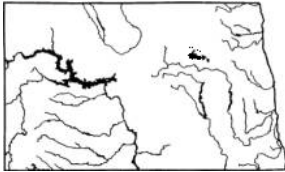


November 2014

North Dakota Water Resources Research Institute
North Dakota State University
Fargo, ND 58108-6050



Newsletter



<http://www.ndsu.edu/wrri>

From the Director

Greetings!

Welcome to the 2014 issue of North Dakota Water Resources Research Institute newsletter. In this issue, 2014 NDWRRI Fellows are introduced. Also highlighted are the 2013 Fellowship research projects. Three selected Institute affiliated faculty are profiled. Institute faculty and fellows presented their research in several conferences and symposia as in the past years. Technical reports of Fellowship projects can be accessed on the Institute web site. I encourage you to visit the Institute website, www.ndsu.edu/wrri or contact the respective Fellows, advisors, or principal investigators for details of research projects. Several WRRI Fellows graduated and moved on to accept responsible positions in various water-related areas of employment.

Again this year, North Dakota State Water Commission extended its support of 15% of the USGS annual base grant to the Fellowship program of the Institute. As in the previous years, the State Advisory Committee provided valuable help in setting Institute's research priorities and reviewing Fellowship applications. Our Fellowship program has won praise and admiration of the institute reviewers in a recent review.

The call for applications for the 2015-2016 NDWRRI graduate research fellowships is already up on the Institute website. Please visit the website for details.

This is the last time you will see "From the Director" section from me. I will be stepping down from my responsibilities as the Director of the NDWRRI effective March 1, 2015. It has been a wonderful 12 years working with NDSU and UND faculty engaged in water-related research, institute's State Advisory Committee members, all state water institute directors, and the USGS. The water research in the ND universities and the state continues to benefit much from this program. Several of our institute Fellows are now working for various water related state and federal agencies.

Energy-water-climate nexus has assumed greater significance in the state with increasing water needs for energy growth and oil development. I am sure the Institute will continue to address state's water research priorities via individual and graduate research fellowship programs.

Bye,

G. Padmanabhan, Director
[North Dakota Water Resources Research Institute](http://www.ndsu.edu/wrri)
Phone: 701 231 7043 e-mail: G.Padmanabhan@ndsu.edu

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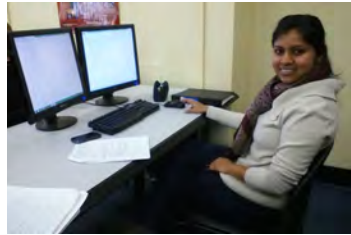
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The Institute Awarded Fifteen Graduate Fellowships for the Year 2014-2015

Fellow: Dasuni Arachchige

Title: Flash Flood Potential Mapping Using GIS and Flash Flood Potential Index (FFPI) in Turtle River and Forest River Watershed, North Dakota

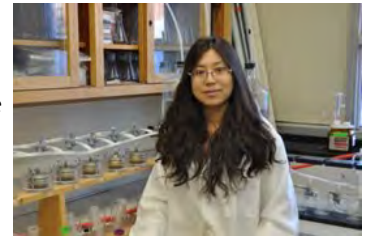
Advisor: Gregory Vandenberg



Fellow: Yangbo He

Title: Sodic Soil Characterization and Management on Subsurface Drainage

Advisor: Thomas DeSutter



Fellow: Abbie Beaudry

Title: Nutrient Loading Reduction and Water Quality of Best Management Practices in Grand Forks, North Dakota

Advisor: Howe Lim



Fellow: Mohammad Hossain

Title: Biopolymers for Phosphate Removal from Eutrophic Lakes

Advisor: Achintya Bezbaruah

Fellow: Derrick Deering

Title: Three Dimensional Analyses of Flow Dynamics & Chlorination of Ground Water Supply Reservoir in a Cold Region

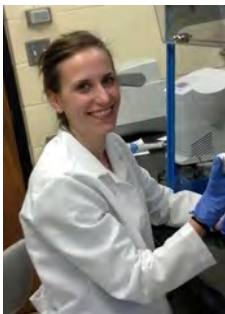
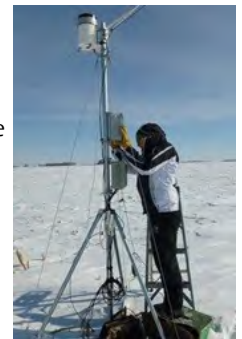
Advisor: How Lim



Fellow: Kelsey Kolars

Title: Development of a Model for Subsurface Drainage and Subirrigation Water Management

Advisor: Xinhua Jia



Fellow: Heather Dose

Title: Where is fertilizer Nitrogen Going, Up in Smoke or Down the Pipe? An Assessment of Nitrogen Transformations and Water Quality Impacts on a Tile Drain Sodic Soil

Advisor: Ann Marie Fortuna



Fellow: Navaratnam Leelaruban

Title: A Study of the Spatial and Temporal Characteristics of Drought and its Impact in North Dakota

Advisor: G. Padmanabhan

Fellow: Prosper Gbolo

Title: Quantifying Phosphorus Cycling and Fate within an Abandoned Feedlot

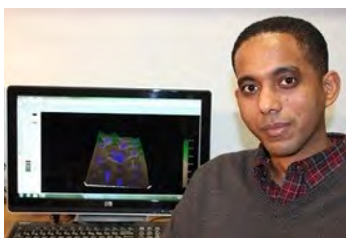
Advisor: Phillip Gerla



Fellow: Debjit Roy

Title: Snowmelt Water Infiltration Into Frozen Soil in Red River of the North Basin

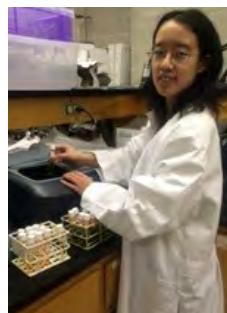
Advisor: Xinhua Jia



Fellow: Noah Habtezion

Title: Quantification of Spatio-Temporal Distribution of Surface Ponding and the Related Dynamic Processes

Advisor: Xuefeng Chu



Fellow: Jingyi Sun

Title: Evaluation of Bioavailable Dissolved Organic Nitrogen Using Various Algal Species

