



Water Resources Center

Biennial Report 2005-2006

UNIVERSITY OF MINNESOTA

About the Cover

Removing native vegetation mechanically or chemically when lakeshores are developed can have adverse consequences for entire lake ecosystems. These consequences include loss of fish and wildlife habitat, shoreline erosion and water quality degradation. Many states, including Wisconsin and Minnesota, have been actively advocating for and participating in shoreland restoration for the past decade, yet many of these efforts fail. University of Minnesota researcher Susan Galatowitsch, along with Water Resources Science graduate student Dana Vandenbosch, set out to investigate why such revegetation efforts are unsuccessful by examining the factors that affect the establishment of the primary species used in revegetation efforts, *Scirpus validus* (soft-stem bulrush). The results of this research, conducted in the seven-county metropolitan area, will be used by governmental and private entities in future lakeshore restoration undertakings. For more information about this project, turn to page 11.

Editing and Design:

Charlie Sawdey

Tracy Thomas Wilson

The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation.

This material is available in other formats upon request. Call the University of Minnesota Water Resources Center at (612) 624-9282.

Copyright © 2007 Regents of the University of Minnesota. All rights reserved.

Table of Contents

From the Directors	1
About the WRC	2–9
Research	3
Outreach	4–6
Education	7–9
Water Resources Center Projects	
Animal Waste Management	10
Environmental Restoration	11
Fate, Transport, and Impacts of Contaminants	12–15
Nutrients and Water Quality	16–21
Water Policy and Economics	22–23
Watershed Management	24–26
Public and Professional Service	27–28
Appendices	29–51
Appendix A: WRC Staff List	29
Appendix B: WRS Graduates and Thesis Titles	30–33
Appendix C: WRS Student Awards	34–35
Appendix D: WRC Council and Committee	36
Appendix E: Refereed Journal Articles	37–38
Appendix F: Presentations and Publications	39–47
Appendix G: List of Projects	49–51

From the Directors

We are pleased to present the fifth biennial report of the Water Resources Center (WRC). Over the past two years, there have been a lot of changes both within the WRC as well as in the collegiate units around us. Deb Swackhamer was selected as the interim director of the newly formed Institute on the Environment. This led to the selection of Faye Sleeper, formerly with the Minnesota Pollution Control Agency, as co-director of the WRC. The WRC mission of providing interdisciplinary research, education, and outreach leading to land and water practices that protect the long-term quality of Minnesota's water resources continues. With recent state legislative appropriations, the need for an inter-disciplinary center that facilitates engagement of faculty and staff at the University of Minnesota on a wide range of water resource issues has never been more apparent. With these opportunities come new challenges; the work becomes more critical, while at the same time more exciting.

As the entry point to the University for questions about water resource issues, the WRC addresses both the day-to-day needs and the long-term issues of the State and of the nation. We think, as you look at the depth and breadth of the projects represented in these pages, you will see that we try to bring our resources to bear on these critical questions.

The WRC's research program continues to expand, but one of the salient features of our center is the integration of outreach and education elements into most of our projects. The close connection and working relationship with University of Minnesota Extension means that information generated gets to where it needs to be in a timely fashion. This integration across research, education and outreach is critical to solving the water problems of the future.

The Water Resources Sciences graduate program remains very strong. There are approximately 80 students working on advanced degrees. There are now over 100 faculty listed as water resources faculty. We attract increasingly well-qualified students as the program matures. We would like to thank the Dean of the College of Food, Agricultural and Natural Resource Sciences, Allen Levine, the Dean and Director of Extension, Bev Durgan, and Vice President and Dean of the Graduate School, Gail Dubrow, for their continued support. We also express thanks to the WRC staff for their hard work and cooperation. Finally, we acknowledge our graduate student editor, Charlie Sawdey, for assembling this document.

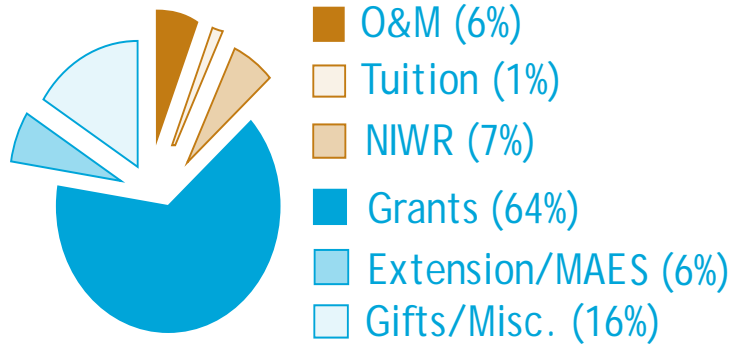
We hope you find this document informative and that it provides not only insight into what we do, but some ideas for future cooperation and effort.

James L. Anderson
Co-Director

Faye Sleeper
Co-Director

About the WRC

The Water Resources Center (WRC) is a multi-faceted center with active programs in research, outreach, and education. The WRC helps coordinate water-related outreach and research within the University, enabling more effective delivery of water research to decision-makers and citizens, opening new avenues for multi-disciplinary and interdisciplinary partnerships, and providing a key link between students and water resources professionals.



WRC biennial budget by percentage

The WRC’s creation in 1996 united three long-standing University of Minnesota water programs, the Water Resources Research Center, the Center for Agricultural Impacts on Water Quality, and the Extension Water Quality Program. The WRC has integrated the missions of the three water programs into an expanded, collaborative partnership.

The WRC is also the administrative home to the innovative Water Resources Science (WRS) graduate program. This program prepares students in a holistic manner for solving complex problems in managing and researching aquatic systems. Details regarding the WRS graduate program can be found on pages 7–9 of this report.

The WRC budget in the 2005–2006 biennium is illustrated by the figure above. The majority of the budget is in the form of external grants. Gifts to the WRC make up the next largest income bracket, the National Institute for Water Resources (NIWR), Extension/Minnesota Agricultural Experimental Station (MAES,) and O&M make up the operations portion of the budget. Establishment of partnerships and integrated approaches allow us to leverage University resources at a 5:1 ratio. For specific projects, the rates can be at the 10:1 level or higher.

Water Resources Center Staff



*Front row, left to right: Tracy Thomas Wilson, Bonnie Anderson, Valerie Were, Faye Sleeper.
Back Row, left to right: Karlyn Eckman, Larry Baker, Roland Sigurdson, Charlie Sawdey, Les Everett, Jim Anderson, Deb Swackbamer, Maria Juergens.*

Not Pictured: Janelle Benusa, Kevin Blanchet, Sara Christopherson, Dave Gustafson, Nick Haig, Daniel Lephardt, Barb Liukkonen, Ray Newman, Isabella Walstrom, Dan Wheeler

*About the WRC***Research**

The Water Resources Center conducts and funds research projects concerned with the water resources of Minnesota and the Midwest, although the applicability of the research is usually broader in scope. For every dollar the Center receives in support from the College of Food, Agricultural and Natural Resources Science, University of Minnesota Extension, and Minnesota Agricultural Experimental Station, we bring in approximately \$5 in grants for research and outreach on issues such as water quality, nutrient management, and water policy. The WRC also awards grants to researchers working on water issues, balancing support between senior faculty with proven track records and young investigators in need of start-up funds to pursue new ideas. For a complete list of all WRC projects and grants awarded, see appendix G on page 48.

WRC Research Projects

WRC faculty and staff were involved in a number of research projects over the 2005–2006 biennium. Research covered topics from the assessment of the effects of arsenic on Minnesota dairy operations to conservation drainage research. Funding for WRC-led research was provided from a variety of sources, such as the National

Science Foundation and the Minnesota Pollution Control Agency. The National Science Foundation provided funding for a research project conducted by WRC fellow Larry Baker to study biogeochemical cycles in urban and agricultural systems. For more information about this project, turn to page 17.

WRC Grants Program

Over the past decade, the WRC has sponsored research in a variety of aquatic sciences and water resource disciplines, such as treatment and control methods for toxic wastes, wetland hydrology, river ecology, and non-point source pollution.

Research projects are usually funded for a one-year period and involve a combination of federal money and matching funds from state, university, or local sources. The WRC contributes funds from two of its component entities,

the Water Resources Research Institute and the Center for Agricultural Impacts on Water Quality. A research advisory committee made up of university, state, and federal personnel meets each year and selects projects for the grant program. An announcement of research program interests is made yearly in a request for proposals. Findings from research supported by the WRC are published in technical reports and scientific journals and presented at conferences and symposia. In the 2005–2006 biennium, the WRC funded seven projects, descriptions of which appear on pages 10–26.



Photo by Dana Vanderhosh

In 2006, the WRC granted funds to a project that assessed factors affecting revegetation success in lakeshore restorations. For more information about this project and others funded by the WRC, see pages 10–26.

About the WRC

Outreach

The WRC engages the public in activities to protect and improve water quality in Minnesota and beyond. We offer a broad array of water quality programming and materials dealing with topics of public concern, such as agricultural best management practices; lakes, rivers, and wetlands; onsite sewage treatment; and youth and water resources.

Our programs put University expertise to use for the public good. We work through University of Minnesota Extension to provide information and education for citizens, for water educators, and for policy makers. For information about WRC Extension and outreach projects directed over the 2005–2006 biennium, see pages 10–24 of this report, or visit <http://wrc.umn.edu/outreach/>. We are committed to building partnerships that enhance and expand our ability to protect the quality and value of our abundant water resources.



Photo by Dave Hansen

Nearly 600 farmers and agricultural professionals gathered for a strip-tillage demonstration in July 2006. This is part of an Extension project funded by the WRC. For more information about this project, turn to page 24.

The WRC also engages the public through seminars, conferences, publications, and its Web site: wrc.umn.edu/.

The Power of Water

The Power of Water lecture series concluded in April of 2005 with a talk given by Dr. Henry Vaux Jr., University of California Professor of Resource Economics, Emeritus, and Associate Vice President Emeritus for Agriculture and Natural Resources. Vaux's address spanned five general topics: safety of drinking water, supporting population growth and a healthy environment, maintenance and enhancement of water quality, water policy, and adaptation to climate change. Underlying these topics, Vaux stressed the importance for sound scientific research to support action. "Often, such research is focused on short-term operation problems, or on issues that fall squarely in an agency's purview, leaving larger, pressing questions unresolved," he said.

The Power of Water lecture series was held at the Bell Museum of Natural History, and was co-sponsored by the WRC, the Consortium for Law and Values in Health, Environment, and the Life Sciences, the Bell Museum, and the Graduate School. Power of Water was part of the President's 21st Century Interdisciplinary Conferences Initiative.

About the WRC

Outreach

Minnegram

The WRC's quarterly newsletter, the Minnegram, reaches over 1700 water professionals, researchers, students, and interested citizens throughout Minnesota and the United States with water news, articles, and community information.

The Minnegram provides feature-length coverage of water issues and research at the University and in the State of Minnesota, highlighting the work of the University's community of water scholars. Topics covered in the last biennium included the future of water quality, whole-watershed nutrient balances, agricultural practices contributing to increased water quality, and the State's most comprehensive water conference, Minnesota Water and Annual Water Resources Joint Conference. Past issues of the Minnegram are available on the Web site at: <http://wrc.umn.edu/newsandevents/minnegram/>. To subscribe, send a message to: mng-ed@umn.edu.

wrc.umn.edu

On the internet at wrc.umn.edu, the Water Resource Center's Web site describes our programs in research, outreach, and education, and includes access to publications, WRC staff pages, an expertise directory of water scholars in Minnesota, and links to many of our colleagues and partners. Complete information about the Water Resources Science graduate program (wrs.umn.edu), Onsite Sewage Treatment Program (septic.umn.edu), and the Volunteer Stream Monitoring Partnership (www.vsmmp.org) is also accessible from the main site.

About the WRC

Outreach

Minnesota Water and Annual Water Resources Joint Conference

The Minnesota Water and Annual Water Resources Joint Conference presents innovative and practical water resource management techniques, and highlights research about Minnesota’s water resources. The conference provides an opportunity to address emerging issues, to present lessons learned and best practices discovered. The conference facilitates interactions among resource managers, researchers, state and local agency staff, and other water resources professionals, including consultants and practicing engineers.

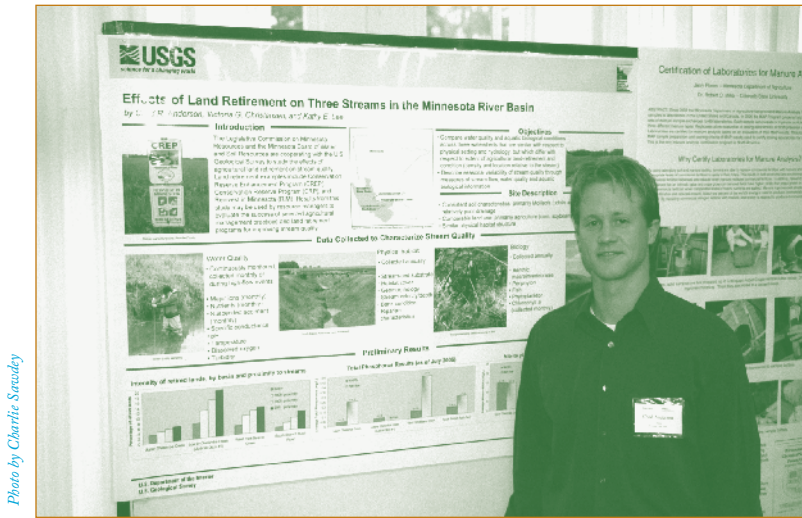


Photo by Charita Savadey

Water Resources Science M.S. student Chad Anderson presented his poster on drainage ditches and water quality in South-western Minnesota at the 2006 Minnesota Water and Annual Water Resources Joint Conference.

