

**New Mexico Water Resources Research Institute
Annual Technical Report
FY 2013**

Introduction

This program report provides the required information for projects funded with the 2013 base grant and mandatory non-federal matching funds. Please note that there may be some overlap in information with our 2012 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 (wri.nmsu.edu) provides online information about the institute, newsletters, technical report series, requests for proposals, upcoming conferences and symposia, links to related entities, and the research reference library.

New Mexico is one of the driest states in the nation, averaging no more than 20 inches of precipitation a year, varying from about 6.5 inches in the Four Corners area to more than 30 inches in the high mountains. The relative humidity is low, resulting in a high rate of evaporation. Summer rain accounts for almost half of the annual precipitation other than in the high mountains. Widely varied precipitation contributes as much to a water allocation problem as water scarcity itself. To compound the situation, New Mexico, like much of the West, continues to suffer from the worst drought in 100 years or longer. As of April 2014, severe to exceptional drought covered 80 percent of New Mexico with January 2014 receiving only 4% of normal precipitation, the driest January on record going back to 1895. By almost any measure, under current trends and trajectories, future water supply will not meet 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 2013 Annual Base Program. Three of these projects fit into the water conservation, planning and management category: "WRRI Information Transfer Program," "Geographic Information System for Water Resources Planning," and "Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)." A water quality project was also funded: "The Transport and Accumulation of Pyrogenic Black Carbon in Fire-prone Watersheds and Implications for Water Quality." 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, 2013 through February 28, 2014, the NM WRRI administered a total of ten projects dealing primarily with water planning and management issues. The total value of these projects was \$1,278,343. Dollar amounts per project award ranged from a small wastewater management system evaluation grant of \$3,361 to an international program effort of nearly \$422,000. During the reporting period, nine projects were conducted at New Mexico State University and one at New Mexico Tech. NM WRRI staff managed nine projects.

Research projects administered by the NM WRRI utilized 15 students during the year including undergraduates, masters, and Ph.D. candidates in the disciplines of agricultural economics, civil engineering, mechanical engineering, engineering technology, education, hydrology, geography, computer graphics, kinesiology, and water sciences.

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.

Information Transfer Program, USGS 104B \$35,028

Geographical Information System for Water Resources Planning, USGS 104B \$22,101

The Transport and Accumulation of Pyrogenic Black Carbon in Fire-prone Watersheds and Implications for Water Quality, NM Tech USGS 104B \$20,497

Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP), USGS 104B \$16,875

Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq, USGS Supplemental \$262,223 (year 4)

Research Program Introduction

Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan, USGS Supplemental \$290,417 (year 1)

Groundwater Exploration, Assessment and Monitoring for Humanitarian Assistance in Ethiopia USGS Supplemental \$421,906 (year 1)

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

Examination of Risk to Groundwater from Onsite Wastewater Management Systems, EPA/SCERP \$3,361

Chihuahuan Desert Network Administrative Support, National Park Service \$148,435

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

Basic Information

Title:	Award--Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan
Project Number:	2008NM114S
Start Date:	9/22/2008
End Date:	9/21/2013
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.

Problem and research objectives

This is the sixth 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.

Three journal articles have been published and two more are currently under review summarizing connections between irrigation institutions and food poverty in Afghanistan. The research examined the development of irrigation institutions that could contribute to reducing food poverty by improved water allocation among canals.

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, weeds, pests and disease infestations) and crop phenological stages (including land preparation) in addition to areas planted (% of the total by agricultural zone), planting and harvesting dates in addition to the expected yields during the agricultural year and final obtained yields after the harvesting; and 3) of 113 sites, 21 sites are complete agrometeorological stations (three observations daily), with 19 classical stations recording 7 weather parameters and 5 automatic stations that can report on up to 20 weather parameters at daily step.

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

Continued climate variability, population growth, and rising food prices present ongoing challenges for achieving food and water security in poor countries that lack adequate water infrastructure. Undeveloped storage infrastructure presents a special challenge in northern Afghanistan, where food security is undermined by highly variable water supplies, inefficient water allocation rules, and a damaged irrigation system due three decades of war and conflict. Little peer-reviewed research to date has analyzed the economic benefits of water storage capacity expansions as a mechanism to sustain food security over long periods of variable climate and growing food demands needed to feed growing populations. This research develops and applies an integrated water resources management framework that analyzes impacts of storage capacity expansions for sustaining farm income and food security in the face of highly fluctuating water supplies. Findings illustrate that in Afghanistan's Balkh Basin, total farm income and food security from crop irrigation increased, but at a declining rate as water storage capacity increases from zero to an amount equal to six times the basin's long-term water supply. Total farm income increases by 21%, 41%, and 42% for small, medium, and large reservoir capacity, respectively, compared to the existing irrigation system unassisted by reservoir storage capacity. Results provide a framework to target water infrastructure investments that improve food security for river basins in the world's dry regions with low existing storage capacity that face ongoing climate variability and increased demands for food security for growing populations.

