



September 2005

Whole-watershed phosphorus balances guide lake management options to improve water quality

by Lawrence A. Baker, WRC Senior Fellow, and Johanna Schussler, WRS alumna

In the 30 years since the Clean Water Act was passed, substantial progress has been made in the reduction of pollutant point sources to waterways. The reduction of nonpoint sources of pollution—pollution coming from many individual sources such as feedlots, cropland, lawns and streets—has been less successful. There are many reasons for this, one of which is the lack of an ecological framework to provide guidance for nutrient management.

The goal of our study, Hot-spots of Landscape Change: Identifying Key Linkages between Water Quality and Land Development Patterns in Riparian Areas of the North Central Region, was to examine relationships between lakeshore development and water clarity. To better understand factors related to changes in clarity, we developed whole-watershed phosphorus (P) balances for eleven recreational lakes in Minnesota that

had undergone substantial development since the 1980s.



Phosphorus balances can relate lakeshore development to water clarity and help guide lake-management decisions.

is retained in the watershed (stream P = input P – deliberately exported P – retained P). Major phosphorus inputs to watersheds dominated by human activity include atmospheric deposition, feed for farm animals, human food, and agricultural and lawn fertilizer. Deliberate exports include crops and animal products. Sewage is sometimes exported from one watershed and imported into another watershed, where it is treated. Sewage sludge may then be exported from the watershed.

In the eleven study watersheds, phosphorus imports varied on an areal basis by about a factor of ten, with agricultural watersheds having the highest phosphorus inputs.

Phosphorus continued on page 4

Two University of Minnesota graduates receive UCOWR Ph.D. dissertation awards

The Universities Council on Water Resources recognized University of Minnesota alumnus, Xiangming Fang, Ph.D., with the 2005 Ph.D. Dissertation Award in Water Policy and Socio-Economics. The title of Fang's dissertation was "Water Shortages, Water Allocation, and Economic Growth: the Case of China." After receiving his degree in Applied Economics in 2004, Fang took a position as an economist with the National Center for Injury

Prevention and Control at the Centers for Disease Control.

A Ph.D. Dissertation Award Honorable Mention went to University of Minnesota Water Resources Science alumna, Mindy Erickson. Her dissertation was titled "Arsenic in Upper Midwest Ground Water: Occurrence and Geochemical Mobilization Mechanisms." Erickson received her Ph.D. in 2005 and now works for the Minnesota Department of Transportation.

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Around the State



WATER
RESOURCES
UPDATES

DNR urges "Be an active lake steward"

How can you help improve the quality of Minnesota's lakes and rivers? It's simple. Show up. Speak up. Write a check. In other words, get in the game.

Get involved. Join your local lake association or neighborhood association. Local development issues, which often impact natural resources, are often guided and inspired by grassroots groups with strong opinions about what kinds of development are appropriate for maintaining the environmental integrity as well as a sense of place in their particular neighborhood.

Make phone calls, write letters and send emails to your elected and appointed officials. Your city council, your planning commission, and your county commissioners need to know how you feel about preserving Minnesota's natural heritage.

Vote in decision-makers who understand the need to balance development with conservation and who will work to make that happen. Campaign for candidates who will stand up for healthy lakes and rivers. And once they're successfully elected, help them accomplish these environmental goals.

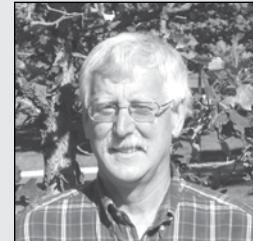
Attend and participate in civic meetings to discuss future growth and development in your community. The rules are made by those who show up. They are not made by those who stay at home and watch reruns. Participate in the betterment of your community.

If you can't be as active as you want, write a tax-deductible check to support a nonprofit organization that is working to preserve the natural environment for public benefit. A couple of examples are 1000 Friends of Minnesota and the Minnesota Lakes Association. Run for an

From the Director's Desk

Another busy fall season at the WRC

It seems with every one of these letters I write, I refer to some type of administrative or structural change on campus that may impact our relationships with communities in Minnesota and elsewhere. This letter is no exception. This fall we will embark as a campus community on the integration of the College of Natural Resources and the College of Agricultural, Food, and Environmental Sciences. To have a plan in place for this integration by the end of the fall semester will require much thoughtful effort on the part of faculty, staff, and students. As we morph into the "new expanded college," the Water Resources Center will be an important part of the discussions, with the clear expectation that we will grow and have an increased campus presence. All of this will happen while our work on water resources issues continues.



