MINNESOTA WATER SUSTAINABILITY FRAMEWORK

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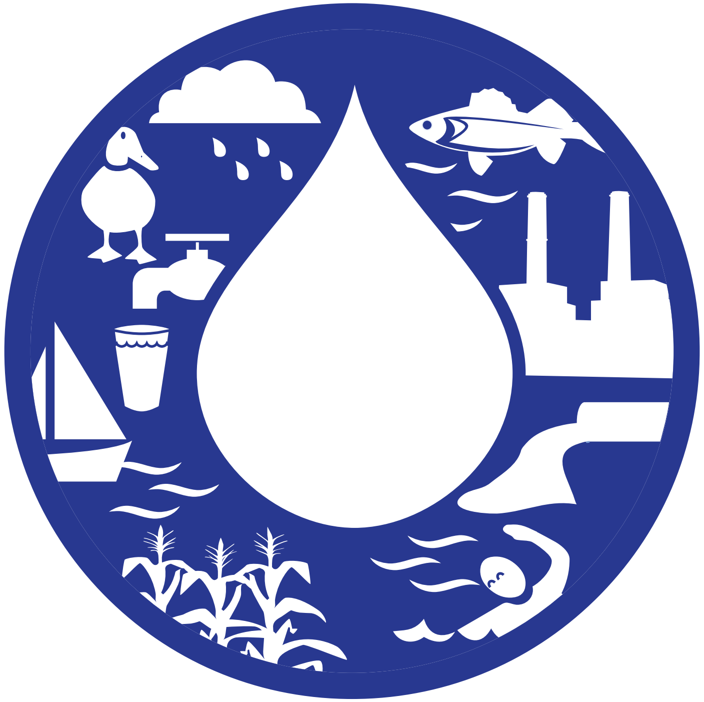

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CLEAN WATER LAND & LEGACY AMENDMENT

MINNESOTA WATER SUSTAINABILITY FRAMEWORK

This document is a product of the
University of Minnesota Water Resources Center.

Water Resources Center
University of Minnesota
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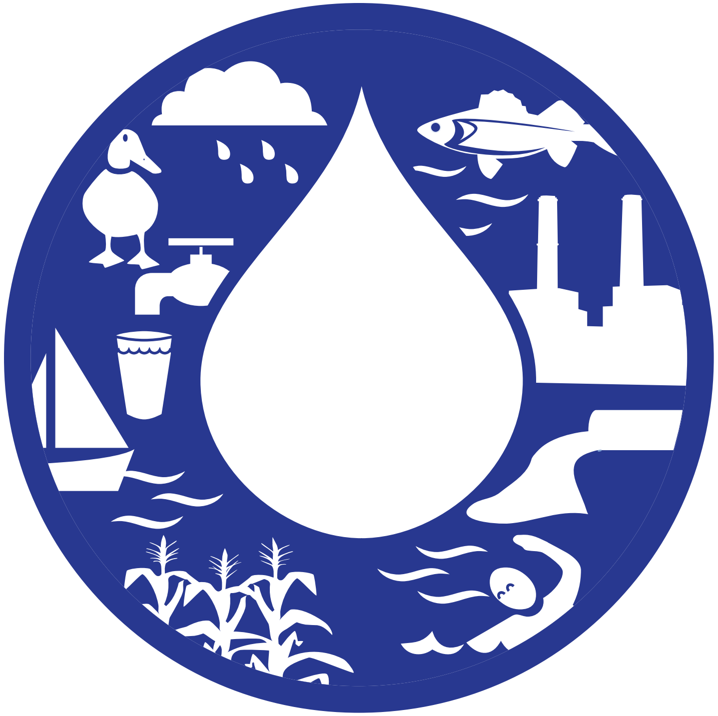
The MINNESOTA WATER SUSTAINABILITY FRAMEWORK

A PLAN FOR CLEAN, ABUNDANT WATER FOR TODAY AND GENERATIONS TO COME



MINNESOTA, THE LAND OF NEARLY 12,000 LAKES AND 63,000 miles of rivers and streams, has more freshwater than any of the country's other contiguous 48 states. Water is part of Minnesota's identity and a defining force in our state's history, heritage, environment, and quality of life. At the headwaters of three of the largest river basins in North America, Minnesota receives 99% of its water from rain and snow—consequently, most of our water quality problems originate right here in our own state. While this means we are not forced to clean up water problems originating elsewhere, it also means we have a responsibility to take care of our waters for our sake and for all those downstream.

We have had a tendency to take this abundance and cleanliness for granted. But this complacency could lead to our undoing. Over time, as Minnesota was settled, cleared, developed, and farmed, and our population grew, these human-induced changes took an unintended toll on our lakes, rivers, groundwater, and their related ecosystems. Minnesota's population will grow—an estimated 22 percent larger by 2035—and that increased population will result in ever greater demands on our finite water supply and its quality unless we make intentional and strategic changes now.

WHAT IS THE MINNESOTA WATER SUSTAINABILITY FRAMEWORK?

It was in part due to Minnesota's love of water and concern for the environment that in 2008, its citizens passed the historic Clean Water, Land and Legacy Amendment to the state constitution, dedicating a portion of a small increase in the state's sales tax for the next 25 years to create the Clean Water Fund to protect and enhance our water resources. This rare and unique opportunity allows Minnesota to do what no other state has done—to truly take action *now* for a sustainable water future.

The Legislature directed the University of Minnesota Water Resources Center to construct a framework describing what needs to be accomplished and how to get it done. The Legislature defined sustainable water use as that which **"does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs."** Aspects of water sustainability to be addressed included drinking water, stormwater, agricultural and industrial use, surface and groundwater interactions, infrastructure needs, and within the context of predicted changes in climate, demographics, and land use. The result is the Minnesota Water Sustainability Framework. The following 150-page report presents the 10 most pressing issues that must be addressed to achieve sustainable water use, presents strategies for what should be done, and provides recommendations for how to meet these challenges.

Over the last 18 months, a core team, led by University of Minnesota Water Resources Center professor and co-director Deborah Swackhamer, collected, compiled, considered, and synthesized the knowledge, insights, and perspectives of hundreds of the best scientists and water management professionals in the state and region, as well as the input of a wide range of citizens and interest groups. The resulting Framework offers a step-by-step road map toward water sustainability, identifying problems in a holistic way and offering concrete solutions and action steps based on current science and best practices.

Minnesota is at a crossroads. To do nothing about our current water management would put our health, quality of life, and environmental and economic future at stake. We have a rare moment in history to make the changes needed to put Minnesota on the path to water sustainability through the Water Sustainability Framework. Moving forward on the Framework recommendations will assure the people of the state that our precious water resources will be here for generations to come.

WATER SUSTAINABILITY TRIAD

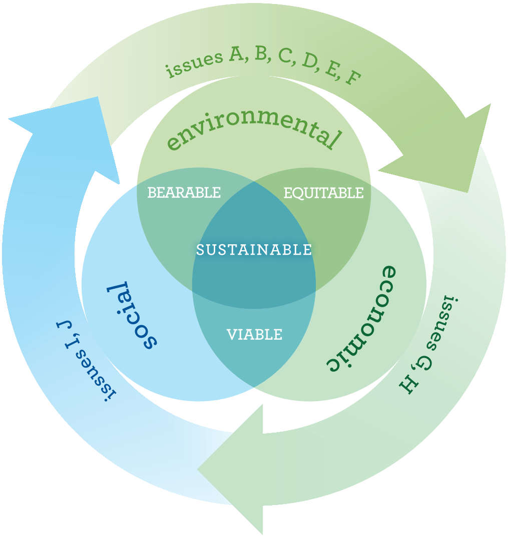


Figure 1-1: Water Sustainability Triad With Framework Issues A–J

WHAT THE FRAMEWORK IS NOT...

The Framework provides a long-range plan that frames major water sustainability issues and provides strategies and recommendations for addressing those issues. It is *not* a specific spending plan for the Clean Water Fund, nor should it be limited by the availability of Clean Water Funds; rather, it includes recommendations for investments that may come from sources beyond the Clean Water Fund (other state funds, private funds, etc.), as well as recommendations that require little or no investment by the state.

THE MOST PRESSING ISSUES

The Framework identifies ten major issues that present the challenges, and solutions to those challenges, that must be addressed if water sustainability is to be achieved in Minnesota. These issues (labeled A – J) fall within the three areas that define sustainability: environmental, economic, and social.

The *Strategies* that address the *Issues* are in the following table, along with the corresponding *Desired Minnesota Future:*

SUMMARY of DESIRED FUTURE, ISSUES, and STRATEGIES

DESIRED MINNESOTA FUTURE	ISSUE	STRATEGIES
A water supply that is protected for all future generations that is of high quality and that is sustainable for all uses of water.	A. The Need for a Sustainable and Clean Water Supply	**A.1:** Determine the state's water balance and improve water appropriations permitting **A.2:** Improve privately supplied drinking water quality **A.3:** Plan for water re-use
The "Land of Unimpaired Waters," where we have met all our water standards for nutrients and solids, we are not contributing to eutrophication problems beyond our borders, we can safely eat local fish.	B. Excess Nutrients and Other Conventional Pollutants	**B.1:** Reduce excess nutrient and conventional pollutant loads by strengthening policies to meet clean water standards, and require implementation of pollutant load reductions by all sources **B.2:** Establish a farmer-led, performance-based approach to meeting clean water standards **B.3:** Address "legacy" contaminants
A society that has embraced green manufacturing and chemistry so as to eliminate new toxic contaminants, and in which drinking water, recreation water, and food are free from harm from microbial contaminants.	C. Contaminants of Emerging Concern	**C.1:** Enact Green Chemistry Act **C.2:** Develop a framework for managing contaminants of emerging concern **C.3:** Address beach pathogens to improve recreation
A society where all of our land use decisions and plans are inextricably linked with sustainable water use and planning.	D. Land, Air, and Water Connection	**D.1:** Require integrated land and water planning; integrate water sustainability in permitting
A society in which healthy ecosystems are considered the foundation on which human well-being is based, all damaged ecosystems have been remedied and all ecosystems are protected, while maintaining a healthy economy. Changes to the hydrological system are minimized and historic changes have been addressed to achieve water quality and aquifer recharge needs.	E. Ecological and Hydrological Integrity	**E.1:** Enact Ecosystems Services Act **E.2:** Prevent and control aquatic invasive species **E.3:** Improve management of hydrologic systems **E.4:** Preserve and encourage land set-aside programs
A society in which energy policy and water policy are aligned.	F. Water-Energy Nexus	**F.1:** Understand and manage water and energy relationships
A society in which water is considered a public service and is priced appropriately to cover the costs of its production, protection, improvement, and treatment, and the economic value of its ecological benefits.	G. Water Pricing and Valuation	**G.1:** Include the value of ecological benefits in the pending water pricing schemes **G.2:** Provide for shared resources between large and small community water supplies
A society that maintains and protects its infrastructure for drinking water, wastewater, stormwater, and flood protection in a manner that sustains our communities and our water resources, maintains and enhances ecosystems, and reuses water where appropriate to conserve our sustainable supply.	H. Public Water Infrastructure Needs	**H.1:** Determine a long-term strategy for funding new, expanded, and updated infrastructure and its maintenance **H.2:** Incorporate new technologies and adaptive management into public water infrastructure decisions
A resilient society that values, understands, and treasures our water resources, and acts in ways to achieve and maintain sustainable and healthy water resources.	I. Citizen Engagement and Education	**I.1:** Ensure long-term citizen engagement **I.2:** Ensure youth and adult water literacy and education
Governments, institutions, and communities working together to implement an overarching water sustainability policy that is aligned with all other systems policies (land use, energy, economic development, transportation, food and fiber production) through laws, ordinances, and actions that promote resilience and sustainability.	J. Governance and Institutions	**J.1:** Provide a governance structure to ensure water sustainability **J.2:** Ensure that the Water Sustainability Framework is reviewed and updated regularly and informed by current, accessible data and information

Figure 1-2: Summary of Desired Future, Issues, and Strategies

THE FRAMEWORK IN SUMMARY: A TEN- AND TWENTY-FIVE-YEAR PLAN

The following "dashboard" presents the complete list of Recommendations in the Framework that are needed to implement the Strategies listed above for addressing the ten important Issues. This summary table provides the following information:

- **Individual Recommendations—**recommendations are grouped by the issue they address (identified by A–J), and in relationship to a specific strategy (identified by number). For example, A.1.a indicates Recommendation "a" for Strategy 1 under Issue A.
- **Who Should Implement—**if funding is appropriated by the Legislature, this indicates whether a given recommendation would be implemented by the Legislature, the executive branch, or others.
- **Research Task—**this column contains an R if the recommendation is a research task rather than an implementation or management task.
- **Implementation Phase—**the phases refer to the general time line for initiation of a given recommendation's implementation. Phase 1 corresponds to the first two years (2011–2012) and is shown in color, blue or green, Phase 2 corresponds to the next three years (2013–2015), Phase 3 corresponds to years 6–10 (2016–2020), and Phase 4 corresponds to years 11–15 (2021–2025). The Ten-Year Plan contains recommendations in Phases 1–3, while the Twenty-Five-Year Plan contains all recommendations from all phases. The time line for implementation does not always correspond to how critical the action is relative to others; rather, it reflects Minnesota's readiness to implement the action (i.e., "low-hanging fruit"), the urgency of starting the action, and/or the fact that outcomes from the action will take significant time (decade or more).
- **Level of Benefit to Water Resources—**this gives an indication of each recommendation's potential impact on improving or protecting water quality and quantity for future generations. The scale is given as 1 to 3 drops, with 3 drops indicating maximal benefit and 1 drop indicating modest benefit.
- **Multiple Benefits—**this indicates whether the recommendation as implemented would benefit other state-defined natural and human resources, including wildlife, fisheries, forest resources, air, recreational resources, or human health.

RECOMMENDATION	IF FUNDED, WHO SHOULD IMPLEMENT	RESEARCH TASK	IMPLEMENTATION PHASE	LEVEL OF BENEFIT TO WATER RESOURCES	MULTIPLE BENEFITS
A.1.a i, ii, iii: accelerate water balance mapping needs and implement hydrologic monitoring network	Executive		Phase 1	💧💧💧	🌐
A.1.a iv: design and complete the water balance hydrologic models	Executive	R	Phase 1	💧💧💧	🌐
A.1.b i, ii: develop a web-based screening permit system	Executive		Phase 1	💧💧💧	🌐
A.1.b iii: restrict water exports from state	Legislative		Phase 3	💧💧💧	

Figure 1-3: Dashboard Summary of Recommendations

RECOMMENDATION	IF FUNDED, WHO SHOULD IMPLEMENT	RESEARCH TASK	IMPLEMENTATION PHASE	LEVEL OF BENEFIT TO WATER RESOURCES	MULTIPLE BENEFITS
A.1.b iv: develop eco-based thresholds for minimum flows	Executive	R	Phase 1	💧💧💧	🌐
A.2.a: improve quality of private drinking water	Other		Phase 2	💧💧	🌐
A.3.a: plan for water reuse	Executive		Phase 4	💧💧	
A.3.b: develop reuse standards	Executive		Phase 4	💧💧	
B.1.a: require compliance of pollutant load reductions by all sectors	Legislative		Phase 1	💧💧💧	🌐
B.1.b: strengthen approaches to stormwater pollution	Executive		Phase 3	💧💧	🌐
B.1.c: strengthen shoreland rules	Executive		Phase 3	💧💧	🌐
B.1.d: increase capacity for local land use compliance	Legislative		Phase 2	💧💧	🌐
B.1.e: strengthen rules managing septic treatment systems	Executive		Phase 3	💧💧	
B.1.f: research cyanotoxin sources	Other	R	Phase 2	💧	
B.2.a: establish farmer-led performance-based approach to meeting standards	Legislative		Phase 1	💧💧💧	🌐
B.2.b: establish agricultural sustainable water certification	Executive		Phase 3	💧	
B.3.a: address contaminated sediments	Executive		Phase 2	💧💧	🌐
B.3.b: evaluate coal-tar sealant alternatives	Executive		Phase 1	💧	🌐
B.3.c: further eliminate mercury sources	Executive		Phase 1	💧	🌐

RECOMMENDATION	IF FUNDED, WHO SHOULD IMPLEMENT	RESEARCH TASK	IMPLEMENTATION PHASE	LEVEL OF BENEFIT TO WATER RESOURCES	MULTIPLE BENEFITS
C.1.a: enact Green Chemistry Act	Legislative		Phase 1	💧💧	🌐
C.2.a: develop framework for managing contaminants of emerging concern	Executive		Phase 1	💧💧💧	🌐
C.2.b: expand MDH Contaminants of Emerging Concern program	Executive		Phase 3	💧💧💧	🌐
C.2.c: prioritize facilities' need for advanced treatment technologies	Executive		Phase 3	💧💧💧	🌐
C.2.d: develop comprehensive policy for pharmaceutical disposal	Legislative		Phase 2	💧💧	🌐
C.3.a: establish state policy for pathogens and beaches	Legislative		Phase 3	💧💧	🌐
C.3.b, c: research pathogen indicators and sources	Other	R	Phase 2	💧💧	🌐
D.1.a: require comprehensive land and water planning	Legislative		Phase 1	💧💧💧	🌐
D.1.b: integrate sustainability in land use permitting	Legislative		Phase 1	💧💧💧	🌐
D.1.c: increase local enforcement and compliance capacity	Legislative		Phase 2	💧💧	🌐
D.1.d: monitor effectiveness	Executive	R	Phase 1	💧💧	🌐
E.1.a i: enact Ecosystems Services Act	Legislative		Phase 3	💧💧💧	🌐
E.1.a ii: determine ecosystem services and their economic value	Other	R	Phase 1	💧💧💧	🌐
E.2.a: develop statewide policy for aquatic invasive species	Legislative		Phase 1	💧💧	🌐
E.2.b: research control measures for aquatic invasive species	Other	R	Phase 1	💧💧	🌐
E.3.a: accelerate watershed hydrological characteristics and response landscape model application	Executive		Phase 1	💧💧💧	🌐

RECOMMENDATION	IF FUNDED, WHO SHOULD IMPLEMENT	RESEARCH TASK	IMPLEMENTATION PHASE	LEVEL OF BENEFIT TO WATER RESOURCES	MULTIPLE BENEFITS
E.3.b: model drainage from field scale to watershed scale	Other	R	Phase 3	💧💧💧	🌐
E.3.c: require multi-benefit drainage management practices with new or replaced tile drainage	Legislative		Phase 1	💧💧💧	🌐
E.3.d: expand cost-share program for retrofitting existing tile drainage	Executive		Phase 1	💧💧💧	🌐
E.4.a: preserve and encourage conservation land set-asides	Executive		Phase 1	💧💧💧	🌐
E.4.b: work to ensure next Farm Bill has strong conservation elements	Executive		Phase 1	💧💧	🌐
F.1.a: understand and quantify the water-energy nexus	Other	R	Phase 3	💧💧	
F.1.b: review energy policy for water sustainability	Legislative		Phase 3	💧💧	
F.1.c: encourage renewable energy that minimizes water impacts	Executive		Phase 3	💧	🌐
G.1.a: include ecological benefits in water pricing	Legislative		Phase 2	💧💧💧	
G.1.b: include other economic incentives in water pricing	Legislative		Phase 2	💧💧💧	
G.1.c: transition business to more equitable pricing	Executive		Phase 2	💧💧💧	
G.1.d: research and model value of water ecological benefits	Other	R	Phase 1	💧💧💧	🌐
G.2.a: provide for shared resources between small and large community water supplies	Executive		Phase 3	💧💧	🌐
H.1a: create standing advisory committee on new technologies .	Executive		Phase 2	💧💧💧	🌐
H.1.b: address water reuse	Legislative		Phase 4	💧	

RECOMMENDATION	IF FUNDED, WHO SHOULD IMPLEMENT	RESEARCH TASK	IMPLEMENTATION PHASE	LEVEL OF BENEFIT TO WATER RESOURCES	MULTIPLE BENEFITS
H.1.c: adopt Effective Utility Management program	Other		Phase 1	💧💧	🌐
H.2.a i: determine long-term funding strategy for public water infrastructure	Executive	R	Phase 1	💧💧💧	
H.2.a ii: implement long-term funding strategy for public water infrastructure	Executive		Phase 3	💧💧💧	
I.1.a: ensure long-term citizen engagement and support	Executive		Phase 2	💧💧💧	🌐
I.2.a: ensure youth water literacy	Other		Phase 2	💧💧💧	🌐
I.2.b: ensure adult water literacy	Other		Phase 2	💧💧💧	🌐
J.1.a: review statutes and laws for water sustainability	Legislative		Phase 1	💧💧💧	🌐
J.1.b: enact Water Sustainability Act	Legislative		Phase 1	💧💧	🌐
J.1.c: re-establish the Legislative Water Commission	Legislative		Phase 1	💧💧💧	🌐
J.1.d: create Water Sustainability Board	Legislative		Phase 2	💧💧	🌐
J.1.e: form Watershed and Soil Conservation Authorities	Legislative		Phase 3	💧💧	🌐
J.2.a: create interagency data and information portal	Executive		Phase 1	💧💧💧	
J.2.b: maintain Framework as "living" document	Legislative		Phase 3	💧💧💧	🌐

As shown in the dashboard, it is evident that most (about two-thirds) of the Framework recommendations should begin in the first five years (Phases 1 or 2). Phase 1 recommendations, shown in **blue** and **green**, relate to issues A, B, D, and J (The Need for a Sustainable Clean Water Supply; Excess Nutrients and Other Conventional Impairments; Land, Air, Water Connection; and Institutions and Governance). With few exceptions, these will provide a high level of benefit to water resources, and most provide multiple benefits to natural and human resources. Phase 2 recommendations relate to strategies within all the issues except Issue F (Water-Energy Nexus). These recommendations would provide good to excellent benefits to water resources, and again, most would provide multiple benefits to natural and human resources. Phase 3 recommendations are less urgent and, though important, do not need to be initiated in the first five years. Phase 4 recommendations, most related to water re-use, are not urgent. Non-urgency should not be interpreted to mean a recommendation is non-essential. In some cases, the Phase 3 or 4 recommendations cannot be initiated until the recommendations in the earlier phases have been instituted, yet are highly essential to sustainable water resources in Minnesota. The most essential actions are shown in **blue** (see below for explanation).

The dashboard also demonstrates that three-fourths of the recommendations have multiple benefits to other natural resources and public health. Many of the remaining one-quarter are positively linked to economic benefits.

THE ESSENTIAL TOP FIVE ACTIONS

The Framework is comprehensive in its recommendations and at first glance may seem like a daunting challenge on many levels, including financial. The quality and diversity of knowledge and perspectives that contributed to the final form of these recommendations cannot be overemphasized, and implementation of them in their entirety provides the best assurance of water sustainability. However, in the expert view of the Framework's authors, there are 5 overall actions (encompassing eight recommendations) that are most critical, in fact are considered essential, to achieving water sustainability—implementing these five actions will take us closer to water sustainability than any other limited combination of actions. These five actions can be grouped into two parts: (i) Protect and restore water quantity and quality and (ii) Address the interconnected nature of water. They are all Phase 1 actions, of high impact to water quality, and have multiple benefits. They are shown in the dashboard above in **blue.**

Protect and restore water quantity and quality through comprehensive, integrated, and informed management and policy:

❶ **Revise water appropriations permitting (Recommendation A.1.b), and model the state's water balance (A.1.a)**

❷ **Comply with water quality standards through implementation plans for reducing pollutants (B.1.a) and bring farmers to the table to be part of this solution (B.2.a)**

❸ **Address future contaminants (C.1.a, C.2.a)**

Address the interconnected nature of water by integrating and aligning planning and policies:

❹ **Integrate water and land use planning (D.1.a)**

❺ **Align water, energy, land, transportation policies for sustainability (J.1.a)**

Part II Introduction

SHARING a VISION

MINNESOTANS WILL REACH SUSTAINABLE MANAGEMENT OF our precious water resources only if we can agree on a shared vision of what this means. A shared vision is not a single vision, but is a collective vision that we all can embrace, even if we have diverse perspectives and differing uses for water. The Minnesota Water Sustainability Framework project's public engagement efforts indicate that citizens embrace the legislative definition of sustainability: "Sustainable water use does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs." Minnesotans can attain a shared vision through strong leadership, robust engagement of citizens, informed decision-making, and management strategies that use evaluation and learning to continually adapt and evolve. The shared vision arising from the Framework is that in the future, Minnesota's lakes, rivers, streams, wetlands, and aquifers are healthy and resilient, and that they are treasured and understood to promote well-being and prosperity of present and future generations. The adoption and implementation of this Framework will move us to this vision.

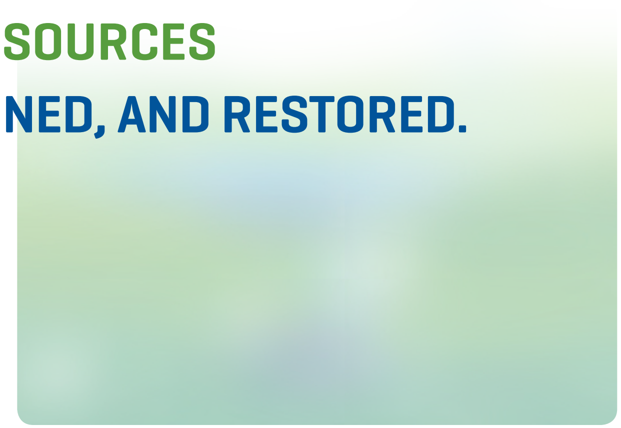
> **"SUSTAINABLE WATER USE DOES NOT HARM ECOSYSTEMS, DEGRADE WATER QUALITY, OR COMPROMISE THE ABILITY OF FUTURE GENERATIONS TO MEET THEIR OWN NEEDS."**
>
> *—Minnesota Laws 2009, Chapter 172*

A SUSTAINABLE WATER POLICY STATEMENT for MINNESOTA:

Preamble to Framework

THE CITIZENS OF MINNESOTA desire a sustainable water future, and this will require a robust, comprehensive, and integrated statewide policy. This policy must ensure that water demand is forever balanced by clean renewable water, and that our water resources are protected, maintained, and restored. This policy must recognize that water resources are intrinsically linked to human health and well-being, a sustainable environment, and economic prosperity. It should recognize the interconnectedness of water: the connection between surface and groundwater, the connection between water and human activity on the land. This policy must embrace the core values of transparency, accountability, and equity, and must use the best science to guide decisions.

THIS POLICY MUST ENSURE THAT WATER DEMAND IS FOREVER BALANCED BY CLEAN RENEWABLE WATER, AND THAT OUR WATER RESOURCES ARE PROTECTED, MAINTAINED, AND RESTORED.



The PRINCIPLES of the Minnesota Sustainable Water Policy should be to:

- **Protect, maintain, and restore the biological, chemical, and physical health of the state's water resources**
- **Provide resiliency to our ecosystems, our communities, and our economies**
- **Increase our understanding of our state water balance and the processes and stressors affecting it to provide for improved decision making**
- **Improve our capacity for water management that can adapt to new knowledge, changing biogeochemical systems, and long-term challenges**
- **Encourage sustainable, conservation-minded land use practices**
- **Recognize and honor our many uses of water, including recreational, cultural, and spiritual values**
- **Preserve our water-rich heritage and ensure our future legacy as national and international water stewards**
- **Provide for a lasting foundation to achieve and maintain sustainable water management.**

The following Framework will provide the guidance needed to develop these principles into long-term action to achieve sustainable water use and management.

IMAGINE a MINNESOTA...

IMAGINE A MINNESOTA in which lakes, streams, and groundwater are clean, where water is abundant and available to all, to meet all needs.

Or imagine a Minnesota in which the ecological integrity of our lakes and rivers has been destroyed by competing, unbridled demands that far exceed their capacity to meet them; where the health of children is threatened by an uncertain water supply; where access to clean water is controlled by a powerful few; where competition for a scarce resource generates crime and graft and separates people and enterprises into haves and have-nots.

Or imagine any scenario in between. Your choice.

Our choice.

We don't know what Minnesota will be like tomorrow. But we do know it will be different than today. Population growth, climate change, and shifts in governance, technology, lifestyle, and land use are moving us toward a future unlike anything we've seen before. The differences of opinion we encounter today around water access, allocation, and protection pale in comparison to those that will emerge in the face of a bigger, more demanding populace—unless we commit ourselves now to a new and sustainable way of thinking, acting, apportioning, and governing that will ensure our water resources maintain ecological integrity while meeting human physical, social, economic, and spiritual needs in a just and sustainable way.

That's what this Framework is all about. In 2009, recognizing that under the new Clean Water, Land and Legacy Constitutional Amendment, Minnesotans would be investing billions of dollars in water management over the next quarter century, the state Legislature called for creation of a comprehensive and independent framework to guide and inform the process. Over the next 18 months, a core team led by University of Minnesota Water Resources Center (WRC) professor and co-director Deborah Swackhamer collected, compiled, sorted through, and thoughtfully considered the knowledge, insights, and perspectives of hundreds of experts and thousands of citizens representing a spectrum of water-related professions and points of view.

The Framework presented here is the result of that massive effort. It is the nation's first state-level plan for ensuring that waters will be preserved, protected, and available for use by all citizens for generations to come. It gives Minnesotans a solid plan for shaping the strong leaders, engaged citizens, and resilient policies needed to not only imagine, but create and pass on to our children, a future in which lakes, streams, and groundwater are clean and water is abundant and available to all, to balance all needs, for all time.

WHAT THE FRAMEWORK IS NOT. The Framework is to provide a long-range plan that frames the major water sustainability issues and provides strategies and recommendations for addressing those issues. It is not a specific spending plan for the Clean Water Fund or limited by it; rather, it includes recommendations for investments that may come from sources beyond the Clean Water Fund (other state funds, private funds, etc.), and recommendations that require little or no investment by the state. The Clean Water Fund can help support the goal of sustainable water use and management, but is not the only vehicle. This Framework addresses long-term needs, so the reader won't see recommendations related to things that Minnesota already does well, or that are currently regulated or managed sufficiently using good science and good process. For instance, the Framework does not address forest management and water, because Voluntary Site-level Forest Management Guidelines are effective. The Framework does not address mining and water, as that is a site-by-site issue handled adequately by permitting; and the politics of siting decisions were not within the scope of the Framework. The Framework does not focus on wetland restoration per se, as the Wetlands Conservation Act is considered successful for the most part. The Framework does not address aspects of the federal Clean Water Act that are considered to be successfully implemented, or comment on what is working well in the state. Instead, the Framework focuses on where actions can be taken now and into the future to move us even further forward.

MINNESOTA LAKES and STREAMS

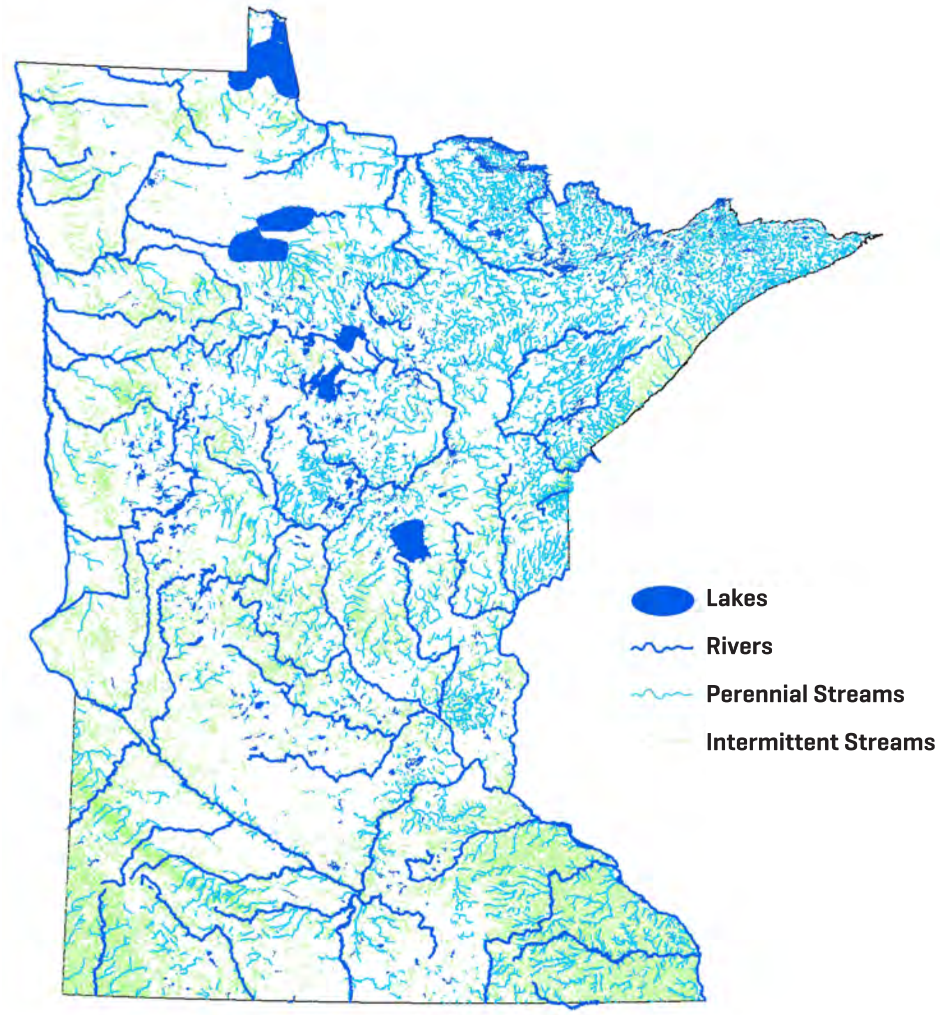


Figure 2-1: Lakes and Streams Map

MINNESOTANS AND WATER

The Minnesota Water Sustainability Framework surveyed Minnesotans' attitudes and beliefs about water. Based on more than 4,500 surveys and 9 listening sessions around the state, the team concluded:

- **Minnesotans consider providing drinking water to be the most important use of water, followed by providing ecological services, offering recreational opportunities, and meeting the needs of agriculture.**
- **Minnesotans rank chemical pollution; nutrients; and nonnative plant, animals, and diseases the three most serious problems facing Minnesota's waters.**
- **Minnesotans understand that we need to change our behavior in order to reverse the trend toward reduced water quality.**
- **Minnesotans equally value improving polluted lakes and rivers and protecting waters that are still healthy.**
- **Minnesotans place equal importance on investing in groundwater and investing in surface waters.**
- **Minnesotans want to address the most serious water problems first, rather than place priority on distributing funding equitably across the state.**
- **Minnesotans want quantifiable measures of water quality to be communicated and accessible.**

The CURRENT STATE of WATER in MINNESOTA

MINNESOTA HOLDS THE HEADWATERS OF three major continental river basins: the Red River of the North flowing to Hudson Bay, the Mississippi River flowing to the Gulf of Mexico, and Lake Superior flowing out to the St. Lawrence River and the Atlantic Ocean. Thus, approximately 99% of the inflow of water to the state is from precipitation. In total, Minnesota is touched by 8 major river basins and has 6 major groundwater provinces defined by geological characteristics and by availability of water. Based on research done by the US Geological Survey (USGS) in the mid-1980s, the major loss of water (about 80%) is evapotranspiration, or loss back to the atmosphere from plants, soil, and surfaces. Much of the remainder flows out of the state in major rivers. The state currently has 13.1 million acres of wetlands and lakes, 63,000 miles of rivers and streams, 11,842 lakes over 10 acres in size, and 23,000 miles of drainage ditches and channels that form 81 major watersheds. However, the current balance of where water is and how it moves and flows in Minnesota is not very well known, and that lack of knowledge represents one of the biggest challenges to managing water sustainably.

In spite of not knowing the quantity of water in the state with any certainty, the use of water in Minnesota is well characterized from data collected by both the Minnesota Department of Natural Resources (DNR) and the USGS. The largest use of water in the state is for cooling of thermoelectric plants, which constitutes 60% of total water use. The water is almost all drawn from surface water sources, used for once-through cooling, and returned to the stream or river from which it was withdrawn. This practice primarily affects a small area of rivers. When water is returned from where it was taken, the practice is termed nonconsumptive use. Other uses of water in the state include domestic use (public and private water supplies), which constitutes 15%, of which about 75% is from groundwater. Mining constitutes 10%, mostly surface water; agricultural irrigation and livestock production constitutes about 7.5%, of which nearly all is groundwater. Other uses, such as industrial use and aquaculture, each make up a few percent. Setting aside nonconsumptive use gives a better picture of water use in Minnesota: domestic use is 22%, mining is 26%, agriculture is 19%, and other uses are each less than 10% of the consumptive water supply. In 2005 the per capita use of water in Minnesota was 788 gal/day, and domestic use

MINNESOTA WATER USE by MAJOR CATEGORY: 1985–2005

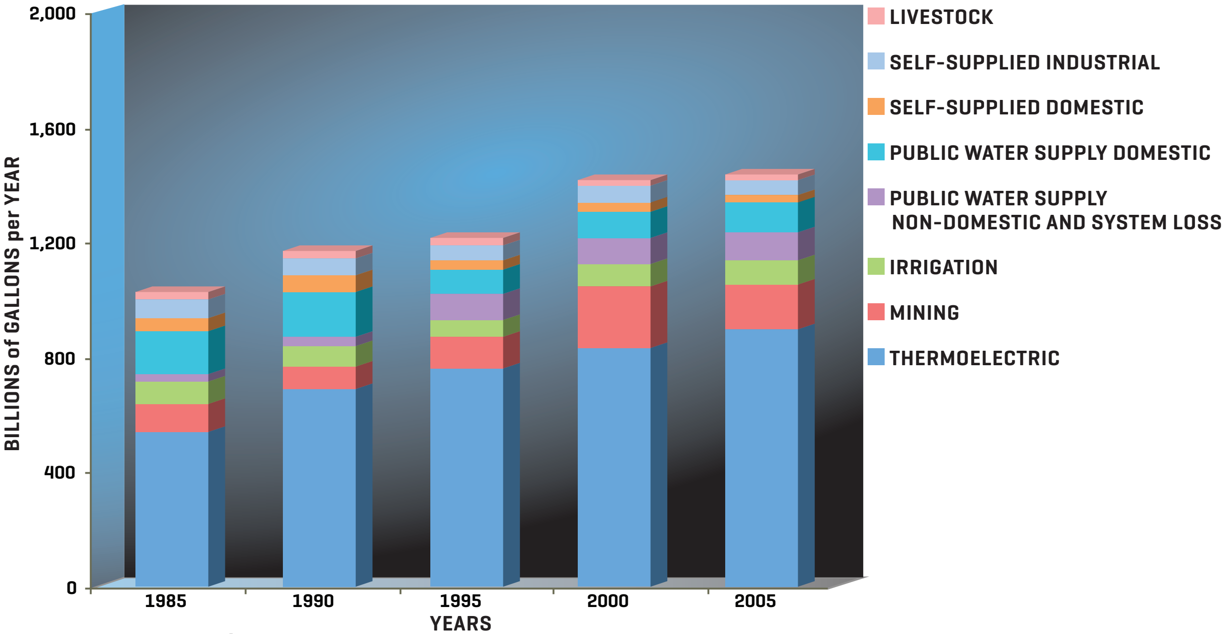


Figure 2-2: Water Use by Major Category

SOURCE: MN DNR AND USGS

was 68 gal/day per person. The per capita use has been rising in Minnesota since the mid 1980s, and is driven by an increasing use for once-through cooling of thermoelectric plants. However, other use categories have also seen increased demand over time (see Figure 2-2). About 78% of Minnesotans get their drinking water from public supplies, and 22% have private water supplies. The public drinking water is largely from groundwater (~70%) with some surface water sources (30%); private supplies all use groundwater.

The quality of Minnesota's water (and the nation's) has improved significantly since the passage of the Clean Water Act in 1972. Most conventional parameters, such as phosphorus, oxygen, and bacteria, have shown some improvements, largely due to strong regulation of industrial point sources through the National Pollutant Discharge Elimination System (NPDES). In spite of this, approximately 40% of the nation's waters do not meet water quality standards, and the same percentage is estimated for Minnesota. Recent studies suggest controlling point sources resulted in significant improvement prior to the last decade. The lack of improvement over the past decade stems from the fact that now pollutant loads are coming mostly from nonpoint sources. However, most nonpoint sources have not been subject to direct regulation of discharges, including agricultural runoff and drainage. Regulations for urban nonpoint stormwater are now being phased in, and as a result, pollution from urban nonpoint sources should be reduced. In Minnesota, the ag-

POINTS of PRIDE

Federal and state laws limit how much people may alter water and waterways. In Minnesota, all groundwater and some surface water must be kept suitable for drinking. In addition, water bodies may not be degraded without compelling need. These limits and the spirit of stewardship behind them have resulted in many positive trends for Minnesota's waters:

- **Control of point-source pollution over the past 20 years has led to improvements in many aspects of water quality.**
- **Minnesota has buy-in at many levels of government as well as funding to protect water resources.**
- **State law has allowed us to leverage state dollars for water protection into many more local and federal dollars.**
- **Minnesota has made some progress in defining groundwater resources.**
- **Citizens are involved in monitoring and protecting waters around the state.**
- **Diverse interests work together to assess and protect water quality.**
- **Minnesota has a good system for recovering from floods, settling well conflicts, and cleaning up chemical spills.**
- **Communities are welcomed to actively manage their water resources.**
- **For the most part, lakes and rivers are home to thriving ecosystems.**
- **For the most part, Minnesota's groundwater is uncontaminated and undepleted.**
- **Strong laws and policies recognize and work to protect the value of wetlands.**
- **Minnesota has been active in establishing boards and councils to help set policy for managing interstate and international waters.**

ROOM for IMPROVEMENT

Despite these successes, Minnesota waters still face many threats. For example:

- **Groundwater pumping has lowered groundwater at least 40 feet in some parts of Minnesota.**
- **Runoff of oxygen-depleting pollutants from farms and cities decreases oxygen in lakes and rivers, altering their ability to support life.**
- **Extensive drain tile continues to be installed each year, which may redirect water flow and increase nutrients, bacteria, and various chemical input to receiving waters.**
- **Removal of species, overfishing, and introduction of nonnative aquatic invasive species has changed and will continue to change aquatic ecosystems.**
- **Lakeshores are increasingly being developed in ways that decrease lakes' ability to function as healthy, sustainable ecosystems.**
- **Nitrate concentrations are increasing rather than decreasing in some parts ofthe state, putting infants at risk from drinking water.**
- **Hundreds of previously undetected, unregulated chemicals have been found in water, and there is evidence that some of them may cause reproductive effects in fish. Impacts on humans are not known.**

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ricultural community has been a national leader in working to implement voluntary best practices, but the state is still out of compliance with the federal Clean Water Act.

The biggest threats to water quality in the state are the continuing (and increasing) concentrations of nitrates from agriculture and other unregulated non-point sources, the presence of mercury that starts as an air pollutant and accumulates in fish, and the potentially hundreds of non-regulated chemicals from household product and pharmaceutical disposal that are found in surface and drinking water (Contaminants of Emerging Concern, or CECs).