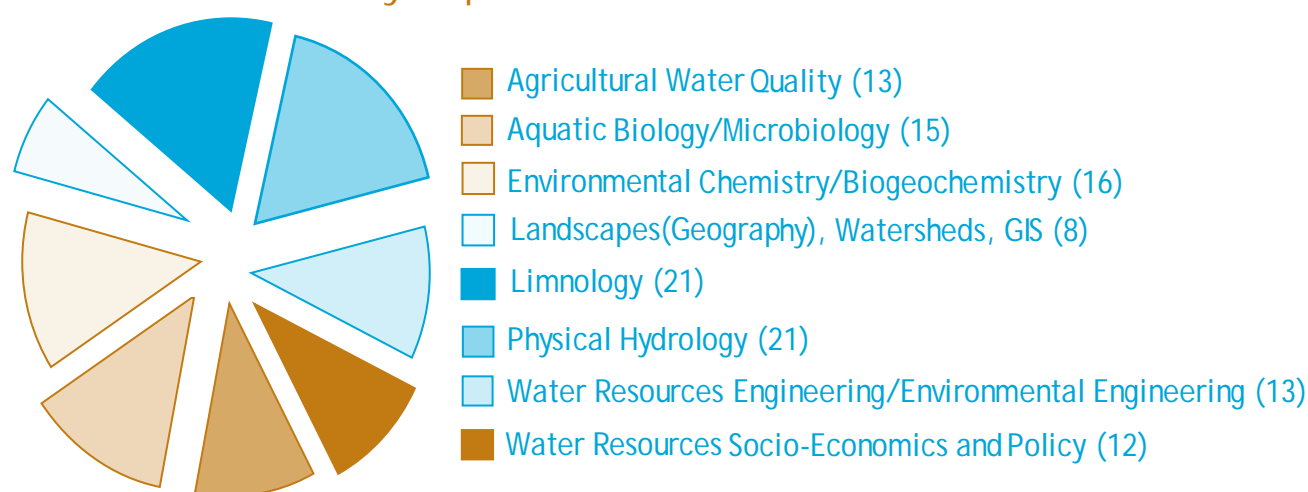
For nearly 40 years, the annual Water Resources Conference presented emerging and implemented water resource management techniques for water resource professionals, including consultants, and city, county, and state practicing engineers. For almost 15 years, the Water Resources Center’s biennial Minnesota Water conference highlighted academic research on Minnesota’s wealth of water resources, and facilitated interactions among resource managers, researchers, and other water professionals. Presenting these water resources conferences together allows for the natural synergy and interactions between the audiences of each. The objectives of the two conferences are complementary, and the joint conference brings them together to create an uniquely relevant program with a broader and more inclusive appeal.

Plenary Speakers at the 2005 and 2006 conferences included John J. Magnuson, Professor Emeritus at the University of Wisconsin Limnological Research Center; Thomas Fontaine, Director, Western Ecology Division, National Health and Environmental Effects Laboratory, Office of Research and Development, U.S. Environmental Protection Agency; Brad Moore, Commissioner, Minnesota Pollution Control Agency; Robert Glennon, Morris K. Udall Professor of Law and Public Policy, University of Arizona Rogers College of Law; and David Tilman, Regents Professor, Department of Ecology, Evolution, and Behavior, University of Minnesota.

The conference was sponsored by the Water Resources Center and the College of Continuing Education, University of Minnesota, with co-sponsorship by Minnesota Sea Grant, the Natural Resources Research Institute, Department of Civil Engineering, University of Minnesota, and the Minnesota Section of the American Society of Civil Engineers.

*About the WRC***Education**

The Water Resources Center (WRC) is the administrative home for the interdisciplinary graduate program in Water Resources Science (WRS). Since its founding in 1995, the program has grown to involve over 110 faculty on the Twin Cities and Duluth campuses of the University with a steady enrollment of 70–80 graduate students. Since its inception, the program has produced 115 graduates, including 87 M.S. students and 28 Ph.D. students. During the 2005–2006, 32 students graduated and began their careers in water resources fields (see Appendix B).

Areas of WRS Faculty Expertise*

** Primary interest only; many faculty have more than one area of interest and expertise (Spring 2007).*

Ray Newman (Fisheries, Wildlife, and Conservation Biology) took over as Director of Graduate Studies in fall 2003, and Erik Brown (Geology, Large Lakes Observatory) continued to serve as Associate DGS in Duluth. Both were re-elected to new three-year terms in summer 2006. Donn Branstrator (Biology, Large Lakes Observatory) filled in as Associate DGS in Duluth during spring 2006, while Erik Brown was on sabbatical. In summer 2006, Bonnie Anderson became the program administrator. Maria Juergens, the program's administrator since its inception, continues to oversee the administration of the program.

The WRS Web site (<http://wrs.umn.edu>) serves as the program's chief recruiting tool and a major resource for current students and faculty. The site is regularly updated and provides the most complete and current information about the program. The Web site guides students to application materials, to faculty seeking students, and to travel grant applications, seminar information and updated alumni information. The Web site provides a wealth of information about the faculty, curriculum, current students, and graduates of the program in a crisp, clean format. In addition, the University has switched to a complete online electronic application process to facilitate the submission of all materials. In 2006, it became possible to assemble the files of the applicants online. Using a secure portal system, the admissions committee and all WRS faculty are able to review and comment on applications online. This has eliminated the need to generate paper copies for distribution to our large and dispersed faculty. The new electronic admissions process has been well received by faculty and has enhanced and

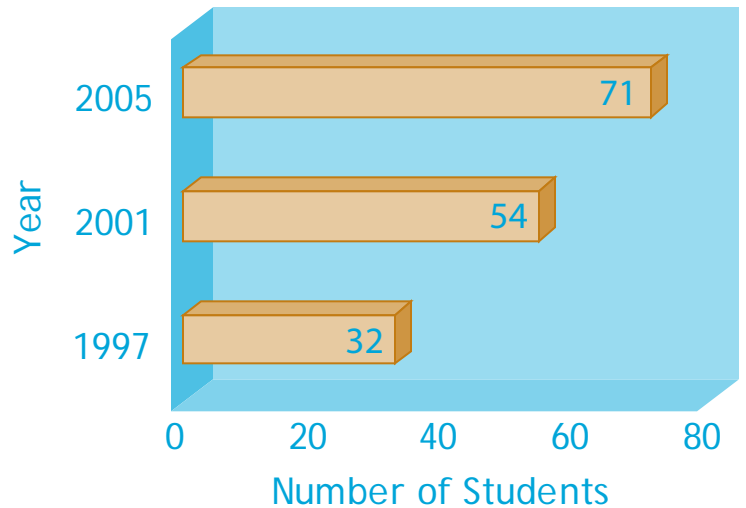
About the WRC

Education

streamlined recruiting and admissions.

WRS “Welcome Weekend,” held for the first time in 2004, takes place in early spring and has been very helpful in recruiting top applicants. Each year we invite 10–15 students, half are from out of state, and half local. Students tour the Minneapolis, St. Paul, and Duluth campuses and meet faculty and students at each campus. Because of its success at recruiting the best students and because it increased interaction among current WRS students and faculty, we plan to continue to host “Welcome Weekend” each spring.

WRS Fall Enrollment 1997, 2001, 2005



Facts about WRS faculty

Current number of faculty: 119
 TC Saint Paul 56
 TC Minneapolis 38
 Duluth 25

Departments/units represented: 26
 Twin Cities 19
 Duluth 7

Colleges represented:
 Twin Cities 8
 Duluth 2

Faculty who have advised/are advising a WRS student: 65

Faculty by rank:
 Full Professors 56
 Associate Professors 27
 Assistant Professors 14
 Other appointments 21

Some changes were made to WRS courses. Larry Baker (WRC) taught the 3.0 credit policy course WRS 5101 Water Resources: Individuals and Institutions, and Ray Newman taught the 0.5 credit ethics course, WRS 8581 Research and Professional Ethics in Water Resources and Environmental Science. Both courses were offered in spring in the Twin Cities campus. Duluth students completed ethics training in their advisor’s departments and fulfilled the policy core with the Duluth course POL 4201 Natural Resources Policy. During spring 2007, WRS 5101 and WRS 8581 will be offered via ITV, so students in Duluth will have the opportunity to take these courses and interact with Twin Cities students. If this format works, we will continue offering these courses via ITV.

The WRS program continues to function with three main committees: Executive, Curriculum and Admissions. The WRS Executive Committee meets once each semester and is composed of three students and 16 faculty, including all committee chairs. During the past two years, John Nieber (Bioproducts and Biosystems Engineering) and Bill Arnold (Civil Engineering) have served as chair of the WRS Admissions Committee, Leonard Ferrington (Entomology) as chair of the Curriculum Committee, David Mulla (Soil, Water, and Climate) and Larry Baker (WRC) as co-chairs of the Seminar Committee. Larry Baker served as faculty advisor for the Water Resources

*About the WRC***Education**

Students in Action (WRSIA) organization for two years and was replaced in 2006 by Leonard Ferrington. Students have recently taken a more active role in the seminar series, and, starting in 2007, the seminar will move to Friday afternoons in a better and more convenient facility to enhance attendance. The Curriculum Committee is reviewing current course offerings and the water quality requirement, and may propose changes in core requirements during the next biennium. For additional information about the Water Resources Science Program and curriculum, please visit wrs.umn.edu/.

Water Resources Students in Action (WRSIA)

Water Resources Students in Action (WRSIA) is the Water Resources Science graduate student organization. WRSIA supports students by providing opportunities to participate in community activities, professional development, and social gatherings, such as barbecues, picnics, and journal club. Each year, WRSIA elects new officers to organize and manage the group and plan events.

WRSIA has worked on several projects to gain experience in monitoring water resources and in teaching people about water resources issues. One such project is the Groundhouse River monitoring project in Mora, Minnesota. WRSIA collaborated with Kanabec Soil and Water District, Mora and Ogilvie High School, and a Kanabec County farmer to develop a monitoring program to assess the success of restoration efforts on the Groundhouse River. WRS students helped develop the monitoring program and each spring led Ogilvie and Mora high school students through water quality and monitoring lessons, both in the classroom and at the river.

These activities enhance WRS students' graduate experience and promote cohesiveness and community among WRS students, who are housed in departments around the University. The WRC recognizes the importance of WRSIA to the WRS experience and supports it administratively by providing office space, supplies, funds for travel, and food for student gatherings.



WRSIA President Giana Gelsey engages high school students during the Groundhouse River Monitoring Project, held in Mora, MN.

WRC Projects

Animal Waste Management

Estrogens and Estrogenic Activity in Swine Manure

PIs: Kuldip Kumar (Soil, Water, and Climate), Ashok K. Singh (Veterinary Population Medicine), Satish C. Gupta (Soil, Water, and Climate)

Funding Source: USDI-USGS-WRRI 104B National Grants Competition

Project Duration: March 2005–February 2006

Swine farming is one of the major food-animal industries in the nation. In 2003, pig growers in the US had an inventory of 59.6 billion pigs and hogs, a production effort in which Minnesota ranked third. It is projected that this industry will continue to grow at a high rate, meaning exacerbation of existing problems associated with disposal of swine waste. Naturally occurring estrogen hormones in such waste products are emerging contaminants that are receiving increased public attention. At low concentrations, these pollutants can adversely affect the reproductive biology of vertebrates such as fish, turtles, frogs, other wild animals, and humans. The goal of this research project was to develop procedures for analyzing different estrogens and estrogenic activities in different types of swine manure. To date, studies have shown that potent estrogens such as estrone (E1), estradiol (E2), and estriol (E3) are excreted into the environment in the urine and feces of all farm animals. Data is lacking, however, in order to accurately assess the scope of estrogenic contamination. It is thought that an important reason for this lack of scientific data is an absence of analytical methods for the screening and confirmation of estrogens, especially the conjugated estrogens found in swine waste.

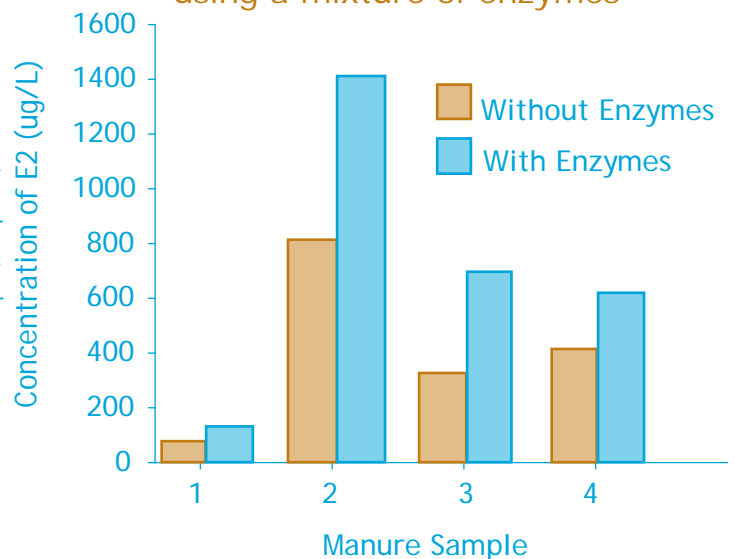
Results:

Researchers found that solvent extraction of feces, urine, and manure slurries sufficiently quantified free

estrogens in manure samples. In general, higher concentrations of free estrogens were present in fecal matter than in urine, and the greatest concentrations were found in pregnant pig samples, followed by non-pregnant pigs, and finally boars.

The initial hypothesis was that conjugated estrogens also contribute to estrogenic activity as they are converted to free estrogens by soil enzymes. This was proven to be correct, as free estrogens noticeably increased in samples that were treated with beta-glucuronidase and sulfatase enzymes (see figure). This shows that in addition to free estrogens, concentrations of conjugated estrogens may be significant in manures, necessitating their quantification. However, conjugates were difficult to separate upon solvent extraction, due to early elution of organic compounds. Future efforts will aim at developing better clean up procedures for separation of conjugates, in order to quantify them accurately.

Hydrolysis of conjugated estrogens using a mixture of enzymes



WRC Projects

Environmental Restoration

Factors Affecting Revegetation Success in Lakeshore Restorations

PI: Susan Galatowitsch (Horticultural Science)

Student: Dana Vanderbosch (Water Resources Science)

Funding Source: USDI-USGS-WRRI 104B National Grants Competition

Project Duration: April 2006–March 2008



A shoreline revegetation site in the Twin Cities Metropolitan Area. This study spanned seven counties: Ramsey, Hennepin, Dakota, Washington, Scott, Carver and Anoka.

The overall objective of this research project was to investigate the factors affecting the establishment of *Scirpus validus* (soft-stem bulrush), the most commonly used species in lakeshore restoration. Revegetation of aquatic zones with native plants such as bulrush is crucial to the overall success of lakeshore restoration, since improving fish habitat and reducing shoreline wave impacts depend on the development of emergent plant beds. Currently, there is little understanding of why most aquatic plantings fail. This lack of understanding stems, in part, from a lack

of knowledge of the effects of planting time, water depth, and root/rhizome development on the survival of emergent aquatic transplants. Results of this study provide essential data needed to determine the critical factors for survival of revegetation transplants (specifically bulrush).

Five case study lakes were chosen from the initial screening process. Seasonal plantings occurred once per month between May and September 2006. The condition of each plant was assessed and classified at planting time using three different measurements to estimate robustness: shoot count, the height of the tallest three stems of the clump, and a rating of overall condition.

Results:

Researchers determined, in general, that initial bulrush mortality is highest in shallow water because of direct and indirect effects of wave impact. Plants installed as mats are more prone to wave impacts in these shallow areas than are those installed in pots, perhaps because of differences in root development. Establishment success is greatest in mid-summer, most likely stemming from differences in the size and quality of plants received from the nursery rather than differences encountered at planting sites. In spite of protecting all plantings from herbivores, muskrat herbivory also limited bulrush establishment at every site. The experimental beds will continue to be monitored to determine over-winter mortality and first-year stand establishment. This information will be used by the Minnesota Department of Natural Resources, Extension Shoreland Educators, watershed management districts, and private landowners in improving lakeshore quality.