Here is a sample of what is happening this fall:

In September, we are sponsoring and facilitating three workshops for watershed managers on determining social indicators to evaluate project progress. This is done as part of our regional U.S. Department of Agriculture-Cooperative State Research, Education, and Extension Service project. The workshops are part of our six-state, U.S. Environmental Protection Agency-Region Five effort to use social indicators along with administrative and environmental indicators to document program success. In conjunction with the Minnesota Pollution Control Agency, we are concentrating the workshops on evaluating Section 319 nonpoint source pollution projects, but we hope they will be a part of evaluating other water programs across our region. Stay tuned for periodic updates on this effort. This is truly covering new territory!

We will launch the first of three campus forums about carbon sequestration in Minnesota landscapes as a part of a program funded by the Initiative for Renewable Energy and Environment to evaluate the potential for obtaining tradable carbon credits. This effort will result in a major conference in fall 2006, and the establishment of pilot projects to demonstrate the viability of sequestering carbon in Minnesota.

As a part of our continuing Memo of Understanding with the Mekong River Commission, we will sponsor a campus forum to discuss how environmental restoration efforts in the Upper Mississippi River Basin can provide guidance in addressing Mekong River Basin environmental problems, while using what we learn from the Mekong to help us with our own trans-boundary issues between states in the Upper and Lower Mississippi River Basin.

All of this in the midst of our campus change! On one hand, when I think of these efforts I am daunted by the tasks at hand, but on the other hand, I am as excited as a Scandinavian can get by all of the great opportunities to increase the University of Minnesota's presence in addressing water resource issues.

Jim Anderson, WRC Co-Director

elected public office. Become a member of your city council, or become a county commissioner, or get appointed to your local planning commission or Board of Adjustment.

Show up, speak up, write a check, and remember the words of anthropologist Margaret Mead, who said, "Never doubt that a small group of thoughtful, commit-

ted citizens can change the world. Indeed, it is the only thing that ever has."

For more information, send an e-mail message to the North Central Minnesota Lakes Project (NCML) at lakewaves@dnr.state.mn.us. NCML is part of Governor Pawlenty's Clean Water Initiative.

Contents taken from a Minnesota Department of Natural Resources press release, August 29, 2005

Schedule set for Minnesota Water 2005 and Annual Water Resources Joint Conference

The conference will be held at the Earle Brown Heritage Center in Brooklyn Center, Minnesota. For more information, visit the conference Web site at <http://wrc.coafes.umn.edu/waterconf>.

Tuesday, October 25, 2005

7:00 a.m.	Registration and Continental Breakfast
8:00	Welcome, Ron Leaf, Short Elliot Hendrickson, Inc.
8:10	Dave Ford Water Resources Award
8:20–9:30	Plenary Session, "Changing Strategies in a Changing Climate," John J. Magnuson, Professor Emeritus, Limnological Research Center, University of Wisconsin-Madison
9:30–10:00	Poster Session and Refreshment Break
10:00–11:30	Concurrent Sessions I A. New Urban BMPs: Implementation Case Studies B. Pollutant Loads and Trends for Large River Systems C. Surface Water Analysis
11:30–1:00	Luncheon Presentation
1:15–2:45	Concurrent Sessions II A. Hydraulic Improvements in Developed Environments B. Remote Sensing and GIS for Watersheds and Streams C. Lake Water Quality Improvement D. Streams and Rivers
2:45–3:15	Poster Session and Refreshment Break
3:15–4:45	Concurrent Sessions III A. Surface and Ground Water Interactions B. Remote Sensing and GIS for Lakes and Wetlands C. Understanding and Managing Nutrient Loads to Aquatic Ecosystems
4:45–5:45	Poster Session and Reception