Economists have tried to place a dollar value on the goods and services water provides so we can factor them appropriately into policy decisions. For some, this process is fairly simple: for example, the value of wild rice harvested in the state exceeds $5 million per year. For other goods and services, the calculations are much more challenging. Water is indispensible to agriculture, which provides $9.3 billion in farm income each year and generates $55 billion in economic activity in the state. Electrical power plants use close to 900 billion gallons of water each year in the process of generating $5.3 billion worth of electricity. Fishing contributes some $4.7 billion in economic activity to the state each year and supports more than 43,000 jobs. The epic 1997 floods along the upper Minnesota River and the Red River of the North were estimated to have a had a total economic impact of more than $1.5 billion; we don't know how many such floods have been prevented thanks to efforts to protect wetlands that slow water's movement. Water's transportation value in Minnesota includes shipping more than $2 billion worth of cargo each year from the Port of Duluth Superior, supporting more than 2,000 jobs and generating a $210 million impact. An additional 8.4 million tons of goods were shipped through the Twin Cities in 2009. The use of water for waste disposal, manufacturing, and other industrial processes is also valuable but extremely difficult to quantify. Water also provides huge, perhaps immeasurable, aesthetic value to the people of Minnesota. Perhaps most personally coveted is water's value for drinking. Minnesotans used 128 billion gallons of drinking-quality water in 2005. At the going rate for water in St. Paul, the equivalent value is about $376 million. Using the price of bottled water brings the the value to $164 billion. But given that access to clean drinking water is literally a life-or-death matter, its value could as easily be set as priceless.

A DIFFERENT FUTURE

A framework for sustaining Minnesota's water quality and quantity into the future cannot succeed if it doesn't recognize and accommodate external forces or external drivers of change. In developing Minnesota's Water Sustainability Framework, team members took into consideration three of these major drivers and their trends that are expected to strongly influence supply, demand, and quality of Minnesota's water resources in the future:

CLIMATE CHANGE. Trends in Minnesota climate today are toward warmer temperatures (especially in winter and at night), more heat advisories, and greater variation in precipitation (recall that precipitation is 99% of the water that comes into Minnesota). Observations of data over the last 150 years provide abundant evidence of climate warming in Minnesota, with readily observable impacts on water resources. Signs of climate warming are difficult to ignore, whether because the solid ice cover prized for winter recreational fishing lasts a shorter time each winter or because an increasing frequency of high intensity rainfall events overwhelms city stormwater management infrastructure. Timing, intensity, and duration of precipitation events are changing, with high intensity thunderstorms contributing a greater share of mean annual precipitation, leading to greater overland flow and less infiltration. Analyses of precipitation records for Minnesota over the last 100 years reveal that fall and spring are notably wetter. With more of the summer precipitation happening in intense, localized rainfall events, precipitation received in one particular area is more variable. This increased variability results in periodic intense flooding events and amplified dryness at other times. There is some indication that we are seeing a seasonal shift in the heaviest rainfalls to August, September, and October.

Climate change projections from a number of models recently analyzed and summarized for the upper Midwest estimate that average annual temperature will be 5.8°F warmer by 2069. An increased frequency of high dew points (increased water vapor in the air) in summer months will result in more heat advisories. Climate change projections indicate that precipitation will be 6-8% higher by 2069, but the precipitation is anticipated to exhibit higher variability and greater extremes. This could mean too much water in too short of a period at some times and not enough water when and where it's most needed at other times. Implications for every aspect of water supply, demand, and quality, as well as ecosystem health, are considerable and need to be factored into planning for sustainability.

DEMOGRAPHICS. Aging, combined with growth and increased diversity, will lead to challenges and opportunities for Minnesota. Minnesota's population is projected to grow to 5.7 million by 2015 and 6.4 million by 2035. These population gains will be driven by both natural increase (more births than deaths) and by net in-migration (more people moving in than moving out). The Twin Cities suburbs and the Rochester and St. Cloud regions are all expected to see substantial growth over the next 30 years. The "lakes" area of north central Minnesota is also projected to grow more than 35 percent over the next 25 years, thus putting increased pressure on fragile lake environments. Slow growth or decline is projected in much of western Minnesota and in the core counties of the Twin Cities.

The continued aging of the baby boomers will result in a large increase in the number of people ages 55 to 69 during the coming decade. Between now and 2035, the population over age 65 will more than double, from 623,200 in 2005 to 1,400,000 in 2035. By contrast, the population under age 65 will grow only 10 percent. Implications of these demographic changes on water sustainability for the state as a whole relate most directly to changes in tax revenues and expenditures, not just immediate impacts on water resources. As our state's population ages, more of the state's spending will be directed toward services for the oldest demographic group, while revenues from the working population will decrease in proportion. Nevertheless, movement of people to lake-rich areas could lead to declines in water quality and corresponding declines in property values without careful planning. Researchers at Bemidji State University demonstrated that decreased water clarity (in Minnesota lakes) results in decreased property values.

As the ratio of workers to residents declines, productivity and efficiency of services will need to increase if we are to maintain our current standard of living while sustaining water resources. For example, many communities are responding to population-based challenges to their fiscal health by joining together to buy equipment, provide services, and manage environmental resources.

Not only is the age and placement of the population projected to change, the diversity of the population will also increase. It is expected that minority populations will grow from 16% today to 25% by 2035. The diversity of Minnesota's citizens will affect values around water use and management.

Intentional planning will be critical to balancing water sustainability with competing societal demands as demographics change. Minnesota has been able to do this in the past. Our current success (e.g., economic growth higher than the national average, higher population growth than the rest of the "frost belt," high scores on social and economic indicators, good educational system) is related to planning decisions made more than 50 years ago. The choices we make now will shape our future for the next several decades.

LAND USE. Deforestation, agriculture, urbanization, mining, recreation, wetland drainage and alteration, damming and channelization of streams, and other land use changes will continue to affect water location, movement, and quality. Between 1950 and 1999, the region including Minnesota, Wisconsin, and Michigan experienced a decline of forest, crop, and pasture land of 3.2, 5.4, and 4.0 million acres, respectively, whereas urban and other land uses increased by 2.1 and 10.3 million acres, respectively. These changes were most pronounced in the 1950s and 1980s. Projections of land uses through 2050 are consistent with historic trends—forest and agricultural lands will decline, and urban and other land uses will increase. In Minnesota, forest land is projected to decline by 1.0 million acres, with a decrease of 0.5 million acres in timberland (representing a 10% reduction); a decline of 0.1 and 0.6 million acres on private industrial and private non-industrial lands, respectively, and an increase of 0.2 million acres on public lands. Land used for crops and pastures is projected to decline, 3.2 and 0.3 million acres, respectively, and urban land is projected to increase by 1.8 million acres by 2050.

The forests that cover nearly a third of Minnesota's land area play an important role in the ecological, economic, and social fabric of the state. They support a healthy aquatic environment by providing wildlife habitat, intercepting precipitation, cooling natural waters, filtering out water pollution, and sequestering carbon. These also support a large forest-products industry and provide opportunities for outdoor recreation. Minnesota's forests systems are vulnerable to fragmentation, invasive species, climate change, and increased atmospheric carbon and nitrogen. Conversion of forestlands causes hydrologic modification that can negatively affect water quality. A forested landscape allows at least 90% of the volume of water from rain events to be taken up by plants and returned to the atmosphere or filtered through the soil and reintroduced to the groundwater, improving water quality, providing needed groundwater resources, and preventing excess runoff. After conversion to an urban setting, only 10% of the volume may be infiltrated, resulting in significant high volume, rapid runoff and subsequent unnaturally low water levels, potentially harmful to aquatic species.

Agricultural land use though declining overall has been intensifying, with annual row crops steadily increasing while land in less-intensive perennial crops, pasture, and non-row annual crops has been decreasing. The lack of early-season ground cover in annual row crops decreases protection from soil erosion and nutrient loss and increases the volume of runoff. Agricultural drainage systems often associated with annual row-crop production alter hydrology by affecting peak stream flows and total volumes, and increasing the potential for streambank erosion.

One of the greatest threats to Minnesota's natural resources is the expansion of urban and developed areas, including more urbanized development along lakes and streams. Development results in many of the most significant causes of loss and degradation of Minnesota's resources, including the loss of prime agricultural land, high-quality forests and prairies, pristine shorelines, and open space, depletion of wildlife and aquatic habitat, increased susceptibility to aquatic invasive species, and habitat fragmentation. Hydrologic modification and loading of solids, nutrients, pathogens, and contaminants such as road salt from land conversion interrupt natural watershed drainage and reduce water quality. Removal of land cover and increased impervious surfaces (hard-surfaced areas that prevent water from soaking into the ground) change the volume, rate, timing, and duration of stormwater runoff, increasing the total runoff of sediment, phosphorus, and contaminants to surface waters as well as the erosive power of the stormwater.

The ability for Minnesota to craft a sustainable water future is closely tied to the ability to maintain the quality and integrity of less-developed lands while planning and managing across land uses intentionally and comprehensively.

PROCESS USED to BUILD FRAMEWORK

The University used a highly collaborative approach to ensure that the diverse topics included in the request from the Legislature were appropriately addressed (see Appendix D for a list of all participants and contributors). Participants and contributors included state agency staff from Minnesota Pollution Control Agency (MPCA), DNR, Minnesota Department of Health (MDH), Minnesota Department of Agriculture (MDA), Board of Water and Soil Resources (BWSR), Public Facilities Authority (PFA), Metropolitan Council, and the Environmental Quality Board (EQB); federal agency staff from the US Environmental Protection Agency (EPA), the USGS, University of Minnesota (UM) faculty and staff; private sector professionals; city and county representatives; Watershed District (WD), Watershed Management Organization (WMO), and Soil and Water Conservation District (SWCD) representatives; nongovernmental organizations (NGOs); and citizens. The Water Resources Center (WRC) formed an external advisory committee, the Headwaters Council, made up of 30 thought leaders on water from the state and region. These water experts brought a variety of perspectives and a wealth of knowledge to the process, and reviewed the project from start to finish. The WRC formed a separate committee, the Stakeholder and Citizen Advisory Group, to provide information from the many water-related interest groups in the state as well as interested citizens, and to serve as a conduit for getting progress on the project out to stakeholders and citizens.

Background papers, or “white papers,” were developed by the WRC on the current knowledge of water use, water supply, and the quality of water in Minnesota. Technical Work Teams were formed of discipline-based experts on specific categories of water use, and each of these teams addressed what we know, what we don’t know, and what issues needed to be addressed by the Framework. These teams addressed domestic water use, agricultural use, industrial and energy use, recreational, cultural, and spiritual use, and ecological benefits provided by water. The WRC formed additional teams to summarize water policy, water education, and water valuation. Other contributors were called on for discipline-specific advice or expert consultation.

These white papers, and information from a variety of other sources, were integrated by the Synthesis Team and considered in the design of Framework. The Synthesis Team was a highly diverse group of water professionals known for their broad thinking and ability to integrate complex information. They met intensively over five months, and were charged with advising the WRC on the issues, strategies, and recommendations that make up the Framework.

CROSSCUTTING THEMES and BALANCE CONSIDERED throughout FRAMEWORK

The Framework addresses ten major issues that need action to reach sustainable water use and management. These issues are not independent, but are highly interrelated (see Part III). There were several overarching themes that emerged in the development of the Framework that appear throughout the recommendations, but deserve special mention here. These themes are:

- **SYSTEMS THINKING: Groundwater and surface water are one “water system” and contain and support ecosystems and human systems—water should be managed as a system, and not managed as individual parts**
- **SCIENCE-BASED DECISIONS: Knowledge of the system should provide the underpinning of decisions**
- **DECISION-MAKING IN THE FACE OF UNCERTAINTY: It is not possible to have all knowledge about an issue; one must make decisions based on weight of evidence and allow for new knowledge to continue to inform decisions**
- **ADAPTIVE MANAGEMENT:Build flexibility into policy and decision-making to allow for new knowledge and on-the-ground learning to improve policy over time**
- **WATERSHED-BASED APPROACH: Water does not follow political boundaries, so should be managed based on its boundaries and not counties or other artificial lines. It should be recognized that groundwater also needs to be managed by its boundaries and not political ones. Many policies require a statewide perspective, but implementation is generally best at the major watershed scale.**

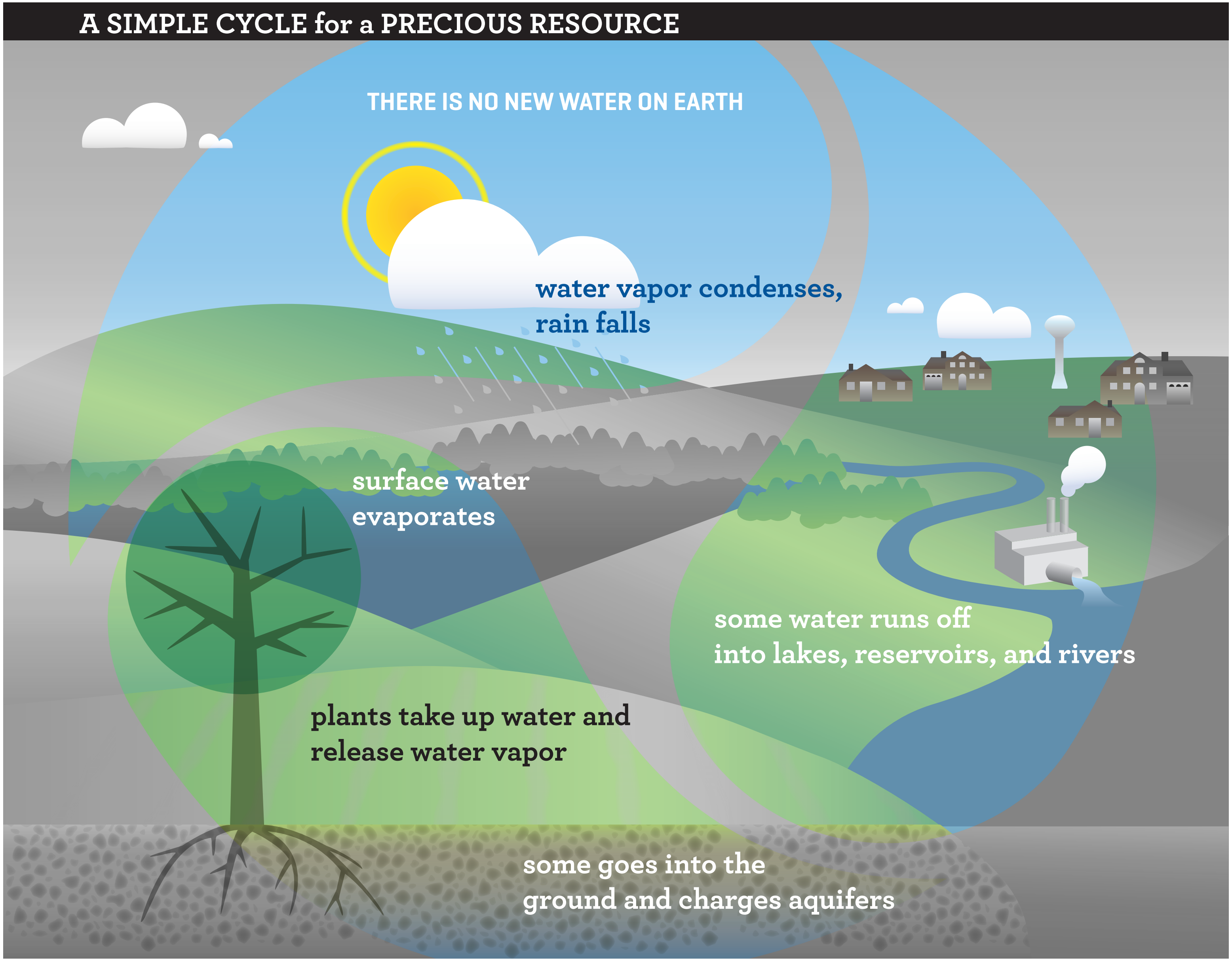


Figure 2-3: Water Cycle

- **OUTCOME-BASED RECOMMENDATIONS: Consistent with the Clean Water Legacy Act, it is essential that actions have clear outcomes for water sustainability and for protecting and restoring water quality and quantity**
- **ACCOUNTABILITY: There is need for government, business, local units of government, and citizens to be responsible and accountable for their actions**
- **SUPPORT FOR COMPLIANCE WITH EXISTING POLICY: While many of Minnesota's policies, laws, and rules are strong, it is important that local capacity be bolstered to ensure compliance**
- **TRANSBOUNDARY STEWARDSHIP: Minnesota is not an island, but must work with its state and national neighbors and share responsibility to affect change—examples include invasive aquatic species, mercury pollution, and federal farm policy. Minnesota also has a special stewardship role as home to the headwaters of three of North America's largest river systems—what is sent downstream matters.**

The Framework balances long-term goals for sustainability with actions that can be taken in the short term, but need to be sustained into the long term to realize the outcomes. It recognizes that a biennial viewpoint must be balanced with a decadal viewpoint. It balances the need for public and private investment and involvement in sustainability, recognizing that investments in the private sector from the public sector are sometimes needed if the benefits accrued affect everyone. The Framework balances recommendations for action by the Legislature, the Executive Branch, and others. The Framework recommendations also incorporate a suite of policy tools, recognizing that regulation is not always the answer and that it provides the least flexibility. These tools include education, voluntary measures, incentives (cost-share, subsidies, tax breaks or credits, market forces) and regulation. They each play a role in achieving a desired policy outcome.

FRAMEWORK POLICY TOOLS

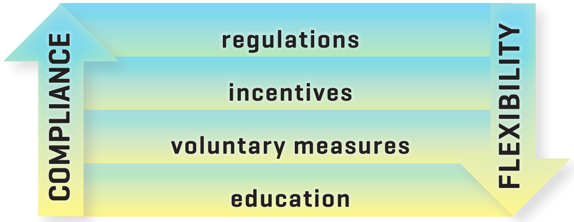


Figure 2-4: Policy Tools

CHANGING MINNESOTA'S FUTURE

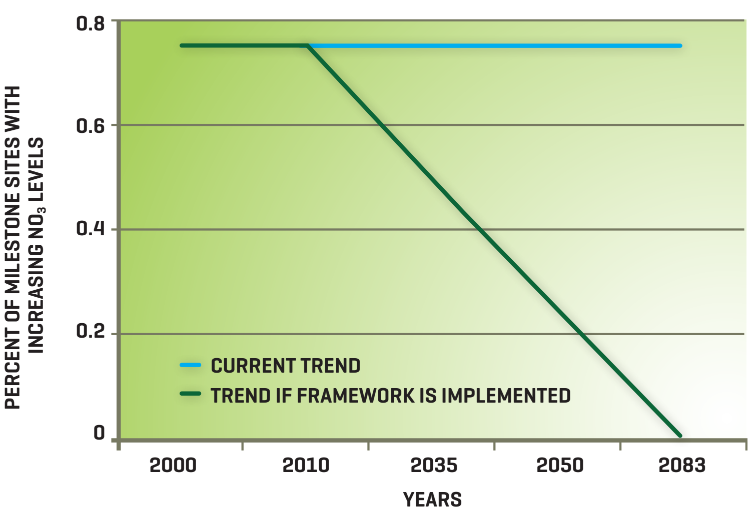
We have a rare moment in history to make the changes needed to put Minnesota on the path to water sustainability. The goal of this Framework is to put us on this path, either by changing the trajectory of measures that are declining, or by accelerating the trajectory of measures that are working. Consider the following examples:

Although many measures of water quality have improved over the last 25 years, nitrate (NO_3) has shown an increase in concentration over time in much of the state. This poses a health hazard to infants who drink that water, and contributes to the hypoxia zone in the Gulf of Mexico. The desired trajectory is to see a decrease in nitrate over time, and reverse the increase.

Minnesota has seen declines in recent years in land set-asides that can protect water quality and flow. The desired trajectory is to see an increase, to protect as much marginal land as possible. There is a clear need to expand drinking water and wastewater treatment facilities as the population grows, to replace them as they age, and to upgrade them in response to new contaminant challenges or changes in standards. The federal revolving funds program for states has diminished in recent years, and the gap between available funds and what is needed has grown and will likely keep growing. The difference will need to be met by a combination of approaches, and the desired trajectory is to reduce that gap with long-term solutions.

The goal of the Framework is to operationalize water sustainability. If the strategies and recommendations are implemented, it will put Minnesota on the right trajectory for the future, on the path to water sustainability.

LEVELS of NO_3 for 69 MILESTONE SITES



SOURCE: MINNESOTA POLLUTION CONTROL AGENCY

Figure 2-5: Levels of NO_3 for 69 Milestone Sites

CROPLAND ENROLLED in CONSERVATION PROGRAMS

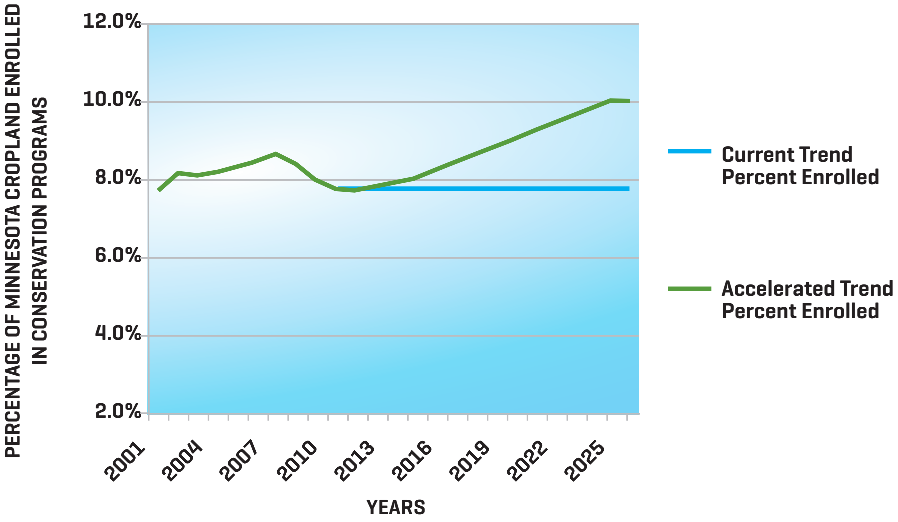
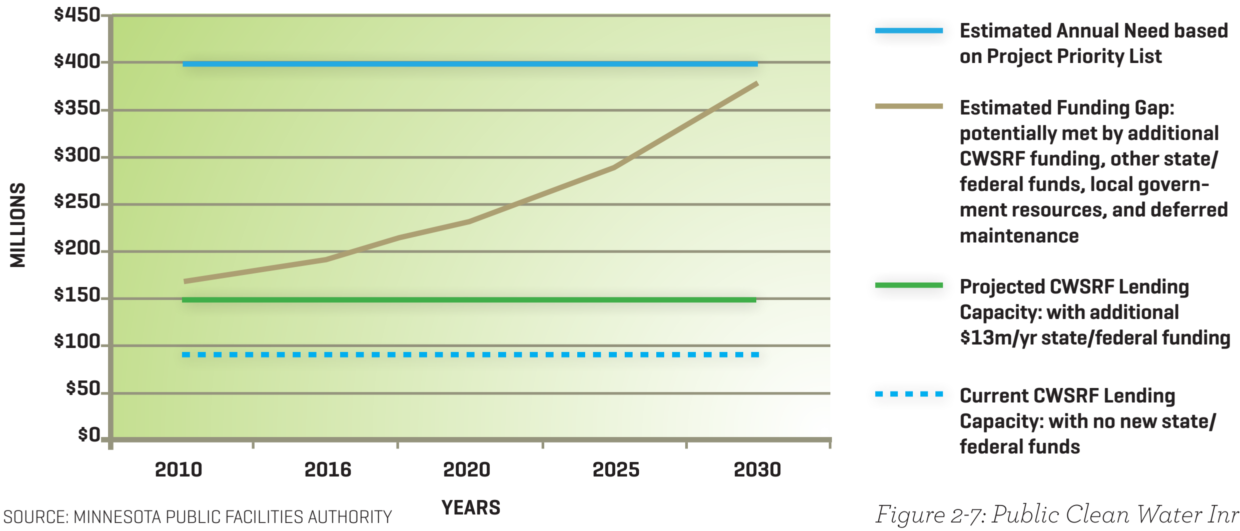


Figure 2-6: Minnesota Cropland Enrolled in Conservation Programs

PUBLIC CLEAN WATER INFRASTRUCTURE FUNDING GAPS



SOURCE: MINNESOTA PUBLIC FACILITIES AUTHORITY

Figure 2-7: Public Clean Water Inrastructure Funding Gaps

DRIVERS of CHANGE for WATER ISSUES

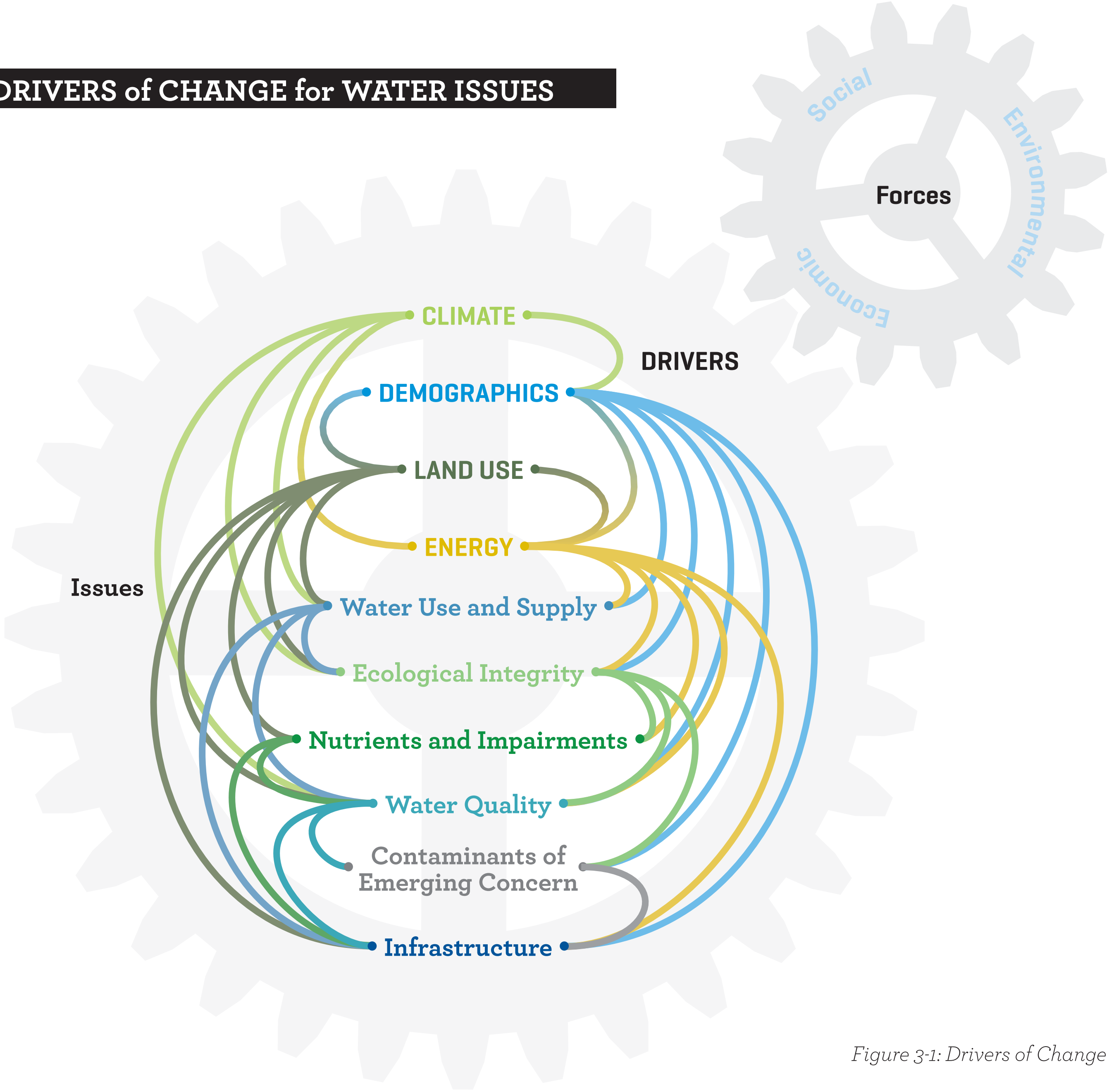


Figure 3-1: Drivers of Change

Part III

Issues, Strategies, and Recommendations

THE PROCESS UNDERTAKEN TO DEVELOP THIS FRAMEWORK identified 10 overarching “big issues” related to water quantity and quality of significance to Minnesota. In addition, these issues have been identified by several national studies (National Research Council reports, International Joint Commission studies, Water Resources Research Institutes survey), and verified as relevant to Minnesota through an expert consultation held by the WRC in July 2009. The technical work teams identified nearly 100 specific problems that need attention to reach sustainability (see Appendix E for a list of the specific concerns). The issues form a logical framework for identifying and organizing recommended actions to resolve them. The WRC believes that by implementing these recommendations, a future in which water use in Minnesota is sustainable can be created—meeting current needs without harming ecosystems, degrading water quality, or compromising the ability of future generations to meet their own needs.

These ten issues are not independent, but are highly interrelated. They are also greatly influenced by the drivers of change described in Part II, including climate change, demographics, and land use. An additional driver of change is energy use. As described below, energy and water are intricately linked, and energy production and use are affected by the other major drivers, and in turn are linked to many of the water issues. The water issues are affected by all the drivers, but are also affected by each other. For example, an increase in population means more water demand, which means more infrastructure is needed, and this will result in more water quality problems, including nutrient impairments from urban runoff, more loss of ecosystem integrity due to development, and more contaminants of emerging concern, as they mostly come from consumer product waste. The relationships are shown in Figure 3-1.

The issues are grouped into the three central themes of sustainability—environmental concerns (water quality and quantity, and land/water connection), economic concerns, and social concerns. Strategies for *what* can be done to address these issues are provided for each of the issues, and a desired Minnesota future condition is described. Under each of these strategies, specific recommendations for action (or for research) for *how* to implement the strategy are given. The core objectives (Appendix B), issues, and strategies share broad agreement from the Synthesis Team. The final recommendations are offered by the WRC, based on advice, discussion, and consultation with the Synthesis Team, the Headwaters Council, the 8 technical work teams, and many other professionals around the state and region.

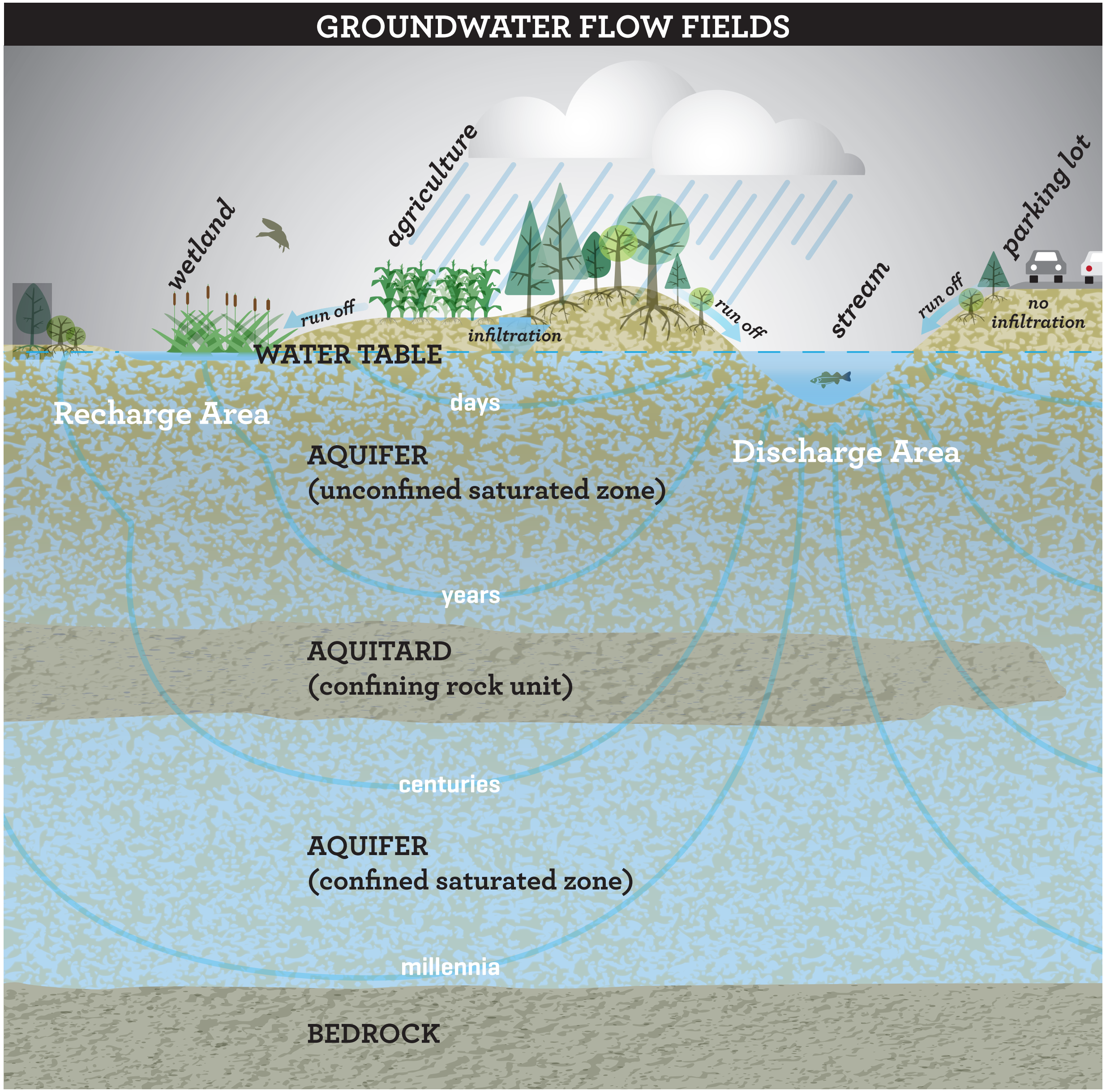


Figure 3-2: Aquifer Flow

ISSUE A: The NEED for a SUSTAINABLE and CLEAN WATER SUPPLY

ADEQUATE AMOUNTS OF WATER IN THE right places, and of sufficient quality, are required to balance drinking water, domestic, manufacturing, agricultural, recreational, and natural resource extraction; and ecosystem needs now and for all time.

Desired Minnesota Future

A water supply that is protected for all future generations that is of high quality and that is sustainable for all uses of water.

PROBLEM STATEMENT: Trend data on the use of water and population growth indicate they are strongly correlated in Minnesota (see Figure 3-3).

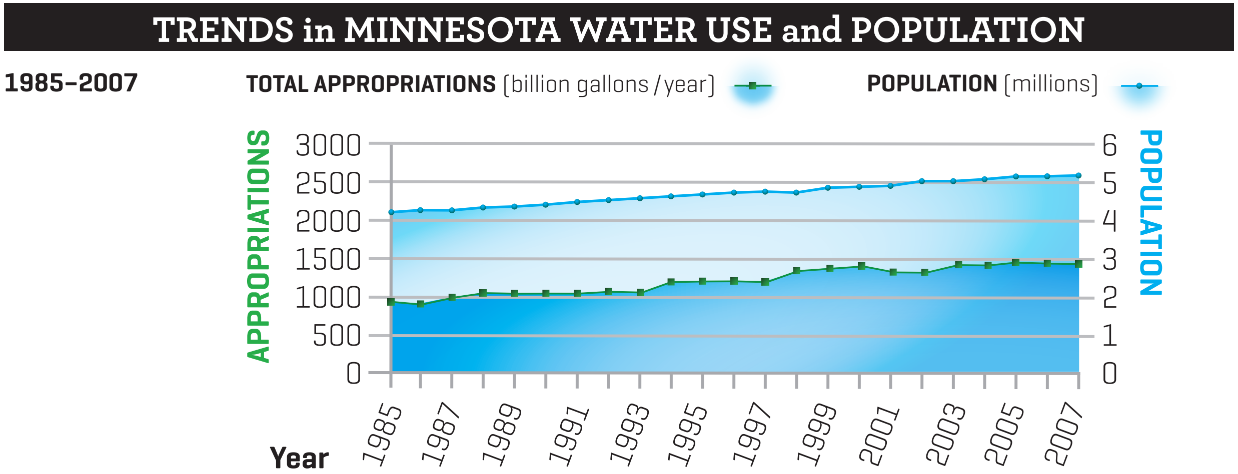

TRENDS in MINNESOTA WATER USE and POPULATION

Figure 3-3: Trends in Water Appropriation

In the rest of the country, per capita water use has leveled off since the mid-1980s, but in Minnesota per capita use has continued to grow. In fact, water use is growing at a faster rate than the growth of population (about 1.6 times faster). Given that population in the state is projected to grow by about 22 percent to 6,446,300 people by 2035 (Minnesota State Demographer office), it is projected that water demand would grow by an even greater amount. So the state would need to reduce its water consumption by about 35 percent over the next 25 years just to stay at today's water consumption. However, there is evidence that today's water consumption levels are not sustainable, particularly in the Twin Cities metro area. The EQB has projected that by 2030, 22 counties may be using more than 10 percent beyond what is considered a renewable water supply, and 18 counties may be using more than 20 percent above what is considered sustainable. Our biggest challenge is determining how much water constitutes a sustainable supply—i.e., how much can be withdrawn without depleting supply beyond a certain threshold. Growing population, climate change, groundwater pollution, fragmented permitting systems, and competing uses of surface water and groundwater mean that the gap between abundant supply and growing demand is quickly closing. As demand increases, a sustainable water supply will require consideration of better conservation practices and reuse of wastewater.

MINNESOTA GROUNDWATER AVAILABILITY

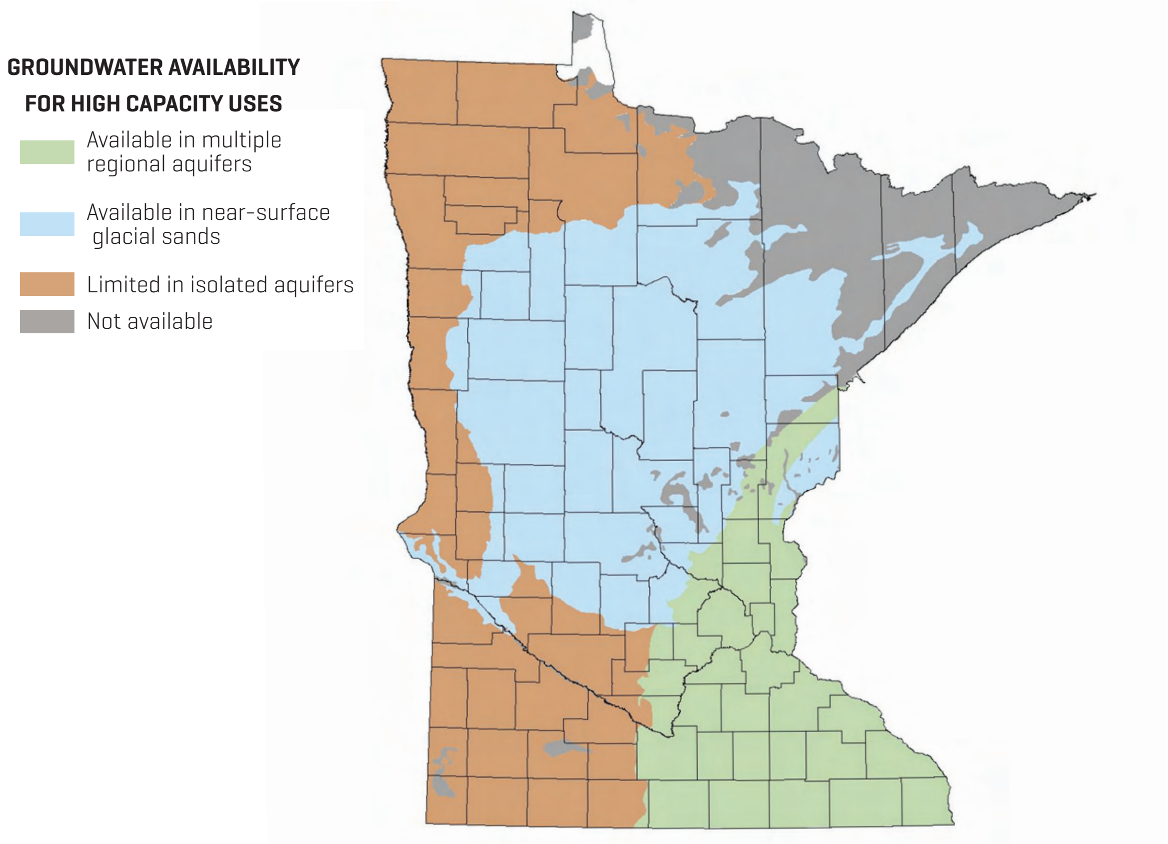


Figure 3-4: Minnesota Groundwater Availability

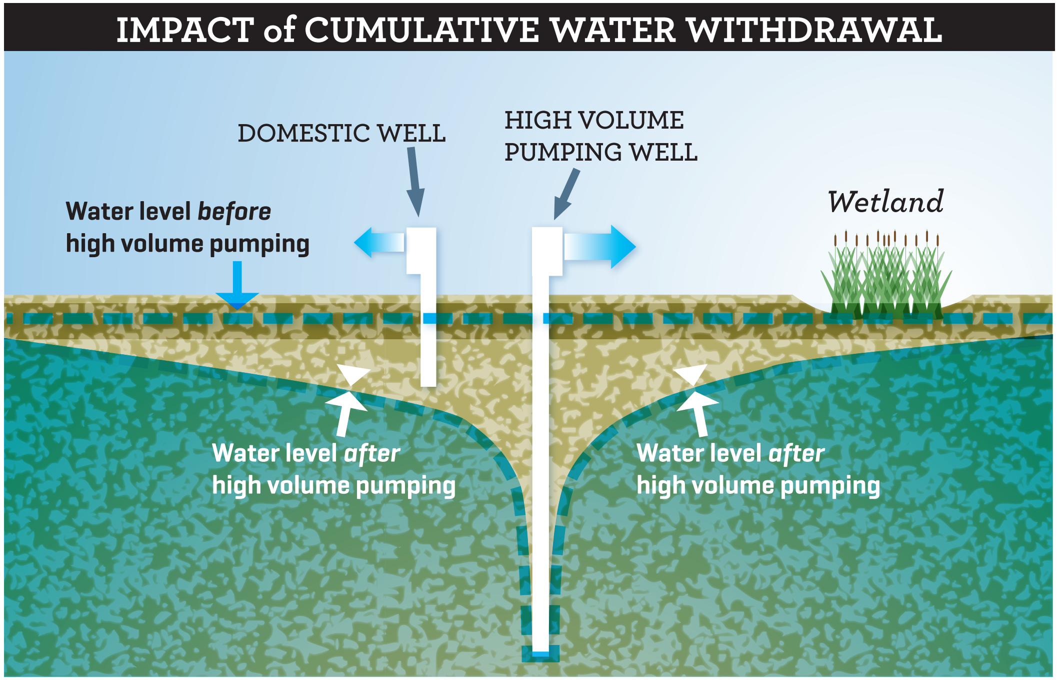
MAP SOURCE: MINNESOTA DEPARTMENT OF NATURAL RESOURCES

A sustainable water supply also depends on having water of sufficient quality. There are many sources of pollutants to surface and groundwater, and when the presence of pollutants exceeds health-based thresholds, it limits the use of water even if there is sufficient quantity. For example, aquifers in the East Metro suburbs that are contaminated with perfluorinated chemicals cannot be used as a drinking water source—another water supply is required until the perfluorochemicals are removed. One of the more pressing concerns is the occurrence of nitrates in groundwater and surface water at concentrations that exceed the maximum contaminant limit (MCL) of 10μg/mL. This limit is to protect infants from developing methemeglobinemia, or “blue baby syndrome.” Children under approximately 6 months of age do not make the enzyme needed to protect their hemoglobin from excess nitrates, and this results in reduced oxygen transport in the bloodstream, causing severe oxygen depletion or even death. Excess nitrates in water are also associated with some forms of cancer, and nitrates in water can disrupt endocrine and other nerve signaling pathways. Specific objectives, strategies, and recommendations related to issues of water quality are addressed here and in subsequent chapters, but the point that quality and quantity cannot be divorced is underscored here.