Award--Transboundary Aquifer Assessment Program

Basic Information

Title:	Award--Transboundary Aquifer Assessment Program
Project Number:	2008NM115S
Start Date:	4/1/2008
End Date:	3/31/2013
Funding Source:	Supplemental
Congressional District:	2
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, None, None
Descriptors:	aquifer assessment, Mesilla Basin, Hueco Bolson, GIS, database,
Principal Investigators:	Alexander G. Fernald, Phillip J King

Publications

1. Hawley, John W. and Alfredo Granados-Olivas, 2008, Progress Report on Development of an Annotated Bibliography for Transboundary Aquifer Systems of the Mesilla Basin-Paso del Norte Area, New Mexico, Texas (USA), and Chihuahua (MEX), poster presented at the 2008 New Mexico Water Research Symposium, Socorro, NM, August 2008, Symposium Program and Abstracts.
2. Kambhammettu, B.V.N.P., Chandramouli, S., and King, J.P. 2011. An improved DEM aggregation technique for models with non-uniform resolution. *International Journal of Geomatics and Geosciences*. 1:4:962-970.
3. Kambhammettu, B.V.N.P., Schmid, W., King, J.P., and Creel, B.J. 2011. Effect of elevation resolution on evapotranspiration simulations using MODFLOW. *Ground Water Journal*. doi: 10.1111/j.1745-6584.2011.00852.x.
4. Kambhammettu, B.V.N.P., Chandramouli, S., and King, J.P. 2011. An improved DEM aggregation technique for models with non-uniform resolution. *International Journal of Geomatics and Geosciences*. 1:4:962-970.
5. Kambhammettu, B.V.N.P., Schmid, W., King, J.P., and Creel, B.J. 2011. Effect of elevation resolution on evapotranspiration simulations using MODFLOW. *Ground Water Journal*. doi: 10.1111/j.1745-6584.2011.00852.x.
6. Phanindra Kambhammettu, BVN, J. P. King, and W. Schmid, 2013. Grid Size Dependency of Evapotranspiration Simulations in Shallow Aquifers – An Optimal Approach. Accepted with revisions, *ASCE Journal of Hydrologic Engineering*, Ms. No HEENG-1735.
7. Alley, William M. (ed). 2013. Five-year interim report of the United States-Mexico Transboundary Aquifer Assessment Program: 2007-2012. USGS Open-File Report 2013-1059. 31 pp.
8. Sheng, Z., M. Darr, J.P. King, J. Bumgarner, and A. Michelsen. 2013. Mesilla Basin/Conejos-Médanos Section of the Transboundary Aquifer Assessment Program. In USGS Open-File Report 2013-1059. pp. 19-31.

Description of problem and research objectives

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

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

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

Description of methodology

A review of all previously developed groundwater flow models was conducted last year. This year field studies were used to develop any additional data that are needed to define aquifer characteristics to the extent necessary to enable the development of groundwater flow models. Additional evaluations of all available data and publications relevant to the aquifer and produce a binational bibliography were conducted. The project utilized the geographic information system database that was created last year to better characterize the spatial and temporal aspects of the aquifer, with emphasis on a digital model of the hydrogeologic framework. The project also continued to expand existing agreements, as appropriate, between the authorities in the United States and Mexico to (1) conduct joint scientific investigations; (2) archive and share relevant data; and (3) carry out any other activities consistent with the program. A basin steering committee of local stakeholders was established to provide review and feedback on tasks and products.

Description of principal findings and significance

A bibliography of previous studies that was compiled in 2008 has been updated and reviewed by the USGS, New Mexico, and Texas team. This is an ongoing process as more literature is found and new literature is written. The basin-scale hydrogeologic

framework model that was produced in 2005, including cross sections and model layer maps, was reviewed and updated with recent information and a new compilation of well-control data. Expansion of this model into Mexico has been proposed and is pending finalization of the binational agreement for conducting joint investigations and basic-data sharing. Mesilla Basin groundwater flow models developed in the last 20 years have been reviewed and evaluated for their possible future use and modification. This evaluation still needs collaborative input from the Mexican authorities before selection of the most appropriate flow model(s) for expansion into Mexico.

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

The basic binational-agreement documents related to conduct of joint investigations and data sharing were signed in August 2009; and specific final arrangements for agreement implementation were planned for completion in March-April 2010.

All final reporting was completed. The USGS has published results in Open-File Report available online only: Five-year interim report of the United States-Mexico Transboundary Aquifer Assessment Program: 2007-2012, edited by William M. Alley.

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

Basic Information

Title:	Award--Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq
Project Number:	2010NM123S
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.