Wednesday, October 26, 2005

7:00 a.m.	Registration and Continental Breakfast
8:00	Welcome, Deborah Swackhamer, Water Resources Center and School of Public Health, University of Minnesota
8:10–9:30	Panel Presentation and Discussion, "TMDLs: Impaired Waters, Impaired Process? Three Perspectives on Improving the Process"
9:30–10:00	Poster Session and Refreshment Break
10:00–11:30	Concurrent Sessions IV A. Pesticides, Nitrates, and Drinking Water B. Surface Water Management C. Fate and Effects of Emerging Aquatic Contaminants
11:30–12:45	Luncheon Presentation, "Everglades Restoration: A Remarkable Convergence of Science, Policy, Advocacy, and Law"
1:00–2:30	Concurrent Sessions V A. Agricultural Issues B. Water Quality Standards and Modeling C. TMDL Assessments
2:30–2:45	D. Sustainable Watersheds, Competing Goals, and the Tool Box
2:45–4:15	Poster Session and Refreshment Break Concurrent Sessions VI A. Nitrogen Management and Modeling B. When the TMDL Rubber Hits the Road C. River and Lake Management

Alkylphenol research through the WRC receives USGS funding

An innovative research project submitted through the WRC has been awarded funding as part of the United States Geological Survey's (USGS) National Competitive Grants Program. The project, "Assessing the Ecotoxicology of Alkylphenol Mixtures Across the Aquatic Food Chain," is led by Dr. Heiko Schoenfuss from St. Cloud State University. Also collaborating on the project are Dr. Matthew Julius (St. Cloud State University) and Dr. Larry Barber (USGS).

Alkylphenols (AP), compounds that are commonly used as industrial and household surfactants, have recently been detected in surface waters and in European and North American drinking water. Because APs are known to interfere with reproduction in mammals, these findings are of great concern. By investigating the effects of different AP mixtures on diatoms, daphnia, and fathead minnows, the researchers will determine the repercussions of AP on biological functions at three levels of the aquatic food chain. In addition, through feeding trials, the researchers will determine the effects of AP across the aquatic food chain.

WRS welcomes new graduate students

The Water Resources Science graduate program welcomed thirteen incoming students at its orientation on Thursday, September 1, 2005. Two of the incoming students will be studying on the Duluth campus, and eleven will be studying on the Twin Cities campus. The diverse students come from as far away as Costa Rica, and are advised by faculty from nine departments on the two campuses. Total enrollment in the WRS program now stands at 80 students (47 M.S. and 33 Ph.D.).

Lewis Lake Association contracts with Center for Urban and Regional Affairs to study water quality

by Sarah Roley, Conservation Biology Graduate Student

Lewis Lake, a quiet lake surrounded by cattail marshes, forest, and cabins, is a paradise for its residents. Members of the Lewis Lake Association would like to keep it that way. Concerned about excess algae and weed growth on the lake, they contracted with the University to learn more about the nutrient inputs, the plants growing in the water, and options for land management.

With funding from the Community Assistance Program at the University's Center for Urban and Regional Affairs, I was hired by the Association to study their lake. I have been taking bi-weekly water samples, performing aquatic vegetation surveys, and researching land-use options. The water samples are taken at several sites in and around the lake, and are being analyzed for phosphorus, nitrates, and chlorophyll-a. I will use the results of these analyses to determine the magnitude of landscape nutrient inputs and the amount of internal recycling of nutrients that occurs.

With the help of several volunteers, I have also conducted the first of two aquatic plant surveys. The result of these surveys will be a catalog of plants in the lake, estimates of their relative abundance, and specific information about each species. The first survey has indicated a moderately diverse plant community dominated by coontail, a common aquatic plant in Minnesota. The lake also has a healthy

population of white water lily, yellow water lily, several native pondweed species, and water celery. Unfortunately, I also found a small population of curly-leaf pondweed, an exotic, invasive species that can grow in thick, extensive mats.

