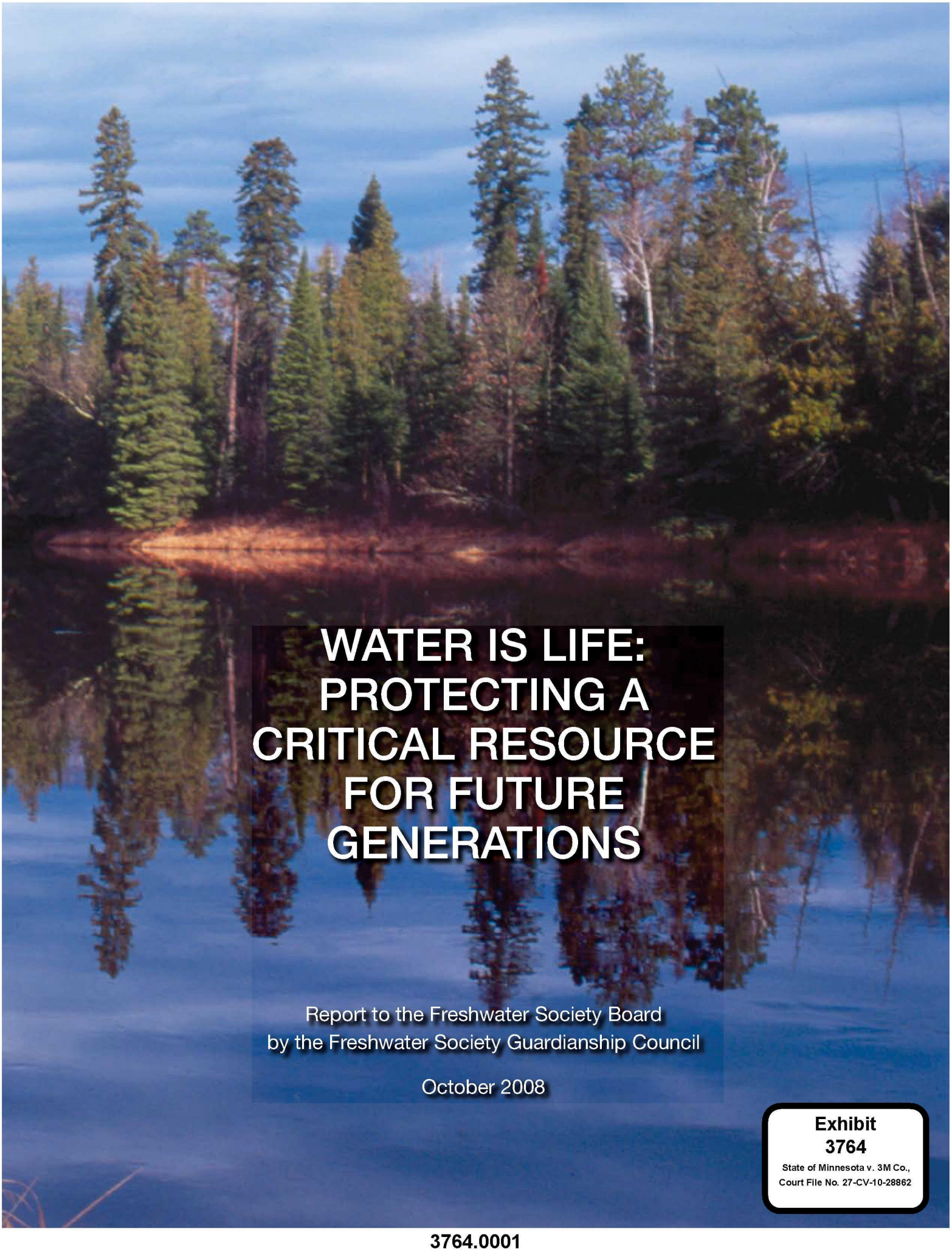

WATER IS LIFE: PROTECTING A CRITICAL RESOURCE FOR FUTURE GENERATIONS

Report to the Freshwater Society Board
by the Freshwater Society Guardianship Council

October 2008

WATER IS LIFE:
PROTECTING A CRITICAL RESOURCE FOR FUTURE GENERATIONS

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I. EXECUTIVE SUMMARY

Clean, fresh water is vital to all life.

It is key to our image of who we are as Minnesotans and what we want for our children, and it is essential for our regional and national economies.

Despite our wealth of water in Minnesota, we cannot presume our access to unspoiled drinking water is sustainable into the future. We know our rivers, lakes and streams are contaminated by runoff from sources near and far.

For 40 years, the Freshwater Society (FWS) has worked for the conservation and rational management of freshwater resources. As part of that effort, the society sought the assistance of eight distinguished Minnesotans to examine our water resources, question our water policies and advise the Society's board on fulfilling the Society's mission.

Members of that group, the Society's Guardianship Council, are:

- Robert Elde, dean of the University of Minnesota College of Biological Sciences
- Luella Gross Goldberg, board member of several large corporations
- Michael Kilgore, director of the University of Minnesota Center for Environmental and Natural Resources Policy
- Lonni McCauley, executive director of the League of Women Voters Minneapolis
- Ronald Nargang, former director of the Minnesota Chapter, Nature Conservancy
- Michael Osterholm, director of the University of Minnesota Center for Infectious Disease Research and Policy
- Jack Pichotta, founder of the Wolf Ridge Environmental Learning Center
- Paige Winebarger, member of the Minnesota Pollution Control Agency board

The Guardianship Council spent six months studying our ground and surface waters and the threats they face. Members reached a consensus that the biggest freshwater challenges demanding attention from Minnesota citizens and policy makers are the sustainability of ground water and the nonpoint source pollution of surface waters, chemicals washed into lakes and rivers from multiple sources.

The Council's findings and conclusions on water resources and policies included:

Ground Water Sustainability

- Ground water is the source of all or part of the drinking water consumed by nearly 90% of Minnesotans. It also is used for a multitude of other purposes. Ground water use

increased 26%–up 52 billion gallons a year–between 1991 and 2005. Minnesota's population increased 18% during the same period.

- Minnesota is blessed with a lot of water, including abundant ground water, but not in all parts of the state. Supplies are limited in southwestern, northwestern and northeastern Minnesota. The Metropolitan Council last year identified 18 Twin Cities suburbs where ground water could be inadequate to meet projected future demand or might meet the demand only through pumping that would dry up streams and wetlands.

- Since the 1960s, a series of official reports has attempted to assess ground water sustainability in the Twin Cities. Many have urged prompt action to prevent future shortages; some have predicted the region's ground water was virtually limitless.

- There is a startling lack of consensus among ground water experts on whether our current use is sustainable and on how to measure the ground water we can safely use.

- The Minnesota Department of Natural Resources issues pumping permits for wells on a case-by-case basis. The agency does not deny permits based on the anticipated cumulative impact of each new well it approves, and the agency lacks authority to restrict development where ground water is scarce.

The Council recommended:

- Time and energy should be devoted to producing a scientifically rigorous study of sustainability that will inspire consensus among experts and citizens. The study should examine water quality and quantity. It should evaluate whether it is sound policy to use ground water in excess of the amount regularly renewed through precipitation.

- While scientists and policy makers debate sustainability, all of us should commit ourselves to conservation. We need to determine the optimal mix of ground and surface water use and find ways to recycle and reuse water.

- Current practices on the permitting of wells should be changed to weigh the anticipated cumulative impact of new water withdrawals.

Ground Water Quality

- Everything we do on the land around us–every natural feature we disturb, every chemical we overuse or carelessly discard–affects water recharging aquifers beneath the land.

- Nitrogen compounds from farm fertilizers and septic systems have been found at elevated concentrations in a number of monitoring wells in central and southeastern Minnesota and the Twin Cities metropolitan area.

- About 40% of Minnesota septic systems do not comply with state standards, jeopardizing ground and surface water quality.

- Some parts of the state, such as central Minnesota and areas near Hastings, have aquifers in which the ground water is close to the land's surface and is particularly vulnerable to agricultural and industrial chemicals.

- Perfluorochemicals (PFCs), an emerging class of ground and surface water contaminants, have been found in private wells in Washington County, in municipal wells in six east metro suburbs, in wastewater effluent discharges throughout the state, in fish tissue in several Twin Cities lakes and in fish from the Mississippi River, between St. Paul and Winona.

The Council recommended:

- Ground water monitoring, including trend analysis of low-level contamination, should be intensified. Increased attention should be paid to private wells.

- Although the impact on human health of many of the pollutants found in small concentrations in ground water has not been proven, we should aggressively research the potential harm of such chemicals and their synergistic interactions.

- We should research and put in place, cost-effective measures to protect aquifers and ground water recharge areas from contamination.

Surface Water Quality

- Like other parts of the country, Minnesota has made huge strides in the last 30 years toward cleaning up our rivers that were being polluted by inadequately treated human sewage and industrial contaminants, typically called point source pollution.

- Minnesota has failed to adequately address harder-to-regulate nonpoint source pollution. About 80% of lakes, rivers and streams have not been assessed for compliance with water quality standards. Of those tested, 40% fail to meet the standards.

- Agricultural runoff and the conversion of rural land into city or suburban developments are the biggest sources of nonpoint source pollution: 60-70% and 10-15%, respectively.

- Recent testing has shown our waters are threatened by chemical compounds known as endocrine disrupters. These chemicals, found in many medicines, soaps and other products, are not effectively removed from water by sewage treatment plants. The

chemicals, which potentially are human health threats, are affecting fish in the Mississippi River.

The Council recommended:

- Testing the 80% of waters that have not been assessed should be quickly completed, and the clean-up of contaminated lakes and rivers should be accelerated. More emphasis should be placed on protecting waters that are not now polluted.

- To reduce pollution coming from agricultural runoff, we need to embrace land and water stewardship practices that have been demonstrated to be effective. Best management practices for preventing runoff should be adopted in both rural and urban settings.

- We should rigorously explore the threat of endocrine disruptors. We all should make the effort to learn about and practice the proper disposal of medicines and personal care products and become knowledgeable about product alternatives.

Other Factors Affecting the Sustainability of Water Resources

- A gallon of pure tap water costs us a thousand times less than we now routinely pay for a gallon of gasoline. Yet we know water is more crucial to our existence.

- Available evidence indicates that global climate change is likely to cause dry areas of the United States to become drier, and–in Minnesota–to concentrate precipitation in severe storms, aggravating pollution from runoff.

- Environmental education is a high priority for Minnesotans, but it is not integrated in a comprehensive manner in the state's schools.

The Council recommended:

- We need a serious policy discussion of a water pricing structure that will allow our economy to flourish, while spurring us all to conserve water resources for the future.

- We should aggressively work to halt climate change. As we do that, we should prepare now for demands that water from Lake Superior or from Minnesota's aquifers be exported to dry regions. We must also prepare for the possibility of increased runoff resulting from climate change.

- Environmental education must receive a greater emphasis in state education standards, and we must encourage environmental education, outside of schools, for children and adults.

Questions Meriting Further Study

Throughout their work, the Guardianship Council members were struck by an apparent lack of definitive information and lack of agreement on essential water issues. The Council urged the Freshwater Society and all Minnesotans to struggle to answer these questions:

- How can we adopt an ethic of stewardship that will lead us to put greater value on water now and in the future? How should we apportion water if it becomes scarce?

- Are current agricultural practices involving drainage, fertilizer and pesticide applications and land use along stream banks consistent with improving water quality? How can we have both clean water and a healthy, growing agricultural economy?

- How much are we currently spending to clean up water we have allowed to become polluted? Are we doing enough to prevent further pollution? Should we be spending more to prevent pollution?

Recommendations to the Freshwater Society Board

To strengthen and focus the Freshwater Society's work, the Guardianship Council recommended:

- The Society should embark on a comprehensive public awareness campaign aimed at helping Minnesotans understand and correct freshwater problems.