SPECIFIC CONCERNS related to this issue that have been identified:

- **Surface-groundwater interactions—**Pumping groundwater can reduce flows to surface waters; contaminated surface water can contaminate groundwater and vice versa
- **Groundwater over-withdrawals—**It is not known if groundwater withdrawals are greater than the amount being recharged
- **Need for conservation—**Minnesota’s seemingly abundant water supply has not encouraged aggressive conservation practices
- **Water reuse—**May be necessary to consider as water demand grows
- **Cumulative impacts of multiple water appropriators—**Permit requirements do not address cumulative impacts until there is a conflict
- **Nitrates, arsenic, bacteria in drinking water—**Can pose health risks to private well owners

Figure 3-5: Water Withdrawal Impact



WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: Water sustainability requires knowing the physical water balance of the state. The *water budget* of the state is just like a bank account. Good fiscal management requires knowing what is in your bank statement—how much was deposited, how much was spent, and how much is currently in the account. Your balance is what results from depositing and withdrawing over time. Thus the *water balance* for the state is the amount of water in the state "water account"—the difference between withdrawals and deposits, and as a function of time.

Groundwater drawdown is not a good measure of water availability because it ignores the connection between groundwater and surface water, and it ignores the time lags involved in moving water from shallow aquifers to deep aquifers. Water sustainability requires knowing the physical water balance of the state, which is the quantity of water available over time or what is stored over time in surface water, groundwater, and soil moisture. Consider the hydrologic cycle, as shown in the Introduction. This depends on the inputs of water from precipitation, overland flows, base flows to streams, infiltration rates to groundwater, outputs of water from evapotransporation (loss of water to atmosphere from all surface water, soils, and plants), movement of water from shallow aquifers to deep aquifers, and withdrawals or use of water by humans. Changes in storage can include changes in aquifer storage as reflected in water table elevationsor changes in surface water storage as reflected in lake levels. When a change occurs in one component of the water budget, the change is offset by a change in another component or components.

Change in water storage over time
= (all inputs over time) – (all outputs over time)
= (precipitation, surface flows) – (surface outflows, infiltration, withdrawals, evapotranspiration)

Lake level and surface storage are well characterized, but groundwater storage is not. Past and current precipitation is very well known; the ability to project future precipitation on a regional basis has a great deal of uncertainty. Infiltration rates are very difficult to measure, and they are not well known for Minnesota in general. The use of water for all major categories (domestic, industrial, recreational, agricultural, etc.) is well characterized by the DNR and the USGS. This information is detailed in the project white paper entitled "Water Use in Minnesota." Assumptions of future demands for water can be made based on projections of population growth. Evapotransporation is a significant term in this equation, and yet it is the least well-characterized term.

Minnesota's water appropriation permitting rules do not regulate withdrawals based on the impact on water balance (since it is not known), but regulate appropriations through a system that requires a permit for withdrawals of 10,000 gallons per day or greater. Permits are generally granted, and then revoked or suspended if there are conflicts among users, such as if groundwater pumping impacts surface flows nearby. While this is a reasonably strong permitting system, it has two main weaknesses. One is that an "impact" is defined as dropping below a physically defined flow of surface water, known as the Q90 flow threshold. This is relatively arbitrary and does not protect ecological functions. In other words, it does not protect against biological impacts. These are also known as "ecosystem services." Ecosystem services is a term that refers to the collective benefits to humans that natural ecosystems provide, such as flood regulation and filtering of contaminants by wetlands or the recreational opportunities they support such as fishing, hunting, and boating. The DNR commissioner currently has statutory authority to "develop and manage water resources to assure an adequate supply to meet long-range seasonal requirements for …fish and wildlife" in state waters (Minnesota Statutes, section 103G.265). While it can be construed that this includes ecosystem services, there are no quantitative thresholds defined or implemented to protect against ecosystem impacts.

A second weakness of the permitting system is that impacts of cumulative extractions are considered in the current statutory language, but there are no science-based indicators defined and implemented.

Drinking water from Minnesota's 7,200 community water supply systems is regulated by the federal Safe Drinking Water Act under the jurisdiction of the MDH. Approximately 80% of the state's population is served by these community systems. The Safe Drinking Water Act requires the regular testing of approximately 100 contaminants, and requires notifying the public when violations of the standards occur and advising them of immediate action regarding their water. In addition, an alternate supply of drinking water is provided until the violations are addressed. All community water systems issue an annual Water Quality Report (or Consumer Confidence Report) that lists the source of the system's drinking water as well as a list of all regulated contaminants that

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **The state's water balance is poorly known. An understanding of the water balance, uses/withdrawals, recharge rates, and amounts of stored water in layered aquifers is needed, all as a function of time. Recharge rates and flows between aquifer systems are particularly unknown.**
2. **The minimum base flows in surface water that are needed to protect ecosystems and sustain other uses are not known.**
3. **The impacts of climate change on future base flows are not known (and likely will never be known with certainty).**
4. **The cumulative impacts of multiple extractions from groundwater, especially the impacts on base flow over time, are not known.**

POLICY GAPS

1. **Resolution of water withdrawal permit conflicts is based on a hierarchy of water uses rather than on a sustainability objective.**
2. **Cumulative impacts of multiple water extractions are not sufficiently considered in issuing permits.**
3. **Only water quantity, and not water quality, is considered in permitting.**
4. **Water sustainability principles are not adequately included in water policies, energy policies, agricultural policies, or land development policies.**
5. **Water reuse policies are needed for Minnesota in anticipation of the time when there will be sufficient demand for reused water.**
6. **Policies to protect public health from nitrate, pesticides, and other contamination of private drinking water wells are insufficient.**

were detected, even in trace amounts well below the legal standard, during the previous calendar year. As a result of the Safe Drinking Water Act, the U.S. is considered to have the safest drinking water in the world. Minnesota has had relatively few violations over time. In 2009, there were no violations for pesticides, industrial chemicals, or nitrates; 13 violations for bacteria; 40 violations for arsenic (reduced to 10 by the end of the year); 10 violations for radium; 2 exceedances of the lead and copper advisory. MDH annual reports and a summary of the state's drinking water quality from 1999 to 2007 can be found at http://www.health.state.mn.us/divs/eh/tracking/dwreport.pdf. Water is reused in Minnesota, but the cost of the infrastructure is not balanced by demand. Currently, the MPCA has permitted over 214 municipal wastewater facilities for reuse. Stormwater reuse is being practiced on golf courses, city parks, ball fields, etc., and can be an effective tool to bring post-development runoff volumes down to pre-development levels. Water reuse technologies have been effectively employed in Singapore, Arizona, and, to a lesser extent, California. Cities like Las Vegas and small cities in Colorado have included water reuse in water management. While there is modest demand for water reuse in Minnesota at present, it will be an important strategy for the future and the state should position itself to be able to respond when demand grows.

A.1 OBJECTIVE: To know the water balance of the state so that it can be managed sustainably and responsibly.

A.1 STRATEGY: Institute a system for permitting in the short term that is based on flow regimes that protect ecosystem services, and develop a long-term strategy for understanding Minnesota's water balance. Design a water use system that recognizes Minnesota's water balance and ecosystem needs. Protect drinking water.

A.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability; *measures* refers to the indicators that are used to assess progress; and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- Protection of ecosystem functions, as measured by monitoring of ecosystem indicators (in development by the MPCA) in various flow regimes included in permitting ➲ BENCHMARK: 90 percent of ecosystem indicators meet state biological standards in 10 years
- Fewer cumulative impacts from multiple withdrawals, as measured by declining reports of water use conflicts between permittees ➲ BENCHMARK: No reports of conflicts among users in 10 years
- Complete picture of groundwater resources in Minnesota, as indicated by rate of completion of county geologic atlases and aquifer characterization and streamshed mapping ➲ BENCHMARK: Atlases and aquifer mapping completed for 80% of state (including all priority areas) within 12 years
- Complete understanding of Minnesota's water balance—full inventory and all major flows and exchanges—as indicated by completed water balance planning modeling tool and necessary data ➲ BENCHMARK: Hydrologic monitoring network in place by 2012, and data collection fo modeling available beginning 2017 ➲ BENCHMARK: Calibrated and validated planning tool to plan for major aquifer effects from a variety of scenarios, including population, demographics, climate, land use change, and water use change by 2030

The following actions are recommended to implement this strategy:

RECOMMENDATION A.1.a: Determine the state's water balance. Develop a long-term robust program that includes the necessary mapping and monitoring to manage water sustainably and proactively. This should be implemented by state agencies and informed through cooperation with other experts. The Framework endorses the detailed plan and recommendations found in *Evaluation of Models and Tools for Assessing Groundwater Availability and Sustainability* (DNR, 2010).

Action Plan: Mapping

i. The completion of the county geological atlases by the Minnesota Geological Survey (MGS) and DNR should be accelerated. At a minimum, the current investment should be doubled to allow completion in about 10–12 years. These atlases provide maps of geology, hydrology, and pollution sensitivity of groundwater, and are one of the essential elements for implementation of this strategy. The atlases should be completed in priority order, focusing on the most sensitive and important aquifers first (such a priority list is currently in development by the Interagency Groundwater/Drinking Water Team). Eventually, these atlases should be supplemented with additional information such as water quality information. The atlases should be reviewed and updated as needed on a regular schedule.

ii. Aquifer characterization mapping by the DNR should be accelerated at the same rate as the geologic atlases. The aquifer characterization studies and springshed mapping are essential for understanding how water moves through the state's aquifers (flow paths), and determining aquifer properties and interactions between groundwater and surface water.

Action Plan: Monitoring

iii. Support the necessary expansion of data collection needed to model the state's water balance. These data describe the system's behavior, and include all aspects of the hydrologic cycle. In many cases these data are being collected, but not at the frequency needed or spatial resolution needed to be useful [see *Evaluation of Models and Tools for Assessing Groundwater Availability and Sustainability* (DNR, 2010)]. A state-of-the-art hydrologic monitoring network is needed that includes geochemical, biological, groundwater level, streamflow, and climate data at appropriate time and space scales.

Research Plan

iv. Develop the tools needed to define and manage the water balance for water managers, land use planners, and developers, and for permitting. This is a long-term goal, and will require the investments described above. This will require the following specific actions: (1) develop complex hydrodynamic models, for different scales; (2) define and implement groundwater management areas; (3) gather the necessary data defined in *Groundwater Sustainability: Towards a Common Understanding* and the extensive and detailed *Guidance for Developing a Groundwater Management Plan* (Water Resources Center and the Freshwater Society, 2009) and in *Evaluation of Models and Tools for Assessing Groundwater Availability and Sustainability* (DNR, 2010); and (4) apply the models to those groundwater management areas using the *Guidance*. The model must have the capacity to include modeling predictions for future conditions of precipitation, temperature, other changing climate variables, population increases, development patterns, etc., and be constructed to adapt to new and changing information and knowledge. The state should begin this process immediately but incrementally, starting in areas where water conflicts are already apparent (Bonanza Valley, Moorhead, others).

TIME FRAME: 1–12 YRS COST*: H

RECOMMENDATION A.1.b: Improve the water withdrawal permitting system in the short term by incorporating a screening system for permit applications and including a sustainability threshold for extractions based on flow regimes that protect ecological functions.

Action Plan

i. The DNR should develop a Web-based, water extraction permit screening system. The screening tool should consider existing permits in assessing effects of cumulative withdrawals for a given permit (i.e., consider new withdrawals in the context of existing withdrawals). Special hydrologic regimes such as fens and wild rice paddies would need special attention. Such an approach has been developed by Michigan, and it could be readily adapted for use by Minnesota. The permitting scheme could use existing stream statistics for surface water, and a simple model could be developed and added for groundwater. Such a system will streamline the permitting process and has the added benefit of getting permits and data into an electronic system, streamlining data reporting. The state agencies should develop and include indicators of cumulative impacts from multiple extractions, and eventually link permits and allowable withdrawals to a long-term planning model (see Recommendation A.1.a).

ii. The permit screening tool should incorporate ecological thresholds (see iv. below) rather than the current "Q90" flow as the threshold for when a permit should be suspended or granted in the first place. The rules governing permits should be strengthened to explicitly include protection of ecosystem services under DNR authority. The DNR capacity to determine ecological thresholds should be expanded. The permitting system should also include provisions to prohibit waste and encourage water conservation and wise water use.

iii. The state should restrict bottling and export of Minnesota water for commercial out-of-state sale, as have Wisconsin and Michigan.

Research Plan

iv. The DNR should determine ecological thresholds as a definition of sustainable water supply in regards to allowable water extractions. The DNR should consult with additional experts, including ecologists and hydrologists. The different types of flow regimes in Minnesota (the pattern of flow in a river or stream that can be described in terms of quantity and variability of water flows) need to be described and ecological thresholds established for each (how ecological components and key species respond to variable flows). Several indicators should be considered to define thresholds (even several per regime) until the best combination is established. The description should eventually include water quality parameters and conditions as well as flow. The Nature Conservancy has begun such a project in the upper Great Lakes region, including Minnesota, and Minnesota's efforts could build on this ongoing work. Also, the biological condition gradient approach to ecological standards being developed by the MPCA could be adapted to this purpose. .

TIME FRAME: 1–5 YRS COST*: M

**Cost: M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

A.1.a.i-iv: Due to the complex layers of shallow aquifers connecting to deep aquifers, effects of shallow-water extractions on the water storage of deep aquifers are poorly understood. In addition, there are long time lags between deep aquifer withdrawals and the subsequent effects on surface water streamflows. Thus, for true sustainable water management, we need to know our entire water balance, including deep aquifers, and design a planning model that will allow for predicting impacts of surface water and shallow and deep aquifer extractions, as well as the predicted impacts due to development, climate, etc. While the DNR is committed to moving toward groundwater management units, it cannot do adequate planning without these investments in mapping, monitoring, and research. MGS has completed or is in process of completing 25 of the 87 atlases. At the current rate of investment, they will not be completed for another 24 years. These atlases are a critical component for long-term planning. In addition, the current monitoring efforts need to be expanded to a finer spatial scale and to collect more data more frequently, within the context of a coherent hydrologic monitoring program.

A.1.b.i: This recommendation borrows from a successful approach developed and implemented by the state of Michigan. Potential permittees provide initial data online to determine if their permit request can be granted or if it will need additional consideration. Minnesota has the necessary data to develop this approach. Improvements to the Michigan approach are included, such as adding cumulative withdrawals as part of the screening process. Impacts of cumulative extractions are considered in the current statutory language, but again there are no science-based indicators defined and implemented. Eventually the ecological thresholds developed from recommendation C.1.a should be included in the screening tool.

A.1.b.ii: This recommendation recognizes and builds on the strengths of the current permitting system. A weakness of the current system is that the Q90 threshold is relatively arbitrary and does not protect ecosystem functions or benefits. These two changes to the statute (addressing cumulative impacts, and using ecological thresholds rather than a flow threshold) and to DNR authority would significantly move Minnesota toward sustainable water management. Groundwater withdrawals can have impacts on surface water. Declining surface flows from water extractions can have impacts on ecological function, and there are numerous DNR examples of this happening. Thus, this recommendation addresses the protection of ecological needs of water and surface water–ground water interactions by defining ecological-based thresholds of surface flow. Ecosystem needs vary by the type of water regime, be it a cold-water stream or a shallow lake or a wetland, and by flow quantity and rate.

A.1.b.iii: This situation arose in Wisconsin, when Perrier attempted to obtain permits for groundwater withdrawal and bottling in Waushara and Adams Counties. This contributed to the passage of the Wisconsin Ground Water Quantity Management Law (2003 Act 310). Most of our watersheds and groundwater resources are not protected by the Great Lakes Compact, which only applies to exports of water from the Great Lakes and its watersheds (but serves as a good model). Having a law in place that protects our water from exportation might put us in good stead when water-scarce states come knocking at our door.

A.1.b.iv: The Nature Conservancy project, "Ecological Limits of Hydrologic Alteration" or ELOHA, is a scientifically robust and flexible framework for assessing environmental flow needs across large regions, when time and resources for evaluating individual rivers is limited. Using this scientific information, water managers and stakeholders can develop regional environmental flow targets and apply them to rivers of their region to protect ecological needs. See http://www.nature.org/initiatives/freshwater/resources/art23977.html for more information.

A.2 OBJECTIVE: To ensure adequate and safe drinking water is available to all Minnesotans from private as well as public supplies.

A.2 STRATEGY: Reduce risk from private well drinking water by better statewide management and education.

A.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Safe drinking water from private wells, as indicated by data provided by homeowners on nitrates, pesticides, arsenic, and radium**
  ➲ BENCHMARK: **All private wells identified, inventoried, and mapped by 2015**
  ➲ BENCHMARK: **80 percent of private well water quality data added to database by 2020**
  ➲ BENCHMARK: **<5% of private wells report contaminant levels in excess of state standards by 2020**
  ➲ BENCHMARK: **any well with reported contaminant levels in excess of state standards remediated to meet standards within 1 year of reporting**

The following actions are recommended to implement this strategy:

RECOMMENDATION A.2.a: Track and reduce pollutant contamination of private wells. The state should:

i. Require all private wells to be tested at the time of property sale or refinancing for nitrates, bacteria, and arsenic, and data reported to the MDH. If nitrates are above the MCL, the well should be tested for pesticides in common use as recommended by the MDA, given the strong correlation of nitrate and pesticide application and occurrence.

ii. The MDH should develop and maintain a geographic information system (GIS) database of the location of each private well and its contaminant concentrations, and should identify aquifers or hydrologic zones with elevated risk.

iii. Require counties to offer annual private well testing clinics, through UM Extension, county departments, or the private sector. These clinics should offer low-cost or cost-share analysis for coliform bacteria, nitrate, and arsenic using state-certified lab protocols and subsidized by state funds.

iv. Fund a public education campaign encouraging private well owners to test their well water every 2–3 years (as per current MDH recommendations). This should include the development of outreach materials that help well owners understand the need for testing and how to test, what test results mean, how to minimize risk and correct problems, and when they should get additional water analysis for contaminants such as pesticides.

TIME FRAME: 4 YRS COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

A.2.a: Minnesota's public drinking water is well managed, and now has systems in place to address new contaminants of emerging concern. This recommendation focuses on the other 20% of the state's residents who drink private well water, and the need to better ensure their water is also safe to drink. These residents need to be encouraged to test and report their data, and educated to understand why. The state (MDH) needs to know where these wells are and track what is known about them.

A.3 OBJECTIVE: To be prepared as a state with a strategy and framework to implement water reuse when the increased demand for water makes water reuse a more cost-effective supply option.

A.3 STRATEGY: Develop a long-term policy for water reuse that specifies water use categories, develops associated water quality standards, and identifies infrastructure needs.

A.3 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **A coherent strategy for water reuse, as indicated by identified categories of use, standards, implementation time frame, and plan for financing infrastructure needs.**
  ➡ BENCHMARK: **A fully articulated plan in 4 years**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION A.3.a: Plan for water reuse. The state agencies, in consultation with outside experts, should: (1) identify and evaluate all water reuse strategies and applications; (2) recommend applications relevant to Minnesota's seasons, geographical water use, soil types, and rainfall; and (3) recommend an implementation strategy.

TIME FRAME: 2–4 YRS COST*: L

RECOMMENDATION A.3.b: The MPCA and MDH should work together to set appropriate standards for water reuse applications identified in Recommendation A.2.a (e.g., drinking water vs. lawn watering vs. irrigation vs. industrial processing).

TIME FRAME: 2–4 YRS COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

A.3.a: As population increases, water consumptive use will increase even faster. Thus, to just stay even, we must find ways to reduce consumptive use. This will require the reuse of water in areas of greater water scarcity and in applications that do not require the use of high-quality (i.e., potable) water. Priority areas for water reuse may include urban areas where water withdrawals and impervious surfaces restrict infiltration and lower the water table, thereby reducing base flows in streams. Standards written for one end of the spectrum of possible stormwater reuse sites, such as a playground or ball field, may be inappropriately restrictive

CAROLYN SAMPSON, ENVIRONMENTAL MANAGER

CAROLYN SAMPSON, AN ENVIRONMENTAL manager for the Innovation, Technology and Quality Division at General Mills, is a member of the Minnesota Water Sustainability Framework project's synthesis team, which is charged with pulling together the Framework's nine subject-specific work team recommendations.

While Sampson was recruited for her technical expertise, the team has also benefitted from her personal interests. She's a dedicated conservationist and outdoors woman, and has chaired and served as a longtime member of the Friends of the Boundary Waters Wilderness board.

Her employer's commitment to sustainability and environmental improvement is impressive, too. Since 2006, General Mills has reduced its water usage rate by 9 percent—nearly twice the company's 5 percent goal.

And General Mills has set even more ambitious sustainability goals for the future. The company has pledged to reduce its water usage, energy usage and greenhouse gas emission rate by 20 percent by 2015, and to trim its solid waste generation rate by 50 percent by then.

"General Mills is committed to protecting and conserving our natural resource base because it's the right thing to do and because our business depends upon those resources being plentiful in the future," says Sampson.

An important part of Sampson's work at General Mills involves overseeing water-related compliance and regulatory requirements for the company's three main research and development facilities.

The largest facility, located near its corporate headquarters in Golden Valley, operates three wells and has an industrial waste discharge permit (wastewater). Each year, the regulatory reporting portion of her work requires Sampson to submit multiple hard copies of reports or applications—all containing similar information—to multiple agencies, including the Metropolitan Council, Minnesota Department of Natural Resources, City of Golden Valley, and Minnesota Department of Public Health.

While Sampson sees great value in tracking and reporting, the current process is cumbersome and a little confounding.

"In business, productivity is everything," she says. "My time and that of others could be much better spent solving technical problems—or better yet, creating and implementing new methods of sustainability."

Not only is the reporting and permitting process onerous, says Sampson, but there's currently no statewide, water-related database that allows companies to easily track trends, model performance, or plan for the future.

"It's a simple technological issue. The state lacks an integrated and accessible data management system for water quantity and quality that allows for electronic reporting and permitting, as well as forecasting," she says.

As a solution, Sampson supports the Framework's recommendations for a Web-based water reporting and permitting database. Such a system not only would make it more efficient for industry to file reports, but could help businesses and communities plan and forecast.

"Once you populate a database, it could be used for a variety of purposes, from running reports to tracking trends and characteristics," says Sampson. Electronic tracking of permitting and withdrawals would also help managers of natural resources line up withdrawals with resources to better protect ecosystems, as well as Minnesota's long-term water budget.

Sampson believes that implementation of the recommendation will give clear signals to industry that the state encourages careful planning and sustainable practices. "Ambiguity is the toughest thing to plan for," she says. "The Framework's recommendations to create a comprehensive, Web-based system would result in regulatory stability and help industry better forecast and plan."

for other reuse sites such as natural areas with little potential for human exposure, and vice versa. A facility's wastewater could be used for its cooling water where there are not points of human contact. It is also much less expensive, and much less energy intensive, to clean already-treated wastewater for watering purposes than to withdraw raw water and clean it to the same level. In June 2010, the MPCA updated its reuse guidance and deregulated some of the regulatory requirements associated with reuse.

A.3.b: To what standard water that is reused must be treated depends on its use. Reused water suitable for drinking water must meet federal and state drinking water standards, while reused water for cooling can meet less stringent standards. Currently, the California Criteria are used as the basis of regulating reuse in Minnesota (MPCA and MDH have had a Memorandum of Understanding to accept these criteria since the 1980s). This has been done *absent a rule* using the agency discretionary authority. The California Criteria establish levels of purity based on the type of reuse. The standards for different applications need to be determined by rulemaking by a team from the appropriate state agencies.

TIME FRAME for COMPLETION of ISSUE A RECOMMENDATIONS

Recommendations for Issue A will take varying amounts of time to act on and implement. The times shown in the chart below represent the time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frames for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Some of the Recommendations depend on others being implemented first—for example, the water balance of the state cannot be determined before the county geologic atlases are completed and the monitoring and modeling are underway. Research Recommendations (Recommendations that address a need for additional scientific or technological understanding) are shown in blue to distinguish them from action Recommendations in black (Recommendations for changes that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

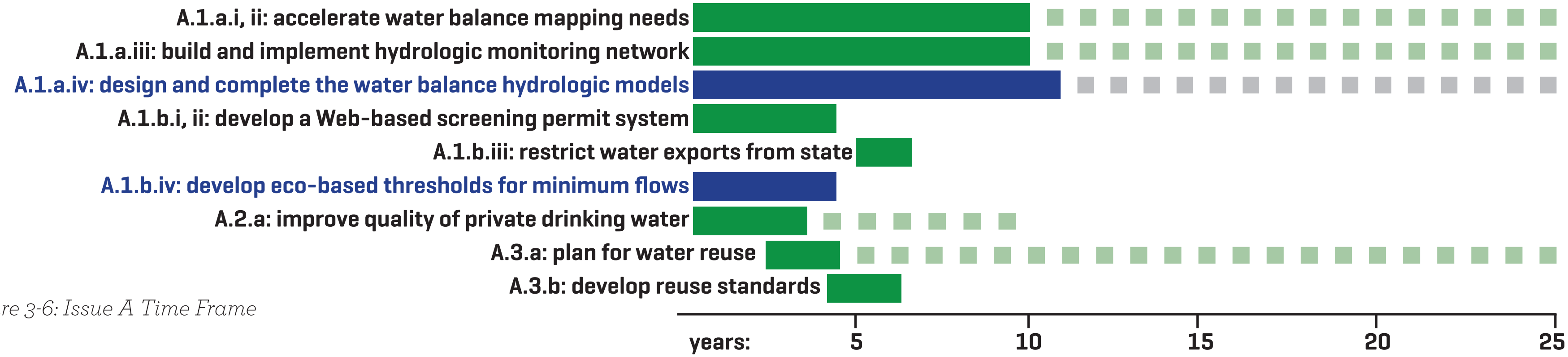
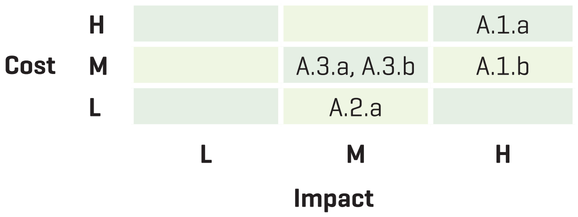


Figure 3-6: Issue A Time Frame

IMPACT MATRIX for ISSUE A RECOMMENDATIONS



Cost	H			A.1.a
	M		A.3.a, A.3.b	A.1.b
	L		A.2.a	
		L	M	H
			Impact	

This figure indicates the impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), relative to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

Figure 3-7: Issue A Impact Matrix

ISSUE B: EXCESS NUTRIENTS and OTHER CONVENTIONAL POLLUTANTS

INPUTS OF NUTRIENTS INTO SURFACE AND groundwater must be reduced. Excess phosphorus and nitrogen reaching lakes and rivers can cause excess algal growth, fouling clear waters, depleting oxygen, killing aquatic life, and disrupting food chains from Minnesota lakes and rivers to the Gulf of Mexico, the Great Lakes, and Lake Winnipeg. Excess nitrates and pesticides that leach into groundwater used for drinking pose risks to children's health. Suspended sediment in rivers and lakes causes turbidity impairments throughout the state. There still remain contaminated sediment hot spots contaminated with "legacy" chemicals such as polycholrinated biphenyls (PCBs). Local fish containing mercury and PCBs pose a health risk if eaten without restriction.

Desired Minnesota Future

The "Land of Unimpaired Waters," where we have met all our water standards for nutrients and solids, we are not contributing to eutrophication problems beyond our borders, we can safely eat local fish.

PROBLEM STATEMENT: Excess nutrients are regarded as one of the top three water quality problems in the country, and have been for decades. A recent study by the USGS reported that the situation is not improving, especially in agricultural and urban rivers and streams.

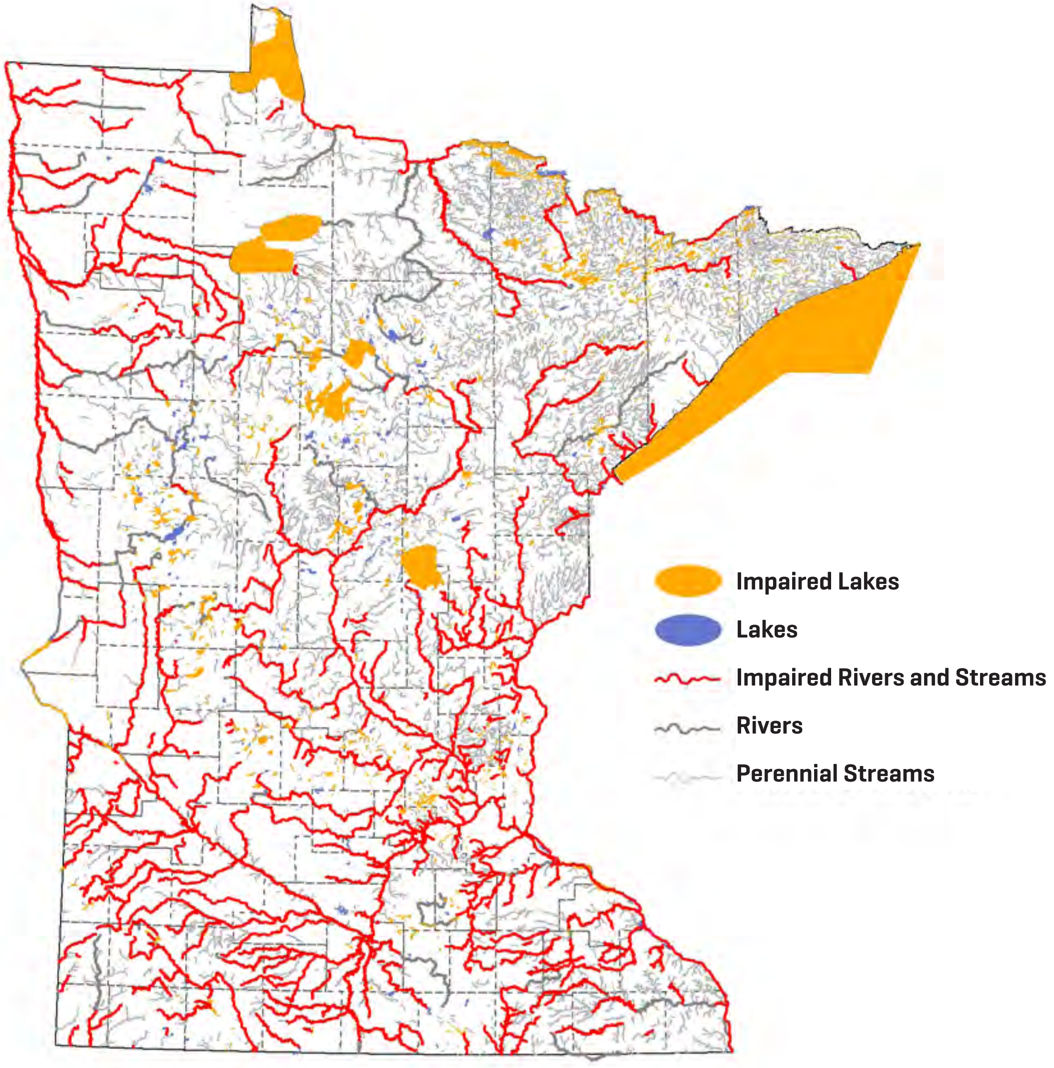
The federal Clean Water Act was enacted in 1972, and it requires states to (1) designate what beneficial use is appropriate for each specific water body (lake or river stretch) ; (2) set water quality standards for certain pollutants for each beneficial use; (3) assess all waters as to whether they meet these water quality standards; (4) report to the EPA every 2 years the list of waters that do not meet standards [the "Impaired Waters" or 303(d) list]; conduct a study on each impaired water body to determine the sources and needed reductions of pollutants needed to meet water quality standards. This is known as the total maximum daily load (TMDL) of a given pollutant that would need to be reduced in order to meet the standard. The TMDL is often likened to a putting a lake on a diet—what is the ideal weight (the standard) and what is the reduction in calories a day (or reduction in pollutant load) needed to achieve that weight. The reduction in pollutant load is shared, or allocated, across all the different sources of the pollutant to that water body. The next step is to prepare an implementation plan for achieving load reductions; however, these are not reviewed or required by EPA; they are reviewed by MPCA. There is no requirement to actually implement the implementation plans, however.

As of 2008, about 18% of Minnesota's 12,200 lakes and 14% of the state's 15,000 miles of rivers and streams had been assessed under this requirement. Approximately 40% of assessed water bodies have been listed as impaired (violating state water quality standards). MPCA expects more than 10,000 total impairments statewide once all waters have been assessed. So far 14 water bodies have been removed from the impaired designation following cleanup efforts.

Excess nutrients refers to nitrates and phosphorus that enter surface waters and leach to groundwater due to human activities, and are one of the biggest water quality challenges in the state. Excess nutrients cause algal blooms—most algae in freshwater lakes are limited by phosphorus, and so when phosphorus is added in excess, it stimulates algal growth. This condition is known as eutrophication. Excess nitrates pose a health risk to infants when they occur above a certain level in drinking water (see Issue A: The Need for a Sustainable and Clean Water Supply). Also, excess nitrates that enter the Mississippi River from runoff and drainage flow to the Gulf of Mexico and contribute to the hypoxia zone. These nutrients, phosphorus and nitrate, are used to fertilize crops and boost productivity. However, in excess, they result in water quality problems. In addition to phosphorus and nitrogen coming from runoff and drainage of agricultural lands, other sources include urban stormwater, wastewater treatment plants, underperforming septic systems, loss of nutrient-filtering shoreland vegetation, reductions in forest cover, increases in impervious surfaces

A detailed summary of the quality of Minnesota's water can be found in the Water Quality in Minnesota background paper referenced in Appendix F.

MINNESOTA IMPAIRED WATERS



SOURCE: MPCA

Figure 3-8: Impaired Waters Map

DAVE LEGVOLD, NORTHFIELD FARMER

A HOMEGROWN FARM KID, DAVE Legvold has been working his own family farm of 800 acres of rolling land outside of Northfield, Minnesota, since 1976. On it, he raises corn, soybeans, hay, beef cattle, and, he jokes, "very spoiled golden retrievers." A member of the Minnesota Water Sustainability Framework project's Citizen Stakeholder Advisory Committee, Legvold endorses the Framework's recommendations calling for strengthening total maximum daily load requirements through a statewide nutrient management plan and the establishment of agricultural management areas on the watershed scale. "I heartily endorse the recommendations because, when put in place, the practices will help farmers preserve soil, build up organic matter, keep soil and fertilizers on the farm, and reduce CO_2 emissions," Legvold says. And while Legvold farms for his living, he also believes that boosting the sustainability of farming systems makes sense from an economic standpoint as well as ensuring the long-term productivity of the land.

“Agricultural management areas would give the agricultural community a structure like cities and suburbs have for meeting the requirements, as well as the technical support for farmers who need it,” he says. “We're losing extension agents rapidly, and with increasing local and county cutbacks, there are fewer and fewer people for farmers to tap for expertise. It's getting harder and harder for farmers to hear the voice of innovation and sustainability.”

Legvold believes the key to the recommendations’ success will be to design a system that's farmer-led, self-regulating and performance based. He also believes another key incentive will to be provide farmers with matching funds or financial incentives to facilitate the adoption of precision farming, advanced drainage management and other state-of-the-art practices and technical assistance. “Every farmer I know wants to do the right thing in terms of the environment and his bottom line,” he said. “A financial incentive would go a long way to help bridge the gap in processes and show commitment on the part of the state.” While soft spoken, Legvold doesn't mind the spotlight or the stage. He's a regular in community theater productions, speaks on sustainability issues before professional and community groups, has testified on water-related concerns before the Minnesota Legislature and U.S. Congress, and has been a participant in the Minnesota River–Lake Pepin Friendship Tours project, an effort to bring together “upstream” farmers from the prairies of central Minnesota and “downstream” farmers from the Lake Pepin area in a sort of cultural exchange. Legvold is quick to speak up on behalf of his profession: “I'm for whatever it takes to move the farmer out of the position of blame and into the role of problem solver.”

from development, and increased temperatures and storm intensity due to climate change. Excess nutrients affect water's ability to meet agricultural, domestic, and recreational needs; harm aquatic life; and disrupt water's ability to meet our needs and provide healthy habitat for other species.

Another problem resulting from excess nutrients is the growth of a specific type of algae, blue-green algae. These algae can, at times, excrete toxins known as cyanotoxins, and cause toxic outbreaks known as harmful algal blooms or "red tides." Cyanotoxins can cause skin rashes, severe stomach upset, seizures, or even death in animals and humans. There are many types of blue-green algae that can produce cyanotoxins, and there are many types of cyanotoxins. The factors that lead to cyanotoxin production are not well understood, however. In Minnesota, there have been several instances of pet poisonings by cyanotoxins.

Conventional water quality pollutants are those that are most frequently above water quality standards. They include sediment, pathogens, nutrients, mercury, dissolved oxygen, and pH, and impair a water body's ability to be used for a designated purpose such as fishing, swimming, or serving as a source of drinking water.

Conventional impairments also include persistent, bioaccumulative, and toxic chemicals such as PCBs and mercury. MDH continues to issue fish consumption advisories due to these contaminants, and sediments at the bottom of waterways around the state still containing "legacy" contaminants—contaminants that persist from past practices—that pose risks to human health and ecosystems. Groundwater, which supplies drinking water to 73 percent of Minnesotans through public and private wells, is also contaminated by conventional pollutants. Although the Clean Water Act focuses on surface water, the interconnectedness of surface water and groundwater requires Minnesota to consider both as one integrated system. The main threat to groundwater, nitrate contamination, comes from nitrogen released into the environment from manure, septic system failure, and fertilizer application. Contaminated groundwater can, in turn, contaminate surface water by providing base flow to streams. Other groundwater pollutants include pesticides from farmlands and city lawns and organic pollutants such as PCBs and perfluorinated compounds (PFCs) from former hazardous waste disposal sites.

Mercury, a neurotoxin that accumulates in the aquatic food chain, is found in fish throughout Minnesota. Although it is a naturally occurring element, more than two-thirds of it is released to the atmosphere through human activities such as burning fossil fuels and mining. Because it can cause nervous system damage, MDH issues advisories for limiting consumption of fish from lakes with high mercury levels. Mercury is a particularly challenging pollutant because it can travel long distances in the atmosphere before being deposited. Mercury accounted for about 77% of the listings on Minnesota's impaired waters list—but only 10 percent of the human-generated mercury polluting Minnesota waterways comes from sources within the state. Mercury has been declining in urban and northeastern Minnesota lakes but increasing in southwestern Minnesota lakes.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Unregulated runoff and drainage from agriculture**
- **Unregulated urban stormwater runoff**
- **Underperforming septic systems**
- **Loss of shoreland to development**
- **Stored phosphorus in lake sediments**
- **"Legacy" pollutants such as mercury and PCBs that continue to cause fish advisories**
- **Historic "superfund" hazardous waste sites in rivers, lakes, and harbors that have not yet been cleaned up**

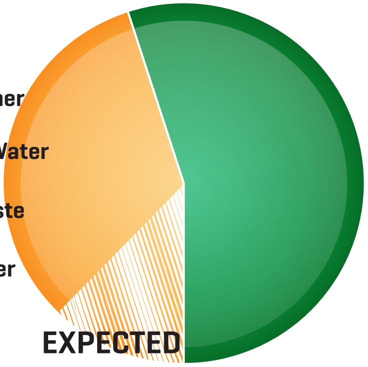
WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: In Minnesota, approximately 99% of the water that enters the state enters it from the atmosphere as precipitation. Because Minnesota contains the headwaters of the major rivers in the Midwest, it does not receive downstream pollution like many other states in the country. The water in Minnesota starts out clean (with the exception of airborne contaminants like mercury), and it is human activities that add pollutants to it.

