

Minnesota Water 2000 examines past, present, and future of Minnesota's water resources



by Stefanie Miklovic

Nearly 350 water professionals from around Minnesota and surrounding states met at the Minneapolis Convention Center on April 25-26 for the 7th biennial *Minnesota Water* conference entitled, "A Watershed Year: Looking Back; Planning



Plenary speaker Steve Morse predicted that success for the future involves ecosystem-based management, interagency cooperation, and community involvement.

Ahead." Participants from state, federal, and local agencies, academia, and non-government organizations listened to plenary speakers address broad issues such as trends in water quality and management, and attended concurrent and poster sessions which featured recent research and new tools (see page 4). The conference encouraged participants to reflect upon changes that occurred over

the past century in attitudes and management strategies, to assess the current status of Minnesota's water resources, and to discuss future issues and ways for addressing them.

Evolution of attitudes and strategies

Several speakers discussed the significant changes in attitudes toward water resources over the past century. Robert Hirsch, chief hydrologist of the USGS, described past management strategies as "command and control approaches." Ron Nargang of The Nature Conservancy expanded on this idea, separating different attitudes toward water resources into eras. He described the start of the 20th century as an "era when [people] treated water as a big problem." Projects to drain and ditch water were encouraged, thereby increasing the acreage of tillable agricultural lands. After awhile, water resources became recognized for their economic importance. In this new era, water levels were tailored to transportation, irrigation, and recreational needs. Finally, during the last quarter of the 20th century, national events such as Love Canal and the publication of Rachel Carson's *Silent Spring* sparked interest in environmental degradation. Minnesotans began to recognize the importance and fragility of their water resources and, as a result, began to regulate activities that affected

MN Water 2000 continued on page 5

Ruffe don't mind the cold

A University of Minnesota Sea Grant study published in the March issue of "Transactions of the American Fisheries Society" has shown that the Eurasian ruffe's metabolism allows it to



thrive in water that is slightly cooler than 17° C (63° F), the average temperature of the deeper regions in the St. Louis River. The study also indicates that temperature affects the growth of ruffe less than it does the growth of yellow perch, but that ruffe need more food than perch do to survive. Non-native ruffe were found among the benthic fauna of the St. Louis River estuary in 1986. Since then, they have become the most abundant fish trawled from the Duluth-Superior harbor and a competitive threat to native perch and other benthic fish.

Ruffe continued on page 7

IN THIS ISSUE	
2	AROUND THE STATE
3	MINNAQUA EVENT
4	MN WATER 2000
6	COMMUNITY NEWS
7	UPCOMING EVENTS



Around the state

WATER RESOURCES UPDATES

Lake Superior shoreland restoration

On May 18-21, fifty volunteers from the Sugarloaf Interpretive Center Association (SICA), the Nature Conservancy, and the Great Lakes Aquarium were joined by 80 fifth graders and other residents of Cook County to restore a wetland and upland site at Sugarloaf Cove (about 70 miles north of Duluth) on Lake Superior's North Shore. About 12,000 trees, shrubs, sedges, rushes, and flowers were planted in a newly re-created wetland basin, along an old roadway and house site, and in an

eroding ravine. The native plants had been started from seed or harvested from sites within 25 miles of Sugarloaf. Fenced exclosures were built to keep deer away from the newly planted cedars and other sensitive plants. Monitoring of survival rates and maintenance of the site will continue for the next several years.

The project, sponsored by SICA with grants from the MN DNR and EPA, was coordinated by Terri Port Wright, a Carlton County Master Gardener who has worked on several shoreland restorations with the University of Minnesota Extension shoreland education program.

make the Twin Cities one of the best places to live, work and do business.”

WaterShed Partners Volunteer Stream Monitoring Program received a \$400,000 grant to coordinate and support new and existing networks of citizens who volunteer to monitor the quality of metro-area streams. WaterShed Partners is a coalition of 45 educational, agency, and nonprofit organizations in the Twin Cities. The Volunteer Stream Monitoring Program will be coordinated through the Water Resources Center.

A \$100,000 grant was awarded toward the development of a Water Quality Best Management Practice Manual, which will describe the designing and installing of best management practices for runoff and erosion control at urban sites smaller than five acres. Collaborating with the Council for this project are the cities of Minneapolis, St. Paul, and Bloomington, and the Minnehaha and Rice Creek watershed districts.