- The Society should build coalitions with other environmental groups and stress the Society's traditional role of convening efforts to educate and inspire Minnesotans to conserve and protect water.

- As a mid-term effort, the Society should seek an official proclamation of 2010 as the "Year of Water," and the Society should sponsor activities throughout the year that stress the singular importance of water to our lives and our economy.

- As a longer-term strategy, the Society should explore partnerships that would reduce the significant water pollution caused by agricultural practices. The strategy could seek third-party certification of sustainable farming practices, similar to efforts that have been successfully implemented in the Minnesota forest products industry.

II. WATER IS LIFE: *PROTECTING A CRITICAL RESOURCE FOR FUTURE GENERATIONS*

A. INTRODUCTION

"Water is the earth's eye, looking into which the beholder measures the depth of his own nature." Henry David Thoreau

Whether we drink it, bathe in it, gaze upon it, grow our crops with it, play or recreate in it, or make our living from it, water and its quality and sustainability are essential aspects of our lives. In Minnesota, we are blessed with better and more extensive ground and surface waters than most places on Earth. But we are not immune to the water crises that we hear about daily from around the world.

We boast of our lakes on our license plates. We take pride in the Mississippi River and the Boundary Waters Canoe Area, and we celebrate our kinship with the greatest of the Great Lakes. We may not often think of the ancient water in aquifers beneath our feet, but we rely heavily on that ground water for many aspects of our lives.

Despite our wealth of water in Minnesota, we cannot presume our access to unspoiled drinking water is sustainable into the future. We know our rivers, lakes and streams are contaminated by runoff from sources near and far.

For 40 years, the Freshwater Society (FWS) has worked for the conservation and rational management of all freshwater resources. Seeing the need for a clear voice to articulate issues and solutions facing our waters today, the Freshwater Society sought the assistance of a multi-disciplinary group of committed Minnesotans to examine our water resources, question our water policies and make recommendations to the Society's Board of Directors on fulfilling the Society's mission.

"The Guardianship Council is the cornerstone and catalyst for the Freshwater Society achieving its strategic goals to create programs that ignite, stimulate, illuminate and challenge citizens and policy makers," said Todd Bolin, chair of the Society's Board.

The Freshwater Guardianship Council members are:

- **Robert Elde, Ph.D.**, dean, College of Biological Sciences, University of Minnesota.
- **Luella Gross Goldberg**, board member for several large corporations including Hormel Foods Corporation, TCF Financial Corporation, Communications Systems, Inc. and the multi-national ING.

- **Michael Kilgore, Ph.D.**, assistant professor, University of Minnesota Forest Resources Department; director, University of Minnesota Center for Environmental and Natural Resources Policy; chair, Governor's Conservation Legacy Council.

- **Lonni McCauley**, executive director, League of Women Voters Minneapolis; past mayor of Coon Rapids.

- **Ronald Nargang**, former director, Minnesota Chapter, Nature Conservancy; former waters division director and deputy commissioner, Minnesota Department of Natural Resources.

- **Michael Osterholm, Ph.D.**, internationally known infectious disease and bioterrorism expert and former Minnesota State Epidemiologist; director, University of Minnesota Center for Infectious Disease Research and Policy.

- **Jack Pichotta**, founder, Wolf Ridge Environmental Learning Center; career environmental educator.

- **Paige Winebarger, J.D.**, retired general counsel Marquette Bancshares; Minnesota Pollution Control Agency board member; former member, Minnesota Environmental Quality Board and Minnesota Forest Resources Council; former board chair, Minnesota Chapter, Nature Conservancy.

The Council spent six months studying our water use and the threats our waters face.

This report is the result of work by Council members and Freshwater Society staff members: Gene Merriam, Joan Nephew, Patrick Sweeney and Cherie Wagner.

Council Process

The Freshwater Society Board of Directors asked the Guardianship Council to assess critical water issues facing Minnesota today, prioritize the issues and recommend Freshwater Society action to address them, moving toward a culture of sound environmental stewardship. This process began with FWS staff reviewing hundreds of research documents, interviewing key experts and preparing briefings for the Council on critical water issues that included:

- Wetland policy
- Impaired waters
- Invasive species
- Energy and water
- Climate change and public policy
- Shoreland standards and land use

The Guardianship Council requested additional briefing documents on the following issues:

- Concept Document: Constitutional Amendment to Protect Water
- Paying for Ecosystem Services
- Value of Water
- Review of Recent "State of the Waters" reports
- Case Study: Nebraska's Attempt to Regulate Competing Water Demands
- Adult Environmental Literacy: Minnesota and National Report Card
- Overview of Western Water Rights
- Overview of State Environmental Education
- Public Opinion Polls—Environment and Clean Water
- Minnesota's Water Governance Infrastructure
    - Watershed Management
    - Water Appropriations
    - Drinking Water
    - Water Rights
    - Regional Water Information
- Minnesota's Water Supply and Sustainability
- European Water Resources and Policy

The Guardianship Council concluded that the sustainability of Minnesota's ground water and the contamination of its surface waters from nonpoint source—pollutants washed into lakes, rivers and streams from multiple sources—are the biggest freshwater threats demanding attention.

Council members made these findings:

- Ground water, a source of all or part of the drinking water consumed by nearly 90% of Minnesotans, is used for a multitude of other purposes, and overall demand has grown in recent years. Total pumping of wells under Department of Natural Resources permits increased 26%–up 52 billion gallons a year–between 1991 and 2005. Minnesota's population increased 18% during the same period.

- Some parts of Minnesota are already running short of water or are in danger of running short. Luverne and Worthington in the dry southwestern part of the state are seeking to import water from wells along the Missouri River in South Dakota. The Metropolitan Council last year identified 18 Twin Cities suburbs where ground water supplies could be inadequate to meet projected future demand or might meet the demand only through pumping that would dry up streams and wetlands.

- There has been a flurry of recent efforts by state agencies, the Metropolitan Council and University of Minnesota researchers to determine whether current patterns of ground water usage are sustainable in the face of a projected state population increase of 1.2 million people by 2035. But there is no consensus on whether our current use is

sustainable, and ground water experts disagree on the best way to measure how much ground water we have and can safely use.

- Ground and surface water are connected by water flow between the two. This connection becomes apparent in areas where the withdrawal of ground water has caused the lowering of stream water levels. Thus they depend on each other. A threat to one is a threat to both.

- Like other parts of the country, Minnesota has made huge strides in the last 30 years toward cleaning up our rivers once fouled by inadequately treated human sewage and industrial pollution. But 40% of our rivers and lakes remain contaminated by harder-to-regulate nonpoint source pollution–chemicals running into our waters from farm fields and city streets, bacteria and nitrate from failed septic systems and pollutants blown on the wind from other areas.

- Research on the Mississippi River from Bemidji to the Iowa border has found evidence of the same disturbing and relatively new pollution trend documented elsewhere in the country, endocrine disrupting compounds that can cause male fish to develop female sex characteristics. This newly studied class of pollutants comes from human products like medicines, shampoos and insect repellants that pass untreated through wastewater treatment plants.

- Ground water is threatened by a variety of pollutants. Nitrogen compounds from farm fertilizers have been found in concentrations that exceed drinking water standards in monitoring wells in central Minnesota. In Washington County, tests found 255 homes with wells that contained elevated levels of chemicals leaking from industrial disposal sites. The Minnesota Pollution Control Agency says that about 40% of the 500,000 septic systems across the state do not comply with state standards in ways that jeopardize ground or surface water quality.

- Minnesotans, like most residents of the United States, pay almost nothing for water, beyond the cost of pumping it from the ground, a lake or a river and transporting it to their homes and businesses. Drinking water delivered by the Minneapolis water system costs users less than four-tenths of a cent per gallon. Water used for irrigation costs farmers only a nominal permitting fee, plus the cost of drilling a well and pumping the water from the ground. Any pricing system that attached greater value to water would spur water users to practice conservation.

- Water management in Minnesota is shared by multiple federal, state, regional and local agencies. In 1979, the state Water Planning Board–a temporary body established following a drought–studied the overlap and wrote: "The existing institutions working in water management have not always worked together effectively. Instead, a fragmented, often disorganized approach has evolved; an approach which tends not to recognize or deal with the interdependence of water problems and management solutions." In 2001, the

Legislature called for a "reorganization of the state water programs and functions…to ensure regulatory efficiency and program effectiveness." This resulted in "…the 17th report on state water organization over the last 30 years." Yet little has changed in the last three decades.

- The Environmental Quality Board was established in the 1970s to help fill gaps and eliminate overlaps in natural resources planning and regulation. State law directs the board to "coordinate public water resource management and regulation activities among the state agencies having jurisdiction in the area." But the board remains largely an unfulfilled promise.

Council members noted that three other factors will have enormous impact on our children's and grandchildren's use and understanding of freshwater resources:

- Global climate change, already occurring and predicted to accelerate, looms over every water issue we face. An expected increase in heavy storms "will likely reduce water quality in substantial ways," a recent federal report predicted. More frequent flooding will flush a larger amount of soil and pollutants into rivers and streams, and faster runoff could reduce the recharge of aquifers.

- Dry areas in the western and southwestern United States are likely to face greater water shortages with climate change. We can expect demands that Lake Superior water or water from Minnesota's aquifers be exported to other areas.

- Environmental education is critical for fostering an appreciation and ethic for water resources. Currently it is not specifically integrated into our education system. The Minnesota Academic Standards do not include environmental education as a distinct subject, and typically environmental education is not taught as part of the curriculum unless individual teachers choose to teach the concepts in their classrooms. The majority of environmental education is offered through day-long field trips to nature centers or week-long experiences at residential environmental learning centers with little integration into classroom learning.

Reports were requested by the Guardianship Council and prepared by the Freshwater Society staff on three subjects: The sustainability of Minnesota's ground water, the quality of ground water and the threat of pollution to surface waters.

B. SUSTAINABILITY

"When the well's dry, we know the worth of water." Benjamin Franklin

Minnesota Water Use, 1991-2005

The years 1991 and 2005 are reasonable bookends for a comparison of recent trends in ground and surface water use in Minnesota. Both years were significantly rainier than usual, but average statewide precipitation in the two years was very similar.

Between 1991 and 2005, total reported ground and surface water use by people and businesses required to obtain water appropriation permits from the Minnesota Department of Natural Resources (DNR) increased 30%, from 1.1 trillion to 1.4 trillion gallons a year. In addition to that permitted use, about 1 million Minnesotans have private wells and pump an estimated 29 billion gallons of water a year for household consumption.

Surface water usage increased slightly faster than ground water between 1991 and 2005. But by far the biggest use of surface water, more than 75%, is power generation. Most of the water used for power generation is river water that cools electric generating plants and is then returned to the rivers.

Ground water use, in almost all its forms, is a consumptive use because it is not returned directly to the aquifers from which it is pumped. The pumping of ground water increased 26% from 200 billion gallons a year in 1991 to 252 billion in 2005, according to DNR usage records.

Within that 26% growth in ground water use, several trends are apparent:

- The seven-county metropolitan area, which has more than half the state's population, used 44% of the total ground water pumped in the state. The metro area–where Minneapolis and several suburbs get all their water from the Mississippi River, and St. Paul and some of its suburbs rely on the river for some of their need—accounted for only a little more than one-fourth of the increase in ground water pumping between 1991 and 2005.

- Irrigation of farm crops with ground water, a use that fluctuates from year to year with changes in the amount and distribution of precipitation, increased 65% between 1991 and 2005. The number of irrigation wells in use increased 25%.

- The next-biggest component of the increase came from municipal water systems, which consumed 26% more ground water, up 27.5 billion gallons, in 2005.

- Legislation, enacted after a drought in 1986-89, to phase out wasteful once-through air conditioning systems that pump ground water through cooling coils and then dump the

water into storm sewers or surface water bodies has been largely successful. There was a 78% reduction, 6.6 billion gallons a year, in ground water consumed by such systems.

