Water Resources Research Institute

Annual Technical Report

FY 1999

Introduction

1999 New Mexico Water Resources Research Institute Annual Technical Report Grant Award 1434-HQ-96-GR02687 Base Grant Award - Year 4 (revision 0005) Regional Competitive Grant Program Award (revision 0001)

This program report provides the required information for projects funded with the 1999 base grant, required cost share non-federal matching funds, and a project awarded through the 1996 Regional Competitive Grant Program for which New Mexico is the lead institute. Please note that there may be some overlap in information with our 1998 report because data collection is based on a July-June fiscal year rather than the March-February USGS Grant Award period.

The financial status report (SF269) will be submitted by New Mexico State University's Current Funds Accounting Office. If you have questions or need further information, please contact Darlene Reeves, 505 646-1194 or email dreeves@wrri.nmsu.edu.

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

The mission of the New Mexico Water Resources Research Institute is to develop and disseminate knowledge that will assist the state, region and nation in solving water resources problems. Specifically, the NMWRRI 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 apprised of new technology and research advances. In addition, the institute maintains a unique infrastructure that links it with many federal, state, regional and local entitites to provide expertise and specialized assistance.

Research Program

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 as well as federal and

state agencies, and the USGS State Water Research Institute Program (WRIP). To make the best use of limited resources, the institute has targeted four areas as high priority for funding: water conservation, planning and management; surface-groundwater relationships; water quality; and utilization of saline and other impaired waters. The 1999 WRIP program consisted of seven projects which collectively represented all of the priority areas.

The continuing project "Concentration of Viral Particles from Water by Ultrafiltration" deals with an important water quality issue. "Miniaturized DNA Biosensor System for Detecting Cryptosporidium in Water Samples" is also aimed at improving the nation's water quality. A new project "Hyperfiltration-induced Precipitation of Sodium Chloride" had as its objective to reduce the reverse osmosis waste stream to a solid, which would significantly increase the ability to use saline water. "Soil Moisture-Rainfall Feedbacks in New Mexico" examined soil moisture-rainfall feedback to better understand atmospheric-surface-groundwater relationships. The proposal "Detection of Groundwater through Ultra-sensitive Magnetic Measurements with Ultra-short Pulse Lasers" related to the area of water conservation, planning and management. "The Impact of Heterogeneous Consumer Response on Water Conservation Goals" also addressed the very important issue of water conservation, planning and management.

A continuing project entitled "Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin," that received funding through the 1996 Regional Competitive Grant Program, hopes to impact the conservation, planning and management of water resources in the western United States.

During the reporting period, the NMWRRI administered a total of 17 projects dealing primarily with water quality and conservation issues. The total value of these projects was more than $2.3 million, including required cost sharing, and came from various federal and state agencies as well as NMWRRI's annual state appropriations. Dollar amounts per project award ranged from under $1k to $882k. Research on four projects was conducted at other universities in the state, while NMSU faculty members were principal investigators on seven projects and NMWRRI staff managed six projects. The institute maintained frequent contact with its researchers through periodic progress updates, site visits and expenditure tracking.

In addition to the 16 students who worked on USGS base and regional competitive grant projects, an additional 21 students (10 undergraduates, 9 master's candidates, and 2 Ph.D. candidates) were utilized on projects funded by or through the NMWRRI.

Projects administered by the NM Water Resources Research Institute during the reporting period that were funded from sources other than the U.S. Geological Survey include the following:

Mapping Services - Regional Water Plans Task Orders #1, #2. Professional Services Agreement with the NM Interstate Stream Commission. $20,000 (PSA total)

NM Mexico Pesticide Management Plan. Memorandum of Agreement with the New Mexico Department of Agriculture -US Environmental Protection Agency funds. $84,700 (EPA funds and NMWRRI cost share match)

Geographic Information System for Water Resources Planning. Previously funded by USGS WRIP; continued with NMWRRI state appropriations. $120,598 (includes USGS and NMWRRI direct and indirect costs)

San Acacia Diversion Dam Study. US Bureau of Reclamation. $20,330

Pecos River Endangered Species Mitigation Study. US Bureau of Reclamation. $23,304

Riparian Evapotranspiration Study of the Middle Rio Grande. US Bureau of Reclamation, NMWRRI and New Mexico State University. $539,407 (BOR funds and NMWRRI/NMSU cost share match)

Sources of Salinity in Rio Grande and Mesilla Basin Aquifers. Joint Powers Agreement with the NM Interstate Stream Commission. $150,000

Trans International Boundary Aquifers in the New Mexico Portion of the El Paso/Juarez Region, Phase II. U.S. Environmental Protection Agency. $272,185 (EPA funds and NMWRRI cost share match)

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin
Project Number	C-01
Start Date	09/01/1996
End Date	02/28/2001
Research Category	Social Sciences
Focus Category #1	Drought
Focus Category #2	Economics
Focus Category #3	Hydrology
Lead Institution	New Mexico State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Frank Ward	Professor	New Mexico State University	01
Robert A. Young	Professor	Colorado State University	02
Ronald D. Lacewell	Professor	Texas A&M University	03
W. Marshall Frasier	Assistant Professor	Colorado State University	04
John Ellis	Assistant Professor	Texas A&M University	05

Problem and Research Objectives

Serving over one-million acres of irrigated land and the domestic and industrial needs of cities like Albuquerque and El Paso, the Rio Grande represents a most significant resource in that portion of the arid southwest. Sixty years ago, an agreement called the Rio Grande Compact was approved by Congress which divided the waters among the three states and Mexico into fixed proportions. Since that time, significant growth in the basin's demand for water, associated with growth in the economy and population and new policies toward fish and wildlife habitat, have strained the region's limited water

supply. Although the inevitable severe drought will cause significant economic damages to the regional economy, the present institutional arrangements have not had to actually confront such an event.