MINNESOTA PHOSPHORUS CONTRIBUTORS

SOURCE: MPCA

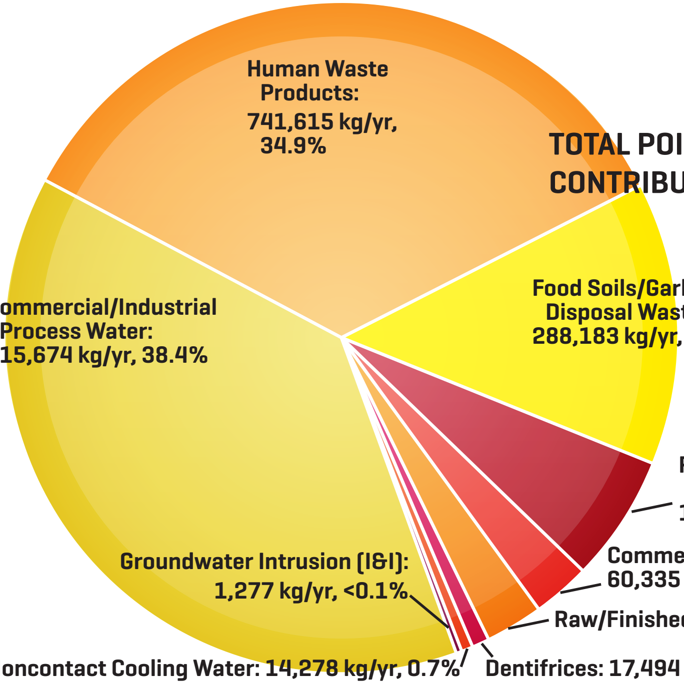
POINT SOURCE
2,123,930 kg/yr, 45%

- Commercial Automatic Dishwasher Detergent
- Commercial/Industrial Process Water
- Dentifrices
- Food Soils/Garbage Disposal Waste
- Groundwater Intrusion
- Residential Automatic Dishwasher Detergent
- Human Waste Products
- Noncontact Cooling Water
- Raw/Finished Water Supply



NONPOINT SOURCE
2,638,067 kg/yr, 55%

- Atmospheric Deposition
- Cropland and Pasture Runoff
- Feedlots
- Individual Sewage Treatment Systems (ISTS)/Unsewered Communities
- Non-Agriculture Rural Runoff
- Roadway and Sidewalk Deicing Chemicals
- Stream Bank Erosion
- Urban Runoff



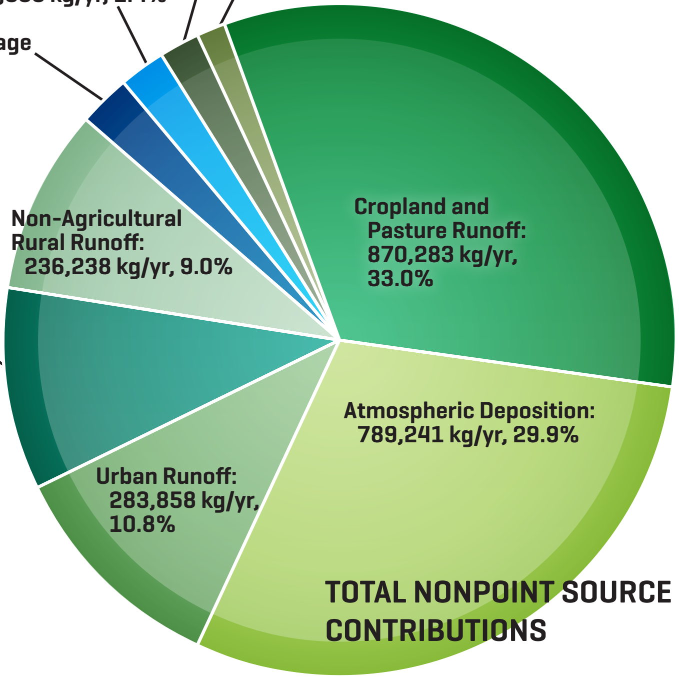


Figure 3-9: Sources of Phosphorus

Since the enactment of the Clean Water Act, water quality in the nation and the state has generally improved, particularly as a result of required reductions in point source discharges from industry. In Minnesota, long-term records on nutrients and some conventional pollutants indicate that many water quality indicators have improved. Phosphorus trends have gone down at 78% of "milestone" sites in the state, while 21% of the sites show no improvement. Bacteria levels have gone down at 82% of the sites, while 18% show no improvement. However, only 41% of sites show an improvement in suspended sediments, while 58% show no improvement or a decline in quality. Finally, only 1% of sites show an improvement in nitrate—75% of sites show an increase in nitrate concentrations over time, and another 23% of sites show no improvement.

A recent report from the USGS summarized national trends in nutrients over a decade. They found that across the nation, there is widespread contamination of nitrate and phosphorus and that in most cases it is not declining. Nitrates are particularly a problem in streams and shallow wells in agricultural regions. Phosphorus is elevated in urban and agricultural surface waters. They also documented that groundwater can be a significant source of nitrate to streams.

The Clean Water Act focused on controlling discharges from point sources, and left the pollutant discharges from non-point sources largely unregulated. As a result, non-point sources have become a more significant contributor over time. Urban nonpoint sources (stormwater runoff) are now regulated to a much greater degree. However, nonpoint discharges of nutrients, pesticides, soil, and bacteria from agricultural practices are not regulated under the same framework as other sources of pollutants. In Minnesota, the state works with the agricultural community to reduce pollutants using voluntary management practices. The proactive work done by the MDA and BWSR to get farmers to adopt best practices is admired by other states as a model for engaging the agricultural community in conservation. However, strictly voluntary programs are inadequate by themselves to achieve Minnesota's water quality goals, as evidenced by the lack of progress in reducing nitrates

DISTRIBUTION OF WATER IMPAIRMENTS

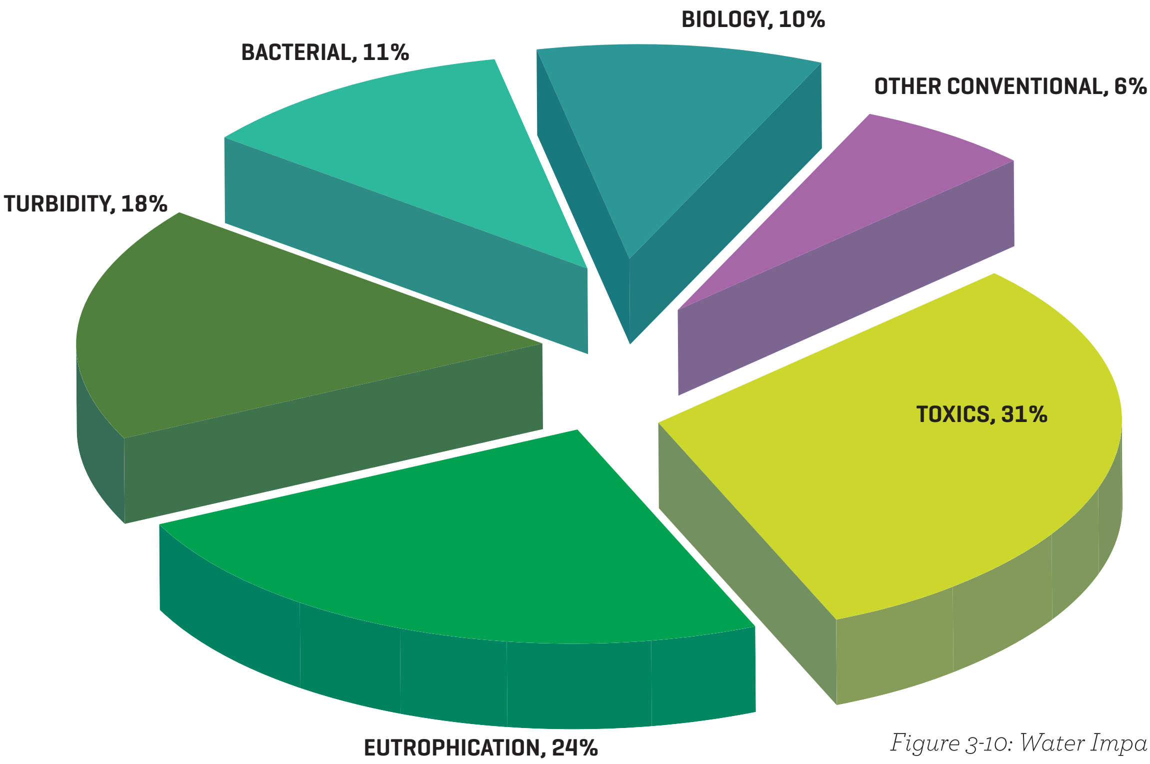


Figure 3-10: Water Impairments

and solids, and continued impairments due to excess phosphorus.

Less than 20% of Minnesota lakes and streams have been assessed for impairments through the impaired waters program. Of these, about 40% have been found to be impaired. Figure 3-10 shows the distribution of impairments in the draft 2010 Impaired Waters 303(d) list.

In Minnesota, phosphorus is the limiting factor for algal blooms (eutrophication), that cause taste, odor and aesthetic problems when mild and oxygen depletion and fish kills when more severe. Figure 3-9 shows the main sources of phosphorus to surface waters in Minnesota in an average water flow year.

Nearly two-thirds of phosphorus comes from nonpoint sources, and about one-third of the total comes from agricultural sources. Within the category of nonpoint sources, agriculture contributes more than 40% of phosphorus to surface waters. Approximately half of all nitrates in water come from agricultural applications of fertilizer, and another quarter come from agricultural manure.

Most of the mercury found in Minnesota comes from out of state, and only about 10% comes from

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The following gaps in knowledge and policy have been identified:

SCIENCE AND TECHNOLOGY GAPS

1. **Impacts of excess nutrients on overall ecosystem structure and function are not well characterized. In addition, the cumulative impact of this nutrient enrichment at the level of a river basin like the Minnesota River or the Red River is not well understood.**
2. **The effectiveness of BMPs or treatment technologies on large scales and long time frames is unknown.**
3. **The effectiveness of pollutant load reductions is not well quantified.**
4. **There is insufficient knowledge of what patterns of nitrogen and phosphorus loading produce blue-green algal blooms; the frequency with which blue-green algal blooms become toxic on a waterbody-by waterbody basis; and ways to conduct rapid assessments for cyanotoxins.**

POLICY GAPS

1. **No integrated regulatory framework is available to address all sources of nutrient pollution on a watershed-by-watershed basis, regardless of whether these sources are regulated under the federal Clean Water Act or whether they are currently under county or state government control through land use policy or delegated authority.**
2. **Many agricultural nonpoint sources are not regulated.**
3. **Manure management is not sufficiently regulated.**
4. **Shoreland rules are not robust enough or based on sustainability principles.**
5. **Zoning is inadequately enforced.**
6. **The system for assessing septic performance is inadequate, thus inhibiting solutions to address failing systems.**
7. **Pollutant load reductions are not mandatory for some contributors but are for others.**
8. **Current policies regarding the implementation of best management practices tend to encourage short-term reactive installations over systematic long-term improvement.**
9. **Current policies for on-the-ground projects tend to support equal distribution of funds across the state rather than targeting funding to priority areas to get the most efficient use of funds.**

sources within the state. About half of the mercury that enters from out of state via the atmosphere comes from regional sources (burning of mercury-containing coal for electricity generation) and the rest is from global sources to the atmosphere. The state has a TMDL study that is approved by US EPA and covers all the impairments in the state due to mercury. However, the state can do very little to reduce mercury emissions from other states and countries.

The MDA is required to sample and report on pesticide concentrations in wells and surface water throughout the state. The most recent trend data (MDA, 2009 Water Quality Monitoring Report) indicate that atrazine, alachlor, acetochlor, metolachlor, and metribuzin are the most commonly detected pesticides in groundwater. Average concentrations of acetochlor have not declined over time, but its principle degradation product has. It is detected in about one-third of all samples annually. Alachlor and its degradates are found in most samples, but at nearly non-detectable levels. Levels have been declining over time. Atrazine and its degradates are the most widely detected and most frequently detected pesticide in Minnesota. Concentrations appear to be declining, but the frequency of detection is increasing. Metalochlor and its degradates are detected throughout the state, and show a steady decline in concentration over time. Metribuzin is found mostly in the Central Sands region, and shows no change or pattern in concentration over time.

B.1 OBJECTIVE: To manage nutrients and other conventional pollutants in a holistic manner to realize water quality improvements and compliance with the Clean Water Act.

B.1. STRATEGY: Develop a statewide nutrient enrichment management framework, with planning and implementation at the watershed scale. These watershed plans should use adaptive strategies, and consider and address all aspects of excess nutrients from all sources, regardless of whether they are currently regulated or managed under federal or state law or by local units of government or are unregulated. This plan also should address solids, bacteria, and pesticide loads, given the interrelationships of these pollutants and their dominant role in causing violation of water quality standards.

B.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Effective management of surface waters and compliance with the Clean Water Act, as measured by monitoring programs and implementation of pollutant reduction plans**

➲ BENCHMARK: **All pollutant reduction plans completed by 2017**
➲ BENCHMARK: **All pollutant load allocations in compliance by 2022**
➲ BENCHMARK: **Fewer than 5 percent of waters listed as impaired by 2025**
➲ BENCHMARK: **Increased trend in compliance with zoning and land management rules**
➲ BENCHMARK: **All subsurface sewage treatments systems (SSTSs) inventoried and mapped by 2015**
➲ BENCHMARK: **SSTS noncompliance less than 5 percent by 2020**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION B.1.a: The state should strengthen and support the process to achieve clean water quality and meet standards under the Federal Clean Water Act:

i. Require that all TMDL studies be followed by pollutant load reduction implementation plans, and require that the allocation of pollutant load reductions in these plans be mandatory for all sectors, including nonregulated, nonpoint sources. implementation plans should include reduction goals, compliance timelines, and benchmarks for achievement of reductions, and require effectiveness monitoring to be done by each source, with consequences for noncompliance or failure to achieve required reductions. implementation plans should require MPCA Board review and approval within one year of the TMDL study. The allocations and implementation of reductions in loadings should be part of each watershed's nutrient enrichment management plan. Nonpoint source pollution cleanup funds from the state should be directed only to projects that have an approved implementation plan. This will likely require approximately 10 years to implement.

ii. Accelerate the assessment by MPCA of the state's watersheds for meeting standards for all water quality parameters, and for effectiveness monitoring best management practices (BMPs) at the field scale of application. Any acceleration of monitoring should be fully funded. The goal should be to intensively assess 20% of the watersheds each year rather than the current 10%, and to increase the number of sites where BMPs are monitored for effectiveness. The schedule for conducting TMDL studies and Implementation Plans to determine and achieve the necessary pollutant load reductions should be accelerated accordingly.

iii. Strengthen the use of science in the beneficial use designations for water bodies, and provide for greater flexibility and adaptive management for water bodies that have naturally high phosphorus or suspended solids.

TIME FRAME: 4–6 YRS COST*: H

RECOMMENDATION B.1.b: The state should address impacts from stormwater beyond current rules and statutes:

i. Enact the MPCA study recommendations (pending) for minimal impact design Standards (MIDS) related to stormwater management. This approach to stormwater management mimics a site's natural hydrology as the landscape is developed. Using the low impact development approach, stormwater is managed on site and the rate and volume of predevelopment stormwater reaching receiving waters is unchanged. MIDS represents the next generation of stormwater management and contains three main elements that address current challenges: (1) a higher clean water performance goal for new development and redevelopment that will provide enhanced protection for Minnesota's water resources; (2) new modeling methods and credit calculations that will standardize the use of a range of "innovative" structural and nonstructural stormwater techniques, and (3) a credits system and ordinance package that will allow for increased flexibility and a streamlined approach to regulatory programs for developers and communities.

ii. Ensure that existing grants programs (BWSR, etc.) include the option of green infrastructure projects and incentives for adoption. As required by the Clean Water Land and Legacy Amendment, such grants must demonstrate outcomes and the effectiveness of green infrastructure.

TIME FRAME: 1–2 YRS COST*: L

RECOMMENDATION B.1.c: The DNR should amend the shoreland rules and dock rules developed by the DNR (2010) to be protective of water quality and to be grounded in the principles of water sustainability management. Compliance should be achieved through shoreland educational programs for shoreland property owners, incentives, and an expansion and strengthening of enforcement capacity. (This is the same as Recommendation E.1.e).

TIME FRAME: 1–2 YRS COST*: L

RECOMMENDATION B.1.d: The state should provide assistance and resources to increase local capacity to enforce and achieve increased compliance with local zoning decisions, shoreland rules, and other land management rules.

TIME FRAME: 1–2 YRS COST*: M

RECOMMENDATION B.1.e: The state should establish a statewide, locally administered program that ensures all subsurface sewage treatment systems (SSTS) are properly managed by responsible professionals. The statewide program should:

- Fund and develop an inventory to identify the location and status of every SSTS in Minnesota, and establish a GIS database of onsite septic system information.
- Require all local SSTS programs to implement a SSTS management program that, in addition to currently required permitting and inspection, incorporates the level of risk posed by (1) SSTS use, (2) treatment technology, and (3) site limitations.
- Require that local SSTS programs educate SSTS professionals and SSTS owners about local requirements and include disincentives for nonparticipation
- Identify appropriate state oversight and enforcement actions for local programs that do not effectively administer ongoing SSTS management programs.
- Require board-licensed SSTS professionals to conduct alternatives analyses for SSTS systems and provide funds for these analyses.

TIME FRAME: 1–2 YRS COST*: M

Research Plan

RECOMMENDATION B.1.f: The state should fund additional research and development of assessment methods for cyanotoxins, and determine the cause-effect relationship between algal blooms and cyanotoxin production.

TIME FRAME: 2–6 YRS COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

B.1.a.i: This would provide a framework for meeting Clean Water Act standards and also impetus for strategy B.2. This meets the requirements of the Clean Water Act while placing addition requirements at the state level. The current Clean Water Act does not require Implementation Plans or mandate the pollutant load reductions from TMDL studies—implementation is voluntary. The state can use NPDES permits to meet part of the allocation, but there is no similar regulatory mechanism for controlling sources of nutrients, solids, and bacteria from agricultural runoff or subsurface drainage. By mandating implementation, the state would provide equity between regulated and unregulated sources.

B.1.a.ii: Currently the state will complete assessing the state's waters in a 10-year cycle. This means that the full condition of the state's surface waters will not be known until nearly half of the Clean Water Fund investments have been made. This recommendation cuts the time for this assessment in half. This would not speed up the recovery of those watersheds, but it would provide for more robust data to assess trends and to enact implementation of pollutant load reductions. The benefit of this recommendation comes with significant costs—intensive monitoring of 20 percent of the watersheds per year would require a very large investment in staff, streamflow data collection, analytical capacity and management capacity. In addition, the assessment of the effectiveness of BMPs on the ground is a significant need, and knowing their effectiveness will improve decision making and allow for better strategies to ensure their adoption.

B.1.b: See http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-minimal-impact-design-standards-mids.html. Also, best practices are identified by the MPCA's GreenStep Cities program.

B.1.c: Shoreland rules and dock rules that were recently developed by the DNR but have not yet been adopted by the state. These rules do not squarely address water sustainability but focus on clarifying private property issues.

B.1.d: A variety of rules and statutes are enforced at the local level (counties, cities) and support for this enforcement is lacking. Thus compliance is not well known.

B.1.e: Currently, local SSTS management is uneven in its effectiveness across the state, and data on location and performance of septic systems are incomplete. This recommendation will provide a statewide framework for management of SSTS with local implementation. The alternatives analysis should be considered in the priority order detailed in the MPCA wastewater hierarchy (currently codified in Minnesota Rules, Chapter 7077) to promote cost-effective, sound decision making.

B.1.f: The specific conditions that make blue green algae produce cyanotoxins are not known. To mitigate the effects of cyanotoxins, this relationship must be fully understood.

B.2.OBJECTIVE: To provide equity in pollutant load reduction solutions to excess nutrients and conventional pollutant water quality impairments. Bring all surface waters in the state into compliance with water quality standards.

B.2 STRATEGY: Reform state policy regarding agricultural sources of nutrients, solids, pesticides and bacteria to accelerate improvements in water quality. This strategy follows directly from Strategy B.1.

B.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Effective management of surface waters and compliance with the Clean Water Act, as measured by monitoring programs and implementation of pollutant reduction plans**
  ➲ BENCHMARK: **95% of agricultural lands are in compliance with water quality standards by 2025**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION B.2.a: Establish a farmer-led, performance-based approach to meeting required water quality standards in agricultural areas and achieve equity in solutions to water quality impairments.

i. **Agricultural Management Areas (AMAs).** AMAs should be established that include all agricultural land within a given watershed (81-scale, 8-digit-hydrologic unit code [HUC]). The AMA members would be owners of agricultural lands in the watershed; thus, not all watersheds would have an AMA. The AMAs would function as cooperatives (but would be required and not voluntary), and be required to meet the agricultural sector's pollutant load reduction allocated by that watershed's TMDLs study and implementation plan. The AMA members would work together in a farmer-led approach to determine how to meet these load reductions. Each area would be overseen by the recommended watershed and soil conservation authorities (see Recommendation J.1.e) to be established throughout the state at the watershed scale. This recommendation provides flexibility and self-determination for farmers, and the solution is performance-based rather than proscriptive to the farmer. It avoids treating each farm as a point source requiring its own permit. The implementation of this recommendation will take time to phase in and require the establishment of the AMAs, development of monitoring and modeling approaches for compliance, and completion of watershed-based implementation plans across the state (10 years).

ii. **Compliance and Enforcement.** The watershed and soil conservation authorities should be responsible for collecting data from receiving waters to show compliance and would be required to provide these data to the state. A small assessment that would be needed to oversee the AMA function could be obtained through the taxing authority of the watershed and soil conservation authorities under Recommendation J.1.e. Noncompliance would result in a tiered response: (1) farmers within the AMAs would have two years to voluntarily enact a remedy to meet compliance for the AMA, such as working with targeted areas needing BMPs or additional conservation management practices; (2) AMAs that are out of compliance for more than two years would be fined (paid by the watershed and soil conservation authority and then assessed back to the AMA; the AMA determines for itself how to distribute the fine) and required to enact a remedy. This provides a consequence for noncompliance and incentive for the agricultural community to find solutions prior to any consequence. The watershed and soil conservation authority could provide matching funds (gathered through their taxing authority) to facilitate the adoption of conservation measures such as precision farming, managed drainage, and other state-of-the-art BMPs, and to provide technical assistance for their adoption.

TIME FRAME: 5–10 YRS COST*: L

RECOMMENDATION B.2.b: The state should establish an agricultural sustainable water certification. All products and agricultural goods that derive from compliant AMAs would receive this official certification.

TIME FRAME: 2–4 YRS COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

B.2.a: This is a key recommendation for both Strategy B.1 and Strategy B.2. The progress Minnesota farmers have made in adopting conservation practices and reducing their impacts on water quality are recognized, and the intent of this recommendation is to build on this momentum, to continue to engage farmers in water quality solutions. It is also to address equity and societal costs in the context of the Clean Water Act, and to provide for greater responsibility and accountability of the agricultural sector in preventing nutrient, bacteria, pesticide, and other conventional impairments. This performance-based approach is based on a farmer-supported model used in Florida to manage agricultural contributions of nutrients to the Everglades, as part of the consent decree governing the Everglades restoration. It has also been used in Nebraska to address nitrates in groundwater and groundwater extractions. A feature of this approach is that it allows for farmers to determine for themselves how to meet these thresholds rather than imposing a permit on each farm source. It also allows for voluntary remedies to be enacted initially under non-compliant conditions, with more severe consequences if noncompliance persists. The watershed and aoil conservation authorities would play an advocate and assistance role, but serve as the point of contact for the AMA; the MPCA would be responsible for enforcement and the levying of fines in the case of noncompliance. The Watershed and Soil Conservation Authority staff would need professional training and assistance with developing monitoring strategies, etc.

B.2.b: This certification will help consumer choice and behavior, and provide additional incentive for agricultural producers to meet their thresholds. Food Alliance and good agricultural practices (GAP) certification are possible models. The Legislature can encourage this certification by directing government purchasing power.

B.3 OBJECTIVE: To clean up and remediate all federally and state listed sediment sites around the state that are contaminated by "legacy" chemicals (PCBs, PAHs, mercury, heavy metals, etc.) and address continuing sources of these contaminants.

B.3 STRATEGY: Aggressively pursue action on all "legacy" contaminated sediment sites and associated natural resource damages, and work toward reduction of sources.

B.3 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **All federal and state listed sites cleaned up, as measured by legal agreement**
  ➲ **BENCHMARK: all cleanups completed by 2025**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION B.3.a: The state should pursue cleanup of all existing Minnesota permanent list of priorities (PLP) and national list of priorities (NPL) sites and remedy all Comprehensive Environmental Response, compensation, and Liability Act (CERCLA or "Superfund") natural resource damages.

i. State agencies should report to the Legislature on progress, projected timelines, and recommended policy changes necessary to complete the cleanup and remedies.

ii. The state natural resource damage assessment trustees (MPCA and DNR) should develop recommendations for funding an enhanced natural resource damage assessment program.

iii. The state should develop and fund a program with incentives to clean up orphan industrial "legacy" sites, analogous to the federal Great Lakes Legacy Act. (These funds have been rolled up into the Great Lakes Restoration Initiative and are used to match funds from local government units (LGUs) that want to clean up orphaned sites around the Great Lakes.) This would establish a cost-share fund to match cleanup costs. Potentially responsible parties should be required to fund monitoring of the efficacy of cleanup (above and beyond cost-share).

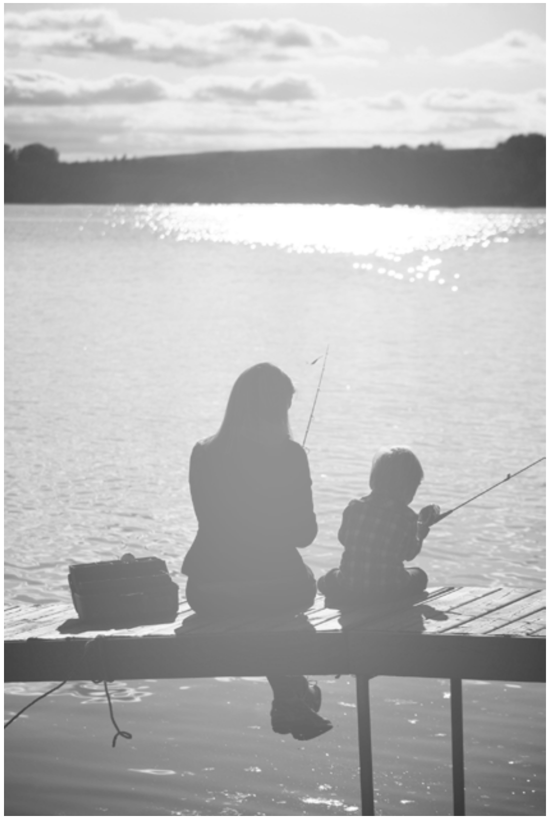
TIME FRAME: 1–2 YRS COST*: L

RECOMMENDATION B.3.b: The MPCA should evaluate the impacts and alternatives to coal–tar based sealants, and report to the Legislature. The Legislature should review this information and consider action at the statewide level.

TIME FRAME: 1 YR COST*: L

RECOMMENDATION B.3.c: The state should work with coalitions, other state partners, Minnesota's congressional delegation, etc., to ensure that EPA-proposed mercury standards achieve substantial and timely reductions. Similarly, Minnesota should push the U.S. government to advance international agreements to significantly reduce mercury releases worldwide in the shortest possible time frame.

TIME FRAME: 1–2 YRS COST*: L



**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

B.3.a: There are many barriers to achieving successful cleanup of legacy sites. These include costs, capacity, and political will, among other considerations. This recommendation would make state agencies accountable to pursue cleanups and natural resource damage assessments and remedies, and provide a leveraged matching fund to assist in cleanups for orphaned sites.

B.3.b: The MPCA will provide information to inform the Legislature's decision. There are a number of questions that should be answered before a full ban might be considered. For example: how much reduced impact on polycyclic aromatic hydrocarbon (PAH) concentrations in pond sediments would be expected from a ban, and what is the relative importance of driveway sealants as a source; what are the statuses of bans elsewhere, for both driveway sealants and any analogous use/sale restrictions of other products; what are the updates on developments from EPA; and what do we know about the ready availability of alternative products, and have they been assessed for unintended consequences?

B.3.c: The MPCA is currently implementing stakeholder-recommended strategies to reduce Minnesota sources to meet a target of 93 percent reduction of 1990 emissions by 2025 with most reductions occurring by 2018. However, it is estimated that about 90 percent of the mercury that pollutes Minnesota waters comes from sources outside the state, and from outside the United States. Thus, avenues beyond state law should be pursued.

TIME FRAME for COMPLETION of ISSUE B RECOMMENDATIONS

The recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frames for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

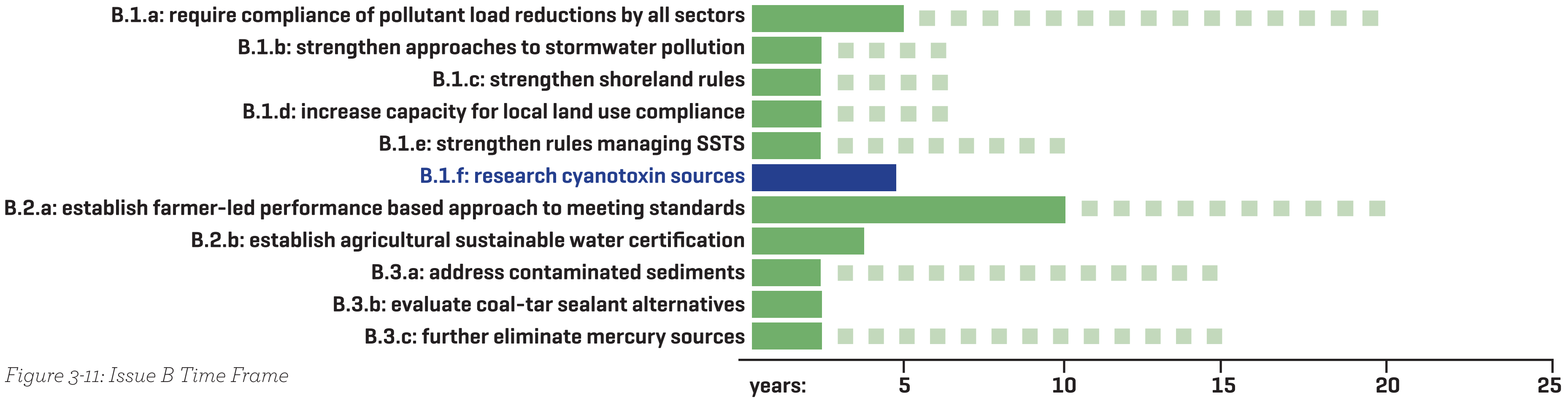


Figure 3-11: Issue B Time Frame

IMPACT MATRIX for ISSUE B RECOMMENDATIONS

Cost	**H**			B.1.a
	M	B.1.f	B.1.b, B.1.d, B.1.e	
	L	B.2.b, B.3.b, B.3.c	B.1.c, B.3.a	B.2.a
		L	**M**	**H**
			Impact	

Figure 3-12: Issue B Impact Matrix

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE C:

CONTAMINANTS of EMERGING CONCERN

HUNDREDS OF CHEMICALS AND pathogens, which are mostly unregulated, continue to enter our water environment and potentially threaten human health and ecosystem function.

Desired Minnesota Future

A society that has embraced green manufacturing and chemistry so as to eliminate new toxic contaminants, and in which drinking water, recreation water, and food are free from harm from microbial contamination.

PROBLEM STATEMENT

Contaminants of Emerging Concern (CECs) are chemicals and microbes that have recently been detected in the environment due to analytical advances, have recently been introduced into the environment as new chemicals in commerce, or are contaminants that have been regulated for one toxic endpoint but have recently been found to have more subtle toxic endpoints at lower exposure doses. The general category of CECs includes the contaminants that are known as endocrine disrupting chemicals (EDCs); prescription and non-prescription pharmaceuticals used by humans and for livestock; additives to personal care and consumer products; and some current-use pesticides. These are described further below.

Most of these contaminants are not currently regulated. The knowledge of their presence in the environment is largely driven by advances in the ability to detect them, but this knowledge is not matched by an understanding of their risk to cause harm. Thus "safe" levels have not been determined by the usual method of risk assessment due to lack of data, and they remain unregulated.

Endocrine disrupting chemicals are those that can mimic chemical signaling chemicals such as hormones and interfere with reproduction, development, growth, metabolism, behavior, and other biological functions. These contaminants can act at very low concentrations, but the impact on human health of most of these contaminants at measured environmental exposures is not well understood. However, effects on fish and wildlife (primarily reproduction) have been well-documented for the last 15 years. The EPA has recently released a list of 201 chemicals that are of highest priority for initial screening and testing by the federal Endocrine Disruptor Screening Program because of their occurrence in drinking water. The Minnesota Legislature recently funded the MDH to design and enact a screening program for contaminants of emerging concern in drinking water (http://www.health.state.mn.us/divs/eh/risk/guidance/dwec/index.html). The sources of these contaminants include consumer products, industrial pollutants, and some current use pesticides. A list of the highest priority contaminants of emerging concern to children's health is soon to be released by the MDH.

Consumer products, such as plastics, detergents, cleaning formulas, and canned food may contain additives that are of concern for their potential to act as endocrine disruptors. The use and disposal of these household products results in the release of the additives to wastewater and to landfills through trash disposal, and there is documented wide-spread occurrence of these compounds in the environment as a result. Because wastewater treatment plants are the "collection points" of residential waste, they also collect contaminants of emerging concern and funnel them into the environment. They are often referred to as sources of CECs to water, but in fact they are the funnel that collects them from lots of other sources and discharges them. Wastewater treatment plants are not designed to remove these contaminants, although some contaminants are removed under some conditions. A subject of much interest, this is discussed in detail in the Wastewater Treatment Best Practices Report (see Appendix G).

Pharmaceuticals are regulated for their therapeutic purposes by the federal Food and Drug Administration, but they are not regulated as environmental contaminants. Drugs enter the environment by direct excretion by humans and animals, and by disposal of expired or unused drugs into the drain or toilet where they enter wastewater systems, or into the trash where they can leach from landfills. National studies by the USGS have demonstrated the regular presence of 10 pharmaceuticals in a representative study of drinking water. The impacts of exposure to the trace levels of these drugs is not known, but has raised concerns.

In addition to chemicals, there are a number of microorganisms that are of concern due to exposures from use of recreational waters, and exposures due to drinking water. These include certain water-borne pathogens (disease-causing microorganisms) such as viruses, protozoa, algae and bacteria. The sources of these microorganisms include runoff of animal waste (domestic animals, pets, and wildlife), stormwater, and sewer spills and overflows. These pathogens can cause gastroenteritis and diarrhea; in rare cases or in individuals with compromised immune systems, more severe effects can result.

Determining how to prevent chemicals and pathogens from polluting water is essential to ensuring our ability to provide water management of domestic, agriculture, manufacturing and energy, ecosystem services, and recreational/cultural/spiritual benefits in a sustainable way. Specific issues that need to be addressed include unregulated or under-regulated chemicals of emerging concern (CECs), such as endocrine-active compounds, nanoparticles, and pharmaceuticals; "legacy" (persistent, bioaccumulative, and toxic, or PBT) chemicals such as PCBs and mercury that cause fish advisories or that research has found to have additional more subtle but harmful effects (e.g., affecting reproduction or obesity at lower concentrations than might cause cancer); current-use pesticides that have adverse effects on humans and/or wildlife; and pathogens of emerging concern that enter water from animal waste and untreated human waste and can impair surface water and contaminate drinking water.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Nonregulated or underregulated CECs, including endocrine-active compounds, nanoparticles, and pharmaceuticals**
- **Certain current-use pesticides that have unintended effects on human and/or wildlife**
- **Pathogens, both regulated and unregulated, from animal and human waste and other sources**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: What is known is small compared to what is not known. We have some understanding of contaminants of emerging concern and their sources. The effects of endocrine disrupting compounds, particularly the effects of those compounds that mimic estrogen in wild fish, are well documented. Impacts on other aquatic species such as reptiles or invertebrates are not as well known. Other endocrine impairments besides reproduction, caused by other modes of action, are not well known. There is little known about the impacts on humans, but rather possible impacts are inferred from controlled laboratory studies with animals. Thus, there are lots of hypotheses about what chemicals might cause what impacts, but a full and integrated understanding of the potential risks of these chemicals in the environment is sorely lacking, and will take many years of research.

Risk assessment is the regulatory tool that is used at the federal and state level to help develop environmental standards for toxic chemicals. The concept is well accepted, but the implementation is very slow. Currently fewer than 10 chemicals are evaluated per year by the EPA, such that the numbers of chemicals overwhelm the process by which they normally would be assessed for regulation. Thus, the chemical-by-chemical risk assessment approach will never be sufficient. Furthermore, the toxicological dose-response data that are needed are not yet available, and will take years to obtain.

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **Sufficient toxicological data on CECs is lacking.**
2. **An understanding of all the sources, movement, and environmental fate of CECs is lacking.**
3. **An understanding of the cumulative impacts of CECs on human health or ecosystem health is lacking.**
4. **A comprehensive research agenda into "green" processes of producing materials and manufactured goods and products is needed.**
5. **Knowledge of the extent of use of unlicensed pesticide application (for home or garden use) and a system for tracking the use, transport, or fate of pesticides used outside licensed application is needed.**
6. **The ability to track and assess pathogens in water in real time to monitor the human health risks from exposure during water-based recreation (at public beaches, etc.) is lacking.**
7. **An understanding of the extent and potential risk of antibiotic resistance in aquatic organisms and humans caused by antimicrobial compounds and antibiotics in the environment is lacking.**
8. **CECs are not removed effectively with our current wastewater or drinking water treatment technologies.**

POLICY GAPS

1. **A robust policy to encourage green chemistry and green manufacturing practices in our state is lacking.**
2. **"Birth to death" ownership responsibility for those companies that manufacture and distribute chemicals in Minnesota is lacking.**
3. **Conventional chemical-by-chemical approaches to evaluate risk are insufficient for assessing the large number of CECs.**
4. **A science policy or regulatory framework that can deal with sub-lethal, cumulative effects of CECs has not been developed.**
5. **The Federal Toxic Substances Control Act (TSCA) is out of date, is not protective of public health in its current form, and needs revision.**
6. **Robust policies and practices for disposal of unused or expired pharmaceuticals have not been adopted.**
7. **Drinking water rules do not consider all pathogens of human health concern.**

One promising approach is to determine the risk by grouping chemicals by common modes of action, rather than studying them one by one.

Minnesota is a leader in research on contaminants of emerging concern, drawing on expertise from the state agencies as well as the state Water Science Center of the USGS, and researchers at the UM and St. Cloud State. The state has conducted or sponsored a number of research studies to better understand the sources of these contaminants. The 2009 report on the MPCA monitoring studies (http://www.pca.state.mn.us/index.php/view-document.html?gid=10280) underscored the difficulty of understanding this complex issue. In addition, the Legislature funded the MDH to design and implement a process to regulate harmful CECs in drinking water (http://www.health.state.mn.us/divs/eh/risk/guidance/dwec/).

To reduce future contaminants, "green chemistry" has been promoted as a more sustainable business model. Green chemistry refers to the utilization of a set of twelve principles that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and application of chemical products. Moving to this model requires certain up-front investments by industry (with savings from reduced waste later on), and widespread adoption will require some incentives. The states of California and Michigan have enacted statewide green chemistry policies that could serve as models for Minnesota.

The knowledge around environmental pathogens is different. The effects are known, but the fate and behavior of the pathogens in the environment is less well understood. A goal that has not been realized is having real-time or rapid assessment of whether a beach should be closed for recreational use.

C.1 OBJECTIVE: To reduce the numbers and concentrations of future CECs in the environment, thereby reducing the risk posed to humans and aquatic ecosystems.

C.1 STRATEGY: Prevent the introduction of toxic chemicals into the environment by policies that promote and encourage green chemistry (elimination of use of toxic chemicals, or replacement with less toxic chemicals, in manufacturing), including economic incentives, working with early adopters, promoting pollution prevention and recycling policies, etc. Promote practices that reduce or eliminate unintentional discharges of toxic chemicals to water.

C.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Decreasing concentrations of CECs in surface water, wastewater, and drinking water, as measured by routine monitoring of certain "sentinel" CECs at representative master sampling sites.** ➲ BENCHMARK: **decreases should be statistically evident within 10 years**

- **Increasing adoption rates of green chemistry and manufacturing practices, as measured by industry sustainability reporting.** ➲ BENCHMARK: **more than half of Minnesota's manufacturing facilities have adopted green chemistry practices in 10 years**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION C.1.a: Enact a *Green Chemistry and Manufacturing Act* that encourages Minnesota businesses to manufacture and use safer chemicals in their processes and products by providing economic incentives such as tax deductions. This act should consider a framework for working with the chemical and manufacturing community in a cooperative way similar to that developed by the University of Massachusetts Lowell Center Framework for Sustainable Products. The process should also include strategies for providing technical assistance needs and support for manufacturing facilities. Although a more comprehensive approach to move towards green chemistry would need a federal focus, this is a value-added action that is appropriate at the state level.
TIME FRAME: 2–4 YRS COST*: M

NOTES

C.1.a: Green chemistry refers to the utilization of a set of twelve principles that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and application of chemical products. The field of Green chemistry is well described (http://www.epa.gov/gcc/pubs/principles.html), but requires sufficient market or regulatory pressures that make it cost effective for business to adopt. An advantage to business is that green chemistry practices also reduce waste, which has costs associated with treatment and disposal, and for some facilities, it reduces occupational exposures and thus liability and health care costs. However, product redesign and/or facility upgrades often require large investments in the short term and accrual of benefits over the long term. Unfortunately tax codes are structured to give deductions for end-of-pipe solutions but do not encourage companies to reform or redesign their processes to eliminate the need for the harmful chemical.

C.2 OBJECTIVE: To manage the presence of existing contaminants of emerging concern to reduce and minimize potential risk to humans and aquatic ecosystems.

C.2 STRATEGY: Create a science and policy framework, including regulatory programs, for a process to manage currently unregulated or under-regulated chemicals of emerging concern.

C.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Decreasing concentrations of CECs in surface water, wastewater, and drinking water, as measured by routine monitoring of certain “sentinel” CECs at representative master sampling sites.** ➲ BENCHMARK: **decreases should be statistically evident within 10 years.**

The following actions are recommended to implement this strategy:

RECOMMENDATION C.2.a: State agencies, in consultation with outside experts and stakeholders, should develop a systematic, science-based process for the identification, risk determination, and regulatory outcome of contaminants of emerging concern in Minnesota. The process needs to include considering groups of chemicals by mode of action rather than considering each chemical separately; it needs to include a range of policy tools including voluntary measures, economic considerations, and regulations.
TIME FRAME: 1–4 YRS COST*: L

RECOMMENDATION C.2.b: Expand the current MDH Drinking Water Contaminants of Emerging Contaminants program to cover CEC exposures from other sources beyond drinking water, and to broaden program to other agencies and include fish and wildlife effects.
TIME FRAME: 3–5 YRS COST*: L

RECOMMENDATION C.2.c: Prioritize the state’s wastewater treatment systems and drinking water systems for the need to add technologies to remove CECs. There is no one system that is appropriate for all drinking water systems or all wastewater systems due to cost and energy consumption and pollutant load. Those systems with the greatest need for intervention should be evaluated for the most suitable technologies tailored to that system. Best practices for treatment technologies are described in the Wastewater Treatment Best Practices Report (see Appendix G).

TIME FRAME: 3–5 YRS   COST*: L

RECOMMENDATION C.2.d: Adopt a comprehensive policy and provide funding for county programs to collect and properly dispose of unused pharmaceuticals. This should build on Session Law 223 and require all pharmaceuticals to be disposed of through an approved county collection and disposal program (similar to what is now required for hazardous waste). Funds should be provided to counties to set up collection and disposal programs for unused or expired prescription and non-prescription pharmaceuticals. This policy should include pharmaceuticals used for both human and veterinary purposes.

TIME FRAME: 1 YR   COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

C.2.a: The University has partnered this year with the Minnesota Environmental Initiative to frame such a process. The MPCA and MDH have been involved in this framing effort. A report of the outcome of the framing process can be found at http://www.mn-ei.org/projects/ChemReg.html.

C.2.b: The MDH is developing a robust process to identify, evaluate, and potentially regulate contaminants of emerging concern, but is limited to considering only drinking water exposures and human health. This misses important exposures, such as those resulting from use of residential pesticides in lawn and garden applications, or adverse impacts of endocrine disrupting compounds on fish and wildlife. This would be a considerable expansion of their current program and require additional staff and funding.