Advisor: Halis Simsek

Fellow: Mitchell Swanson

Title: The Role of Algal Species on Phosphorus Bioavailability

Advisor: Eakalak Khan



Fellow: Anthony Wamono

Title: Effects of Calcium Based Surface Amendments on the Hydraulic Conductivity and Selected Physical Properties of Subsurface Drained Sodic-Saline Soils

Advisor: Dean Steel



Fellow: Lucas Wandrie

Title: Bird-mediated Transport of Toxic Heavy Metals and Selenium From Marine and Terrestrial Sources to Freshwater Wetlands in North Dakota

Advisor: Wendy Reed

2013 – 2014 NDWRRI Fellowship Research Highlights

Prosper Gbolo: The Cycling, Fate, and Quantification of Nutrients at an Abandoned Feedlot

Nutrients are chemical species that play important roles in soils, water, and living organisms, and are transformed from one species to another through different biogeochemical processes and cycles. Currently, there are research gaps in the cycle, mobility, speciation, and sequestration of P in different environments. Nutrient quantification in runoff and nutrient leaching in groundwater systems have received attention lately. In view of this, this research examines the P cycle within a sandy ridge and adjacent wetlands. This study will analyze groundwater, soils, surface water, plant tissues, and microorganisms as part of a larger study to test the hypothesis that when P is transported by runoff, it is sequestered and immobilized, with increasing abundance in wetlands. This research will bridge some of the research gaps concerning nutrient pathways in surface and subsurface systems, and the relationship between nutrients, organic matter, soil physiochemical properties, and some trace elements. Result of this research will benefit feedlot management and mitigate pollution, and also help guide the development of regulations for protecting surface and groundwater quality without excessively restricting animal production.

Yangbo He: Sodic Soil Characterization and Mangement on Subsurface Drainage

Excessive levels of salts occur in large areas around the world and profoundly affect land use. Usually, these problematic soils are defined into two major types, namely, saline and sodic soils. When saline soils are dominated by sodium salts, soils are termed “sodic.” Sodic soils occur in many areas of Northern Great Plains, and in North Dakota, about 4.7 million acres are negatively affected by sodium. One of the main concerns that NDSU soil scientists have about the draining of these sodium-affected soils is the potential of decreased soil water hydraulic conductivity (Ksat) due to the factors that control soil swelling and dispersion: (1) sodium on the exchange sites and (2) decreased electrical conductivity (EC) of the soil solution due to drainage. The tile-drainage installers and landowners need to become more aware of this concern and need to have a tool by which they can learn more about their soils. This project addressed the problem.

Kyle Horntvedt: Measurement and Modeling of Soil Moisture Change for Subsurface Drainage and Subirrigated Fields in the Red River Valley

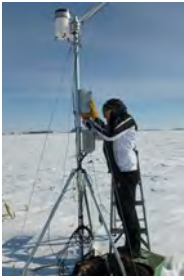


In order to accurately understand when water should be removed and added to the fields to optimally manage water tables and moisture content, researchers must gain an understanding of how water moves through each field and how the soil moisture changes in the root zone, in order to develop a water management plan for producers to follow. A large field experiment with four water management plans has been set up in the RRV and is scheduled to run in 2011 - 2014. Various instruments have been installed to measure the water balance components. To predict the effects of water management on water table position and soil moisture for a region, hydrological simulation models are required, such as Hydrus-2D and DRAINMOD. By measuring real-world moisture conditions in the field and comparing them to modeling results, a water management plan and irrigation schedule will be able to be developed to help producers make critical decisions throughout the year regarding the addition and abstraction of water in their fields. This study focuses on this problem

Ruchi Joshi: Understand the Survival of Cryptosporidium Oocysts in North Dakota Under Winter Conditions

Considering both, the climate conditions in North Dakota and survival conditions of Cryptosporidium, it is apparent that Cryptosporidium oocysts can survive in North Dakota. Besides these conditions, data has been provided by the Centre for Disease Control & Prevention (CDC) reflecting a gradual increment in the number of Cryptosporidiosis cases within North Dakota. Therefore, taking in account the capability of Cryptosporidium of causing a public health outbreak, it is very important to understand the effect of low temperature on Cryptosporidium. This study focuses on understanding the survival of Cryptosporidium oocysts in North Dakota





Kelsy Kolars: Development of a Model for Subsurface Drainage and Subirrigation Water Management Decisions

The use/installation of Subsurface Drainage, Controlled Drainage, and Subirrigation systems in the Red River Valley has dramatically increased over the last decade. With this increase also comes an increased need for a better understanding of how to optimally manage these systems such that an increase in yield is seen along with a decrease in nitrate loadings and soluble salts to surrounding surface waters. This study incorporates incorporating net irrigation via a SI system and drainage via a SSD system in the Checkbook method so the landowners have a simple, familiar, and effective way to manage their system.

Amanda Krieger: Electron Donor Contributions to Denitrification in the Elk Valley Aquifer, ND

Nitrate is the most significant threat to surface and subsurface waters, where it is costly to remediate, it elevates trophic levels, and it is related to hypoxic zones throughout the world and the US, notably that in the Gulf of Mexico. Furthermore, 135 million people in the United States, which includes 99% of its rural population, rely on groundwater as their drinking water source. Rural regions in the US are especially susceptible to nitrate contamination of aquifers because of the predominance of agriculture and the associated use of fertilizers. Therefore, it is no surprise that nitrate is the most common groundwater contaminant. This research involved the study of the variation in the contributions of electron donors in aquifer sediments over a long period of nearly eight years. This will be yet another step in the denitrification research in predicting aquifer denitrification parameters based on the electron donors present in aquifer sediment. Furthermore, this research will provide insights into which type of electron donor causes the greatest aquifer denitrification rates.

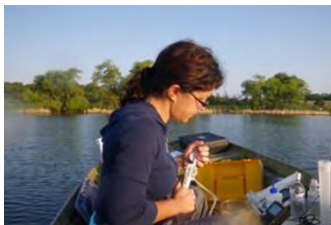
Brian Mager: Physical Model Evaluations of Scour Holes Below a Singular and Multiple Step Rock Weirs

During the last 15 years, rock weirs have become increasingly popular in the Red River Valley. However, very little research has been conducted as to the design parameters of rock weirs. Once constructed, rock weirs begin to form a scour hole downstream which if not properly designed will undermine the foundation of the rock weir, leading to failure of the site. Existing research has been limited to singular weir structures and doesn't evaluate the effects of stepped weirs to aid in downstream scour reduction. This study focused on developing design parameters for rock weirs.