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

- A. Secure agro-meteorological data for water and crop monitoring and forecasting
- B. Secure meteorological data for dust storm forecasting
- C. Development of crop monitoring and production estimating tools
- D. Temperature and photoperiod inputs to yield estimation
- E. Development of hydro-economic policy analytic tools
- F. Improved rainfall forecasts
- G. Improved understanding of relations between snowpack and streamflow
- H. Teach short courses in Iraq on the development and use of hydro-economic models to support policy analysis of irrigation water management and drought adaptation in Iraq

Principal findings and significance

Climate variability and population growth have intensified the search internationally for measures to adapt to fluctuations in water supplies. An example can be found in the lower part of the transboundary Tigris-Euphrates Basin where water shortages in 2008-2009 resulted in high economic costs to irrigation farmers. Losses to irrigators in the lower basin have made a compelling case to identify flexible methods to adapt to water shortage. Few published studies have systematically examined ways to enhance the flexibility of water appropriation systems to adapt to water shortage. This article addresses an ongoing challenge in water governance by

examining how profitability at both the farm and basin levels is affected by various water appropriation systems. Four water appropriation systems are compared for impacts on farm income under each of three water supply scenarios. Results show that a (1) proportional sharing of water shortages among provinces and (2) unrestricted water trading rank as the top two appropriation systems. The shadow price of water for irrigation rises from zero at a full water supply level to US \$93/1,000 m³ when supply falls to 20% of full levels. Similar methods could be used to analyze challenges facing the design or implementation of water appropriation systems in the world's irrigated region.

Ongoing work is beginning that examines water allocation interventions in Iraq that can protect dietary food grain security in the face of future variability in surface water supplies coming into the country. It is anticipated that work will begin soon that will examine the use of groundwater pumping as a backup source for reduced surface water supplies.

Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)

Basic Information

Title:	Updating the Digital Hydrogeologic-Framework Model of the Mesilla Basin Area with Specific Reference to the Transboundary Aquifer Assessment Project (TAAP)
Project Number:	2012NM141B
Start Date:	3/1/2012
End Date:	12/31/2013
Funding Source:	104B
Congressional District:	NM02
Research Category:	Ground-water Flow and Transport
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	John W Hawley

Publications

1. Monger, H.C., Buck, B.J., Hawley, J.W., and Rachal, D., 2012, Geochronology of the Bolson sand sheet, New Mexico and Texas, and its archaeological significance: Discussion: Geological Society of America Bulletin; 124:9/10:1552-1556, 3 figures; doi: 10.1130/B30517.1
2. Hawley, J.W., and Granados-Olivas, A., 2012, Progress report on development of an annotated bibliography for transboundary aquifer systems of the Mesilla Basin-Paso del Norte area, New Mexico, Texas, and Chihuahua, in Aquifers of West Texas-Theme Session T5: Geological Society of America, Abstracts with Programs, 44:1:38., No.199147 on CD-ROM.
3. Hawley, J.W., Kennedy, J.F., and Granados-Olivas, A., 2012, Hydrogeologic framework of transboundary aquifer systems in the Paso del Norte region--Texas, New Mexico, and Chihuahua, in Aquifers of West Texas-Theme Session T5: Geological Society of America, South-Central Section, Abstracts with Programs, 44:1:32., No. 199140 on CD-ROM.
4. Hawley, J.W., Kennedy, J.F., and Ortiz, M.A., 2012, The Tularosa Basin and Hueco Bolson transition zone: A linked hydrogeologic system in south-central New Mexico, USA, in Hydrogeology of the Sierra Blanca, Sacramento Mountains, and Tularosa Basin, New Mexico-Theme Session T6: Geological Society of America, Abstracts with Programs, 44:6:No. 203247 on CD-ROM.
5. Monger, H.C., Buck, B.J., Hawley, J.W., and Rachal, D., 2012, Geochronology of the Bolson sand sheet, New Mexico and Texas, and its archaeological significance: Discussion: Geological Society of America Bulletin; 124:9/10:1552-1556, 3 figures; doi: 10.1130/B30517.1
6. Hawley, J.W., and Granados-Olivas, A., 2012, Progress report on development of an annotated bibliography for transboundary aquifer systems of the Mesilla Basin-Paso del Norte area, New Mexico, Texas, and Chihuahua, in Aquifers of West Texas-Theme Session T5: Geological Society of America, Abstracts with Programs, 44:1:38., No.199147 on CD-ROM.
7. Hawley, J.W., Kennedy, J.F., and Granados-Olivas, A., 2012, Hydrogeologic framework of transboundary aquifer systems in the Paso del Norte region--Texas, New Mexico, and Chihuahua, in

Aquifers of West Texas-Theme Session T5: Geological Society of America, South-Central Section, Abstracts with Programs, 44:1:32., No. 199140 on CD-ROM.

8. Hawley, J.W., Kennedy, J.F., and Ortiz, M.A., 2012, The Tularosa Basin and Hueco Bolson transition zone A linked hydrogeologic system in south-central New Mexico, USA, in Hydrogeology of the Sierra Blanca, Sacramento Mountains, and Tularosa Basin, New Mexico-Theme Session T6: Geological Society of America, Abstracts with Programs, 44:6:No. 203247 on CD-ROM.