The primary objective of the research was to test the hypothesis that new institutions for interstate coordination of surface water withdrawal and reservoir operations could promote more economically efficient spatial and temporal water use patterns, particularly during drought.

Methodology

The following institutional innovations were selected for evaluation: short-term leasing, dry-year options, water banking, water rights markets, and reservoir management options.

A three-state research team of economists, hydrologists and a lawyer was formed to perform the analysis. A linked hydrologic-economic-institutions model was developed. At this stage, the modeling effort includes only the Upper Rio Grande basin, from Colorado through New Mexico to Fort Quitman, Texas, just below El Paso. Modeling of the lower basin, including water uses and inflows from Mexico has not been attempted.

The general approach reflects the random supplies and uncertain demands from economic growth and endangered species policies for water and river and reservoir management rules. Water supplies, which include all major tributaries and interbasin transfers, and hydrologically connected groundwater, are represented in a monthly time-step over a thirty-year planning horizon. The portion of the basin selected for study is represented by 16 reaches or nodes. Drought damage functions have been estimated for agricultural water uses, the major source of demands for each significant irrigation district. Urban and instream demands are also represented. The optimization procedure, which maximizes economic benefits subject to hydrologic, engineering and institutional constraints, is solved with GAMS optimization software.

Principal Findings and Significance

Intrastate and interstate innovations in allocative institutions were tested against the baseline "Law of the River." Each institutional innovation was tested for robustness and economic efficiency under several drought scenarios. Results are presented as economic and hydrologic impacts of drought by state, economic sector, institutional drought-coping alternative and drought scenario.

Completing the drought study report has taken considerable time due to the difficulty in developing the agricultural and institutional components needed to make the model functional and represent real-world drought policy. The analyses of agricultural drought response for the San Luis Valley Irrigation District of Colorado and Elephant Butte Irrigation District (EBID) of New Mexico have been completed. Analyses of the last two districts, El Paso Irrigation District of Texas and Middle Rio Grande Conservancy District of New Mexico, are based on crop cost and return budgets that use the same structure as EBID and are expected to be completed in July 2000. The drought coping institutions require these agricultural analyses to know how the drought policy impacts will be spread around the various economic sectors. The institutional analysis are expected to be completed by September with the final peer-reviewed report printed by December 2000.

Descriptors

drought, institutional relationships, economics, hydrology, policy, models

Articles in Refereed Scientific Journals

Ward, F.A. 1998. Economics of Water Conservation. New Mexico Journal of Science 38:127-139. Ward, F.A., M. Frasier, J.F. Booker, R. Lacewell, J. Ellis and R.A. Young. 1998. An Economic-Hydrological Modeling Approach for Assessing Alternative Institutional Innovations for Coping with Drought on an Interstate River. American Journal of Agricultural Economics. 80,5:1 page abstract. Ward, F.A. and J.P. King. Reducing Institutional Barriers to Water Conservation in Dry Regions. Water Policy. (in press) Ward, F.A., J. Booker and R. Lacewell. Instream Flows and Endangered Species in an International River Basin: The Upper Rio Grande. American Journal of Agricultural Economics. (in press)

Book Chapters

Dissertations

Sperow, Mark. 1998. Three Essays Addressing Production Economics and Irrigation: Managing for Drought and Pests Transported in Irrigation Water. Ph.D. Dissertation. Department of Agricultural and Resources Economics, Colorado State Univeristy. 184 pp.

Water Resources Research Institute Reports

Conference Proceedings

Ward, F.A., M. Frasier, J.F. Booker, R. Lacewell, J. Ellis and R.A. Young. "An Economic-Hydrological Modeling Approach for Assessing Alternative Institutional Innovations for Coping with Drought on an Interstate River," presented at the American Agricultural Economics Association Meetings, August 1998, Salt Lake City. Ward, F.A., M. Frasier, J.F. Booker, R. Lacewell, J. Ellis and R.A. Young. "An Economic-Hydrological Modeling Approach for Assessing Alternative Institutional Innovations for Coping with Drought on an Interstate River," presented at the Universities Council on Water Resources meeting, August 1998, Hood River, OR.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Concentration of Viral Particles from Water by Ultrafiltration
Project Number	B-01
Start Date	07/01/1997
End Date	02/28/2001
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Methods
Focus Category #3	None

Lead Institution	New Mexico State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kevin H. Oshima	Assistant Professor	New Mexico State University	01

Problem and Research Objectives

This project was continued as project B-04. Please refer to project B-04 for report details.