Rick Thalacker: 3D Mapping Techniques for Soil Channelization in Agricultural Fields Using Aerial and Digital Camera LiDAR and GIS

In this study Stream Power Index (SPI) created from Digital Elevation Models (DEM) were used to identify potential critical erosion areas adjacent to the Turtle and Forest Rivers above Larimore and Fordville dams. As part of this study, the models produced from the airborne vs. digital camera LiDAR were compared. SPI at or above critical erosion levels can be used to target precision conservation in individual fields adjacent to the Turtle and Forest Rivers. This information can be used by landowners, the local Soil Conservation District as well as the Red River Resource Conservation and Development Council. A comparison between the airborne LiDAR and digital camera LiDAR will help to determine the viability of using digital camera LiDAR for applications such as this.

Veselina Valkov: The Effect of Artificial Aeration on Phytoplankton Growth in a Small Eutrophic Lake in North Dakota



The long-term goal of this research is to apply knowledge on the variation of phytoplankton population distribution and diversity contributions to a better understanding of ecological status of eutrophic lakes. Understanding the effect of artificial destratification on nutrient availability and its impact on the physiology of Cyanobacteria species is considered necessary for the development of artificial destratification as a remediation technique to control problematic Cyanobacteria blooms. This problem is addressed in this study.

Tanush Wadhawan: Investigation of Cryptosporidium Oocysts in Influent and Effluent of the Fargo Water Treatment Plant

Cryptosporidium is an infective protozoan which is one of the most important contaminants found in drinking water and is associated with a high risk of waterborne illness. The mechanism of *Cryptosporidium* transport in the environment remains poorly understood. Cattle and other livestock are reservoirs of human pathogenic *Cryptosporidium* species. Application of liquid manure to fields is a common practice in many North American farm operations. Surface runoff from agricultural fields and animal facilities contain *Cryptosporidium* which pose a health hazard for animals and humans. *Cryptosporidium* has been identified to be prevalent in the Red River and its tributaries. The prevalence of *Cryptosporidium* in North Dakota and their high potency to infect humans requires us to understand transport of *Cryptosporidium* into surface waters during spring thaw. This information will help in risk assessment and development of control practices. This study focused on understanding the transport mechanism of *Cryptosporidium* in the environment.

Jiexia Wu: Drought Monitoring and Prediction Using NOAA Land Surface Model and GRACE Satellite Observation

The purposes of this study are: 1) to evaluate the performance of an agricultural drought index, Soil Moisture Deficit Index (SMDI) at continental scale; 2) to develop an agricultural drought prediction method based on precipitation, evapotranspiration and terrestrial water storage. This study applied multiple linear regression (MLR) with the inputs of precipitation from Parameter-elevation Regressions on Independent Slopes Model (PRISM), evapotranspiration from Moderate Resolution Imaging Spectroradiometer (MODIS) MOD 16 product and terrestrial water storage (TWS) derived from the Gravity Recovery and Climate Experiment (GRACE) to predict soil moisture and SMDI. The inputs of the MLR model were chosen based on the mass conservation of the hydrological quantities at the near surface soil layer (two meters). In addition, the model also accounts for seasonal and regional variations. Comparisons with the US drought monitor (USDM) showed that SMDI can be used as a proxy of agricultural drought. The model exhibited strong predictive skills at both one- and two-month lead times in forecasting agricultural drought (correlation >0.8 and normalized root mean square error <15%).

Melissa Wygant: A Place Vulnerability Analysis of Flood Hazard Risk at Grand Forks 1990-2010

The purpose of this study is to evaluate flood hazard risk and vulnerability at Grand Forks, North Dakota from 1990-2010 prior to and following completion of their U.S. Army Corps of Engineers certified \$420 million levee system to identify the extent to which flood risk has actually been reduced over time. A place vulnerability approach was used as the organizing framework to provide a quantitative spatial assessment of flood risk over time. It is anticipated that the place vulnerability maps will show a reduction in flood risk over time due to the implementation of the dike system, and other various mitigation strategies, but reveal that substantial residual risk is still present within Grand Forks. This should be helpful to city leaders in Grand Forks and other North Dakota communities who are responsible for building more flood-resilient communities.

Mengqi Xiong: Application of Soil and Water Assessment Tool (SWAT) Model for Estimating Nutrient Loads to Lake Ashtabula, ND, Under Different Climate Scenarios

A fully calibrated and operational SWAT model for the Lake Ashtabula watershed to estimate nutrient loads to Lake Ashtabula for TMDL development is the goal. The SWAT model will also be coupled with a reservoir water quality model to study nutrient transport processes on upland and in surface water bodies. The SWAT model will also be used to investigate the impact of the Devils Lake diversion on the water quality in Lake Ashtabula under different climate scenarios. This project will benefit watershed model development for TMDL purposes and surface water quality management in North Dakota. Model set up and flow calibration has been completed. Work is in progress on nutrient and sediment load calibration.

Jun Yang: Improved Overland Flow Modeling for Hydrologic Connectivity Analysis of Potholes

Surface microtopography affects a series of complex and dynamic hydrologic and environmental processes that are associated with both surface and subsurface systems, such as overland flow generation, infiltration, soil erosion, and sediment transport. Due to the influence of surface depressions, overland flow essentially features a series of progressive puddle-to-puddle (P2P) filling, spilling, merging, and splitting processes; and hydrologic systems often exhibit threshold behaviors in hydrologic connectivity and the associated overland flow generation process. It is inherently difficult to realistically simulate the discontinuous overland flow on irregular topographic surfaces and quantify the spatio-temporal variations in dynamic behaviors of topography-dominated hydrologic systems. This research focused on developing to develop a hydrologic model to simulate the discontinuous, dynamic P2P overland flow processes under the control of surface microtopography for various rainfall and soil conditions, and propose new approaches to quantify hydrologic connectivity.