WRC Projects

Fate, Transport, and Impacts of Contaminants

Assessing the Ecotoxicology of 4-nonylphenol, a Ubiquitous Environmental Estrogen, in Two Organismal Bioassays

PIs: Heiko L. Shoenfuss, Matthew L. Julius (Biological Sciences, SCSU), Kathy Lee, Larry B. Barber (U.S. Geological Survey)

Students: Travis Bistodeau, Roberto Cediell, Angela Allen (Undergraduate), (Biological Sciences, SCSU)

Funding Source: UDI-USGS-WRRI 104B National Grants Competition

Project Duration: March 2004–February 2005

Environmental estrogens have been identified as an important source of endocrine disruption in aquatic wildlife. It remains unclear, however, whether environmentally relevant concentrations of these compounds adversely affect the different tiers of the aquatic food chain. In addition to potent natural and synthetic estrogens (estrone, estradiol, ethynylestradiol), alkylphenolic surfactants based on the parent compound 4-nonylphenol have been suggested as contributing to the estrogenicity of treated wastewater effluents and ultimately surface waters in the US. In this project, researchers developed a sensitive methodology to assess the estrogenicity in two tiers of the aquatic food chain, a primary producer (diatom) and a secondary consumer (fathead minnow), to determine whether exposure to 4-nonylphenol at environmentally relevant concentrations has adverse effects on aquatic organisms.

Results:

The two modules developed by researchers in this study represent two tiers of the aquatic trophic cascade. Diatoms represent an important component of the primary producer community while fathead minnows are an important intermediate consumer.

4-Nonylphenol at environmental concentrations had significant adverse effects on the lipid concentrations of diatoms (see photo) and adversely affected fathead minnow reproductive behavior. Together, these findings indicate that the effects of environmental estrogens need to be studied across the aquatic trophic cascade. Furthermore, this study suggests that environmental concentrations of 4-nonylphenol could adversely impact the aquatic trophic cascade.

The results of this study provided the foundation for a 104G National Grant Project that links these assays in the assessment of alkylphenol mixtures effects across different tiers of the food chain. Details and progress of this study may be found on the following page.



Control Bleached Control 2 ug/L 20 ug/L 200 ug/L

Diatom cultures exposed to a nonylphenol mixture at various concentrations. Darker colored cultures (right) indicate greater light absorption (= greater Chlorophyll A content). Increased light absorption is indicative of a diminished nutritional value of the diatom as a food source of fingerling fish (as chlorophyll A is produced at the expense of lipid reserves). At the highest nonylphenol concentration cell death occurs (200 ug/L flask is slightly more transparent than the flask containing 20 ug/L).

WRC Projects

Fate, Transport, and Impacts of Contaminants

Assessing the Ecotoxicology of Alkylphenol Mixtures Across the Aquatic Food Chain

PIs: Heiko L. Schoenfuss, Matthew L. Julius, (Biological Sciences, SCSU), Larry B. Barber, (US Geological Survey, Boulder, Colorado)

Students: Kent Grove, Jason Koch, Nathan Jahns, Roberto Cediél, Carolyn Gamble, Angela Allen (Undergraduate), Tim Loes (Undergraduate), Bradley Sivanich (Undergraduate), Josh Stepanek (Undergraduate), (Biological Sciences, SCSU)

Funding Source: USDI-USGS-WRRI 104G National Grants Competition

Project Duration: September 2005–August 2007

The goal of this research project is to examine the effects of alkylphenol mixtures on three tiers of the aquatic food chain: the primary producer community (diatoms), a primary consumer (*Daphnia magna*), and a vertebrate near the top of the food chain (fathead minnow). To date, alkylphenol studies have focused on 4-nonylphenol, the metabolic product of both aerobic and anaerobic microbial degradation of higher-chained alkylphenols. As a result, the United States Environmental Protection Agency has recently proposed effluent emissions criteria for this compound. However, the combined effect of mixtures containing nonylphenols and higher chained alkylphenols are largely unknown.

Preliminary Findings:

It has been demonstrated that the combined effects of alkylphenols exceeds that of individual alkylphenols previously determined in fathead minnows. It has also been established that diatoms serve as sensitive indicators of biological disruption caused by the presence of alkylphenol mixtures. Furthermore, protocols for

the *Daphnia* exposure have been developed, and are currently being tested. Finalization of the aggregated food chain exposure experiment is also underway, and will be finished by the summer of 2007.

Publications:

Bistodeau, T.J., L.B. Barber, S.E. Bartell, R.A. Cediél, K.J. Grove, J. Klaustermeier, J.C. Woodard, K.E. Lee and H.L. Schoenfuss. 2006. Larval exposure to environmentally relevant mixtures of alkylphenolethoxylates reduces reproductive competence in male fathead minnows. *Aquatic Toxicology* 79: 268-277.

Schoenfuss, H.L., S. E. Bartell, T. B. Bistodeau, R. A. Cediél, K. J. Grove, K. E. Lee, L. B. Barber. In Review. Environmentally relevant exposures to 4-nonylphenol impair the reproductive potential of male fathead minnows. Currently in USGS Peer Review.

For a complete list of presentations and publications relative to this project and others over the 2005–2006 biennium, turn to Appendices E and F on pages 37–47.

WRC Projects

Fate, Transport, and Impacts of Contaminants

Assessing the Impact of Arsenic on Upper-Midwestern Dairy Operations

PIs: Barbara Liukkonen (WRC), Vince Crary (University of MN Extension), Melinda Erickson (Minnesota Pollution Control Agency), Jim Linn (Animal Science), Mike Murphy (Veterinary Diagnostic Laboratory)

Funding Source: Extension Regional Water Quality Leadership Team; College of Food, Agricultural, and Natural Resource Sciences

Project Duration: September 2004–2007

The USEPA's decision to lower the standard for arsenic in drinking water from 50 to 10 ppb has elevated public concern about potential health risks from naturally-occurring arsenic in ground water across the U.S. Following a study conducted by the MN Department of Health in 1999, farmers in west central Minnesota were concerned about whether naturally-occurring arsenic in ground water would have an effect on their dairy products. They wondered if their dairy cows drank water containing high levels of arsenic, would arsenic end up in milk, cheese, and butter? Literature surveys and a meeting of experts held in Minneapolis in March 2005 indicated no prior investigation of this question.

The WRC led multi-disciplinary team of researchers from Extension, CFANS' Department of Animal Science, the College of Veterinary Medicine and the Minnesota Department of Agriculture. With funding from the Extension Great Lakes Regional Water Program, we conducted an initial study (2004–2005) on dairy cattle from four farms in Minnesota and Wisconsin with high arsenic concentrations in well water (>50 ppb). We identified that urine serves as a reliable biomarker of arsenic exposure in dairy cattle



Photo by Barb Liukkonen

Arsenic and Dairy team members collect urine for arsenic analysis to identify a biomarker for arsenic exposure in dairy cattle.

and that arsenic was not detected in bulk milk from the four farms. Additional funding from the CFANS' Agricultural Rapid Response program allowed us to further explore the effects of arsenic on dairy products and beef from dairy cattle exposed to arsenic in drinking water.

Private well water was tested on 92 additional dairy farms in west central Minnesota; eighteen dairy farms were recruited for the second phase of the study. The farms were divided into three groups: high, with arsenic concentrations >40 ppb in their water supply; medium, with arsenic between 10 and 40 ppb; and low, with arsenic levels <10 ppb. The U of MN St. Paul dairy herd, using a municipal water supply, was in the low group as a control.

We sampled feed and mineral supplements and

Arsenic continued on page 15

WRC Projects

Fate, Transport, and Impacts of Contaminants

Arsenic continued from page 14

conducted questionnaires to identify other possible sources of arsenic in the cattle's diet. Bulk milk from all farms and urine from 6–8 cows on each farm were analyzed for arsenic using ICP-MS. Milk from the farms in the high and low arsenic groups was processed into cheese. Meat samples and organ tissue were collected from cull cows. Well water was sampled quarterly to investigate possible seasonal variation.

Arsenic was not detected in any bulk milk samples, whey, skeletal muscle, liver, or pancreas (at 5 ppb detection limit) or in cheese (at 50 ppb detection limit).



Photo by Barbara Liukkonen

Milk and urine samples were analyzed from dairy cows at over 90 farms in west-central MN.

In 2005 and 2006, the team held five public meetings to inform study participants, other producers, veterinarians and county commissioners about the study and results. All analyses and on-farm information was kept anonymous, so no one knew which farms or farmers participated in the study. Participants received results as the analyses (water, feed, milk, urine, tissue)

from their farms were completed.

Several property owners took action to reduce their families' exposure when they learned they had elevated arsenic in their drinking water. One producer wrote, "We were certainly surprised to learn that our water had such a high level of arsenic. When the first test results arrived, we quickly installed a reverse osmosis filter for our drinking water. We were relieved to learn that the RO system was removing a high percentage of the arsenic [when the water was tested after passing through the system]."

Results of the study were presented at three national professional meetings and through several presentations to agencies and other departments within Minnesota and Wisconsin.

Presentations:

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. 2006. Arsenic in Ground Water: Potential Affects on RRV Dairy Operations. 23rd Annual Red River Basin Land & Water International Conference. Winnipeg, MAN, Jan 11-13, 2006.

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. 2006. Assessing the Impacts of Arsenic on Midwestern Dairy Operations. USDA-CSREES National Water Quality Conference, San Antonio, TX, Feb 5-8, 2006.

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. Assessing the Impacts of Arsenic on Midwestern Dairy Operations. National Water Quality Monitoring Conference, San Jose, CA, May 7-11, 2006.

For a complete list of presentations and publications relative to this project and others over the 2005–2006 biennium, turn to Appendix F on pages 39–47.

WRC Projects

Nutrients and Water Quality

Small Group Preparation of Nutrient Management Plans

PI: James Anderson (WRC; Soil, Water, and Climate)

Collaborators: Les Everett (WRC), David Wall (Minnesota Pollution Control Agency), Kevin Blanchet, Jodi DeJong-Hughes, (Extension Educators)

Funding Source: Minnesota Pollution Control Agency (EPA 319 grant)

Project Duration: January 2003–June 2006

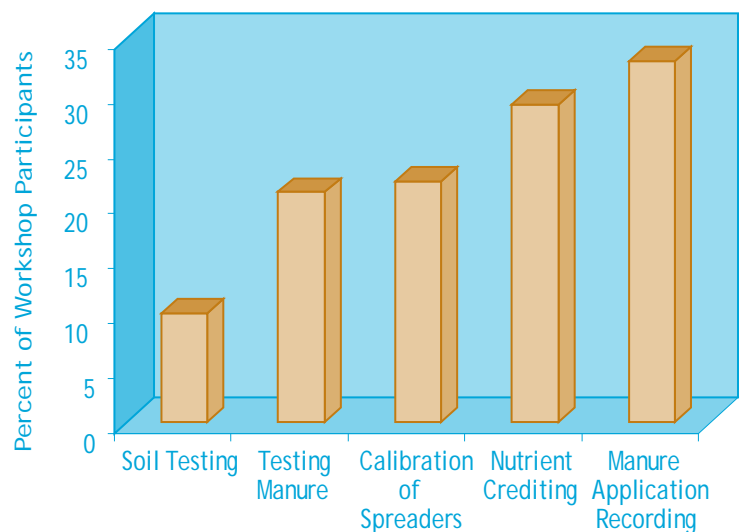
The goal of this Extension project was to improve nutrient and manure management practices by 1) directly increasing the number of crop nutrient and manure management plans through a personalized education program and 2) providing clear access to all necessary information for nutrient and manure management through development of a central Web site.

From February 2003 to March 2006, 843 participants in 80 small-group University of Minnesota Extension-led workshops prepared two-field nutrient management plans (NMP) for their own farms. The three-hour workshops were hosted by county feedlot officers, conservation districts, local Extension offices, or livestock producer organizations. Most participants were non-confined animal feeding operation livestock producers with manure management requirements under state rules. In the sessions, 86% of participants calculated that they would save \$6 or more per acre in fertilizer purchases if they followed their new plans; 56% would save more than \$10 per acre. A survey was sent to 669 participants following the cropping season when the NMP would first have been implemented. The survey return rate was 50%. Of respondents, 55% had completed their plans for the entire farm as a result of the sessions, 3% were still completing their plans, while 6% had completed them prior to the sessions.

Of those not completing their plans, 11% indicated that a plan is not required of their operation, while others cited complexity of the plan, shortage of time, not being a farm operator, or the lack of professional plan preparer.

Of respondents, 92% were producers, managing an average of 785 acres, which indicates that the total crop area managed by all producer participants is approximately 609,000 acres. Of respondents, the increase in practice adoption from pre-workshop to post-season was 10% for soil testing, 21% for manure testing, 22% for calibration of spreaders, 29% for crediting nutrients in manure, and 33% for keeping records of manure applications (see figure). An additional 10–20% indicated that they intended to adopt the practice within two years. It was concluded that the hands-on, small-group approach was effective in increasing participant understanding of the planning process and in motivating producers to adopt recommended manure and nutrient management practices.

Increase in respective practice adoption from pre-workshop to post-season (by percentage)



WRC Projects

Nutrients and Water Quality

Coupled Biogeochemical Cycles in Urban and Agricultural Systems

PIs: Patrick Brezonik (Civil Engineering), Larry Baker (WRC)

Faculty Co-PIs: Kristen Nelson (Forest Resources), Sarah Hobbie (Ecology, Evolution, and Behavior), Jennifer King (Soil, Water, and Climate)

Students: Paul Hartzheim, Luke Stuewe, Vinay Nangia, (Water Resources Science), Vicki Kalkirtz (Undergraduate Research Opportunities Program)

Funding Source: National Science Foundation

Project Duration: September 2003–August 2006

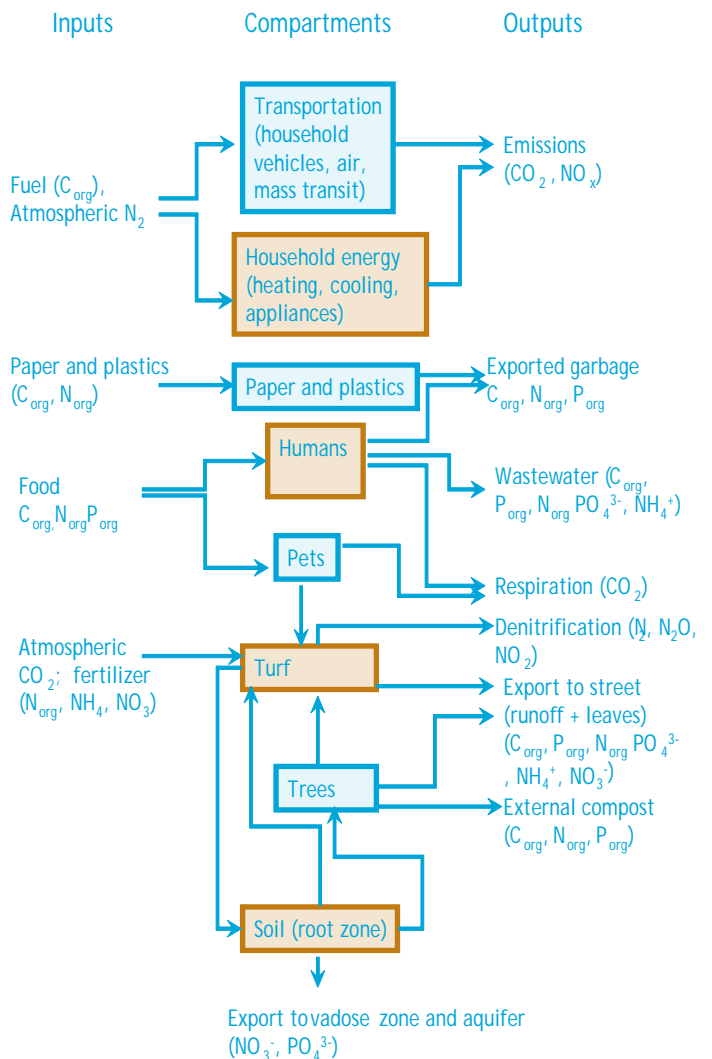
The main goal of this research project was to develop knowledge regarding the flows of nutrients through urban ecosystems at different scales and to understand social and biophysical factors that control these flows. A “household flux calculator” (HFC) was developed to calculate carbon (C), nitrogen (N), and phosphorus (P) fluxes through households. Scenario simulations showed that a high consumption household used approximately three times more C and nitrogen N than a low consumption household (both scenarios were based on a middle class suburban lifestyle). Thirty-five households were surveyed to provide inputs to the HFC.

