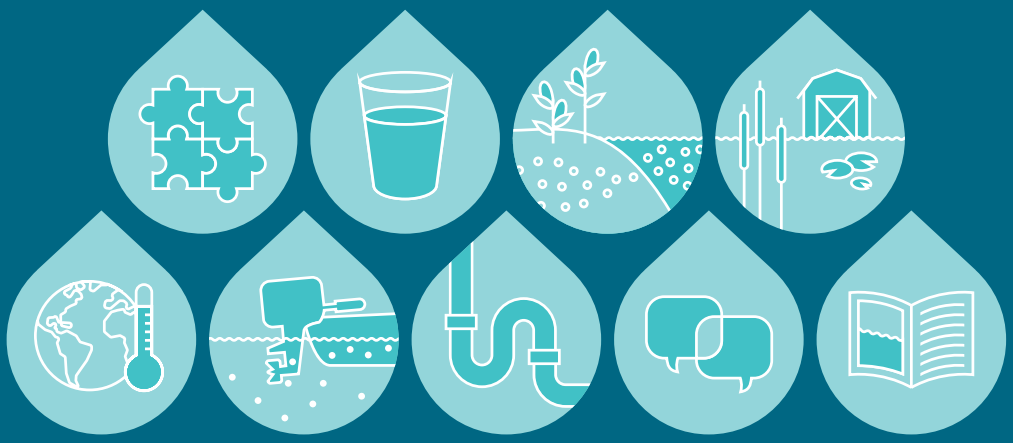
SHIFTING CURRENTS

PROGRESS, SETBACKS, AND SHIFTS IN POLICY AND PRACTICE



A Waters of Wisconsin Initiative Report
of the Wisconsin Academy of Sciences, Arts & Letters

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About the Wisconsin Academy of Sciences, Arts & Letters

Founded in 1870, the nonprofit Wisconsin Academy of Sciences, Arts & Letters is a trusted resource for informed and engaged citizens who appreciate the value of discovery and learning. The Wisconsin Academy produces programs and publications that explore, explain, and sustain Wisconsin thought and culture. We bring people together at the intersection of the sciences, arts, and letters to inspire discovery, illuminate creative work, and foster civil dialogue on important issues. In this way, we connect Wisconsin people and ideas for a better world.

About this Report

In 2003, the Wisconsin Academy's first Waters of Wisconsin Initiative released its capstone report: *Waters of Wisconsin: The Future of Our Aquatic Ecosystems and Resources*. Recognizing that many of the same challenges outlined in the report still affect our waters today, the Academy revisited the 2003 recommendations in 2012, while exploring new and more complex threats to water quality, water quantity, and aquatic ecosystems. The culmination of this exploration is *Shifting Currents: Progress, Setbacks, and Shifts in Policy and Practice*, an update to the Academy's 2003 *Waters of Wisconsin* report. Designed for use by water researchers, government leaders, and engaged citizens alike, the *Shifting Currents* report is the product of three years of work with a network of leaders across many areas of expertise, with the collective goal of advancing leadership and stewardship for the waters of Wisconsin. The report reflects the Academy's aim to foster nonpartisan, science-based strategies and solutions to safeguard Wisconsin's freshwater ecosystems and water supply for generations to come.

The *Shifting Currents* report does not necessarily reflect the policies or views of the Wisconsin Academy's partner groups, sponsors, or funders; nor does it necessarily reflect the policies or views of the organizations or agencies that employ the Waters of Wisconsin Steering Committee, Report Editorial Team, and other report contributors.

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About the Waters of Wisconsin Initiative at the Academy

Wisconsin Academy Initiatives

Initiatives are the Wisconsin Academy's expression of the Wisconsin Idea and a reflection of a 145-year commitment to "gathering, sharing, and acting upon knowledge in sciences, arts, and letters for the betterment of the people of Wisconsin."

As a nonpartisan, interdisciplinary organization, we play a unique role in bringing leaders together to examine Wisconsin challenges. The Wisconsin Academy Initiatives convene Wisconsin leaders from an array of fields for deliberation, analysis, and distillation to identify strategies and solutions for a sustainable world. Our two current Initiatives are:

- **Waters of Wisconsin:** Safeguarding Wisconsin's freshwater ecosystems and water supply; and
- **Climate & Energy:** Addressing climate change and diversifying energy choices in Wisconsin.

Waters of Wisconsin I (2000 to 2003)

In 2000 the Wisconsin Academy embarked on a multi-year investigation to identify strategies that would secure the health of Wisconsin's aquatic ecosystems and sustain the abundance of the state's water supplies. The effort culminated in a conference that drew over 700 attendees from across the state and a report issued in 2003 (*Waters of Wisconsin: The Future of Our Aquatic Ecosystems and Resources*) with recommendations that continue to shape water policy and practice in Wisconsin. The Initiative served as a catalyst for changes in public policy and new public education efforts, and deepened institutional and individual relationships that provided the undergirding for important collaborations over the following decade. Its steering committee was led by John Magnuson (University of Wisconsin–Madison Center for Limnology), Stephen Born (UW–Madison Department of Urban & Regional Planning), and Patricia Leavenworth (then with the U.S. Department of Agriculture's Natural Resources Conservation Service in Wisconsin and now owner of Spring Oak Farm).

In 2012, the Academy set out to renew its Waters of Wisconsin Initiative, assessing the impact of the original project and the state of our waters a decade later. In doing so, we sought to reinvigorate public dialogue about Wisconsin's waters by providing a process and structure to explore new issues and challenges with the next generation of citizens, advocates, and leaders while building on the wisdom from many engaged in the previous effort.

Waters of Wisconsin II (2012 to Present)

Building on the successes and recommendations of our first Waters of Wisconsin (WOW) Initiative a decade ago, the Wisconsin Academy has revisited those recommendations, recognizing that many of the same challenges are still with us today while new and more complex threats to water require a fresh examination of the way forward. Our aim is to foster nonpartisan, science-based strategies and solutions to safeguard Wisconsin's freshwater ecosystems and water supply for generations to come. Our renewed Initiative has focused on several key program elements to further develop these strategies and solutions for healthy water and a healthy Wisconsin: examining current challenges related to phosphorus pollution in the state's waters, advancing strategies to safeguard water supplies, identifying some of the systemic challenges that complicate water conservation strategies in Wisconsin, and helping water leaders become more effective communicators about today's water challenges and solutions. Working with a growing network of leaders across many fields (over 60 are currently participants in our WOW Leadership Network), we aim to advance leadership and stewardship for the waters of Wisconsin.

Since 2012, the WOW II program has:

- Developed thoughtful and productive discussion about the root causes and drivers of current threats to Wisconsin waters. This has helped build the capacity to move strategies from those focused primarily on reacting to symptoms, to longer-term systemic and structural solutions.
- Shed light on the various lenses through which policy-makers and the public view water.
- Identified overarching needs that are common denominators across many water issues in moving forward with responsive solutions, such as:
  1. The need to elevate awareness of the role water plays in Wisconsin's economy and culture;
  2. The need to acknowledge and address ethical choices (and consequences) we face in making water decisions in Wisconsin, and to better understand how water decisions affect various communities, stakeholders, and individuals;
  3. The need to grapple with whether water will remain a protected "commons" in Wisconsin, or will increasingly become a private commodity, and how a shift toward commodification will affect life in Wisconsin; and
  4. The need to reinvigorate public participation and explore fresh approaches to engaging people in decision-making about water in Wisconsin.

We will be reflecting on the above conclusions, as well as other findings, in this report.

2015–2016 Waters of Wisconsin Initiative Funders and Sponsors

The Joyce Foundation
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2016

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Foreword

The Wisconsin Academy's initial Waters of Wisconsin project (WOW I) facilitated a statewide conversation between 2000 and 2003 around one main question: *How can we ensure healthy aquatic ecosystems and clean, abundant water supplies for tomorrow's Wisconsin?* Robust participation in this conversation underscored the important role citizens have in the stewardship of our waters, and we found enthusiastic support for farsighted policies—based on sound science—to manage our water legacy.

Overall, we found that Wisconsinites cherish water and see our waters as essential to our way of life in Wisconsin. Nationally, our state ranks 25th in land area but has the fourth-highest area covered by water. Wisconsin is 20th in population but is second only to Florida in the number of fishing licenses sold each year. Clean water supports billions of dollars' worth of economic activity through tourism, agriculture, and industry.