Description of problem and research objectives

The arid-semiarid Mesilla Basin area of the south-central New Mexico border region includes major irrigation-agriculture projects in the Rio Grande Valley, and two large metropolitan centers: Las Cruces (NM) and the binational El Paso/Ciudad Juárez area, the latter with a population of about two million. Ever expanding municipal-industrial (M&I) water-supply requirements are now partly met by Elephant Butte Project surface-flow diversions, which are still primarily used for agriculture. Groundwater of varying quality in the large, but still-finite basin-fill aquifer systems of the region remains the primary water source for M&I uses; and in times of surface-water shortages, available subsurface-water resources are increasingly being exploited as a supplemental source for irrigation agriculture. Projected shortages in upstream river-basin source areas, reflecting both natural and anthropogenic environmental changes, only serve to exacerbate the long-term water-supply problems that face New Mexico's Lower Rio Grande region. Continued work on the hydrogeology of basin-fill aquifer systems of the Mesilla Basin area are therefore especially relevant, simply because it provides the state-of-the-art baseline information needed for development of the geohydrologic and hydrochemical models, which are in turn are required for equitable resolution of ongoing and future water-resource management disputes.

This study's primary research objective is to provide digital hydrogeologic information on basin-fill aquifer systems of the Mesilla Basin area in GIS formats (primarily ArcGIS) at scales appropriate for development of *basin-scale* groundwater-flow and hydrochemical models (~1:100,000). The hydrogeologic framework of these extensive and thick intermontane-basin fills has now been characterized in a large area between Caballo Dam and El Paso del Norte/Ciudad Juárez that includes the Mesilla Basin (USA and Mexico), the Mesilla and Rincon Valleys of the Rio Grande, and contiguous parts of the southern Jornada (del Muerto) and Palomas Basins (NM WRRI Technical Completion Report [TCR] 332, Hawley and Kennedy, 2004-05). However, complete digitation of 3-D hydrogeologic map and cross-section components started in 2007 by NM WRRI as part of the interagency Transboundary Aquifer Assessment Act (PL 109-448) Project (TAAP) was significantly curtailed in early 2010 following the untimely death of the original Project PI, Dr. Bobby J. Creel and unforeseen cutbacks in NM WRRI program support.

The above-described events notwithstanding, Co-PI John W. Hawley (JWH) made substantial progress in hydrogeologic-framework characterization during the Phase 2 TAAP work completed in March 2011. Primary products included final hard-copy drafts of 1) four structure-contour maps (1:100,000 scale) of the model-boundary surfaces that define basal, middle, upper, and shallow parts of the basin-fill aquifer system; and 2) twenty-three hydrogeologic cross sections (sea-level base) that illustrate aquifer-system lithology, hydrostratigraphy and structure in the intermontane-basin and river-valley area between Caballo Dam and El Paso/Ciudad Juárez. However, digital formatting of these items, final editing of the study area's hydrogeologic base map, and compilation of the map and cross-sections into a 3-D hydrogeologic-framework portrayal remained uncompleted in 2011. Therefore 104b-Project funding was requested in early 2012 to

complete the hydrogeologic-framework characterization required for numerical modeling of groundwater flow and hydrochemistry in aquifer systems of the TAAP study area.

Description of methodology

According to the methodology outlined in the original (1/14/2012) 104b funding proposal, specific items that needed to be scanned and digitized, “after final editing,” at the NM WRII GIS Laboratory include:

a. Drafts of new structure-contour maps of major hydrostratigraphic-unit (HSU) surfaces in the part of the study area between the lower Rincon Valley and El Paso del Norte. These maps illustrate best-available interpretations of subsurface topography and significant geologic features (e.g., faults) of the four bounding surfaces that separate the primary HSU components of the basin-fill aquifer system as well as derivative groundwater flow-model layers: 1) basal contact of basin and/or valley fill (Santa Fe Group and/or river-valley alluvium) on underlying and basin-border bedrock units; 2) Middle/Lower Santa Fe HSU boundary surface; 3) Upper/Middle Santa Fe HSU boundary surface; and 4) base of an inferred “shallow-aquifer” system, which includes a) river-valley fill, and b) the upper 300 to 500 ft of hydrologically linked Santa Fe Group HSUs in the east-central and southeastern Mesilla basin area. Provisional hydrogeologic interpretations are also shown in the Mesilla Basin area south of the International Boundary that includes the new Conejos-Médanos Basin well field.

b. Drafts of 23 hydrogeologic cross sections (MSL base elevation, 10x-vertical exaggeration) for the Rio Grande Valley and adjacent basin areas between Caballo Dam and El Paso del Norte. Digital versions of most of these sections (Adobe Illustrator format) were originally created for NM WRII-TCR 332 (2004-05); but subsequent editing (2007-11) showed that the 10-m DEM originally used in surface-profile construction could not provide needed precision in areas of low topographic relief, and some profiles had to be manually redrawn using more-detailed elevation control. In addition, minor well-location errors had to be corrected; and some revisions were needed to insure that the combined x-section and structure-contour-map formats are geometrically consistent.

c. During the 3/1/2012 to 2/28/2013 “Project Period,” the critical “final editing” phase of the hydrogeologic base map (ArcGIS product) in collaboration with Ms. Heather Glaze, NM WRII GIS Coordinator, proved much more time-consuming than originally envisioned. It also was soon determined that scanning and digitation of the four structure-contour maps (7a) would be most efficiently accomplished by using student-assistance at the GIS-lab facilities of the USGS-Albuquerque Office rather than at the NM WRII. This enabled the PI (JWH) to actively participate in the process of map compilation and editing without extended trips to Las Cruces. With respect to updating and editing the hydrogeologic sections (7b), most of which were already digitized in Adobe Illustrator (AI) format, both the NM WRII and USGS lacked staff with experience with AI software and/or AI-ArcGIS integration during this “Project Period.” In this situation, the

additional sections (4) and several section-extensions needed to fill gaps in 3-D coverage were scanned in pdf/jpg formats to facilitate future conversion to AI/ArcGIS products.