A \$258,000 grant will support a project to document the historical accumulation of suspended sediment, phosphorus, heavy metals, polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs) in a portion of the lower St. Croix River, which is ecologically and recreationally among the most important water resources in the metro area. The study will provide baseline information on the accumulation of these materials in the St. Croix before deforestation, agricultural development and urbanization. This information will be used to develop a management plan for the St. Croix River Basin. The project will be a cooperative effort of the Council, MPCA, and the Science Museum of MN.

Excerpted in part from a Met Council News Release

MetroEnvironment Partnership grants awarded

In April, the Metropolitan Council approved nearly \$760,000 in grants as part of a new MetroEnvironment Partnership Grants Program. This program will award \$7.5 million over the next five years toward projects aimed at preventing urban and rural surface runoff pollution from entering lakes and rivers in the Twin Cities region. The grants support technical, educational, and research and development projects that reduce levels of phosphorus in rivers and lakes; protect taxpayer investment in the regional wastewater treatment system; and advance Smart Growth objectives of using natural resources wisely and preserving the environment. This year's Metro-Environment Partnership grants target three projects with regional impact.

“These three grants are targeted at water quality issues that span community boundaries,” said Council Chair Ted Mondale, “It's a great example of working with our partners to plan for smarter growth and leverage additional funding for environmental projects. These tools and incentives will improve the region's quality of life and ability to compete, and

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Water Resources students share knowledge of streams

by Joshua Woodward

The Water Resource Students in Action (WRSIA), composed of Water Resources Science graduate students, traveled north to Mora and Ogilvie High Schools on April 27-28 to help students with their river monitoring project. The objective of this project is for middle and high school students to detail the success of farmer Tim Fischer's restoration efforts on the Groundhouse River and, in the process, gain an understanding of river ecology and the impacts our society has on river systems. Restoration of the river began four years ago, and monitoring of the river began last year, under the direction of WRSIA. WRSIA students helped plan the monitoring program and have continued their involvement by leading of students through lessons both in the classroom and at the river. The Kanabec Soil and Water District also plays a vital role in this project by supplying funds and equipment.

WRSIA's goal for the two days was to prepare the students for monitoring, help them collect data, and most importantly, instill in them an understanding of why scientists are interested in macroinvertebrate and fish communities, what indicators reveal about the condition of a stream or river, and why their monitoring project is important. To teach these concepts, WRSIA president Joshua Woodward tried to reveal to the students during classroom lessons that they already know the answers to these questions. By understanding how society uses



Students share in the excitement of investigating the fish community of the Groundhouse river.

water, they were able to describe how we can pollute water. By discerning how pollution affects the uses and users of water, they were able to understand how the river system can be expected to change as a result of pollution. And finally, by grasping the fact that monitoring, over time, identifies changes that occur in systems, students were able to understand how the data they collect will be important for determining the effectiveness of Fischer's restoration efforts. This process of revealing a chain of knowledge and understanding to the students rather than lecturing to them proved to be a powerful tool in stirring the students' interest both in water quality and in the field work they performed the following day.

MinnAqua and students teach U President and college deans that fishing is fun!

by Roland Sigurdson

On May 8, thirty Chiron Middle School students met with University of Minnesota President Mark Yudof and other University staff on the East bank of the Mississippi



Roland Sigurdson baits a hook for anxious students.

River below the Minneapolis Campus to prepare for this year's fishing opener. Roland Sigurdson (MinnAqua and the Water Resources Center), Barb Liukkonen and Jim Anderson (the Water Resources Center) began the event by leading the 7th and 8th

grade students through an examination of the river's oxygen levels, turbidity and flow rates, teaching them in the process about the importance of good water quality for managing healthy fisheries. Afterwards, President Yudof; Al Sullivan, Dean, College of Natural Resources; Chuck Muscoplat, Dean, College of Agriculture, Food, and Environmental Sciences; and Sandee Gardebring, VP Institutional Relations; joined the group to learn the basics of casting and fishing on the Mississippi. Although no fish were caught during the event, the group had a great time learning new skills and the importance of water quality in the overall health of aquatic ecosystems.

Seven graduate students from the WRSIA joined the middle and high school students for monitoring. WRSIA members guided students through the process of collecting macroinvertebrates, measuring select habitat variables, identifying the samples, and producing a score of biotic integrity for the river. In addition, students were given the chance to observe the practice of electroshocking, another tool of river monitoring.