From the Northwoods cabin to the Port of Milwaukee to the Wisconsin Dells, water shapes our state's identity. Our tradition of safeguarding Wisconsin's waters is grounded in values such as responsibility to family and future generations, respect for land and wildlife, protecting public health and safety, and caring for water as a common good, as articulated in the state's Public Trust Doctrine (see page 9). These deeply held values have also shaped a conservation ethic, and its legacy has served many generations who depend upon and enjoy the waters of the state.

Through WOW I, we identified the need to overcome the institutional and disciplinary separation of science, policy, and management protocols through a more integrated approach to water management. WOW also affirmed that the Wisconsin Department of Natural Resources (DNR) and other public agencies play a critical role in sound scientific application, citizen participation, and the practical implementation of policy while balancing public and private interests toward the goal of a clean water future.

More than a decade has passed since our first statewide WOW conversation and the report that captured recommendations from its participants: *Waters of Wisconsin: The Future of Our Aquatic Ecosystems and Resources*. Drawing from a diverse and growing set of stakeholders from across the state, the Wisconsin Academy initiated a new conversation in 2012 (known as WOW II) to assess progress in regard to our 2003 recommendations. We also sought to review the status of waters in Wisconsin today.

The result of this renewed conversation is *Shifting Currents: Progress, Setbacks, and Shifts in Policy and Practice*. The new report assesses progress in brief, and explores in greater depth the continuing and emerging challenges to water quality, supply, and aquatic ecosystems in Wisconsin.

In this report, we first review the context and frameworks for public decision-making about water and then examine some of the root causes—or "drivers"—and ecological stressors that underlie many of the symptoms we see in the form of pollution or ecosystem degradation in Wisconsin. This is followed by a summary of current water issues, many of which had been identified in the 2003 report and remain relevant today. We examine progress since 2003 but also setbacks, and discuss issues that we are likely to continue to face in the

coming decades, including controlling agricultural runoff, mitigating climate change and grappling with its effects on the state's waters, protecting groundwater from bacterial contamination and other pollutants, and preventing groundwater depletion. We also attempt to anticipate issues on the horizon. We offer a deeper look at some particular challenges, such as phosphorus pollution and groundwater contamination. We then consider the current decision-making framework and how it is shaping our capacity to respond to water challenges in Wisconsin. Finally, we offer recommendations and identify opportunities to safeguard Wisconsin's waters in the decades ahead.

From its inception, the Wisconsin Academy's Waters of Wisconsin Initiative has brought together a diverse community of experts from across the state and from varied fields and areas of interest, to address challenges and seize opportunities related to our precious waters. We have done so as a matter of both principle and practical reality: the state of our waters reflects the ways we interact not only with them, but also with one another and our institutions. The WOW Initiative has aimed to provide guidance for Wisconsin citizens in sustaining the health of our aquatic ecosystems and the resilience of our water supplies over the long term.

—Jane Elder, *Executive Director, Wisconsin Academy of Sciences, Arts & Letters*

FRAMEWORKS FOR DECISION-MAKING

Frameworks for Decision-Making

We perceive water and water policy through multiple frameworks or lenses that influence the way we observe the world—and the way we react when problems arise. In this report we look at water through the lenses of science, economics, governance, and ethics and consider how each lens shapes decision-making about water.

This chapter was developed by a special Waters of Wisconsin (WOW) working group (active from 2013 to 2014) that examined frameworks for decision-making and systemic issues that influence water in the state.[1] The group identified the four key lenses we discuss in this chapter. To ensure a healthy water future for our citizens and for all life in Wisconsin, our actions and decisions must be guided by:

- The appropriately rigorous *scientific knowledge* of the state of our waters and our human interactions with water;
- A comprehensive understanding of *the full economic value* of water;
- An appreciation of *the ethical significance of water* in our human and environmental relationships; and
- *Policies that reflect the reality of water* as an interconnected hydrologic system and common resource essential to life and intrinsically involved in all our other public policy choices and decisions.

Science

Science tells us how water works in the world, how our aquatic systems are changing, and how we as humans interact with our waters and with what effects. An important assumption—or even a truism—is that management of water resources and related public policy will be more effective and longer lasting when informed by science. Bringing science to bear can reduce the occurrence of unexpected and undesirable consequences of public policy and management actions. It can also aid in adaptive management, where we monitor or track the consequences of our decisions and make adjustments in management and policy as we learn by doing.*

The science of water resources involves a suite of interacting disciplines to resolve and help us understand most issues. These disciplines include hydrology, limnology (a combination of physics, chemistry, and biology), fisheries science, conservation biology, game management, and ecology, as well as economics and other social sciences. The humanities, too, can offer insight into and wisdom about how water affects our daily lives and our connection to places in Wisconsin.

Science does not serve us well when the information and knowledge are cloistered or ignored. The need is great for decision-makers, managers, and the public to understand the significance of water and water resources, as well as how those work. The science of water-related issues and problems must be available to the public and decision-makers in useful and understandable forms.

Science and technology can be linked closely and applied to accomplish particular management goals. The role of professionals and the public is to discern how the information that science provides

* The World Bank defines *adaptive management* as "a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices." See: The World Bank, *World Development Report 2010: Development and Climate Change*, (Washington, DC: World Bank, 2010), pp. 90, 353.

and options that technologies offer can best be applied to safeguard water resources under a broad set of specified management objectives. Original research can be conducted to shed light on a particular action, and, if the findings are shared and the public is consulted, it can support a better-informed decision-making process.

Science should be policy-relevant rather than policy-prescriptive. Relevant science can be brought together, synthesized, and made available to decision-makers. Examples of bringing the science together for policy-makers are well illustrated by the reports of the Intergovernmental Panel on Climate Change (IPCC)[2] and the Millennium Ecosystem Assessment.[3] Both assessments synthesize existing knowledge and information to present possible future scenarios to help inform the decisions of policy-makers. Such scenarios are particularly useful for conveying compelling research areas where uncertainties are large.

Change is continually occurring around us. But without repeated observation and measurement over time, we can be blind to these changes, or at best have badly impaired vision. Tracking changes allows us to identify the better decisions and to sound the alarm when we fall short of our goals to sustain Wisconsin's waters—or when new influences become apparent. Both policy and management require a commitment to active and well-designed monitoring by many levels of government and by individuals.

Some facts about water are, with our present state of knowledge, self-evident. Such general knowledge should be recognized in any decision regarding water resources. Not to do so imperils both the resource and the broader public interest. Examples of these facts are:

- Waters are interconnected to the land in watershed units;
- Surface water flows downhill;
- Surface water and groundwater form a single interactive system;
- Water quantity (flows and amounts), water quality (nutrients, toxic contaminants, temperature), and the life sustained by aquatic systems are intricately connected;
- Waters respond to climate change and variability; and
- Interrelationships among physical, chemical, biological, and human components of the water world are complex and interactive.[4]

All water issues are long-term. Short-term thinking, or quick fixes, can divert attention away from decisions that would have more lasting success. Variability between seasons, years, even decades should be incorporated into management and policy decisions. For example, if both drought and flood could occur over the period for which a decision is intended to apply, both conditions must be considered.

Continually improving and expanding our base of scientific knowledge and information is essential for educators and decision-makers alike. Again, this relates not only to gathering new information, but also to keeping informed about changes in the waters.

A commitment to examining decisions that affect water resources through a scientific lens is important. One responsibility of scientists, educators, and water resource organizations is to communicate scientific information in clear and compelling ways. This is a requirement to help managers and decision-makers craft the most informed choices possible.

These and other thoughts on the role of science in sustaining Wisconsin's waters are detailed in our first WOW report, *Waters of Wisconsin: The Future of Our Aquatic Ecosystems and Resources*

(2003). Science can and should continue to influence policy and management decisions about Wisconsin's waters.

Economics

Economic factors play a driving role in shaping the challenges we face in water conservation and protection today. Economics examines the choices people make in efforts to satisfy their needs and wants using scarce resources, including managing, allocating, utilizing, and conserving our water resources. Each choice has implications for public policy.