Upcoming Events

2014 Annual water Resources Conference, American water Resources Association, Nov. 3-6, Tyson's Corner, VA
<http://www.awra.org/meetings/Annual2014/>

NGWA Expo 14, National Ground Water Association, Dec. 9-12, Las Vegas, Nevada <http://groundwaterexpo.com/>

International Low Impact Development Conference 2015, EWRI/ASCE, January 19 – 21, Houston, Texas
<http://content.asce.org/conferences/lid15/index.html>

32nd Annual Red River Basin Land & Water International Summit Conference, January 20-22, 2015, Winnipeg, Manitoba, Canada
<http://www.redriverbasincommission.org/Conference/conference.html>

NGWA Groundwater Summit 2015, National Groundwater Association, March 16-18, San Antonio, Texas <http://groundwatersummit.org/>

2015 Spring AWRA Conference, Water for Urban Areas: Building for risk and resilience, March 30-April 1, Los Angeles, CA
<http://www.awra.org/meetings/LosAngeles2015/>

2015 WESTERN SOUTH DAKOTA HYDROLOGY MEETING, Theme: Reliability, Vulnerability, and Resiliency, April 15, 2015, Rushmore Plaza Civic Center, Rapid City, South Dakota <http://sd.water.usgs.gov/WSDconf/>

World Environmental & Water Resources Congress, EWRI/ASCE, May 17-21, 2015, Austin, Texas <http://www.ewricongress.org/>

2015 Summer Specialty Conference on Climate Change Adaptation, American Water Resources Association, June 15-17, 2015, New Orleans, Louisiana <http://www.awra.org/meetings/NewOrleans2015/>

Watershed Management Conference, EWRI/ASCE, August 5-7, 2015, Wenatchee, Washington <http://watershedmanagementconference.org/>

NDWRRRI Graduate Research Fellows, and faculty present at the 2014 North Dakota Water Quality Monitoring Conference

NDWRRRI partnered with North Dakota Department of Health, ND State Water Commission, ND Game and Fish Department, US Geological Survey, and US Department of Agriculture to host the 2014 North Dakota Water Quality Monitoring Conference, March 4-6, Bismarck, ND. G. Padmanabhan, director of NDWRRRI and professor of civil and environmental engineering, served on the conference planning committee. The conference was attended by more than 100 water professionals from North Dakota and surrounding states.

Francis Casey, professor and director of School of Natural Resource Sciences was one of the key note speakers. His talk was titled “Estrogenic Hormones in the Environment.” Several past and present ND WRRRI Graduate Fellows, NDSU students, and their advisers presented at the conference:

Podium Presentations

- Under the radar: Nanoparticles and rare earth elements as emerging pollutants - Marinus Otte and Donna Jacob
- What, When, and Where in Studying the Best Management Practices (BMPs) in Grand Forks, North Dakota—Yeo Howe Lim (UND)
- Prioritizing aquifer monitoring in North Dakota: Geochemistry is important too.— Scott F. Korom (UND) and William Schuh (ND State Water Commission)
- Plant Phosphorus, Nitrogen, and Carbon and Soil Phosphorus in North Dakota Wetlands—Lindsey Meyers
- The National Wetland Condition Assessment in North Dakota: Preliminary Results— Shawn DeKeyser
- Three Discovery Farms...Three Unique Water Quality Stories - Rochelle Nustad
- Monitoring tile drainage and subirrigation water quality using electrical conductivity—Xinhua Jia
- Monitoring water quality in Devils Lake in real time—Xiaodong Zhang (UND)

Poster Presentations

- Multi-Elements in Pothole Wetlands – investigating the trace and rare earth elements - Donna Jacob
- Iron Cross-linked Biopolymers for Phosphate Removal - Mohammad Hossain
- Uncertainty analysis of load estimation for the nutrient TMDLs for Lake Ashtabula—Mengqi Xiong, Zhulu Lin, G. Padmanabhan
- Mapping the Fate of Nutrients at the Abandoned Crookston Cattle Company Feedlot—Phil Gerla and Prosper Gbolo (UND)



ND WRRRI Graduate Fellows and other students with the Director of NDWRRRI.

From left to right: Dr. Padmanabhan, Mohammad Hossain, Achintyamugdha Sharma, Amanda Grosz, Priyanka Deka, Anthony Wamono, Debjit Roy, and Mengqi Xiong



Dr. Xinhua Jia, Associate Professor, Agriculture and Biosystems

Darcy Lecture Hosted by the Geology and Geological Department, University of North Dakota

The Geology and Geological Engineering department of the University of North Dakota, Grand Forks, hosted the 2014 Darcy Lecture on February 28, 2014. The Henry Darcy Distinguished Lecture Series in Groundwater Science was established in 1986 by the National Groundwater Association (NGWA) to foster interest and excellence in groundwater science and technology. The series — which has reached more than 85,000 groundwater students, faculty members, and professionals — honors Henry Darcy of France for his 1856 investigations that established the physical basis upon which groundwater hydrogeology has been studied ever since.

Dr. Dorthe Wildenschild is this year's Darcy Lecturer. Dorthe Wildenschild is an Associate Professor in the School of Chemical, Biological and Environmental Engineering at Oregon State University. Research in her group focuses on physics, chemistry, and microbiology of relevance to flow and transport in porous media. Much of her work is supported by high resolution imaging and applications primarily involve subsurface multiphase flow phenomena. She had a busy lecture circuit through Germany, France, The Netherlands, Israel, Scotland, and Switzerland before coming to Grand Forks.

Dr. Wildenschild presented two lectures, one at noon and another at 3:00 pm. The event was organized by Dr. Phil Gerla and Dr. Scott Korom from the department of Geology and Geological Engineering, UND. Both of them are NDWRRI affiliate faculty.

Dr. Wildenschild's lecture at noon was titled, "What Happens in the Pore, No Longer Stays in the Pore: Opportunities and Limitations for Porous Media Characterization and Process Quantification Using X-ray Tomography" and the 3:00 pm lecture was titled, "Optimizing Capillary Trapping as a Carbon Dioxide Mitigation Strategy: Pore-Scale Findings in Support of Larger-Scale Implementation."