Methodology

Principal Findings and Significance

Descriptors

water-borne virus, viral concentration methods, ultrafiltration, viral contamination, enteroviruses, water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

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Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Ultrafiltration Based Concentration of Viruses and Cryptosporidium Oocysts from Environmental Water Samples
Project Number	B-04
Start Date	07/01/1997
End Date	02/28/2001
Research Category	Water Quality

Focus Category #1	Groundwater
Focus Category #2	Surface Water
Focus Category #3	Water Quality
Lead Institution	New Mexico State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kevin H. Oshima	Assistant Professor	New Mexico State University	01

Problem and Research Objectives

In terms of drinking water safety, very little is known about the extent of viral and parasitic contaminants in source (influent) and product (finished) drinking water and their relationship to disease. Critical to identifying and quantitating water-borne pathogens is the development and use of methods that reliably concentrate pathogens from drinking, surface and groundwater.

The U.S. Environmental Protection Agency (EPA) has mandated that large water utilities in the U.S. test their source and product water for viral pathogens from surface or groundwater systems. There is growing concern for the potential health risks associated with the presence of pathogens in surface, ground and drinking water, however, little data was available to determine how significant the risks.

Objectives of this phase of the project include 1)optimize method(s) to recover viruses under field size (100-1000 L) samples along with documentation to indicate potential detection sensitivity and reproducibility; 2)determine the correlation between small and field scale testing for virus recovery; 3) determine the recovery efficiency of Cryptosporidium parvum oocysts from environmental water using the small-scale hollow fiber ultrafiltration system; 4)develop and optimize a downstream sample processing procedure; and 5)detail information on the feasibility of PCR methods using concentrated samples processed through ultrafiltration.

Methodology

A prototype of the field-scale ultrafiltration system has been developed with a variable pump that can be easily adjusted to accommodate either a field-scale hollow fiber or tangential flow ultrafiltration system. Five-hundred gallon circular tanks are used for the input and permeate reservoirs. Pump speed and transmembrane pressure regulation will be used to control the input flow as well as the permeate flow rate. The objective is to have a sanitizable system that can process 100-1000 L in less than two hours.

Based on experiments with small-scale testing, experimentation with field scale system will consist of the addition of 0.5% FBS after the initial sample has been concentrated to 10 L. The final concentration of FBS and the timing of its addition to the retentate will be optimized for virus recovery, permeate flow rate and cost.

The final evaluation and selection of optimized filtration conditions will be based on a number of characteristics including recovery efficiency, consistency between different viruses and water conditions, cost reagents, flow rate, ease of use and speed. Near the end of the funding period, field-scale volumes of surface and groundwater will be tested to determine if enteroviruses and oocysts can be recovered. This will be done to determine if these agents can be isolated from local waters as a final step in demonstrating the feasibility of this system.

Principal Findings and Significance

The initial phase of this project established the stability of the model viruses in suspension fluids that will be used in the ultrafiltration experiments. Maintaining the stability of the model viruses for the duration of the ultrafiltration steps is needed in order to accurately assess the efficiency of virus concentration. These results formed the basis for virus suspensions to be done in PBS for testing recovery from different types of water. Initial filtration experiments were done with reagent water where the recovery of virus is most straightforward and easy to characterize.

Results from the hollow-fiber ultrafiltration system indicated that all blocking agents had a positive effect on the efficiency of virus recovery compared to filters that were not pretreated. Based on these results, a smaller regiment of blocking agents was tested with the tangential flow system. The results indicate that recovery also improved with the addition of a blocking step for the tangential flow system. For both systems, the highest recovery appeared to be when 1% FBS was used as a blocking agent.

Results indicate that for surface water with high turbidity, both prevention of virus adsorption to the filter and to particulates in the water sample is important to achieve high recoveries of virus.

Descriptors

water-borne pathogens, ultrafiltration, viral contamination, enteroviruses, Cryptosporidium, water quality

Articles in Refereed Scientific Journals

Winona, L., A. Ommani, J. Olszewski, J. Nuzzo and K. Oshima. Characterization and optimization of ultrafiltration for concentrating viruses from environmental water from small volumes of water. Applied and Environmental Microbiology. (submitted) Ommani, A.H., J. Winona, J. Olszewski, J.B. Nuzzo and K.H. Oshima. Efficient and predictable recovery of viruses from water by small scale ultrafiltration. (submitted) Oshima, K.H., T.T. Evans-Strickfaden and A.K. Highsmith. 1998. Comparison of filtration properties of hepatitis B virus (HBV), hepatitis C virus (HCV) and simian virus 40 (SV40) using a polyvinylidene fluoride (PVDF) membrane filter. Vox Sanguinis. 75:181-188

Book Chapters

Dissertations

Ommani, A. 1998. Concentration of viruses using ultrafiltration. Master's Thesis, Department of Biology, College of Arts and Sciences, New Mexico State University.

Water Resources Research Institute Reports

Conference Proceedings

Oshima, K.H. May 1999. "Concentration of viruses from water using ultrafiltration," presented at American Society for Microbiology Annual Meeting, Chicago, IL.

Oshima, K.H. January 1999. "Concentration of viruses from water using ultrafiltration," presented at American Society for Microbiology Annual Branch Meeting, Albuquerque NM.