d. Continuous update of Excel spreadsheets that summarize basic information on about 500 *key wells* in the basin and river-valley area south of Caballo Reservoir (465 in NM, 25 in TX, and 10 in Chihuahua). This database supports interpretations used in development of the above-described hydrogeologic maps and cross sections, and includes hydrostratigraphic-unit and potentiometric-surface elevations, and reference citations. The annotated bibliography on a broad range of topics related to aquifer systems of the Transboundary region, which started being compiled in TAAP Phase I, is being expanded on an ongoing basis (*see Part 9: Hawley and Granados-Olivas, 2012*).

Principal findings and significance

Project work completed:

(1) A new digital base map (1:100,000) of the entire study area has been compiled (i.e., Mesilla Basin, and parts of the Jornada del Muerto and Palomas-Rincon Basins between Caballo Reservoir and El Paso del Norte). It includes the basic hydrogeologic elements (hydrostratigraphic, lithofacies, and structural) required for basin-scale groundwater-flow and hydrochemical model development. The ArcGIS format facilitates a) mapping of significant geohydrologic-boundary conditions (surface and subsurface), b) integration with four structure-contour maps of model-layer interfaces (subsurface), and c) preparation of schematic hydrogeologic sections that illustrate 3-D distribution of hydrostratigraphic and lithofacies units. At present, however, the only map area prepared for NM WRRI publication comprises the Mesilla Basin and adjacent parts of the southern Jornada Basin and Rincon Valley that have at least some hydrologic connection with Trans-International Boundary aquifer systems. A simplified version of the hydrogeologic map is used primarily as an index map for cross-section and key-well locations, and shows only major classes of basin-fill deposits, bedrock units, and fault types.

(2) Four new structure-contour maps of major hydrostratigraphic-unit (HSU) surfaces in the study area between the lower Rincon Valley and El Paso del Norte have been digitized and are in final stages of editing in collaboration with the USGS-Albuquerque Office, Hydrologic and GIS staff (7a). These maps illustrate best-available interpretations of subsurface topography and significant geologic features (e.g., faults) of subjacent bedrock units, and the bounding surfaces that separate the primary hydrostratigraphic (HSU) components of the basin-fill and (river) valley-fill aquifer systems. They are designed specifically to provide a robust geohydrologic framework for definition of groundwater-flow-model layer boundaries.

(3) A grid of twenty-seven hydrogeologic sections has now been completed that covers the entire study area between the Caballo Reservoir part of the central Palomas Basin and the southernmost Mesilla (northern Conejos-Médanos) Basin-El Paso del Norte in Chihuahua and western Texas (7b); and they complement the above-described structure-contour maps (7a, 8a (2)). These cross sections schematically illustrate the best-available interpretations of subsurface topography and significant geologic features (e.g., faults and

lithofacies distribution) of the bounding surfaces that separate major hydrostratigraphic (HSU) mapping units of the basin-fill and valley-fill aquifer systems. Their most important geohydrologic function is to provide a robust framework for defining the internal composition of layers that form the basic components of groundwater-flow and hydrochemical models. As already noted (7c), preparation of the set of 27 cross sections in a GIS format suitable for publication has not been completed (See 8b).

Project work remaining:

With respect to updating and final editing the hydrogeologic sections (7b, 8a (3)), both the NM WRRI and USGS still lack staff with user experience involving AI software and/or AI-ArcGIS integration during the remainder of the present (3/1 to 6/30/2013) “Project Period.” Because of this, original sections published in NM WRRI TCR 332 (2004-05) continue to be utilized; and additional sections (4) and several section-extensions needed to fill gaps in 3-D coverage have been scanned in pdf/jpg formats to facilitate future conversion to AI/ArcGIS products. To be able to complete this remaining task the PI (JWH) is now (5/2013) formally authorized as a USGS volunteer to have access to their Albuquerque Water Science Center GIS lab and ESRI-licensed software. This will greatly facilitate final editing of the digitized structure-contour maps.

The major remaining task involves final digital compilation of the 27 hydrogeologic sections in appropriate Adobe Illustrator format and then integrating them with the ArcGIS hydrogeologic base map and four structure-contour maps. The USGS-Albuquerque Office has all the licensed software to do the work, but qualified personnel are currently not available. To help resolve this problem the PI has obtained the temporary services of a recent NMED retiree, geologist Baird Swanson, who is also a USGS volunteer and has requisite AI and ArcGIS skills to assist in completing this particular task. To date, this has been a strictly *pro bono* effort; but application is being made to the NM WRRI for a short-term contract that will cover the bulk of the expenses that Mr. Swanson incurs in this component of unfinished “Project Work.”