The two days were very successful. Over one hundred students from the two high schools participated in the monitoring of the river. WRSIA members enjoyed sharing their knowledge, and also sharing in Tim Fischer's enthusiasm for restoring the Groundhouse River to a healthy, enjoyable state. WRSIA looks forward to helping with the project again next year.

New findings and tools in water resources

Minnesota Water 2000 concurrent and poster sessions

Concurrent and poster sessions at *Minnesota Water 2000* covered a wide array of topics focused on recent research and new technologies in water resources.

◆ Assessment and understanding of resources

Several presentations detailed efforts made toward understanding the water quality and integrity of resources. Dan Engstrom and Jim Almendinger, St. Croix Watershed Research Station, Science Museum of Minnesota, investigated the phosphorus and sediment loading rate of Lake Pepin as determined by sediment core analysis. Their data revealed that both sediment and phosphorus have been accumulating since the 1830s, with the greatest increase occurring since 1940. They calculated that about 17% of the lake's 1830 volume has been replaced with sediment, and, at the current rate of accumulation, the lake will fill completely in 340 years.

Other presentations described data collected from monitoring programs such as the USGS's National Water-Quality Assessment program and the MN Department of Natural Resources Stream Survey, and offered insights as to how natural and engineered chemicals behave in the environment.

◆ New tools for watershed management

Presentations in the plenary sessions revealed the usefulness of monitoring as a tool for detecting trends and assessing the integrity of water resources. New technologies and approaches for enhancing this tool were featured in several outbreak sessions. Remote sensing tools such as Landsat Thematic Mapper images were shown in several talks to be useful for determining lake water quality and trophic condition as well as percent-impervious surface in a landscape. Spectral bands within these

images are strongly correlated with different types of surfaces, allowing the estimation of water quality characteristics such as Secchi depth from satellite images. Steve Kloiber, Metropolitan Council, commented in his presentation that these tools can enhance current monitoring programs because the method for using these images is accurate and fairly simple, and the data are inexpensive.

Indices of Biological Integrity (IBIs) and mathematical models were also presented as tools to enhance monitoring efforts.



Poster sessions gave attendees an opportunity to ask presenters questions about their projects.

◆ Water supply issues

Several presentations introduced new technology and techniques for improving surface and ground water resources used for public water supplies. Jenny Baeseman and Paige Novak, U of MN Department of Civil Engineering, reported the discovery of methanogen-produced extracellular biomolecules which effectively degrade chlorinated organic pollutants in groundwater systems. Such biomolecules may provide an effective remediation tool. Mark Ferrey, MN Pollution Control Agency, stressed the importance of understanding how remediation efforts affect natural degradation processes, as his study showed that groundwater circulation systems designed to remove volatile contaminants actually slowed the

degradation process by interfering with an intrinsic dehalogenation process in groundwater.

◆ Agricultural advancements

Several presentations featured technologies and techniques for reducing and monitoring agricultural impacts. Derek Fisher, MN Board of Water and Soil Resources and the U of MN Water Resources Center (WRC), highlighted advantages of coupling tillage transect surveys with stream monitoring data to identify locations where greater efforts are needed, to assess the effectiveness of tillage programs, and to demonstrate the importance of conservation tillage. Kevin Blanchet, U of MN Extension Service and U of MN WRC, reviewed training materials that have been made available to state and federal agencies to assist producers in developing and implementing crop nutrient management plans. He also described a software program that is being developed to assist producers in determining crop nutrient recommendations, thereby helping them determine when to add nutrients.

◆ Educational and cooperative programs

Several presentations discussed projects promoting collaboration between agencies, businesses, and citizens. Anthony DeMars, Emmons & Olivier Resources, Inc., presented a poster that detailed efforts of local citizens, the Mill Stream Association, the Marine on St. Croix Watershed Management Organization and the MN Department of Natural Resources to protect the Old Mill Stream, a trout stream of high ecological integrity.

Other presentations featured programs designed to educate citizens. Ken Olson, U of MN Extension Service, described the results of homeowner education

Findings continued on page 6

MN Water 2000 continued from pg 1

water quality, direct more money toward studies to understand water resources, and restore lost or degraded resources. Over the course of the century, management strategies changed from modifying water resources to meet human needs to modifying human activities to preserve water resources in their natural state.