C.2.c: The need for the system, the cost of the system, and the increased energy demands to add new treatments must be considered as well as public health protection. A given CEC removal technology may be appropriate for drinking water treatment but is not at all appropriate for wastewater treatment (an example would be ozonation). Some technologies are more cost effective for larger plants than for smaller plants. The geology of the area, and water source or discharge are all important variables in choosing treatment options.

C.2.d: Pharmaceuticals have been documented to occur in surface water and in drinking water throughout the nation, including Minnesota. This is to minimize disposal practices that allow pharmaceuticals to get into waterways via wastewater treatment plants or septic systems, or from leaching from animal waste. Session Law 223 facilitates the implementation of collection programs. Federal law (S.3397), introduced by Senator Klobachar and passed in 2010, further facilitates such actions. Voluntary guidance and best practices are offered to individuals from a variety of sources (e.g. http://www.pca.state.mn.us/waste/hhw/pharmaceuticals.html), but there would be even greater water quality benefits to regulating these disposal practices, and great benefit to including veterinary drugs. Similar policies and programs are in place for electronic consumer good disposal, hazardous waste, etc.

C.3 OBJECTIVE: Minimize risk of microbes in drinking water and in recreational uses of water.

C.3 STRATEGY: Reduce potential for exposures to microbes in drinking water and from recreational use of water.

C.3 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Improved beach management (testing, procedures, communication to public) for minimizing exposures to microbes and their effects, as indicated by health data related to water-borne microbial illness.**
  ➲ BENCHMARK: **as a systematic approach to assessing beach health is implemented, beach closings may increase due to increased testing. This is not an indicator of water quality, but is a process indicator. Decreased illness data related to beach attendance is the best indicator that beaches are being managed more effectively, and these data should show a downward trend within 3 years of implementation of a statewide program.**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION C.3.a: Establish and enforce a consistent statewide policy for assessing pathogens at public beaches and swimming areas and informing the public about potential risks from exposure.
TIME FRAME: 2–4 YRS   COST*: M

Research Plan

RECOMMENDATION C.3.b: Fund research to identify and adopt a more appropriate indicator organism (or organisms) that is representative of pathogen risk (rather than using E. coli) so that potential health risks from exposure can be determined.
TIME FRAME: 3–5 YRS   COST*: M

RECOMMENDATION C.3.c: Fund research to identify and characterize the sources of pathogens in Minnesota waters ("source-tracking"), so as to better manage specific sources in real time, protect drinking water, and develop tools for monitoring use.
TIME FRAME: 3–5 YRS   COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

C.3.a: We do not have consistent policies for when to monitor or close beaches and swimming areas. Coastal beach monitoring has significantly improved in recent years due to passage of the Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act), which provides assistance to state and local governments to develop monitoring programs. This only applies to the east and west coasts and the Great Lakes, and not to Minnesota's inland waters. This recommendation would expand the Lake Superior monitoring programs to the rest of the state.

C.3.b: Currently, we use *E.coli* as an indicator organism for fecal pathogens of all types. However, it is not necessarily representative of all pathogens or all sources. There is considerable attention and interest in this topic at the national level, and Minnesota has a number of nationally recognized researchers in this area.

C.3.c: Pathogens can end up on beaches and in surface waters from humans (e.g., dirty diapers), pets, stormwater, wildlife (deer have been shown to be a source to North Shore streams), water fowl (geese are a large source in many areas), and livestock. In order to remediate or stop a source, it is critical to know what and where the source is. Minnesota is a leader in research on source-tracking.

TIME FRAME for COMPLETION of ISSUE C RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from Action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

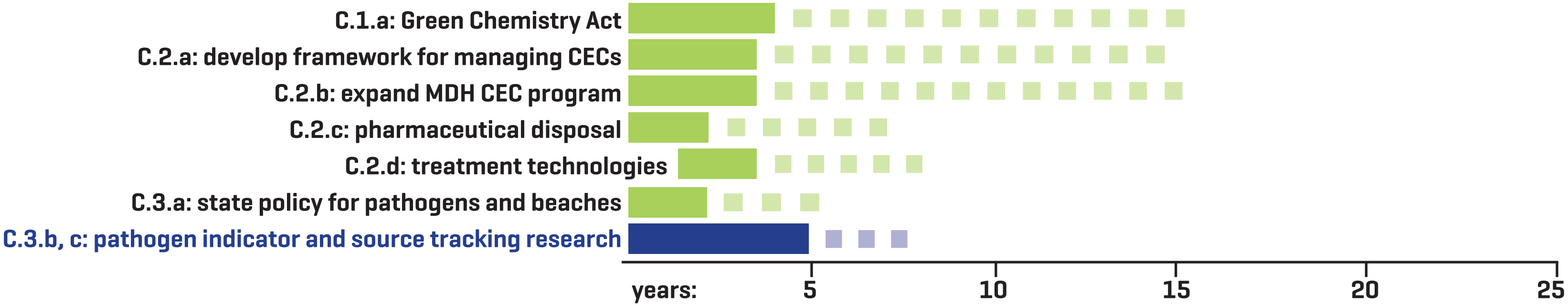


Figure 3-13: Issue C Time Frame

IMPACT MATRIX for ISSUE C RECOMMENDATIONS

Cost	**H**			
	M		C.1.a, C.3.a, C.3.b	C.3.c
	L			C.2.a, C.2.b, C.2.c, C.2.d
		L	**M**	**H**
			Impact	

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

Figure 3-14: Issue C Impact Matrix

ISSUE D: LAND, AIR, and WATER CONNECTION

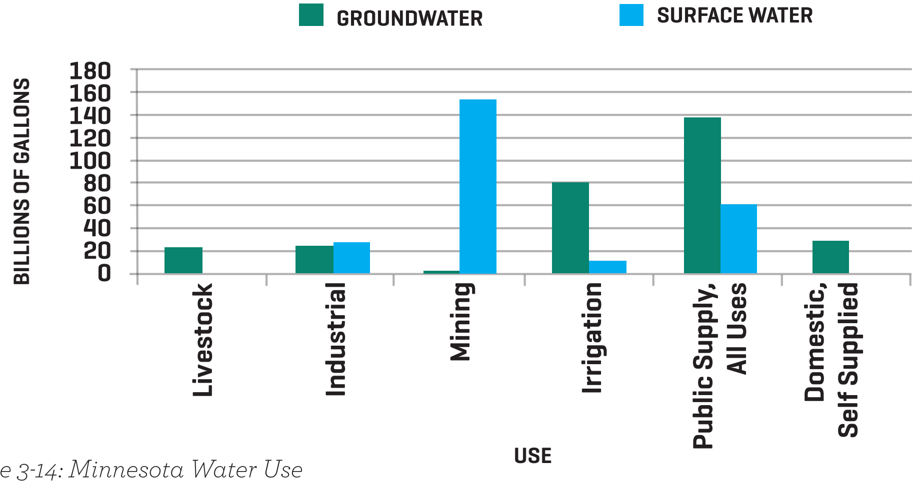
USING WATER SUSTAINABLY REQUIRES that we use our land sustainably. Everything we do on land—urban development, farming, forest management, mining, transportation, energy production, even recreation—affects water quality and quantity.

Desired Minnesota Future

A society in which all of our land use decisions and plans are inextricably linked with sustainable water use and planning.

PROBLEM STATEMENT: Water does not exist in isolation in the environment; rather, it influences and is influenced by the surrounding air and land. Poorly considered actions on land can lead to turbidity of lakes and streams, cultural eutrophication, toxic chemical pollution, air pollution, wetland loss, changes in the hydrological cycle, groundwater contamination, and moving water too quickly off the land. Pollutants that enter the air can be carried great distances, then deposited onto land and lakes, and can run off into rivers. Damage to water through the land-water-air connection can harm water's ability to meet agricultural, domestic, recreational, manufacturing, energy, and transportation needs. To maintain healthy water resources, the water implications of land-based and air-quality-impacting activity and decisions must be considered.

MINNESOTA WATER WITHDRAWALS 2005



SOURCE: MN DNR

Figure 3-14: Minnesota Water Use

Population increases and related land development affects water. Demand for drinking water and the use of water for wastewater treatment increase with population. In Minnesota, domestic use (publicly supplied and self-supplied) accounted for approximately 8.7 percent of total estimated use (128 billion gallons of 1,476 billion gallons) in 2005. If one excludes the use of water for cooling (nonconsumptive), domestic use is 22% of consumptive uses of water.

As homes, roads, and businesses are built, the amount of vegetated surface area available to absorb precipitation diminishes. Paved ("impervious") surfaces and rooftops shed water, sending it toward lakes and streams carrying sediment and other pollutants. From 2000 to 2020, the area covered by these impervious surfaces is expected to increase by 900,000 acres, according to the MPCA. Nearly all of this increase will occur in watersheds of the Minnesota and Mississippi rivers.

Impervious surfaces coupled with surface ditching and straightening of natural streams increase peak flows, which results in flooding, channel scouring (erosion) and alteration. Impervious surfaces cause flow velocities and amounts to increase and then decrease more rapidly in response to a given rain event (a "flash flood effect"). Impervious surfaces cause lower base flows, which exacerbate drought impacts, especially temperature and oxygen extremes.

Rainwater runoff from lawns can be five to 10 times higher than from natural land cover, and carry up to nine times more phosphorus pollution. Salt used to keep roadways safe in winter ends up in lakes and streams, altering their chemistry. Development of land along lakeshores has a particularly powerful impact on water quality in Minnesota because of the land's proximity to waterways; with populations in counties with abundant lakes expected to grow at least 35% over the next quarter century, development's threat to such waters is likely to expand.

1990s MINNESOTA LAND USE

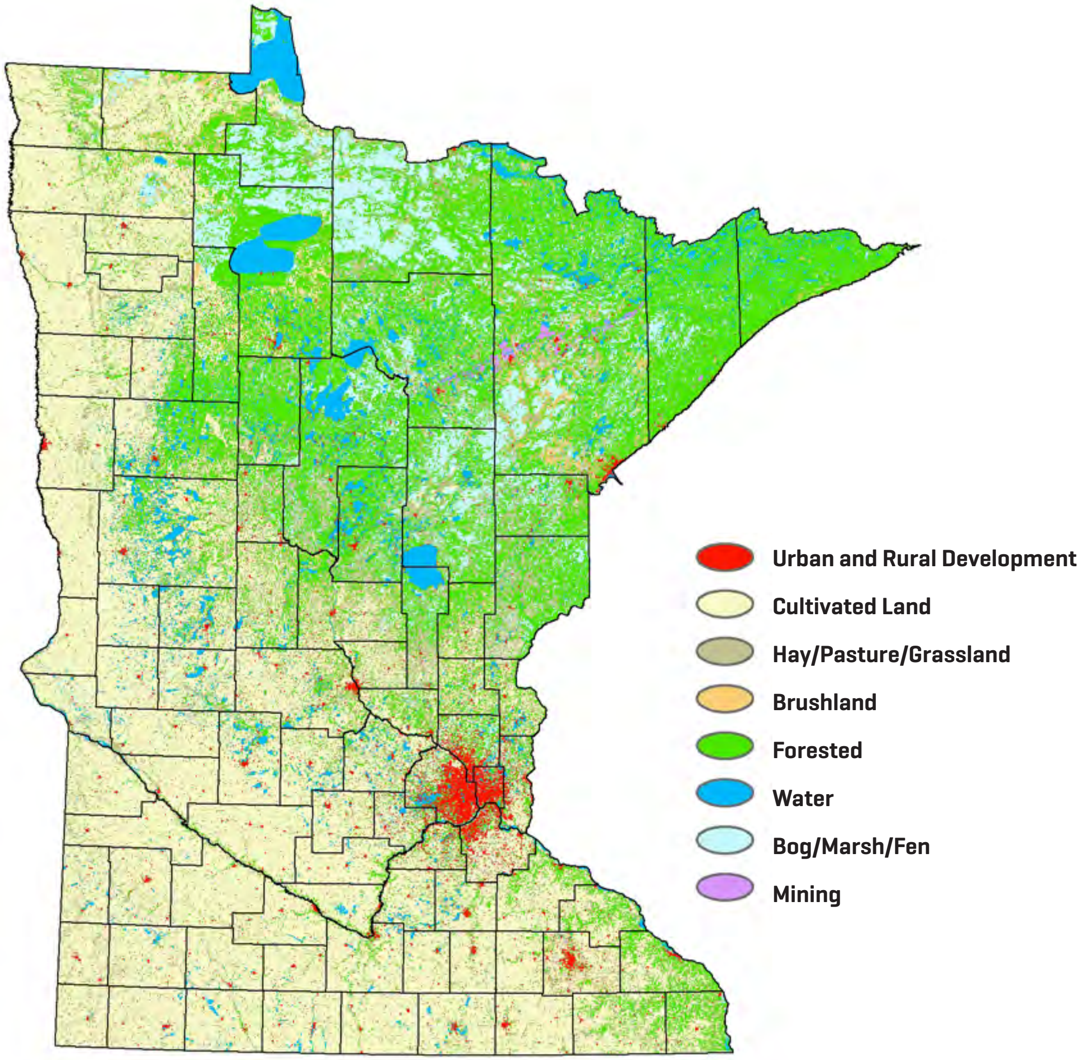


Figure 3-15: 1990s Minnesota Land Use

SOURCE: LAND MANAGEMENT INFORMATION CENTER

One major land use that affects water is agriculture. About 45% of Minnesota's land area is used for crops and pasture. In the process of providing food for the world and contributing to Minnesota's economy, farming alters the natural location and movement of water on the land. The 21,000 miles of ditches built to remove water from Minnesota farmland so it can be cultivated move precipitation rapidly to surface waters, altering natural hydrology and draining wetlands that help cleanse water. Some 89 billion gallons of water, most of it groundwater, were used in 2005 to irrigate farmlands, and another 22 billion gallons were used to water livestock. Farming also contributes polluting sediments, nutrients, and other chemicals to surface water and groundwater (see Issue B: Excess Nutrients and Other Conventional Pollutants).

Other commercial uses of land also influence water. In 2005, mining used nearly 1.5 trillion gallons of water. Runoff from mining operations can pollute surface waters if not handled properly. Tree harvesting and forest management also can pollute waterways if care is not taken to prevent damage. Forested areas are also threatened by impervious surface increases caused by second home development along lake shores and streams. Runoff-related changes from increased stream crossings by roads, and the amount of logging have also degraded water in forested areas. Some of the more sensitive forest areas are affected by forest practices such as wetland areas, riparian zones and where the terrain is steep and has thin or poorly drained soils.

Human activities that affect air quality affect water, too. Mercury occurs naturally in the environment but is mostly released to the atmosphere through human activities such as burning fossil fuels and mining. In the atmosphere, it can circumnavigate the globe, and come back to earth in rain. Once in water, it moves to sediments where microbes convert it to a particularly toxic form, methylmercury, which mobilizes in water and ends up accumulating in the food chain. This ubiquitous neurotoxin is found in fish throughout Minnesota. Because it can cause nervous system damage, the MDH issues advisories for limiting consumption of fish from lakes with high mercury levels. Mercury accounted for 77% of the listings on Minnesota's impaired waters list—but only 10 percent of the human-generated mercury polluting Minnesota waterways comes from sources within the state. Mercury has been declining in urban and northeastern Minnesota lakes but increasing in southwestern Minnesota lakes.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Turbidity of lakes and streams**
- **Excess nutrients**
- **Toxic chemical pollution**
- **Loss of wetlands**
- **Changes in hydrologic cycle**
- **Moving water off land too quickly**
- **Deposit of mercury in lakes and streams**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: Over the years, numerous practices have been developed and applied to minimize the adverse impact of land uses on waterways. Best management practices BMPs for stormwater management, agricultural practices, and timber harvesting have been developed to minimize adverse impacts to water.

Much is known about shoreland development practices to protect waterways. On average, aquatic vegetation drops by two thirds when shorelands are developed. And this loss is linked to lower fish production and water quality. But shoreland development done with an eye to protecting the land's ability to slow the flow of stormwater to lakes and streams can dramatically reduce flow of sediments and nutrients into waterways.

Residential and commercial development also is increasingly informed by efforts to keep waterways healthy. Rain gardens, rain barrels, vegetated swales, and other practices retain water on the land, boosting surface water quality and reducing flooding. Still, land use permits are typically issued without due consideration of impacts on water resources, even though impacts of land use on water are clear. And when BMPs are not followed, surface and groundwater is unnecessarily fouled.

The benefits of mining can be sustainable, even as the supply of the mineral resource is finite. If comprehensive planning recognizes that mining will not go on indefinitely, and the community uses the economic benefits of mining to prepare for or develop an alternative industry or other land use in the wake of mine closure, the community can be sustainable. Mining is, or can be, a temporary use of land. However, the degree to which the land is changed varies greatly depending on the size and depth of the mining operation. Some mineland can be easily converted to other uses (gravel pits to shopping centers or parks and lakes, for example, as in the large commercial area in the city of Maple Grove or Cascade Lake in Rochester). Other mineland is changed greatly and probably for all time (iron mines hundreds of feet deep filling with water). In Minnesota, mining impacts on water are controlled by permits issued by the DNR and MPCA.

Forests in Minnesota are well-managed for water quality as a result of two forestland certification programs adopted in Minnesota: the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC). Sustainable forest management as defined by SFI is "To meet the needs of the present without compromising the ability of future generations to meet their own needs by practicing a land stewardship ethic that integrates reforestation and the managing, growing, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water quality, biological diversity, wildlife and aquatic habitat, recreation, and aesthetics." More than 4.8 million acres of DNR-administered forestland have earned dual certification under SFI and FSC; more than 1.8 million acres of county forestland are certified under one or both of these programs; and nearly 830,000 acres of private forestland are certified under one or both of these programs.

The following gaps in knowledge and science have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **The effects of land use changes on groundwater quantity and quality are not fully understood.**
2. **The impacts of climate change are not well understood.**
3. **The effectiveness of climate change adaptation strategies is unknown.**
4. **The effectiveness of landscape restoration techniques to treat or recharge water, provide habitat, protect shorelines, or manage stormwater is not fully understood.**
5. **The cumulative impacts of extractive land uses on ground and surface waters are not fully understood.**

POLICY GAPS

1. **The loci of decision making on land and water issues are mismatched (generally, land use decisions are made locally, while water is regulated and enforced at state and federal levels).**
2. **The county water planning system does not lead to integrated land and water planning.**
3. **Minnesota lacks climate change adaptation policies and strategies.**
4. **See Issue B for gaps related to agricultural policy.**
5. **Mining discharge is permitted on a case-by-case basis, with no larger water protection framework.**

D.1 OBJECTIVE: To achieve an effective and enduring connection between water sustainability and land use decisions.

D.1 STRATEGY: Integrate water quality and quantity sustainability principles into state land use statutes and rules, and local plans, ordinances, and development review.

D.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Local comprehensive land use plans incorporate water sustainability, which guides land use decisions across the state** ➲ BENCHMARK: **Every local government adopts a comprehensive land use plan with water sustainability goals and actions** ➲ BENCHMARK: **Growth and development plans are conform to water sustainability goals**
- **Permits are only issued for new development and new land use activities that do not degrade water quality or negatively impact water supply sustainability** ➲ BENCHMARK: **All local land use applications require information on water quality and quantity impacts** ➲ BENCHMARK: **Local governments deny new development and land use activities that have the potential for negative impacts on water quality and quantity**
- **Full compliance with Minnesota's locally administered land use related water laws** ➲ BENCHMARK: **Shoreland, wetland, floodplain, water supply, wastewater, and stormwater management rules are consistently and aggressively enforced**
- **Local elected and appointed officials understand the impact of land use decisions on water sustainability and act on that understanding** ➲ BENCHMARK: **All land use decisions support water sustainability**
- **The effectiveness of land management activities on water sustainability is understood** ➲ BENCHMARK: **All land management activities have a water sustainability effectiveness score**
- **Land management activities improve impaired waters, do not contribute to water quality impairments, and do not negatively impact water supply** ➲ BENCHMARK: **Water quality and water supply outcomes detailed under other Issues in this framework are met**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION D.1.a: Integrate water sustainability and land use planning. Amend Minnesota land use planning statutes and rules (Minnesota Statutes Chapters 462, 394, and 473) to require water sustainability planning for comprehensive plans, and improve the connection between land use planning and county water planning as required by Minnesota Statutes Chapter 103B. Specifically:

i. Amend Chapter 103B, the Comprehensive Local Water Management Act, to include a definition of water sustainability, and require local water plans to address water sustainability in addition to other water planning requirements.

ii. Amend Chapter 473 to make water sustainability planning a stated requirement of the regional plan that is required by the Metropolitan Council. Chapter 473 also guides comprehensive planning by local governments in the Twin Cities metropolitan region. Water supply, wastewater treatment, stormwater management, and natural resource components are currently required for comprehensive plans in the metropolitan region. Water sustainability could become a unifying concept for these current requirements and should be extended as a significant criterion for required transportation, land use, and housing elements of these plans.

iii. Require that water sustainability be added as a primary consideration in the development of comprehensive land use plans by all municipalities. Chapter 462 includes comprehensive planning requirements for municipalities. Municipalities in the Twin Cities metropolitan region must create comprehensive plans to conform with provisions as stated in Chapter 473. Other municipalities are not mandated to create comprehensive land use plans: however, if they choose to adopt a plan, they must consider terrestrial natural resources and the provision of water and wastewater services.

iv. Require that water sustainability be added as a primary consideration in the development of comprehensive land use plans by all counties. Minnesota Statutes Chapter 394 lists comprehensive planning requirements for counties. Similar to municipalities, counties outside the Twin Cities metropolitan region are not required to create comprehensive land use plans.

v. Amend Chapter 462 and 394 to require comprehensive plans for communities outside of the metropolitan region to achieve uniform coverage of water sustainability plans throughout the state. This action would produce a strong connection between county water plans and local land use plans.

vi. State agencies should review and adjust timing requirements for local water planning, water permitting, and land use planning to better align schedules, so local water planning can occur concurrently to reduce duplicated efforts.

TIME FRAME: 2–4 YRS   COST*: L

RECOMMENDATION D.1.b: Integrate water sustainability principles and accountability into local land use permitting. Minnesota land use statutes require local governments to amend land use ordinances to implement adopted land use plans and implement required local water plans. Following the adoption of local land use plans incorporating water sustainability, local land use ordinances should be updated to reflect water sustainability. Local land use ordinances establish criteria for reviewing and approving land use permits. Updated ordinances should specifically include water sustainability criteria for approval of land use permits. A record of variances from water sustainability criteria should be kept and reported to the state.

TIME FRAME: 2–4 YRS   COST*: L

RECOMMENDATION D.1.c: Increase compliance with water sustainability laws and rules that are enforced at the local level by providing oversight and resources to increase local enforcement capacity.

i. State water laws are often implemented and enforced at the local government level. For example, shoreland, floodplain, and Wild and Scenic Rivers laws (Minnesota Statutes 2010 Chapter 103F) are implemented and enforced by local governments. Recommendation D.1.a. would add water sustainability to local government responsibilities. Strong, consistent local enforcement is necessary to achieve the state goal of compliance with these laws. Local governments should receive additional financial or staffing support from the state to enforce these mandates.

ii. To ensure enforcement goals are met, the state should require annual auditing of inspections, compliance, and enforcement actions and outcomes, and publication of findings. Subsequent-year funds should be contingent on acceptable inspection and compliance rates. Targets (rates and when achieved) should be standard across the state and established by the state agencies.

iii. In addition to financial resources, state agencies should provide technical assistance to local governments. State agency staff are often uniquely positioned to understand state requirements, observe a range of local units, and provide skilled educational and technical support.

TIME FRAME: 2–6 YRS   COST*: H

Research Plan

RECOMMENDATION D.1.d: Monitor the effectiveness of land use design and land use activities designed to protect water (e.g., minimizing impervious surfaces, requiring vegetative buffers, on-site infiltration of stormwater) and incorporate what is learned from effectiveness monitoring into future land use decisions.

i. Allocate resources to monitor the effectiveness of land use activities at the site and watershed level.

ii. Require effectiveness monitoring data for land use practices be made available to all potential data users. Involve data users in identifying user needs and improvement strategies for the databases. Encourage the sharing of cost effectiveness information for best management practices.

TIME FRAME: 2–20 YRS **COST*: H**

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

D.1.a.i.v: During the 1980s, the Minnesota Legislature adopted recommendations of the Water Planning Board calling for a new local role in statewide comprehensive water planning and establishment of a consolidated board of water and soil resources to administer local water planning and related programs. Policy programs were created to prevent pollution and to address nonpoint pollution. Today, many state agencies and local governments work together to protect and conserve Minnesota's water resources. Recommendation D.1.a. moves Minnesota into the next generation of water planning, where ensuring sustainable water quality and water supply into the future becomes the goal.

D.1.a.vi: Multiple state agencies (BWSR, MPCA, MDH) require components of water planning (water supply plans, county water plans, surface water management plans, stormwater permitting, etc.). Local governments often find that these required plans do not align in time nor align with local land use planning schedules. This misalignment results in duplication and inefficient effort.

D.1.b: Planning is only a precursor to action. Local land use permitting is where discrete decisions are made that result in changes in how land is used and how it is developed. It is very important that water sustainability is applied through the permitting process. Permit language and drawings determine whether a development conserves water or wastes water, and whether stormwater is infiltrated on site or is moved off the land and downstream.

D.1.c: Many of the problems of land use practice have been addressed by previous legislation, but they are not effective because of the lack or unequal enforcement of compliance rates, as well as a lack of transparency and accountability. Enforcement is also not equal across local jurisdictions. This recommendation provides a framework to put all local governments on a level playing field of leadership and accountability. One example is compliance with the zoning rules: many counties do not have the resources to inspect, so compliance rates are not known. Environmental enforcement competes with crime and other enforcement priorities for limited local resources.

D.1.d: The design of lots, structures, landscaping, and other water management site features can have a negative or positive impact on water resources. Knowledge about the effectiveness of various design and water management features on water sustainability is spotty at best. In order to make land use permitting decisions that will have a positive impact, local government decision makers must have good information on the effectiveness of design and water management features. Investment in effectiveness monitoring and dissemination of results will lead to increasingly better land use decisions.

TIME FRAME for COMPLETION of ISSUE D RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are *not* the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

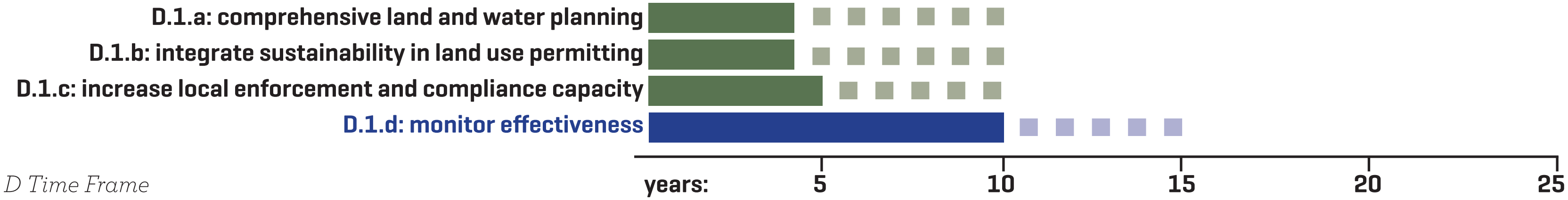


Figure 3-16: Issue D Time Frame

IMPACT MATRIX for ISSUE D RECOMMENDATIONS

	H		D.1.c, D.1.d	
Cost	M			
	L			D.1.a, D.1.b
		L	M	H
			Impact	

Figure 3-17: Issue D Impact Matrix

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE E:

ECOLOGICAL and HYDROLOGICAL INTEGRITY

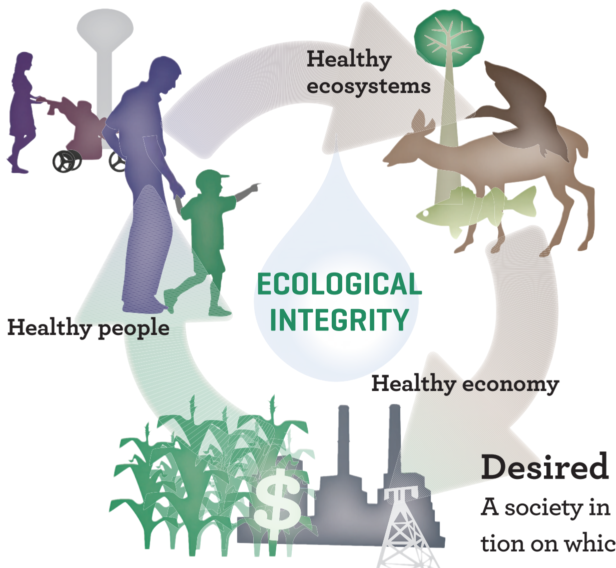


Figure 3-18: Ecological and Hydrological Integrity

SUSTAINABLE WATER REQUIRES SUSTAINABLE ecosystems. Disruptions in the balance of life alter ecosystem integrity and limit ecosystems ability to perform valuable aquatic ecological functions such as providing habitat for native species, filtering polluted runoff, and buffering floodwaters. Modifications of hydrological flows affect the entire water cycle, with both positive and negative consequences.

Desired Minnesota Future

A society in which healthy ecosystems are considered the foundation on which human well-being is based, all damaged ecosystems have been remedied and all ecosystems are protected, while maintaining a healthy economy. Changes to the hydrological system are minimized and historic changes have been addressed to achieve water quality and aquifer recharge needs.

PROBLEM STATEMENT: Minnesota cannot have a healthy population or a healthy economy without healthy ecosystems. Nor can Minnesota have naturally clean water without having healthy ecosystems, and vice versa. Ecosystems purify air and water; provide habitat for native species; protect the natural resource base for agriculture, forestry, industry, and commerce; buffer flood waters; support recreational activities; and much more. Part of what affects and controls ecosystem health is how water flows over and through the landscape. Thus the physical hydrologic system (water movement) is intertwined with the ecological system. Both must have sufficient integrity to support each other and to support a healthy people and a prosperous economy. Slowing the rate of water across the landscape allows for more infiltration and recharge of aquifers as well as a greater filtering capacity on the surface to cleanse water and support healthy ecosystems.

Human activities can disrupt the balance in ecosystems and in hydrological systems, reducing their ability to meet human needs. For example:

- Modifications to the hydrologic cycle include dams, hardening of riverbanks, tile drainage, surface ditches, wetland drainage, and withdrawal of water from groundwater aquifers. Such alterations can benefit society by preventing flooding, increasing agricultural productivity, or facilitating water transportation. However, they also can have adverse consequences such as altering the availability of clean water and disrupting the movement of game fish.
- Development along waterways can destroy habitat that supports native species and

helps keep an ecosystem in balance. Growing population, growing demand for lakeshore property, and subdivision of large tracts of wild lands are leading to increased destruction of ecosystem-supporting habitat along the shores of lakes around the state.

- When nonnative invasive species are introduced into waterways, they can displace native species or alter the habitat in a way that affects its ability to maintain proper function.
- If not planned correctly, agriculture, urban development, and other human activities along lakes and streams can reduce the ability of healthy shoreland ecosystems to keep sediments from washing into waterways.
- Plants and animals are adapted to specific ranges of temperature, precipitation, and other environmental conditions. Climate disruptions make it easier for some species to thrive and more difficult for others, affecting the overall balance of life in a particular area.

Protecting ecological and hydrologic integrity does not mean that ecosystems and hydrology should not be altered. Integrity can be maintained by strategically planning changes so they provide the benefit sought without compromising the underlying systems. An emerging tool called ecosystem services valuation provides a promising way to do so.

MINNESOTA SURFACE HYDROLOGY

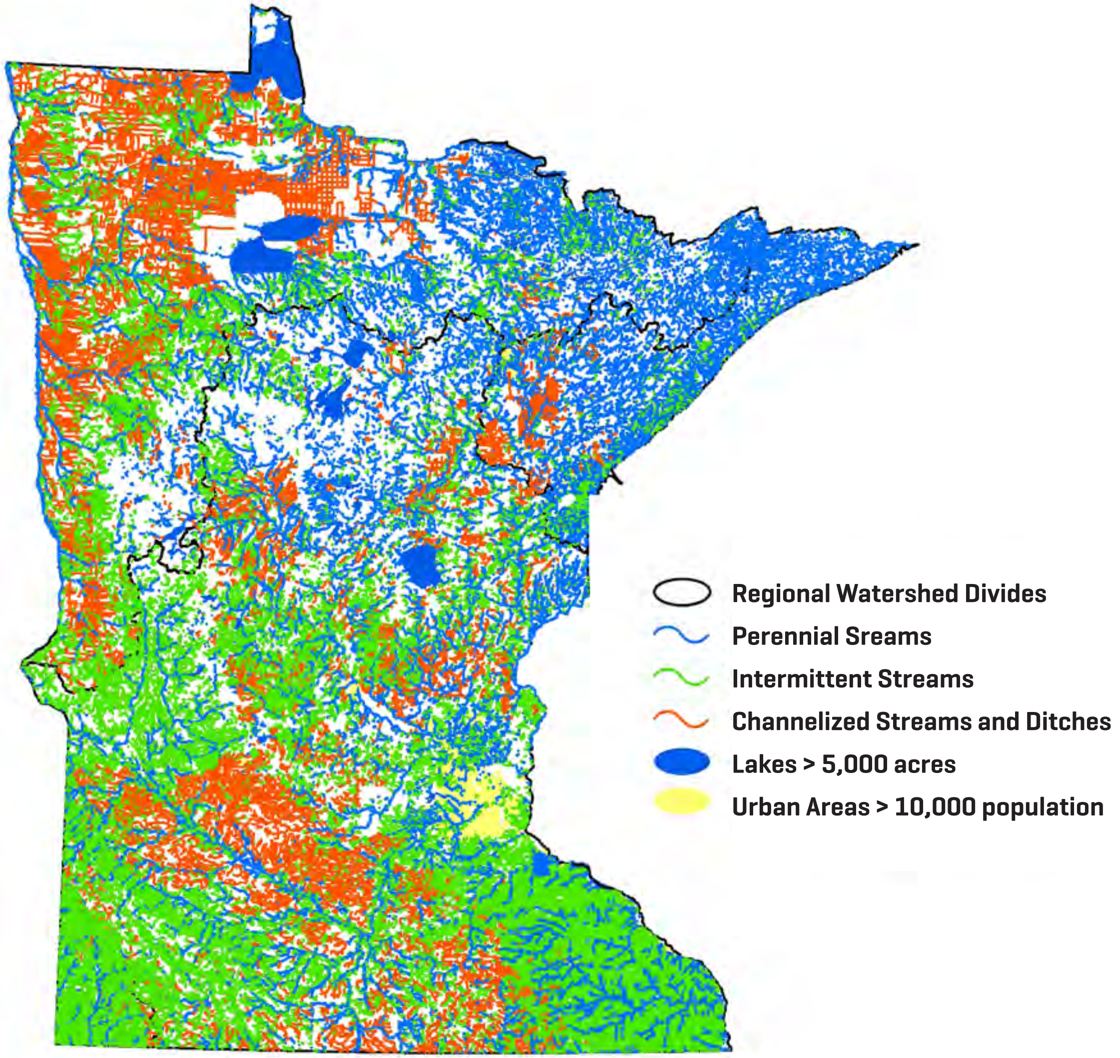


Figure 3-19: Minnesota Surface Hydrology

SOURCE: MINNESOTA DNR

This strategy involves identifying the economic value of the services healthy ecosystems provide, and factoring the cost of replacing those services into cost-benefit analyses. Thus, if a wetland provides $10 million per year in water-cleansing, waterfowl-supporting, and other services, a decision to fill in that wetland would include factoring the $10 million per year needed to provide those services through other means.

Finally, water movement and ecological communities should be managed as systems—holistic, connected, and integrated systems. Minnesota cannot address this issue one lake at a time.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **invasive species**
- **loss of biological diversity**
- **shoreland and aquatic habitat loss**
- **hydrologic modifications, including drainage and dams**
- **lack of ecosystem services valuation**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: Ecological integrity is affected by aquatic habitat loss caused by shoreland development, introductions of nonnative aquatic invasive species, and climate change. Land use practices and their impacts were discussed in Issue D: Land, Air, and Water Connection.

Nonnative species are introduced at a rate of about one per year in Minnesota. They are introduced by unintentional releases such as moving boats from one water body with an invasive species to a that has not been colonized, intentional releases of bait fish or aquaria fish, or by the migration of bighead and silver carp approaching Minnesota via the Mississippi River. Lake Superior alone has 87 aquatic invasive plants, fish, invertebrates, and parasites. Zebra mussels, sea lamprey, rusty crawfish, round goby, spiny water flea, curly-leaf pondweed, purple loosestrife, and Eurasian watermilfoil are some of the most common and well-known. Invasive species cause harm by introducing novel functions into an ecosystem and using or destroying the resources needed by native species. They can affect native gene pools, affecting biodiversity and reproductive success. Once they have taken hold, it is nearly impossible to eradicate them; one can just control their spread. In the U.S., the worst 79 invasive species are estimated to cost $79 billion in control measures. Wisconsin spends more than $1 million controlling zebra mussels in water intake pipes alone. The combined costs of aquatic invasive species control in Minnesota total in the millions of dollars a year.

In addition, there are costs that are not yet figured into the true cost of losing ecological benefits. Ecosystem services that water resources provide to Minnesotans include water for agricultural, industrial, and residential use; fish, waterfowl, mussels, and aquatic foods such as aquaculture and wild rice; recreation opportunities (boating, swimming, fishing, hunting, nature viewing); flood control; and aesthetic, spiritual, and cultural benefits. Studies that have tried to estimate the value of ecosystem services provide an indication of the magnitude of their worth. One study estimated a value of $5 million per year in cost reduction of treating groundwater in Rochester. Another estimated a value of $9.37 per milligram of sediment prevented from entering a water body. The value of wild rice harvest in Minnesota is approximately $5 million annually. The value of sport fishing is estimated at $465 per year per person.

The DNR has an aquatic invasive species program to curb the spread and minimize harmful effects of invasive species. Its goals are to prevent introductions of new invasive species into Minnesota, prevent the spread of invasive species within Minnesota, and reduce the impacts caused by invasive species to Minnesota's ecology, society, and economy. Many threats come from outside the state, via ballast water from ocean-going vessels in the Great Lakes to or from unwanted fish and mussel species migrating north in the Mississippi and St. Croix transboundary rivers.

RON PALMER, LEECH LAKE RESORT OWNER

LEECH LAKE RESORT OWNERS RON AND Sharon Palmer live a life many people would envy. The couple are owners and operators of Agency Bay Lodge, a picture-perfect resort that inspires its happy guests to return generation after generation. But, while enviable, the Palmers' lifestyle is hard work. Says Ron, "I think of my wife and I as stewards of both Agency Bay Lodge and Leech Lake."

For 30 years, Palmer has tended the 60-acre property with loving care. "I love the fact that we have a chance to be part of our visitors' dreams and traditions," he says. "While some of them take responsibility for the lake very seriously, others use and enjoy the lake without realizing that it does require maintenance."

Central to Palmer's success is the water quality and ecosystem health of Leech Lake. "It's definitely the most important aspect in preserving our gift to our guests," he says. "We need to give them something to write home about, a lasting impression which includes a healthy lake with an abundant supply of catchable fish."

To that end, Palmer served many years on the Leech Lake Area Chamber of Commerce, service groups, and other local organizations dedicated to preserving the health of ecosystems and economic vitality of the area. "With a lake as large as Leech, one might guess it will never be overused, but in reality, each and every footprint can be detrimental to its health," he says. "Like my buildings, boats, and motors, the lake can get tired without the proper care."

Palmer has seen the signs of invasive species in the form of habitat-choking Eurasian water milfoil, fish-egg-eating rusty crawfish, and disease-carrying banded snails. He worries about the impact they might have on the lake's fish population and water quality. Palmer spoke of a disturbing sight he saw about 10 years ago on a trip to Lake Minnetonka to buy a boat:

"There was piece of machinery out on the lake, a combine of sorts, threshing milfoil out of the water," he recalls. Workers were hard at cutting a trail through what seemed a like a forest of milfoil from the boat ramp to deeper water just to allow boat access. He'll never forgot the scene: "There were dumpsters on the boat ramp just filled with milfoil, trucks coming and going emptying them. It just seemed so futile, a never-ending job."

When Palmer returned to Leech Lake he told others what he'd seen. "I questioned myself and wondered, if that were Leech Lake, would we still be able to attract boaters and fishermen?" While always concerned for Leech Lake's health, Palmer's apprehension increased. "I'm quite certain those Lake Minnetonka lakeshore residents would love to back up the clock 20 years and provide any and all precautions to prohibit the infestation," he says.

"If I were to be able to give one gift to the lake, it would be to preserve the quality of its incredible beauty and clarity," he says. "The water quality of Leech Lake is like looking into one of your friends' eyes. It says to me, I'm tired at times, but with proper care, education, and maintenance, I can be around for your grandkids and their grandkids to love and enjoy with the same passion we have."

Hydrologic changes have taken place since the initial settlement of the land, with conversion of forests and prairies to farm land and the draining of wetlands to allow greater use and productivity of the land. The pendulum has swung back to greater wetland protection and restoration as the state recognizes the ecosystem benefits of wetlands. However, there are tens of thousands of subsurface agricultural drain tiles and ditches in the state, and new areas of the state continue to be tiled. Drainage is both good (removes water from land to improve agricultural productivity) and bad (tile-drained water carries nitrates and other pollutants to ditches and to rivers). The issue of drainage is laden with political, economic, and social values and there is little firm science on best practices. Dams and locks were constructed for hydropower and for transportation. There is now movement to remove dams, but it creates conflict between reconnecting a free flowing river ecosystem uninterrupted by dams or reservoirs (a good idea) and allowing the upstream movement of unwanted or destructive invasive species (a bad idea). Such decisions will need to weigh both considerations.

The Federal Farm Bill has a number of land conservation programs, including the CRP, consisting of temporary easements; the Wetlands Reserve Program, which utilizes permanent easements; and the Environmental Quality Incentives Program (EQIP), which offsets the cost of adopting conservation practices; among many others. These programs are intended to provide technical and financial

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **The cumulative impacts of water quality and water quantity stressors on critical ecological processes and their associated aquatic ecosystem functions for both lakes and streams are unknown.**
2. **There is insufficient understanding of the effects of climate change on ecosystem function and the effectiveness of adaptation strategies to protect vulnerable ecosystems.**
3. **The effects of modifications to physical habitat associated with sediment transport and channel modifications on ecological integrity and ecosystem function in streams are unclear.**
4. **There is insufficient understanding of the effectiveness of best practices and of incentives needed to change individual behaviors regarding shoreland management.**
5. **There are no tested methods for determining the economic value of the ecosystem services provided by aquatic systems.**

POLICY GAPS

1. **Aquatic systems and terrestrial systems are treated separately, when in fact they are interconnected (see Issue D: Land, Air, and Water Connection).**
2. **Monitoring and protection policies do not include sufficient biological or effects-based indictors.**
3. **Great Lakes ballast water rules are too weak.**
4. **Mechanisms to avoid introducing and spreading invasive species are insufficient.**
5. **Shoreland rules and policies are insufficient to protect important aquatic habitat.**
6. **The economic value of ecosystem services is not included in policies or cost-benefit analyses.**

assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. Farmers are compensated for not farming lands that are considered marginal for productivity but if used may contribute considerably to soil erosion and water quality problems. Many of the provisions of these programs directly address ecosystem integrity as well as hydrologic integrity. In Minnesota, BWSR manages the Reinvest in Minnesota (RIM) Reserve Program which complements the federal CRP.