Markets

We make choices in the context of an economy that depends on markets. Economists recognize that markets play an often-unseen role in coordinating the countless choices we make. Market prices convey the signals that drive these choices. Most people take the invisible hand of the market for granted, if they think about it at all.

Externalities

At the same time, the invisible hand has limitations, and these limitations are very evident when we consider any common good like water. Consider, for example, manufacturing. In the making of a product, a manufacturer's production process may release wastes and by-products that could pollute a nearby stream, and this could have negative effects on the local ecosystem and people downstream who use the water. In the open market, there may be nothing to compel the producer to consider these negative effects when making waste disposal choices at the production plant. In economists' jargon, the impacts from the pollution are "externalities"—the impacts are external to the production process, and the costs are passed on to others. Regulations are one way that governments can protect people and aquatic ecosystems from the impacts of externalities. Manufacturers bear external costs through the practices they adopt to comply with regulations. But, often, the regulatory safeguards are inadequate to offset all the external impacts and costs. In addition to externalities, the invisible hand may fail to account for the wants and needs of future generations.

Economic arguments can be made for policies to protect Wisconsin's water resources from long-term or permanent degradation in the interest of future generations. Economists are coming to recognize that markets can be shortsighted, focusing price signals on what happens in a few years or at most the next decade or two. The market system gives longer-term impacts much less weight. Thus, economists, along with others, are weighing in on issues of sustainability.

Economic Tools to Care for Water

While we have made substantial progress in caring for our water resources, significant challenges lie ahead. A challenge for Wisconsin will be to capitalize on the strengths of our market system while devising public policies to address externalities and protect future generations and environmental systems. Economics can help. The following are three suggestions for citizens and public officials to consider.

First, some economists suggest that more attention be given to "polluter pays" policies. This might be accomplished directly through fees levied by the state for discharge of pollutants into waters. Such fees could be set high enough to achieve environmental goals. Alternatively, permits sufficient to achieve such goals could be issued, and local governments and businesses own-

ing the permits could be allowed to buy and sell them. Either way, market-like incentives would be created to achieve pollution goals at costs that would be lower than those associated with past approaches to pollution control. If environmental goals can be achieved at lower cost, why not do it?

Second, more attention could be paid to the monetary values of improvements in the protection and restoration of water and other environmental resources. Over the last 50 years, methods have been developed for placing a value on environmental improvements. Several studies have been conducted by UW–Madison's Department of Agricultural & Applied Economics. For example, one study estimated that improvements in water clarity in Green Bay would be worth $10 million per year to those living on the shore or nearby.[5] Other studies have focused on water quality in Lake Mendota, Lake Winnebago, and the lakes of Vilas and Oneida Counties, as well as groundwater quality in the central part of the state. Still other work has focused on monetary values for wetlands protection, control of aquatic invasive species, and the recreational fisheries of Lake Michigan and Green Bay. Without a doubt, costs and other financial impacts of environmental policies in the market economy will be considered. Nonmarket valuation studies can help citizens and decision-makers recognize that the environment has financial values, too. This can result in decisions based on a more complete set of economic values.

Finally, economics can *add* support to arguments for policies that would protect water and other environmental resources for future generations. Opponents to such policy proposals often marshal economic arguments to make their case, stating concerns about jobs, profits, and the robustness of the state's economy. While these may deserve to be considered, they are based on market values that can be overly narrow and shortsighted when considering the natural "endowments" that, if protected, future generations of Wisconsin's people will inherit from us.

Governance

In a democratic society, the governing structures and systems through which we make decisions about water are complex. Policy and regulation are shaped by cultural, social, economic, aesthetic, and many other influences; governing *bodies* are influenced by these as well.

Water interactions are also complex, and are typically not bound by the same political boundaries, borders, and jurisdictions of our governing system. In Wisconsin, our decisions are shaped by town councils, city alders, county boards, regional authorities, state government, federal government, tribal government, and bi-national agreements that govern the Great Lakes. Some solutions may be local; others may involve multiple layers of decision-making.

In addition to policy directly focused on water, our governance processes also set the rules of the economic game, including providing incentives and dealing with competing interests when it comes to who can use water and how they can use it.

Inherent Complexities in Water Governance

Because of the specialized and technical nature of water resources and their uses, it is no surprise that there is a fragmented approach to water management. Yet, piecemeal decision-making seldom yields positive outcomes in any endeavor. The complexities in water management understandibly result in the division of resource components (groundwater, surface waters, lakes, streams,

wetlands, floodplains, etc.) and resource uses (polluting discharges, high-capacity wells, riparian and floodplain development, dams and diversions, etc.). Furthermore, we necessarily manage water at many scales, from relatively short reaches to small agricultural watersheds, to lake regions to large river basins. The scale of management is often a reflection of the problem(s) we are trying to solve or the nature of the resource(s) we are trying to protect. And a wide array of governmental entities—from federal and state agencies to local governments and special-purpose districts—exercise some jurisdiction over water resources and uses.

Increasing numbers of interests and sectors are involved with managing and protecting water and related resources, adding another layer of complexity to managing aquatic resources. While historically water management in Wisconsin was seen as the purview of government (primarily because of Wisconsin's Public Trust Doctrine—see In Focus, page 9), a growing list of actors are engaging in and providing water leadership. These include nonprofit watershed organizations, business entities, farmer organizations, and conservation groups, as well as individual thoughtful and impassioned citizens. While this change may be due in part to diminished governmental resources, the salience of water issues and the desire to collaborate on solutions are important driving forces for increased public participation in water management.

The rarity of unitary or centralized governmental authority for managing water (true for Wisconsin and the United States generally) argues strongly for a system of coordinated and shared governance. No single entity can make *all* the decisions pertaining to water management; therefore distributed roles and responsibilities must be worked out as part of a collaborative and adaptive system of water governance. Of course there are inescapable conflicts in building and sustaining viable systems. For instance, differing viewpoints and values exist with regard to balancing statewide consistency and local flexibility in planning and regulatory decisions. Therefore, a governance system must acknowledge and respect the different perspectives of local, county, and regional interests as well as statewide views. But all these interests must be engaged in the decision-making process, and exposed conflicts must be resolved in order to successfully address water resources management issues.

The scale at which we address these issues adds to the complexity. Many water issues and problems spill over local, regional, and state boundaries. It is a requisite to "right-size" water management so that the governance system and the arena for decision-making fit the scale of the watershed or aquifer. As we weigh the appropriate scale(s) for taking action, we cannot lose sight of the interconnections between land and water management; these realities may suggest the need to reframe the scale.

Toward Better Integration

Throughout the WOW I effort more than a decade ago, those involved with the report stressed the complex interconnected nature of water and related resources (land, plants, wildlife, etc.) and the interdependence among various uses and demands. The 2003 WOW report urged that if Wisconsin is to secure a sustainable water future, we must move beyond incremental, reactive, and fragmented approaches for managing water resources and aquatic ecosystems, and find ways to bring all the pieces together in our policy-making framework. Despite modest progress since then, the need for integrated policies and actions that

consider science, economics, and ethics, and that assure the long-term health of all our waters, is even more urgent. In the face of growing competing demands for, and stresses on, our waters, we must improve the systems through which we govern ourselves and make decisions about the use and protection of our waters.

Clearly it is not easy to achieve successful and effective coordination in our water management efforts. Fragmentation appears to be a fact of life in water governance, just as there are always competing values and views. Addressing this complexity requires recognizing the areas in which fragmentation occurs and developing democratic and dynamic arrangements that foster progress toward sustainable water management. There are no permanent "fixes," and engaged parties in water management must communicate and negotiate to have success. Successful governance outcomes are likely to be the result of flexible couplings between organizations on different levels and at different scales through non-rigid organizational arrangements, formal and informal interaction and communication processes, and shared objectives. Three ways we can improve governance processes are anticipating and managing conflict, improving transparency, and embracing inclusivity.