Preparation of a Project Completion Report (PCR) on the current status of digital-baseline hydrogeologic information on the Mesilla Basin area, including contiguous parts of the Jornada Basin and connecting valley reaches of the Rio Grande that are located between the southern Rincon Valley and Paso del Norte. Emphasis will be on research aspects with direct bearing on groundwater-flow and hydrochemical model development.

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:	
Principal Investigators:	Daniel Cadol, Michael Heagy, Fred Phillips

Publications

There are no publications.

Brief 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 and positive 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 will measure the black carbon concentration in depositional zones of two recently burned watersheds in Valles Caldera National Preserve, New Mexico. We will test for the presence of certain contaminants found by previous researchers to be associated with wildfires. We will measure the PAH partitioning characteristics of a subset of our depositional zone soil samples.

Objectives: The primary objective of this work is to quantify the relative abundance of black carbon in two potential depositional zones – channel margins/floodplains and depositional fans. There are two secondary objectives: 1) Quantify the capacity of depositional zone soil samples from recently burned watersheds to absorb PAHs; and 2) Document the presence or absence of PAHs, 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 have selected two field areas in New Mexico with recent fires: the Las Conchas fire (2011) and the Thompson Ridge fire (2013) (Table 1). 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. Stream/valley study reaches were selected in a GIS at random distanced down the digitized channel, and study fans and hill slopes were selected at random from among those identified from aerial photographs. Characteristics of fluvial and colluvial study sites were measured, including gradient, width (channel, valley, fan), contributing area, channelization (depth,

abundance), and grain size. These data will be used to generalize results beyond our study areas. Fire intensity is also expected to control black carbon production, and thus mobilization and deposition potential. Fire intensity maps have been obtained from the Santa Fe National Forest, and the intensity of the burn in the contributing area for each site will be quantified. Post-fire rainfall history is expected to affect black carbon mobilization and deposition, and meteorological data from SNOTEL sites, located within 12 km of each study basin, will be used to document this influence.

Black Carbon Quantification Methods: Two methods will be used to quantify the amount of BC in samples. The Chemo-thermal oxidation method (CTO-375) is 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 375°C, acidifies inorganic carbon and converts it to CO₂, and finally quantifies the remaining carbon in the sample as black carbon. The alternative benzene polycarboxylic acid (BPCA) method captures a fuller spectrum of the black carbon continuum. This method is capable of analyzing both the char and soot content of soil samples, and can also measure the dissolved black carbon (DBC) content of water samples. The BPCA method assumes that BC polymers can be broken down into BPCA monomers, which can then be analyzed via a High Performance Liquid Chromatograph (HPLC). Samples are acidified with nitric acid, which enables the breakdown of BC into BPCA monomers. Chromatographic BPCA separation is performed and the ultra-violet absorbance spectra are correlated to a BC concentration.

Contaminant Sequestration Analysis: Selected samples will be tested for the presence of chromium (Cr), mercury (Hg), lead (Pb), and PAHs. Heavy metals will be tested using ICP-MS analysis methods (Moor et al., 2001; Melaku et al., 2005), while PAHs will be measured using gas chromatography. Selected samples will also be analyzed for PAH sorption using isotherm batch equilibrium experiments, performed using a range of concentrations of one or two representative species of PAH. A small subset of soil samples from each field site will be chosen for analysis, each sample with a different black carbon content and covering the range of black carbon concentrations observed, with control samples containing no recent black carbon deposition included as well. Subsamples will be placed in beakers containing solutions with a range of PAH concentrations. When the soil sample concentration of PAH equilibrates with the solution concentration of PAH, the amount of PAH remaining in solution will be determined.

Principal findings and significance

Work thus far using the CTO-375 method has found similar concentrations of soot in both the burned and the control study site soils. No trends or differences among geomorphic settings are yet apparent. Graduate student Amy Galanter will begin analyzing soils for total BC content (both soot and char) in May 2014 using the BPCA method.

Detailed experimental design plans have been developed for the contaminant sequestration portion of the study, with most sorbants and sorbates acquired and all analytical equipment prepared. Graduate student Phoebe Nicholls will begin these analyses in May 2014.

Geographic Information systems for Water Resources Research Planning

Basic Information

Title:	Geographic Information systems for Water Resources Research Planning
Project Number:	2013NM162B
Start Date:	3/1/2013
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	NM02
Research Category:	Not Applicable
Focus Category:	None, None, None
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 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.

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 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 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 GIS sophisticated mapping and geo-spatial database management system, originally designed to support NM WRRI-funded research activities, has been used for external research grants (e.g., the compilation and creation of statewide maps for water planning and budgeting funded by the New Mexico Office of the State Engineer (NMOSE) and the National Science Foundation (NSF), Examination of Mesilla Basin Aquifer Pollution Sensitivity Using DRASTIC for the Border Environment Cooperation Commission (BECC), and Creation of a Digital Hydrogeologic Framework Model of the Mesilla Basin and Southern Jornada del Muerto Basin) by water resources management and planning agencies in the state. A research grant has also 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.