Oshima, K.H. October 1998. "Concentration of viral particles from water by ultrafiltration." Proceedings of the New Mexico Water Resources Research Institute's 43rd Annual Water Conference. WRRI Report No. 310, 1999, New Mexico State University, Las Cruces, NM. pp 105-110.

Oshima, K.H. and A. Ommani. May 1998. "The concentration of viruses from water using ultrafiltration," presented at American Society for Microbiology Annual Meeting, Atlanta, GA.

Winona, L. May 1999. "Recovery of viruses from environmental water samples by ultrafiltration," presented at American Society for Microbiology Annual Meeting, Chicago, IL.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Miniaturized DNA Biosensor System for Detecting Cryptosporidium in Water Samples
Project Number	B-02
Start Date	10/01/1997
End Date	09/30/1999
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Water Supply
Focus Category #3	Methods
Lead Institution	New Mexico State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Joseph Wang	Professor	New Mexico State University	01

Problem and Research Objectives

The project addressed the urgent need for improved analytical methods for detecting Cryptosporidium in water samples. The microbial pathogen Cryptosporidium has been recognized as a serious public health threat. Due to this threat, there are growing demands for a routine test that reliably and rapidly detects the presence of Cryptosporidium in water supplies.

The primary goal of this project was to develop and test a cost-effective, user friendly, portable analytical system, based on new DNA biosensor technology, for rapid on-site detection of Cryptosporidium in water samples. The resulting easy-to-use hand-held PCR/sensor system will address various deficiencies of current tests for Cryptosporidium, and should accelerate the realization of wide-scale screening for this deadly pathogen in water samples.

Methodology

Advanced biosensor technology has been used to achieve this project's goal. Biosensors, which intimately couple specific biological recognition elements with physical transducers, show great promise for numerous on-site environmental monitoring applications. Oligonucleotide probes, specific to Cryptosporidium, have been immobilized onto various tranducers. Because of the miniaturized character and low-power requirements of modern biosensors, such devices hold great promise for the proposed detection of water-borne pathogens in a field setting.

Principal Findings and Significance

The research resulted in several protocols for the electrochemical biosensing of DNA hybridization. Special attention was given to the introduction of new nucleic-acid recognition elements (dendrimers and PNA) that enhance the specificity and sensitivity of the assay, and to new label-free strategies for transducing the hybridization event into useful analytical signals. These new electrochemical routes offer similar analytical performance characteristics such as sensitivity, specificity and reproducibility, and can be adapted for on-site testing of Cryptosporidium in water samples. Such suitability is attributed to the inherent miniaturization and low-power requirements of electrochemical devices.

The realization of routine on-site environmental applications would require further attention to various challenges, particularly matrix effects and the assay sensitivity. Lower detection limits and/or proper amplification would thus be required to meet the requirements of direct detection of Cryptosporidium in water samples.

Current efforts in this laboratory are aimed at integrating flow-through electrochemical hybridization biosensors with on-chip sample collection, preparation/handling and amplification (usings a "Lab-on-a-Chip" format). Advanced micromachining technologies are being used for providing the microfluidic network essential for such integration as well as for microfabricating the PCR microchambers. By performing all the steps of the biological assay on a single chip platform, we expect significant advantages in terms of cost, speed, and simplicity.

Descriptors

biosensors, Cryptosporidium, environmental monitoring, water-borne pathogens, hand-held analyzer

Articles in Refereed Scientific Journals

Palecek, E., M. Fojta and J. Wang. 1998. Electrochemical Biosensors for DNA Hybridization and DNA Damage. Bioelec. 13:621 Wang, J. 1999. Towards Genoelectronics: Electrochemical Biosensing of DNA Hybridization. Invited Concept Article. Chem. - A European J. (Angnew Chem.) 5:1681 Wang, J., M. Jiang and B. Mukherjee. 1999. Flow Detection of Nucleic Acids at a Conducting Polymer-Modified Electrode. Ana. Chem. 74:4095 Wang, J., S. Bollo, J. Paz, E. Sahlin and B. Mukherjee. 1999. Ultratrace Measurements of Nucleic Acids by Baseline-Corrected Adsorptive Stripping Square-wave Voltammetry. Anal. Chem. 71-1910 Wang, J., J. Fernandes and L. Kubota. 1998. Polishable and Renewable DNA Hybridization Biosensors. Anal. Chem. 70:3699 Wang J., G. Rivas, J. Fernandes, J. Lopez, M. Jiang and R. Waymire. 1998. Indicator-Free Electrochemical DNA Hybridization Biosensor. Anal. Chim. Acta. 375:197 Wang, J. 1998. DNA Biosensors based on PNA Recognition Layers. A Review. Biosensors Bioelec. 13:757 Wang, J., M. Jiang, T. Nilsen and R. Getts. 1998. Dendritic Nucleic Acid Probes for DNA Biosensors. J. Am. Chem. Soc. 120:8281

Book Chapters

Dissertations

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Wang, J. 2000. Miniaturized DNA Biosensor System for Detecting Cryptosporidium in Water Samples. New Mexico Water Resources Research Institute, New Mexico State University, Las Cruces, NM. WRRI Technical Completion Report No. 311, pp 12.