Present status of Minnesota's water resources

The past century has yielded great advancements in water science. Patrick Brezonik, U of MN Water Resources Center, described how theoretical advances, such as the Resource Competition and Ratio Theory conceived by David Tilman, and technological advances, such as Geographic Information Systems (GIS), have increased our understanding of water resources, enabling the development of effective management strategies. Since the start of the environmental era, management strategies have been used to assess the status of Minnesota's water resources and lessen the impact of human activity on natural systems.

Monitoring of water resources has proven to be an important strategy in



Plenary speaker Robert Hirsch discusses the future of water issues with conference attendees.

detecting spatial and temporal trends and assessing the success of management efforts. The Minnesota Milestone program, conducted by the Minnesota Pollution Control Agency (MPCA), is designed to monitor concentrations of conventional pollutants in streams

throughout Minnesota. Data collected over the past 44 years of the program show significant decreases in concentrations of biological oxygen demand (BOD), total phosphorus, unionized ammonia, and fecal coliform in



Extension Educator Ken Olson asks University professor Bob Sterner how the U of MN Extension Service can help the citizens of Minnesota access the broader University.

more than 70% of river sites. "The decreases in these pollutants," said Michael Sandusky, MPCA, "can be attributed to the dramatic improvements in wastewater treatment that have occurred during this same time period."

Wastewater treatment improvements have not been effective for reducing all pollutants, however. Over 60% of river sites, both in agricultural and non-agricultural areas, showed significant increases in nitrite-nitrate, a pollutant that results from both point sources such as wastewater treatment plants and non-point sources such as fertilizer applied to crops and lawns. These results indicate that management efforts employed toward point sources have, to a certain extent, been successful in improving water quality. Non-point source pollution still presents a problem, however, and a challenge to water resources managers in the next millenium.

The future of water resources management

How will water professionals deal with challenges in the future? Hirsch predicted that the future of water resources management lies in watershed-based approaches and meaningful measurement and analysis. He stressed the need for developing monitoring

studies that take painstaking measurements at carefully selected sites to ensure that data collected are meaningful and accurate. He also emphasized the importance of data-driven models for gaining a better understanding

of chemical fluxes and the effectiveness of various management practices.

Sandusky said that integrated monitoring, which encompasses biological, chemical, and habitat characterizations, and long-term monitoring networks for both surface and ground water resources were essential for dealing with future issues. He also recognized the importance of citizen-monitoring programs, which many organizations have already implemented. Such programs give citizens a pro-active role in water resources management. They learn how their actions affect ecosystems, and they develop insights into ways to remediate problems.

Steve Morse, Deputy Commissioner, MN Department of Natural Resources, built upon this idea of cooperation and predicted that success for the future involves ecosystem-based management that incorporates interagency cooperation and community involvement. Because ecosystems can encompass a large area and have a variety of human activities occurring within their boundaries, it is essential for people within them and people involved in managing them to have similar goals and to cooperate on

MN Water 2000 continued on page 7



Minnesota Water Community News

Emi Ito (Geology and Geophysics), **Kerry Kelts** (Geology and Geophysics), **Tom Johnson** (Director of the Large Lakes Observatory, UMD), and **Doug Schnurrenberger** (LRC Core Facility Scientist) recently were awarded a grant of \$832,276 over five years from NSF-Earth Systems History for the development of a national facility to archive and curate sediment cores from lakes. This National Lacustrine Core Curation Facility will make lake sediment cores from around the world available for study by the national community and preserve the cores in usable form for future generations armed with new investigative techniques and scientific questions. **Ito** also was named Acting Director of the Limnological Research Institute, succeeding **Kelts** who stepped down from that role for health reasons. **Ito** will direct both the LRC and the Stable Isotope Lab, in addition to getting the new National Lacustrine Core Facility off the ground. **Schnurrenberger** will be promoted to the position of Curator of the newly funded National Lacustrine Core Curation Facility, and **Linda Shane** (LRC Senior Research Associate) will assume the LRC Core Facility Scientist position this summer.

Jim Perry (Interim Head, Fisheries and Wildlife) co-taught a five-day workshop on integrated environment assessment and reporting for UNEP/Nairobi. He worked with Laszlo Pinter, IISD, Winnipeg. After the workshop, **Perry** stayed over to lead an institutional development workshop for 14 East African nations. A month later, he led an institutional development workshop for 10 days in Lome, Togo, bringing together 17 West African nations. **Perry** also assumed the role of interim department head in Fisheries and Wildlife, replacing **Ira Adelman** who held the position for 18 years. **Perry** will lead development of

the department head's position description and search, with the hope of getting a permanent person in place by September 2001.