The pressure to maximize corn and soybean yields for both food and biofuel feedstocks, as well as favorable commodity prices, has in turn provided incentives to farmers to take land out of conservation protection and place it back in production. In 2007, Minnesota had 7% of agricultural lands (1.8 million acres) enrolled in the Conservation Reserve Program. More than 60% of that enrollment is specifically devoted to restoring and enhancing wetlands, habitat, or water quality. However, 1.5 million acres is due to expire over the next 10 years. Generally these lands are marginal lands that do not provide maximum productivity but pose greater risks to water resources. Thus keeping land in conservation reserve should be a priority for managing water resources. The Federal Farm Bill has a great impact on farmers' choices as to how they use their land, and will be reauthorized in coming years. While the current Farm Bill has strong conservation measures, it is unclear what future incentive programs may focus on, given the constantly changing political landscape. Many professionals that are knowledgeable about the land easement programs have expressed the specific concern that if lands currently in conservation were placed back in production, it could negate all the other efforts the state is making to restore and protect water quality.

E.1 OBJECTIVE: To protect ecological benefits provided to humans from aquatic ecosystems.

E.1 STRATEGY: Restore and protect critical aquatic ecosystems using a watershed approach.

E.1. OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Protection of ecosystem functions, as measured by monitoring of ecosystem indicators.** ➲ BENCHMARK: **90 percent of ecosystem indicators meet standards in 10 years.**
- **Inclusion of cost of ecological benefits in policy decisions.** ➲ BENCHMARK: **Valuation of key ecosystem services completed in 5 years and inclusion in state policy and decisions within 10 years.**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION E.1.a: Enact an Ecosystem Integrity Act that includes strong rules for ecosystem protection, invasive species prevention, penalties for violations, and funding for enforcement, and requires the economic value of diminished ecosystem services to be considered in all policy and regulatory deliberations, including environmental review, cost-benefit analyses, and all rulemaking affecting our environment. Review all statutes and rules that address terrestrial and/or aquatic habitat protection, and revise them to take an integrated, whole watershed approach to protection and restoration.

i. The act should be adaptive to new knowledge and lessons learned in the application of the statute over time (adaptive management principles); it must explicitly address climate change impact on ecosystem integrity and recognize that some habitats and ecological niches are not going to be preserved.

Research Plan

ii. Fund research to identify a suite of ecosystem services to be included as indicators of ecosystem integrity (large watershed scale), and to determine their value in economic terms. This will provide necessary information to the Ecosystem Integrity Act.

TIME FRAME: 5–10 YRS COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

E.1.a: An overarching statute is needed to connect and leverage the state's efforts on all fronts of this complex issue. This act must address climate change and strategies to adapt to it, and include the steps needed to identify the best set of ecosystem services to be used as indicators for valuing the overall services that water provides to society. The costs of diminished ecological health are not paid directly by the person or group that caused them, but are an externality or cost paid for indirectly by taxpayers or by no one.

E.2 OBJECTIVE: To reduce impacts caused by new and existing aquatic invasive species.

E.2 STRATEGY: Prevent additional introductions of and reduce the ecological, recreational, economic, and health impacts of nonnative aquatic invasive species.

E.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Reduction in introductions and impacts of aquatic invasive species on ecosystem services.** ➲ BENCHMARK: **A slowing of the introductions of aquatic invasive species to less than 1 per every five years by 2020** ➲ BENCHMARK: **A reduction of 50 percent in the number of water bodies negatively impacted by aquatic invasive species by 2035**

The following actions are recommended to implement this strategy.

Action Plan

RECOMMENDATION E.2.a: Develop statewide policies and dedicate funding to implement consistent policies for the prevention of new and managing of existing aquatic invasive species infestations. This requires a long-term and broad geographic perspective. Prevention strategies require:

- Thinking globally, regionally, and locally
- Determining whether a species is an invasive problem
- Predicting probable dispersal routes
- Increasing isolation of the species
- If not possible to keep a species out, prepare for its arrival

Once a species has a foothold, strategies include restoration, eradication and re-introduction of natives, redesigning the habitat or community, and adapting.

Interstate issues are key here as well. For example, keeping invasive mussels out of the upper St. Croix north of Stillwater depends mostly on what Wisconsin agencies and residents do in the Wisconsin waters upstream.
TIME FRAME: 2–4 YRS   COST*: M

Research Plan

RECOMMENDATION E.2.b: Fund research and demonstrations that investigate the cost-efficiency of biological, chemical, and mechanical control measures of aquatic invasive species.
TIME FRAME: 2–4 YRS   COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

E.2.a: The best course of action is to prevent the invasion of aquatic nonnative species. Once they have taken hold, it becomes an expensive and frustrating effort to contain them or control them, and the loss of native species and habitat is often permanent.

E.2.b: There has been research on control measures, but we need to know the cost effectiveness of different control measures. For example, organized citizen groups may play a cost-effective role in identifying infestations, remediating infested areas, and educating other citizens of best practices for preventing invasive species infestations.

E.3 OBJECTIVE: A hydrological system that supports economic activities and minimizes impacts on aquatic ecosystems.

E.3 STRATEGY: Keep more water on the land where it falls, and slow its movement across the landscape. Mitigate the water quality and aquifer recharge impacts of hydrological changes made for the benefit of agriculture and other economic activities, and plan for future hydrologic changes that balance water resource needs with economic needs.

E.3 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Effective management of surface waters and compliance with the Clean Water Act, as measured by implemented pollutant reduction plans and monitoring programs due to better drainage management.** ➲ BENCHMARK: **agricultural lands in compliance with water quality standards in 2025**
- **Reduction of flooding, as measured by both frequency and intensity.** ➲ BENCHMARK: **20% reduction in floods in the state by 2035**

The following actions are recommended to implement this strategy.

Action Plan

RECOMMENDATION E.3.a: Accelerate the development and application of the gridded surface subsurface hydrologic assessment (GSSHA) model to assess watershed hydrological characteristics and response. This tool is a landscape model that can depict, in high resolution and at a fine scale, how water flows across the landscape, and can provide better technical support to LGUs in understanding and managing their watersheds. GSSHA can run for both single extreme precipitation events or over the long term. It couples groundwater to surface water interactions, which is especially important for Minnesota. The effects of hydrological changes and hydrological management, including controlled drainage and flood control structures, can be predicted for choosing effective drainage structures and controls and their precise locations.

TIME FRAME: 5–10 YRS COST*: M

Research Plan

RECOMMENDATION E.3.b: Develop a tool to assess individual farm contributions to water flow and water quality of receiving waters. This tool should be a series of integrated models that will allow the prediction of the impact of best drainage management practices used on the field scale to be addressed on a cumulative basis at the watershed scale. This is critical to addressing flood control, and also addresses water quality concerns from agricultural runoff and tile drainage. This recommendation is essential for implementing Recommendations B.1.a and B.2.a. It also would provide accurate quantification of the benefits of best farming practice, currently underestimated or not counted in many water quality assessments.

TIME FRAME: 1–2 YRS   COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

RECOMMENDATION E.3.c: Require all future construction and replacement construction of tile drainage systems to incorporate some aspect of multipurpose drainage conservation technology, specifically selected for that location and activity from a suite of accepted conservation practices. The multipurpose intent is to control water discharge speed, improve quality of the discharge, and increases groundwater recharge.

TIME FRAME: 2–4 YRS   COST*: L

RECOMMENDATION E.3.d: Expand incentives and grants programs for retrofitting existing drainage tile. BWSR currently provides cost-sharing to farmers for this purpose with Clean Water Fund support; this program should be increased considerably.

TIME FRAME: 2–4 YRS   COST*: H

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

E.3.a: The GSSHA model was developed by the U.S. Army

GSSHA MODEL: FLOODING HYDROGRAPH

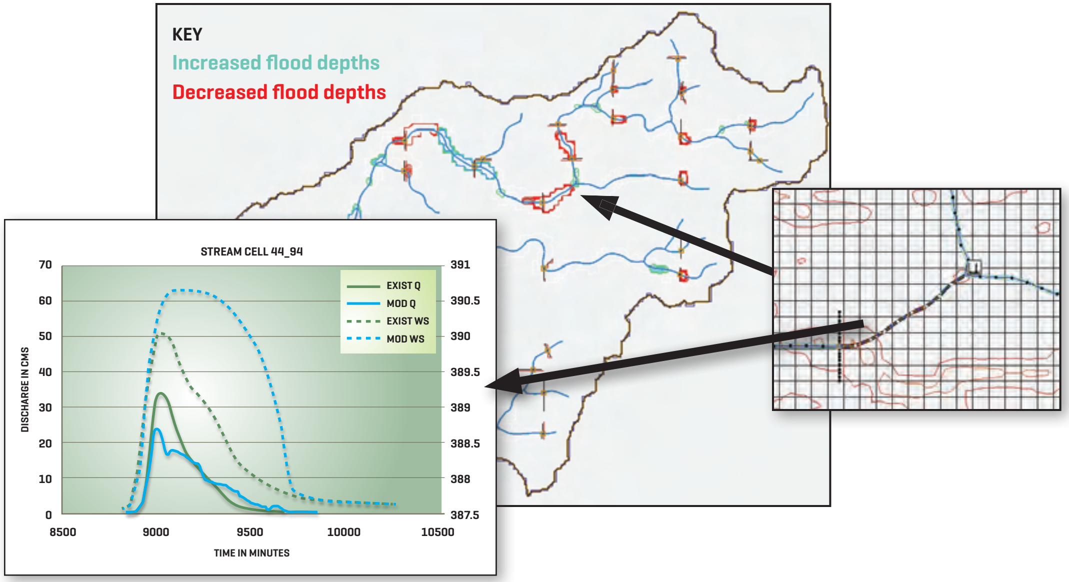


Figure 3-20: GSSHA Model, Effect of Downsized Culverts Illustrated by a Flooding Hydrograph

SOURCE: DNR

Corps of Engineers and is being used and further developed by DNR. Its development was targeted specifically to help understand the processes that result in cumulative impacts in watersheds. See http://files.dnr.state.mn.us/fish_wildlife/roundtable/2010/erw/emergingscience.pdf. and http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;528. The DNR has been evaluating the potential of the GSSHA model to address the cumulative impacts of drainage and is conducting a number of ongoing pilot studies. These studies show much promise for the use of GSSHA in assessing best management practices and in TMDL implementation. This model works at the fine scale of sub-watersheds. Figure 3-20 illustrates the application of information from the GSSHA model. The figure shows the geographic areas where flooding is increased or decreased by the downsizing of culverts in stream cell 44_94. The associated hydrograph shows that downsizing of culverts holds water on the land for a slightly longer period resulting in more infiltration on site

E.3.b: This could be done by linking existing models that work at different scales, from fine-scale field models to sub-watershed scale (e.g., GSSHA) to medium scale watershed models such as HSPF and SWAT, and filling the gaps with additional model development. Such an approach is being discussed as part of the Minnesota River Integrated Watershed Study, a partnership of the U.S. Army Corps of Engineers, EQB, DNR, MPCA, MDA, BWSR, and UM.

E.3.c: Much of the existing tile drain systems are aging and being replaced at an accelerating rate. Also, new systems are being installed. This recommendation recognizes that no one solution fits all, and that individual farmers in different parts of the state have different problems and thus have different solutions. BWSR, UM Extension, and the MDA have identified multipurpose drainage conservation practices, including controlled subsurface drainage systems, woodchip bioreactors, water and sediment control basins, etc.

E.3.d: This program is currently funded at approximately $600,000 per year from the Clean Water Fund, and this can provide the 75% cost-share to only a handful of farmers.

E.4 OBJECTIVE: To maximize the placement of marginal lands in conservation protection

E.4 STRATEGY: Aggressively use all tools and programs to retain conservation-protected lands already set aside, and to encourage additional set-asides and protections of marginal lands.

E.4 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Keep existing set-aside lands in conservation protection.** ➲ BENCHMARK: **Re-enroll all existing acres as they expire, each year**
- **Increase enrollment of marginal lands enrolled in conservation protection.** ➲ BENCHMARK: **increase enrollment to 10% of total agricultural lands by 2020**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION E.4.a: Invest in ways to keep existing lands in reserve and accelerate land easements in the state. Enhance the RIM program; preserve the current practices for the most environmentally sensitive and beneficial parcels using targeting tools and state funding to leverage federal funds; and expand the marketing and technical capacity in the state to get federal project funds on-the-ground, as that is the short-term limiting factor.

TIME FRAME: 4–5 YRS   COST*: H

RECOMMENDATION E.4.b: Work with coalitions, state partners, and the Minnesota congressional delegation to maximize provisions for land conservation programs within the Farm Bill and to adjust agricultural incentives to minimize water quality impacts (e.g., have crop subsidies that encourage use of marginal lands redirected towards paying farmers to preserve land).

TIME FRAME: 2–4 YRS   COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

E.4.a: The federal programs will pay for land and project costs but pay very little for the personnel or for contracting to accomplish on-the-ground conservation programs. A recent report on the Farm Bill conservation programs stated that the implementation of these federal programs is not limited by funding but by local capacity.

E.4.b: Minnesota worked to ensure conservation programs were strengthened in the 2008 Farm Bill, and they were successful. The time frame for the next reauthorization of the Farm Bill will likely be in 2012.

TIME FRAME for COMPLETION of ISSUE E RECOMMENDATIONS

The recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from Action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

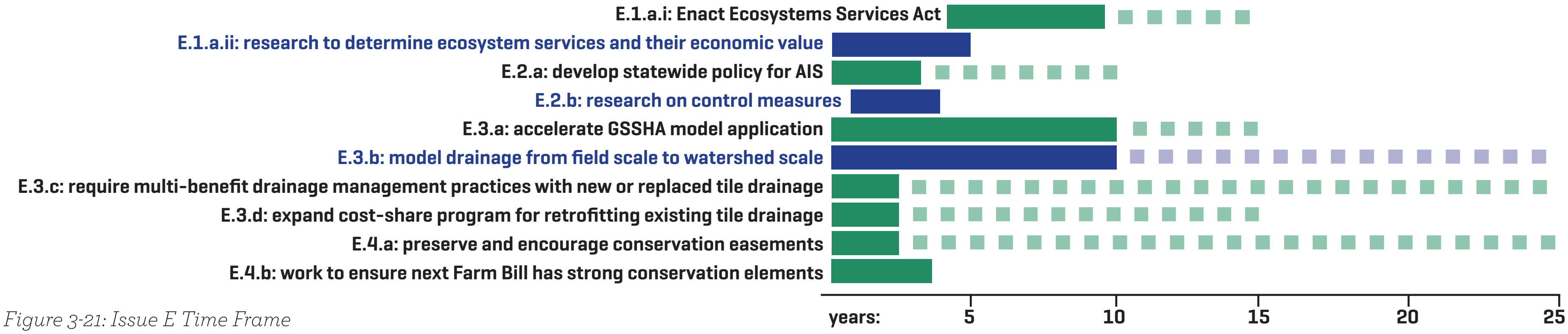


Figure 3-21: Issue E Time Frame

IMPACT MATRIX for ISSUE E RECOMMENDATIONS

Cost	L	M	H
H			E.3.d, E.4.a
M		E.2.b	E.1.a, E.3.a, E.3.b
L		E.2.a, E.4.b	E.3.c

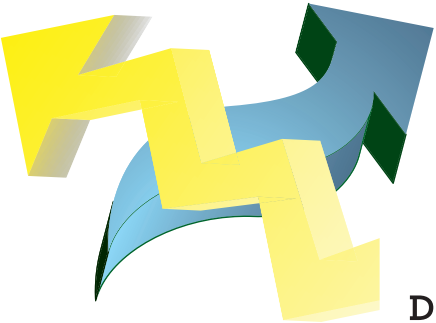
Impact

Figure 3-22: Issue E Impact Matrix

This figure indicates the impact of implementing a given Recommendation (how much of difference it will make to achieving sustainable water use and management), relative to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE F:

WATER-ENERGY NEXUS



Desired Minnesota Future

A society in which energy policy and water policy are aligned.

WATER AND ENERGY ARE INEXTRICABLY linked. It takes energy to supply water, and it takes water to supply energy. Water quantity and quality must be considered in the context of energy needs, and energy in the context of water quality and quantity needs.

PROBLEM STATEMENT. Water and energy are both essential to life, and to modern society. These two valuable resources are interconnected and interdependent. Constraints on one will result in constraints on the other. However, these connections are not very visible to the public, and thus are not always managed to maximize benefits for both and the environment. This topic was first acknowledged on a national level with the 2006 Report to Congress, *Energy Demands on Water Resources,* by the U.S. Department of Energy.

What are some of these interrelationships? First, water use and water management require energy inputs, from pumping groundwater for industrial or domestic purposes, to building and running locks and dams and irrigation systems, to operating wastewater treatment plants. Water is very heavy, and requires considerable energy to move—one acre-foot of water (325,724 gal), weighs approximately 1,231 metric tons (2,713,890 lb). Water treatment, both for drinking water purposes and for wastewater discharge, is highly energy-intensive. In California, water pumping is the single largest use of electricity in the state.

Second, water is used in the process of transforming energy to forms people can readily use. Flowing water provides energy for hydroelectric power production. By far, the predominant use of water in Minnesota is as once-through cooling for thermoelectric power production. Water is also used in refining oil, growing fuel crops, and manufacturing bio-based fuels.

Approximately 4 percent of U.S. power generation is used for water supply and treatment and about 75 percent of the cost of municipal water processing and distribution is electricity, according to the U.S. Department of Energy. This means that Minnesotans may indirectly use as much water running household appliances and turning on lights as they directly use taking showers, washing clothes, and watering lawns.

Energy production also affects water quality. Most electricity used in Minnesota comes from coal-fired power plants. Coal-fired power plants are an important source of mercury to the environment, so more electricity may result in more mercury in fish. Combustion of fossil fuels produces greenhouse gases that contribute to climate change, which affects the hydrologic cycle. Climate change will also lead to increased water use due to an increase in demand for electricity.

As demand for other sources of energy grows, it will also increase the demand for water. Biofuel production and refining, nuclear power production, and natural gas production all use significant water resources. The 2007 Minnesota legislation establishing a goal of 80% greenhouse gas reduction by 2050 (Next Generation Energy Act, Session Law Chapter 136) will result in shifting the fuel mix for electricity production, and this may reduce water demand for coal-fired electric plants and shift water demand to rural areas for increased biomass crop production.

Achieving a sustainable balance between water and energy will benefit domestic, manufacturing, energy, and agricultural water uses. So will increasing efficiency of water use in energy production, and in increasing efficiency of energy use in handling water—reducing the economic, social, and environmental costs of each. Specific issues that need to be addressed include cooling water for thermoelectric plants, biomass and biofuel production, electricity use to distribute and treat water, and hydropower.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Cooling water for thermoelectric plants**
- **Biomass and biofuel production**
- **Electricity use to distribute and treat water**
- **Hydropower**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: There have been very few studies to determine and inventory the quantitative relationships between water and energy, such as the energy costs required to operate a wastewater treatment plant (WWTP). The federal government considers the water-energy nexus to be a top priority, as both energy demands and water demands are increasing. Both the DOE and the EPA have ongoing programs to understand these relationships in depth, such as the interagency Water-Energy Roadmap (http://www.sandia.gov/energy-water/roadmap_process.htm).

California has created such an inventory for the state, and some of the relationships reported to Congress in 2006 appear in *Figure 3-23*. Each kWh of electricity uses approximately 25 gallons of water for cooling purposes. About 10% of this is lost to evaporation. Wastewater treatment in California uses 500 to 1,500 kWh per acre-foot.

Production of hydroelectric power in Minnesota involves approximately 7.2 trillion gallons of water each year (this is an instream use, rather than a consumptive or nonconsumptive use). Some 892 billion gallons of water are temporarily withdrawn from the state's surface water and groundwater annually to cool condensers and reactors in power plants generating electricity from nuclear or fossil fuels (considered a nonconsumptive use). Low-temperature geothermal energy use was reviewed by the Framework participants, but not considered further for recommendations. Current Minnesota statute and practice allows for only closed-loop systems, and thus consumptive use is minimized.

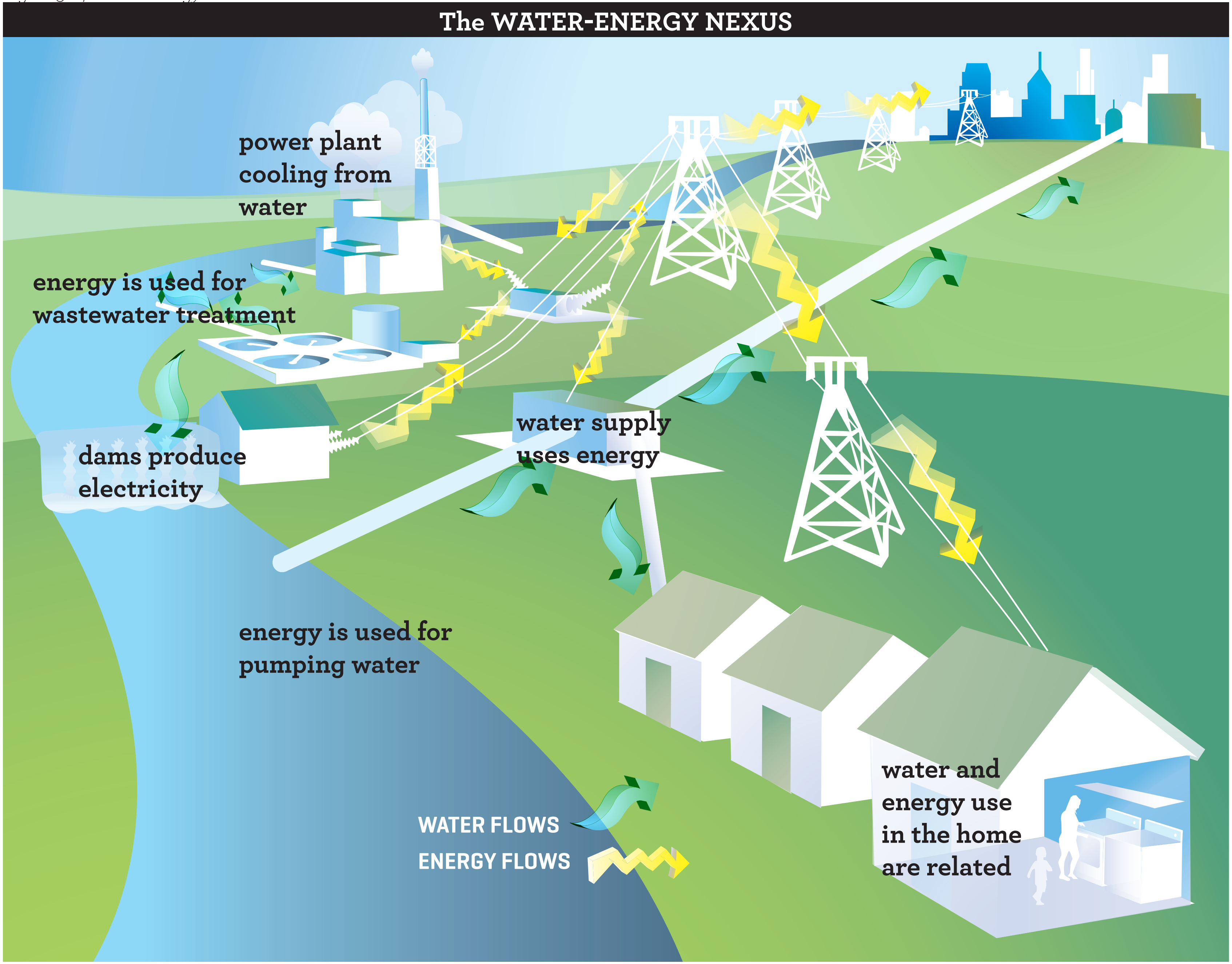
An EXAMPLE of a WATER-ENERGY INVENTORY

	kWh/million gallons	
WATER CYCLE SEGMENTS	**LOW**	**HIGH**
Supply Conveyance	**0**	**16,000**
Treatment	**100**	**1,500**
Distribution	**700**	**1,200**
Wastewater Collection and Treatment	**1,100**	**4,600**
Wastewater Discharge	**0**	**400**
TOTAL	**1,900**	**23,700**
Recycled Water Treatment and Distribution for Non-Potable Uses	**400**	**1,200**

Figure 3-23: California Water-Energy Inventory

US DEPARTMENT OF ENERGY REPORT TO CONGRESS, DECEMBER 2006, FROM CALIFORNIA ENERGY COMMISSION

Figure 3-24: Water-Energy Nexus



The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **Interrelationships between water and energy have not been quantified.**
2. **The economic costs of these relationships are not well understood.**
3. **The ecological costs of water-energy relationships are not well understood.**

POLICY GAPS

1. **Energy is not sufficiently considered in water policy, nor is water sufficiently considered in energy policy.**

F.1 OBJECTIVE: To understand all the relationships in the water-energy nexus and manage water and energy for maximum benefit to both.

F.1. STRATEGY: Identify all relationships between water and energy, and determine the full costs of all water uses for all sources of energy generation, and costs for all energy uses to produce water.

F.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Accounting for all costs of water-energy interdependencies, as measured by completed inventory** ➲ BENCHMARK: **A completed inventory of relationships by 2012; accounting for full costs completed by 2016**

The following actions are recommended to implement this strategy:

Research Plan

RECOMMENDATION F.1.a: Understand the nexus of water and energy. For all water-energy connections (biofuel production, cooling water for thermoelectric plants, hydropower, electricity used to produce and distribute municipal water, water used in fuel refining, etc.), the state agencies in consultation with other experts should compile and inventory what is quantitatively known about each of these relationships (how much water is used for how much energy produced in Minnesota by sector, and vice versa) and determine the costs associated with these relationships.

TIME FRAME: 2–4 YRS   COST*: L

Action Plan

RECOMMENDATION F.1.b: Review and revise energy policies as needed for reducing impacts on water quality and quantity, and establish water sustainability thresholds (water quality and quantity) for energy policies to meet in order to be enacted. This is also part of Recommendation J.1.a.

TIME FRAME: 2–4 YRS   COST*: L

RECOMMENDATION F.1.c: Position and encourage Minnesota business to develop specific future renewable energy technologies that minimize impacts on groundwater and surface waters by providing incentives, tax credits, etc.

TIME FRAME: 2–4 YRS   COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

F.1.a: The intersection of energy policy and water policy is understood conceptually, but not quantitatively. To make smart and effective decisions about aligning water and energy policies, one needs to understand the full dimensions of these relationships.

F.1.b: See Recommendation J.1.a.

F.1.c: This Recommendation recognizes that we cannot foresee or predict the next generation of renewable energy, but we should be poised to be a leader in both renewable energy and water management by creating a welcoming environment for this sector. The focus should be on those technologies that minimize effects on water resources.

TIME FRAME for COMPLETION of ISSUE F RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from Action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

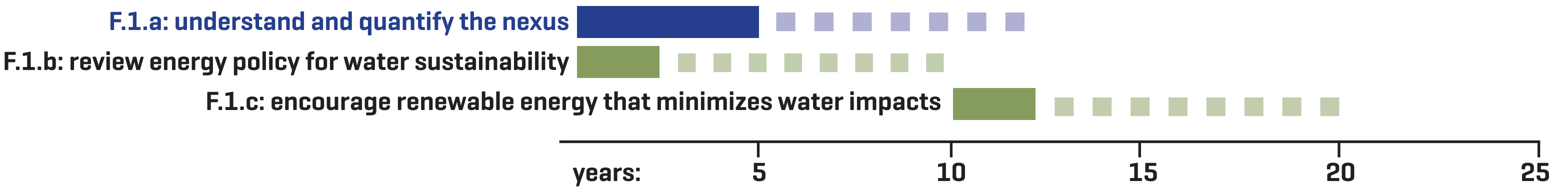


Figure 3-25: Issue F Time Frame

IMPACT MATRIX for ISSUE F RECOMMENDATIONS

Cost

	L	M	H
H			
M	F.1.c		
L		F.1.a, F.1.b	

Impact

Figure 3-26: Issue F Impact Matrix

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE G: WATER PRICING and VALUATION

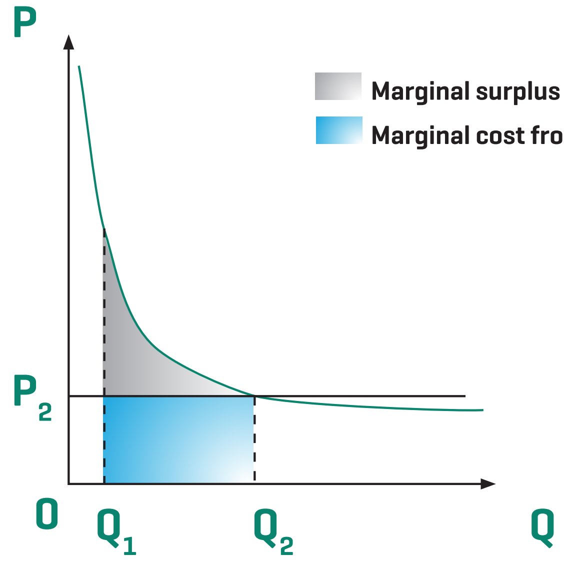
THE TRUE PRICE OF WATER IS NOT accounted for in our society. Tension exists between environmental restoration and protection and economic growth. Tension exists between those who see water as a (free) public good and those who prefer to see water as an economic good.

Desired Minnesota Future

A society in which water is considered a public service and is priced appropriately to cover the costs of its production, protection, improvement, and treatment, and the economic value of its ecological benefits.

PROBLEM STATEMENT: Conventional models and decision-making applied to water pricing fail to fully take into account the true or actual value of water and aquatic resources. As a result, policies that influence how water is managed are based on an inaccurate picture of the costs and benefits of various possible courses of action. This skewed perspective influences all uses of water—for agricul-

WATER QUANTITY DRIVES WATER PRICE



Economic studies of the value of water focus on the change in value with a change in water quantity or quality (marginal value versus total value). The marginal surplus represents benefits that are not included in the cost.

DEMAND CURVE **Points on the demand curve indicate a willingness to pay a given price for a given quantity of water.**

Figure 3-27: Water Price / Water Quantity ture, domestic use, recreation, ecosystem services, manufacturing and energy, and transportation.

The true value of water includes all the real costs associated with its use (pumping, moving through pipes, treatment, distribution) and maintenance. What is overlooked from an economic perspective is the equivalent cost(s) of the value that water has to people indirectly. These are the ecological benefits, or "ecosystem services," that water provides (see Chapter D, Issue: Air, Land, and Water Connections). The value of these benefits (or services) is very difficult to put a price tag on—there are a number of approaches that economists use, but they are not yet widely accepted or validated.

Putting a more accurate value on water should lead to better decision-making and to wiser and more conservative use of water. A variety of incentives are available to encourage conservation and water quality protection, including water pricing structures, restrictions on certain uses during drought, subsidies for water-saving technologies, and markets. Water pricing structures for municipal drinking water have been developed that promote conservation and, in general, consist of a fixed-base cost that covers the costs of distribution and treatment to the municipality, with increasing block rates per unit of water used. This means that the cost per unit volume of water increases with larger volume use, so that those who use more water pay more per volume and thus pay more overall. The Twin Cities metro area has required conservation water pricing in 2010, and the concept has now been adopted for municipal water suppliers who serve over 1,000 people across the entire state (103G.291), effective in 2013. Currently (and not including the 2010 changes), 116 community water systems have some form of conservation pricing, 26 communities have a decreasing block price structure that discourages conservation, and the remainder of communities have a flat fee, uniform structure, or have not reported their structure.

Resolving the disconnect between the true value of water and the way water is valued in economic discussions will require dealing with issues of ecosystem services valuation, public benefits vs. private rights, and costs of remediation vs. costs of protection. It will require Minnesotans to thoughtfully consider the concept of treating water differently for different uses. It will demand that energy production be balanced with water impacts, a healthy economic environment with water resources protection. It will mean viewing wild rice production as both a spiritual need and an economic need for Native Americans. It will mean including recreational, cultural, and spiritual value in decision making. Finally, it will require an economic model for water pricing that considers future infrastructure need costs.

SPECIFIC CONCERNS related to this issue that have been identified:

- **Water pricing structures that do not encourage conservation**
- **Lack of ecosystem services valuation in water pricing**
- **Public ownership vs. private use rights**
- **Costs of remediation vs. costs of protection**
- **Treating water to different degrees depending on use**
- **Balancing economic environment with water resources protection**
- **Including recreation value, cultural value, and spiritual value in decision making**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: Water used for industrial purposes includes the "non-consumptive" use of water for cooling of thermoelectric plants (water returned to same water body it was taken from) and water used for a diverse array of industries. The value of water for industrial use in Minnesota cannot currently be calculated because detailed data on quantities, expenses, and other characteristics of such use are not available.

Water use for residential purposes and its price is well documented for the Twin Cities metro area. The price charged for residential water varies substantially. For 91 communities in the metro area, for instance, the average price paid by consumers in 2005 varied from $0.58 per 1,000 gallons to $5.40 per 1,000 gallons, a range of nearly an order of magnitude. The average was $2.11 per 1,000 gallons. The average cost per person per year was $53.45. The Water Valuation Technical Work Team Report prepared for this project by the UM estimated that the marginal value associated with the indirect benefits of improved water quality and quantity would be approximately $6 per person per year. In other words, Twin Cities metro area residents pay approximately $50/yr to cover the costs of bringing clean drinking water to their homes, and would need to pay approximately $6/yr above that to account for protecting the indirect benefits provided by water resources. There are not enough data for areas outside the metro area to determine the marginal, or indirect, value of water.

Indirect benefits, or ecosystem services, provided by water resources include:

- **Providing habitat for fish, wild rice, waterfowl, mussels, and supporting aquatic ecosystems**
- **Providing food from fish, wild rice, and waterfowl**
- **Purifying water and filtering pollutants from wetlands and buffers**
- **Mitigating flooding**
- **Mitigating drought**
- **Providing water for groundwater recharge**
- **Storing water**
- **Offering recreational opportunities**
- **Satisfying aesthetic, cultural, and spiritual needs and desires**
- **Conserving biodiversity**

While rough estimates are available for the value of some of these benefits individually, there is a great deal of uncertainty due to lack of Minnesota-specific data, and lack of validation of the models used.

Hedonic property price studies (the use of market values to assess people's values of an environmental attribute) show that water quality (as measured by clarity) is positively associated with land value, and that proximity to open-water wetlands is positively associated with property value but proximity to forested wetlands is negatively associated with property values. A contingent valuation study (surveys to assess people's willingness to pay for environmental improvements) in Minnesota found that residents were (hypothetically) willing to pay a

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **A lack of data and modeling approaches that integrate economic costs with the additional costs of water benefits, including ecosystem services.**
2. **A lack of research-based data on the true comparative cost of protection vs. restoration activities.**
3. **A lack of accurate data over time on residential and commercial water use and the effectiveness of pricing strategies in reducing water use (price elasticity).**
4. **A lack of understanding of the influence of various incentive programs (grants, loans, tax benefits, etc.) on long-term conservation behaviors of people, businesses, organizations, and governments.**

POLICY GAPS

1. **The value of ecosystem services and the spiritual and cultural value of water are not included in planning, regulatory, or economic evaluations.**
2. **The public value of water is not integrated into state regulatory programs for water allocation or water quality management.**
3. **Current policies do not consider fairness of who pays, and policies frequently don't consider cost effectiveness.**
4. **Policies tend to consider economic growth and environmental protection an "either-or" rather than "both-and" proposition.**
5. **Current policies and permitting processes focus on small individual mitigation actions, rather than systemwide improvement.**
6. **Water supply and wastewater treatment pricing structures are not integrated.**
7. **The costs of meeting new standards and providing safe drinking water are becoming prohibitive for small communities.**

total of $141 million in 1997 dollars to achieve a 40% reduction in phosphorus in the Minnesota River.

Agricultural use of water is approximately 6% of total water use in Minnesota (19% of consumptive use, or non-thermoelectric cooling use), with more than 90% of agricultural water used for irrigation. The value of irrigation water use on the national scale is $9.98 per acre, determined by the difference in profit per acre for non-irrigated and irrigated lands. Based on this national water cost-per-acre and Minnesota's water use, the marginal value of irrigational use (which is equivalent to the difference between precipitation and irrigation water), is approximately $0.04 per 1,000 gallons. This value has significant uncertainty due to the lack of a Minnesota-specific cost-per-acre estimate of irrigation.

See the Water Valuation Technical Work Team Report for additional details.

G.1 OBJECTIVE: To encourage conservation of water and achieve informed decision making by incorporating the actual or "true" value of water in policies.

G.1. STRATEGY: Incorporate the economic value of ecological benefits provided by water (or the value of the diminished capacity to provide such benefits) in decision-making and assessments without commodifying water.

G.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Reduced water consumption per capita, as measured by water utilities** ➲ BENCHMARK: **decreased water use that more than offsets increased demand from population growth. Trends discernable in 5 years.**
- **Improved ecosystem health and improved water quality in municipalities with an ecosystem service fee added to base price of water, as indicted by water quality and biological indicators used in monitoring programs** ➲BENCHMARK: **water quality and ecosystem improvement seen with in 10 year period.**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION G.1.a: Improve water pricing structures to be inclusive of all the costs of water and to encourage conservation. Require that the conservation water pricing structures enacted under 103G.271 include the economic value of ecological benefits (as determined in Recommendation G.1.d, below) for all users. Initially, an across-the-board fee could be instituted immediately, with clear direction to replace this with a scientifically based value after the completion of the research in G.1.d. The initial fee should be comparable to the current MDH connection fee—a $3.00 per year per connection is recommended. In addition to the public water suppliers covered under 103G.291, all other appropriators required to have a permit under 103G.271 and Minnesota Rules 6115.0620 should be required to pay a fee to cover the economic value of ecological benefits. This fee should be added to the water use fee under 103G.271—an additional $5.00 per million

gallons is recommended. The recovered costs should be dedicated for ecosystem restoration and protection within the watershed from which the appropriation occurs, which would eventually lead to a more reliable, safer source of water. Thus, the recovered fee would be used to directly benefit the payers.
TIME FRAME: 1–2 YRS   COST*: L

RECOMMENDATION G.1.b: Include other economic incentives to promote homeowner conservation in concert with conservation pricing structures, such as subsidies for installing water-saving technologies.
TIME FRAME: 1–2 YRS   COST*: M

RECOMMENDATION G.1.c: Provide some resources (subsidies, matching grants, etc.) for transitioning businesses to the use of conservation technologies (e.g., drip irrigation systems, water reuse systems). The health of the business and agricultural community is essential to the state's economic well-being, and this transition should not be punitive. Disincentives should also be considered, such as taxes or fees on products or services that impact water, which could be used to offset the costs of the incentives.
TIME FRAME: 1–5 YRS   COST*: H

Research Plan
RECOMMENDATION G.1.d: Fund a research project to estimate the economic value of the diminished ecological benefits provided by water as a result of environmental degradation (i.e., the cost of restoring and protecting these benefits). An economics model for estimating their overall value should be developed using the best available knowledge and science and applied to Minnesota. This project should also be funded to collect the necessary site-specific data to calibrate and validate the model. This value of diminished benefits should be incorporated into all community water pricing structures, as described in G.1.a.
TIME FRAME: 3–4 YRS   COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

G.1.a: Human activities on land and water have affected ecosystem function and, in turn, have diminished the capacity of ecosystems to provide certain services such as nutrient removal or flood mitigation. The draining of a wetland diminishes its ability to filter runoff of nutrients and provide a reservoir for excess water in times of extreme precipitation. The presence of chemicals in a lake's sport fish causes a loss of "services" (the lake should provide clean fish to eat) to those who would want to eat the fish they catch from that lake. The economic value of the services that a wetland or lake would have provided had it not been adversely impacted is what is meant here, and that economic value is what is rarely included in the pricing schemes of water or in policy analysis in general. Research is needed to quantify the relationship of the economic loss associated with a change or loss in ecological function; the UM is a nationally recognized leader of this cutting-edge economics research. The recovery of these costs, added as an additional amount to the base price, should be collected by the municipality and provided to the DNR to conduct ecosystem restorations in that municipality. This Recommendation would provide approximately $10–15 million on an annual basis to restore ecosystem benefits related to water use in communities.

G.2 OBJECTIVE: To achieve equity in access to safe drinking water and adequate wastewater treatment for all Minnesota communities.

G.2. STRATEGY: Ensure that small communities have the resources (funding, technical staff) to provide safe drinking water supplies and adequate wastewater treatment.

G.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **All small community systems should be able to pay for basic testing and treatment of drinking water, including removal of natural pollutants such as arsenic, and have adequate wastewater treatment** ➲ BENCHMARK: **A shared revenue system should be established and provided for these resources within 5 years.**

The following actions are recommended to implement this strategy:

RECOMMENDATION G.2.a: Develop funding streams or strategies to help share revenues from all sources across large and small communities regardless of the number of connections. This Recommendation reinforces the principle that safe drinking water and adequate sanitation is a right of all Minnesotans.

TIME FRAME: 1–5 YRS COST*: H

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

G.2.a. It is important to ensure that all Minnesotans have equal access to safe drinking water. In some cases, small communities have localized issues and cannot afford to address them to the same extent as do large systems with many connections and thus higher revenues. For example, some communities in western Minnesota have concentrations of arsenic in their drinking water that are considered unsafe, but putting in treatment systems is very costly for them.

TIME FRAME for COMPLETION of ISSUE G RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from Action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

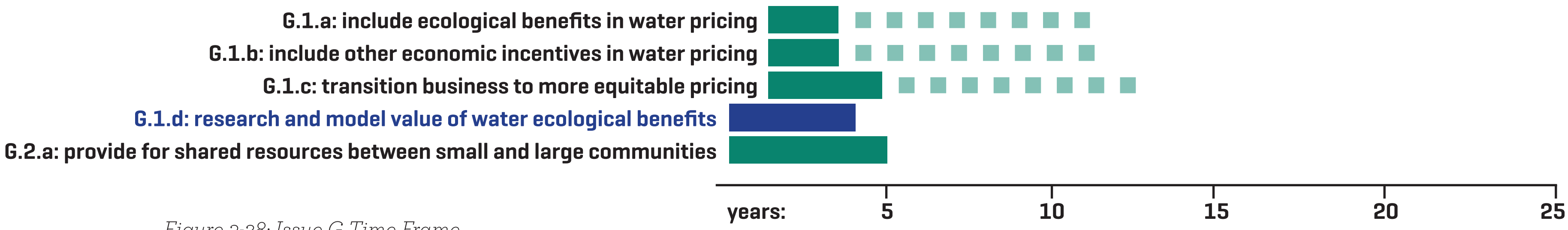


Figure 3-28: Issue G Time Frame

IMPACT MATRIX for ISSUE G RECOMMENDATIONS

Cost	H			G.1.c
	M		G.2.a	G.1.b
	L			G.1.a, G.1.d
		L	M	H
			Impact	

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

Figure 3-29: Issue G Impact Matrix

ISSUE H: PUBLIC WATER INFRASTRUCTURE NEEDS

As INFRASTRUCTURE FOR WATER delivery and treatment ages, we must replace it. As new pollutants become a concern and new technologies develop, we must implement them. As the population grows and moves, and as we shift to water re-use, we must build new infrastructure to meet new needs.