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Hyperfiltration-Induced Precipitation of Sodium Chloride
Project Number	B-03
Start Date	07/01/1999
End Date	06/30/2000
Research Category	Water Quality
Focus Category #1	Waste Water
Focus Category #2	Treatment
Focus Category #3	None

Lead Institution	NM Institute of Mining and Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
T. Michael Whitworth	Professional Staff	NM Institute of Mining and Technology	01

Problem and Research Objectives

Less than two percent of the world's water supply is fresh water suitable for drinking. The rest is too saline for human consumption. Especially in arid or semiarid areas, fresh water supplies are being used up faster than they can be naturally replaced. It is increasingly important that cost-effective methods be developed for use of saline or other impaired waters in order to ensure adequate future water supplies for the state of New Mexico, as well as the rest of the world.

Conventional reverse osmosis shows great promise of providing an economical method of purifying saline and other impaired waters. However, reverse osmosis is presently limited by a relatively large waste stream which, for some applications, can be as much as 80% of the total volume treated. High waste disposal costs rule out or severely limit the use of reverse osmosis for many applications.

The goal of this project was to reduce the reverse osmosis waste stream to a solid - a reduction in waste volume of up to four orders of magnitude - thus allowing all of the water input into the system to be purified.

Methodology

Two types of experiments were to be performed. The first set passed undersaturated NaCl solutions through montmorillonite clay membranes and focused on 1) measuring the non-equilibrium thermodynamic membrane coefficients of the clay membranes, 2) measuring precipitation rate constants, and 3) testing theoretical models. The second set of experiments would focus on testing and refining the bench-scale, reverse-osmosis waste reduction system and collecting performance data to aid further design work to 1) scale up the system for commercial use, and 2) design an under-sink system for home-owner use.

Principal Findings and Significance

The purpose of this project was to test the ability of clay membranes to concentrate NaCl solutions to a high enough level so that saturation and/or supersaturation is achieved in the concentration polarization layer and NaCl precipitates. A series of approximately 12 experiments was performed in which undersaturated NaCl solutions were passed through smectite and kaolinite membranes under presures ranging from 100 to 3000 psi. Most of these experiments resulted in NaCl precipitation within the experimental cell. This precipitation was confirmed using both light microscopy and electron microprobe studies. All remaining solution in the cell and membrane at the end of the experimental runs was displaced with light weight vegetable oil to prevent any crystals from forming due to evaporation of remaining solution. The Nail crystals typically showed a dendritic form characteristic of rapid crystallization.

Although not within the scope of the current project, the next step is to continue with the experiments and ascertain kinetic coefficients to be used for process design.

Descriptors

saline water, salinity, membrane, reverse osmosis, waste reduction, hyperfiltration, precipitation, clay membrane

Articles in Refereed Scientific Journals

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Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Detection of Groundwater through Ultra-sensitive Magnetic Measurements with Ultra-short Pulse Lasers
Project Number	B-06
Start Date	07/01/1999
End Date	08/31/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Water Supply
Focus Category #3	None
Lead Institution	The University of New Mexico

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Jean-Claude Diels	Professor	The University of New Mexico	01

Problem and Research Objectives

There are two basic areas of water resources that this proposal addresses: exploration of new, unknown sources of groundwater, and monitoring of the growth/decay of large aquifer layers. This research project proposed to develop new tools to locate hitherto unknown groundwater reservoirs, and to monitor the growth and decay of known groundwater layers.

The goal for this one-year project is to demonstrate and compare new methods of magnetic sensing (vertical component of the earth magnetic field, or susceptibility measurement), which meet certain criteria. The objective is to produce an experimental demonstration of two approaches, as well as their applicability to the detection of groundwater from the air.

Methodology

Two new techniques were developed, using a mode-locked ring laser, to resolve such variations of magnetic susceptibilities: 1) monitoring the vertical component of the earth's magnetic field, and 2) measurement of a change in resonance frequency of a large coil. Both methods are based on the use of a mode-locked ring laser as the most sensitive detector of variation of phase along a light path.

Principal Findings and Significance

The project developed instrumentation to detect or monitor underground water pockets through 1) change of the vertical component of the earth magnetic field, or 2) extremely accurate measurements of the magnetic susceptibility. The first approach involved developing a new type of magnetometer better than the SQID superconducting magnetometer. The sensitivity is to be reached by using an atomic vapor, as in a conventional potassium magnetometer, inside a mode-locked laser. This approach requires active stabilization of a mode-locked laser, a hitherto untested task that was significantly more challenging than anticipated. It is the success of that part of the project that led to the invitation of a plenary talk in Japan.

A practical instrument has to portable, which is not the case of the Ti:sapphire laser that was stabilized. For this reason, development of a diode laser pumped mode-lock has been started in parallel. So far, success has been made in observing a mode-locked operation, but it pulsed at 500 kHz instead of continuous. Further research is in progress to try to overcome this difficulty.

Another alternative that was pursued in parallel was the development of a parametric oscillator ring laser gyro. Here also, stabilization problems have been in the way of the final magnetic field detection phase.