Carol Johnston (Natural Resources Research Institute) has been appointed Program Director of the Ecosystem Studies Program at the National Science Foundation in Arlington, VA. **Johnston** will facilitate the peer review of grant proposals submitted to the Ecosystems Program to insure integrity and consistency. She will also represent the Program and the Foundation within the scientific community, with other agencies, organizations, and with the public.

John Gulliver (Civil Engineering and St. Anthony Falls Laboratory) will travel to Beijing, China, to give a keynote lecture entitled "Stochastic approach to free-surface turbulence," at the 8th International Symposium on Stochastic Hydraulics on July 25-28.

Patrick Brezonik (Civil Engineering and Water Resources Center), **Erin Day** (Water Resources Science), **Bob Megard**, and **Jim Cotner** (EEB), will traveled to Copenhagen on June 5-9 for the annual meeting of the American Society of Limnology and Oceanography. **Brezonik** chaired a special session on "astrolimnology," a term he coined (tongue-in-cheek) to describe the use of satellite imagery for lake monitoring. **Day** presented a talk in that session on her work using Landsat images to assess lake clarity. **Cotner** co-presented "Importance of terrestrial and other non-algal carbon sources to bacteria in large lakes" with B. Biddanda and T. Johengen and "Contribution of bacteria to planktonic biomass and respiration in lakes and oceans" with Biddanda.

Barb Liukkonen (Water Resources Center) and **Terri Port Wright** (Carlton County Master Gardener) presented a paper, "Involving Master Gardeners in Restoring Shorelines," at the National Extension Natural Resources Conference in Lake Tahoe, NV, May 15-18.

Sue Galatowitsch (Horticulture), **Emily Green** (Conservation Biology), **Laurie Fairchild** (Water Resources Science), and **Carrie Reinhardt** (Water Resources Science) will travel to Quebec City, Quebec, on August 6-12 for the 6th International Wetland Symposium of the International Association of Ecology. **Galatowitsch** will present "Revegetation success of planted and unplanted wetland restorations in Minneapolis-St. Paul, Minnesota." **Green** will present "Effects of nitrate-nitrogen addition and Phalaris competition on wetland community establishment." **Fairchild** will present "Long-term vegetation recovery in restored prairie pothole wetlands," and **Reinhardt** will present "Phalaris arundinacea control: implications for wetland restoration."

Findings continued from page 4

efforts for on-site sewage treatment. Evaluations for the publication, *Septic System Owner's Guide*, revealed that the guide influenced homeowners into installing new water-saving appliances, eliminating the disposal of non-decomposable products in the septic systems, and recognizing the importance of their septic systems in protecting human health and the environment.

Visit the Water Resources Center website at <http://wrc.coafes.umn.edu/water2000/> for abstracts of both concurrent and poster sessions.



Upcoming Events

June 12-16. **Water, Webs & Widgets: Using Technology and the Environment to Teach Science.** This five-day workshop will teach participants how to integrate advanced tools such as Water on the Web and GIS technology into their school curricula. For more information, visit <http://www.d.umn.edu/seagr/areas/education.html>.

July 17-19. **Year 2000 Water Planners Conference.** Bemidji, MN. This annual local water planners conference, entitled "North American Waters-Protection from the Top of the Divide," is sponsored by the Beltrami Soil and Water Conservation District. Call (218) 755-4339 for more information.

June - October. **Landscaping for Wildlife and Water Quality Workshops.** Fifteen workshops designed to help shoreland owners understand and adopt landscaping concepts will be offered across the state through a partnership led by the DNR and funded through an LCMR grant. For more information about dates and locations, contact Lori Naumann at (651) 296-6157.

2000 continued from page 5

management efforts. This cooperation cannot occur, however, if the players involved do not receive adequate education. Morse suggested using technologies such as GIS to distribute data to other water professionals, and using trends discovered in monitoring programs to educate those who are not trained in understanding raw data from such programs.

Betsy Damon, Keepers of the Waters, introduced in a luncheon presentation the concept of using ecological parks to engage the public in water resources

issues. She described the Living Water Garden in Chengdu, China, that incorporates art and science into a model for teaching the public about natural water treatment processes, such as filtration, aeration, and settling, used to clean river water.