Preliminary results show no relationship between income and C flux but a good relationship between number of occupants and per capita C flux. A parallel study of ~ 30 middle-class households in Tirana, Albania, showed that C and N fluxes increased with income, but income levels were much lower than observed in a study conducted in Falcon Heights, Minnesota. Complete N and P balances developed for the Blue Earth agricultural region in south-central

Minnesota showed that overall nutrient transfer efficiencies were 50% for all N inputs and 73% for all P inputs. Much of the N input came from soil mineralization; in contrast, soils were accumulating P.

Cycles continued on page 18

Schematic of nutrient fluxes through a household ecosystem



WRC Projects

Nutrients and Water Quality

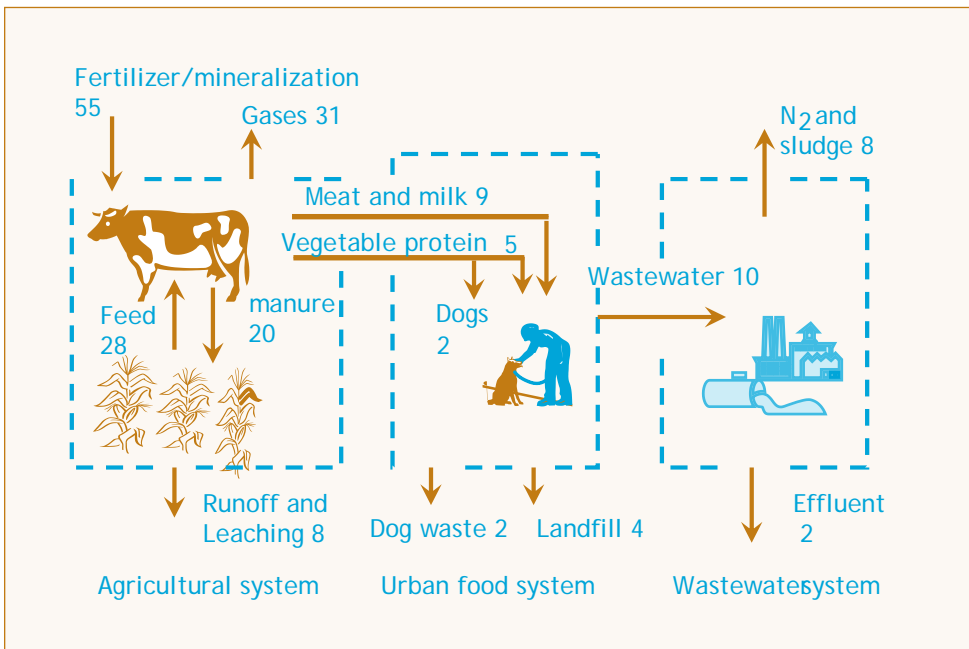
Cycles continued from page 16

Modeled N losses indicate that more N is being lost now than was lost 50 years ago, in part because of drainage modifications.

N and P balances for the Twin Cities showed that much of the P entering the system accumulated in sewage sludge and landfills; about one-third accumulated in urban soils and about one-fourth was exported in sewage effluent and urban runoff. The major flux in the N balance was abiotic N fixation by combustion processes. Export in runoff and sewage effluent was < 10% of total input, whereas gaseous exports accounted for 70% of inputs. Dietary habits by urban dwellers had a major impact on the N balance of farms supplying food to cities.

Nitrogen balances for the Twin Cities were linked to the agricultural N balance to develop a view of N flows through the Twin Cities and examine impacts of protein consumption by urban dwellers (see figure).

Flows of N from farms through the Twin Cities, MN (Gg/yr)



Publications:

Kaye, J., P. Groffman, N. Grimm, L. Baker, and R. Pouyat. 2006. A distinct urban biogeochemistry? *Trends in Research in Ecology and Evolution* 4: 192-199.

Baker, L. Minnesota's energy: past, present and future. Facts Unfiltered, *Minnesota Journal*, Sept. 2006.

Baker, L. Perils and pleasures of multidisciplinary research. 2006. *Urban Ecosystems* 9: 45-47.

Hope, D., W. Zhu, C. Gries, J. Oleson, J. Kaye, N. B. Grimm, L. Baker. 2005. Spatial variation in soil inorganic nitrogen across an arid urban ecosystem, *Urban Ecosystems* 8: 251-273.

Baker, L.A., T. Brazel, and P. Westerhoff. 2004. Environmental consequences of rapid urbanization in warm, arid lands: case study of Phoenix, Arizona (USA). In: *The Sustainable City III*, edited by N. Marchettini, C. Brebbia, E. Tiezzi, and L.C. Wadhwa, Advances in Architecture Series, WIT Press, Boston.

For a complete list of presentations and publications relative to this project and others over the 2005–2006 biennium, turn to Appendices E and F on pages 37–47.

WRC Projects

Nutrients and Water Quality

Assessment of Stormwater Management Practices on Water Quality

PIs: James Anderson (WRC; Soil, Water, and Climate), John Gulliver (Civil Engineering)

Collaborators: Ray M. Hozalski, Heinz Stefan, (Civil Engineering), John Nieber, Bruce Wilson, (Bioproducts and Biosystems Engineering), Peter Weiss (Engineering, Valparaiso University), John Chapman, Ronald Struss (Minnesota Department of Agriculture), Andrew Erickson, William Herb, Omid Mohseni (Saint Anthony Falls Laboratory), Larry Baker, Valerie Were, Tracy Thomas Wilson (WRC)

Students: Brooke Asleson, Paul Hartzheim, (Water Resources Science) Ben Janke, Rebecca Nestingen, Trent Riter, Matt Wilson, (Civil Engineering), Joshua Brand, Geoffrie Kramer, Tom Natwick, Andrew Sander, Adam Markos, Geoffrey Fischer, Nick Olson, (Undergraduate Research Assistants)

Funding Source: Minnesota Pollution Control Agency, Metropolitan Council

Project Duration: July 2005–September 2007

The Minnesota Pollution Control Agency (MPCA) is required by the Clean Water Act Section 303 (d) Total Maximum Daily Load (TMDL) to assess water quality and to identify impaired streams and lakes. In the most recent of these assessments (MPCA 2006), 2,250 impaired water bodies were identified in Minnesota alone, including 1013 lakes and approximately 1162 streams covering 9099 river miles. Excluding those affected by mercury, approximately 938 water bodies are listed due to one or more pollutants such as nutrients, sediments, chloride, temperature, and bacteria that are common to stormwater runoff. In addition, 118 of the 938 listed water bodies are impaired lakes located within municipalities. The large number

of impaired lakes and rivers indicates that municipalities and communities need to control both the *quantity* and the *quality* of urban stormwater runoff.

A lack of standard protocols for stormwater BMP assessment has prompted the MPCA to

call on the University of Minnesota's St. Anthony Falls Laboratory and the Water Resources Center to develop and test a manual for the assessment of stormwater best management practices (BMPs). This Extension project comprises six tasks: quarterly reports, establishment of dialog and collaboration on stormwater assessment, development of an assessment criteria and protocol, assessment of study sites, development and implementation of a tool to predict and assess the impact of stormwater runoff on trout streams, and training and outreach. To view the progress and preliminary results of this project, visit <http://wrc.umn.edu/outreach/stormwater/bmpassessment/>.



Photo by Brooke Asleson

A Philip-Dunne permeameter is used as part of capacity testing to measure infiltration rates in a rain garden.

WRC Projects

Nutrients and Water Quality

Assessment of Stormwater Treatment Practices on the Quantity and Quality of Runoff

PI: James Anderson (WRC; Soil, Water, and Climate)

Collaborators: John Gulliver, Ray Hozalski, (Civil Engineering) John Nieber (Bioproducts and Biosystems Engineering), Omid Mohseni, Andrew Fyten, Andrew Erickson, (Saint Anthony Falls Laboratory)

Students: Brooke Asleson (Water Resources Science), Rebecca Nestingen, Matt Wilson (Civil Engineering), Joshua Brand, Geoffrie Kramer, Tom Natwick, Andrew Sander, Adam Markos, Geoffrey Fischer, Nick Olson, (Undergraduate Research Assistants)

Funding Source: Minnesota Pollution Control Agency

Project Duration: January 2005–October 2006

The primary goal of this outreach project was to assess rain garden and underground proprietary device practices to determine their effectiveness. Rain gardens (also called bioretention practices) and underground proprietary devices are two stormwater best management practices (BMPs) of recent interest. Rain gardens are low lying depressions that capture and infiltrate stormwater runoff into the surrounding soils. They are typically built with two-to-three feet of soil and are designed to support plants while draining rapidly. Underground proprietary devices are commercial, prefabricated structures that are installed underground to remove solid pollutants from stormwater runoff. The effectiveness of rain gardens at infiltrating water

and of underground proprietary devices at removing suspended solids is not generally known.

Assessment of rain gardens throughout the Twin Cities Metropolitan Area has included visual inspection, capacity testing for permeability, and synthetic runoff testing for infiltration capacity. Synthetic runoff testing and tracer studies have been used to determine the effectiveness of underground proprietary devices for removing solids from stormwater runoff. In addition to the assessment, project funds have been used to investigate the accuracy of devices that measure permeability in the field.

Instructions for performing the three levels of assessment

for rain gardens have been shared with several audiences, including those responsible for maintaining the sites that were tested. A written form of these instructions is also under development. An overview of the research, including some preliminary results of the field testing, was presented at two local conferences in the fall of 2006. A poster was exhibited at the National Non-point Source Monitoring Workshop held in September in Minneapolis and an oral presentation was delivered at the Minnesota Water 2006 and Annual Water Resources Joint Conference 2006 held in Brooklyn Center in October. An abstract and final paper were also accepted for oral presentation at the World Environmental & Water Resources Conference to be held in Tampa, FL, in May 2007.



Photo by Brooke Asleson

Synthetic runoff testing is used to determine the infiltration rate of a rain garden.

WRC Projects

Nutrients and Water Quality

Minnesota Terrestrial Carbon Sequestration Initiative

PIs: James Anderson (WRC; Soil, Water, and Climate)

Project Coordinator: Cheryl Miller (WRC)

Students: Megan Lennon, (Soil, Water, and Climate), Yang Liu (Applied Economics)

Funding Source: Initiative for Renewable Energy and the Environment

Project Duration: July 2005–December 2007

A key natural resource issue of the 21st century is carbon management, defined as activities to reduce carbon dioxide buildup in the atmosphere, including protection and enhancement of terrestrial carbon sinks. An array of forestry, farming, and conservation practices could help protect and enhance the ability of ecosystems to store, or “sequester,” carbon relatively quickly and inexpensively. In 2005, the University of Minnesota Institute for Renewable Energy and Research provided initial funding for a multi-year, interdisciplinary endeavor entitled the Minnesota Terrestrial Carbon Sequestration Project, which encompasses research, education, and outreach on biophysical, economic, and market aspects of terrestrial carbon sequestration in Minnesota.

The over-arching purposes of this outreach project are:

- to assemble and report scientific information estimating the carbon sequestration capacities in Minnesota forests, agricultural lands, and conservation lands and the costs and benefits of optional carbon-enhancing practice;
- to evaluate existing carbon trading systems

and guidance; and

- to engage diverse sector groups on optimal carbon sequestration strategies for Minnesota and to plan demonstration projects of the most promising strategies.

The project presented four forums in 2005–2006 on biological, economic, and institutional aspects of terrestrial carbon sequestration. Sector group meetings were held in Mankato, Grand Rapids, Minneapolis, and St. Paul to solicit ideas from agricultural, forestry, conservation, business, and government representatives. Literature reviews were conducted on the sequestration potential of different practices in Minnesota’s landscape; the costs and benefits of capturing that potential; and different government and marketplace options for financing increased adoption of sequestration practices.

Preliminary Findings:

Preliminary findings indicate that wetland restoration and afforestation on marginal land, and use of cover crops in corn and soybean systems may provide the greatest sequestration benefits at least cost. Other findings include a survey of government and market incentives being developed around the U.S., along with a discussion of scientific, technical, and policy issues needing resolution before broad promulgation of these programs in Minnesota. Recommendations for future project initiatives include the development of a terrestrial carbon sink inventory for Minnesota, the creation of a sequestration stakeholder council, assisting Minnesota landowners in the participation in carbon sequestration projects, and further development and implementation of research and demonstration projects that address the critical scientific, economic, management and policy issues of sequestration.

WRC Projects

Water Policy and Economics

Building Capacity of *E. coli* Monitoring by Volunteer Networks: A Multi-state Effort

PI: James Anderson (WRC; Soil, Water, and Climate)

Collaborator: Barbara Liukkonen (WRC)

Funding Source: Cooperative State Research, Education, and Extension Service; Legislative and Citizens Commission on Minnesota's Resources

Project Duration: September 2003–September 2007

Six upper-Midwest states were awarded a three-year grant (2003–2006) to assess the accuracy and reliability of *E. coli* bacteria test kits when used by volunteers monitoring surface water. The WRC served as the lead for that research grant from the Cooperative State Research, Education, and Extension Service (CSREES). In addition, the Legislative and Citizens Commission on Minnesota's Resources (LCCMR) has awarded the WRC two years of funding (2005–2007) to enhance surface water monitoring by involving volunteers in monitoring bacteria.