Desired Minnesota Future

A society that maintains and protects its infrastructure for drinking water, wastewater, stormwater, and flood protection in a manner that sustains our communities and our water resources maintains and enhances ecosystems, and reuses water where appropriate to conserve our sustainable supply.

We must build resiliency into our public-built environment to protect it from unanticipated threats.

PROBLEM STATEMENT

Three broad categories of physical water management systems are associated with use of water in Minnesota: systems to provide drinking water; systems to handle and cleanse wastewater; and systems to manage drainage, which includes agricultural stormwater and urban stormwater. Agricultural drainage is addressed in Issue E: Ecological and Hydrological Integrity, and urban stormwater infrastructure is discussed here. Although not technically public facilities, private wells and individual subsurface sewage treatment systems (septic systems, or SSTS) are often considered part of this basic water infrastructure. Their impacts are interconnected, so they need to be considered and managed together (see Issue B: Excess Nutrients and Other Conventional Pollutants for specific issues regarding private wells and SSTSs.) In Minnesota, all three categories of infrastructure systems are in need of upgrading to replace aging and deteriorating systems, to put effective systems in place to meet needs and regulatory requirements, and to meet the growing needs of a growing population. Specific issues to be addressed include drinking water and wastewater treatment plant building, expansion, new technologies, and maintenance; stormwater infrastructure; infrastructure related to water re-use, and water security (being addressed by the state in partnership with the federal government and not further addressed here).

In Minnesota, drinking water comes from surface water (approximately 25%) and groundwater (approximately 75%). Drinking water infrastructure includes (1) community water systems—publicly owned municipal systems, regional water systems, and privately owned condominium and trailer park systems; (2) nonprofit non-community systems, such as schools, day care centers, churches, and retreat centers; and (3) private wells. In addition, six rural water systems have been installed in northwestern and southwestern Minnesota due to insufficient shallow groundwater for private wells.

Drinking water systems consist of four main parts: the water source, transmission and distribution infrastructure, treatment infrastructure, storage facilities, and other components, such as security and data acquisition facilities.

The need for new water delivery and treatment infrastructure is driven by two converging forces: the aging of existing infrastructure, and demographic changes that are shifting the location, time, and intensity of need for water. Some changes may also be called for by changes in understanding of threats to water safety—for instance, the need to protect drinking water supplies from terrorism, or the growing awareness of the presence and possible health impacts of CECs. In addition, new approaches and technologies for addressing water issues have emerged in recent years. Some utilities are turning to advanced treatment options, including activated carbon, ozonation, ultraviolet (UV) light, and reverse osmosis, in order to remove nitrates and remove CECs, such as EDCs, pharmaceuticals, and pathogens that are not removed by conventional disinfection. The issue of CECs is addressed in Issue C and for a full discussion of the technologies listed here, the Wastewater Treatment Best Practices report (See Appendix G).

A major challenge for (and opportunity for improvement in) drinking water supplies in Minnesota is that drinking water is commonly and extensively used for purposes besides drinking: watering lawns, cleaning, and so on. In the Twin Cities metro area, lawn watering and other outdoor water uses account for some 20 percent to 30 percent of annual public water supply use. As infrastructure is replaced and upgraded, an important consideration should be whether modifications to current approaches could help reserve drinking water for drinking water purposes, and use water not treated to drinking water standards, including water that has already served another purpose, for tasks such as watering lawns as a way to reduce demands on water supply infrastructure and on the waterways that serve as sources.

Municipal separate storm sewer systems, known as MS4s, gather water from the community and route it away from streets and walkways to prevent flooding. In the past, municipal stormwater often fed into wastewater treatment infrastructure, adding a huge intermittent burden to wastewater treatment systems and occasionally causing an overflow that resulted in the release of untreated sewage into receiving waters. All but a small percentage of Minnesota's stormwater infrastructure has now been separated from wastewater systems (i.e., the elimination of combined sewer overflows, or CSOs). This reduces the load on wastewater treatment facilities, but it also results in water from streets, which often carries sediment and contaminants, running directly into waterways. To reduce the adverse effects of such flow, communities are starting to route stormwater to land, to containers for use, or to temporary small ponds via rain gardens, rain barrels, pervious pavements, and vegetated swales. Known as low-impact design (LID), such systems are becoming more common across the state. Other innovative management approaches such as pollutant trading, reuse of stormwater, and polluter-pays pricing systems could also impact stormwater management. The federal MS4 program is designed to reduce surface water pollution from storm sewers. MS4s that discharge into designated "special waters" and "impaired waters" require additional runoff controls and BMPs.

Wastewater treatment facilities in Minnesota fall into two main types: municipal treatment facilities and individual sewage treatment systems (ISTSs), or SSTSs, often known as septic systems. Wastewater treatment facilities remove pollutants from used water and then discharge the water to surface waters or to land.

Most municipal wastewater systems in Minnesota operate under federal NPDES permits or state disposal system (SDS) permits for land discharge. Septic systems do not operate under these permits. Costs for wastewater treatment systems include construction, maintenance, and operation (chemicals, etc.).

Many of Minnesota's WWTPs were built in the 1970s and 80s. Some wastewater treatment systems in Minnesota date to the 1800s. Most are approaching the end of their useful lives, estimated at 40 years. New challenges and opportunities may call for new technologies that will need to be considered in future wastewater treatment infrastructure. These new technologies are being developed to remove CECs, such as EDCs and pharmaceuticals, and may be needed in new construction or as upgrades in existing plants. Other opportunities include using wastewater as a feedstock for algae-based renewable energy systems, potential for capturing and recycling nutrients (nitrogen and phosphorus), and potential for reusing some wastewater before sending it to wastewater treatment facilities.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Drinking water and wastewater treatment infrastructure building, expansion, and maintenance**
- **Stormwater infrastructure**
- **New treatment technologies**
- **Infrastructure related to water reuse**

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE:

About 23% of Minnesotans get their drinking water from private wells. The EPA estimates that Minnesota's drinking water infrastructure will need approximately $6 billion for infrastructure upgrades over the next 20 years—not including accommodations for a growing population *(Figure 3-30)*. Drinking water systems will also need increasing flexibility and resiliency to deal with the unexpected events of climate change (drought, flood, etc.).

The MPCA estimates that Minnesota's public wastewater infrastructure will need more than $4.5 billion in improvements over the next 20 years. In addition, individual wastewater systems will need more than $1.2 billion in improvements to protect the environment and public health *(Figure 3-31)*.

A 2009 needs survey identified 1,200 wastewater projects around Minnesota with a total estimated cost of $4.3 billion. This is a substantial increase over the $2.5 billion reported by a similar survey in 2003.

Sewer systems over 50 years old are generally considered beyond their reasonable life. Minneapolis and St. Paul have the largest percentage of collection pipes above 50 years of age (72%), in contrast with greater Minnesota, where approximately one-third of the collection system is over 50 years old, and the Twin Cities metropolitan area suburbs, with only 10% of sewers over 50. Major structural components of wastewater treatment facilities have an estimated useful life of 40 years. Most treatment facilities were built in the early to late 1970s and are rapidly approaching the end of their useful lives *(Figure 3-32)*.

The current model that is used to pay for infrastructure needs for wastewater and drinking water includes the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund, both of which are programs within the EPA. These programs pass funds to the states to finance infrastructure improvements. The Drinking Water State Revolving Fund also emphasizes providing funds to small and disadvantaged communities and to programs that encourage pollution prevention as a tool for ensuring safe drinking water. The Clean Water State Revolving Fund supports water quality protection projects for wastewater treatment, stormwater control, nonpoint source pollution control, and watershed management. In Minnesota, the revolving funds are provided to the MPCA, and the MPCA and MDH determine the priority in which projects are funded for wastewater/stormwater and drinking water, respectively. The Public Facilities Authority, a multi-agency authority, administers and oversees the financial management of the revolving loan funds. The revolving funds provide low-interest loans and grants to finance infrastructure that might otherwise be unaffordable to communities, and require a 20% state match. The communities must provide a general obligation bond to secure the loan.

The growing expenses of these systems are encountering reduced federal support. For example, the federal government cut funding for the Clean Water State Revolving Fund from $1.35 billion in 1998 to $689 million in 2008.

MINNESOTA WATER INFRASTRUCTURE NEEDS by PROJECT TYPE

20-year drinking water needs

PROJECT TYPE	NEEDS (millions)	PROPORTION
Source	$372.0	6.2
Transmission/ Distribution	$2,819.3	47.1
Treatment	$1,982.9	33.1
Storage	$770.3	12.9
Other	$43.9	0.7
Total	$5,988.4	100.0

SOURCE: DRINKING WATER INFRASTRUCTURE NEEDS SURVEY AND ASSESSMENT, EPA, 2007

Figure 3-30: Drinking Water Infrastructure Needs

20-year wastewater needs

INFRASTRUCTURE NEED	2009 WINS (millions)	2003 WINS (millions)	DIFFERENCE (millions)
Sewer System Rehabilitation	$1,890	$315	$1,575
New Collection	$187	$486	($299)
New Interceptors	$475	$206	$269
Combined Sewer Overflow	$17	$5	$12
Inflow and Infiltration	$216	$206	$10
Unsewered Area Projects	$188	$277	($89)
Advanced Treatment	$192	$272	($80)
Secondary Treatment	$1,167	$773	$394
Total	$4,332	$2,540	$1,791

SOURCE: FUTURE WASTEWATER INFRASTRUCTURE NEEDS AND CAPITAL COSTS, MPCA, 2010

Figure 3-31: 20-Year Wastewater Needs

future wastewater needs

PROJECT TYPES	QUANTITY (million $)		% TYPE	% TOTAL
Sewer System	**2,773.05**			**64**
Rehabilitation		1,897.15	68	
New Interceptors		450.55	16	
Infiltration/Inflow		215.36	8	
New Collection		193.36	7	
Combined Sewer Overflow (CSO) Correction		16.63	1	
Wastewater Treatment Facilities	**1,379.69**			**32**
Secondary Treatment		1,188.21	86	
Advanced Treatment		191.46	14	
Unsewered Area*	**187.63**			**4**
Total	**4,340.37**			**100**

SOURCE: FUTURE WASTEWATER INFRASTRUCTURE NEEDS AND CAPITAL COSTS, MPCA, 2010

*Does not include areas with failed or inadequate SSTS.

Figure 3-32: Future Wastewater Needs

Approximately 450,000 Minnesota homes, 75,000 cabins, and 10,000 businesses (resorts, commercial and industrial buildings) are outside areas served by public wastewater treatment systems. In total, approximately 535,000 locations should have a functioning septic system. Of these, 208,000 —39 percent—are failing or an imminent threat to public health and safety, with a total cost to upgrade of $1.2 billion.

A 2006 MPCA survey found 1,025 small communities in Minnesota with inadequate wastewater management. The combined population of the communities was 108,970, and total discharge was 2.3 billion gallons per year. Problems included straight pipes without treatment, aging equipment and structures, and untreated sewage discharged at the surface. The number of failing or inadequate systems reported each year is most likely lower than the actual number.

With the exception of the Twin Cities metro area, most of Minnesota struggles with the affordability of wastewater infrastructure. Minnesota has new limits for phosphorus and nitrogen discharges from wastewater treatment systems as a part of EPA regulations. In many cases, new limits will require costly upgrades to WWTPs.

Studies done by a variety of cities have concluded that “greening” the “gray” infrastructure is more cost effective. For example, New York City spent $1.5 billion protecting and restoring the ecosystem that surrounds (and filters) its Catskill water supply reservoir rather than invest $9 billion in the equivalent treatment structures that would have been needed. Seattle concluded that green stormwater infrastructure investments in one neighborhood cost only one-quarter of the estimated costs of traditional stormwater pipes and collection systems.

All three types of water infrastructure systems face new challenges today due to global climate change. Increased intensity of summer rainfalls due to climate change could render past stormwater designs inadequate. Climate change will increase the likelihood of pathogen occurrences that will require treatment in drinking water systems.

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **The life-cycle costs of all water-related infrastructure are not well known.**
2. **The current status of most infrastructure in the state is unclear.**
3. **There is no system for assessing the status of public and private infrastructure.**

POLICY GAPS

1. **There is no plan by the state and local governments to pay for infrastructure needs not covered by the state revolving funds.**
2. **There is little resiliency or redundancy in current drinking water and wastewater systems.**
3. **State and local governments lack criteria and policy for the management of infrastructure in a manner that encourages sustainable land and water use.**
4. **Minnesota lacks adequate and appropriate water reuse policies.**

H.1. OBJECTIVE: Get ahead of the curve on planning water infrastructure for future needs.

H.1 STRATEGY: Incorporate adaptive management strategies, new technological advances, and water reuse technologies into drinking water and wastewater treatment plant and stormwater infrastructure decision-making.

H.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Achievement of on going process to identify and recommend new technologies to the MPCA and the Public Facilities Authority** ➲ BENCHMARK: **Report to the MPCA every 2 years with updated review and efficacy of treatment and reuse technologies, and recommendations for their adoption**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION H.1.a: Create a standing Emerging Technologies and Green Infrastructure advisory committee of water treatment experts; utility managers; scientists from the water treatment industry, consulting, and academic sectors; League of Minnesota Cities, the American Council of Engineering Companies (ACEC); and MPCA staff to provide biennial updates and advice to the Legislature, MPCA, MDH, and LGUs on new treatment technologies (including green infrastructure), their efficacy, their costs and benefits, and their appropriateness for adoption. They would serve as an expert clearinghouse for this important and rapidly changing information.
TIME FRAME: 1–2 YRS COST*: L

RECOMMENDATION H.1.b: Implement appropriate water reuse strategies—See Recommendation A.2.a.
TIME FRAME: 1–2 YRS COST*: L

RECOMMENDATION H.1.c: Adopt Effective Utility Management promoted by EPA to help utilities respond to current and future challenges (See also new EPA Clean Water and Drinking Water Infrastructure Sustainability Policy)
TIME FRAME: 1–2 YRS COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

H.1.a: Treatment technologies and their applications are changing very rapidly, as are the costs. The regulation of wastewater may also change rapidly in response to CEC regulation (see Issue C: Contaminants of Emerging Concern). Current best practice reports are listed in Appendix G of this report; however, the knowledge base is currently in its infancy and will expand greatly over the next decade. Experts in green infrastructure and treatment technologies can position the state and cities to be ready to incorporate state-of-the-art approaches rather than plan for infrastructure replacement that is out of date, and identify green infrastructure options for use across the state. This reduces redundancy in effort, and gets the information up front to improve decision making. This advisory group should consider innovative technologies, such as water-free waste treatment.

H.1.b: see Recommendation A.2.a

H.1.c: In this national program, EPA is developing technical assistance for utility managers.

H.2 OBJECTIVE: To develop a strategy for paying for future infrastructure needs as they are needed, rather than deferring the problem.

H.2 STRATEGY: Adopt improved methods for economic valuation of water infrastructure investments to pay for future investments, and for life cycle of water-related infrastructure.

H.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **An ongoing plan to pay for infrastructure needs will be designed and implemented**
  ➲ BENCHMARK: **Implementation within 5 years, with review of strategy and its ability to fund future projections completed every 5 years thereafter**

The following actions are recommended to implement this strategy:

RECOMMENDATION H.2.a: Develop a long-term strategy for funding new and expanded infrastructure and its maintenance.

Research Plan

i. Fund research to identify different funding options and approaches that are sustainable, and incorporate the cost of future technologies and infrastructure replacement into utility pricing to make infrastructure sustainable, including life-cycle costs. This research should also consider the costs and benefits of centralized vs. decentralized treatment, and relative economic impacts of reuse feasibility for both approaches.

Action Plan

ii. Adopt a funding structure after consideration of the recommendations from the panel in J.2.a.i; costs required above those covered by the state revolving funds should be shared by the state and communities (since benefits are accrued both locally and statewide).

TIME FRAME: 2–4 YRS COST*: H

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

TIME FRAME for COMPLETION of ISSUE H RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. Research Recommendations (those that need additional scientific or technological understanding) are shown in blue to distinguish them from Action Recommendations in black (those that have sufficient scientific justification and can be undertaken now). *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

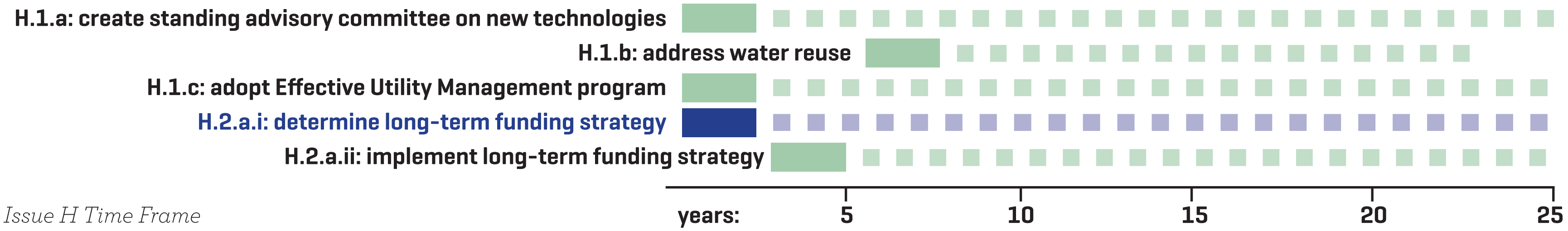
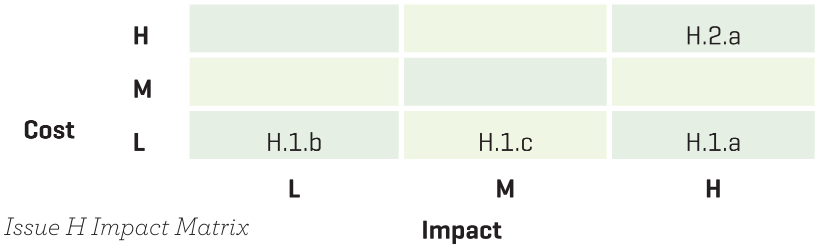


Figure 3-33: Issue H Time Frame

IMPACT MATRIX for ISSUE H RECOMMENDATIONS



Cost	L	M	H
H			H.2.a
M			
L	H.1.b	H.1.c	H.1.a
	Impact		

Figure 3-34: Issue H Impact Matrix

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE I: CITIZEN ENGAGEMENT and EDUCATION

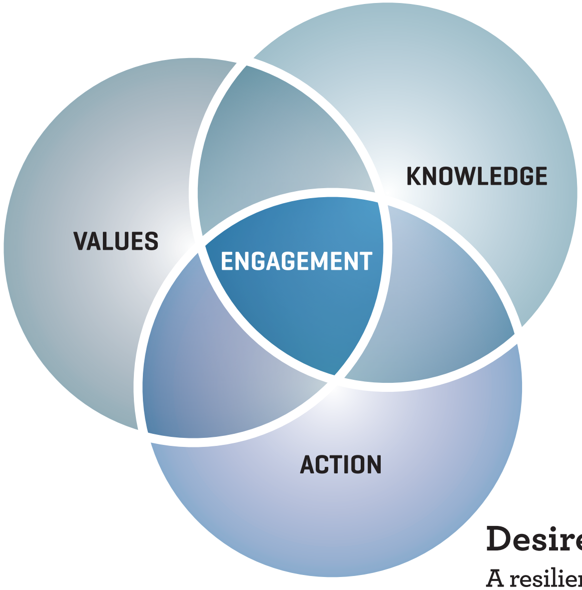


Figure 3-35:
Tools for Community Engagement

SUSTAINABLE WATER CAN ONLY BE achieved by empowering Minnesotans to make substantial changes in how water is valued, how water is used, how water is conserved, and how water stewardship is instilled in future generations. Humans are part of ecosystems, not separate from them. Therefore, planning for water sustainability must support and engage citizens as learners, as decision makers, and as actors on whom water sustainability depends. Most important, sustainable behaviors must be woven through our cultural fabric.

Desired Minnesota Future

A resilient society that values, understands, and treasures our water resources, and acts in ways to achieve and maintain sustainable and healthy water resources.

PROBLEM STATEMENT: Minnesotans place a high value on a clean, abundant water supply and healthy aquatic ecosystems. Relatively few understand the benefits to nature that water provides, the connection between ecosystem health and human well-being, what protecting water and waterways entails, or how their own behavior and choices affect it. Relatively few know exactly where their water comes from; this reflects a disconnect between using water and protecting and valuing water at its source. Decreased time spent outdoors means less engagement with water resources, and less of a sense of appreciation for and ownership in water resources. Unsustainable behaviors with respect to water quality and quantity are more common than not.

A second, related problem is that we do not have a clear understanding of the best way to engage citizens in caring for and about water resources. Education certainly plays a role, but education alone is insufficient. Education is about *learning*, citizen engagement is about *doing*. As Minnesota becomes more culturally diverse and communication and education technologies advance, new ways of sharing knowledge and creating conversations hold new promise for building water literacy and engendering a sense of concern, responsibility, and stewardship in everyone who benefits from Minnesota's water resources.

If future water supplies are to be healthy and sustainable, they will need the support of a well-informed public that cares about water and takes personal responsibility for ensuring that the policies and practices are in place to take care of it in the long term. This means ensuring that all Minnesotans, from children to adults, learn about water and its role in supporting human activity and environmental quality. It means ensuring that citizens understand the interactions between water and all aspects of human activity, from agriculture, domestic use, manufacturing and energy, and transportation to recreational use and ecosystem services. It means engaging citizens in conversations and activities that lead to a better understanding of and involvement in the determination of the long-term fate of our water supplies. It means building an awareness of the role of water in human well-being and ecosystem well-being and the interactions between them. Most critically, it means identifying and putting into practice successful approaches for connecting the dots from knowledge to sustainable behavior.

SPECIFIC CONCERNS related to this Issue that have been identified:

- **Unsustainable behavior—**Conservation practices are not widely practiced
- **Health/environment disconnect—**Regulations address human health or ecosystem health, but rarely both
- **Insufficient education—**There is a lack of coordinated, ongoing water education across the continuum from K–12 to adult and a lack of opportunity for meaningful civic action as part of ongoing water education.
- **Citizen engagement in water stewardship—**Participation is uneven, and organizations to promote it are hindered by a lack of long-term strategies and support.

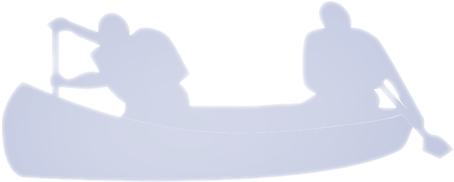
WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: The survey of Minnesotans' knowledge and attitudes about water conducted as part of the development of this Framework indicated that Minnesotans understand that humans and ecosystems need healthy water, that behavior needs to change to reverse trends toward water degradation, that most citizens need to learn more about how their behavior affects water quality, and that most citizens need to learn more about the basics of water.

The findings of this Framework's education technical work team indicate that it is important for people to understand (1) the connection between individual and corporate actions, and (2) the importance of water to our physical and economic well-being. Education involves

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **There is a lack of understanding of what techniques, incentives, and policies are most effective at encouraging conservation and sustainable practices.**



POLICY GAPS

1. **A comprehensive strategy for public engagement in water planning and policy is lacking.**
2. **A comprehensive approach to environmental literacy and water resources education for all ages and all stages of learning is lacking.**
3. **K–12 environmental education is governed under waste management statutes instead of being managed under education standards.**

changing not only knowledge but also values and action; civic engagement is key to creating behavior change.

Environmental education in Minnesota has enjoyed successes and setbacks over time, as documented by the Minnesota Association for Environmental Education (http://minnesotaee.org/Resources/Documents/History%20of%20EE%20in%20MN.pdf). Legislative action in 2010 has articulated environmental education goals and adopted a renewed plan for students and citizens (115A.073). However, it should be noted that environmental education resides in the statutes regulating waste management (115A), and not in public education. Thus few teachers are aware of what these statutes are, and they are not required to use them. In other words, environmental education is not part of the public education code.

I.1 OBJECTIVE: Have an engaged and active citizenry.

I.1 STRATEGY: Build a sense of ecological and social responsibility, ownership, and efficacy—a water ethic—through citizen engagement. Design and incorporate meaningful and effective citizen engagement in planning and implementation that affects water sustainability. Build capacity in state and local government, community-based organizations, and citizens for public engagement. Engage citizens across the state and include traditionally underrepresented groups in the "water conversation" to increase awareness, promote diverse values, build a sense of shared responsibility, and promote civic action and water stewardship.

I.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcome should result:

- **Increased participation by citizens at the local level, as indicated by increased membership, philanthropy, and volunteer activities in engagement organizations.** ➲ BENCHMARK: **an increased rate of engagement of 5% every two years, with an overall goal of more than 50% engagement by 2025**

The following action is recommended to implement this strategy:

RECOMMENDATION I.1.a: Provide stable funding for a long-term program to expand the engagement of the public, communities, and business in water conservation and stewardship. Such a program should be designed to evolve and adapt over time, but should have a long-range (20+ year) time frame of implementation. This program must develop leadership capacity, citizen engagement capacity, networks, and knowledge in a suite of approaches. It must be supported by all state agencies and local government units. It must develop a culture of responding to input from citizens, businesses, and other levels of government. These programs should have state, local, and NGO collaboration and partnership.

TIME FRAME: ONGOING COST*: M

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

I.a.1: Successful strategies for citizen engagement and societal change include education, incentives, peer-to-peer interactions, group interactions, removal of barriers, trust, and economic drivers for individual engagement and behavioral change; and sometimes enforcement as a last resort (such as seat belt laws to ensure public safety). It requires leadership, effective networks, knowledge, fiscal and human resources, and effective governance at the community level. Ultimately successful strategies require the state to promote, teach and foster values around freshwater.

I.2 OBJECTIVE: Have an informed and educated citizenry.

I.2 STRATEGY: Develop and implement a comprehensive program to achieve the goal of "water literacy" and sustainable water behavior for all citizens.

I.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Improved water literacy in the general public, as measured by improved scores in Minnesota's environmental literacy survey (conducted 3 times over last 12 years)** ➲ BENCHMARK: **a statistical increase in water literacy questions with each survey, and a final benchmark of achieving 90% water literacy in surveyed Minnesotans within 10 years**
- **Improved water literacy in K–12 students, as measured by improved test scores as part of the state education standards and goals** ➲ BENCHMARK: **Passing scores in water literacy assessment in 90% of K-12 students within 10 years**

The following actions are recommended to implement this strategy:

RECOMMENDATION I.2.a: Ensure the education of children using a suite of learning and behavioral tools to transform the sustainability values of the next generation of Minnesotans.

i. Amend the K–12 education standards to require sustainability education, including water literacy education, for all Minnesota schoolchildren in all grades. Curriculum development should coherently bring together the many excellent resources already available, but should include an understanding of basic water hydrology and its relation to ecosystems and water sustainability, and an understanding of how human behavior and choices affect our water resources. The development of curriculum modules for Web-based and distance learning should be funded. Such curricula should be reviewed and updated on a regular schedule by the Department of Education. A wiki site for teachers should be developed where best practices, case studies, etc., could be shared and improved. An assessment tool or test should be created to track learning. Sustainability education will require an interdisciplinary approach.

ii. Develop and implement long-term water literacy education campaigns to reinforce existing sustainable behaviors and encourage behavior change of all citizens. The goal of water literacy should be more than merely an understanding of water sustainability and an understanding of how our behaviors and choices affect sustainability, it should go the additional step of affecting behaviors and choices (similar to "stop smoking" campaigns). This campaign should also be tied to incentive and enforcement campaigns. Education does not result in behavior change without the other two approaches.

TIME FRAME: ONGOING COST*: H

RECOMMENDATION I.2.b: Ensure the education of adult citizens and professionals using a suite of approaches and strategies, including those found in *A Greenprint for Minnesota: State Plan for Environmental Education, 3rd Edition* (http://www.seek.state.mn.us/publications/p-ee5-01.pdf). The state should:

i. Nurture "citizen science:" State agencies and local governments involved in water decisions should find opportunities to engage citizen volunteers in gathering water quality and quantity data. Engagement of this type will result in experiential learning while building needed databases.

ii. Adopt voluntary or mandatory certification and mandatory education requirements for water resource professionals, technical assistance providers, and other professionals involved in land and water issues. These professionals must also change perspectives and behaviors. Just as septic installers and pesticide applicators must be educated and certified, professionals involved in land and water issues should receive interdisciplinary instruction on water sustainability issues and professional practices.

iii. Fund 8 basin educators through UM Extension to work in watersheds within the 8 major river basins to provide and coordinate water resources education and citizen engagement. This will increase capacity at both the state and local level.

iv. Require wastewater and drinking water utility operators to participate in the EPA Effective Utility Management courses that include sustainability training and tools.

v. Establish a mechanism for providing ongoing information and research on water policy to inform and improve the water literacy of legislators and local elected and appointed officials based on the model provided by the Minnesota Forest Resources Council. This program should educate decision makers on the potential water sustainability consequences of their decisions, include tools for achieving water sustainability in a local land and water context, and build capacity for adapting planning to new information.

vi. Construct programs to instill conservation and stewardship practices with incentives, education, voluntary actions, and also enforcement (parallel to Minnesota seat belt law and compliance).

vii. Incentivize and then, with time, require water sustainability training at all (large) facilities that hold a wastewater, drinking water, appropriation, etc., permit or license (i.e., leverage business to do some education).

TIME FRAME: ONGOING COST*: H

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

I.2.a: Such actions are critical to achieving transformative behavior change necessary to achieve sustainable individual actions. Culture change is best achieved over a generation, so this needs to begin now.

I.2.b: Cultural change requires education for all ages, with different approaches used for citizens, for professionals, and for decision makers. Social media and digital communications should be used to their fullest; for example, the use of technology such as smart phones to report real-time data may appeal to younger adults. Because all professionals are also adults, adult education programs double their impact when coordinated with professional education programs.

TIME FRAME for COMPLETION of ISSUE I RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

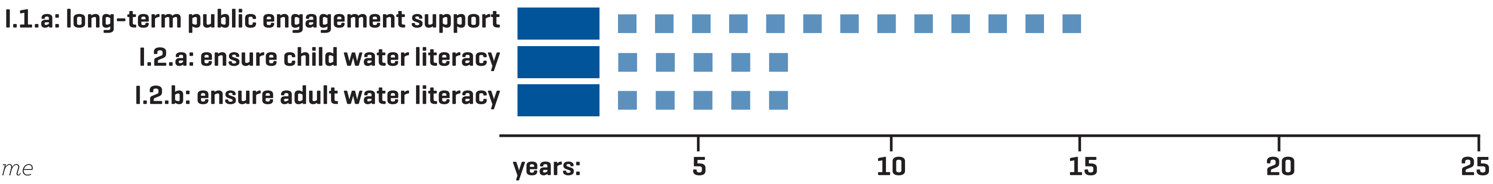


Figure 3-36: Issue I Time Frame

IMPACT MATRIX for ISSUE I RECOMMENDATIONS

Cost		Impact: L	Impact: M	Impact: H
	H			I.2.a, I.2.b
	M			I.1.a
	L			

Figure 3-37: Issue I Impact Matrix

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

ISSUE J: GOVERNANCE and INSTITUTIONS

MINNESOTA HAS NUMEROUS water polices, but they have been developed to react to specific issues, and thus the whole is less than the sum of its parts. Current governance structure is fragmented and diffuse and should be strengthened to address the complexity of issues that must be faced to reach sustainable water management.

Desired Minnesota Future

Governments, institutions, and communities working together to implement an overarching water sustainability policy that is aligned with all other systems policies (land use, energy, economic development, transportation, food and fiber production) through laws, ordinances, and actions that promote resilience and sustainability.

PROBLEM STATEMENT

Minnesota's waters are governed by hundreds of laws, regulations, rules, and ordinances involving more than 20 federal agencies, seven state agencies, and hundreds of local units of government. Governance affects every aspect of water use, from drinking water to irrigation, recreation, waterfowl protection, energy production, and wastewater discharges. Because the governance evolved over time and somewhat independently at federal, state, and multiple local levels, there are some inefficiencies, disconnects, gaps, and at times, contradictions that get in the way of good water management. Insufficient coordination of federal, state, and local agencies; legislative capacity; and organization can impede the ability to govern water and create frustrating and wasteful inefficiencies. However, these various scales of governance also lead to resilience and to greater citizen involvement.

Water policies also suffer from insufficient integration across natural water systems. Lakes, streams, and groundwater are often treated as separate systems from a regulatory standpoint, even though they are intimately interconnected in the environment.

Complicating the governance picture is the fact that insufficient staff resources are available to carry out permitting and compliance enforcement. At the same time, Minnesotans have high expectations for exceptional water management due to the presence of Legacy Amendment funding.

Water in the environment in its various forms and reservoirs is all part of an interconnected system that does not pay attention to political boundaries. Impacts on one aspect of this system reverberate through the others. It is critical that efforts to manage and protect water take into account the connections and how impacts on one aspect of the system affect others. It is all one system.

MINNESOTA WATER GOVERNANCE AND RECOMMENDED CHANGES

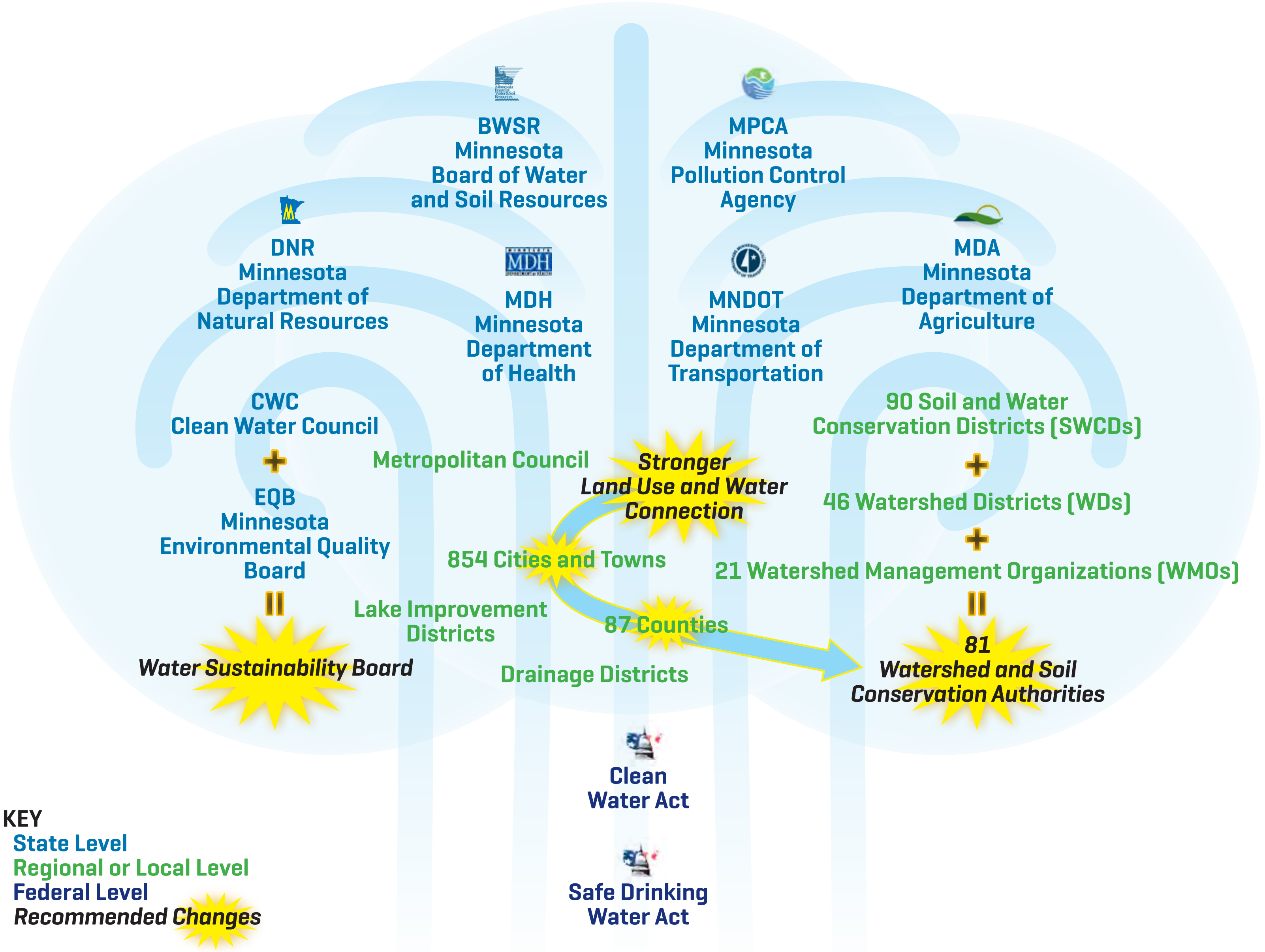


Figure 3-39: Minnesota Governance and Recommended Changes

SPECIFIC CONCERNS related to this Issue that have been identified:

- **State-level coordination—**Water management has not always been coordinated across state agencies
- **Legislative capacity—**With so many critical issues vying for attention, and with water management being so complex, it is difficult for legislators to give water issues the attention they need
- **Multiplicity of local players—**through time, a complex and challenging patchwork of local organizations (SWCDs, WDs, WMOs, NGOs, cities, and counties) has evolved to govern water at the local level
- **History—**Water policy has developed in an additive manner over time in reaction to specific issues
- **Lack of systems thinking regarding water—**A misperception prevails that groundwater and surface water are independent and can each be regulated without consideration of the other; a similar misperception exists for drinking water, wastewater, and stormwater

WHAT IS KNOWN AND NOT KNOWN ABOUT THIS ISSUE: Minnesota is considered to be a leader in developing water policy by its sister states, particularly with regard to wetland conservation and its landmark Clean Water Legacy Act. However, Minnesota state water policy lacks big-picture goals and priorities. While Minnesota Statutes, chapter 103A, identifies policy objectives, programs, or implementation, authority does not always accompany them; while agencies have individual goals and priorities, they are not governed by overarching goals or priorities. The state does not do a good job of balancing the competing interests impacting our water system in light of overall policy goals. The policy pieces do not always fit together to create a seamless whole because they were cut at various times, by various people, out of different materials. A summary of the history of Minnesota water policy is found in the Policy Technical Work Team Report (http://wrc.umn.edu/prod/groups/cfans/@pub/@cfans/@wrc/documents/asset/cfans_asset_220216.pdf).

Water governance in Minnesota has been fragmented and reactive rather than proactive (responding to a specific need). It has been evolutionary rather than visionary (one specific policy at a time rather than policy developed to meet overarching goals). It operates at different scales, each scale with strengths and weaknesses. Agency goals and objectives sometimes conflict. Water governance has been driven by specific issues, problems, and special interests followed by a reaction from the Legislature, which has no group with a long-term dedication to water policy. There has been little comprehensive assessment and strategic intent to protect and manage Minnesota's waters, with the exception of the recent Clean Water Legacy Act. Laws related to energy, economic development, land use, food production, water quality and quantity, and land acquisition or land retirement issues are adopted and implemented on a silo basis.

The approach to managing the state's water should recognize that water is a system and is connected to other natural and human systems. Actions in one part of the system can result, and have resulted, in significant adverse impacts in other parts of the system. For example, land use and water quantity and quality are intimately connected, but this connection is not always recognized in our land use or other resource management policies. A comprehensive approach to land use, water quality, water quantity, and population growth should be used. Integrated water policy across the major river basins and major aquifers is needed, in addition to the watershed scale. Community planning and growth planning has not been tied to water availability, so in some cases development occurs where there is the least amount of water. Economic incentives for growth and business development do not consider water availability.

Water policies currently are not integrated across natural water systems—they do not consider the interconnected nature of surface waters and groundwater and their connections to other natural systems. This has resulted in adverse impacts on water quantity, water quality, and fish and wildlife health. Nor do they adapt to allow new knowledge or experience to shape policy over time. Adaptive and flexible state water plans and policies will be important as we begin to face the challenges presented by climate change. Future water policy must connect water quantity and water quality, groundwater and surface water, human health and ecosystem health.

Current policies should recognize the long-term health of the natural system and the ecological benefits it provides. Water decision making tends to emphasize short- over long-term values and does not always balance current needs, policies, and values against long-term priorities.

Water policy is not always integrated across agencies and scales of governance, and statutes do not encourage integration. For example, much more might be accomplished if the requirements of the Clean Water Act and the Safe Drinking Water Act were better aligned, and if they were implemented at the state level using an integrated approach. Drinking water, wastewater, and stormwater should be managed in an integrated manner—they are all part of one system.

MINNESOTA BASINS and WATERSHEDS

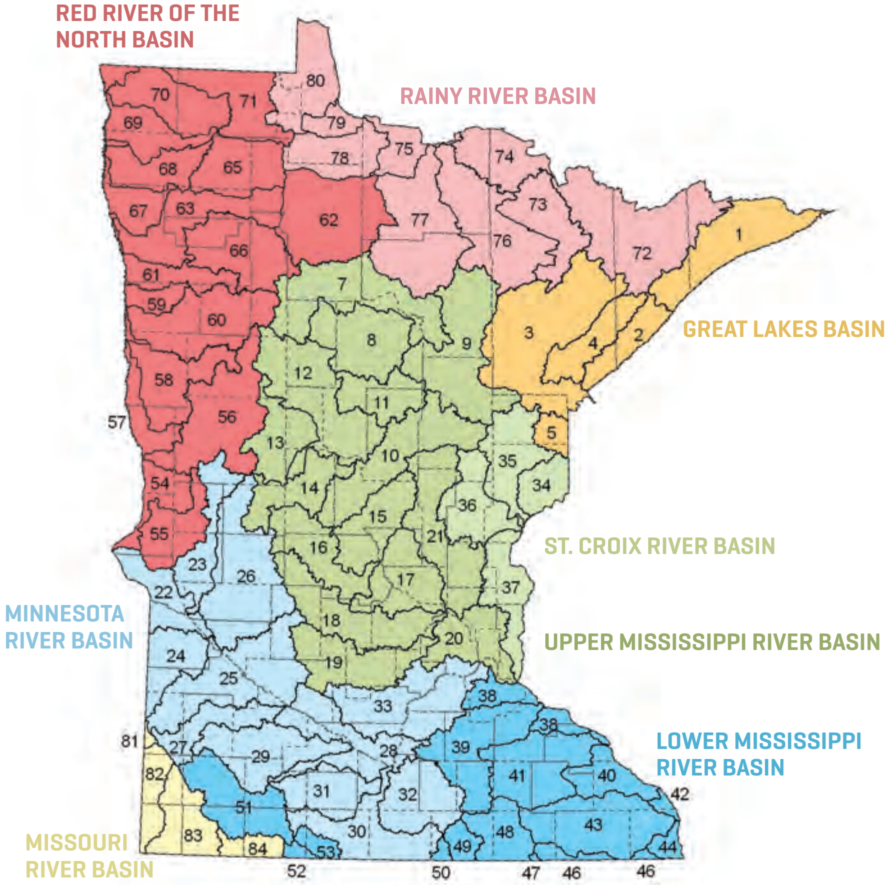


Figure 3-40: Minnesota Basins and Watersheds

SOURCE: DNR

Short-term goals tend to defer long-term costs to water (e.g., development in the Twin Cities, some alternative energy programs, some economic development programs). The state has no sustainable water plan or vision and no single entity to hold other units of government and scales accountable to the larger vision. Although needs are different across the state, state agencies and LGUs focus on their individual missions, not on the big picture, possibly due to limitations in funding and statutory authority.

