Mexico Water Resources Research Institute, Technical Completion Report. In preparation.
5. Ortega Klett, C.T., 2014, Proceedings of the 57th Annual New Mexico Water Conference, Hard Choices: Adapting Policy and Management to Water Scarcity. New Mexico Water Resources Research Institute, Conference Proceedings Report No. 361, New Mexico State University, Las Cruces, New Mexico.
6. Wilson, J.L., and K. Henry, 2014, Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance to Contaminant Transport and Chemical Reactions. New Mexico Water Resources Research Institute, Technical Completion Report No. 362, New Mexico State University, Las Cruces, New Mexico.

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, including the state's policy makers, 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 59 years, the NM WRRI 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. However, the past three years have seen an increase in attendance: the 2012 conference had an attendance of over 500, the 2013 conference attracted 326 participants, and the 2014 conference had nearly 350 participants in attendance. A few years ago, the New Mexico State Engineer called the NM WRRI annual conference the premier water meeting in the state. For the past four years, the annual water conference has included a poster session, which highlights water research taking place across the state and region. Students are encouraged to present posters at the annual water conference and in 2014, 44 students did so. NM WRRI made 16 Student Water Research Grants in 2014, and most of the recipients attended the annual water conference and presented a poster.

Publications include technical completion reports resulting from NM WRRI-sponsored projects, special in-house publications, and conference proceedings. The institute has published more than 388 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 NM WRRI 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. NM WRRI water conference proceedings for the past 58 years are also available online in full text.

The institute's 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 NM WRRI homepage.

The institute-housed reference room, is undergoing a major reorganization. All books and documents were checked for online availability; for books found to be available online, the library database was noted with the link. Hard copies of these books were recycled. Over 1,500 books were donated to the New Mexico State University Library. Currently, remaining books and documents are being catalogued. A complete catalog of holdings, 10,500 books and references, can be searched through the NM WRRI homepage library webpage at http://wrri.nmsu.edu/wrdis/library/librarysearch.html, accessible by faculty, students, and the general public.

NM WRRI's homepage (http://wrri.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, originally created in 1995, is undergoing a complete redesign and should be ready to launch in June 2015. The website 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. For the reporting period, the NM WRRI website received over 57,000 unique visits.

NM WRRI 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. In recent years, the NM WRRI has provided GIS expertise on a regular basis to the National Park Service.

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 59th Annual New Mexico Water Conference was held in Santa Fe on November 18-19, 2014. The conference theme was "New Mexico's Water Future: Connecting Stakeholder Needs to Water Information." The conference focused on a new NM WRRI initiative, made possible through the 2014 New Mexico State Legislature. Projects are underway to develop critical data synthesis to address water scarcity challenges. The Institute, with many collaborators statewide, is developing a statewide water assessment that will help identify the relative magnitudes of water issues and will help move state water planning forward. An up-to-date assessment for water policy guidance will help New Mexico plan for a sustainable water future as every sector of our economy, including jobs, education, culture, and health relies on available and good quality water. The 2014 conference featured investigators from the major projects associated with the statewide water

assessment. It was attended by nearly 350 participants and included 54 posters, of which 44 were presented by students. PowerPoint presentations made at the conference are available on the institute's website. The conference proceedings is in preparation and will be posted on the website. All conference participants will receive a copy on CD.

Again this year, the annual technical symposium was combined with the annual water conference. Fifty-four posters were presented, many by students. The poster session was held during a morning break and participants voiced their pleasure at the quality and quantity of posters. All poster abstracts are available on the institute's conference website.

The 58th Annual New Mexico Water Conference proceedings is nearing completion and will be produced in hardcopy and on CD. As papers are completed, they are posted on the institute's website as are all publications. Technical Completion Report No. 362, *Computational Fluid Dynamics Modeling of Karst Conduit-Matrix Exchanges with Relevance to Contaminant Transport and Chemical Reactions*, by NM Tech investigators Dr. John L. Wilson and PhD student Katrina M. Henry was published in July 2014.

For the past year, the institute's website has averaged 5,227 unique online visits each month. It averages 2,391 online unique visits for publications from its technical and miscellaneous report series and an average of over 16,605 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 newsletter, *The Divining Rod*, is an eight- to twenty-page newsletter that focuses on research projects administered by the NM WRRI 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 NM WRRI's website. 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 one newsletter, a 16-page issue of *The Divining Rod*. The newsletter received an average of 647 downloads per month online during the past year. The institute initiated a monthly online news update, NM Water *e*News, in March 2015. Online unique visits per month of the NM WRRI's reference room averaged 206 for the reporting period.