Curly-leaf pondweed doesn't always cause problems—sometimes the population remains small and unobtrusive—but it

often does well in lakes with poor water quality. Because of this risk, it becomes even more important that Lewis Lake maintain or improve its water quality. This can be achieved through land management projects, including shoreline restoration, septic system improvements, and erosion prevention. Some Lewis Lake residents have installed shoreline rip-rap, and most understand the importance of shoreline vegetation buffers. These projects can be expensive and technically difficult to per-

form, however, and so I am in the process of compiling a list of funding options and shoreline restoration information.



Sarah Roley collects a sample of Lewis Lake's aquatic vegetation as part of a project to reduce algae and weed growth and improve water quality in the lake.

I will be presenting this information, along with the results of my water sampling and aquatic vegetation surveys, at the Association meeting in September. My research and presentation will help the Lewis Lake Association better understand how their lake functions, and give them several options for improved land management. With help from my advisor, Ray Newman (Fisheries, Wildlife, and Conservation Biology), this project will lead to my M.S. in Conservation Biology.

Phosphorus continued from page 1

Agricultural watersheds also tended to have high deliberate exports, in the form of animal products. Phosphorus retention in the watersheds varied from eight to 85 percent of input. Phosphorus retention, as a percentage of total input, was highest for watersheds with little agricultural activity. Stream export of phosphorus to lakes varied from one to 68 percent.

The mass balance approach used shows that phosphorus retention often comprises a major fraction of phosphorus input to watersheds. In other words, most of the phosphorus entering watersheds is being retained within those watersheds. Over the short term, retention of phospho-

rus is desirable, but we hypothesize that phosphorus retention is not sustainable for soils that receive very high phosphorus loads, such as farm fields and lawns that have received high phosphorus inputs over time, and septic leach fields. This hypothesis is supported by theoretical considerations and some published field studies. A potential problem for Minnesota may be the 600,000 septic systems, which are significant sites of phosphorus retention often located very near lakes.

Our research suggests the potential effectiveness of reducing phosphorus inputs or increasing outputs to reduce watershed phosphorus retention. The current lawn phosphorus restriction in Minnesota is a

good example of input-side phosphorus management. For some farms, improvements in animal nutrition could reduce phosphorus inputs and therefore reduce the amount of phosphorus in manure. For lakes that are heavily developed, sewerage the lakeshore would remove sewage phosphorus from the watersheds of important recreational lakes, thereby reducing the potential for eutrophication.

This watershed phosphorus mass balance approach was reported as a M.S. thesis by Johanna Schussler. The study was supported by the U.S. Forest Service's North-Central Research Station. The full report will be available in 2006.

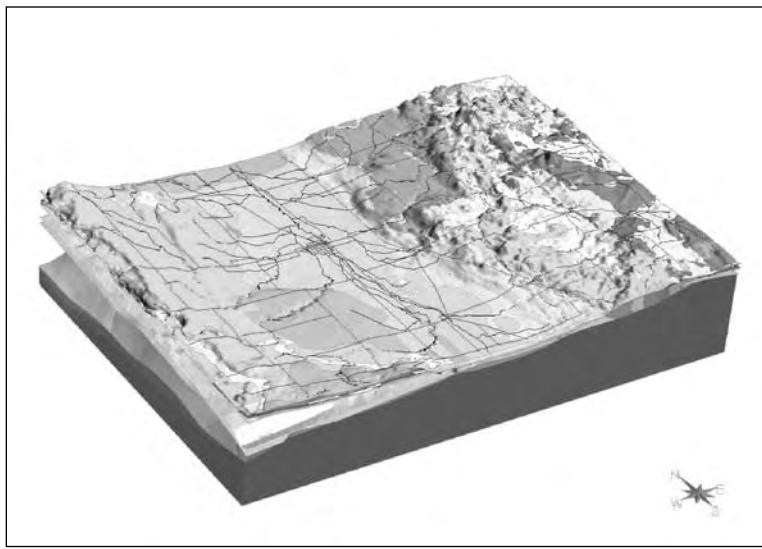
MGS coordinates Fargo-Moorhead ground water study