Researchers investigated the accuracy, reliability, volunteer preference, and cost of six different test kits for monitoring *E. coli*. In 2004, volunteers in Indiana and Iowa assessed five different test kits. From that initial research, two kits were identified that received high ratings from volunteers and produced accurate results when compared with certified lab analyses: 3M Petrifilm and Coliscan Easygel®. In 2005, volun-

teers in Michigan, Minnesota, Ohio, and Wisconsin monitored streams using those two test kits and also sent split-samples to a certified laboratory for analysis. Following the protocols they learned during a half-day training session, volunteers produced test results that correlated well with results from certified labs. Similar results were observed for 2006.



Photo by Ed Deberstein

Coliscan Easygel® plate showing growth of E. coli bacteria. Volunteers monitored thirty-one lakes and stream sites in thirteen Minnesota counties.

Preliminary Results:

Statistical analysis comparing the accuracy of the test kits with certified lab results from 2006 and from all of the years combined is in progress. Results from individual sites usually track well when comparing the Easygel® and Petrifilm™ kit results with certified lab results, but regression analysis comparing all results have not produced strong correlations. The test kits appear to work very well to indicate whether bacteria counts exceed threshold levels used to evaluate risk associ-

ated with body contact (e.g., 235 cfu and 1000 cfu). Results of analyses from 2005 indicate that 95 percent of the time both the test kit and the certified lab result showed the *E. coli* count was above 235 or both the results were below 235 cfu/100 ml.

Data collected through the project can be, and have been, used by local units of government in decision-making. In 2006, volunteers identified unauthorized discharges from the wastewater treatment plant in Pine City. Several associations have invested in additional monitoring equipment and have implemented targeted bacteria testing in tributaries.

WRC Projects

Water Policy and Economics

Developing Social Indicators for NPS Evaluation

PI: James Anderson (WRC; Soil, Water, and Climate)

Collaborator: Karlyn Eckman (WRC)

Funding Source: Minnesota Pollution Control Agency

Project Duration: April 2006–September 2007

This project is an extension of a United States Environmental Protection Agency (USEPA) program that evaluates the effectiveness of nonpoint source pollution management under section 319 of the Federal Clean Water Act in the USEPA's Region 5 (see photo). In Minnesota, the Minnesota Pollution Control Agency (MPCA) and the Water Resources Center (WRC) are partnering on the USEPA-led social monitoring and evaluation framework.

Work began in Region 5 in 2005 with a series of stakeholder workshops to identify socioeconomic indicators. Indicators are measures that provide insight into the conditions, qualities, interrelationships, or problems of a complex system (US EPA 1997). Performance indicators for nonpoint source programs can be environmental, such as drinking water safety, percent of impervious surface in a watershed, or total suspended solids in a water body. They can be administrative, as in the number of comprehensive nutrient management plans written, the dollars spent on installing stormwater best management practices, or the number of newsletters distributed to watershed groups. Indicators can also be characterized as social. Such indicators are typically used to assess current conditions or attainment of social goals related to human health, housing, education levels, recreational opportunities, social equity issues and the like. For the purposes of this project, they will most often be used



USEPA Region 5 includes Minnesota, Illinois, Indiana, Michigan, Ohio, and Wisconsin. This is a satellite photo from the National Oceanic and Atmospheric Administration's CoastWatch, MODIS satellite.

to measure intermediate outcomes that we anticipate will lead to the goal of improved water quality.

In Minnesota, three workshops were organized by the MPCA and WRC in 2005, yielding a large number of possible indicators and written comments. These were refined by a web-based Delphi survey in 2005. Currently, the social indicators team is working on refining the draft handbook and indicators, and is obtaining feedback from the state pollution control agencies on the drafts. The handbook and indicators will be piloted at a few sites in Minnesota and the Upper Midwest in 2007. Discussions with MPCA and other stakeholders are currently underway to identify Minnesota-based 319 or total maximum daily load (TMDL) projects that can serve as pilot sites. The outputs will be modified based upon pilot testing.

WRC Projects

Watershed Management

Conservation Tillage Demonstration Project

PIs: James Anderson (WRC; Soil, Water, Climate), Gyles Randall (Southern Research and Outdoor Center)

Collaborators: Les Everett (WRC), Chris Zadak (Minnesota Pollution Control Agency),

Jodi DeJong-Hughes, Brad Carlson, David Pfarr, David Bau, Dan Martens, Liz Stahl, Ryan Miller, Dave Nicolai, (Extension Educators), Jeff Vetsch (Assistant Scientist)

Funding Source: Minnesota Pollution Control Agency

Project Duration: October 2002–September 2006

The overall objective of this Extension project was to reduce sediment delivery to surface waters and preserve agricultural soils through increased crop residue cover on row-cropped fields of southern Minnesota. This is being accomplished by changing farmers' behavior through on-farm demonstrations of the economic and environmental benefits of reduced tillage systems.

Tillage systems were compared at 10 farms in 2004 and 9 farms in 2005 in the southern half of Minnesota. Tillage treatments were applied in field-length strips, three replicates per farm, using farmer-owned or custom-hired commercial-scale equipment. Four treatments, no-till, strip-till, spring field cultivate, and chisel plow plus spring field cultivate were compared at 7 sites in 2004 and 6 sites in 2005, while strip-till was compared only to chisel plow at the other 3 sites in both years. Sites were farmer-managed in partnership with University of Minnesota Extension (6 of the locations each year) or Monsanto Corporation. Similar to previous on-station research, results from these on-farm trials indicate that strip-tillage and

spring field cultivate are good alternatives to conventional tillage (chisel) for corn following soybeans in most of Minnesota. No-till, except in Southeast MN, risks reduced yields, especially where drainage is not optimal.

Trial results, as well as management recommendations for reduced tillage, have been presented at field days, winter meetings, and strip-tillage expos. Field days were held at all on-farm trial locations in 2004 and at 4 locations in 2005, with approximately 1200 total attendance. Winter meetings, attended by approximately 1100 farmers and agricultural professionals, were held at 17 locations in 2005 and 2006. In 2006, two large Strip-Tillage Expos were held at University of Minnesota Research and Outreach Centers in the Southern corridor of the state. Over 300 participants at each Expo watched 9 strip-tillage implements in the field, probably the largest number of these units ever demonstrated side-by-side. Auto-guidance systems were also demonstrated. Farmers attending manage a total of about 350,000 acres, while acres managed by attending crop consultants exceed 500,000, as reported on event registration cards.

Trial results are expected to be published in 2007 as a University of Minnesota Extension bulletin.

WRC Projects

Watershed Management

Impaired Waters: Conservation Drainage Research

PIs: Gary Sands, Inhong Song, (Bioproducts and Biosystems Engineering)

Student: Sheila Amenumey (Water Resources Science)

Funding Source: Minnesota Department of Agriculture

Project Duration: July 2006–June 2007

This research project is an extension of a previous study that aimed to analyze drainage systems and the associated water quality and agricultural impacts in Southern Minnesota. Such drainage systems are important because they help to mitigate various water quality stresses, such as drainage flow and nitrate loading.

From 2001 through 2005, a study was conducted at the University of Minnesota Southern Research and Outreach Center (SROC) in Waseca, MN, in order to examine annual drainage flows and nitrate loads in conventional, shallow, and intense drainage treatments. When analysis of drainage plot variance was performed on all six years of these data, approximately twenty-percent reductions in annual drainage volume and nitrate load were associated with the shallow and less intense drainage treatments.

An analysis of crop yields at the SROC site using

combine yield monitor data for 2001 through 2005 was presented. These analyses showed that shallow drainage and conventional drainage intensity typically out-yielded the conventional drainage depth and high intensity treatments, but statistical significance was only found for drainage intensity in 2001.

The objectives below are a continuation of drainage research that has been conducted at Waseca since 1999. There have been several additional grants and

bonding money for infrastructure improvements to the research site. In addition, federal grants have funded conservation drainage demonstration and applied research sites on cooperating farms in Nicollet and Mower Counties, MN. This work is conducted in close consultation with producer groups, drainage industry representatives and the Minnesota Department of Agriculture.



Project research site at the University of Minnesota Southern Research and Outreach Center (SROC) in Waseca, MN.

Specifically,

- Examine the impacts of selected conservation drainage practices on the volume of drainage water removed, the loss of nitrogen, crop yields, and crop uptake and utilization of water and crop nutrients for a corn-soybean cropping system. This will involve the

Impaired Waters continued on page 26

WRC Projects

Watershed Management

Impaired Waters continued from page 25

following tasks:

- Develop a report summarizing the effectiveness of conservation drainage practices based on data from previous work at the SROC
- Develop and implement plans for modification and further development of the research drainage plots at SROC
- Develop and implement plans for additional research and demonstration sites for conservation drainage practices in Nicollet and Mower Counties, MN
- Monitor the impacts of conservation drainage practices on drainage-water flow, nitrogen losses in drainage water, water table levels, and soil moisture at SROC
- Measure impacts of conservation drainage practices on crop grain yield and quality, and stover nitrogen content to determine changes in crop uptake and utilization of water and nutrients for a corn-soybean cropping system
- Develop educational materials and conduct education events on conservation drainage practices by:
 - Developing reports and educational materials on conservation drainage practices
 - Conducting and assisting with educational events on conservation drainage practices

a rain event, and potentially increase base flows in nearby ditches and streams. However, the mechanisms of decreased annual drainage volume are not yet clearly understood.

The proposed research aims to build on previous work by improving our understanding of the mechanisms and the crop nutrient balance by which conservation drainage works. Project will attempt to answer unresolved issues of nutrient movement by landscapes conventionally drained and those with conservation drainage practices. Then the project can further build upon the data and knowledge base of the existing water quality and flows.

Previous drainage research work demonstrates that shallow and controlled drainage can decrease annual drainage volume, decrease peaks in hydrographs after

Public and Professional Service

WRC staff members are active in many professional societies and contribute their time, energy, and expertise to support the goal of the University to be engaged in activities that serve the public good. Such activities include serving on review panels, advisory boards, expert study committees, and presenting seminars to community organizations. During the reporting period, WRC staff participated in such activities for local, state, and federal government agencies, as well as within the University of Minnesota and in non-governmental organizations.

James Anderson

Co-Chair, Lake Pepin Science Advisory Panel, advisory to MPCA
Extension representative, Minnesota Board of Water and Soil Resources
Member, Project Coordination Team for Clean Water Partnerships and EPA 319 projects, MPCA
Member, Board of Directors, National Association of Wastewater Transporters
Member, Great Lakes Regional Water Quality Leadership Team, USDA-CSREES
Member, MPCA Stormwater Advisory Committee
University representative, Water Resources Committee, Minnesota Environmental Quality Board
Member, Planning Committee, Minnesota Water and Annual Water Resources Joint Conference, 2005–2007

Larry Baker

Member, Executive Committee and Seminar Committee, Water Resources Science Program, University of Minnesota
Faculty Advisor, Water Resources Students in Action, University of Minnesota, 2003–2006
WRS Seminar Committee, 2003–2007
Member, Editorial Board, *Urban Ecosystems*, 2001–present
Member, Planning Committee, Minnesota Water Conference, 2004–2006
Organizer, Symposium “Effect of Human Choices on Characteristics of Urban Ecosystems,” to be held at 2007 ESA Conference, San Jose, CA
Invited participant, Workshop on Integrating Social Science into CLEANER, National Science Foundation, Alexandria, VA, January 24–25, 2007

Les Everett

Member, NRCS State Technical Committee, including the EQIP and CSP Subcommittees
Member, University of Minnesota Waste Abatement Committee
Member, Regional Water Quality Teams, including Animal Waste Management, Nutrient Management, and Technical Service Provider Training
Member, Lake Pepin TMDL Stakeholder Advisory Committee and Science Advisory Panel

Public and Professional Service

Barbara Liukkonen

National Science Advisory Board, Maltby Natural Science Center, 2004–present

Minnesota Master Naturalist Program, Science Advisor

NextStep Sustainability Web site, Guide to the Water page, 2000–present

Rice Creek, Watershed District Citizens Advisory Committee, 2004–present

Planning Committee, 8th International Conference on Mercury, 2005–2006 (held August 6–9, 2006, Madison, WI)

Planning Committee, Public Issues and Leadership Development Conference, 2006–2007 (held April 22–25, 2007)

Planning Committee, Minnesota Water and Annual Water Resources Joint Conference, 2005–2007

CFANS Awards committee representing the WRC, 2006–2007

Deborah Swackhamer

Member, Science Advisory Board of the International Joint Commission of the U.S. and Canada, 2000–present
U.S. Co-Chair, Working Group on Emerging Issues, International Joint Commission Science Advisory Board, 2004–present

Member, Science Advisory Board (Chartered) U.S. Environmental Protection Agency, 2003–present

Member and Chair, Great Lakes Environmental and Molecular Sciences Center Technical Advisory Board, Western Michigan University, Kalamazoo, MI, 2002–present

Member, Science Advisory Board of the National Undersea Research Program for the North Atlantic and Great Lakes, NOAA, 2003–present

Member, Editorial Advisory Board, Journal Environmental Monitoring, Royal Society of Chemistry, UK, 2003–present

Chair, Minnesota Water 2004 Conference, Minneapolis, MN

Co-Chair, Minnesota Water and Annual Water Resources Joint Conference 2005, 2006, Minneapolis, MN

Co-Chair, Lake Pepin Science Advisory Panel, advisory to MPCA

Chair, University of Minnesota Stormwater Linkage Committee

Appendix A: WRC Staff List

Name	Position
Bonnie Anderson	Executive Office and Administrative Specialist
James Anderson	Co-Director
Larry Baker	Senior Fellow
Janelle Benusa	Senior Accountant
Kevin Blanchet	Extension Educator
Laurie Brown	Extension Educator, Onsite Sewage Treatment Program
Sara Christopherson	Extension Educator, Onsite Sewage Treatment Program
Jodi DeJong-Hughes	Extension Educator
Karlyn Eckman	Senior Fellow
Les Everett	Extension Water Resources Coordinattor
Dave Gustafson	Extension Educator, Onsite Sewage Treatment Program
Nicholas Haig	Program Associate, Onsite Sewage Treatment Program
Maria Juergens	Administrative Professional
Barbara Liukkonen	Extension Water Resources Coordinator
Doug Malchow	Extension Educator, Onsite Sewage Treatment Program
Eric Otto	Student Editor
Connie Post	Senior Accountant, Minnesota Sea Grant
Valerie Prax	Extension Educator, Onsite Sewage Treatment Program
Charlie Sawdey	Student Editor
Roland Sigurdson	Aquatic Education Specialist, DNR
Faye Sleeper	Incoming Co-Director, 2007
Deborah Swackhamer	Co-Director
Isabella Walstrom	Executive Office and Administrative Specialist
Valerie Were	Technical Specialist, Web Editor
Tracy Thomas Wilson	Editor
Dan Wheeler	Research Fellow, Onsite Sewage Treatment Program