The institute's director participates in local, state, and national conferences and workshops and speaks before many groups. He is an active member of the National Institutes for Water Resources and is the chair of the NIWR-USGS Partnership Committee. The director is also a member of the Universities Council on Water Resources and serves on their board. The NM WRRI 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. Of particular note this year, the director gave two presentations to the NM Legislature, one

to the House Committee on Agriculture, Water & Wildlife and another to the Senate Conservation Committee, updating legislators on the institute's programs and on the Statewide Water Assessment initiative. The Director also spoke at the 2015 New Mexico Legislature's Water Policy Day Press Conference.

This past year, the institute was successful in obtaining additional funding from the NM State Legislature for its base state funding. After a severe 52% reduction in 2010 of its state funding, $300,000 was added for FY 16 base funding. Also, NM WRRI will receive $500K to continue the Statewide Water Assessment initiative to improve water management in New Mexico. The FY 16 funding was provided by the legislature with the support of the Governor. It will elevate the institute's ability to address New Mexico's myriad water problems. The funding will go toward the institute's core mission of supporting faculty and student grants as well as to address three priority topic areas: the Statewide Water Assessment; brackish and produced water research and coordination; and data acquisition to acquire, process, synthesize, and deliver data to assist in policy decisions.

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

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	9	0	0	0	9
Masters	6	0	0	4	10
Ph.D.	1	0	0	1	2
Post-Doc.	1	0	0	0	1
Total	17	0	0	5	22

Notable Awards and Achievements

New Mexico State University's interdisciplinary Water Science and Management graduate degree program currently has 35 students enrolled representing 10 countries. Seven students have graduated from the program. The program has increased enrollment in graduate education, increased water research, and has added doctoral level courses offered in the departments of Civil Engineering, Geography, Plant and Environmental Sciences, Agricultural Economics/Agricultural Business, and Animal and Range Sciences. Graduate program coordinator, Desa Daniel, received two master's degrees during the reporting period and received two national awards: the A. Toy Caldwell-Colbert Student Contributions to Service Award from American Psychology Association Division 45 for student contribution and service to the field of multicultural psychology and the Timothy R. Donoghue Graduate Leadership Scholarship.

New Mexico Tech faculty grant recipient, Professor Daniel Cadol was very successful in using research results from his 104B-supported grant to obtain an NSF research grant from the Earth Sciences Geomorphology and Land Use Dynamics directorate in the amount of $89,634 to extend this research. Three of Dr. Cadol's students working on the research project were also successful in obtaining research grants to support the project, one award from the Geological Society of America and two from the New Mexico Geological Society. Content from Professor Cadol's research project was added to ERTH 440 Physical Hydrology and HYD 543 Ecohydrology at New Mexico Tech.

Three supplemental USGS international awards are in progress, which include projects in Afghanistan, Iraq, and Ethiopia. A new graduate course at New Mexico State University has been developed as a result of the projects WSAM 610: Water Sustainable Economic Development, a PhD seminar taught for the first time in the fall of 2014. Also associated with these projects, graduate student Dina Salman and Dr. Frank Ward taught a short course in Erbil, Iraq in August 2013 dealing with drought adaptation by irrigated agriculture in the Lower Tigris-Euphrates Basin. A master's thesis, "Mutually Beneficial and Sustainable Management of Ethiopian and Egyptian Dams in the Nile Basin," was completed under the direction of the Ethiopia project.

New Mexico State University Professor Pei Xu led the 104B-supported grant, "Self-sustaining Produced Water Treatment for Concurrent Renewable Energy Production, Desalination, and Organic Removal" and developed a new course at NMSU from the project ENVE 598 MO5: Advanced Water Treatment and Wastewater Reuse. One of Dr. Xu's students on the project was first author on a paper published in the "Journal of Hazardous Materials," is preparing another article for "Bioresources Technology," and presented research results at three meetings. The project was featured in a New Mexico State University news release, "NMSU studies treatment, uses for wastewater from oil and gas, fracking" in April of 2014.

Publications from Prior Years

1. 2006NM63G ("Validation, Calibration, and Improvement of Remote Sensing ET Algorithms in Mountainous Regions") - Water Resources Research Institute Reports - Hendrickx, J.M.H. and J. Kleissl, 2015, Validation, Calibration, and Improvement of Remote Sensing ET Algorithms in Mountainous Regions Using Scintillometers, NM WRRI Technical Completion Report No. 366, New Mexico State University, Las Cruces, NM.