Conflict Management

To address competing priorities, conflicting values, and a wide range of expected outcomes, a healthy democratic process needs to anticipate conflict and design processes to resolve it. When there is agreement about both the causes of a problem and the outcomes for potential solutions, then conflict is low and actions can move forward. Conflicts arrive when there is disagreement about causes or solutions:

- How the information around the problems was gathered or interpreted (computation);
- The judgment of those involved in the decisions; and
- The method deployed and/or participants engaged in the bargaining process to reach agreement. [6]

Some of the most challenging conflicts are those of ideology or values. The Institute for Global Ethics (IGE) describes these deeply rooted values conflicts as "right vs. right" conflicts, as opposed to "right vs. wrong," which is one of the reasons these are so difficult to resolve or even address through constructive dialogue.[7] The IGE identifies four common values and ethical conflicts, all of which can play out in environmental conflicts. These include:

- Truth vs. loyalty;
- Justice vs. mercy;
- Individual rights vs. community; and
- Long-term vs. short-term.

Intractable environmental conflicts are often centered on short-term economic benefits versus long-term environmental protection, or the rights of individual property owners versus the rights of the community or future generations. The lasting resolution of conflicts surrounding values requires dialogue, listening, and respect for the alternative view—all of which can be challenging when the stakes of the decision are high for both sides.

Transparency and Inclusivity

The processes of governance and decision-making should be inclusive and transparent. All stakeholders and interests should have a voice in water-related plans, policies, and decisions that directly affect them. To the maximum degree possible, scientific knowledge should be incorporated

and shared in decision-making. It is critical that what is known about water science and water problems and issues be conveyed to the public and decision-makers so that a) decisions are based in reality, and b) areas of scientific uncertainty are recognized and considered. Finally, both the process and the content of water-related policies and decisions deserve to be framed in the context of sustainability in order to ensure that outcomes look to the well-being of future Wisconsinites.

The lenses through which we view water, and the spheres in which information is gathered, interpreted, and acted upon, shape decisions about water in Wisconsin every day. Given these many facets, the case for inclusivity and transparency in public decision-making is even more compelling.

Ethics

Science can describe for us how water works in the world and how our human actions affect—for ill or good—our water resources and aquatic ecosystems. Economics can provide information on resource trade-offs with regard to how we as individuals, communities, and institutions use Wisconsin's waters. Water governance and policies reflect the ways we choose to govern ourselves with respect to water. Fundamentally, however, the state of our waters also reflects our concept of our relationship with water—and that is a matter of ethics. Our ethics express what we as a community value and believe, providing guidelines for appropriate behavior and action in our human relationships and in our relationships with the world around us, including our waters. Our ethics, in turn, shape the ways we choose to govern ourselves, the ways we use water, and the questions we ask water scientists to study.

The channels of a water ethic run deep through Wisconsin's history. Wisconsin has a landscape shaped by ancient glaciers and the dynamic flow of waters over, under, and through the land. The stories, histories, lifeways, and worldviews of the varied Indian Nations of the area reflect a long-standing, profound sense of connection with the waters of the state. The value of water as a commons resource, held in trust by the state for its citizens, is encoded within the Wisconsin constitution's Public Trust Doctrine (see In Focus, page 9).

Early episodes of water and watershed degradation after European settlement and statehood led to the emergence of a conservation movement that included water as a part of its broad agenda of reform. Aldo Leopold's formulation of a "land ethic" explicitly called upon us to see land as a community that included "soils, *waters*, plants, animals, and people."[8] Generations of elected representatives, of varying political loyalties, have taken steps to safeguard, restore, and sustainably manage our waters.

As ingrained as respect for water is in our state's culture, most people are still not accustomed to or comfortable with thinking about water in ethical terms. We are still liable to take our relationships with water for granted. Sometimes we do so to avoid facing unpleasant facts and trends or to put off difficult decisions. Other times it is just easier to fall into simple calculations of economic cost.

Whatever the reason, we are still prone to treating water as an infinite resource with infinite capacity for meeting our needs, sustaining our human and natural communities, and assimilating our human impacts. We find it difficult to reflect in our policies, or in the marketplace, the invaluable significance of water in our relationships with our neighbors, future generations, and other species. Short-term and narrow calculations of

WISCONSIN WATERS AND THE PUBLIC TRUST DOCTRINE

As Wisconsin developed its founding constitution, the framers were aware that the state's waterways were essential to trade, transportation, and economic development. The Public Trust Doctrine was their affirmation that these waterways were public resources held in common—forever:

> *[T]he river Mississippi and the navigable waters leading into the Mississippi and the St. Lawrence, and the carrying places between the same, shall be common highways and forever free, as well to the inhabitants of the state as to the citizens of the United States, without any tax, impost or duty therefor.*

Over the years, case law has expanded the scope of water as a commons beyond the original concept of "highways" to include streambeds, recreational uses, and also ecological functions and their values to society. Specific examples include:

- A 1914 case (*Diana Shooting Club v. Husting*) established that "riparian owners on navigable streams have only a qualified title to the beds thereof, which title is entirely subordinated to, and not inconsistent with, the rights of the state to secure and preserve to the people the full enjoyment of navigation and the rights incident thereto."
- In 1952, another case (*Muench v. Public Service Commission*) established that "the state holds the navigable waters of this state in trust for the public, and that such trust extends to the uses of such waters for fishing, hunting, and other recreational purposes, as well as for pure navigation."
- In *Just v. Marinette County* (1972), the courts determined that "the active public trust duty of the state of Wisconsin in respect to navigable waters requires the state not only to promote navigation but also to protect and preserve those waters for fishing, recreation, and scenic beauty. To further this duty, the legislature may delegate authority to local units of government." (The state did so by requiring counties to pass shore land zoning ordinances.) This same decision also recognized the "vital role in nature" that swamps and wetlands serve, reinforcing that these "are essential to the purity of the water in our lakes and streams."

Sources:

Content for this section was adapted from the following presentation: Carl A. Sinderbrand, "The Public Trust Doctrine and Groundwater Law in Wisconsin" (presentation, 2014 Wisconsin Lakes Partnership Convention, Stevens Point, WI, April 25–24, 2014), http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/convention/2014/CarlSinderbrand-PublicTrustDoctrine-GroundwaterLawinWI.pdf.

Wisconsin State Constitution, Article IX, Section 1 (see online at http://docs.legis.wisconsin.gov/constitution/wi_unannotated).

Diana Shooting Club v. Husting, 156 Wis. 261, 145 N.W. 816 (1914).

Muench v. Public Service Commission, 261 Wis. 492, 55 N.W.2d 40 (1952).

Just v. Marinette County, 56 Wis. 2d 7, 201 N.W.2d 761 (1972).

economic value often trump the value of water as an essential ingredient of all life and all economic relations, now and into the future.

And yet, ethics are inherently involved in our conversations about water and the choices we make. We are engaged in ethical discussions when we ask:

- What is the appropriate relationship between people and water?
- How do we value water?
- Is water a public good, or is it a private commodity? Who decides?
- If water is a common good, how do we decide which needs are of the highest value? Who decides? What should be the goal in managing water, and who pays for this management?
- Do we have a responsibility to our neighbors downstream? To future generations? To other species that depend on clean and abundant water?
- What principles should guide our relationship to and use of water?

Our answers to these and other questions express our water ethic. Science can and must inform our answers, but it cannot tell us what to do with that information. We turn, then, to the varied sources of our ethics: our families and communities; our religious and spiritual traditions and faith communities; our inheritance of philosophical concepts and traditions, and of literature, stories, and mythologies; our knowledge of history and our economic and political schools of thought; and our personal experiences and reflections. Ethics are difficult or impossible to quantify. But we live in relation to water; we *are* water. Hence, we are inescapably bound to consider the health and resilience of our relationship with water.

Alongside the necessary work of scientific research, economic analysis, and policy development, we in Wisconsin must, for the sake of a sustainable water future, continually emphasize our ethical relationship to water. We must foster and encourage continuing discussion of water ethics among our citizens, educators, faith communities, businesses, local governments, and institutions. Because the fate of Wisconsin's waters cannot be separated from the fate of water regionally, nationally, and globally, we are part of a yet larger discussion of an emerging water ethic. In the last decade, that conversation has expanded dramatically as water needs, issues, and opportunities for sustainability have become increasingly evident.[9] Wisconsin can contribute importantly to that conversation while reinvigorating its own historic legacy of water ethics.

Notes

1. Wisconsin Academy of Sciences, Arts & Letters, *Deeper Waters: A Systems Perspective on Water in Wisconsin*, contribution of Waters of Wisconsin Water Systems Working Group (see p. 27 in *Deeper Waters* for authors) (Madison: Wisconsin Academy of Sciences Arts & Letters, 2014), https://wisconsinacademy.org/files/WOW%20Systems%20Report%20Draft%20FINAL%209.19.14.pdf, pp. 15–24.