by Harvey Thorleifson, Director, Minnesota Geological Society

Over the past year, the Minnesota Geological Survey (MGS) has coordinated a broad assessment of ground water resources in the Fargo-Moorhead region. The work was sponsored by the U.S. Department of the Interior, Bureau of Reclamation, and the Garrison Diversion Conservancy, who are jointly preparing an environmental impact statement for the Red River Valley Water Supply Project, intended to ensure that the future comprehensive water quality and quantity needs of the Red River Valley are met. As part of the effort, a team led by the USGS Minnesota office has compiled quantitative information on currently utilized ground water sources in the Minnesota portion

of the region. Concurrently, MGS, Minnesota DNR, and North Dakota agencies

confirmed and potential groundwater sources across the entire region. Work by the Survey agencies will now be used to assess options for future water supply. According to Harvey Thorleifson, MGS Director, the project has been seen as an excellent example of agencies working as a team to respond to a pressing societal issue.



A 3D model of ground water resources in the Fargo-Moorhead region developed by the MGS and other agencies

constructed a 3D model based on geological mapping and available drillhole data, to outline the context and controls on

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Conservation tillage field days educate farmers

by Les Everett, WRC

Summer field days at four on-farm research-demonstration sites this year and at nine sites in 2004 provided opportuni-

ties for approximately 1200 participants to see strip-tillage equipment in action, and hear directly from Extension specialists, host farmers, Natural Resources Conservation Service and Soil and Water Conservation District staff, and crop consultants about management of conservation tillage. Farmers do not make expensive equipment changes quickly—the field days provide an opportunity for them to get the information from specialists and practitioners that is essential in making these business decisions.

Summer field days are part of a WRC-managed 319 grant that will also produce two publications. A new

water quality protection in South Central Minnesota-Minnesota River Basin," by Gyles Randall and Jeff Vetsch was released in August. The bulletin summarizes recent tillage research at the University's Southern Research and Outreach Center and presents tillage recommendations for that region. It can be viewed on-line or ordered at www.extension.umn.edu.

A second publication, to be released in 2006, will summarize the results of on-farm trials comparing tillage systems with field scale equipment across the southern half of Minnesota. This project, currently in the second of two field seasons, is testing four tillage treatments in three replications at ten locations per year. Yield results, economic analyses, and management considerations will be addressed in the Extension publication.

The next major Conservation Tillage event will be the regional Conservation Tillage Conference, to be held February 1–2, 2006, in Sioux Falls, South Dakota.



Extension Educator David Pfarr and host farmer Pete Kramer explain machinery management for strip-tillage at one of four summer conservation tillage field days.

ties for approximately 1200 participants to see strip-tillage equipment in action, and

Extension bulletin, "Optimum tillage systems for corn and soybean production and



U of M Water Community News

Jim Anderson (Water Resources Center and Soil, Water, and Climate) received two grants, one from the Metropolitan Council of the Twin Cities and one from the Minnesota Pollution Control Agency, for a project titled "Assessment of Stormwater Treatment Practices on the Quantity and Quality on Runoff."

Bill Arnold (Civil Engineering) presented research sponsored by the Water Resources Center at the American Chemical Society meeting held August 28–September 1, 2005. The title of the research is "Methanotrophic bacterial populations in constructed wetland sediments."

Bill Arnold was promoted from Assistant Professor to Associate Professor of Civil Engineering.

Driss Ennaanay (Water Resources Science) presented a poster titled "Modeling Hydrologic Response of Converting Annual Crops to Agroforestry and Other Perennial Cropping Systems: An assessment of SWAT and HSPF capabilities" at the 9th North American Agroforestry Conference in Minnesota this past June.

Feng Fang (Water Resources Science alumnus) co-authored the following papers: "Point-Nonpoint Source Water Quality Trading: A Case Study in the Minnesota River Basin" in the Journal of the American Water Resources Association and "Characterization of Soil Algal Bioavailable Phosphorus in the Minnesota River Basin" in Soil Science Society of America Journal.

Emi Ito, Avery Cook Shinneman (Limnological Research Center and Geology and Geophysics), and **Len Ferrington** (Entomology), along with researchers from the St. Croix Watershed Research Station, St. Olaf College, and

the Belgian National Museum returned to Mongolia in August to conduct field work with scientists from the National University of Mongolia. Their project is a continuation of a survey begun last summer of water chemistry, biology, and sediment composition in lakes of the Valley of the Great Lakes between the Altai and Khangai mountains.