The measurements of magnetic susceptibility are to be performed with fiber lasers. Achieving the necessary mode-locked bidirectional operation in the ring fiber laser has been much more difficult than anticipated, and also more costly. A stable passive mode-locked operation has been successfully demonstrated, but the bidirectional operation with fixed crossing point has not been controlled. The

modulator required for this work was damaged during the test. A replacement ($3700) is expected for August.

It appears at this point that the remaining work will extend for one or two years, before prototypes of the various designs are tested and ready to fly in an airplane. Private support for the continuation of this research is being pursued. Select University Technologies, Inc. (SUTI) has expresed interest, and will hopefully support this development.

Descriptors

groundwater, magnetic, susceptibility, laser, ultrashort, remote-sensing

Articles in Refereed Scientific Journals

Jones, R.J., J.-C. Diels. Stabilization of FS Lasers for Optical Frequency Metrology. Optics Letters (submitted). Jones, R.J. and J.-C. Diels. Metrologic Applications of CS Mode-Locked Lasers Stabilized Via a Fabry-Perot Reference Cavity. Journal of the Optical Society of America (in preparation). Meng, X., J.-C. Diels, D. Kuhlke, R. Batchko and R. Byer. Bidirectional, Synchronously Pumped, Ring Optical Parametric Oscillator. Optics Letters (submitted).

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Diels, J.-C. Femtosecond Lasers, the Transition from Exotic Tools for Exotic Applications to a Multipurpose Tool. Plenary talk at the International Workshop for Femtosecond Technology, FST2000, Tsukuba, Japan, June 28, 2000. Meng, X., J.-C. Diels, D. Kuehlke, R. Batchko, and R. Byer. Ultra-short Pulses OPO Laser. CLEO 2000, San Francisco, CA, May 2000. Paper CMW7.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	The Impact of Heterogeneous Consumer Response on Water Conservation Goals
Project Number	B-07
Start Date	07/01/1999
End Date	09/30/2000
Research Category	Social Sciences
Focus Category #1	Economics
Focus Category #2	Conservation

Focus Category #3	Law, Institutions, and Policy
Lead Institution	The University of New Mexico

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Janie M. Chermak	Assistant Professor	The University of New Mexico	01
Kate Krause	Assistant Professor	The University of New Mexico	02

Problem and Research Objectives

It has long been recognized that water is one of the most critical resources in the Southwest. Growth and demographic changes, as well as refined estimates of the available water resource are requiring suppliers to plan for the future and implement changes in the current system. In order to assure an adequate supply of water, conservation is and will continue to be an important factor in efficiently managing water resources. Comsumer response to policy initiatives will be a decisive factor in the role conservation plays in the effectiveness of water management. To incorporate consumer response into evaluation of proposed conservation programs and into forecasts of future water demand, it is necessary to employ consumer demand models that are sufficiently robust to account for heterogeneity across consumer groups.

The objectives of this research are to 1)identify statistically significant consumer characteristics that are factors of demand for water through a series of economic experiments and surveys, 2)test consumer response to wide ranges of pricing options, 3)econometrically model water demand at a disaggregate level by incorporating the significant consumer charactertiscs into the model, and 4)design a conservation incentive program that allows individuals to choose their own best conservation alternative while, in aggregate, achieving the conservation program goals.

Methodology

Three distinct methodologies are employed in this research: 1) Collection of data - In order to collect a data set that is sufficiently rich in detail to allow modeling of disaggregated demand functions, an experimental game design will be used, supplemented by a survey administered to all participants to collect salient demographic and economic information. 2) Demand modeling - Using the non-parametric results for guidance, an econometrically estimated consumer demand model will be developed for each specific consumer group. 3) Construction of an incentive compatibility (non-linear price) model - Combining the empirical results, specific to this research with the theory presented in the extant literature will allow the development of a non-linear pricing structure which gives the customer flexibility, while allowing the water manager to meet conservation or policy goals.

Principal Findings and Significance

Experiments have been conducted that were designed to investigate consumer attitudes toward water use in an environment of varying degrees of scarcity. Earlier research had indicated substantial variance across consumers (which is not surprising), and that some of that variance is systematically correlated with observable characteristics of the consumer. For example, women display different consumption

habits from men; political and religious affiliation appear to have some predictive power; and older people differ from young adults. Current experiments are an effort to refine these findings and verify whether they are robust across different settings.

Data must still be analyzed from experiments conducted in the Spring of 2000 and those experiments must be replicated on a different group of consumers.

Descriptors

water conservation, policy analysis, model studies, survey, consumer response

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Basic Project Information

Basic Project Information	
Category	**Data**
Title	Soil Moisture-Rainfall Feedbacks in New Mexico
Project Number	B-05
Start Date	07/01/1999
End Date	06/30/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Climatological Processes
Focus Category #2	Hydrology
Focus Category #3	Drought
Lead Institution	NM Institute of Mining and Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Eric E. Small	Assistant Professor	NM Institute of Mining and Technology	01

Problem and Research Objectives

Roughly half of the annual precipitation in New Mexico accumulates during July, August and September. This precipitation is heavily used in the semi-arid climate of the state. Problems associated with this water resource arise because the amount of precipitation that accumulates during the summer season in New Mexico varies substantially from year to year. Both drought and flood conditions have negative consequences on a wide variety of human activities. The negative effects of summertime precipitation variability could be lessened by a prediction system that allows for planning and preparation for season-long rainfall anomalies.