Appendix B: 2005–2006 WRS Graduates and Thesis Titles

Student	Degree	Thesis or Paper Title
Darin Albrecht	M.S.	Geochemical Fingerprinting and the Role of the Nemadji River in Sediment Transport within Western Lake Superior
Stanley Asah	Ph.D.	Empirically Understanding Social-Ecological Systems: Case of Agro-Ecological Resilience within the Logone Floodplain
Adam Birr	Ph.D.	Paired Watershed Studies for Nutrient Reductions in the Minnesota River Basin
Meghan Brown	Ph.D.	The Ecology of the Exotic Zooplankter, Bythotrephes Longimanus in a Reservoir System: Evaluating the Role of Multiple Environmental Factors in Life-Cycle Completion
Dennis Busch	Ph.D.	Vertical-Flow Wetlands for the Treatment of Subsurface Agricultural Tile Drainage Water
Yi-Wen Chiu	M.S.	Establishing Standardized Procedure for Ecological Engineering Projects in Taiwan
Michael Donahue	M.S.	Inferred Sulfate Reduction Rate and Associated Sulfur Isotope Fractionation from the Cariaco Basin
Driss Ennaanay	Ph.D.	Modeling the Effects of Perennial Vegetation and Wetland Restoration on the Hydrological Regime in Watersheds of the Minnesota River Basin
Melinda Erickson	Ph.D.	Arsenic in Upper Midwest Ground Water: Occurrence and Geochemical Mobilization Mechanisms

Appendix B: 2005–2006 WRS Graduates and Thesis Titles

Student	Degree	Thesis or Paper Title
Kim Grosenheider	M.S.	Human Health Risk of Using Waste Materials in Road Sub-Base
Nathaniel Hemstad	Ph.D.	The Effects of Riparian and Catchment Forest Harvest on Stream Habitat and Fish Assemblages
Debra Hinterleitner-Anderson	Ph.D.	Cranberry Marsh Nutrient and Pesticide Effects on Receiving Lake and Groundwater
Dawn Huff	M.S.	Trophic State and Food Web Evaluation of Two Urban, Connected Lakes in Northeastern Minnesota
Brian Huser	Ph.D.	Phosphorus Sorption by Sediments in Eutrophic and Acidic Lakes
Winfried Ksoll	M.S.	Growth and Persistence of Fecal Indicator Bacteria in Lake Superior Epilithic Periphyton
Randy Lehr	Ph.D.	Assessment and Management of Environmental Estrogens
Michelle Marko	Ph.D.	The Chemical Ecology of Watermilfoil-Weevil Interactions
Vinay Nangia	Ph.D.	Field and Watershed Scale Evaluation of Water Quality Trends Due to Changes in Landscape and Management Practices

Appendix B: 2005–2006 WRS Graduates and Thesis Titles

Student	Degree	Thesis or Paper Title
Heather Offerman-Johnson	M.S.	Assessing River Water Quality Trends in the Minnesota River Basin
Jennifer Olson	M.S.	Infiltration as a Stormwater Management Technique: A Catalog and Inventory of Infiltration Practices in the Twin Cities Metropolitan Area and Ground Water Mounding Beneath an Infiltration Basin
Eric Otto	M.S.	Two Methods to Evaluate the Potential Negative Impact of Stormwater BMPs on Roadway Infrastructure
Lindsay Powers	Ph.D.	Calibration and Application of a New Paleotemperature Tool in Lacustrine Systems: TEX86 for Continental Paleoclimate Reconstruction
Heidi Rantala	M.S.	Landscape Evolution and a Relict Fish Community, North Slope, Alaska
Kari Rolf	M.S.	Evaluation of Alternative Versus Conventional Farming Systems Impacts on Subsurface Drainage Flow and Water Quality
Brennon Schaefer	M.S.	Simulation of Storm Runoff Using the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) Model
Johanna Schussler	M.S.	A Comparison of Phosphorus Sources and Fate in Eleven Minnesota Watersheds
Kevin Springob	M.S.	The Influence of Biological Factors on the Effectiveness of Alum Treatments

Appendix B: 2005–2006 WRS Graduates and Thesis Titles

Student	Degree	Thesis or Paper Title
Luke Stuewe	M.S.	Agricultural Nitrogen and Phosphorus Mass Balances in South Central Minnesota
Jason Ulrich	M.S.	Analysis of Stream Health Indicators for TMDL Assessment in the Minnesota, St. Croix, and Upper Mississippi River Basins of Minnesota
Jeffrey Werner	Ph.D.	The Environmental Photochemical Kinetics of Pharmaceutical Compounds in Natural Water and on a Clay Surface
Yan Yuhu	Ph.D.	Water-Surface Chlorophyll Detection by Remote Sensing and Vertical Structure of Chlorophyll Analysis in Lake Superior: Water-Surface Chlorophyll as an Estimate of Water-Column-Integrated Chlorophyll

Appendix C: WRS Student Awards

The following WRS students received awards during the 2005–2006 biennium:

Asah, Stanley	2005-2006 UMN Doctoral Dissertation Fellowship
Asmus, Brenda	2006 Bonestroo, Rosene, Anderlik and Associates Travel Grant
Brown, Meghan	2005-2006 UMN Doctoral Dissertation Fellowship
Coleman, Jill	2006 Wilke Research Fellowship
Dadaser, Filiz	2005 Doctoral Dissertation International Research Grant; 2006 Honorable Mention Award for Excellence in Communication Science and Engineering Research, Sigma Xi Juried Research Poster Exhibit or Graduate Students-UMN
Dolliver, Holly	2006 Graduate Student Award in Soil Science, Soil Science Society of America
Dolph, Christine	2006-2007 UMN Graduate School Fellowship
Gelsey, Giana	2005-2006 UMN Graduate School Fellowship; 2006-2007 National Science Foundation GK12 Fellowship
Green, Mark	2005 Emmons and Olivier Resources, Inc., Travel Grant
Green, Mark	2005 GAPSA Award to WRSIA for Frontiers in Water Resources Science
Green, Mark	2006 Co-recipient of Award for Excellence in Communicating Science and Engineering Research, Sigma Xi Juried Research Poster Exhibit for Graduate Students-UMN
Hartzeim, Paul	2006 Barr Engineering Company Travel Grant
Lenhart, Chris	2006 Merit Award from American Society of Landscape Architects, MN Chapter, Co-author of MN Bioengineering Handbook, MN DOT & Kestrel Design Group, Inc.

Appendix C: WRS Student Awards

Marko, Michelle	2006 Charles and Dorothy Andrew Bird Award for Outstanding Research In Any Field of Pure or Applied Science, UMN Chapter of Sigma Xi
Olmanson, Ole	2006 Honorable Mention Award for Excellence in Communication Science and Engineering Research, Sigma Xi Juried Research Poster Exhibit for Graduate Students-UMN
Otto, Eric	2005 Professional Engineer license in Civil Engineering, State of Minnesota
Ruzycki, Elaine	2005 Best Student Poster, North American Lake Management Society (NALMS)
Schram, Erica	2005 Beautiful U Day Grant to WRSIA for Sarita Wetland interpretive signage; 2006-2007 National Science Foundation GK12 Fellowship
Sealock, Adam	2005 Bell Museum Dayton Research Fellowship; 2006 Best Oral Presentation by a Graduate Student, 1st Runner-Up, XXI International Symposium on Chironomidae, Portugal
Serieyssol, Claire	2005 Iowa Lakeside Merit Scholarship; 2006 Bell Museum Daton-Wilke Grant
Streets, Summer	2006 Runner-up Best Student Platform Presentation, Midwest Environmental Society of Toxicology and Chemistry Conference
Werner, Jeffrey	2006 Graduate Student Award, American Chemical Society, Division of Environmental Chemistry; 2006 Graduate Student Paper Award, American Chemical Society, Division of Environmental Chemistry

Appendix D: WRC Council and Committee

WRC Administrative Council

Bev Durgan (2006)/ Charles Casey (2005), Dean and Director, University of Minnesota Extension

Fotis Sotiropoulos (2006)/Efi Foufoula-Georgiou (2005), Director, Saint Anthony Falls Laboratory; Professor, Department of Civil Engineering

Emi Ito, Director, Limnological Research Center; Professor, Department of Geology and Geophysics

Tom Johnson, Director, Large Lakes Observatory; Professor, Department of Geology, Duluth

Allen Levine (2006)/Charles Muscoplat (2005), Dean College of Food, Agricultural and Natural Resource Sciences

Gerald Niemi, Director, Center for Water and the Environment and Natural Resources Research Institute; Professor, Department of Biology, Duluth

Stephen Bortone (2006)/ Carl Richards (2005), Director, Minnesota Sea Grant

WRC External Advisory Committee

Jim Anderson, Co-Director, Water Resources Center; Professor, Department of Soil, Water, and Climate

David Biesboer, Associate Professor, Department of Plant Biology

Ken Brooks, Professor and Director of Graduate Studies, Department of Forest Resources

Greg Buzicky, Minnesota Department of Agriculture

William Easter, Director, Center for Food and Agricultural Policy; Professor, Department of Applied Economics

Fotis Sotiropoulos (2006) /Efi Foufoula-Georgiou (2005), Director, Saint Anthony Falls Laboratory; Professor, Department of Civil Engineering

Jack Frost, Metropolitan Council of Environmental Services

Anne Kapuscinski, Director, Institute for Social, Economic, and Ecological Sustainability; Professor, Department of Fisheries, Wildlife, and Conservation Biology

Kathy Klink, Associate Professor, Department of Geography

Gerald Niemi, Director, Center for Water and the Environment and Natural Resources Research Institute; Professor, Department of Biology, Duluth

Faye Sleeper (2006)/ Glen Skuta (2005), Minnesota Pollution Control Agency; Co-Director, Water Resources Center (Sleeper, 2007)

Deborah Swackhamer, Interim Director, Institute on the Environment; Co-Director, Water Resources Center, Professor, Division of Environmental Health Sciences, School of Public Health

Bruce Wilson, Professor, Department of Bioproducts and Biosystems Engineering

Donald Wyse, Professor, Department of Agronomy and Plant Genetics

Appendix E: Refereed Journal Articles

Baker, L. Minnesota's energy: past, present and future. Facts Unfiltered, *Minnesota Journal*, Sept. 2006.

Baker, L. Perils and pleasures of multidisciplinary research. 2006. *Urban Ecosystems* 9: 45-47.

Bistodeau, T.J., L.B. Barber, S.E. Bartell, R.A. Cedie, K.J. Grove, J. Klaustermeier, J.C. Woodard, K.E. Lee and H.L. Schoenfuss. 2006. Larval exposure to environmentally relevant mixtures of alkylphenoethoxylates reduces reproductive competence in male fathead minnows. *Aquatic Toxicology* 79: 268-277.

Boreen, A.L., W. A. Arnold, K. McNeill. 2005. Triplet-sensitized photodegradation of sulfa drugs containing six-membered heterocyclic groups: Identification of an SO₂ extrusion photoproduct. *Environ. Sci. Technol.* 39: 3630-3638.

Bouchard, R.W. Jr., M.A. Carrillo, & L.C. Ferrington Jr. 2006 Lower Lethal Temperature for Adult Male *Diamesa mendotae* Muttkowski (Diptera: Chironomidae), a Winter-Emerging Diamesinae. *Aquatic Insects*, 28(1): 57-66.

Bouchard, R.W. Jr., M.A. Carrillo, S.A. Kells & L.C. Ferrington Jr. 2006. Freeze tolerance in larvae of the winter-active *Diamesa mendotae* Muttkowski (Diptera: Chironomidae): a contrast to adult strategy for survival at low temperatures. *Hydrobiologia* 568(1): 403-416.

DeJournett, T.D, W.A. Arnold, T.M. LaPara. 2006. The Effect of Vegetation on Methanotrophic Bacterial Populations in a Constructed Wetland. *Applied Soil Ecology*, in review.

DeJournett, T.D., J.M. Fritsch, K. McNeill, and W.A. Arnold. 2005. Preparation of ¹⁴C-cis-1,2-dichloroethylene from ¹⁴C-trichloroethylene using a cobalt porphyrin catalyst. *Journal of Labelled Compounds and Radiopharmaceuticals*, 48(5): 353-357.

Edhlund, B. L., W. A. Arnold, K. McNeill. 2006. Aquatic Photochemistry of Nitrofurantoin Antibiotics. *Environ. Sci. Technol.* 40: 5422-5427.

Hope, D., W. Zhu, C. Gries, J. Oleson, J. Kaye, N. B. Grimm, L. Baker. 2005. Spatial variation in soil inorganic nitrogen across an arid urban ecosystem. *Urban Ecosystems* 8: 251-273.

Julius, M.L., Stepanek, J., Tedrow, O., Gamble, C. and H.L. Schoenfuss. Estrogen-receptor independent effects of two ubiquitous environmental estrogens on *Melosira varians* Agardh, a common component of the aquatic primary producer community. In review - *Aquatic Toxicology*.

Appendix E: Refereed Journal Articles

- Kaye, J., P. Groffman, N. Grimm, L. Baker, and R. Pouyat. 2006. A distinct urban biogeochemistry? *Trends in Research in Ecology and Evolution* 4: 192-199.
- Latch, D.E., J.L. Packer, B.L. Stender, J. VanOverbeke, W.A. Arnold and K. McNeill. 2005. Aqueous photochemistry of triclosan: Formation of 2,4-dichlorophenol, 2,8-dichlorodibenzo-p-dioxin and oligomerization products. *Environ. Toxicol. Chem.* 24 (3): 517-525.
- Savanick, S., L.A. Baker, J. Perry. In final revision. Nitrogen budget of the University of Minnesota, Twin Cities Campus. *Urban Ecosystems*.
- Schoenfuss, H.L., S. E. Bartell, T. B. Bistodeau, R. A. Cediell, K. J. Grove, K. E. Lee, L. B. Barber. In Review. Environmentally relevant exposures to 4-nonyphenol impair the reproductive potential of male fathead minnows. Currently in USGS Peer Review.
- Schussler, J., L. Baker and H. Chester-Jones. In press. Whole-system phosphorus model for analysis of P management in watersheds. *Ecological Engineering*.
- Wammer, K.H.; T.M. LaPara, K. McNeill, W. A. Arnold, D.L. Swackhamer. 2006. Changes in Antibacterial Activity of Triclosan and Sulfa Drugs due to Photochemical Transformations. *Environ. Toxicol. Chem.*, 25: 1480-1486.
- Werner, J.J., K.H. Wammer, M. Chintapalli, W.A. Arnold, and K. McNeill. Environmental photochemistry of tylosin: efficient, reversible photoisomerization to a less-active isomer, followed by photolysis. *J. Ag. Food Chem.* Submitted.
- Werner, J.J.; W.A. Arnold.; K. McNeill. 2006. Water Hardness as a Photochemical Parameter: Tetracycline Photolysis as a Function of Calcium Concentration, Magnesium Concentration, and pH. *Environ. Sci. Technol.* 40: 7236-7241.
- Werner, J.J., K. McNeill, W.A. Arnold. 2005. Environmental photodegradation of mefenamic acid. *Chemosphere* 58: 1339-1346.
- Xu, Y., L. Baker, and P. Johnson. In press. Effect of land use changes on temporal trends in groundwater nitrate concentrations in and around Phoenix, Arizona. *Ground Water*.