To learn more about her lectures visit <http://www.ngwa.org/Foundation/darcy/Pages/Current-Darcy-Lecturer.aspx>.

NDWRRI Fellows and Advisors Present at the Midwest Groundwater Conference in Bismarck

Several North Dakota Water resources Research Institute (NDWRRI) Fellows and affiliated faculty presented at the 58th Annual Midwest Groundwater Conference, September 23-25, 2013 in Bismarck, ND. Approximately 140 researchers and practicing professionals from government agencies, industries, and universities from the Midwestern states attended the conference. A tour of the Bakken oil country was a highlight of the conference. The tour included an oil drilling site, production well, water depots and transport, wastewater handling, and a man camp. An intake tower with horizontal wells on the Missouri river for Bismarck water supply was also a part of the tour.

The Midwest Groundwater Conference is a forum in which individuals, universities, industry, and government agencies of the Midwestern states come together annually to share research and case studies related to all aspects of groundwater. The conference began in 1956 in Illinois and has been held at one of the member states ever since.

G. Padmanabhan, Director, NDWRRI, served on the Planning Committee and chaired a session. Scott Korom, Associate Professor of Geology and Geological Engineering, UND, an NDWRRI affiliate faculty, and also a planning committee member was the banquet speaker. His talk was about nitrogen issues in the Lake Taupo Catchment in New Zealand. He also chaired a session. Other NDWRRI affiliate faculty members who chaired sessions are Francis Casey, Professor of Soil Science and Director of School of natural resources, NDSU, and Xinhua Jia, Assistant Professor, Agriculture and Biosystems Engineering, NDSU.

Presentations by Fellows (F) and affiliate faculty (AF) include:

- Underground Coal Gasification: What is it? What role does hydrogeology play?- Scott Korom (AF)
- Stationarity Revisited: A Physical Geographer's Perspective – Paul Todhunter (AF)
- Surface Modification of Nanoparticles with Food Starch for Groundwater Remediation Applications – Achintya Bezbaruah (AF)
- Fate and Transport of Estrogenic Hormone in Subsurface Waters – Francis Casey (AF)
- Electron Donor Contributions to Denitrification in the Elk Valley Aquifer – Amanda Krieger (F), Scott Korom (AF), and William Schuh
- Groundwater Level Response to Droughts in North Dakota – Navaratnam Leelaruban and G. Padmanabhan (AF)
- Groundwater Bioremediation for Alternating Contaminants using Enricher Reactor – Entrapped Cell Permeable Reactive Biobarrier – Murthy Kasi (F)



Achintya Bezbaruah presenting

Bakken Oil Patch tour participants



Navaratnam Leelaruban presenting

Meet Our Faculty

Dr. Ann Marie Fortuna



Dr. Ann-Marie Fortuna has been an Assistant Professor of Soil Health in the Soil Science Department at North Dakota State University since July of 2012. She has a Ph.D. in Crop and Soil Sciences from Michigan State University and a master in Agronomy from the University of Kentucky. Ann-Marie worked as a Research Associate for the USDA-ARS, New England Plant, Soil and Water Lab at the University of Maine and as an Assistant Professor of Soil Biology at Washington State University. Her research teaching and outreach focuses on Soil Health, Salinity, and Land Management. Her research program addresses: microbial and soil process regulating nutrient cycling, soil health, and global climate change; use of soil health indicators as a measure of the effectiveness of remediation and land management; nutrient management, loading of nitrogen and phosphorous to water resources and the impact of soil health and land management on water quality. Dr. Fortuna has a 90% research and 10% teaching appointment. Each year she teaches Soil Ecology (Soils 351) to undergraduates from several majors and is involved in undergraduate research projects. Ann-Marie and her graduate students participate in the Environmental & Conservation Sciences Graduate Program at NDSU.

Dr. Fortuna's PhD student, Heather Dose is a current NDWRRI fellowship recipient. Her research uses indicators of soil health and water quality to determine the impact of tile drainage and land management to remediate sodic soils, marginal soils that occur on over 4 million acres in North Dakota. Due to excess sodium, sodic soils have poor physical structure that reduces crop growth and water drainage. Strategies for managing sodic soils include perennial grassland, application of calcium amendments and subsurface tile drainage to remove sodium from the soil profile. The impact of these strategies on water quality and soil health has not been fully assessed. Heather's efforts to identifying indices of soil health and water quality for sodic soils will aid producers in their land management decisions and potentially lead to improvements in soil health and water quality.

Dr. Jack Norland



Dr. Jack Norland is an Associate Professor of Natural Resources in the School of Natural Resource Sciences at North Dakota State University. He earned a B.S. at Iowa State University and a M.S. at Montana State University. His PhD degree was in Natural Resource Management at North Dakota State University. Prior to joining the faculty at NDSU in 2008 he worked as a research biologist in Yellowstone National Park and as a research specialist at NDSU.

Dr. Norland interests are varied. He has worked on issues ranging from understanding the effects of wildfire on forests, grasslands, and wild ungulates, to remote sensing of various ecosystem variables in different landscapes. His interest in water quality/quantity issues has resulted in research on the effects of road dust on wetlands along with an inventory and assessment of wetlands in North Dakota with emphasis on phosphorus movement which was supported by a NDWRRI scholarship. His teaching efforts include teaching a course on watershed management in rangeland systems and a course on GIS for natural resource management with many examples directly related to water management.

Dr. Paul Todhunter



Dr. Paul Todhunter is a Professor in the Department of Geography at the University of North Dakota. He has a B.A. in Geography-Ecosystems from UCLA, and a M.A. and Ph.D. in Geography from UCLA. He was a Visiting Assistant Professor in the Graduate School of Geography at Clark University in Worcester, MA before joining the faculty at the University of North Dakota in 1989. He regularly teaches introductory courses in physical geography, as well as upper-division courses in Water Resources, Climatology, Environmental Hazards, and Human Impact on the Environment.