David Mulla (Soil, Water, and Climate) gave a keynote speech titled "A U.S. perspective on TMDLs and effectiveness of BMPs for erosion control" for an all-European-Union conference on soil conservation management, perception and policy held in Mont Saint Aignan, France, on June 5, 2005.

Vinay Nangia (Water Resources Science) received a travel grant from the Water Resources Science Graduate Program to present a paper at the American Society of Agricultural Engineers' (ASAE) Third Conference on Watershed Management to Meet Water Quality Standards and Emerging TMDLs, March 5–9, 2005, in Atlanta, Georgia. He also presented two papers at the ASAE 2005 Annual International Meeting, July 17–20, 2005, in Tampa, Florida.

Ray Newman (Fisheries, Wildlife, and Conservation Biology) received the College of Natural Resources' Richard C. Newman Art of Teaching award in May 2005.

Eric Otto (Water Resources Science) received his Professional Engineer license in civil engineering from the State of Minnesota on June 17, 2005.

Carl Richards (Sea Grant, Biology-UMD) has been appointed Director of the U.S. Environmental Protection Agency's (EPA) Mid-Continent Ecology Division (MED) in Duluth, Minnesota. The MED is part of the EPA's National Health

University of Minnesota Water Resources Science Program Degree Recipients

Heidi Rantala received her M.S. in May 2005. Her thesis was titled "Landscape Evolution and a Relict Fish Community, North Slope, Alaska." Rantala was advised by **Howard Mooers** (Geology-UMD).

Kevin Springob received his M.S. in August 2005. The title of his Plan B paper was "The Influence of Biological Factors on the Effectiveness of Alum Treatments." Springob was advised by **Larry Baker** (Water Resources Center).

and Environmental Effects Research Laboratory, headquartered in North Carolina.

Fotis Sotiropoulos (Civil Engineering and St. Anthony Falls Laboratory) has accepted the position of Director of the St. Anthony Falls Laboratory, beginning in January 2006. Sotiropoulos was previously a professor of civil engineering at the Georgia Institute of Technology, where he conducted research in the Computational Hydrodynamics and Biofluids Laboratory.

Deb Swackhamer (Water Resources Center and Environmental Health Sciences) will be hosting renowned biologist Dr. David Schindler (University of Alberta) in one of the Great Conversations series, February 28, 2006. Schindler researches the effects of anthropogenic disturbance on alpine lakes.

Jeff Werner (Water Resources Science) was the lead author on a recent article in the Center for Urban and Regional Affairs' Reporter titled "Photochemical Transformation of Antibiotics in Minnesota Waters."



Upcoming Events

September 27, 2005. Minnesota Erosion Control Association 2005

Low Impact Development Twin Cities Stormwater Tour. Maplewood and St. Cloud, Minnesota. The tours offer a rare opportunity to visit the most innovative stormwater management systems in the Twin Cities. Don't miss the opportunity to discuss the intricacies of these state-of-the-art techniques with the project managers and engineers who designed them. The tour is packed with innovative retrofits and designs for parking lots and residential and commercial developments. For more information, visit www.mnerosion.org.

September 27–29, 2005. Great Lakes Commission Annual Meeting. Michigan League, University of Michigan, Ann Arbor, Michigan. The meeting theme is "50 Years of Building a Better Future for the Great Lakes!" This meeting will be a time to consider the progress and many successes that have occurred over the past half century but, more importantly, to assess how our past accomplishments can be turned into opportunities to help protect and restore the Great Lakes ecosystem over the longer term. Visit www.glc.org/meeting/ for additional information.

October 17, 2005. Mississippi-Mekong Partnership Forum. Room 105, Cargill Building, University of Minnesota, St. Paul, Minnesota. The forum will offer presentations on "National Research Council Studies of U.S. River System

Management" and "Building Partnerships Between Two Major River Systems: The Mississippi and the Mekong." For more information, visit the WRC Web site at <http://wrc.coafes.umn.edu>.