Prediction of these summertime precipitation anomalies in New Mexico would be aided by a more complete understanding of how different components of the climate system contribute to rainfall variability. One source of persistent rainfall anomalies may be the soil moisture state. The goal of this research is to assess how soil moisture affects land-atmosphere interactions in the semi-arid climate of New Mexico. If soil moisture effects are substantial, then soil moisture-rainfall feedbacks may contribute to the variability of summertime precipitation in New Mexico.

Methodology

The research will be conducted in the Sevilleta LTER located in central New Mexico, well suited for the study because the meteorological stations deployed can be linked to the network that is already in place. Numerous data sets already exist which will be used to guide the research. Field measurements will be conducted during the summer season which will allow observation of the land surface changes associated with the onset of the Mexican monsoon at the end of June. Data analysis will be completed in subsequent months.

A meteorological station designed to measure surface fluxes via the Bowen ratio method will be installed. It will be designed to make measurements of the following variables: 1) soil moisture; 2) ground temperature; 3) ground heat flux; 4) latent and sensible heat fluxes; 5) downward and upward shortwave and longwave radiation; 6) boundary layer moist static energy; and 7) precipitation. Soil moisture will be measured daily, and more frequently after precipitation events at several depths using Time Domain Reflectometry (TDR).

Principal Findings and Significance

A summary of research findings and significance was unavailable from the investigator as of report deadline. However, because funding was not available for the project until July 1999, the experiment was not completed during last summer's monsoon season. Additional data are being collected during summer 2000 to be included in the investigator's technical completion report. It is anticipated that a three-month extension to the project will be requested and granted.

Descriptors

precipitation, soil moisture, evaporation, variability, land-atmosphere interactions; hydrologic persistence

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Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Information Transfer Program
Description	Supplement to State Information Transfer Program
Start Date	07/01/1999
End Date	06/30/2000
Type	Newsletter
Lead Institution	New Mexico State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Tom Bahr	Professional Staff	New Mexico State University	01
Bobby J. Creel	Professional Staff	New Mexico State University	02
Catherine T. Ortega Klett	Professional Staff	New Mexico State University	03

Problem and Research Objectives

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. The program goal is to provide people with water information appropriate to their level of training and interest. Information transfer activitites are funded primarily from non-federal sources. Funds from this USGS program were utilized to cover a portion of the production costs of the newsletters.

The primary methods for information transfer are conferences, publications and audioi/visual presentations. Publications include technical completion reports resulting from NMWRRI sponsored projects, special in-house publications, conference proceedings and a quarterly newsletter.

Responsibilities for different segments of the program have been assigned to various professional and support staff at the institute.

Methodology

The institute director and other professional staff were frequently invited to speak at local, regional and national conferences and workshops, in addition to serving on a number of committees that focus on water resources. The NMWRRI staff also regularly provided expertise for solving specific problems and general concerns. The staff played a central role in planning for the water future of the region by cooperating with a host of water resources entitites throughout the state and region.

Since its inception in 1956, the most visible component of the information transfer program has been the Annual New Mexico Water Conference. In December 1999, the 44th annual conference, held in Santa Fe, attracted over 350 participants to hear presentations on the theme, "The Rio Grande Compact: It's the Law." The conference proceedings will be available both in hard copy and on the institute's home page in summer 2000.

The institute's newsletter, "The Divining Rod" was distributed to more than 1700 individuals or agencies.

Principal Findings and Significance

The institute averages about 125 requests for general information and more than 60 requests for specific publications each month. A reference room, housed at the institute, contains almost 10,000 documents and is used frequently by faculty, students, and others. A complete catalog of holdings can be searched through the NMWRRI home page on the internet, along with an extensive water resources and information system database and other information about the institute. Several hundred inquiries per month are recorded on the home page.

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USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	3	N/A	N/A	6
Masters	7	1	N/A	N/A	8
Ph.D.	2	N/A	N/A	N/A	2
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	12	4	N/A	N/A	16

Awards & Achievements

Research investigator Jean-Claude Diels, University of New Mexico (UNM), was invited to present results related to his WRIP project "Detection of Groundwater through Ultra-sensitive Magnetic Measurements with Ultra-short Pulse Lasers" as a plenary talk at the Femtosecond Technology FST2000 conference in Tsukuba, Japan. x x x x x

Dr. Joseph Wang, New Mexico State University (NMSU), received the American Chemical Society, Division of Analytical Chemistry, 1999 Chemical Instrumentation Award. He was chosen as the sole recipient of this prestigious international award for research based in part on his WRIP project "Miniaturized DNA Biosensor System for Detecting Cryptosporidium in Water Samples." x x x x x

For the third year in a row, the graduate program in hydrology at New Mexico Institute of Mining and Technology (NMIMT) was rated among the best in the nation in US News & World Report's annual issue of graduate school rankings. x x x x x