2. See, for example: the IPCC's Fifth Assessment Report: Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report*, contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, ed. R.K. Pachauri and L.A. Meyer (Geneva: IPCC, 2015), https://www.ipcc.ch/report/ar5/syr/.

3. See, for example: Millennium Ecosystem Assessment Core Writing Team, *Ecosystems and Human Well-Being: Synthesis*, a report of the Millennium Ecosystem Assessment (Washington, DC: Island Press, 2005), http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

4. Wisconsin Academy of Sciences, Arts & Letters, *Deeper Waters*, p. 16.

5. Rebecca Moore, Bill Provencher, and Richard C. Bishop, "Valuing a Spatially Variable Environmental Resource: Reducing Non-Point-Source Pollution in Green Bay, Wisconsin," *Land Economics* 87, no. 1 (2011), http://le.uwpress.org/content/87/1/45.full.pdf, pp. 45–59.

6. Kai N. Lee, "Appraising Adaptive Management," *Conservation Ecology* 3, no. 2 (1999), http://www.ecologyandsociety.org/vol3/iss2/art3/.

7. Nancy J. Miaoulis, "Right v. Right Conflicts: A Process for Ethical Decision Making," in *Ethics for a Small Planet: A Communications Handbook*, ed. Robb Cowie, Jane Elder, Marian Farrior, et al. (Madison: Biodiversity Project, 2002), pp. 70–73.

8. Aldo Leopold, *A Sand County Almanac with Essays on Conservation from Round River* (New York: Ballantine Books, 1966), pp. 258–259. Emphasis added. (*A Sand County Almanac* was originally published in 1949.)

9. See, for example: Gary Chamberlain, *Troubled Waters: Religion, Ethics, and the Global Water Crisis* (Lanham, MD: Rowman & Littlefield, 2008); Peter G. Brown and Jeremy J. Schmidt, *Water Ethics: Foundational Readings for Students and Professionals* (Washington, DC: Island Press, 2010); Cynthia Barnett, *Blue Revolution: Unmaking America's Water Crisis* (Boston: Beacon Press, 2011); and David Groenfeldt, *Water Ethics: A Values Approach to Solving the Water Crisis* (New York: Routledge, 2013).

STRESSORS, ROOT CAUSES, AND TRENDS

Stressors, Root Causes, and Trends

Part of making informed decisions about water management in Wisconsin is understanding the ways in which we have used—and misused—water in the past, and the larger influences that are shaping environmental conditions and policy.

Many of the water issues that Wisconsin grapples with are symptoms of underlying stresses on ecological systems and water infrastructure. If we look for the root causes of any particular water problem, from algal blooms to seasonal water shortages, we can identify a set of policies and practices, or other systemic influences, that are driving the conditions that cause ecological stress.

For example, some water quality conditions are directly related to agricultural practices across Wisconsin, and these practices are often driven by federal and global agricultural policies that influence the types of crops, livestock, and dairy products we provide to the global marketplace. Our product choices, in turn, influence the way we farm on the land, from cultivation techniques to the types of fertilizers and pesticides farmers use in production.

Energy policy also influences the types of crops we grow (such as corn for ethanol production), in addition to directly shaping our climate and influencing our water quality, supply, and aquatic ecosystems. Energy production also influences water quality through water use, from extraction (e.g., frac sand mines) and transportation systems to power plants that produce electricity.

Other types of drivers include increasing urbanization, aging water infrastructure, and hydrological changes to and across watersheds (e.g., dams, wetland loss).

Any discussion about water in Wisconsin would be incomplete without acknowledging the role these drivers play in water management, protection, and conservation strategies. Projects such as the United Nations Millennium Ecosystem Assessment provide a model for analyzing the impact of ecological drivers and stressors. The Millennium Ecosystem Assessment's 2005 report examined the state of the world's ecosystems and their relationship to human well-being.[10] For our purposes, we want to flag certain influences in Wisconsin as essential in developing future strategies and responsive actions. They include:

- Agricultural policy and practice
- Energy policy and practice
- Climate change impacts on aquatic ecosystems
- Ecological changes driven by invasive species
- Aging water infrastructure
- Long-term impacts of hydrological change
- Negative synergies
- Population shifts and consumption patterns

Agricultural Policy

Agricultural production in Wisconsin is dominated by dairy, corn, and soybeans—three significant commodities regulated and incentivized (through crop insurance, price controls, and other instruments) under the U.S. Farm Bill and global trade policies. Meat animals are also a major agricultural product. Vegetable production (primarily potatoes and green beans) in the Central Sands region plays a significant role in Wisconsin agriculture.[11] All of these types of production have major influences on water quality and water use in the state.

Over the last decade, dairy and beef cattle, poultry, and hog production has been shifting rapidly from small and mid-sized family farms to large concentrated animal feeding operations

(CAFOs). As of 2014, Wisconsin had 296 CAFOs in operation, with more applications pending for Wisconsin Department of Natural Resources (DNR) permits (see In Focus, page 17).* Some dairy CAFOs now have 5,000 or more cows concentrated in a single site. Confined animals do not graze and thus depend on high-nutrient feed or silage for food. Through this enriched feed, farmers bring additional phosphorus and nitrogen into a watershed. Whether spread on fields, stored in lagoons, or composted in a digester, animal waste retains a portion of these additional nutrients. All too often, the nutrients and bacteria from manure end up in our streams, lakes, and groundwater.

Conventionally grown field corn and soybeans also need nutrient inputs to grow. Farmers apply phosphorus and nitrogen to fields in the form of commercial fertilizers or by spreading manure. Various herbicides and pesticides, which can pollute lakes and streams, are often applied to these crops as well.

Farmers are attracted to producing corn and soybeans because they are among the most profitable crops due to the incentive systems incorporated into the federal Farm Bill. However, these crops need high nutrient inputs. Because these crops are ubiquitous in Wisconsin, even farmers who adhere to best nutrient management practices cannot offset the overall volume of nutrients applied to corn and soybeans that end up in our waters.

The expansion of vegetable production in Wisconsin has also meant a shift to routine irrigation in order to safeguard commercial harvest. The soils of the Central Sands region do not hold much moisture, but irrigation that draws on local aquifers has made crop production in this region profitable. In the last decade, the growth in this type of farming and its water use has been both rapid and extensive. This growth has had significant impacts on local water supply and, subsequently, baseflows in streams.** According to a 2011 study, baseflows decreased by one-third or more (on average) in the Central Sands region. Levels in some bodies of water have dropped by as much as a meter. The study concludes that regions (such as the Central Sands) with "strong groundwater-surface water connections" are indelibly "tied to concerns for surface water health, requiring a focus on managing the upper few meters of aquifers on which surface waters depend rather than the depletability of an aquifer."[12]

Some agricultural practices have also compromised the quality of our groundwater supply. Groundwater contamination in the form of nitrates (from fertilizers) and pesticides, such

* The Wisconsin DNR last updated its database of CAFO permits in 2012, which shows 282 permitted CAFOs, while a 2014 map shows that 296 CAFO operations (some operate under one permit for multiple sites) currently are in effect. See: Wisconsin Department of Natural Resources, "CAFO Permittees," last modified October 10, 2012, http://dnr.wi.gov/topic/AgBusiness/data/CAFO/cafo_all.asp; Wisconsin Department of Natural Resources Bureau of Watershed Management, Wisconsin WPDES Permitted Concentrated Animal Feeding Operations (Madison: Wisconsin Department of Natural Resources, 2014), http://dnr.wi.gov/topic/AgBusiness/documents/cafo_statewide_map.pdf.