- Water use by the booming ethanol industry increased six-fold, from 263 million gallons to 1.7 billion over a slightly different time frame, between 1996 and 2006. Most of that water was ground water. Other uses of ground water for industrial processing declined.

- About 4.7 billion gallons of water were pumped from contaminated aquifers for pollution remediation in 2005. The water was chemically treated or filtered, then released into surface water bodies or sent to sewage treatment plants.

1991–2005 Ground Water Use (in millions of gallons)

Use	1991 Pumping	2005 Pumping	1991-2005 Change	% Change
Air Conditioning	8,442	1,865	-6,577	-78%
Municipal Waterworks	105,283	132,832	27,549	26%
Golf Course Sprinkling	2,708	5,733	3,025	112%
Major Crop Irrigation	43,276	71,232	27,957	65%
Industrial Processing	22,891	19,816	-3,075	-13%
Pollution Clean-Up	5,074	4,688	-385	-8%
Other	12,734	16,351	3,616	28%
Total	200,408	252,518	52,110	26%

Source: Derived from DNR pumping totals

Is our Ground Water Use Sustainable?

Sustainability is a term that is widely used these days in relation to lifestyle choices, energy use and water.

There is a mandate in law for the Department of Natural Resources commissioner to manage the waters of the state to "assure an adequate supply to meet long-range seasonal requirements" for a variety of uses. But Minnesota law has no specific definition of sustainability, as it applies to water.

In 2005, the DNR, in a report on sustainability, proposed this working definition:

"Sustainable use of ground water is the use of water to provide for the needs of society, now and in the future, without unacceptable social, economic, or environmental consequences."

One water planner has offered a shorthand definition that captures the popular notion of sustainability: "Thinking and acting as if the long-term future matters."

Most ground water scientists and ground water planners in Minnesota agree the state does not currently face a ground water crisis. But they say:

- There are a few areas of the state where ground water is already in short supply, and other areas where ground water shortages, contamination or interference with surface waters will prevent wells from keeping pace with expected development and population growth.

- Ground water pumping has already interfered with surface waters such as trout streams and wetlands in some places.

- The state has enjoyed higher-than-normal precipitation in 13 of the last 18 years, and a drought like the ones Minnesota experienced in the 1930s, in 1976 and in 1986-89 could cause significant water supply problems.

- To be prudent, communities in the metro area should use more surface water, and less ground water, for their future drinking water supplies. The ability to use both sources lessens vulnerability in a drought and places less pressure on ground water supplies.

Four Decades of Evaluating Sustainability

Official reports over the last 45 years have repeatedly attempted to assess the sustainability of ground water use in the Twin Cities. Some have urged prompt action to prevent future shortages; some have predicted the region's ground water was virtually limitless.

In 1961, the Minnesota Department of Conservation, the agency that later became the DNR, issued a report that said ground water use at the time was 136 million gallons a day and projected the maximum that could be pumped "on a sustaining basis under ideal conditions" would be 380 million gallons a day.

By comparison, at least 335 million gallons a day were pumped in the Twin Cities in 2005, according to DNR pumping records and an estimate of water used by households with private wells.

The 1961 report warned that the metro area was rapidly approaching a situation in which the "margin of safety between supply and demand is too small." The report said the metro area should use river water to meet more of its water needs.

Fifteen years later, the DNR issued a report warning that future development could deplete ground water stocks. But the report also quoted a United States Geological Survey estimate that Twin Cities wells could safely pump 1 billion gallons a day. That estimate later was lowered to 650 million gallons a day, still far more than the metro area currently uses.

In 1989, the DNR issued another report, published as a severe drought was ending. The report was a description of aquifers and water levels, not a call to arms to meet a current or looming crisis. But it stated:

"Overall, since 1880, withdrawals have caused declines in ground water levels in the Mt. Simon-Hinckley and Prairie du Chien-Jordan aquifers of 200 and 90 feet, respectively, in the Twin Cities area. Future ground water allocation problems, related to lower water levels, will only be avoided by careful resource management."

In 1990, the DNR issued another report to the Minnesota Legislature with an extensive series of recommendations, many of which were adopted. The report advised lawmakers:

"What the impacts of consumptive use on ground water resources are and whether or not a problem exists can be debated. However, it is not sound management to treat ground water as an unlimited resource until a problem develops. The efficient and wise use of Minnesota's ground water resources should be done before there is a problem that can be quantified. The protection and conservation of ground water now is important to future economic development and the quality of life in Minnesota."

The report urged lawmakers to ban all pumping from the Mt. Simon-Hinckley aquifer in the Twin Cities for anything other than drinking water and to allow it then only if there was no practical alternative. It also recommended legislation phasing out once-through air conditioning systems throughout the state. Lawmakers enacted both recommendations.

Another DNR recommendation in the 1990 report urged that "non-essential and inefficient" uses of water–uses such as lawn watering and golf course sprinkling–should be charged the much higher rate the Legislature set for the once-through air conditioning systems. Eventually a softened version of that proposal, a new fee of $20 per million gallons for summertime pumping by city water systems, was imposed.

Still another DNR recommendation in the 1990 report urged the Legislature to fund yearly "mass measurement" of hundreds of wells across the Twin Cities to monitor water levels. That type of measurement is finally being conducted this year by the United States Geological Survey, the first such measurement since 1990.

No Easy Answer to the Sustainability Question

There is no easy answer to the question of whether our ground water use is sustainable into the future.

Ground water is out of sight, hidden in sometimes -overlapping layers of saturated sand, gravel and porous or fractured bedrock. In some parts of Minnesota, aquifers are isolated pockets of water; in other parts they lie nearly everywhere beneath the ground's surface.

Aquifers are dynamic, taking on water from surface rainfalls and discharging water to rivers, lakes and wetlands. Pumping from one part of an aquifer does not necessarily reduce the water level in other parts. Rainy years raise aquifer levels; dry years and heavy summertime pumping lower them.

In 2004, hydrologists from the DNR and the Minnesota Department of Health, writing in the Minnesota Ground Water Association's newsletter, estimated the water in just one of the state's aquifers, the Mt. Simon, at 92 trillion gallons. That's more than 300 times the water pumped from all of Minnesota's aquifers at current annual usage levels.

But that number and others estimates like it are of little value. Much of that 92 trillion gallons could never be pumped, and if it could be, surface waters would suffer.

Two Strategies for Evaluating Sustainability

Instead of trying to measure how much water there is underground at any given moment, the agencies studying the sustainability of Minnesota's ground water employ several broad–sometimes conflicting–strategies.

The DNR, the state agency that issues pumping permits on a well-by-well basis, requires a permit seeker to drill a well and then conduct a pumping test. The test, which can vary from a few days to up to 30 days, is to determine whether the new well interferes with existing nearby wells, lowers surface water levels or produces a continuing decline in the aquifer feeding the new well.

In some cases, the DNR requires that a nearby monitoring well be drilled so the aquifer can be regularly measured outside the immediate area drawn down by pumping.

The DNR also maintains a network of about 750 observation wells throughout the state that it monitors eight times a year to measure aquifer levels. But the monitoring is not as frequent as it once was, and DNR staff members have told the Legislature that the agency needs ten times more wells.

The core of the DNR strategy is to manage for equilibrium. The strategy assumes that any new well lowers the water table at the well site. Then, if the pumping is sustainable, the water level should reach relative stability, fluctuating only in relationship to precipitation and different winter and summer pumping levels. The DNR can, and does, limit pumping or order it halted if water levels show a continuing decline or if there is a drop in surface water levels.

The DNR does not deny permits based on anticipated cumulative impact of each new well the agency approves. The agency lacks authority to restrict development in areas where ground water is scarce.

While the DNR is managing ground water on a well-by-well basis, the state Environmental Quality Board and the Metropolitan Council, are conducting longer-term, wide-area studies that employ more-theoretical methods to estimate the annual recharge of aquifers, the amount of water trickling into them from rainfall.

Some research indicates that about 20% of rain ends up in aquifers. The Environmental Quality Board and Metropolitan Council studies assume that some significant part of that recharge is available for pumping.

State Rep. Jean Wagenius of Minneapolis, the chair of the Environmental and Natural Resource Division of the Minnesota House Finance Committee, said she was convinced none of the agencies currently has a handle on whether Minnesota's ground water use is sustainable over a long time period that covers, not only our children, but our grandchildren.

Early in the 2008 legislative session, the DNR's Division of Waters told Wagenius' committee that creating an "adequate statewide network" of monitoring wells would require drilling 6,000 new wells at a cost of $120 million.

While the Legislature did not commit to expanding the DNR's network of monitoring wells to that level, lawmakers did provide funding for new or expanded ground water research. The DNR received nearly $1.4 million for about 20 new monitoring wells and the Minnesota Geological Survey (MGS) received $706,000 to prepare atlases of aquifers in three south-central Minnesota counties. The MGS has completed atlases for 16 other counties. The 2008 Legislature also appropriated $270,000 for University of Minnesota research on the sustainability of ground water in light of the growth in ethanol production.

Two Recent State Reports on Sustainability

Top officials of the DNR Division of Waters say ground water use is sustainable in most areas of Minnesota and that DNR well management practices are sufficient to maintain sustainability.

But in 2005 the DNR issued a report, titled *Sustainability of Minnesota's Ground Water: A Statement of Issues and Needs*, that portrayed the issue of sustainability as a glass half-empty scenario. The report did not attempt to quantify either the supply of ground water or the future demand for water.

Instead, the report called for more state money to conduct research and made the philosophical argument that the sustainability question is "not a technical one, but a public policy one." It stressed the connection between ground and surface waters.

The report noted that pumping already was shrinking surface waters in some parts of Minnesota. It cited streams in Brooklyn Park, Park Rapids and Luverne, wetlands in Savage, Brooklyn Park and Eden Prairie and parts of aquifers in southeastern and southwestern Minnesota where water levels were being lowered by pumping.

"If 'sustainable water use' is considered to mean use that does not cause adverse impacts on these resources or render water unavailable for future use, then these uses are **not** sustainable," the report said. The bold-face emphasis was part of the report.

The report suggested planners and policy makers in the Twin Cities metro area should look to the Mississippi and Minnesota rivers to supply more of the water used in fast-growing suburban communities.

In a fact sheet published in conjunction with the 2005 report, the DNR questioned the agency's current practice of considering each request for a pumping permit individually. "There is currently no standard procedure for evaluating the potential for cumulative reduction in ground water levels due to pumping by multiple users," the supplement said.

Two years after the DNR report, the Environmental Quality Board and the DNR issued another report titled *Use of Minnesota's Renewable Water Resources: Moving Toward Sustainability.*

Unlike the DNR's sustainability report, the later document attempted to put numbers on how much water each county in the state has available each year and compare that to current and future demand.

The report was based on a study that employed three methods of estimating annual recharge to aquifers.

Two methodologies used by the Environmental Quality Board estimated recharge from precipitation and evaporation data. Another method calculated available ground water by measuring stream flows in February and assumed–at that time of year, with no runoff entering the streams–the entire volume was water being discharged from aquifers.

The three methods were calculated on a county-by-county basis, and the median of the three in each county was then compared to reported and estimated water usage.

The assumption was that some significant portion of the water flowing into and out of the aquifers is available for pumping by humans, but regularly drawing down aquifers beyond that is not sustainable. The portion of water coming out of aquifers that is desired for surface waters was not determined.

The report, which did not count either the source or the use of Mississippi River water pumped by the Minneapolis and St. Paul water systems, estimated that Ramsey County was using 135% of the renewable water within its borders and that Hennepin County was using 72%.

By 2030, the report predicted, four metro counties–Ramsey, Hennepin, Washington and Dakota–could all be using 99% or more of their renewable water.