October 17–20, 2005. Fourth National Conference on Nonpoint Source and Stormwater Pollution Education Programs. Holiday Inn Chicago Mart Plaza, Chicago, Illinois. This conference will provide a unique opportunity—at a national scale—to explore practical, state-of-the-art examples of successful outreach programs through multimedia sessions. The conference's target audiences include professional staff and volunteers at the local, regional, state, and federal levels involved with education programs relating to nonpoint source, MS4 Phase I and Phase II (stormwater), watershed protection, and TMDLs—as well as environmental service groups that work closely with adult and youth education programs. The full conference program is available at <http://www.chicagobotanic.org/aquatics/nonpoint/>.

October 25–26, 2005. Minnesota Water 2005 and Annual Water Resources Joint Conference. Earle Brown Heritage Center, Brooklyn Center, Minnesota. The two-day conference will feature 60 technical presentations, four plenary speakers, and a poster session. For more information, refer to page three.

November 2–3, 2005. Lake Michigan: State of the Lake & Great Lakes Beach Association Joint Conference.

KI Convention Center and Regency Suites, Green Bay, Wisconsin. This conference brings together scientists, resource managers, planners, policy makers, officials, students, and citizens working to improve and protect Lake Michigan and all Great Lakes beaches. The theme for this year's conference is "Restoring Lake Michigan and Green Bay—Assessing What is Possible." For more information, visit www.aqua.wisc.edu/solm/.

November 14, 2005. Minnesota Terrestrial Carbon Sequestration Forum. Room 105, Cargill Building, University of Minnesota, St. Paul, Minnesota. The forum will include presentations by experts on the biophysical, economic, and institutional aspects of carbon sequestration and trading in Minnesota. For more information, visit the WRC Web site at <http://wrc.coafes.umn.edu>.

November 17, 2005. Volunteer Stream Monitoring Partnership River Summit. Science Museum of Minnesota, St. Paul, Minnesota. The purpose of the summit is to celebrate the work of Twin Cities area volunteer monitors and share data collected over past years. E-mail Barb Liukkonen (liukk001@umn.edu) to register.

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Publications and Resources



Environmental Information Management System. Metropolitan Council. 2005. Metropolitan Council has a storehouse of environmental information, including information on a variety of lake monitoring programs, data from the Volunteer Stream Monitoring Partnership, and numerous other water quality resources around the state. The new web tool, at <http://es.metc.state.mn.us/eims>, is called the Environmental Information Management System (EIMS). It is loaded with information to help with environmental planning and decision-making. The EIMS is a system for providing timely and reliable information for environmental planning and decision-making for the metropolitan area of Minneapolis and St. Paul, Minnesota. Metropolitan Council Environmental Services, a division of the Metropolitan Council, developed the EIMS to provide access to environmental data, analysis, and documents from various sources through a single, integrated system.

Estimated Withdrawals from Principal Aquifers in the United States, 2000. United States Geological Survey. 2005. In its latest report on water use in the U.S., the survey looked at the nation's dependence on ground water. The report provides details of ground water withdrawals and use from principal aquifers in each state. The survey found that more than 90 percent of ground water withdrawals are used for irrigation, public supply, and self-supplied industrial uses. On a daily basis, 76.5 billion gallons are used for these three purposes with irrigation accounting for nearly three-quarters of this amount. The full report is available online at: <http://pubs.water.usgs.gov/circ1279>.

Sustainability of Minnesota's Ground Water: a Statement of Issues and Needs. Minnesota Department of Natural Resources, Division of Waters. 2005. Ground water is the source of drinking water for more than 75 percent of Minnesotans. Therefore long-term ground water supply is a continuing concern. In response to a legislative query, the department has completed this brief report, which is now available to the public at www.dnr.state.mn.us/waters/. This report summarizes research and discussions by department staff during the 2004–05 biennium as to how the concept of sustainability might be defined and applied to water supply management in Minnesota. The report is further supported by information contained in a series of fact sheets that will be accessible on the Web at the same site. Several of the fact sheets are available now and others will be added as they are readied for publication.

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