Dr. Todhunter has conducted research on a variety of flood hazard topics, including the hydroclimatological basis of the 1997 Grand Forks flood, the hydrology of flooding in the Devils Lake Basin, remote detection of prairie wetlands, pervasive wetland flooding in the Prairie Pothole Region of North Dakota, and use of the Hazus-MH model to assess relocation as a flood mitigation alternative for Minnewaukan, ND. He has also investigated atmosphere-snow cover-soil thermal regime coupling at Fargo, ND. His current research focuses upon microclimatological forcing of frost depth variation beneath prairie snow covers, and the non-linear relationship between precipitation input, surface runoff, and lake volume at Devils Lake.

Navigable Waters Are Not Necessarily Navigable: A State v. Federal Perspective (From the North Dakota State Water Commission Oxbow Oct 2014)

When water managers hear the term “navigable waters” these days, their thoughts will likely go to the recent news stories and concern related to the US Environmental Protection Agency’s (EPA) proposed rule changes to expand the Clean Water Act and its definition of that term. At the same time, North Dakota’s Office of the State Engineer has ramped up enforcement and public education efforts to reduce littering and off-road vehicle usage on sovereign lands – which include beaches and islands on “navigable waters.” Naturally, the state and federal government’s usage of the same term has caused concern and confusion. But when the state and federal government are talking about “navigable waters” – they are not always talking about the same thing.

When the State of North Dakota says “navigable” it typically means: *“used, or are susceptible of being used, ... as highways for commerce, over which trade and travel are or may be conducted in the customary modes of trade and travel on water.”* This wording comes from an 1870 U.S. Supreme Court case, *The Daniel Ball*, and has been repeatedly affirmed by both the North Dakota and United States Supreme Courts. To apply this definition of navigability, the test is to determine whether a waterbody was used or could have been used at the time North Dakota became a state in 1889. If evidence shows that a waterbody was or could have been “navigable” at statehood, then the state owns the bed of that waterbody (i.e., it is sovereign land). If evidence cannot show that the waterbody was “navigable” at statehood, then the riparian owner, or the person who owns the land adjacent to that waterbody, also owns the bed of that waterbody.

When the federal government uses the term “navigable waters,” typically the context is in relation to the Clean Water Act (CWA). “Navigable water” under the CWA means “waters of the United States (WOTUS) including the territorial seas.” Federal regulations further define WOTUS to include seven different categories of water. The first category of water defined under WOTUS is the same as what the State would consider “navigable waters.” The federal government sometimes refers to this category of water as “traditional navigable waters” or “A1” waters (because the language is found in Section 328.3(a)(1)). However, the federal WOTUS waters are much broader and encompass other categories.

In 2006, the infamous Rapanos decision from the US Supreme Court discussed which waters are considered WOTUS waters. Rapanos limited the EPA’s jurisdiction under the CWA to water with a “significant nexus” to navigable waters. The Rapanos decision is confusing for many reasons, but one reason is because it is unclear what “significant nexus” means. Because agencies have been struggling for nearly a decade to apply the “significant nexus” test, the Army Corps of Engineers and EPA are currently in the process of rule making to revise the definition of WOTUS.

Regardless of how the proposed federal rule changes proceed in defining navigable water and WOTUS, it will not impact how the state identifies navigable waters for sovereign land management purposes. For purposes of sovereign land management, the state’s navigable waters only include the “traditional navigable waters” or “A1” water.

Current Definition Of WOTUS

- (1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
- (2) All interstate waters including interstate wetlands;
- (3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
 - (i) Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
 - (ii) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
 - (iii) Which are used or could be used for industrial purpose by industries in interstate commerce;
- (4) All impoundments of waters otherwise defined as waters of the United States under the definition;
- (5) Tributaries of waters identified in paragraphs (a)(1) through (4) of this section;
- (6) The territorial seas;
- (7) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a)(1) through (6) of this section.

Aquifer Recharge and Recovery (From the North Dakota State Water Commission Oxbow June 2014)

Agricultural water, which is primarily used for irrigation, remains the single greatest consumptive water use, by volume, in North Dakota. While irrigation can enhance yields in crop production and allows agriculture in areas that would not receive sufficient precipitation in “normal” years, it can face serious challenges in terms of water availability.

Groundwater supplies are less prone than surface water to extreme variations in quantity from short-term changes in climate, which is why it is often used as a source for irrigation. However, even aquifers are eventually affected by long-term climate trends, where extended droughts can reduce available groundwater.

Another challenge to developing new irrigation is that, in many areas of the state, available surface and groundwater supplies are already highly appropriated, making it very challenging to find sufficient water for new or expanded projects.

A technology that has shown potential for mitigating the challenges to existing and available water supplies is Aquifer Recharge and Recovery (ARR). ARR generally involves the capture of waters from rivers and streams during periods of high flow (often in the spring), and then the storing of that water in an aquifer for later recovery and use. Water is placed in aquifers by surface infiltration through excavated basins. In areas that have soils with low permeability, or where the aquifer is especially deep, injection wells may be used.

ARR has been used periodically in North Dakota over the past 80 years. In 1932, Valley City was using Sheyenne River water to recharge local groundwater during high river flows for later municipal use. During the 1950s, Minot used ARR to supplement water in a local aquifer with water pumped from the Mouse [Souris] River. In the late 1980s and 1990s, the U.S. Bureau of Reclamation and the Garrison Conservancy District supplemented groundwater in the Oakes aquifer using spring infiltration of water pumped from the James River. Also in the late 1980s, the North Dakota State Water Commission worked with the U.S. Bureau of Reclamation to conduct studies on a pilot recharge basin, infiltrating water from the James River into the Oakes aquifer in Dickey County. Possible use of ARR to augment groundwater in the Englevale Aquifer (Ransom and Sargent Counties) was also examined in the early 1990s. In recent years, the Bureau considered ARR as part of an integrated plan for stabilizing water supplies in the Red River Valley.

In 1992, the Forest River Hutterite Community, near Fordville, ND in eastern North Dakota, began the planning, testing, and operation of an ARR basin and well field facility. The project, which is still being operated today, was developed in close consultation with the State Water Commission. Water Commission hydrologists provided assistance to ensure that all of the necessary scientific instrumentation was put into place to measure the effectiveness of the process, to confirm that all of the appropriate Water Commission permits were acquired and that the project would not impact prior water permits, and to ensure that groundwater was adequately protected from contamination. The project examined the feasibility of taking Forest River water during higher spring flows for injection into an aquifer for irrigation when needed.