It predicted that, even in 2030, most counties not in the seven-county metro area or adjacent to it would be using relatively small percentages of their renewable water.

The report drew criticism from a number of ground water professionals.

The notion that ground water use in Ramsey County–which is the smallest county in the state, is highly urbanized and sits atop aquifers that extend far beyond its borders–should be measured only against recharge originating as rain falling within those borders struck many of those experts as illogical.

But the controversial part of the report was the percentages calculated for some southwestern Minnesota counties, where ground water historically has been hard to find in reliable quantities.

For example, the report calculated that Rock and Nobles counties were using only 3% and 4%, respectively, of their available ground water. Those are the counties where officials of Luverne, Worthington and two rural water systems have been working for years to get funding for a pipeline bringing water from South Dakota.

Ground Water Studies in Progress

At present, three major efforts–by the United States Geological Survey, the Environmental Quality Board again and the Metropolitan Council–are looking at Minnesota's ground water and aspects of the sustainability question. Two other state-funded studies of ground water are under way or are pending.

The United States Geological Survey sent crews out in March to measure water levels in 300 wells across the Twin Cities metro area and plans to repeat the measurements in August to capture winter and summer levels. The effort will show whether water levels in aquifers have risen or dropped since 1990, the last time such a measurement was made.

The Environmental Quality Board is conducting a follow-up to its 2007 sustainability study. The follow-up was requested by the Minnesota Pollution Control Agency to shed light on demands being placed on ground water by existing and proposed ethanol plants. The board expanded the mandate to include all aspects of sustainability. But the current study is supposed to review and evaluate existing research rather than conduct new research.

The Metropolitan Council is finishing a two-year $250,000 effort to update a "metro model" of ground water resources that was begun by the Minnesota Pollution Control Agency but discontinued in 2001.

Like most of the Environmental Quality Board's methodology, the Metropolitan Council modeling begins with a theoretical approach to estimate recharge. The method, developed at the Wisconsin Geological and Natural History Survey, measures precipitation and evaporation on a daily basis. Those measurements are combined with data on long-term climate patterns, surface topography, soils and underground geology to yield an estimate of the water entering aquifers as recharge.

The results so far estimate that recharge of the aquifers beneath the Twin Cities has averaged 1.1 million gallons a day over about the last 30 years. That's about three and one-half times the

amount of water that was pumped in 2005. But the modeling also indicates that by 2050 current patterns of ground water use would further draw down aquifer levels in densely populated parts of the metro area.

The Metropolitan Council plans to use the modeling, in part, to encourage communities lacking access to substantial ground water to build river water treatment plants or join multi-city water systems that already use river water or can pump more ground water.

Conclusions and Recommendations

We are fortunate that Minnesota has as much ground water as it does. But measuring and managing that water hidden below our feet is frustratingly difficult.

It is prudent to conclude, as the Environmental Quality Board and the DNR did in 2007, that "the label of Minnesota as water-rich does not fit as well as once thought." Despite the studies that have been done and that are still under way, it also seems prudent to conclude, as Rep. Wagenius does, that no one knows for certain whether our current reliance on ground water for so many of our needs is sustainable into the future.

It is worth re-reading and taking to heart the advice the DNR gave legislators in 1990:

"It is not sound management to treat ground water as an unlimited resource until a problem develops. The efficient and wise use of Minnesota's ground water resources should be done before there is a problem that can be quantified."

We need a serious, scientific discussion of the best way to measure sustainability–whether doing it right requires a better-funded effort to drill and closely monitor many more observation wells than the DNR now has, or whether the Environmental Quality Board and Metropolitan Council approaches to estimating aquifer recharge are sufficient.

It seems apparent that the DNR's case-by-case, well-by-well approach to managing ground water is limited, and probably has been allowed to continue because of our relative abundance of ground water so far has minimized conflict between competing claims on it. Development should be restricted in areas where water supplies are inadequate.

We also need to devote serious attention to weaning our communities off relying on ground water for so many of our needs. Instead, we should look to river water, stormwater runoff or treated wastewater to meet some of our needs.

While the Legislature took important steps in 1990 to protect our ground water after a drought, we should not have to wait for the next drought to spur a thoughtful, sustained discussion of what else we can do to protect a vital resource that so many of us depend on for drinking water. As citizens, we should all commit ourselves to conserving all water, especially ground water.

C. GROUND WATER QUALITY IN MINNESOTA

"If we hope to live a good life in this state without compromising the quality of life of future generations, we must live in harmony with our environment." John Tester

The water that most Minnesotans drink comes from stocks of ground water that, in large part, are hundreds, sometimes thousands, of years old. That old, pure water is continually being replenished by rain water falling on forests, fields and lawns. Younger water entering aquifers is being contaminated by human activities and modern lifestyles.

When we apply fertilizers and pesticides to our farm fields, some of those chemicals trickle down to aquifers or flow through drain tiles to streams and rivers that exchange water with aquifers. When we pave our streets and parking lots, we create a ready path for leaking engine oil, antifreeze, lawn chemicals and any other contaminants to quickly flow into streams and sometimes into aquifers. Chemicals used in everyday life which appear benign can be discovered years later in our aquifers.

Some parts of the state–the sand plains of central Minnesota and areas near Hastings–have aquifers close to the surface that are particularly vulnerable to contamination by agricultural and industrial products and practices that came into use in recent decades.

The recent highly publicized discovery of perfluorochemicals (PFCs) in wells in eastern suburbs of the Twin Cities has highlighted concerns about the quality of our ground water. The method for detecting PFCs in ground water is brand-new, and techniques for finding chemicals at ever-lower concentrations are evolving. Our public agencies must be vigilant about monitoring ground water quality and preventing contamination. As individuals, we must be aware that today's benign substance may be tomorrow's health threat. And chemicals from everything we make, everything we use, everything we put into or onto our bodies may end up in the water we drink.

Evidence of Ground Water Pollution

At a number of locations throughout Minnesota, polluted ground water is being pumped from the ground, treated or filtered, and then discharged to sewage treatment plants or surface waters every day. This pump-and-treat process has been going on for years. Ground water monitoring by the Minnesota Pollution Control Agency (MPCA), the Minnesota Department of Agriculture (MDA) and the Minnesota Department of Health (MDH) has found:

- Nitrate concentrations that exceed the health standard for drinking water in monitoring wells in the central and southeastern parts of the state, and in parts of the Twin Cities metropolitan area. The nitrate often comes from farm fertilizers or failed septic systems, and it is a particular health threat to infants, reducing the oxygen-carrying capacity of their blood.

- Detectable levels of Volatile Organic Compounds (VOCs) in ground water in parts of the Twin Cities and the St. Cloud metro areas. The compounds are, or once were, commonly found in gasoline, diesel fuel, carpets, paints, glues and cleaners.

- Evidence of farm chemicals in ground water in rural areas of the state. Concentrations of atrazine, a common herbicide, and its break-down products seem to be decreasing, while the number of wells in which the chemicals are being detected is increasing.

- Perfluorochemicals (PFCs), a class of chemicals used as fire retardants, stain and grease repellents, and emulsifiers, are being found in lakes and drinking water wells in the Twin Cities metro area and in treated wastewater throughout the state. The PFC contamination comes from industrial waste disposal sites, industrial processing and, in the case of Lake Calhoun in Minneapolis, from an unknown source. In Washington County, 255 households have been connected to public water supply systems or have been given water filters or bottled water because their private wells were found to be contaminated with the chemicals. The Minnesota Department of Health says that PFCs have caused birth defects and weakened immune systems in lab animals but at the levels found in the wells present a low, and uncertain, health risk for humans.

Who Monitors Ground Water Quality?

Three state agencies share responsibility for water quality. The MPCA and the MDA monitor ground water quality by testing wells throughout the state. The MPCA samples for nonagricultural chemicals, and it is also responsible for sampling related to feedlots, manure storage facilities and agricultural industry sewage. The MDA samples for chemicals originating from farm pesticides and the application of manure and chemical fertilizers. The MDH monitors drinking water for compliance with federal drinking water standards. The MDH operates protection programs for municipal wells and regulates well construction and the sealing of old wells. It also collects and interprets data from private wells in connection with specific cases of contamination where human health is a concern, such as in the Washington County landfill site.

How the Testing is Conducted

From 1992 to 1996, the MPCA conducted a comprehensive ground water study of Minnesota's principal aquifers. The Statewide Baseline Study sampled water at 954 locations with a goal of establishing baseline concentrations of chemicals against which future test findings could be measured.

For the last three years, the MPCA has been collecting continuous data from about 120 wells–half private wells and half monitoring wells–in aquifers considered vulnerable to contamination. The goal is to identify changes over time in concentrations of chloride, nitrate and volatile organic compounds (VOCs) and to show whether ground water quality in the state is getting better or worse. Because the testing is so new, data that would show a trend toward improvement or deterioration are not currently available. The aquifers where the testing is being conducted are

considered vulnerable because they are shallow or not confined by low-permeability material. In addition, two bedrock aquifers, the Prairie du Chien-Jordan in the Twin Cities and the Galena in southeast Minnesota, are being monitored.

Chloride in Ground Water

Chloride is a major ion in ground water. It occurs naturally and is found throughout Minnesota. But it also accumulates in ground water because of the use of salt as a road de-icer. Studies have documented a dramatic negative impact on both surface and ground water quality from the use of road salt in the snow belt of the United States and Canada. Minnesota's 2008 report on polluted surface waters includes seven streams–Shingle Creek, Bevens Creek, Battle Creek, Minnehaha Creek, Ninemile Creek, the Redwood River and the Joe River–that are impaired by chloride. Chloride is known to disrupt the metabolism of many aquatic organisms and can be toxic.

Nitrate in Ground Water

Nitrogen makes up 78% of the atmosphere by volume as nitrogen gas and is a major constituent of living plants and animals. In ground water, nitrogen is primarily present in the form of nitrate and occurs naturally at low concentrations of less than 1 milligram per liter (mg/L). The health standard for drinking water is 10 mg/L.

Sources of nitrate in ground water from human activity are abundant. They include farm and lawn fertilizers, septic systems and manure from livestock. Nitrate is one of the most common contaminants of ground water in Minnesota.

Testing by the MPCA in 2004 and 2005 revealed that the ground water samples collected from most wells had relatively low concentrations of nitrate, less than 2.5 mg/L. Concentrations between 2.5 and 10 mg/L–elevated, but below the health standard for drinking water–were also found, especially in southeast Minnesota, in the eastern half of the Twin Cities metro area and in central Minnesota.

In general, samples from relatively shallow monitoring wells had a higher number of elevated nitrate concentrations than samples from deeper domestic wells at homes and farms. The median concentration found in monitoring wells was 2.5 mg/L and 0.5 mg/L in the domestic wells tested. Several domestic wells in the eastern part of the metro area had elevated concentrations of nitrate in the range of 2.5 to 10 mg/L.

In Minnesota's Central Sands area–Benton, Cass, Crow Wing, Hubbard, Morrison, Stearns, Todd and Wadena counties–the median concentration of nitrate in monitoring wells was above the drinking water standard of 10 mg/L, at 16.1 mg/L. The high nitrate concentrations found in the Central Sands region result, at least in part, from the irrigation of many farm fields. Farmers using irrigation often apply higher levels of fertilizer, and the irrigation facilitates the passage of nitrogen to ground water.

Elevated levels of nitrate in drinking water are a concern primarily for infants under the age of six months. Methemoglobinemia occurs when nitrate is converted to nitrite in their bodies, which reduces the oxygen-carrying capacity of their blood and causes the skin to turn blue. Nitrate poisoning can be fatal, but prompt medical treatment can result in full recovery.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are a class of manufactured and refined organic chemicals that have been used extensively since the 1940s by industries, households and the military. Because of their widespread use and persistence in the environment, they pose a serious threat to ground water quality. Proof of adverse effects on human health, such as damage to the liver, kidneys and central nervous system, and cancer has been documented for some of the compounds.