A water treatment process developed at NMSU was recently demonstrated in China. Research was started in the early 1990s on the inexpensive, efficient and safe method for cleaning contaminated water retrieved in the oil drilling process and was partially funded through a NMWRRI/USGS seed money award to Dr. N. Nirmala Khandan entitled "Low Volatile Organics in Groundwater - Techno-economic Evaluation of an Innovative Treatment Process." x x x x x

A hyperfiltration system developed as a result of research partially funded through two NMWRRI/USGS seed money awards has been submitted for a patent and could help the state's water conservation effort by enabling recovery of drinking water from deep into the groundwater aquifer where water becomes more salty from prolonged contact with rocks and minerals. Dr. Michael Whitworth of NMIMT was the principal investigator on the projects, "Geologic Membrane Controls on Saturated Zone Heavy Metal Transport" and "Hyperfiltration-Induced Precipitation of Sodium Chloride," and led the New Mexico Institute of Mining and Technology team of researchers in the development of the technique. x x x x x

The prestigious Hiram Hadley Founders' Award of Excellence was presented to Tom Bahr, director-emeritus of the NMWRRI, in recognition of his leadership in the protection and development of water resources for New Mexico. Hiram Hadley was one of New Mexico State University's founding leaders in the late nineteenth century. x x x x x

The New Mexico Water Resources Research Institute (NMWRRI) was judged to be one of the top four institutes in the nation by a U.S. Geological Survey (USGS) evaluation team, in their most recent review cycle which

covered the period 1993 - 1997.

According to evaluators, the NMWRRI director "should be commended for creating and maintaing an exemplary water resources institute program, which has been of great value to the state, the region and the nation." Furthermore, the panel was "highly impressed with the quality and breadth of the program. The director has a well-earned national reputation as one of the most experienced and successful water institute directors," evaluation comments stated. The report indicated that "the institute's research, information transfer, and educational programs are all excellent. The research program is relevant and balanced and all indicators show that the resulting research is of the highest quality. The information transfer program is of great value to the state and region and is excellent in all regards." The evaluation panel noted the role the New Mexico WRRI played in writing and publishing the early editions of the Water Science Reporter and commended the director for accepting special responsibilities in supporting the national information transfer program. It praised the NMWRRI's support of students, noting several students involved in research had won state, regional and national awards.

During the evaluation period, the New Mexico Water Resources Research Institute was led by Director Tom Bahr and Assistant Director Bobby Creel. Other professional staff during the evaluation period were Darlene Reeves, Catherine Ortega Klett, and Leslie Blair.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Bowman, R.S. and J.M.H. Hendrickx. 1998. Determination of Agricultural Chemical Impacts on Shallow Groundwater Quality in the Rio Grande Valley: Las Nutrias Groundwater Project. New Mexico Water Resources Research Institute Technical Completion Report No. 308, New Mexico State University, Las Cruces, NM.

Caldwell, C.A. and C.M. Canavan. 1998 Spatial and Temporal Distribution of Mercury in Caballo and Elephant Butte Reservoirs, Sierra County, New Mexico. New Mexico Water Resources Research Institute Technical Report No. 306, New Mexico State University, Las Cruces, NM.

Creel, B.J., T.W. Sammis, J.F. Kennedy, D.O. Sitze, D. Asare, H.C. Monger and Z.A. Samani. 1998. Ground-Water Aquifer Sensitivity Assessment and Management Practices Evaluation for Pesticides in the Mesilla Valley of New Mexico. New Mexico Water Resources Research Institute Technical Report No. 305, New Mexico State University, Las Cruces, NM.

Kearns, A.K. and J.M.H. Hendrickx. 1998. Temporal Variability of Diffuse Groundwater Recharge in New Mexico. New Mexico Water Resources Research Institute Technical Completion Report No. 309, New Mexico State University, Las Cruces, NM.

Vogels, C.M. and M.D. Johnson. 1998. Arsenic Remediation in Drinking Waters Using Ferrate and Ferrous Ions. New Mexico Water Resources Research Institute Technical Report No. 307, New

Mexico State University, Las Cruces, NM.

Conference Proceedings

Ortega Klett, C.T. (ed.) 1999. Proceedings of the 43rd Annual New Mexico Water Conference, "Water Challenges on the Lower Rio Grande." New Mexico Water Resources Research Institute Technical Report No. 310, New Mexico State University, Las Cruces, NM.

Ortega Klett, C.T. (ed.) 1998. Proceedings of teh 42nd Annual New Mexico Water Conference, "Water Issues of Eastern New Mexico." New Mexico Water Resources Research Institute Technical Report No. 304, New Mexico State University, Las Cruces, NM.

Other Publications

Transboundary Aquifers of the El Paso/Ciudad Juarez/Las Cruces Region. 1997 - prepared by the Texas Water Development Board and the New Mexico Water Resources Research Institute. Trans-International Boundary Aquifers in Southwestern New Mexico. 2000 - prepared by New Mexico Water Resources Research Institute and California State University, Los Angeles. Herrera, E.A., T.G. Bahr, C.T. Ortega Klett and B.J. Creel (eds.) 1998.New Mexico Journal of Science, Water Resources Issues in New Mexico. New Mexico State University, Las Cruces, NM.