The Forest River Community ARR project, includes two infiltration basins, each about 3.5 acres in area. Topsoil was removed from both basins to two feet below grade, with that removed soil being used to build a berm around the infiltration basins. The excavated topsoil, which was high in the less water-permeable clay, exposed a bed material of fine and medium sand, which is more permeable to water.

This project takes water from the Forest River during high flows in the spring and early summer, flows that would otherwise have been unavailable to beneficial use, for storage in a shallow aquifer. The water is pumped from the river into the two basins, allowing gravity to move that water into an aquifer through infiltration. That aquifer then serves as a water “bank” where the water can be saved from a part of the year when it was not needed, to be used later, when the presence of that water will benefit the crops being grown.

In order to quantify the amount of water that could be reliably withdrawn from the Forest River for aquifer injection, an analysis based upon two climate scenarios, a “dry” and a “wet” cycle was developed by the Water Commission. The dry cycle allowed for 200 acre-feet of aquifer recharge annually, and the wet cycle allowed 600 acre-feet of aquifer recharge annually. For the period of operation of the project, the region has been in an extended wet cycle.

Results and Future Work

The project has operated for 21 years, and over that relatively long period of time, a much better understanding of ARR has been gained. Between 1992 and the most recently published report in 2009, the following things have been learned.

The valuable information gathered by the Water Commission through the Forest River Aquifer Recharge Project sets the stage, and provides a good guide for how to design an ARR system in the future, and in other locations in North Dakota. Research such as this exemplifies the commitment of Water Commitment staff in conducting and supporting investigations promoting the development of water-use technologies to optimize the use of state water resources.

Information on ARR can be downloaded as pdf files from the North Dakota State Water Commission web site, under Reports and Publications/ Water Resource Research (WRI No. 47 and WRI No. 48.) Oakes pilot ARR projects are documented in WRI Nos. 5-8. The evaluation of potential ARR use for the Englevale Aquifer is in WRI No. 23, <http://swc.nd.gov/4dlink9/4dcgi/GetSubCategoryRecord/Reports%20and%20Publications/Water%20Resource%20Investigations>

Repairs on Devils Lake Outlet Completed (From the North Dakota State Water Commission Oxbow May 2014)

Repairs to the West Devils Lake Outlet are expected to be completed in May of this year. After operating for eight years, the West Devils Lake Outlet, required repairs on the standpipes located at the Round Lake and Josephine Pump Stations, replacement of a transformer, and general maintenance on the outlet channel.

In late 2013, damage was found on the center column of the Round Lake standpipe structure. The water enters the standpipe through the top of the center column, which has a series of baffle plates attached to it. The center column serves to reduce the velocity of the water being pumped into the standpipe before the water is gravity fed into the pipeline that runs from the bottom of the structure. The baffle plates had been torn away from the center column by the flow of water into the standpipe, and sections of the column needed to be replaced.

An analysis of the structures determined that the baffle plates were the source of the problem. Inspection of the Josephine Standpipe revealed similar damage was occurring to that structure's center column, although the damage was not as severe. To fix the damages, the Water Commission bid out contracts to remove the baffles from the center columns, repair the columns, and reinforce the center columns. Total costs of repair for the two standpipes are not expected to exceed \$350,000.

A transformer at the Josephine Pump Station overheated in 2013. Repairs were completed over the winter, with parts being replaced. Annual channel maintenance on the outlet was completed as well, with vegetation and sediment removed where it had been an issue.

Because the West Devils Lake Outlet design represented a pioneering approach to moving such a large volume of water, occasional issues such as this have been discovered and dealt with over the years. Operation of the outlets has been a learning experience, with an improved understanding being gained every year.

With a relatively dry winter in the Devils Lake basin, both the West and East Devils Lake Outlets will be ready to begin operation as soon as conditions permit. An earlier spring than last year, makes it likely that the outlets will be able to surpass the almost 142,000 acre-feet of water that was removed from the lake in 2013. With the completion of the repairs, the outlets will again begin their work to reduce the elevation of Devils Lake and restore previously flooded lands.

Moving Water East—Red River Valley Water Supply (From the North Dakota State Water Commission Oxbow May 2014)

Despite recent growth in population in western North Dakota, the vast majority of the state's population still resides in eastern counties along the Red River. Logistically, this presents a problem, because the Missouri River is the state's most reliable and high quality source of drinking water, but it is nearly 200 miles west of North Dakota's most populated areas.

Although the water needs of the Red River Valley are currently being met through a combination of ground and surface water sources, future demand will exceed available supplies during dry years. And in the case of an extended drought, as was experienced in the 1930s, the eastern portion of North Dakota would not have enough water to meet the needs of its citizens.

Over the years, various projects have been proposed to supply Missouri River water to eastern North Dakota. More recently, between 2000 and 2007, the U.S. Bureau of Reclamation in cooperation with the Garrison Diversion Conservancy District (GDCD), developed studies and plans related to a Red River Valley Water Supply Project (RRVWSP). This effort culminated in an Environmental Impact Statement (EIS), with a preferred alternative of a Missouri River system transfer of water via pipeline from the McClusky Canal to the Sheyenne River. Although all of the studies and reports required for the federally preferred option were completed, the U.S. Secretary of the Interior never signed a Record of Decision - a requirement for proceeding with a federal project. Despite this, the state of North Dakota will be able to take advantage of the tremendous amount of work that has been invested in this concept by the GDCD and others, as project development moves forward.

Findings of Value Engineering Study:

At the June 2014 State Water Commission meeting, the final VE was presented. From those findings, three alignments were identified as being the most likely to meet the criteria for future consideration. Those options were the (Option 1) Washburn to Baldhill Creek, (Option 2) Bismarck to Lake Ashtabula, and (Option 3) Bismarck to Fargo and Grand Forks routes.

Subject to further analysis, these alternatives were chosen as being the most likely to avoid impacts to sensitive environmental resources. They also support a project configuration that will minimize negative environmental impacts, and achieve compliance with federal, state, and local requirements as a state and local project.

Current Efforts:

Based upon the VE results, the Commission voted in June 2014 to begin a feasibility study for the siting of water intakes for the three project routes, using adjacent wells lateral to the Missouri River.