VOCs were detected in 2004 in ground water in clusters of wells in the Twin Cities and the St. Cloud metro areas. Of the 90 wells sampled for VOCs, about 20% contained detectable concentrations of at least one of the compounds. In most cases, they were detected at very low concentrations.

As with nitrate and chloride, the VOCs were more commonly found in monitoring wells than in domestic wells. Twenty-eight percent of monitoring wells had detections, compared to 15.5% of domestic wells.

Pesticides in Ground Water

Ground water monitoring by the MDA from 1998-2006 detected the pesticides acetochlor, alachlor, atrazine, dimethenamid, metolachlor and metribuzin or break-down products associated with them in several areas throughout the state.

Analysis of trend data from 2000-2005 shows that in the Central Sands area there was a steady concentration of pesticides and their degradates although overall detections of pesticides increased for the same period. For atrazine and its degradates, concentrations decreased while the frequency of detection increased.

One recent study for this area revealed that 62% of the samples contained detectable concentrations of pesticide or degradates.

All of the pesticides that are tested for have different health standards that are based on exposure to a single chemical. These standards do not take into account possible synergistic effects of pesticide mixtures (even in low concentrations) like those being found in central Minnesota aquifers.

The human health risks vary for the many different kinds of pesticides, but some of the chemicals are known to affect the central nervous system or endocrine system, and some are

known carcinogens. Ecological health impacts include killing nontarget organisms; reduced growth and altered development; reduced reproductive capabilities, including birth defects; and genetic changes.

The 2008 Legislature appropriated $368,000 for the Minnesota Department of Agriculture and the Minnesota Department of Health to accelerate the testing of municipal water supply systems for pesticides and their break-down products.

Preventing Ground Water Contamination

The MDA and a number of other agencies, including the MPCA, the University of Minnesota Extension Service, Soil and Water Conservation Districts and the Board of Water and Soil Resources, develop and promote agricultural best management practices to minimize ground water contamination. The MDA has developed water quality best management practices specific to products containing the herbicides acetochlor, alachlor, atrazine, metolachlor and metribuzin. Other best management practices address general pesticide use and water resource protection.

The MDH and public water suppliers attempt to protect ground water through the state wellhead protection program. Wellhead protection areas are areas where ground water infiltrates and where possible contamination of the well could occur. Wellhead protection plans protect the well from possible contamination sources and have a strategy for dealing with contamination, if it occurs.

Septic Systems and Ground Water

Poorly constructed or badly maintained septic systems at homes, seasonal cabins and businesses can allow nitrate or bacteria to seep into ground water. No one knows, for certain, how many septic systems there are in Minnesota. The MPCA reports, based on estimates by counties and cities, that about one-fourth of the 2 million homes in the state are not connected to central sewage treatment systems. Of the approximately 500,000 septic systems in use, about 40% failed to meet state standards in 2007. In the Minnesota River basin, an estimated 80% of septic systems did not conform to the standards, the MPCA reported.

Protection of Municipal Water Systems

The MDH enforces the federal Safe Drinking Water Act and regulates approximately 7,300 public water systems. Of those systems, 963 are community systems that provide water to residences and most rely on ground water.

The most common violation by community systems of drinking water standards in 2007 was from contamination by fecal coliform bacteria. The MDH reported 20 violations of the coliform standard and 13 violations of the standard for radium 226 and 228. There were 11 systems that still exceeded the new federal arsenic standard at the end of 2007. The rule revision lowered the limit from 50 parts per billion to 10 parts per billion. These systems are working with the MDH

to come into compliance. There was also one violation for tricholoroethene (TCE) and one for cyanide. The systems have corrected the problem with a new treatment plant and by discontinuing the use of the affected well.

The health effects related to drinking water with coliform bacteria, which is used as an indicator of other bacteria, include intestinal illness. Radium and other radioactive compounds can cause cancer where there is long-term exposure at high levels. Arsenic is known to cause decreased production of red and white blood cells, abnormal heart rhythm and damage to blood vessels.

The EPA and the MDH have no drinking water standard for endocrine disrupting compounds – a new class of contaminants that in surface waters have caused male fish to develop female sex characteristics – and do not test for those compounds at this time. Research on the health effects of these chemicals on aquatic animals and humans is needed.

Perfluorochemicals in Minnesota

Perfluorochemicals (PFCs) are a globally distributed family of chemicals that have been used since the 1950s in products that resist heat, oil, stains, grease and water. Common uses include nonstick cookware, stain-resistant carpets and fabrics, fire-fighting foam, industrial applications, coatings for packaging and other uses. The chemicals persist in the environment and accumulate in the bodies of wildlife and humans.

Following a 2003 federal risk assessment of perfluorooctanoic acid (PFOA), one of dozens of chemicals in the family of PFCs, the MDH and other labs began using new methods for detecting chemicals in low concentrations to measure PFOA levels in ground water. In 2004, the MDH, along with the MPCA began collecting samples from private wells south and southeast of the Washington County landfill, where waste that included PFCs had been buried, and found low levels of PFOA. In 2005, more testing detected the chemical and a related compound, perfluorooctane sulfate (PFOS), in a larger group of private wells in Lake Elmo and several Oakdale municipal wells. In 2006, the MDH lab developed methods to detect five more PFCs.

Three PFCs have been found in drinking water near the Washington County Landfill in Lake Elmo and the Oakdale Disposal Site. In Lake Elmo, PFCs were detected at levels above state health criteria in 255 private wells. Approximately 200 homes have been connected to the municipal water system and 55 households are being provided bottled water and whole-house activated carbon filters. Bottled water and filters will be provided until remediation efforts at the sites achieve concentrations below state health criteria.

The MPCA has continued to test for PFCs in landfills, wastewater, fish tissue, lakes, streams and ground water throughout the state. PFC contamination has been found in the Twin Cities and in municipal wastewater throughout the state. Specifically, one of the chemical compounds was found in low levels in municipal wells in Woodbury, Cottage Grove, Newport, St. Paul Park, South St. Paul and Hastings. PFCs also have been found in fish tissue in several Twin Cities lakes and in fish from the Mississippi River between St. Paul and Winona.

Major manufacturers of PFCs have signed an agreement with the U.S. Environmental Protection Agency to reduce PFOA emissions and product content level by 95% by 2010 and work toward product elimination by 2015.

The MPCA and the MDH have been considering various methods for treating ground water to remove PFCs. Current remediation steps are being implemented at four Washington County disposal sites where PFC wastes were found.

The recent ability to test for PFCs in ground water and their detection in water and fish tissue have caused a concern about human health impacts from exposure. The MDH has set health risk limits, levels that are safe for consumption over a lifetime, for PFOA and PFOS in drinking water. It has also set fish consumption advisories for specific lakes where PFOS has been found in fish. The MDH points out that few studies of health effects have been done on people, but that in lab animals high concentrations of PFCs have caused harmful changes to the liver and other organs and developmental problems in offspring. The MDH also reports that PFOS and PFOA, in high concentrations over a long period of time, have caused cancer in lab animals.

Conclusions and Recommendations

Everything we do on the land around us–every natural feature we disturb, every chemical we overuse or carelessly discard–potentially affects the water recharging underground aquifers.

The degradation of ground water quality is apparent in many areas of the state. In urban areas, elevated concentrations of chloride and nitrate and detectable concentrations of volatile organic compounds have been found, as well as elevated concentrations of toxic chemicals from old waste sites. In some rural areas, nitrate concentrations are frequently elevated and many exceed standards; and pesticides and pesticide degradates are commonly detected.

Many chemicals are only broken down by sunlight or organisms and will not break down once they enter the ground water. With most Minnesotans relying on ground water for drinking and personal use, it is imperative that we protect our ground water resources.

There is a need for a greater emphasis on ground water quality monitoring. Also, a more consolidated effort of testing and reporting by the state agencies would improve the effectiveness of monitoring programs. Monitoring trends in ground water quality is necessary in order to better understand pollution prevention and to protect human and ecological health.

The testing for ground water contaminants needs to be more comprehensive, and it needs to be based on a thorough testing of potential sources of pollution. The testing strategy should be based on regional variations in aquifer geology–in some areas surface water rapidly penetrates to the deepest aquifers, in some areas it does not–and it must take into account changes that heavy pumping produces in the movement of water within aquifers. More expanded monitoring as well as the promotion of effective best management practices for land use would better address the

problems associated with ground water contamination. Education and outreach related to ground water pollution prevention should be a priority at the statewide level with effective action plans at the local level.

Emerging contaminants such as PFCs need further study to determine risks to human and ecological health. Ecological and toxicological studies that look at cumulative concentrations as well as combinations of chemicals in the body are needed. Pollution prevention measures are important in order to slow down environmental pollution while remediation of known contamination areas is done.

D. POLLUTION OF MINNESOTA'S LAKES, RIVERS AND STREAMS

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land." Luna Leopold

Minnesota has a wealth of water types, varying from small streams to large rivers, cold to warm water lakes, shallow to deep wetlands and underground aquifers. Minnesotans place a high value on the benefits of good water quality: the ability to swim, fish and boat; as well as appreciate the aesthetic beauty of lakes, streams and wetlands. The health of our waters is threatened by activities on the land and in the water that change natural ecosystems resulting in polluted lakes, rivers and streams.

We know:

- Only about 18% of our lakes and 14% of our rivers have been evaluated for contamination as required by the federal Clean Water Act. To complete the assessment within ten years, resources need to be dedicated to assessment and restoration of polluted waters. The current level of pollution prevention is insufficient to prevent further contamination.

- Of the waters that have been evaluated, 40% are polluted and are designated "impaired" under the federal law because they fail to meet water quality standards.

- Pollutants from nonpoint sources, such as agricultural runoff, construction and development sites, forestry and urban runoff, contribute to the pollution of Minnesota's waters. Agricultural runoff and conversion of rural to urban land are by far the biggest contributors of nonpoint source pollutants, 60-70% and 10-15% respectively.

- Pollution has been greatly decreased from regulations placed on point sources such as wastewater treatment plants and industrial wastewater. Nonpoint source pollution is getting worse: there is no systematic policy to prevent land use practices that harm water quality, and pollutants such as excess fertilizers accumulate in the landscape and pollute rivers and lakes during heavy rain and snowmelt.

- Polluted waters not only endanger our health, well being and the environment, but also threaten the recreational opportunities that are a heritage of all Minnesotans and the cornerstone of a $10 billion annual tourism industry.

- In public opinion polls, Minnesotans consistently rank protecting surface waters as their top environmental priority.

- Emerging contaminants such as pharmaceuticals have been found in wastewater effluent, streams and rivers and drinking water throughout the U.S. and here in Minnesota. Some of these contaminants belong to a group of chemicals with endocrine disrupting effects. Fish

and wildlife impacts have already been seen and more research is needed to determine human health effects.

Threats to our Waters

Fourteen percent of Minnesota's water pollution problems result from point sources such as wastewater treatment plants, industries and feedlots. The remaining 86% are caused by nonpoint sources, including runoff from farm fields, lawns, streets, parking lots and atmospheric pollution blown into Minnesota from other states and countries.

The U.S. Environmental Protection Agency (EPA) recognizes the greatest contributors to nonpoint source pollution as: agricultural activities, hydromodification (ditching, drainage and dams), land changes and urban stormwater runoff. Contributions of each of these sources to nonpoint source pollution and water quality vary by watershed depending on the geology, topography, soils, climate, landscape cover, and land use, as well as the size of the chosen watershed. Throughout the U.S., 64% of affected rivers and 57% of affected lakes are impaired by agricultural runoff.