Water resources education is not only important for the general public, but for water professionals as well. Brezonik described the past century as "an era of discipline science." Bob Sterner, U of MN Department of Ecology, Evolution, and Behavior, expanded on this observation, recalling that student training in the past was focused in a specific field, though real-life problems tend to span multiple fields of study. This narrow focus impeded communication and cooperation between management efforts. Sterner stressed that an interdisciplinary approach must be taken to educate future water professionals so that they will have the necessary knowledge and tools to deal with interdisciplinary problems that occur at ecosystem and planetary scales. This approach to education, which has begun within the past ten years at the University of Minnesota, encourages communication and cooperation needed to understand and solve complex problems by encouraging students to network with professionals in a variety of fields.

An outlook for the future

Plenary talks throughout the conference revealed that water professionals are gaining a better understanding of Minnesota's water resources and how human activities affect them, and have learned how to remediate some problems. Other problems, such as non-point source pollution, present challenges for the future. Water managers are armed to deal with such issues, however. Holistic approaches, meaningful measurement and analysis, and inter-disciplinary training, management, and cooperation will be

essential for developing solutions.

So, what is the future of Minnesota's water resources? As Brezonik concluded in his talk, "the best is yet to come."

Ruffe continued from page 1

University of Minnesota professor Ray Newman and graduate student Fred Henson conducted laboratory experiments with ruffe taken from the Duluth-Superior harbor. They found that adult ruffe, fed amounts of food similar to what they eat in the field, grow best and convert food to energy most efficiently when the temperature is about 14° C (57° F). Perch, on the other hand, grow best in warmer water—about 23° C (73° F). Ruffe also attained sexual maturity sooner than perch.

The researchers concluded that ruffe are temperature generalists; temperature affects their growth less than it does perch. Even so, ruffe need more food. "One of the key issues, in comparison to published research on perch, is that ruffe are less efficient at processing food," said Newman. "More food is needed to sustain a given biomass of ruffe than the same biomass of perch. Ruffe leave a bigger ecological footprint and are more likely to significantly alter the benthic forage base." Newman and Henson suspect that the ruffe's ability to devour benthic prey and continue growing in colder months enhances its ability to compete with native species and impact the estuary's forage base.

For a copy of Newman's and Henson's research paper, "Effect of Temperature on Growth at Ration and Gastric Evacuation Rate of Ruffe," contact Minnesota Sea Grant at (218) 726-6191.

Minnesota Sea Grant News Release



New Publications

Sustainable Lakes Workbooks.

Minnesota Lakes Association. 2000. This workbook details the Sustainable Lakes Project and Sustainable Lakes Management Model. It contains detailed descriptions of the model process for lake management planning, including instructions on conducting a lakeshore property owners survey, color watershed maps and information on how to obtain 21 watershed maps, the five pilot lake management plans, a data assessment manual and a series of articles on land-use impacts to water quality. Contact the MLA at (800) 515-5253 or lakes@mnlakesassn.org.

Atlas of America's Polluted Waters.

2000. In order to better illustrate the extent and seriousness of water pollution problems around the country, EPA prepared this atlas of state maps that identify the polluted waters in each state. States listed these waters in their most recent submission to EPA, generally in 1998, as required by section 303(d) of the Clean Water Act. The maps are color

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coded to indicate the type of pollutant causing the pollution problem. Available at <http://www.epa.gov/owow/tmdl/atlas/index.html>.

Working Trees for Treating Waste. 2000.

This publication from the USDA Forest Service, Natural Resources Conservation Service, and National Agro Forestry Center describes technology for putting fast-growing trees to work recycling nutrients from solid and liquid waste. Contact Nancy Hammond, US Forest Service, at nhammond@fs.fed.us or visit <http://www.unl.edu/nac>.

1998 Citizen Stream-Monitoring Program (CSMP) report on the water quality of Minnesota streams. MPCA.

1999. This report provides background information on the program, summarizes data collected by 17 volunteers during the 1998 pilot season, and discusses future direction of the program. Contact Laurie Sovell, MPCA, at (800) 657-3864 or visit <http://www.pca.state.mn.us/water/csmp.html>.

A Retrospective Analysis on the Occurrence of Arsenic in Ground-Water Resources of the United States and Limitations in Drinking-Water-Supply Characterizations, and Arsenic in Ground-Water Resources of the United States. USGS. 2000. This document and factsheet present an analysis of arsenic ambient ground water occurrence data obtained from approximately 18,500 wells in the U.S. used for public supply, research, agriculture, industry and domestic supply in the U.S. Available at <http://co.water.usgs.gov/trace/arsenic>.

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