** According to Portage County, baseflow is "the sustained flow (amount of water) in a stream that comes from groundwater discharge or seepage. Groundwater flows underground until the water table intersects the land surface and the flowing water becomes surface water in the form of springs, streams/rivers, lakes, and wetlands. Baseflow is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms. Groundwater continues to discharge as baseflow because of the new recharge of rainwater in the landscape." See: Portage County, "Glossary of Groundwater Terms," accessed July 28, 2016, http://www.co.portage.wi.us/groundwater/undrstnd/gloss.htm

as atrazine, continue to be detected in wells used for drinking water (see In Focus, page 49).* One factor in groundwater contamination is the use of irrigation as a mechanism for the application of pesticides,[13] such as neonicotinoids that are increasingly associated with bee colony collapse.[14] Concerns have driven efforts to improve practices and reduce the amount of fertilizer and pesticide applied, especially through practices such as integrated pest management (IPM).[15]

Energy Policy and Practice

Electrical Generation

In 2014, Wisconsin used more than 1.95 trillion gallons of water—roughly three times the volume of Lake Winnebago. About 75% of this volume was used in thermoelectric power production.[16] This represents greater water usage than that of all other sectors in Wisconsin combined, including municipalities, industry, and agriculture. According to the DNR, most of Wisconsin's major power production facilities are concentrated along the Lake Michigan shoreline and the Wisconsin and Mississippi Rivers, and pull water from these sources for most of the water they use, although groundwater is also sometimes used in various plant processes.[17]

Although a portion of the water used in generating electricity is for creating steam that drives the turbines, much of the water used in power production is for cooling systems. Without adequate cooling systems, the heated water returned to local surface waters can also be a source of thermal pollution. Traditional cooling systems work by evaporating warm water vapor into the atmosphere, so that water is lost from local stream flows or groundwater.[18] Older plants were typically built with "once-through" processes, where most of the water is lost to the atmosphere after the first use. After 2001, U.S. Environmental Protection Agency (EPA) regulations required "closed-loop" systems in new construction. In these systems, cooling waters are captured with condensers and reused within the cooling process. Closed-cycle cooling can reduce total water withdrawals by about 95%.[19] In Wisconsin, the DNR is authorized to monitor and regulate water use in most power plants.

Currently, and for the near future, Wisconsin's electrical generation is highly dependent on clean, abundant water supplies. Some renewable energy sources such as solar and wind power do not generate electricity through steam, and thus use only a tiny fraction of water as compared to conventional thermoelectric generation. However, as of 2015, 55.9% of the electricity in Wisconsin came from coal-burning power plants—with only 8.4% generated from renewable sources.[20]

Energy Production and Transportation

Fifteen years ago, hydraulic fracturing and frac sand mining were not on Wisconsin's radar. Over the last decade, hydraulic fracturing has transformed natural gas production, using hydraulic technologies that fracture deep geological rock formations to release deposits of trapped natural gas. A key component in this process is fine-grained silica sands that can withstand high pressures. These are used to prop open the cracks in the rocks after they have been fractured, and allow the gas to escape. Wisconsin has significant deposits of the sandstone bedrock that produces this type of sand. Since 2011, sand mining operations

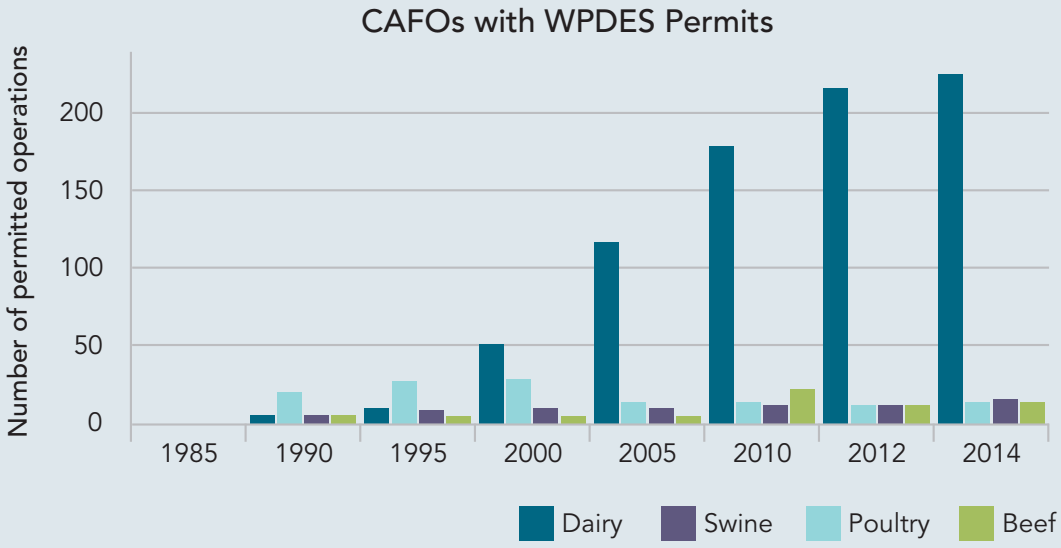
* According to the DNR, between 1990 and 2010, 33 wells in Wisconsin were replaced due to atrazine contamination through grants offered by the agency. See: Dana Singer, "Longstanding Debate About Farmers' Use of Atrazine in Wisconsin," The Confluence, January 9, 2015, http://confluence.journalism.wisc.edu/2015/01/09/longstanding-debate-about-farmers-use-of-atrazine-in-wisconsin.

CAFOS IN WISCONSIN

Concentrated animal feeding operations (CAFOs) are emerging as one of the predominant methods of livestock and dairy production in the United States. The U.S. Environmental Protection Agency (EPA) defines a CAFO as any animal feeding operation with:

> more than 1,000 animal units (an animal unit is defined as an animal equivalent of 1,000 pounds live weight and equates to 1,000 head of beef cattle, 700 dairy cows, 2,500 swine weighing more than 55 lbs., 125,000 broiler chickens, or 82,000 laying hens or pullets) confined on site for more than 45 days during the year. Any size animal feeding operation that discharges manure or wastewater into a natural or man-made ditch, stream, or other waterway is defined as a CAFO, regardless of size. CAFOs are regulated by the EPA under the Clean Water Act in both the 2003 and 2008 versions of the 'CAFO' rule.

The graph below is a reproduction of a chart from the Wisconsin Department of Natural Resources (DNR). It illustrates the rapid increase in approved WPDES (Wisconsin Pollutant Discharge Elimination System) CAFO permits—and subsequent construction of CAFOs—over the last twenty years.



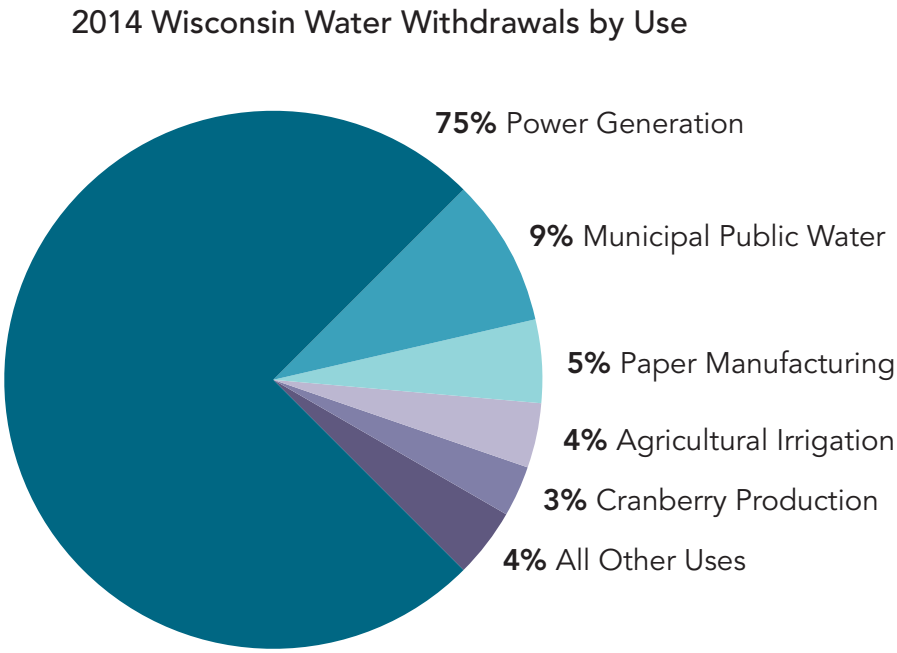
Note from the Wisconsin DNR: Beginning July 1, 2002, a single permit issued to Jennie-O Turkey Store (JTS) covered 55 of their operations (the 2014 Wisconsin WPDES Permitted Concentrated Animal Feeding Operations map claims that 37 JTS were covered under one permit). Previously, there were 17 separate permits for each of the operations with 1,000 animal units or higher. This reduction in the number of separate permits issued to JTS reduced the number of total permits issued in Wisconsin.