As water passes over land it picks up pollutants that affect water quality such as:

- Sediment from the erosion of soils (agriculture and construction)
- Nutrients from fertilizer, animal wastes and septic systems
- Fecal coliform bacteria from livestock and septic systems
- Pesticides (herbicides, insecticides, fungicides, etc.) applied in agricultural and urban areas
- Chloride (mostly from applied road salt)
- Toxic Compounds (manufactured and refined products like oil, paints and antifreeze from urban runoff or dumping)

Sediment and nutrient input to surface waters have caused the eutrophication of many of the water bodies in Minnesota. Eutrophication is the process by which waters change because of an overabundant supply of nutrients. Excess phosphorus, nitrogen and other materials in the water causes rapid growth of aquatic plants and algae and have been found to greatly benefit invasive species to the detriment of native plant and aquatic life. This growth leads to the buildup of muck on the bottom and the replacement of sport fish, such as bass and walleye, by fish such as carp. Pesticides and other chemicals such as salts in water bodies have caused damage and death to aquatic life. Bacteria in streams and lakes have made the water unhealthy for human contact in some areas. Global climate change could likely aggravate the problem of eutrophication due to nonpoint source pollution. Climatologists generally agree that rainfall will come in more extreme events, which is likely to increase the runoff of soil, fertilizers and pesticides to streams and lakes.

Most of the nonpoint source pollution can be attributed to the following:

Agricultural runoff. The U.S. Department of Agriculture (USDA) indicates agricultural runoff is the primary source of pollution to water bodies affected by nonpoint source pollution. Agricultural sources, especially crop land, are the most significant contributors of pollution to Minnesota's rivers and streams. Soil erosion removes valuable and irreplaceable topsoil, which often carries pesticides and nutrients (nitrogen and phosphorus) into surface waters. Soil erosion is strongly linked to agricultural practices–the types of crops and soil tillage practices in a given area. Soil erosion occurs when open soil is exposed to wind and water, as happens in row crop agriculture, especially in highly sloped areas. Planting crops adjacent to a stream or lake decreases the natural buffer needed to filter contaminants. Improper manure management, such as storing manure in large piles or near a steam, or applying manure to fields prior to a rainfall, increases the chance of bacteria and nutrient runoff to streams. Manure also enters water bodies when animals are allowed to graze or drink water in a stream or pond.

Urbanization. Minnesota's population has grown from 1.7 million in 1900 to about 5.3 million in 2008 which has created major changes in the landscape. At the present growth rate, Minnesota will double its current area of developed land in less than 40 years. Expanding suburban areas cause an increase in impervious surfaces by the conversion of farmland and wildlife habitat and the paving of ground water recharge areas. This in turn causes greater runoff into streams and lakes and less ground water infiltration. Stormwater runoff from impervious surfaces can contain soil, fertilizers, animal waste, pesticides, salt applied to roads and walkways, oil, gasoline, antifreeze and metals from tires. The EPA lists urban runoff as one of the leading sources of pollutants to impacted water bodies and in Minnesota lakes. Contaminants from industrial discharges or dumping, such as PCBs and other "legacy" chemicals, as well as "emerging contaminants," such as pharmaceuticals and compounds found in everyday products like shampoos, are finding their way into surface waters, affecting plant and animal life reproduction through endocrine system disruption.

Shoreland development. Development at the land-water interface, along the shoreline of lakes and rivers, has significant impacts on a body of water. Loss of shoreline and aquatic life and habitat, destabilization of shoreline soils, decreased water quality and an increase in nonnative and invasive species result from shoreland alterations. A natural landscape produces 10% runoff, while lawns and hard surfaces produce 50% runoff.

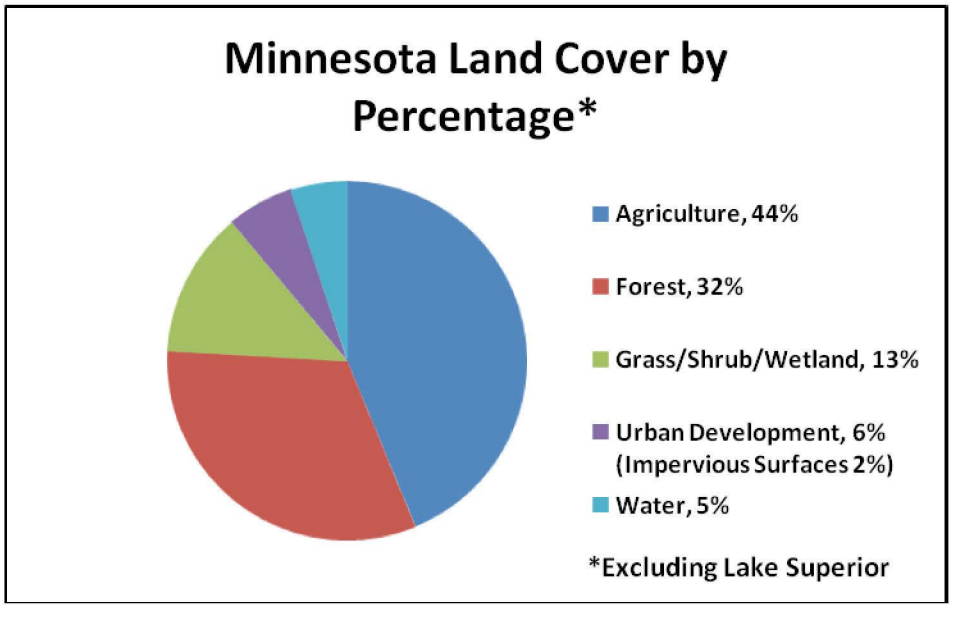
Wetland loss. Since the time of Minnesota settlement in the 1850s, over 50% of the approximately 20 million acres of wetlands in Minnesota have been filled or drained to make the land more economically productive for agriculture and other development. Over 90% of the original wetlands in the southern and western parts of the state, where agricultural drainage produced great economic benefit, have been destroyed. Some areas within those regions have less than 1% of wetlands remaining. This great loss of wetlands in the state is a concern because of the loss of ecological services wetlands provide. These include filtering contaminants, mitigating floods, slowing down water runoff to recharge ground water and providing critical wildlife habitat.

Septic Systems. Septic systems, some of which empty directly into ditches or streams, threaten surface water, as well as ground water. Outdated or noncompliant septic systems can add bacteria, viruses and other disease causing pathogens to surface water. A system that fails to treat sewage can also allow excess nutrients to reach nearby lakes and streams and is a major contributor to lake eutrophication.

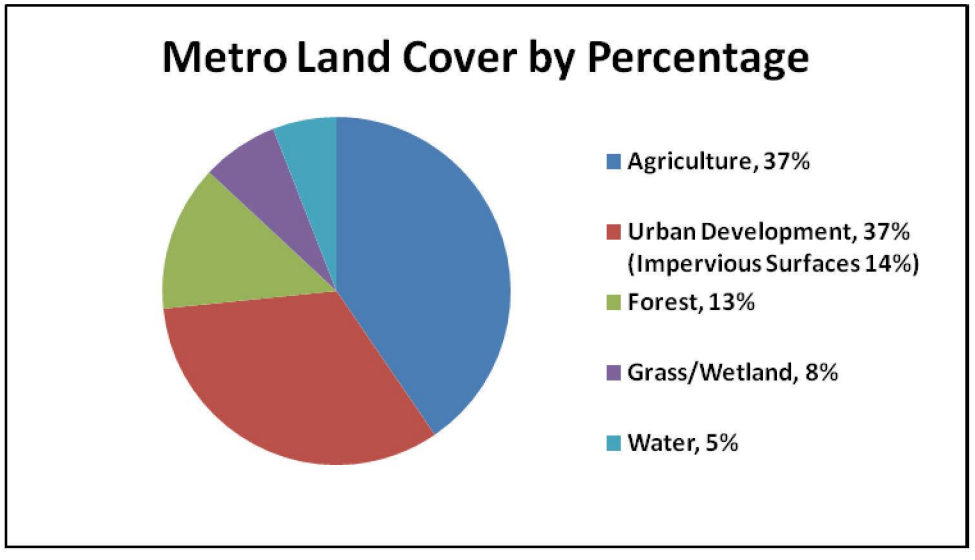
Forestry. Erosion and sedimentation along with increased dissolved nutrients, organic debris, pesticides, petroleum products, and changes in the flow of water within the soil and over land are all impacts to water quality associated with unsustainable forestry practices. In recent years Minnesota has taken remarkable steps in sustainable forest practices.

Land Use Effects on Water Quality

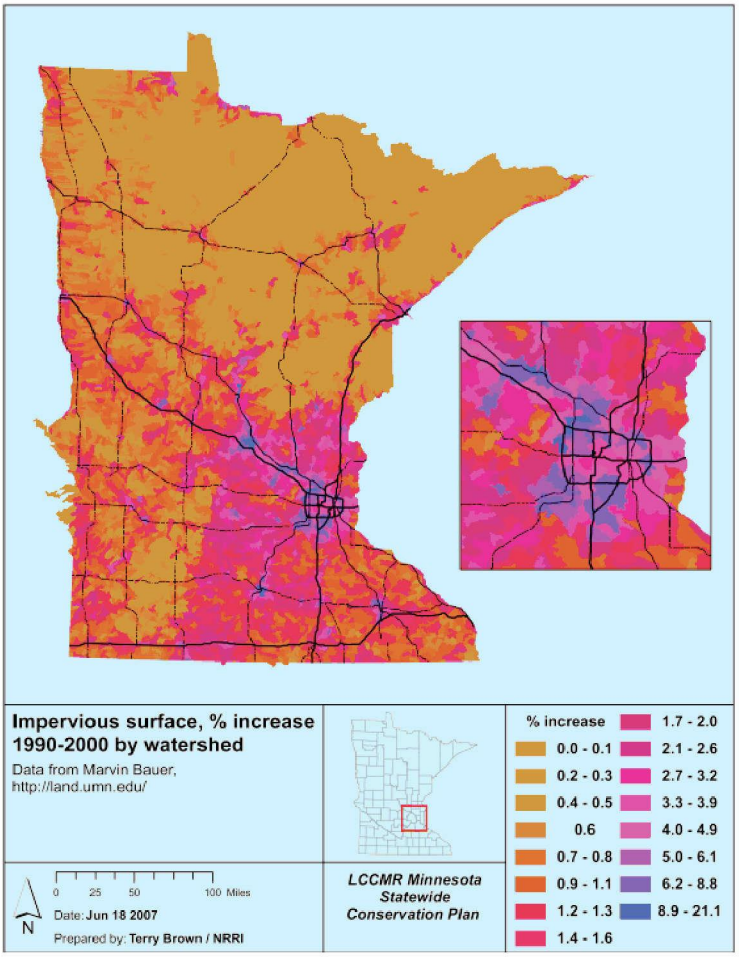
Minnesota, the Land of 10,000 Lakes, actually has approximately 12,200 lakes, not counting ponds and potholes less than 10 acres in size. The state has about 105,000 miles of rivers and streams. Geographically, water represents 5% of our surface area, excluding Lake Superior. Land use in the state varies by type and this in turn places different stressors on surface water quality. The land cover types of the state by percent are:



The seven-county Twin Cities metropolitan area is less than 3.5% of the state's land area, but supports 54% of the state's population and is projected to grow by 3.3 million by 2020, continuing a trend of being one of the fastest growing metro areas in the nation. When land cover in the metro area is examined, the amount of impervious surfaces increases dramatically as compared to the statewide percentages (14% and 2%). The land cover types for the Twin Cities metro area by percent are:



From 1986 to 2000, the amount of developed area in the Twin Cities metro area increased by 38.5% with the greatest increase occurring from 1991 to 1998. During the same period agricultural area decreased 15%, forest area decreased 7.9% and wetland area decreased 12.4%. This increase in developed land creates impervious surfaces that impact water quality by increasing pollutant and runoff in lakes, rivers and streams. With the metro area's population forecasted to grow 17 percent by 2020, development will continue to have a major impact on water quality unless measures are implemented to reduce pollution. Increase in impervious surface area between 1990 and 2000 is shown to the right.