Appendix F: Presentations and Publications

Allen, A.K., T. Loes and H.L. Schoenfuss. 2006. Assessing two species of cypriniform fish for signs of endocrine disruption in a historically estrogenic wastewater outfall. Poster Presentation. 2006 Midwest SETAC Meeting, St. Cloud, MN March 20–22, 2006.

Asleson, B. Assessing rain garden effectiveness, 5th National Monitoring Conference, San Jose, CA, May 10, 2006.

Asleson, B. Techniques for assessing the effectiveness of rain gardens. Minnesota Erosion Control Association Low Impact Development Stormwater Tour 2006. September 21, 2006

Asleson, B. Assessing rain garden effectiveness. 14th National Nonpoint Source Monitoring Workshop September 24–28, 2006

Asleson, B. Techniques for evaluating the effectiveness of rain gardens as a stormwater BMP. Erosion and Sediment Control Program, U of M Successful Infiltration Seminar - Designing to Meet Volume Control Requirements, Cocoran, MN. October 11, 2006

Asleson, B. Techniques for evaluating the effectiveness of rain gardens as a stormwater BMP. Minnesota Water 2006 and Annual Water Resources Joint Conference, Minneapolis, MN. October 24–25, 2006

Asleson, B. Techniques for evaluating the effectiveness of rain gardens as a stormwater BMP. Annual AWRA Conference, Baltimore, MD. November 6–9, 2006.

Arnold, W.A. and H. Dolliver. 2006. Pharmaceuticals in Groundwater: Fate, Transport, and Effects. Minnesota Groundwater Spring 2006 Conference, St. Paul, MN, April 12, 2006.

Baker, L. A. and P.L. Brezonik. In press. Using whole-system mass balances to craft novel approaches for pollution reduction: examples at scales from households to urban regions. Chapter to appear in *Cities of the Future: Green Cities-Blue Waters*, edited by V. Novotny, the Wingspread Workshop, Racine, WI.

Baker, L., P. Brezonik, D. Mulla, K. Nelson, S. Hobbie, J. King, D. Hope, J. Kaye, S. Kloiber, P. Hartzheim, M. Payton and V. Kalkirtz. Nutrient cycling in human ecosystems (poster). Biocomplexity in the Environment, NSF workshop, Alexandria, VA, March 21–23, 2005.

Baker, L., and J. Schussler. Limitations to the P retention paradigm. Minnesota Water 2005 and Annual Water Resources Joint Conference, Minneapolis, October 2005.

Baker, L. Are streets the source of pollutants? 17th Minnesota Transportation Research Conference, Minneapolis, May 24–25 2006.

Appendix F: Presentations and Publications

Baker, L. and J. Shussler. Phosphorus balances for watersheds (invited poster). "Agriculture for the 21st Century" 4th Annual Open House, Southern Research and Outreach Center, University of Minnesota, Waseca. September 14, 2006.

Baker, L. and P. Brezonik. Biogeochemical cycles in cities. (Invited) Cities of the Future, the Wingspread Workshop. NSF and others, Resort, Racine, WI, July 12-14, 2006.

Baker, L. (panelist) 2006. The Future of Minnesota's Environment. Panelist, "Policy and a Pint" Series, Minnesota Citizens League event, Varsity Theater, Minneapolis, April 20, 2006.

Baker, L. Sources of urban stormwater pollution. Minnesota Water 2006 and Annual Water Resources Joint Conference, Minneapolis, MN. October 24-25.

Baker, L., and J. Schussler. Limitations to the P retention paradigm. North American Lake Management Society Conference, Nov. 9-11, 2005.

Baker, L. Source reduction for urban stormwater management. Public Works Forum, Ramsey-Washington Watershed District, Dec. 21, 2006.

Bistodeau, T., R. Cediél, K. Groove, J. Klaustermeier, H. L. Schoenfuss. 2005. Reproductive Consequences of Environmentally Relevant Exposures of Fathead Minnow Larvae to a Mixture of Alkylphenol Ethoxylates. Poster Presentation. 2005 Midwest SETAC Meeting, Madison, WI, April 5, 2005.

Bistodeau, T.J., Cediél, R.A., Grove, K.J., Klaustermeier, J.A. and Schoenfuss, H.L.. 2005. The reproductive consequences of an environmentally relevant exposure of alkylphenol polyethoxylates on fathead minnow larvae. SETAC North America 26th Annual Meeting, Baltimore, MD, November 13-17, 2005. Abstract # WP022 pg. 285.

Birr, A. 2005. Paired watershed studies for nutrient reductions in the Minnesota River Basin. Ph.D. Dissertation. Water Resources Science. College of Agricultural, Food and Environmental Sciences. Univ. Minnesota. St. Paul, MN.

Boreen, A.L. 2006. Enhanced photolysis in natural waters: naturally occurring sensitizers and substrates and application to the fate of aquatic pollutants. Ph.D. Dissertation, Department of Chemistry, University of Minnesota, Minneapolis, MN.

Crighton, L., Iles, J., Liukkonen, B. O'Brien, E., Stepenuck, K., Wolfson, L. Building the Capacity of Volunteer Monitoring for E. coli in the Upper Midwest, North American Lakes Management Society International Symposium, Indianapolis, IN, Nov 5-9, 2006.

Appendix F: Presentations and Publications

Crighton, L., Iles, J., Liukkonen, B. O'Brien, E., Stepenuck, K., Wolfson, L. Building the Capacity of Volunteer Monitoring for E. coli in the Upper Midwest, Innovations in Reducing Nonpoint Source Pollution: Methods, Policies, Programs, and Measurement, Indianapolis, IN, Nov 29-30, 2006.

DeJournett, T.D. 2006. Removal of cis-1,2-dichloroethylene from groundwater using a restored wetland. Thesis. Department of Civil Engineering, University of Minnesota, Minneapolis, MN.

Edhlund, B.L., W.A. Arnold, K. McNeill. 2005. Aquatic Photochemistry of Nitrofurantoin Antibiotics. Poster Presentation. ENVR, 230th ACS National Meeting, Washington, DC, August 2005.

Edhlund, B.L., W.A. Arnold, K. McNeill. 2005. Aquatic Photochemistry of Nitrofurantoin Antibiotics. Poster Presentation. Minnesota Water 2005 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 2005.

Edhlund B.L., W.A. Arnold, K. McNeill. 2005. Aquatic Photochemistry of Nitrofurantoin Antibiotics. Poster Presentation. Minnesota ACS Meeting, St. Paul, MN, November 2005.

Edhlund, B.L., W.A. Arnold, K. McNeill. 2006. Aquatic Photochemistry of Nitrofurantoin Antibiotics. Celebrating Women Chemists Luncheon, University of Minnesota, Minneapolis, MN, February, 2006.

Edhlund, B.L., W.A. Arnold, K. McNeill. 2006. Aquatic Photochemistry of Nitrofurantoin Antibiotics. Poster Presentation. Environmental Sciences: Water Gordon Research Conference, Plymouth, NH, June 25-June 30, 2006.

Erickson, A. Enhanced Sand Filtration: Removing dissolved phosphorus from stormwater runoff. EWRI World Environmental and Water Resources Congress, Omaha, NE, May 21-25, 2006.

Erickson, A. Assessment of stormwater infiltration. Erosion and Sediment Control Program, U of M Successful Infiltration Seminar - Designing to Meet Volume Control Requirements, Corcoran, MN. October 11, 2006

Erickson, A. Assessment of stormwater BMPs. EPA Region 5 TMDL Workshop, Kalamazoo, MI. October 16-19, 2006.

Erickson, A. Cost and effectiveness of stormwater BMPs. EPA Region 5 TMDL Workshop, Kalamazoo, MI. October 16-19, 2006.

Erickson, A. Testing Versus Monitoring in the Assessment of Stormwater BMPs. Minnesota Water 2006 and Annual Water Resources Joint Conference, Minneapolis, MN. October 24-25.

Appendix F: Presentations and Publications

Erickson, A. Four levels of assessment of stormwater BMPs. Minnesota Association of Watershed Districts (MAWD) Annual Conference and Trade Show, Alexandria, MN. November 30 – December 2, 2006.

Everett, L.A., and Vetsch, J.A. Poster, On-farm conservation tillage research and demonstrations in Minnesota. 2005. Abstracts, Annual Meetings of the American Society of Agronomy.

Ferrington, L.C., Jr. and R.W. Bouchard. 2006. TMDL for trout streams: Winter dynamics matter. Oral Presentation. Minnesota Water 2006 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 24-25.

Gamble, C., A. Gikineh and M.L. Julius. 2006. The effects estradiol and nonylphenol on *Melosira varians*, a common tycho planktonic diatom. Oral Presentation. 2006 Midwest SETAC Meeting, St. Cloud, MN March 20-22, 2006.

Gulliver, J.S. Assessment of stormwater management practices on the water quality of runoff, presentation before Area Managers, Minnesota Pollution Control Agency, May 15, 2006.

Gulliver, J.S. Developing a storm water assessment protocol for the State of Minnesota: pros and cons of extensive engagement. Water Resources Science Seminar, University of Minnesota, November 15, 2006.

Hagley, C., B. Liukkonen, M. Blickenderfer, E. Burkett. 2005. University of Minnesota Shoreland Education—Creating Shoreland Stewards. IAGLR, Ann Arbor, MI, May 25-27, 2005.

Hartzheim, P., L. Baker, S. Hobbie, K. Nelson, J. King, and M. Payton. Effect of consumption choices on fluxes of carbon, nitrogen and phosphorus through urban households: case studies from Minnesota and Albania. Ecological Society of American, Memphis, August 6-9, 2006.

Hartzheim, P., and L. Baker. Urban landscape scenarios and cycling of carbon, nitrogen and phosphorus. 2006 Minnesota Water 2006 and Annual Water Joint Conference, Brooklyn Center, MN, October 24–25.

Hondzo, M.; Arnold, W.A.; Novak, P.J.; Hozalski, R.M. 2006. Wireless technologies and embedded networked sensing: application to integrated urban water quality management. ASCE World Environmental and Water Resources Congress Oral Presentation, Omaha, NE, May 21-26, 2006.

Iles, J., Crighton, L., Liukkonen, B., O'Brien, E., Stepenuck, K., Wolfson, L. Volunteer Monitoring of *E. coli* in Upper Midwest Streams: Comparison of Methods and Preferences. USDA-CSREES National Water Quality Conference, San Antonio, TX, Feb 5-8, 2006.

Iles, J., Crighton, L., Liukkonen, B. O'Brien, E., Stepenuck, K., Wolfson, L. Volunteer Monitoring of *E. coli* in Upper Midwest Streams: Comparison of Methods and Preferences. Association of Natural Resource Extension

Appendix F: Presentations and Publications

Professionals (ANREP) National Conference, Park City, UT, May 14-17, 2006.

Jazdzewski, J.D., M. Hondzo and W.A. Arnold. 2006. Stream Water Quality Monitoring using Wireless Embedded Sensor Networks. Poster presentation at the Minnesota Water 2006 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 24– 25.

Julius, M.L., Stepanek, J., Tedrow, O., Gamble, C. and H.L. Schoenfuss. Estrogen -receptor independent effects of two ubiquitous environmental estrogens on *Melosira varians* Agardh, a common component of the aquatic primary producer community. In preparation.

Kim, S.-C., M. Hondzo, R.M. Hozalski, P. Novak, W. Arnold, J.D. Jazdzewski, N. Jindal, P.D. Capel. 2006. Integrated urban water quality management: wireless technologies and embedded networked sensing. Poster Presentation. American Geophysical Union National Meeting, San Francisco, CA, December, 2006.

Kumar, K. Gupta, S.C., Singh, A.K., Gupta, S., and Chander, Y. 2006. Estrogens in Swine Manure. Paper presented at Minnesota Water 2006 and Annual Water Resources Joint Conference. October 24-25, 2006, Brooklyn Center, MN.

Kumar, K. 2006. Occurance of Estrogenic Compounds in Manures and Biosolids. Invited Paper in Special Symposium on Emerging Contaminants and Land-applied Biosolids and Manures: State of the Science and regulatory implications. ASA-CSSA-SSSA International Annual Meetings. November 12-16, 2006.

Latch D. E. 2005. Environmental photochemistry: Studies on the degradation of pharmaceutical pollutants and the microheterogeneous distribution of singlet oxygen. Ph.D. Dissertation, Department of Chemistry, University of Minnesota, Minneapolis, MN, 2005, 256 pp.

Lennon, M. and E. Nater. 2006. “Biophysical Aspects of Terrestrial Carbon Sequestration in Minnesota.” University of Minnesota, Minneapolis.

Liukkonen, B., E. O’Brien, L. Crighton, K. Stepenuck, J. Iles, L. Wolfson, L. Seigley, M. Skopec. 2005. Building the Capacity of Volunteer Monitoring for *E. coli* in the Upper Midwest. USDA-CSREES National Water Quality Conference, LaJolla, CA. February 7-9, 2005.

Liukkonen, B. and W. Bouchard. 2005. Guide to Aquatic Invertebrates of the Upper Midwest. International Water Conference. Winnipeg, MN, Canada. April 5-7, 2005.

Liukkonen, B., L. Crighton, J. Iles, E. O’Brien, K. Stepenuck, L. Wolfson. 2005. Building the Capacity of Volunteer Monitoring for *E. coli* in the Upper Midwest. National Nonpoint Source and Stormwater Education Conference. Chicago, IL, Oct 17-20, 2005.

Appendix F: Presentations and Publications

Liukkonen, B. 2006. Preventing the Spread of AIS through Water Gardening. Part of Aquatics Recertification, Green Expo, Mpls, MN, January 3-6, 2006.

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. 2006. Poster Presentation: Arsenic in Ground Water: Potential Affects on RRV Dairy Operations. 23rd Annual Red River Basin Land & Water International Conference. Winnipeg, MAN, Jan 11-13, 2006.

Liukkonen, B., L. Crighton, J. Iles, E. O'Brien, K. Stepenuck, and L. Wolfson. 2006. Building the Capacity of Volunteer Monitoring for E. coli in the Upper Midwest. 2006. EPA Region 5 Surface Water Monitoring and Standards meeting. Chicago, IL, Feb 1-2, 2006.

Liukkonen, B. and E. Burkett. Preventing the Spread of Aquatic Invasive Species from Water Gardening. USDA-CSREES National Water Quality Conference, San Antonio, TX, Feb 5-8, 2006.

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. Assessing the Impacts of Arsenic on Midwestern Dairy Operations. National Water Quality Monitoring Conference, San Jose, CA, May 7-11, 2006.

Liukkonen, B., V. Crary, M. Erickson, J. Linn, M. Murphy. Does Arsenic in Drinking Water Affect Dairy Products? Association of Natural Resource Extension Professionals (ANREP) National Conference, Park City, UT, May 14-17, 2006.