Sources:

Wisconsin Department of Natural Resources, "CAFO and CAFO WPDES Permit Statistics," last modified July 16, 2014, http://dnr.wi.gov/topic/AgBusiness/CAFO/StatsMap.html.

Wisconsin Department of Natural Resources Bureau of Watershed Management, *Wisconsin WPDES Permitted Concentrated Animal Feeding Operations* (Madison: Wisconsin Department of Natural Resources, 2014), http://dnr.wi.gov/topic/AgBusiness/documents/cafo_statewide_map.pdf.

U.S. Department of Agriculture Natural Resources Conservation Service, "Animal Feed Operations," accessed July 30, 2016, http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/livestock/afo/.



Source:
Wisconsin Department of Natural Resources, *Wisconsin Water Use: 2014 Withdrawal Summary* (Madison: Wisconsin Department of Natural Resources, 2014), http://dnr.wi.gov/topic/WaterUse/documents/WithdrawalReportDetail.pdf, p. 1.

in Wisconsin have mushroomed to supply sand for hydraulic fracturing producers in other states. As of 2013, the scale of the combined area permitted for frac sand mining across Wisconsin was estimated to be 40,000 acres, an area larger than the city of Green Bay—or roughly 30,250 Lambeau Fields.[21] In 2015, Wisconsin had more than 125 active or proposed facilities for frac sand mining.[22]

While early environmental concerns were raised about silica sand dust and air quality, the impacts on landscape, watershed, and groundwater are less well known. Frac sand mining operations use water and chemicals for processing and cleaning the sand, and poorly managed sand and mining wastes on mine sites can also be a source of polluted runoff to nearby streams.

Wisconsin lacks a regulatory framework designed for this industry. Frac sand mining operations are still regulated under policy originally designed for gravel pits, and the patchwork of local regulations that have sprung up to address impacts and concerns in communities affected by these mines do not provide an integrated and consistent approach to regulation and monitoring across affected areas of the state.* As of this publication, mining has slowed due to a period of low energy prices. But demand could easily rise again.

In addition to supplying the fine-grained sand used in the hydraulic fracture mining of natural gas, Wisconsin is also a major transportation corridor for Bakken oil from North Dakota. Bakken oil comes from the Bakken Formation—one of the largest contiguous oil and natural gas deposits in

* According the Eggleston article, "The sandstone formations of Cambrian age being mined are the Jordan, Wonewoc, and Mt. Simon, and the St. Peter is of the slightly younger Ordovician era." Affected counties include Barron, Buffalo, Chippewa, Clark, Columbia, Crawford, Dunn, Eau Claire, Green Lake, Jackson, La Crosse, Monroe, Pepin, Pierce, St. Croix, Trempealeau, Waupaca, and Wood.

the United States—found in southern Saskatchewan and Manitoba in Canada, and eastern Montana and western North Dakota. This oil moves through pipelines and via rail corridors that cross under or over many streams. In 2012, the Enbridge (North America's largest oil and gas pipeline operator) Line-14 pipeline spilled about 1,200 barrels, or 50,000 gallons, of oil in a field near Grand Marsh, Wisconsin.[23] The Grand Marsh spill happened two years after the Kalamazoo River spill in Michigan, from Enbridge's Line 6B, which caused significant damage to water quality and habitat in a Great Lakes tributary and required an extensive, expensive multiyear cleanup.[24]

In recent years, the volume of oil transported through the state on rail has increased exponentially. A 2015 analysis by WISC-TV/Channel 3000 has found that there was a weekly average of 40 to 50 trains, each carrying as much as one million gallons of Bakken crude oil, moving through La Crosse, Monroe, Juneau, Sauk, Columbia, Dodge, Jefferson, Waukesha, Milwaukee, Racine, Buffalo, Crawford, Grant, Pepin, Pierce, Trempealeau, and Vernon counties.[25] While accidents are very rare, they do happen (the U.S. Department of Transportation predicts that, on average, at least ten train derailments will occur per year over the next two decades among trains carrying oil or ethanol).[26] As such, there has been pressure to strengthen regulations to protect populated areas and to safeguard waterways through more stringent bridge and track inspections and better pipeline protections.[27] It should be noted that as a provision included in the 2015–17 Wisconsin state budget, the Wisconsin Legislature acted to prevent local governments from requiring additional insurance by companies that transport oil through their jurisdictions via pipeline. The provision has led to affected Dane County landowners filing a lawsuit against Enbridge Energy to compel the company to obtain special insurance in case of potential spills.[28]

Climate Change

According to the Wisconsin Initiative on Climate Change Impacts (WICCI), "Water resources are intimately linked to local and regional climate conditions."[29] Over the last decade, global climate change has begun to influence water quality, precipitation patterns, water supply, and aquatic habitats in troubling ways across Wisconsin. Yet there has been little movement toward adopting recommended adaptation or mitigation strategies in Wisconsin or the United States. WICCI's 2011 report, published by the Nelson Institute for Environmental Studies at the University of Wisconsin–Madison in partnership with the Wisconsin DNR, provides extensive analysis of likely impacts on water and aquatic habitat, and related impacts on human health, agriculture, and our economy, as well as recommendations for adaptation and mitigation in Wisconsin.

An increased intensity of spring and summer storm events has influenced nutrient and sediment loadings in Green Bay, the Yahara watershed, and near-shore Great Lakes waters. For example, 77% of the phosphorus pollution and 88% of total suspended solids in Green Bay came from storm events in April and May 2013, contributing to degraded water quality and the size and scale of oxygen-depleted "dead zones" that cannot support aquatic life.[30] Moreover, a shift in summer wind patterns over the last decade means that the waters in Green Bay are exposed to less mixing with colder, cleaner Lake Michigan water, which also exacerbates dead zone conditions.[31] Storm-driven nutrient flushes also affect inland lakes and streams. Lake Mendota's water quality

is better in drought years, because fewer nutrients are washed into the lake from farms and lawns. In years with intense, frequent rainfall, nutrient levels rise significantly.[32]

Climate change is also putting Wisconsin's coldwater fish at risk. Wisconsin is blessed with over 10,000 miles of classified trout streams. If the state's average air temperature increases, so should the temperature of its waters. Coldwater fish, such as trout, are uniquely sensitive to these changes. Recent scientific models from the WICCI show that a five-degree-Fahrenheit increase in water temperature could eliminate 95% of Wisconsin's brook trout and 88% of the state's brown trout population.[33] This would be damaging to Wisconsin's multibillion-dollar tourism industry, let alone its vibrant fly-fishing culture (see chapter IV, page 56).

Invasive Species

Invasive species (invasives) are both a symptom and a driver of degraded ecosystems. Invasive plant or animal species can displace or crowd out native species and disrupt food webs, energy exchange, habitat, and the composition and distribution of species. This in turn can weaken resilience, degrade water quality, and reduce filtration, stormwater retention, and water supply. Invasives can even compromise water infrastructure (e.g., mussel colonization on water intake pipes). Below are some significant updates on aquatic invasive species from the last decade:

- Aquatic invasive species were a problem in 2003 and challenges are ongoing. Invasive plants such as phragmites have become the dominant species in wetlands surrounding much of the Fox River and lower Green Bay, reducing the diversity of native plants and wildlife species in these wetlands.[34]
- In 2009, limnology students discovered the spiny water flea in Lake Mendota. Since then, this tiny invasive animal has been aggressively preying on the daphnia (a native zooplankton) that eat algae and help prevent algal blooms. Since 2009, Lake Mendota's native daphnia have been reduced by 95%, thereby compromising the lake's native food web.[35]
- Limnology students found invasive zebra mussels in Lake Mendota in 2016. Zebra mussels have the potential to significantly compromise the lake's food web, as they have done in the Great Lakes Basin (see next bullet).[36]
- Zebra mussels and quagga mussels have fundamentally transformed the Lake Michigan food web, harming native fish species and other aquatic life, and altering water clarity.[37] As noted in the discussion on negative synergies below, they can also serve as a contributing factor in harmful algal blooms.[38]
- Asian carp remain a threat on the threshold of the Great Lakes. Beyond interim controls and prevention strategies, experts are currently exploring methods to re-separate the Great Lakes and Mississippi River Basin watersheds in Illinois (historically connected only through canals and locks).[39]