How Are We Addressing the Pollution of our Waters?

In 2006, the Legislature enacted the Clean Water Legacy Act which established a Clean Water Council to provide advice for undertaking a comprehensive assessment of our waters. It also provided $24 million in Clean Water Legacy funding. In 2007, the Legislature approved an additional $54 million for the first two years of a proposed 10-year effort to complete the testing and begin clean up of impaired waters. State agencies involved in the Impaired Waters process are the:

- Minnesota Pollution Control Agency (MPCA)—water quality assessment and Total Maximum Daily Load (TMDL) development
- Minnesota Department of Natural Resources (DNR)—water quality assessment and TMDL development
- Board of Water and Soil Resources (BWSR)—technical and financial assistance for restoration
- Minnesota Department of Agriculture (MDA)—water quality research and monitoring as well as technical and financial assistance

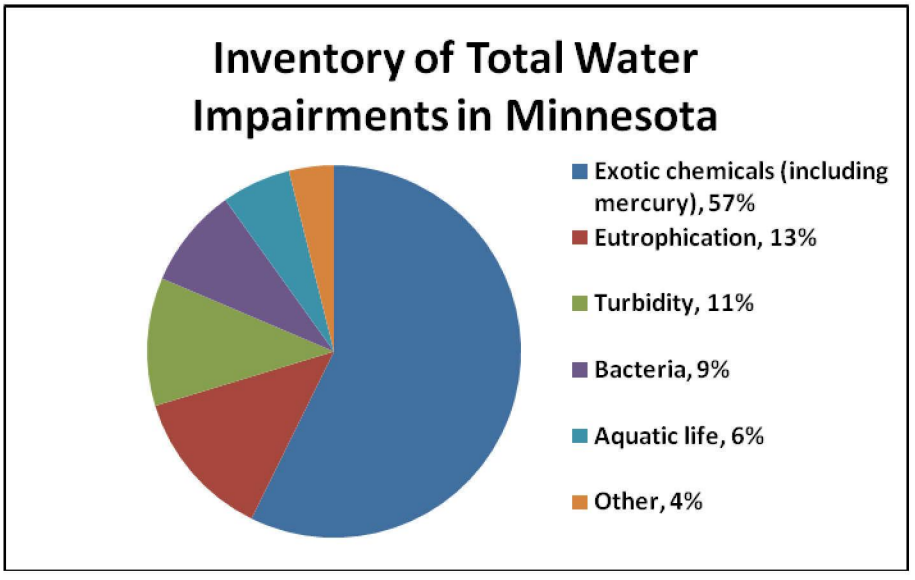
Most of the Clean Water Legacy funding is being used to assess the quality of lakes, rivers and streams and to develop TMDL plans that calculate the maximum safe level of pollutants in water bodies and prescribe strategies for restoring water quality. A small portion of Clean Water Legacy funding is available for nonpoint source pollution protection projects such as replacement of failing septic systems through BWSR and agricultural management practices such as buffer strips through the MDA.

However, surface water pollution prevention is not being effectively addressed in Minnesota. Currently Clean Water Legacy funding is supporting the identification of impaired waters and the development of remediation plans for water bodies. A targeted plan for prevention and remediation activities in areas with key problems would greatly enhance the protection of clean water. The Clean Water Council is also addressing prevention and protection activities for water quality and the MPCA is also working on designing a watershed-wide management approach to accelerate the clean up and protection of waters from further pollution. This approach which would benefit water quality in the state by preventing water quality degradation should be accelerated and expanded.

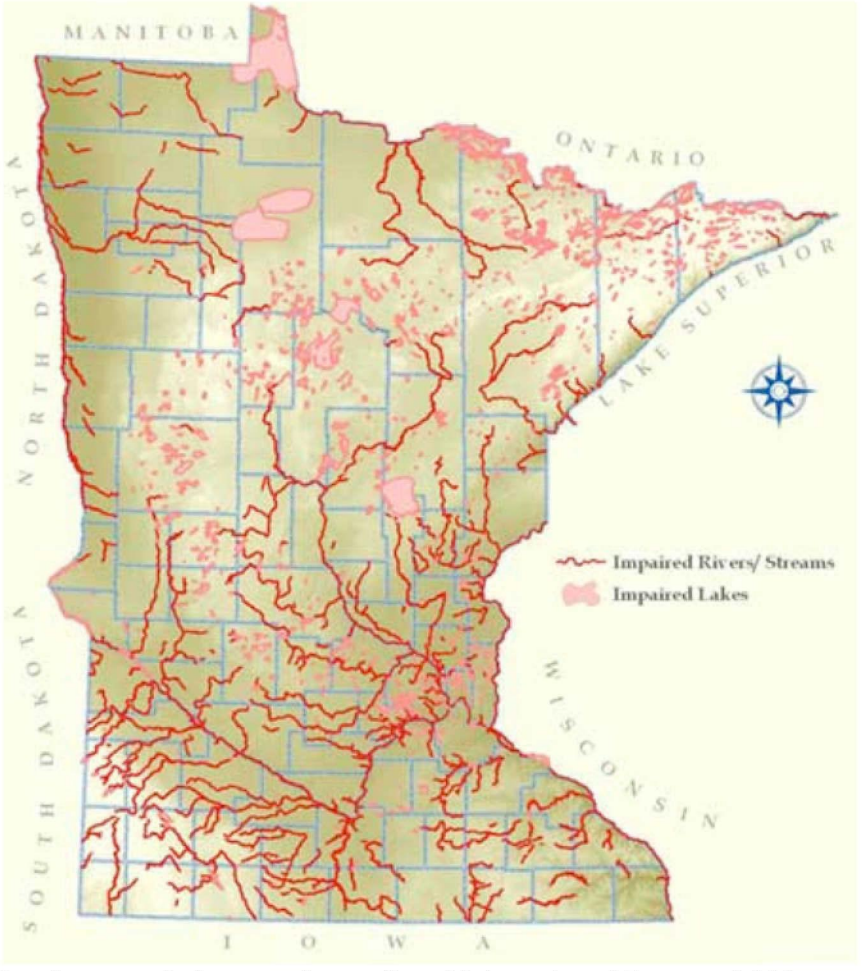
Surface Water Pollution Status

As part of the impaired waters process, lakes, rivers and streams are monitored to determine if they are fishable and swimmable. The water quality criteria are based on if the river or lake supports aquatic life, if consumption of aquatic life is safe for humans, and if recreation is safe for humans. Water quality in the state is impaired by nutrients, sediment, bacteria and toxic contaminants. Hydrologic modifications such as dams can also affect water quality. The current number of impaired lakes is 1,028 and the number of impaired rivers and streams is 349, although over 80% of lakes, rivers and streams are yet to be assessed.

As of 2008, only about 18% of our lakes and 14% of our rivers have been assessed, revealing one or more contaminants in the categories as follows:



Location of Impaired Waters in Minnesota



Some progress has been made in reversing polluted lakes. As of January 2008 seven water bodies have been removed from the impaired waters list due to water quality improvements. Some examples include:

- **Tanner's Lake** in St. Paul had high levels of phosphorus and sediment. Sedimentation ponds and a treatment facility for stormwater were built and the lake now meets water quality standards.
- **A portion of the Swan River** in Todd and Morrison counties was impaired by fecal coliform bacteria in 1994. A watershed management plan and major feedlot upgrades in 2000-2001 reduced the contaminants to an acceptable level.
- **A portion of the Redwood River** in southwest Minnesota was impaired by low dissolved oxygen (an indicator of eutrophication) and ammonia due to wastewater facility effluent. Upgrades to the Marshall waste water treatment facility were made in 1994 and water quality standards for dissolved oxygen were met in 2002 and standards for ammonia were met in 2008.

Emerging Contaminants

An emerging water quality concern is the detection of chemicals from personal use products that are not effectively treated by wastewater treatment plants or septic systems. These chemicals, called endocrine disrupting compounds (EDCs), mimic or block normal hormonal function in animals and humans. Many of these compounds are being found in our streams, lakes and aquifers and have also been found in treated drinking water in homes throughout the nation. They include:

- Medications
- Cosmetics
- Nutraceuticals (e.g. vitamins)
- Fragrances
- Sun-screen products
- Veterinary drugs

A nationwide preliminary study in 2000 by the U.S. Geological Survey as part of the Emerging Contaminants Program found the following chemicals in more than half of the streams tested:

- Coprostanol (fecal steroid that is an indicator of fecal matter)
- Cholesterol (plant and animal steroid)
- N-N-diethyltoluamide (DEET, insect repellent)
- Caffeine (a common contaminant used as an indicator of pharmaceuticals)
- Triclosan (antimicrobial disinfection)
- Tris (2-chloroethyl) phosphate (fire retardant)
- 4-nonylphenol (nonionic detergent metabolite)

The report stated that "knowledge of potential human environmental health effects of these 95 chemicals is highly varied." Drinking water standards or other human or ecological health criteria have been established for only 14 of these compounds and measured concentrations in this study rarely exceeded any of the standards or criteria. The study concludes that more research is needed on the possible effects to aquatic organisms exposed to low levels and mixtures of chemicals.

As part of this study, there were 65 sampling sites in Minnesota along the Mississippi River from St. Cloud to Hastings. Seventy-four chemical compounds were found (including herbicides, a flame retardant, a compound associated with animal waste, insecticides and a disinfectant byproduct), 13 of which are known endocrine disrupters. Results of this study indicate the ubiquitous distribution of organic wastewater compounds in the environment that originate from numerous sources and pathways.

Concerns about health risks of these varied chemicals include failure to understand the risk of cumulative lifetime exposures and concentrations in sensitive subpopulations such as children, as well as the effects of complex mixtures and possible synergistic effects of these compounds. There is growing evidence that chemical mixtures can act collectively to cause adverse effects, even when each component is below its individual effect level. One such study found a decrease in the reproductive success of fish when exposed to five estrogen compounds.

Exposures to aquatic life are a major concern because aquatic organisms have continual exposures, multigenerational exposures, exposure to higher concentrations of these compounds in untreated

water and possible effects from low doses. A study along the Mississippi River from Bemidji to the Iowa border found feminization (presence of female egg yolk protein) of male fish at approximately 50% of all sampling sites that correlated to detected levels of endocrine disrupting compounds. Studies elsewhere in the U.S. have found fish with both ovarian and testicular tissue, and the ratio of female fish outnumbering male fish 5 to 1. It is still uncertain what effects this will have on fish populations as these chemicals increase in surface waters.

Recently, EDCs have received attention in Minnesota and the state Legislature funded a report that concluded:

- Suspected effects of EDCs have been found in humans, wildlife and lab animals, and some impacts are being seen in wildlife populations.

- Further research is needed to more fully understand the possible long-term effects of EDCs on humans and the environment.

- A combination of strategies is needed to address EDCs in the environment such as treatment of the chemicals in wastewater, encouraging product stewardship among industries, encouraging pharmaceutical collection programs, and educating the public about making informed consumer choices.

Invasive Species

Invasive species—nonnative plants, animals and microbes—have the potential to cause significant damage to terrestrial and aquatic ecosystems. In the past century, two-thirds of the 40 North American freshwater fish species extinctions have been caused by invasive species. Invasive species are recognized as one of the greatest threats to biodiversity, second only to habitat destruction. The economic impacts of invasive species on land and water resources in the United States have been estimated at $138 billion annually and invasive species increasingly threaten Minnesota's natural resources. Prevention of further invasions and the spread of invasive species are necessary to prohibit the potential loss of many of Minnesota's native species.