Liukkonen, B. and E. Burkett. Preventing the Spread of Aquatic Invasive Species from Water Gardening. Association of Natural Resource Extension Professionals (ANREP) National Conference, Park City, UT, May 14-17, 2006.

Liukkonen, Barbara. 2006. E. coli Happens - Bacteria Monitoring. The Changing Landscapes of Minnesota's Waters, Lakes & Rivers Conference, Duluth, MN. September 7-9, 2006.

Liukkonen, B., L. Crighton, J. Iles, E. O'Brien, K. Stepenuck, L. Wofson, L. Seigley, M. Skopec. 2006. Building the Capacity of Volunteer Monitoring for E. coli in the Upper Midwest. 14th National Nonpoint Source Monitoring Workshop, Minneapolis, MN. September 24-28, 2006.

McNeill, K. 2005. Mechanistic Environmental Chemistry: Photo-generated Reactive Species and Pollutant Degradation, University of California, Berkeley, Department of Chemistry, February 25, 2005.

McNeill, K. 2005. Mechanistic Environmental Chemistry: Photo-generated Reactive Species and Pollutant Degradation, Northwestern University, Department of Chemistry, February 18, 2005.

McNeill, K. 2005. Mechanistic Environmental Chemistry: Photo-generated Reactive Species and Pollutant Degradation, University of Rochester, Department of Chemistry, March 4, 2005.

Appendix F: Presentations and Publications

- McNeill, K. 2005. Mechanistic Environmental Chemistry: Photo-generated Reactive Species and Pollutant Degradation, Cornell University, Department of Chemistry, March 7, 2005.
- McNeill, K. 2005. Photo-generated Reactive Species and the Degradation of Pharmaceutical Pollutants, Stanford University, Civil and Environmental Engineering Student Seminar Series, May 20, 2005.
- McNeill, K. 2005. Photochemical approaches to environmental pharmaceutical pollutants, American Chemical Society (ACS) National Meeting Symposium: Strategies and Molecular Mechanisms of Contaminant Degradation Chemistry, Washington, D.C., August 28-Sept. 1, 2005.
- McNeill, K. 2005. Photosensitized reactions in natural waters: Implications for pollutant degradation and the carbon cycle, University of Minnesota, Department of Chemistry, September 20, 2005.
- McNeill, K. 2005. Photosensitized reactions in natural waters: Implications for pollutant degradation and the carbon cycle, University of Minnesota-Morris, Department of Chemistry, October 27, 2005.
- McNeill, K. 2006. Phototransformation Reactions of Antibiotic Pollutants, Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy Symposium on “Degradation and Treatment of Pharmaceuticals in the Environment,” Orlando, FL, March 12-17, 2006.
- Miller, C. and D. Current. 2006 “Terrestrial Carbon Sequestration: A Survey of Policies and Programs.”
- Nangia, V., P. Gowda, D. Mulla and G. Sands. 2005. Modeling nitrate-nitrogen losses in response to changes in tile drain depth or spacing. International Annual Meeting Am. Soc. Ag. Eng. Tampa, FL. Paper No. 052022
- Nangia, V., P. H. Gowda, D. J. Mulla, and G. Sands. 2005. Field scale application of a water quality modeling approach for alternative agronomic practices. Pp 364-372. In: Proc. 3rd ASAE Conference on Watershed Management to Meet Water Quality Standards and Emerging TMDLs. Atlanta, GA. ASAE, St. Joseph, MI.
- Sadowsky, M. J. 2006. Genomic Insights into the Degradation and Bioremediation of s-Triazine Herbicides. IERC Workshop, Gwangju, Korea.
- Sadowsky, M. J. 2006. Genomic Insights for the Degradation and Bioremediation of s-Triazine Herbicides. Osaka University-San Francisco Office Lecture, San Francisco, CA.
- Sadowsky, M. J. 2006. Has Human Activity Outstripped the Environments Ability to Rid Itself of Fecal Bacteria? Albrecht Lecture, Earth Day, University of Missouri, Columbia, MO.
- Sadowsky, M. J. 2006. Alternate source and sinks of Pathogens in the Environment. ASA/CSSA/SSSA Annual Meetings, Indianapolis, IN. November 12-16, 2006.

Appendix F: Presentations and Publications

Sadowsky, M. J. 2006. Development and Use of a High-Throughput Robotic Method to Determine Sources of *E. coli* in the Environment, University of South Florida, Tampa, FL.

Schoenfuss, H.L., T. Bistodeau, S. Bartell, J. Woodard, L. Barber, K. Lee, L. Zintek, A. Alwan and J. Lazorchack. 2005. Concentration Dependent Effects of 4-Nonylphenol on Male Fathead Minnows in a Competitive Reproductive Assay. Oral Presentation. 2005 Midwest SETAC Meeting, Madison, WI, April 5, 2005.

Schoenfuss, H.L. 2005. Biological Effects of Biologically Active Compounds: Experimental Considerations in the Study of Endocrine Disrupting Chemicals. Symposium Presentation at the Annual Meeting of the American Oil Chemists Society, Salt Lake City, UT, May 3, 2005.

Schoenfuss H. L. 2005. Concentration dependent effects of 4-nonylphenol on male fathead minnows in a competitive reproductive assay. Minnesota Water 2005 and Annual Water Resources Joint Conference Oral Presentation, Brooklyn Center, MN, October 25-26.

Schoenfuss, H.L. and T.J. Bistodeau. 2006. Effects of alkylphenol polyethoxylates (AP) alone and in mixture on two life stages of the fathead minnow (*Pimephales promelas*). Oral Presentation. 2006 Midwest SETAC Meeting, St. Cloud, MN March 20-22, 2006.

Schoenfuss, H.L. and T.J. Bistodeau. 2006. Effects of Alkylphenol Polyethoxylates (AP) Alone and in Mixture on Two Life Stages of the Fathead Minnow (*Pimephales promelas*). Minnesota Water 2006 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 24-25.

Schoenfuss, H.L., T.J. Bistodeau, and L.B. Barber. 2006. Larval exposure to environmentally relevant mixtures of alkylphenolethoxylates reduces reproductive competence in male fathead minnows. SETAC North America 27th Annual Meeting, Montreal, Canada, November 5-9, 2006. Abstract #333 pg. 73.

Schussler, J., and L. Baker. Whole-watershed P balances for 11 Minnesota recreational lakes Minnesota Water 2005 and Annual Water Resources Joint Conference, October 2005.

Stepenuck, K., Crighton, L., Iles, J., Liukkonen, B. O'Brien, E., Wolfson, L. 2006. Volunteer Monitoring of *E. coli* in Upper Midwest Streams: A Comparison of Methods and Preferences, National Water Monitoring Conference, San Jose, CA, May 7-11, 2006.

Stuewe, L. 2006. Agricultural nitrogen and phosphorus mass-balances in south-central Minnesota. M.S. Thesis. Water Resources Science. College of Agricultural, Food and Environmental Sciences. Univ. MN St. Paul, MN.

Appendix F: Presentations and Publications

Wammer, K.H., T.M. LaPara, L.J. Onan, The effects of long-term low-level antibiotic exposure on the development of antibiotic resistance. Poster presentation. Minnesota Water 2006 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 24-25.

Weiss, P.T. Cost and effectiveness of stormwater management practices, Sixteenth Annual Transportation Research Conference, February 26, 2006.

Werner, J.J., A.L. Boreen, B. Edhlund, K.H. Wammer, E. Matzen, K. McNeill, W.A. Arnold. 2005. Photochemical transformation of antibiotics in Minnesota waters, CURA Reporter 35(2): 1-5.

Werner, J.J., and K. McNeill. 2005. Water Hardness as a Critical Photochemical Parameter: The Case of Tetracycline Antibiotics, Pacifichem 2005 Congress, Symposium on Environmental Contaminants of Emerging Concern: Anticipating, Understanding and Intercepting Future Environmental Crises, Honolulu, HI, December 15, 2005.

Werner, J.J., W.A. Arnold, K. McNeill. 2006. The environmental photochemical kinetics of tetracycline as a function of pH and water hardness. Presented in "Environmental Chemistry Awards," Environmental Chemistry Division, American Chemical Society National Meeting, San Francisco, CA, September, 2006.

Werner, J.J. 2006. The environmental photochemistry of pharmaceutical compounds in aqueous solution and on a clay surface. Ph.D. Dissertation, Graduate Program in Water Resources Science, University of Minnesota, Minneapolis, MN.

Werner, J.J., W. A. Arnold, K. McNeill. 2006. Environmental photochemistry of the antibiotic compound tetracycline: dependence on acid-base and metal binding speciation. Paper presented at the Minnesota Water 2005 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 25-26, 2006.

Wilson, M. Solids removal efficiency of underground structures for stormwater treatment. 14th National Non-point Source Monitoring Workshop September 24-28, 2006.

Wilson, M. Performance assessment of underground structures for stormwater treatment. Minnesota Water 2006 and Annual Water Resources Joint Conference, Brooklyn Center, MN, October 24-25.

Wolfson, L., B. Liukkonen, L. Crighton, K. Stepenuck, J. Iles, E. O'Brien, L. Seigley, M. Skopec. 2005. Bacteria Monitoring in the Upper Midwest: Developing Consistent Training and Monitoring Methods. USDA-CS-REES National Water Quality Conference, LaJolla, CA. February 7-9, 2005.

Appendix G: List of Projects

Water Resources Center Research Projects

Water Resources Center faculty and staff were involved in several research projects spanning the 2005–2006 biennium. Funding for WRC-led research is provided by a variety of sources, including the National Science Foundation and the Minnesota Pollution Control Agency.

Proposal Title	PIs	Duration of Project	Amount
Regional Water Quality Leadership for North-Central States in the U.S.	Jim Anderson	9/1/00–6/29/05	\$248,017
Conservation Tillage Demonstration Project	Jim Anderson, Les Everett	10/1/02–9/30/06	\$247,200
Small Group Preparation of Nutrient Management Plans	Jim Anderson, Les Everett	12/4/02–6/30/06	\$263,040
Coupled Biogeochemical Cycles in Urban and Agricultural Systems	Patrick Brezonik, Larry Baker	9/1/03–8/31/06	\$355,317
Building Capacity of <i>E. coli</i> Monitoring by Volunteer Networks: A Multi-State Effort	Jim Anderson, Barbara Liukkonen	9/15/03–9/14/06	\$275,000
Decentralized Wastewater Treatment Practitioner Training Program	Jim Anderson	4/15/04–9/30/05	\$20,000
Sand Plain and Hayden Soils Training and Technical Assistance	Jim Anderson	8/12/04–6/30/06	\$40,000
Regional water quality leadership for the North Central United States	Jim Anderson, Barbara Liukkonen	9/1/04–9/14/08	\$301,640
On-Farm Manure Management Demonstrations	Jim Anderson, Les Everett	12/7/04–3/7/07	\$279,600
Assessment of Stormwater Treatment Practices on the Quantity and Quality of Runoff	Jim Anderson, Andy Erickson	1/11/05–10/31/06	\$580,000

Appendix G: List of Projects

Proposal Title	PIs	Duration of Project	Amount
Assessment of Stormwater Management Practices on Water Quality	Jim Anderson, Andy Erickson	7/1/05–9/30/07	\$175,000
Minnesota Terrestrial Carbon Sequestration Project	Jim Anderson, Cheryl Miller	7/1/05–12/31/07	\$185,000
Lake Pepin TMDL Science Advisory Panel Initiation	Deb Swackhamer	1/12/06–6/30/07	\$20,930
Professional Sewage Treatment Workshop Manual Update	Jim Anderson	2/15/06–6/30/07	\$206,760
A Great Lakes Basin Screening Model for Emerging Chemicals	Deb Swackhamer	3/23/06–7/31/08	\$201,680
Developing Social Indicators for NPS Evaluation in Minneosta	Karlyn Eckman	4/1/06–9/30/07	\$120,000
Impaired Waters: Conservation Drainage Research	Jim Anderson, Les Everett	7/1/06–6/30/07	\$161,400

Water Resources Center Grants Program

The WRC grants funds to research projects concerned with the water resources of Minnesota and the Midwest, although the applicability of the research is usually broader in scope. Research projects are usually funded for two-year periods and involve a combination of federal money and matching funds from state, university, or local sources. The WRC contributes funds from two of its component entities, the Water Resources Research Institute and the Center for Agricultural Impacts on Water Quality.

Proposal Title (WRRRI 104-G)	PIs	Duration of Project	Amount
Photochemistry of antibiotics and estrogens in surface waters	Kris McNeill	9/1/03–2/28/06	\$134,092
WRRRI-WRC internship program	Deb Swackhamer	8/1/05–8/27/08	\$66,641

Appendix G: List of Projects

Proposal Title	PIs	Duration of Project	Amount
Assessing the ecotoxicology of alkylphenol mixtures across the aquatic food chain	Deb Swackhamer, Heiko Schoenfuss	9/1/05–8/31/07	\$63,041
Application of wireless and sensor technologies for urban water quality management	Bill Arnold	9/31/06–8/31/08	\$149,176
Proposal Title (WRRR 104-B)	PIs	Duration of Project	Amount
Phyto-enhanced remediation: A wetland treatment system for surface water protection	Bill Arnold, Tim LaPara	3/1/04–2/28/06	\$24,262
Assessing the ecotoxicology of 4-nonylphenol, a ubiquitous environmental estrogen, in two organismal bioassays	Heiko Schoenfuss	3/1/04–2/28/05	\$45,208
A rapid bioassessment approach for integrating biological data into TMDL development for organic enrichment of streams in urbanizing watersheds	Len Ferrington	4/1/04–2/28/06	\$57,599
The effects of long-term low-level antibiotic exposure on the development of antibiotic resistance	Kristine Wammer	6/1/04–5/31/05	\$10,980
Wireless technologies applied to environmental variables and nutrient loadings	Miki Hondzo, Bill Arnold	3/1/05–2/28/06	\$84,340
Water quality monitoring strategy based on agroregion boundaries in the Minnesota River Basin	David Mulla	3/1/05–2/28/06	\$70,730

Appendix G: List of Projects

Proposal Title	PIs	Duration of Project	Amount
Use of <i>Arthrobacter aurescens</i> for remediation of groundwater contaminated with triazine herbicides	Michael Sadowsky, Lawrence Wackett	3/1/05–2/28/06	\$23,120
Estrogens and estrogenic activity in swine manure	Satish Gupta	3/1/05–2/28/06	\$74,750
Ecological stoichiometry and microbial biodiversity effects on water quality in Minnesota lakes	Jim Cotner	3/1/06–2/28/08	\$49,065
Development of a DNA marker gene system to determine sources of fecal <i>Escherichia coli</i> in watersheds	Michael Sadowsky	3/1/06–2/28/08	\$74,850
Factors affecting revegetation success in lakeshore restorations	Susan Galatowitsch	4/1/06–3/31/08	\$27,000



Water Resources Center
173 McNeal Hall
1985 Buford Ave.
St. Paul, MN 55108
phone: (612) 624-9282
fax: (612) 625-1263
web: <http://wrc.umn.edu>