During the reporting period, projects funded through the GIS lab were sponsored by the USGS, BECC, the Experimental Program to Stimulate Competitive Research (EPSCoR) through the NSF, and the National Park Service.

The EPSCoR statewide water budget 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
Start Date:	3/1/2013
End Date:	2/28/2014
Funding Source:	104S
Congressional District:	
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Alexander G. Fernald

Publication

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.

Brief description of problem and research objectives

The 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.

Brief description of methodology

The University'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.

Principal findings and significance

Prototype models have been developed to examine the most economical use of newly-discovered groundwater in Ethiopia to promote humanitarian and agricultural food security goals in the Somali region of Ethiopia. An Ethiopian student was recently hired to secure data from his home country in cooperation with a Nigerian student. Related work is exploring barriers to safe drinking water in rural and urban African areas.

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 WRII homepage (wrii.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 WRII homepage.

Information Transfer Program

Basic Information

Title:	Information Transfer Program
Project Number:	2013NM161B
Start Date:	3/1/2013
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	NM02
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	water research information transfer
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.

Statement of Critical Water Problem

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

Statement of Results and Benefits

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

Nature, Scope, and Objectives

The primary methods for information transfer are conferences, publications, audio/visual presentations, and information posted on the institute's website. For the past 58 years, the NM WRI 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 2012 conference had an attendance of over 500 and the 2013 conference attracted 326 participants. A few years ago, the New Mexico State Engineer called the NM WRI annual conference the premier water meeting in the state. The NM WRI began hosting a technical research symposium in 2002 and the annual event had become the focal meeting for researchers from around the state and region to share their water-related research and demonstration projects. Due to budget restrictions, for the past three years the technical symposium has been combined with the annual water conference. Students are encouraged to present posters at the annual water conference and in 2013, 22 students did so.

Publications include technical completion reports resulting from NM WRI-sponsored projects, special in-house publications, and conference proceedings. The institute has published more than 386 technical and miscellaneous reports. The peer reviewed technical completion reports are directed toward water professionals working in disciplines related to the research projects. All technical reports are now available via the NM WRI 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 WRI water conference proceedings for the past 57 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 WRI homepage.

A reference room, housed at the institute, contains nearly 12,000 documents and is used by faculty, students, and the general public. A complete catalog of holdings can be searched through the NM WRRI homepage on the Internet, along with an extensive water resources and information system database.

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

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 58th Annual New Mexico Water Conference was held in Albuquerque on November 21-22, 2013. The conference theme was "New Water Realities: Proposals for Meaningful Change" and followed the well-attended 2012 conference, "Hard Choices: Adapting Policy and Management to Water Scarcity." The 2013 conference built on the 2012 conference report by asking speakers to make hard choices and to present at least one proposal for change. The 2013 conference was attended by 326 participants and included 38 posters, of which 22 were presented by students. The conference proceedings is in preparation and will be posted on the institute's website. All conference participants will receive a copy on CD.

Again this year, the annual technical symposium was combined with the annual water conference. Thirty-eight 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 this year. All poster abstracts are available on the institute's conference website.

The institute's 2012 publication, "One Hundred Years of Water Wars in New Mexico 1912-2012,"

which contains 16 chapters on the many complex legal and otherwise fights over water in New Mexico, continues to sell well. The book has also been given to state legislators to educate them on how New Mexico has arrived at its present water status and provides the history, management decisions, and consequences of those decisions. The 57th Annual New Mexico Water Conference proceedings was produced in hardcopy and on CD. It is posted on the institute's website as are all publications.

For the past year, the institute's website has averaged 7,048 unique online visits each month. It averages 2,683 online unique visits for publications from its technical and miscellaneous report series and an average of over 15,550 unique visits and pdf downloads per month of its proceedings series. Because of the ability to view and print all institute publications online, the WRRRI 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 WRRRI 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 WRRRI'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 three newsletters, one 12-page issue, one 16-page issue, and a 20-page issue of *The Divining Rod*. The newsletter received an average of 685 downloads per month online during the past year. Online unique visits per month of the NM WRRRI's reference room averaged 143 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 WRRRI 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 a presentation to the NM Legislative Subcommittee on Drought on "Agricultural Water Conservation Hydrology" and two presentations to the NM Legislative Science, Technology and Telecommunications Committee on "Desalination" and on "Technology Improvements in Agricultural Water Use."

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, \$100,000 was added for FY 15 base funding. Also, NM WRRRI will receive \$1 million for water research initiatives to improve water management in New Mexico. The FY 15 funding, with potential to recur in the future, 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 faculty and student grants and address three priority topic areas: integrated statewide water budget, water policy for planning, and water-supply innovation.

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	4	0	0	0	4
Masters	5	0	0	5	10
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	10	0	0	5	15

Notable Awards and Achievements

New Mexico State University Dr. Bernd Leinauer received the university's 2013 Distinguished Career Award. Leinauer's research program focuses on developing water management strategies for turf areas aimed at reducing the amount of potable water used for irrigation. Since joining NMSU, Bernd has secured more than \$1.6 million in competitive and industry grants, and more than \$500,000 in unrestricted gifts to support the Turfgrass Extension and Research program. Leinauer has lectured and presented around the world on turfgrass water conservation, irrigation efficiency, turfgrass selection, rootzone repellency, and soil modification. He is a recipient of several NM WRI grants and is the author of several publications including the 2012 NM WRI technical completion report, "Utilization of Saline and Other Impaired Waters for Turfgrass Irrigation."