Aquatic invasive species are found in increasing numbers in Minnesota's waters. Approximately 35% of primary recreational lakes in the state have been found to have at least one invasive species. Aquatic invasive species rated as being a serious threat in Minnesota include: Eurasian watermilfoil, curlyleaf pondweed, the round goby, the Eurasian ruffe, the common carp, the zebra mussel, and the spiny water flea. Eurasian watermilfoil is found in 190 lakes in the state. Curlyleaf pondweed is found in over 740 lakes and zebra mussels are found in four lakes, isolated areas in Lake Superior, and parts of the Mississippi and St. Croix rivers. Lake Superior has 27 invasive species of plants, fish, aquatic invertebrates, diseases, and parasites. These trends are expected to accelerate with time as aquatic invasive species become more established in Minnesota. Aquatic invasive species are a long term problem that will need continued management and educational outreach programs.

Improving Water Quality—Best Management Practices for Nonpoint Source Pollution Reduction

Best management practices (BMPs) are ways to work with the land to reduce undue environmental harm. Best Management Practices can be incorporated into many types of land uses including agriculture, forestry, shoreland management and urban landscapes. Implementation of agricultural BMPs have been shown to be successful at significantly reducing soil erosion and phosphorus washing into the Minnesota River. Conservation tillage is one technique known to reduce erosion, and in 2004 was used on 25% of the total crop acreage in the state.

An innovative program measuring onsite water quality improvements is the Wisconsin Discovery Farms program. The program mission is "to determine the impacts of production agriculture on the environment, while learning the economic and environmental ramifications of adopting BMPs on a diverse group of Wisconsin farms." The baseline information that is collected at selected farms includes: agronomic, livestock and financial data, as well as practices related to water quality such as buffer strips, changes in tillage, manure handling practices, nutrient management, soil conservation, sensitive area identification and phosphorus measurements.

Ann Lewandowski, a researcher at the University of Minnesota Water Resources Center (WRC) who worked on this program in Wisconsin said that "the producers (farmers) come up with practical solutions and other producers pay attention to the results." Lewandowski and researchers at the WRC recently completed a feasibility study for the Minnesota Department of Agriculture that recommends that Minnesota establish a Discovery Farms program. Such a program would provide information on pollution contributors as well as effective practices to reduce pollutant runoff.

Another program involves best management practices used in forestry. The Minnesota Forest Resources Council (MFRC) provides guidelines for sustainable management of forest land in the state for state owned and private forest land. The Forest Stewardship Council (FSC) and the Sustainable Forest Initiative (SFI) also provide third-party certification for state and qualified public and private forest land.

The MFRC sustainability guidelines are an integrated set of site-level timber harvesting and forest management guidelines for forest landowners, resource managers, loggers, contractors and equipment operators. The guidelines focus on six components of a healthy forest ecosystem: cultural resources, forest soils, riparian areas, visual quality, water quality and wetlands, and wildlife and habitat. Activities that are covered include forest road construction and maintenance, timber harvesting, mechanical site preparation, pesticide use, reforestation, timber stand improvement, fire management and forest recreation management.

These guidelines are being used to direct timber harvests and other practices on all state forest land and on private land throughout the state. Landowners are eligible for incentive payments, through the Sustainable Forest Incentive Act, for enrolling at least 20 acres of contiguous forest land for eight years or more. Currently about 712,000 acres of the 5.7 million acres (12%) of privately owned forest land that is used for timber are enrolled in the incentive program. In addition, all of the 4.8 million acres of state forest land are certified for sustainability by both the SFC and SFI programs. This certification assures that forests are being managed to sustain both current and future use for timber, wildlife habitat, water quality and healthy ecosystems.

Conclusions and Recommendations

To improve water quality, controlling nonpoint source pollution needs to be a priority. We need to embrace land and water stewardship practices that have been demonstrated to be effective in controlling agricultural runoff. Incentives or regulations should be put in place to ensure that best management practices are continuously implemented in both rural and urban areas. Performance and compensation for best management programs should have a more precise targeting of payments to specific outcomes based on water quality improvements.

A comprehensive plan for pollution prevention in watersheds with impaired and nonimpaired waters not only reduces the continued degradation of our waters, but also reduces the cost of lake restoration and reclamation. The MPCA appears to be working on making this part of the

agency's strategy for improving water quality in the state, but we should make this a top priority.

To achieve results in improved water quality, control of pollutants needs to be done in small geographic areas, such as small watersheds, in order to produce immediate, obvious improvement that would persuade land owners and other stakeholders to adopt preventative practices.

The effective management of invasive species requires that it be treated as a high priority for control and public education. Monitoring and evaluation of the effectiveness of different prevention and control programs will help to successfully manage invasive species.

More attention needs to be given to emerging contaminants in our waterways and drinking water. The possible health effects of exposure to pollutant mixtures need further research, and appropriate technologies for treatment need to be developed. Strategies to prevent continued pollution by these chemicals need to be identified and implemented.

E. QUESTIONS MERITING FURTHER STUDY

"High quality water is more than the dream of the conservationists, more than a political slogan; high quality water, in the right quantity at the right place at the right time, is essential to health, recreation, and economic growth." Edmund Muskie

Throughout their exploration process, members of the Guardianship Council were repeatedly struck by the apparent lack of definitive information and lack of agreement on essential water issues, which makes it difficult to confidently solve the problems Minnesotans will surely face in the near future. Public discussion must focus on these subjects and questions in order to secure our most precious resource for the next generation. The Council posed these further questions about water to all Minnesotans:

- How can we adopt an ethic of stewardship that will lead us to put greater value on water now and in the future? How should we apportion water if it becomes scarce?

- Are current agricultural practices involving drainage, fertilizer and pesticide applications and land use along stream banks consistent with improving water quality? How can we have both clean water and a healthy, growing agricultural economy?

- How much are we currently spending to clean up water we have allowed to become polluted? Are we doing enough to prevent further pollution? Should we be spending more to prevent pollution?

F. INDICATORS OF SUCCESS

"Anything else you're interested in is not going to happen if you can't breathe the air and drink the water. Don't sit this one out. Do something. You are by accident of fate alive at an absolutely critical moment in the history of our planet." Carl Sagan

If the Guardianship Council's recommendations on ground water sustainability, ground water quality and the protection and clean-up of surface waters are taken to heart and acted on by citizens and policy makers, we would expect to see, within the next decade**:**

- Evidence that individuals and communities are putting greater value on water and working to conserve it.

- Agreement reached, and work begun, on a comprehensive evaluation of ground water sustainability.

- Less reliance on ground water for uses that can be met with surface water and recycled water.

- Renewed planning, even in the absence of a current crisis, for the next crisis–whether it be a drought or contamination of a major surface or underground source of drinking water.

- Sufficient understanding of our water resources to respond to expected demands from dry areas of the country for export of our water.

- A significant increase in trend analysis that would tell us, not only whether ground water meets minimum health standards, but whether it is getting better or worse.

- Major new scientific study and monitoring aimed at assessing the health risk of emerging contaminants and combinations of them.

- Completion of the Pollution Control Agency's assessment of pollution in lakes, rivers, streams and wetlands, evidence that clean-ups are being completed more quickly and evidence of significant new attention to protecting waters that are not polluted.

- Evidence that farmers and other landowners have adopted proven best management practices and achieved measurable reductions in pollution within small watersheds.

- A reduction in the rate at which invasive species are spreading within Minnesota waters.

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V. ACRONYMS

BMPs - Best management practices

BWSR - Board of Water and Soil Resources

EDCs - Endocrine disrupting compounds

FWS - The Freshwater Society

DNR - Minnesota Department of Natural Resources

EPA - U.S. Environmental Protection Agency

FSC - Forest Stewardship Council

MDA - Minnesota Department of Agriculture

MDH - Minnesota Department of Health

MFRC - Minnesota Forest Resources Council

MGS - Minnesota Geological Survey

MPCA - Minnesota Pollution Control Agency

NGOs - Nongovernmental organizations

PFCs - Perfluorochemicals

PFOA - Perfluorooctanoic acid

PFOS - Perfluorooctane sulfate

SFI - Sustainable Forest Initiative

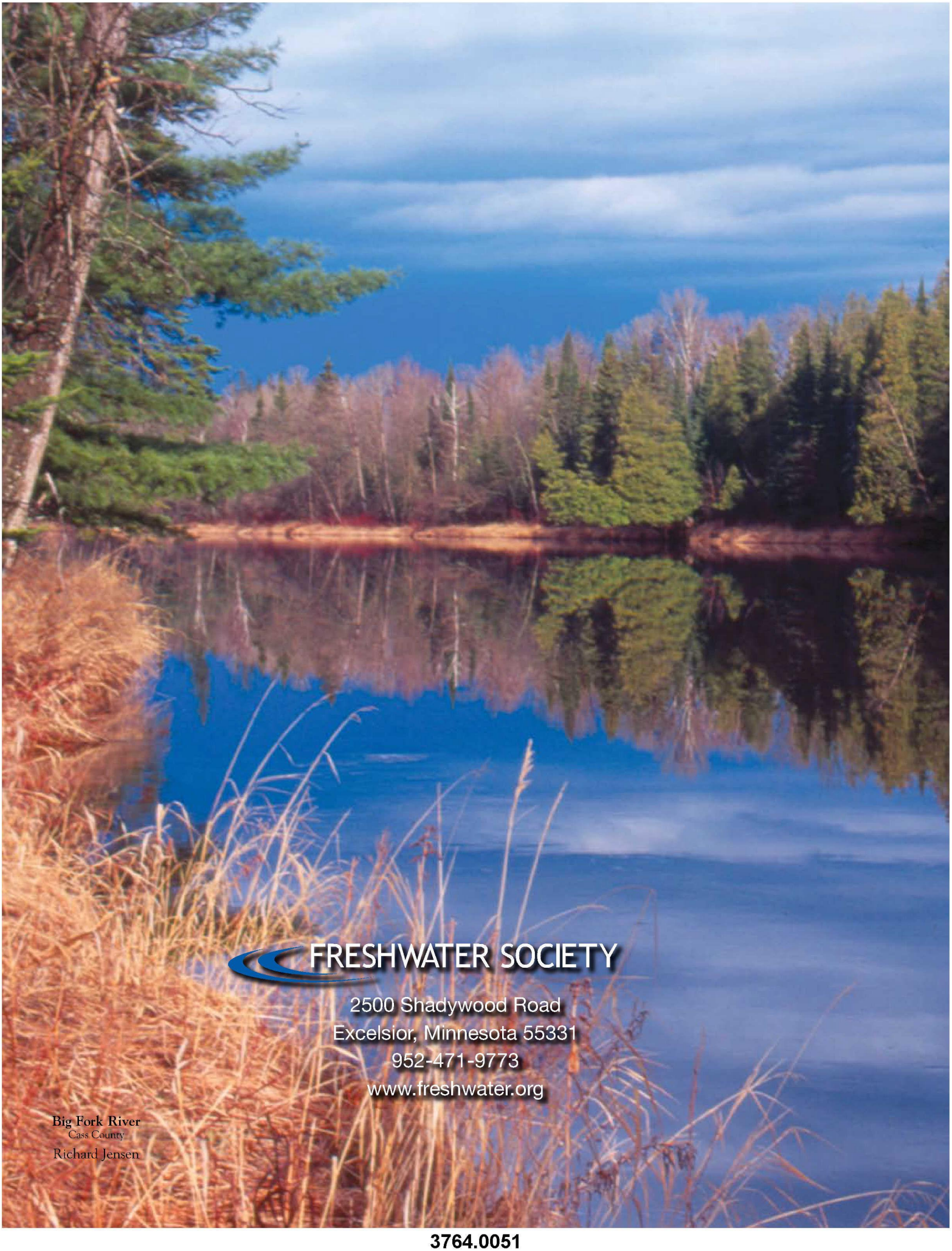
TCE - Tricholoroethene

TMDL - Total maximum daily load

USDA - U.S. Department of Agriculture

VOCs - Volatile Organic Compounds

WRC - University of Minnesota Water Resources Center



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