The wells on the banks of the Missouri River would work by intersecting the water table of the Missouri River, allowing the project to access that water, without requiring a surface water intake to be physically located in the river itself.

As part of this study to determine the feasibility of acquiring necessary amounts of Missouri River water for any future alignments, CH2M Hill will conduct a hydrogeologic analysis. The study will include a review of existing data, geophysical exploration, soil borings, aquifer pumping tests, and conceptual design of an intake - along with estimates of probable costs. Fieldwork is expected to begin in October 2014, with the final report scheduled for completion in January 2015.

Option 1: Washburn to Baldhill Creek Route



Option 2: Bismarck to Lake Ashtabual Route



Option 3: Bismarck to Fargo & Grand Forks



Recent Publications and Presentations by Institute Fellows and PIs

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Theses and Dissertations

Fellow: Amanda Kreiger, M.S. in Geology and Geological Engineering, graduated in May, 2014
Adviser: Scott Korom, Associate Professor, Geology and Geological Engineering, UND
Title: Electron Donor Contributions to Denitrification in the Elk Valley Aquifer, North Dakota

Fellow: Brian Mager, Master of Engineering Report, graduated in May, 2014
Adviser: Howe Lim, Associate Professor, Civil Engineering, UND
Title: Physical Model Studies of Scour Holes below Singular and Multiple Step Rock Weirs

Fellow: Jiexia Wu, M. S. in Earth System Science & Policy, University of North Dakota, Graduated May 2014
Adviser: Xiaodong Zhang Assoc. Professor, Dept. of Earth System Science and Policy, UND
Title: Agricultural drought monitoring and prediction using soil moisture deficit index

Fellow: Jun Yang, Ph. D in Civil Engineering, North Dakota State University, graduated May 2014
Adviser: Xuefeng Chu, Assoc. Professor, Civil and Environmental Engineering, NDSU
Title: Microtopography-dominated Discontinuous Overland Flow Modeling and Hydrologic Connectivity Analysis

Fellow: Rick Thalacker, M.S. in Geography, University of North Dakota, graduated in May 2014
Adviser: Gregory Vandeberg, Associate Professor in Geography, UND
Title: Mapping Technics for Soil Erosion: Modeling Stream Power Index in Eastern North Dakota

Fellow: Ruchi Joshi, M.S., Environmental and Conservation Sciences Program, College of Graduate and Interdisciplinary Studies, North Dakota State University, graduated in April 2014.
Advisers: Eakalak Khan, Professor, Civil and Environmental Engineering and Dr. John McEvoy,
Title: In Vitro Enrichment of Phosphorylated Proteins from Synchronously Exeysted *Cryptosporidium parvum*.

Fellow: Melissa Wygant, M.S., University of North Dakota, graduated in Summer 2014
Adviser: Paul Todhunter, Professor in Geography, UND
Title: A Place Vulnerability Analysis of Changing Flood Risk for Grand Forks, North Dakota 1990-2010

Institute Publications

Technical Report No: ND13-05
Impact of Subsurface Drainage on Stream Flows in the Red River of the North Basin
Mohammed M. Rahman and Zhulu Lin
Featured faculty

Recent USGS Reports

Simulation of groundwater flow and the interaction of groundwater and surface water in the Willamette Basin and Central Willamette subbasin, Oregon
(Released: Mon, 6 Oct 2014 16:00 -0500) <http://pubs.er.usgs.gov/publication/sir20145136>

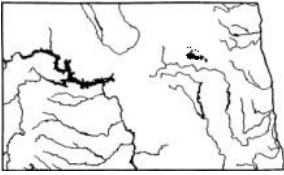
The effects of Missouri River mainstem reservoir system operations on 2011 flooding using a Precipitation-Runoff Modeling System model: Chapter K in 2011 Floods of the Central United States
(Released: Fri, 3 Oct 2014 14:32 -0500) <http://pubs.er.usgs.gov/publication/pp1798K>

Southwest North Dakota Broke Streamflow Records in August (new window)
(Released: 9/11/2014 12:42:13 PM) <http://www.usgs.gov/newsroom/article.asp?ID=3998#.VDRk0jYo61s>

Streamflow Increasing in Eastern Missouri River Basin, Decreasing Elsewhere (new window)
(Released: 7/28/2014 1:06:44 PM) <http://www.usgs.gov/newsroom/article.asp?ID=3944#.VDRIKTYo61s>



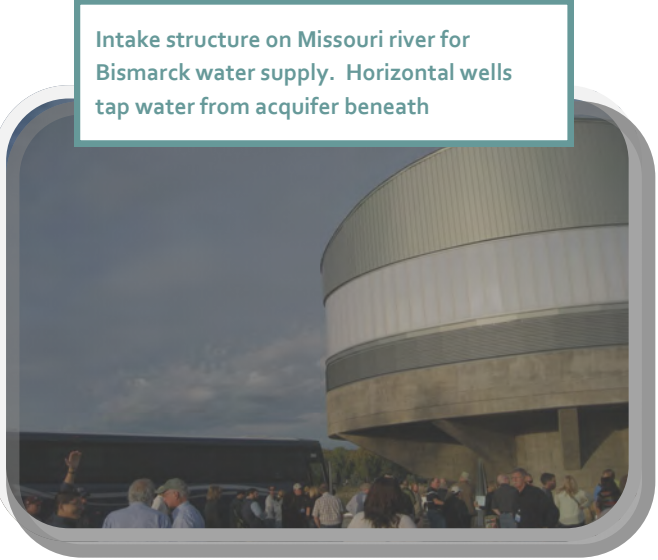
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An Oil well blowout site



Intake structure on Missouri river for Bismarck water supply. Horizontal wells tap water from aquifer beneath

North Dakota Water Resources Research Institute (NDWRRI)

The Institute was founded in 1965 by authority of Congress as one of the 54 Institutes throughout the nation and is administered through the United States Geological Survey. The NDWRRI receives funding through section 104 of the *Water Resources Research Act of 1984* and it applies its Federal allotment funds to research that fosters: A) the entry of new research scientists into the water resources field, B) training and education of future water resources scientists, engineers, and technicians; C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena; and D) the dissemination of research results to water managers and the public.