John W. Hawley and Catherine T. Ortega Klett presented an invited paper at the National Ground Water Association Conference on Water Scarcity in the Rio Grande Basin in Albuquerque in February 2014. The presentation was entitled, "New Mexico Water Resources Research Institute (1964 - present), and Institute-Supported Hydrogeology-Related Studies in the Binational Mesilla Basin Region, USA and Mexico." It highlighted the impact of the Water Resources Research Act to stimulate and support faculty-directed graduate-student level research by providing funding acquisition and administration and scientific and technical support for initial, peer-reviewed publication of project completion reports. The presentation described the institute's multi-disciplinary/institutional program in publishing and training that has benefitted the state of New Mexico for five decades as well as many federal, state, and local water agencies.

New Mexico Tech NM WRI 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 his research. Two of Dr. Cadol's research project students were also successful in obtaining research grants to support the research: one from the Geological Society of America and another from the New Mexico Geological Society.

Dr. Saud Amer, co-investigator on two supplemental projects funding through the USGS, ("Monitoring and Forecasting Climate, Water and Land Use for Food Production in Afghanistan" and "Monitoring and Forecasting Climate, Water, and Land Use for Food Production and Business Development in Iraq") was quoted in the October 2, 2013 "National Geographic" article on water in the Turkana region of Kenya. (<http://news.nationalgeographic.com/news/2013/10/131002-kenya-aquifer-lotikipi-groundwater/>)

New Mexico State University interdisciplinary Water Science and Management graduate degree program currently has 33 students enrolled representing 9 countries. 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 Range Science. Graduate student program coordinator, Desa Daniels received two awards during the reporting period: an award from Delta Sigma Theta Sorority for Uncompromising Commitment to Service and an award from Columbia University Teachers College at the 31st Annual Teachers college winter roundtable on cultural psychology and education student scholarship.

In October 2013, the NM WRI hosted a reception for the New Mexico Legislative Drought Subcommittee. Seventy people attended the reception including 11 legislators. Legislators met with students, faculty, and stakeholders on information highlighting NM WRI research-based successes in dealing with water scarcity. For the first time in its over five-decade history, the sitting Governor of New Mexico held a press conference at the institute's home, Stucky Hall, on the NMSU campus. Governor Martinez announced her proposal for \$2M to support water research through the NM WRI. The Governor met with students and staff and

responded to questions from the media.

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: Water Sustainable Economic Development. The upper level graduate course will be taught beginning in Fall 2014 by Professor Frank A. Ward, the co-PI on the three awards. Also associated with these projects, graduate student Dina Salman and Dr. Ward taught a short course in Erbil, Iraq in August 2013 dealing with drought adaptation by irrigated agriculture in the Lower Tigris-Euphrates Basin.

Publications from Prior Years

1. 2009NM103B ("Land application of industrial effluent on a Chihuahuan Desert ecosystem: Impact on soil physical and hydraulic properties") - Articles in Refereed Scientific Journals - Deb, S.K., M.K. Shukla, P. Sharma, and J.G. Mexal, 2013, Patterns of Soil Water Depletion in Irrigated Mature Pecans of Arid Southern New Mexico, *Irrigation Science*, Vol. 31, pp. 69-85.
2. 2008NM90B ("Estimating Water Use through Satellite Remote Sensing (Bleiweiss)") - Articles in Refereed Scientific Journals - Elsadek A., M.K. Shukla, M. Bleiweiss, S. Fernald, and S. Guldan, 2013, Evaluating Sensitivity Analysis and Auto-Calibration of a Semi-Distributed Hydrological Model for Two Semiarid Watersheds of New Mexico, *New Mexico Journal of Science*, Vol. 46: pp. 65-88.
3. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Gutiérrez-Jurado, H.A. and E.R. Vivoni, 2013, Ecogeomorphic Expressions of an Aspect-controlled Semiarid Basin: I. Topographic Analyses with High Resolution Data Sets, *Ecohydrology*, Vol. 6 (1): pp. 8-23.
4. 2006NM44B ("Development of Geospatial Modeling Tools for Watershed-based Water Resources Management in New Mexico (Vivoni)") - Articles in Refereed Scientific Journals - Gutiérrez-Jurado, H.A. and E.R. Vivoni, 2013, Ecogeomorphic Expressions of an Aspect-Controlled Semiarid Basin: II. Topographic and Vegetation Controls on Solar Irradiance, *Ecohydrology*, Vol. 6 (1): 24-37.
5. 2010NM118G ("Karst Conduit Hyporheic Zone Exchange") - Articles in Refereed Scientific Journals - Henry, K. and J. Wilson, 2013, Karst-conduit hyporheic exchange. *Hydrology & Earth System Science*, in preparation.