Minnesota water policy should embrace the principle of equity. There is inequity between the requirements imposed on LGUs and businesses and the fact that the agriculture industry is exempt from many water requirements but is a major contributor to nonpoint pollution of nutrients. Under the “polluter pays” principle, a polluter would pay whether the source of pollution is a point source or an unregulated nonpoint source. (This issue is addressed in Issue B: Excess Nutrients and Other Conventional Pollutants).

Minnesota water laws are neither flexible nor adaptive across landscapes. A “one size fits all” approach creates a challenge for LGUs because different parts of the state have different water issues. Water governance has been dealt with on a statewide basis, yet there is a lack of policy focusing on geographically based hydrologic conditions (with a notable exception being the Wetland Conservation Act). The number of state agencies with authority over water makes it hard for LGUs to determine who's in charge, and agencies and the Legislature often shift the target. LGUs are responsible for implementing many state water policies, but are given inadequate resources, tools, and authority to do so. LGUs perceive there are too many requirements, especially overlapping planning requirements (e.g., comprehensive plans, watershed plans, county water plans).

The many state-level agencies and organizations are not always effective. The agencies have specific missions and are bound by specific federal and state law, which can create silos, overlap, or contradictions in implementation. However, the "right" constellation of agencies for Minnesota is not clear, and an optimal form should follow function. As water policy changes in response to this Framework, the agency missions may change as a result. There is widely held belief that the EQB adds little value to water policy and management at the state level. The ten-year Water Plans produced by the EQB are excellent documents that present the challenges of water management but offer little in the way of solutions. The EQB is somewhat constrained by its relationship to the executive branch. Another state-level board, the governor-appointed Clean Water Council (CWC), was created by the Clean Water Legacy Act but does not have clear authority or purpose since the adoption of the Legacy Amendment. Its primary mission was to advise on the Clean Water Legacy Account (which has no funds) and its authority regarding the Clean Water Fund is highly limited under the best interpretation.

The water-related state agencies have coordinated to a much greater degree since the Clean Water Legacy Act and the formation of the Clean Water Fund Interagency Coordinating Team, composed of the senior leadership of the agencies with responsibility for water. They meet frequently and have created interagency work groups to address specific aspects of the intent of the Clean Water Fund, from prevention strategies to outcomes and measures. However, there still remains a need for greater coordination across different scales of governance, from the local level to the statewide level.

The following gaps in knowledge and policy have been identified:

SCIENCE & TECHNOLOGY GAPS

1. **A fully integrated, accessible information and data management system for water quantity and quality data has not been developed.**

POLICY GAPS

1. **It is unclear what water governance structure is best for sustainable water in Minnesota, or what should be the criteria for deciding.**
2. **Water policy tends to focus on the short term, and needs a longer range to avoid deferring longer term costs and issues.**
3. **Water governance policies are not generally not adaptive, flexible or resilient (one size fits all).**
4. **Water governance policies are not consistently constructed to be outcome-based.**
5. **Drinking water, stormwater, and wastewater are interconnected but are managed independently.**
6. **Groundwater and surface water are interconnected but often managed independently.**
7. **Treaty rights requiring clean water are not fully recognized by state government and the general public.**

J.1 OBJECTIVE: To have state environmental and natural resource policies aligned with water sustainability goals that efficiently direct on-the-ground actions.

J.1 STRATEGY: Provide uniform state guidance for water sustainability policy and a governance delivery structure to ensure that Minnesota has a comprehensive, well-integrated, and effective water policy for the future.

J.1 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: *Outcomes* refers to improvements in water quality and movement toward water sustainability, *measures* refers to the indicators that are used to assess progress, and *benchmarks* refers to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Water sustainability quality and quantity goals are reached efficiently. The outcomes to the recommendations are governance outcomes, but will lead to reaching the overarching goal of water sustainability. Specific benchmarks include** ➲ BENCHMARK: **The Water Sustainability Congress completes recommendations for changes in state statutes and rules within 3 years of convening** ➲ BENCHMARK: **The recommendations of the Water Sustainability Congress are adopted into existing statute and rules within 4 years of the termination of the congress** ➲ BENCHMARK: **Minnesota adopts the Minnesota Water Sustainability Act at the termination of the Congress** ➲ BENCHMARK: **State agencies and boards review all their programs for water sustainability by 2013** ➲ BENCHMARK: **State agencies and boards change programs to align with water sustainability by 2018** ➲ BENCHMARK: **The Water Sustainability Board is established by 2013** ➲ BENCHMARK: **The Water Sustainability Board annually reviews progress toward water sustainability goals beginning at its inception and then ongoing** ➲ BENCHMARK: **Watershed and Soil Conservation Authorities are established statewide by 2020**

The following actions are recommended to implement this strategy:

Action Plan

RECOMMENDATION J.1.a: Convene a one-time *Minnesota Water Congress* to review all current state statutes and rules for alignment with water sustainability goals. A congress to review progress on environmental issues currently exists in Minnesota statute (see MN Stat. 2010 §116C.04). This review should include areas of law both directly and indirectly related to water sustainability (e.g., land use, see Issue D; energy, see Issue F; building codes; transportation; economic development; drainage; food and fiber production), using water sustainability as a core principle throughout. The review should consider maximizing multiple benefits across issues (e.g., achieving water quality improvements and energy cost savings over the life of a building; reducing stormwater runoff impacts and addressing climate change impacts). The review is not intended as a comprehensive rewrite of water statutes; rather the charge of the Congress is to identify overlap, gaps, conflicts in current statutes and rules, and alignment with sustainability principles. State law should be reviewed in the context of federal and local laws and rules. The Congress should recommend specific and comprehensive statutory changes based on the review.

TIME FRAME: 3 YRS   COST*:L

RECOMMENDATION J.1.b: Enact a Minnesota Water Sustainability Act at the termination of the Minnesota Water Congress. The act will serve as the umbrella statute guiding all law and actions related to water sustainability. It should include a water sustainability vision and policy statement as articulated by the Minnesota Water Sustainability Framework, and principles and policy characteristics to guide future state and local actions.

The act should direct state agencies and boards to evaluate their programs and operations for alignment with the act. The results of the alignment evaluation and subsequent actions taken to fully align should be reported to the Water Sustainability Board (see J.1.d below). This shall include agencies that directly and indirectly implement and enforce water policies. The evaluation shall inform a reorientation of programs and operations toward water sustainability goals.
TIME FRAME: 4 YRS COST*: L

RECOMMENDATION J.1.c: Re-establish the bicameral Legislative Water Commission to provide leadership on water policy development. The water commission should be a staffed, enduring entity designed to increase knowledge about water issues and provide a forum for considering implications of proposed legislation addressing water sustainability.
TIME FRAME: 1 YR COST*: L

RECOMMENDATION J.1.d: Create a Water Sustainability Board as a crosscutting governance structure bridging state and local action. The Water Sustainability Board will have the responsibility for coordinating and overseeing implementation of the Minnesota Water Sustainability Act (see recommendation J.1.b above) and advising on expenditures from the Clean Water Fund.

i. The Water Sustainability Board would replace the current CWC and the water responsibilities of the EQB but draw on the most effective aspects of each, and have greater authority than either body presently possesses. Thus, two governance structures would be eliminated and replaced with one. The CWC would be disbanded and the water functions of the EQB would be placed under the Water Sustainability Board. The charge of the Water Sustainability Board would be to coordinate and advise on all aspects of water, with representation and support from both the legislative and executive branches.

ii. The Water Sustainability Board membership should represent all state agencies and boards directly or indirectly involved in water policies. In addition, the board would have legislative members and members representing local governments, environmental organizations, and citizens to provide well-rounded perspective but not serve as stakeholders. [This executive/legislative/citizen structure borrows the best from the models of the Legislative-Citizen Commission on Minnesota Resources (LCCMR), the CWC, and other commissions.]
TIME FRAME: 2–5 YRS COST*: L

RECOMMENDATION J.1.e: Create watershed-scale Watershed and Soil Conservation Authorities (WSCAs) throughout the state with the responsibility of implementing the goals of the Minnesota Water Sustainability Act. The creation of WSCAs would arise through a process of transition from water planning within the political boundaries of a county to water planning at roughly the watershed level (8-digit HUC or 81-watershed scale) but the boundaries would be determined locally. The transition would occur over a 10-year period to allow existing water planning entities within a watershed (SWCDs, WMOs, and WDs) to negotiate a process of transition to a single WSCA. BWSR would be empowered to work with local water planning entities to establish watershed boundaries and plan for transition.

WSCAs would be the entity responsible for working with the Water Sustainability Board to develop and implement watershed and land sustainability plans (see Recommendation J.1.d. iv above). WSCAs would be responsible for working with local governments with land use authority to integrate the Watershed and Land Sustainability Plans into local land use planning as stated in Recommendation D.1.a. WSCAs would have the responsibilities and roles of the current SWCDs, including the valuable function of linking local landowners with state and federal programs. They should be granted taxing authority, and serve as the official partner with local governments on water planning (see Recommendation D.1.a). The WSCA authority would include groundwater and surface water, and water quantity and quality issues. WSCAs would oversee and ensure compliance of the performance of all agricultural landowners in the AMA of their watershed (see Recommendation B.2.a).
TIME FRAME: 10 YRS COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

J.1.a: The intent of this Recommendation is to take the bold step of redesigning our water (and related) policies around sustainability principles, in a proactive way. Many of our existing statutes and rules are effective, so the Recommendation is not to throw the baby out with the bathwater—the recommendation is to examine all policies at the same time and keep the pieces that are effective and improve and add where needed to make the policies holistic, consistent, effective, and sustainable. These changes must recognize that water is a system and is connected to other natural and human systems. Our actions in one part of the system can result, and have resulted, in significant adverse impacts in other parts of the system. As public policy pieces have been added, there has been little real consideration of how they interact with the existing pieces. There is almost always a gap between expectations for new programs and actual delivery, given the resources allocated to carry them out. Further, given the complexities of the system, a fix for one issue may cause a negative result somewhere else. The pieces will not always fit together to create a seamless whole because they were developed at various times, by various people.

Land use and water quantity and quality are intimately connected, but this connection is not always recognized in our land use or other resource management policies. Examples include: we lack meaningful comprehensive planning that reflects an understanding of how activities on land affect water; agricultural land use is not always well linked to state water policy; water policies are not integrated across natural water systems; water policy is not always integrated across agencies and scales of governance, and statutes do not encourage integration; and cumulative impacts of water extraction permits on aquifers or natural systems are not always calculated or evaluated in the permitting process. Actions on land harm water; without understanding and acting on this interrelationship, we are not in a position to protect, preserve, and enhance natural water systems. Finally, to ensure that these new policies are effective, changes to the form of state agency organization should be considered to best conform to the function of the agencies reflected in the recommended changes to the laws. The Congress would require staff, and these should be new hires rather than reassignments of existing state agency or legislative staff.

The following tasks are envisioned for the Congress:

i. Develop and apply criteria in the review that are derived from the vision, core objectives, strategies, and actions recommended in the Minnesota Water Sustainability Framework.

ii. Consider how to integrate the Recommendations of the Framework into statutes and rules, as appropriate.

iii. Consider how to apply the principles and practice of adaptive management to statutes and rules related to water sustainability. Adaptive management is a structured, iterative process of optimizing decision making as new knowledge or information or learning accrues over time. It is a policy that allows decision making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring.

iv. Identify deficiencies, inconsistencies, and opportunities in implementation and enforcement of statutes and rules. The Congress should recommend specific means to increase effectiveness of implementation and enforcement. The review should also consider how to gain cost efficiencies in compliance.

v. Identify overlap, gaps, conflicts, and opportunities in the responsibilities of state agencies and boards in implementing laws and rules related to water sustainability. The Congress shall clearly identify roles and responsibilities of state agencies and boards in implementing recommendations of the congress, including any improvement to current organizational structure.

J.1.b: The recommended changes to statute, rules, and governmental organization will need an overarching statute with a clear policy statement to bind our water policy into an integrated whole.

J.1.c: This Recommendation addresses the need to provide greater depth of understanding of the complex issues surrounding our water resources within the Legislature, and an organizational structure to ensure that the needed research support is provided. The former Legislative Water Commission is perceived by many to have been very effective in this role.

J.1.d: This Recommendation streamlines the oversight of the Clean Water Fund to a single body that includes both legislative and executive branch participation. This recommendation also provides a "vertical" structure for connecting local government (81-watershed scale) to the statewide governance structure. This Board would also provide needed review and approval of local water and land sustainability plans—with the exception of the Metro area, these plans do not require approval.

J.1.e: This Recommendation addresses the need for effective local water planning advocates statewide and recommends a mechanism and organizational structure for doing so at the watershed scale. It also addresses the need to reduce the redundancy and overlap at the local level. Management of land and water resources at the watershed scale makes sense because of the relationship of land use activities to water quality within a watershed. State and federal water programs are increasingly recognizing the watershed as a geographic area for planning and funding. The model of watershed-based water planning and streamlining of organizations suggested in this recommendation reflects the success of the 25-year-old Metropolitan Surface Water Management Act (Minnesota Statutes, sections 103B.201–253). The recommendation suggests extending the model used in the Metro area to the entire state for success over the next 25 years. The recommendation uses the term "roughly at the watershed level" in recognition that some flexibility may be needed in determining the boundaries of watershed planning.

J.2 OBJECTIVE: To have a "living" Water Sustainability Framework informed by current, accessible data and information.

J.2 STRATEGY: Provide a comprehensive, accessible data portal (a single, coordinated entry point for accessing multiple databases) of all water quality and water quantity data from all relevant agencies, and ensure adaptive changes are made to the Framework as new data and information become available.

J.2 OUTCOMES, MEASURES OF SUCCESS, AND BENCHMARKS: Outcomes refer to improvements in water quality and movement towards water sustainability; measures refer to the indicators that are used to assess progress, and benchmarks refer to the time frame over which progress is achieved. Generally, progress requires considerable time and data, and thus achieving or measuring progress has a longer time frame than the time frame for implementing the related recommendation.

If the Recommendations are implemented, the following outcomes should result:

- **Complete access to all water quality and quantity data, as measured by** ➲ BENCHMARK: **All agencies have completed internal databases within 5 years** ➲ BENCHMARK: **The interagency portal designed and completed 5 years after the agencies complete internal databases.**

The following actions are recommended to implement this strategy:

RECOMMENDATION J.2.a: Fund the creation of an interagency data and information portal. This portal would provide a single door, or entry, via the Internet to access all state water-related databases. It would provide an alignment of the data, but not require all data to conform to the same single database or structure. Conceptually, it would be a wheelhouse design with spokes to the agencies; agencies would still maintain their own data. This would require the following steps: (1) jointly determine the common architecture for the portal, identify what data would be included, and specify requirements for the individual databases to be included in the portal; (2) have individual state agencies develop, upgrade, or expand databases that would contain agency-specific data; and (3) design the architecture to allow the portal to access and translate the data for a data user, and finally link the databases within the portal. For example, the MDH maintains well logs, drinking water monitoring data, fish consumption advisories, etc., and these data would need to be digitized and placed in a relational database. Similarly, the water quality monitoring data from the MPCA and the water appropriation permitting data from DNR would be fully digitized for linking to the portal, and so forth. The MPCA has begun this process for its data with Clean Water Fund support (see November 2010 TMDL Database Development Outcomes and Rules Promulgation Report), and such support would need to be expanded to include the other agencies as well as the portal development. This is a long-term investment but continually is identified as a high priority need for the state.
TIME FRAME: 10 YRS   COST*: H

RECOMMENDATION J.2.b: Ensure that the Water Sustainability Framework is adaptive and continues to be useful to the state over its 25 year lifespan by requiring a review and update every 5 years. This review should be conducted independently (in the spirit of the original Framework development) and it is recommended that it be done in a collaborative and consultative manner by the UM WRC.
TIME FRAME: EVERY 5 YRS   COST*: L

**Cost: L is estimated to be $1 million or less; M is estimated to be greater than $1 million and less than $10 million; H is estimated to be greater than $10 million.*

NOTES

J.2.a: For example, the MDH maintains well logs, drinking water monitoring data, fish consumption advisories, etc., and these data would need to be digitized and placed in a relational database. Similarly, the water quality monitoring data from the MPCA and the water appropriation permitting data from DNR would be fully digitized for linking to the portal; and so forth. The MPCA has begun this process for its data with Clean Water Fund support (see November 2010 TMDL Database Development Outcomes and Rules Promulgation Report), and such support would need to be expanded to include the other agencies as well as the portal development.

J.2.b: A constant theme throughout the Framework is the need for adaptive management of our water resources.

It seems fitting that the final recommendation of the Framework is to ensure that the Framework itself is adaptive by a regular review and update. UM is ideally suited to convene and lead the broad expertise needed to provide such periodic reviews.

TIME FRAME for COMPLETION of ISSUE J RECOMMENDATIONS

The Recommendations above will take varying amounts of time to act on and implement. The times shown represent time for the state to act, and are not the times when outcomes would be realized. The dotted lines are the time frame for outcomes, or indicate ongoing repeated outcomes, if they are different from the implementation time frame. *Note: Each time frame bar represents the progression after start of implementation. For recommended actual start date, see Figure 2-3, Implementation column and the table's preceding explanatory text.*

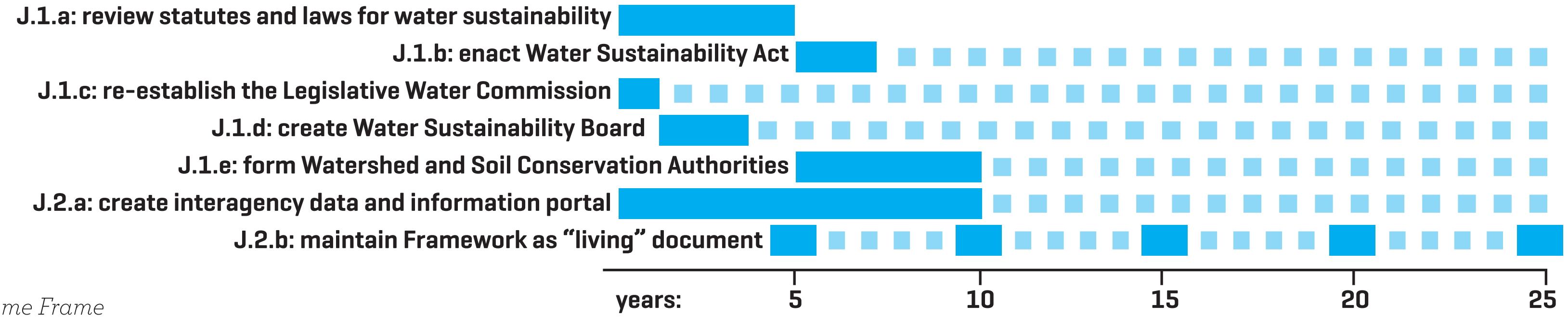


Figure 3-41: Issue J Time Frame

IMPACT MATRIX for ISSUE J RECOMMENDATIONS

Cost	H			J.2.a
	M			
	L		J.1.b, J.1.d, J.1.e	J.1.a, J.1.c, J.2.b
		L	M	H
			Impact	

This figure indicates the relative impact of implementing a given Recommendation (how much difference it will make to achieving sustainable water use and management), compared to an estimate of the total cost of the Recommendation to the public sector (i.e., state funds) for its full implementation. Cost estimates: L (low) is estimated to be $1 million or less; M (medium) is estimated to be greater than $1 million and less than $10 million; H (high) is estimated to be greater than $10 million.

Figure 3-42: Issue J Impact Matrix

Part IV Appendices

ACRONYMS and ABBREVIATIONS

APPENDIX A

ACEC	American Council of Engineering Companies
AMA	Agricultural Management Area
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CEC	Contaminant of Emerging Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSO	Combined Sewer Overflow
CWC	Clean Water Council
CWF	Clean Water Fund
DNR	Department of Natural Resources
DOE	Department of Energy
EDC	Endocrine Disrupting Chemical
EPA	Environmental Protection Agency
EQB	Environmental Quality Board
GAP	Good Agricultural Practices
GIS	Geographic Information System
GSSHA	Gridded Surface Subsurface Hydrologic Analysis model
HUC	Hydrologic Unit Code
IJC	International Joint Commission
ISTS	Individual Sewage Treatment System
KWH	Kilowatt Hour
LCA	Life Cycle Analysis
LCCMR	Legislative-Citizen Commission on Minnesota Resources
LID	Low-Impact Design
LGU	Local Government Unit
MCL	Maximum Contaminant Limit
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MGS	Minnesota Geological Survey
MIDS	Minimal Impact Design Standards
MOU	Memorandum of Understanding
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MWSF	Minnesota Water Sustainability Framework
NGO	Non-Governmental Organization
NPDES	National Pollutant Discharge Elimination System
NPL	National List of Priorities
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PBT	Persistent, Bioaccumulative, and Toxic
PCB	Polychlorinated Biphenyl
PFC	Perfluorinated Compound
pH	A measure of the acidity or basicity of a solution
PLP	Permanent List of Priorities
Q90	A measure of stream flow when flow level is exceeded 90% of the time
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment System
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TSCA	Toxic Substances Control Act
UM	University of Minnesota
USGS	United States Geological Survey
UV	Ultraviolet
WD	Watershed District
WINS	Water Infrastructure Needs Survey
WMO	Water Management Organization
WRRI	Water Resources Research Institute
WSB	Water Sustainability Board
WSCA	Watershed and Soil Conservation Authority

CORE OBJECTIVES

APPENDIX B

AFTER REVIEW OF BACKGROUND INFORMATION ON WATER USE, water supply, and water quality, the project Synthesis Team developed core objectives to guide the development of recommendations.

CORE OBJECTIVES	DESCRIPTION
Scientific and Technical Objectives	
ST 1 **Understand and act on linkages to land use** The Framework must make it easy to link land use and land management to water resource sustainability.	Water resources affect and are affected by many other major environmental, social, and economic systems, including energy generation and use, transportation systems, urban development, agricultural land use, natural resource extraction (forestry and mining), and ecological systems. Because water resources are strongly connected with these other systems, we can not manage water resources in isolation from how we live on and use the land. Our land use policies (urban, agricultural, and forestry) must be linked to water policies with the goal of sustainable water qualities and quantities.
ST 2 **Address variations among regions and scales** The Framework must address variability in regions and scales.	Minnesota is an ecologically and hydrologically diverse state containing parts of at least five major water basins and seven ecoregions. Thus most solutions to identified issues are not "one size fits all," and should not necessarily be implemented uniformly statewide. Solutions must be tailored to specific geographical regions based on differing population densities, climatic conditions, soil and geological conditions, ecosystems, land uses, and levels of degradation.
ST 3 **Measure our actions to determine sustainability** The Framework must make it easy to link land use and land management to water resource sustainability.	For many issues data are inadequate, or costly to acquire, or scientific understanding is insufficient to assess whether if our actions are sustainable. Monitoring programs (both to assess condition and to assess effectiveness of actions) are insufficient. While we must be willing to act based on the best scientific knowledge currently available, our ability to attain a sustainable water policy is dependent upon cost-effectively developing our incomplete scientific understanding of the sustainability of our actions through monitoring and modeling.
Social and Economic Objectives	
SE 1 **Recognize divergent values and perspectives** The Framework must allow for and recognize divergent values and perspectives.	Individuals have differing personal values that result in different priorities for water use; diverse views on the value of the various types and quality of water resources; and varying opinions about the seriousness of threats to water resources. We may not ever have one common view, but we should have shared goals that honor different values and perspectives while allowing for sustainable water quality and quantity.

CORE OBJECTIVES

CORE OBJECTIVES	DESCRIPTION
SE 2 **Embrace sustainable behaviors** The Framework must move Minnesotans to adopt sustainable behaviors among its citizens, communities, businesses, and industries.	Our society has an insufficient conservation ethic/behavior; has limited understanding of the connection between land use, water use, water quality, and where water comes from; and engages in inadvertent behaviors, such as invasive species introductions. Humans often see ourselves as disconnected from the natural environment, when in fact we are a part of it. Behavior change is needed throughout society at individual, organizational, and governance levels to achieve sustainability. It is important to identify mechanisms that make it in the self-interest of people to adopt sustainable behaviors.
SE 3 **Clarify and balance economic, environmental, and social needs** The Framework must acknowledge, clarify, and improve balance between economic, environmental, and social justice needs.	Tension exists among various interests (private sector, local, state, and federal government units, NGOs, citizens) between economic growth and environmental protection. Sustainability requires a healthy economy, and healthy environment, and healthy society, so solutions must find balance in the use of our public water resource.
SE 4 **Mediate competing or contradictory demands on water** The Framework must provide a means to mediate among competing or contradictory water resources demands while ensuring sustainability.	Different economic and social sectors use and value water differently; ecosystem needs are not always recognized; and there is growing demand for water by all sectors. Water quality and quantity are sometimes limited, resulting in competing or contradictory demands. Life-cycle costs and cost effectiveness across pollutant sources or between water uses are typically not considered when making decisions. Policies and processes must be in place to make and enforce sustainable choices between conflicting demands.

CORE OBJECTIVES	DESCRIPTION
Governance Objectives	
G 1 **Design a holistic, comprehensive institutional framework and policies for water** The Framework must provide a holistic, comprehensive approach to water resource governance and management.	We lack a state water vision that can provide a unified framework for our water policies. Policies have historically been developed in response to a specific issue, and thus are piecemeal, inconsistent, fragmented, and reactive. Federal, state, and local agencies tend to have isolated responsibilities and structures based on issue-specific statutes (i.e., exist in silos). This governance structure results in tension among entities charged with the implementation of water policy both vertically and horizontally.
G 2 **Plan for the long term** The Framework must address water resource sustainability into the long term.	Most attention to issues is focused on the short term; sustainable solutions require long-term strategic planning and solutions and the leveraging of resources to meet long-term challenges. We must move out of the crisis du jour mode.
G 3 **Create actions and processes that are flexible and adaptable** The Framework must be flexible and adaptive to allow it to remain effective in the face of changing challenges from both human and natural systems.	Our statutes and policies rarely allow for adapting to the future, including adapting to climate changes, economic changes, and demographic changes—potentially transformative forces over which we have little direct control. Since we cannot predict the future, policies must include processes that permit them to be flexible and resilient while providing real solutions to changing challenges.

CORE OBJECTIVES

CORE OBJECTIVES	DESCRIPTION
G 4 **Motivate the will to act** The Framework must create an environment that pushes us out of the status quo.	A will to act is necessary for policy change that leads to sustainability. A lack of will to act arises from the inertia that comes with the status quo; fear of changing; the 2 to 4 year political cycle; and other political considerations that interfere with wise decision-making about our public water resource. The will to act must occur at all levels: legislative, administrative, local governmental, individual, in businesses and industries.
G 5 **Take action in the face of knowledge gaps and uncertainty** The Framework must move forward and encourage action while continuing to refine our knowledge and understanding.	Uncertainty in the science and knowledge around issues will always be present to some degree. The failure to act in the face of imperfect knowledge may exacerbate problems. We must be willing to act on the best available scientific information, understanding that our decisions may be modified as we gain new information. This includes decision-making in the face of complexity, conflicts, and an unsupportive political landscape.
G 6 **Recognize limited capacity and resources** The Framework must recognize and address limited human and funding resources.	Solutions are sometimes limited by insufficient funding and human resource capacity, both in numbers and appropriate education and skills. Policy development that does not consider the constraints imposed by limited resources leads to policies that may be unimplemented or unenforced. Policy development must consider implementation resource needs, and funding should be reliable, long-term and integrative.

GUIDING PRINCIPLES

APPENDIX C

To guide the content of the Recommendations:

SUSTAINABILITY The Framework ensures sustainable water use. Water use is sustainable when the use does not harm ecosystems, degrade water quality, or compromise the ability of future generations to meet their own needs. The Framework recognizes the necessity of protecting, conserving, and enhancing water systems to ensure economic, ecologic, and social sustainability.

COMPREHENSIVENESS/INTERCONNECTEDNESS The Framework addresses water resources in all forms, recognizing the interconnections among the components of the water system, whether above or below ground. The Framework also addresses the connectedness of the water system to other systems, such as land, air, and habitat. The Framework recognizes effective water management requires intentional collaboration to avoid managing one part of the system in isolation from the entire system.

QUALITY OF LIFE The Framework acknowledges that healthy aquatic systems contribute to enhanced quality of life, and that social change may be necessary to achieve sustainable water use.

EFFICIENCY The Framework serves as a guide to integrate, coordinate, and increase efficiencies in water planning, management, and monitoring systems.

SCIENCE-BASED, FLEXIBLE, AND ADAPTIVE The Framework is founded in the most widely accepted current science and awareness of ongoing efforts while fostering generation of, and adaptation to, new information, changed conditions, and new solutions.

IMPLEMENTATION AND ATTAINABILITY The Framework will focus on factors that Minnesotans can positively influence within the 25-year time frame and that are measurable, attainable, and recognizable.

To guide process and product:

INCLUSIVENESS Representatives of all levels of government, the private and nonprofit sectors, academia, and citizens provide input to the Framework.

CLARITY The Framework is easy to understand.

PERSUASIVE The Framework is compelling and clearly explains issues and how recommended actions will benefit people and ecosystems.

TEAM MEMBERS and other CONTRIBUTORS APPENDIX D

THE LEGISLATIVE MANDATE FUNDING THE MINNESOTA WATER Sustainability Framework project envisioned a collaborative effort involving experts on all aspects of water from throughout the state. Embracing this vision, the UM WRC directly collaborated with a broad group of scientists, water professionals, and citizens. The 200 team members and advisors listed below were vital to the development of the Framework. They contributed countless hours advising the project core team, developing technical team white papers, synthesizing knowledge, commenting on draft documents, and communicating with citizens and colleagues about the project.

While the final content of the Framework is the product of the WRC, team members were indispensible in developing the knowledge base on which the Framework stands. The Framework is a document for the citizens of Minnesota largely because of the effort of everyone included below.

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SPECIFIC CONCERNS WITHIN EACH ISSUE APPENDIX E

FOLLOWING THE LEGISLATIVE MANDATE, THE MINNESOTA WATER Sustainability Framework project convened groups of scientists and experts around eight aspects of water: agricultural use; domestic use; manufacturing and energy use; recreational/spiritual/cultural use; ecosystem services; water education; water policy; and water valuation. Each of these Technical Work Teams identified specific concerns to address in order to achieve water sustainability in Minnesota. The teams identified 53 specific concerns. Some concerns were identified by multiple teams. These specific concerns were grouped into the 10 Issues that form the structure of the Minnesota Water Sustainability Framework. Listed below are the specific concerns under each Issue.

For its subject area, each Technical Work Team produced a white paper documenting what is known about the subject area, identifying knowledge gaps, and identifying issues that must be addressed to achieve sustainability. The Technical Work Team white papers are available on the University of Minnesota Water Resources Center's website: wrc.umn.edu.

Issue A: The Need for a Sustainable and Clean Water Supply

SPECIFIC CONCERNS

- **Surface-groundwater interactions—**Pumping groundwater can reduce flows to surface waters; contaminated surface water can contaminate groundwater.
- **Groundwater over-withdrawals—**It is not clear if groundwater is being used more quickly than it is recharged.
- **Need for conservation—**Minnesota's seemingly abundant water supply has not encouraged aggressive conservation practices.
- **Water reuse—**May be necessary to consider as water demand grows
- **Cumulative impacts of multiple water appropriators—**Permit requirements do not address cumulative impacts until there is a conflict.
- **Nitrates in drinking water—**Can restrict the use of public water supplies for drinking and can pose health risks to private well owners

Issue B: Excess Nutrients and Conventional Pollutants

SPECIFIC CONCERNS

- Unregulated runoff and drainage from agriculture
- Unregulated urban stormwater runoff
- Underperforming septic systems
- Loss of shoreland to development
- Legacy sources of phosphorus
- "Legacy" pollutants such as mercury and PCBs that continue to cause fish advisories
- Historic "superfund" hazardous waste sites in rivers, lakes, and harbors that have not yet been cleaned up

Issue C: Contaminants of Emerging Concern

SPECIFIC CONCERNS

- Nonregulated or underregulated chemicals of emerging concern (CECs), including endocrine-active compounds, nanoparticles, and pharmaceuticals
- Certain current-use pesticides that have unintended effects on human and/or wildlife
- Pathogens, both regulated and unregulated, from animal and human waste and other sources

SPECIFIC CONCERNS WITHIN EACH ISSUE

Issue D: Land, Air, and Water Connection

SPECIFIC CONCERNS

- Turbidity of lakes and streams
- Cultural eutrophication
- Toxic chemical pollution
- Loss of wetlands
- Changes in hydrologic cycle
- Moving water off land too quickly
- Deposit of mercury in lakes and streams

Issue E: Ecological and Hydrological Integrity

SPECIFIC CONCERNS

- Invasive species
- Loss of biological diversity
- Shoreland and aquatic habitat loss
- Hydrologic modifications, including drainage and dams
- Lack of ecosystem services valuation

Issue F: Water-Energy Nexus

SPECIFIC CONCERNS

- Cooling water for thermoelectric plants
- Biomass and biofuel production
- Electricity use to distribute and treat water
- Hydropower

Issue G: Water Pricing and Valuation

SPECIFIC CONCERNS

- Water pricing
- Lack of ecosystem services valuation
- Public ownership vs. private use rights
- Costs of remediation vs. costs of protection
- To what degree is water treated water and for what use
- Balancing economic environment with water resources protection
- Including recreation value, cultural value, and spiritual value in decision making

Issue H: Public Water Infrastructure Needs

SPECIFIC CONCERNS

- Drinking water and wastewater treatment infrastructure building, expansion, and maintenance
- Stormwater infrastructure
- New treatment technologies
- Infrastructure related to water reuse
- Water security

SPECIFIC CONCERNS WITHIN EACH ISSUE APPENDIX E

Issue I: Citizen Engagement and Education

SPECIFIC CONCERNS

- **Unsustainable behavior—**Conservation practices are not widely practiced.
- **Health/environment disconnect—**Regulations address human health or ecosystem health, but rarely both.
- **Insufficient education—**There is a lack of coordinated, ongoing water education across the continuum from K–12 to adult.
- **Citizen engagement in water stewardship—**Participation is uneven and organizations to promote it are hindered by a lack of long term strategies and support

Issue J: Governance and Institutions

SPECIFIC CONCERNS

- **State-level coordination—**Water management is not always coordinated across state agencies.
- **Legislative capacity—**With so many critical issues vying for attention, and with water management being so complex, it is difficult for legislators to give water issues the attention they need.
- **Multiplicity of local players—**Through time, a complex and challenging patchwork of local organizations (SWCDs, WDs, WMOs, NGOs, cities, and counties) has evolved to govern water at the local level.
- **History—**Water policy has developed in an additive manner over time, with insufficient attention paid to coordinating new policy with old.
- **Lack of systems thinking regarding water—**Misperception prevails that groundwater and surface water are independent and can each be regulated without consideration of the other; a similar misperception exists for drinking water, wastewater, and stormwater.

BACKGROUND WHITE PAPERS

OVER THE COURSE OF A YEAR, PROJECT TEAM MEMBERS worked to build a strong knowledge foundation for the Minnesota Water Sustainability Framework. The Framework itself represents only the final conclusions derived from these foundational documents. Scientific papers comprehensively documenting Minnesota data on water use, water availability, and water quality were prepared and used by all project teams. Eight technical work teams were organized around water policy and education, and how water is used and valued. Each team prepared a white paper describing what we know about the topic area, what we don't know, and issues that must be addressed to reach water sustainability. In addition, a report was prepared summarizing the extensive citizen and stakeholder outreach efforts during the project. Comprising an additional 250 pages, the thirteen background documents described below are available on the University of Minnesota's Water Resources Center website **wrc.umn.edu.**

Water Use in Minnesota

Water Availability in Minnesota

Water Quality in Minnesota

Agricultural Water Use Technical Work Team Report

Domestic Water Use Technical Work Team Report (includes drinking water, wastewater, and stormwater)

Manufacturing and Energy Water Use Technical Work Team Report

Recreational, Spiritual, and Cultural Uses of Water Technical Work Team Report

Ecosystem Services Technical Work Team Report

Policy Technical Work Team Report

Water Education Technical Work Team Report

Water Valuation Technical Work Team Report

Public Water Infrastructure Needs Report

Citizen Stakeholder Outreach Efforts Report

BEST PRACTICES

APPENDIX G

THE LEGISLATION FUNDING THE MINNESOTA WATER SUSTAINability Framework requires identification of best practices and methods for determining the effectiveness of those practices for wastewater treatment, drinking water source protection, pollution prevention, water conservation and water valuation. Best practices are actions that are currently considered the most effective in reaching a goal or standard. For example, the Natural Resources Conservation Service (NRCS) and Minnesota Department of Agriculture (MDA) consider the development and implementation of a manure management plan meeting established standards a best practice for managing the impact on water of manure storage and field application.

Because best practices are constantly evolving based on new information about their effectiveness, we have chosen to create web-based best practice documents that can be updated periodically. Best practice documents for the topics listed below are available on the University of Minnesota's Water Resources Center website **wrc.umn.edu.**

Wastewater Treatment Best Practices

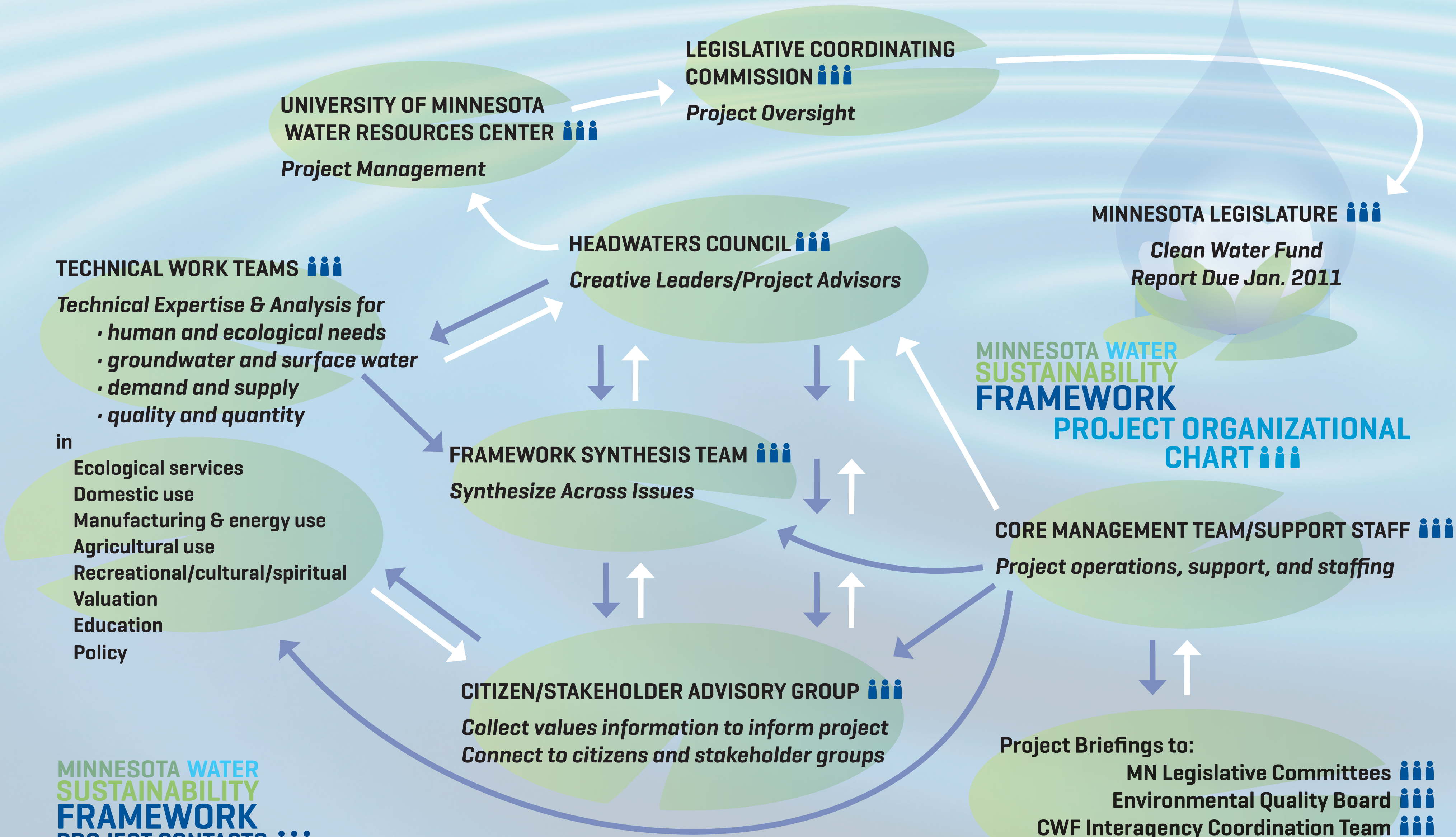
Drinking Water Source Protection Best Practices

Pollution Prevention Best Practices

Water Conservation Best Practices

Water Valuation Best Practices

MINNESOTA WATER SUSTAINABILITY FRAMEWORK
PROJECT ORGANIZATIONAL CHART



UNIVERSITY OF MINNESOTA WATER RESOURCES CENTER

Project Management

LEGISLATIVE COORDINATING COMMISSION

Project Oversight

MINNESOTA LEGISLATURE

Clean Water Fund
Report Due Jan. 2011

HEADWATERS COUNCIL

Creative Leaders/Project Advisors

TECHNICAL WORK TEAMS

Technical Expertise & Analysis for
- *human and ecological needs*
- *groundwater and surface water*
- *demand and supply*
- *quality and quantity*

in

Ecological services
Domestic use
Manufacturing & energy use
Agricultural use
Recreational/cultural/spiritual
Valuation
Education
Policy

FRAMEWORK SYNTHESIS TEAM

Synthesize Across Issues

CORE MANAGEMENT TEAM/SUPPORT STAFF

Project operations, support, and staffing

CITIZEN/STAKEHOLDER ADVISORY GROUP

Collect values information to inform project
Connect to citizens and stakeholder groups

Project Briefings to:
MN Legislative Committees
Environmental Quality Board
CWF Interagency Coordination Team
Clean Water Council

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