Aging Infrastructure

Wisconsin, like much of the nation, is grappling with aging infrastructure, including drinking water and water treatment systems. A 2013 analysis by the American Association of Civil Engineers projected that over the next twenty years, Wisconsin will have $7.1 billion in drinking water infrastructure needs and another $6.4 billion in wastewater infrastructure needs.[40] Part of that aging infrastructure includes at least 176,000 service lines of old lead pipes in many municipal drinking

A CHANGING CLIMATE IS CHANGING WISCONSIN'S WATERS

As the Wisconsin Initiative on Climate Change Impacts points out, our waters are "intimately linked to local and regional climate conditions." Climate change has the potential to dramatically shift those conditions, thereby affecting the state of Wisconsin water quality, quantity, and associated ecosystems. Scientists tell us that that climate change could alter—and may already be altering—the health of our waters in a variety of ways. These include:

- Increase in frequency and intensity of storms
- More extremes between drought and flood conditions
- Increase in air temperature and thus warmer water temperature in lakes and streams
- Expanded range for warm-weather invasive species
- More extreme fluctuations in lake and stream water levels
- Decline in ice cover (Lake Mendota ice durations have already decreased on average from four months in the 1850s to three months in the last ten years)
- Losses expected in the populations of coldwater (i.e., trout) and coolwater (i.e., perch, walleye) fishes

Sources:

Wisconsin Initiative on Climate Change Impacts, *Wisconsin's Changing Climate: Impacts and Adaptation* (Madison: University of Wisconsin Board of Regents, 2011).

Steve Vavrus, Michael Notaro, and David Lorenz, "Interpreting Climate Model Projections of Extreme Weather Events," (presentation, 39th Annual Climate Diagnostics & Prediction Workshop, St. Louis, MO, October 21, 2014), http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw39_proceedings/Day_2/Session_4_Cont/Vavrus.pdf.

See also resources available at: Great Lakes Integrated Sciences + Assessments, "Summary Climate Information," accessed July 31, 2016, http://glisa.umich.edu/resources/summary.

water systems, as well as old, leaking supply lines and sewers. It should be noted that the Wisconsin DNR has recently invested $11.8 million to help water utilities replace lead pipes across the state (see chapter IV, page 46).[41]

By failing to keep up with maintenance and modernization, municipalities and ratepayers will face cost increases down the road. Moreover, postponing action will increase leaks, overflows, exposure to lead, and the possibility of insufficient treatment from aging wastewater facilities.

As we look to the future, drinking water and wastewater systems will also need to adapt to the impacts of climate change, such as the potential for more extreme rain events where massive volumes of water rush through storm drains in a short period, the potential for increased fluctuations in lake and stream levels (which may require flexibility in infrastructure for both water intake systems and wastewater discharge), and the potential for episodes of more extreme floods and droughts.

Hydrological Changes

Ever since early European settlement, people have changed the way water flows through Wisconsin landscapes. In modern times, the scale of these changes has continued to affect water supply, quality, and habitat. For example, changes to wetlands, streams, and lakes imposed by deforestation actions of the logging era more than one hundred years ago still influence water quality in northern Wisconsin. In agricultural areas, ditches and drainage tiles installed to increase farmable acreage continue to move water out of damp soils and wetlands. In the current Wisconsin landscape, drainage activities continue to cause water to travel swiftly from headwaters to low-lying areas such as lakes and large rivers. This increase in water movement results in increased erosion and sedimentation, increased flooding of downstream areas, less groundwater replenishment, less surface water filtration, higher nutrient loads, and loss of high-quality habitats in agricultural watersheds.

Dams originally installed to capture water energy to power sawmills and gristmills and to generate electricity created reservoirs that continue to concentrate sediments, prevent fish migration, and promote invasive plant communities. While Wisconsin has restored some of its rivers to free-flowing conditions, hundreds remain segmented by dams or impoundments.

Road development, urbanization, and many other land-disturbing activities further alter the natural flow of hydrological systems. Wisconsin currently lacks sufficient strategies to safeguard water supplies for the long term. Landscape-level restoration of wetlands, floodplains, stream channels, and natural vegetative communities is needed to begin the process of returning water quality, supply, and fish and wildlife habitat to healthy conditions across Wisconsin.[42]

Negative Synergies

Across the spectrum of water concerns, it is important to note that environmental stressors rarely happen in isolation. In combination, multiple stressors can exacerbate and magnify impacts. For example, invasive species like quagga mussels are filter feeders (aquatic animals that feed on small particles or organisms suspended in the water, which they filter out of the aquatic ecosystem), and by removing small organisms from water, they can increase water clarity and thus increase the penetration of sunlight in nearshore waters. That sunlight can increase algae growth in deeper waters, especially if those waters are warmer than historic averages due to a chang-

ing climate and have higher nutrient concentration from the downstream flow of fertilizers and wastewater. The combination can create ideal conditions for the growth of toxic blue-green algae called *cyanobacteria*. Thus, water management strategies need to factor in the range of drivers and stressors in any given situation, because solutions targeted at only one aspect of a problem may be insufficient.[43]

Populations Shifts & Consumption Patterns

A growing global population and its demands for basic needs and consumer goods also drives environmental stress. There were over 6.3 billion people in the world in 2003. By 2016, that number rose by another billion (to over 7.3 billion), adding to global demands for food, water, and myriad goods.[44] Projections are such that, by 2050, the world's population will reach 9.6 billion, placing unprecedented demands on the world's limited freshwater supply.[45]

Over this same span, Wisconsin has grown by about 300,000 people (from 5.48 to 5.78 million).[46] In addition, Wisconsin's population profile is continuing a shift to an older population. In what has been called a "brain drain," many educated young people are leaving the state, which has implications for future economic growth, health care needs, and other factors.[47]

Notes

10. Millennium Ecosystem Assessment Core Writing Team, *Ecosystems and Human Well-Being: Synthesis*, p. vii.

11. U.S. Department of Agriculture and Wisconsin Department of Agriculture, Trade and Consumer Protection, *2013 Wisconsin Agricultural Statistics* (Madison: Wisconsin Department of Agriculture, Trade and Consumer Protection, 2015), https://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Annual_Statistical_Bulletin/2015AgStats_web.pdf, p. 7.

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3

THE STATE OF OUR WATERS: A SUMMARY

The State of Our Waters: A Summary

Given the multiple influences on water supply and quality and the health of aquatic ecosystems, as well as the frameworks that shape public and private decisions about water, what have we learned since 2003 about the state of Wisconsin waters and the mechanisms to safeguard them for the future?

Over the last decade water outcomes have been a mix of gains, setbacks, and both continuing and emerging challenges. The status of our waters is summarized below, while discussion of specific issues and recommendations for responsive action and needs going forward follow in subsequent chapters.

Gains

Since 2003 there have been notable advances in water policy and improvements in some environmental conditions.

Water Supply

- In 2008, the Great Lakes Compact was adopted to manage Great Lakes water use (see chapter IV, page 42).
- In 2003, the Groundwater Protection Act (Wisconsin Act 310) was adopted in 2003 (see chapter IV, page 43).
- In 2011, the Wisconsin Supreme Court issued the Lake Beulah decision, which held, among other things, that the Wisconsin Department of Natural Resources (DNR) has the responsibility to take into account cumulative impacts when determining whether to permit a high-capacity well (see update under "Setbacks: Water Supply," page 31).[48]

Water Quality

- New rules (NR 102, NR 217, and NR 151) were adopted in 2010 to reduce phosphorus pollution in what is known as the Wisconsin Phosphorus Rule (see In Focus, page 54).
- Wisconsin engaged in a nutrient-reduction strategy in Mississippi River Basin target watersheds through projects initiated under the federal Mississippi River Basin Initiative, including projects along the Kickapoo River, the Rush River, and Sixmile Creek.[49]
- Green infrastructure is growing rapidly as an effective strategy to capture and filter stormwater, with major investments in the Milwaukee River watershed and the Yahara watershed.
- Combined sewer overflow incidents have been dramatically reduced over the last decade through improvements in green infrastructure, water conservation, and other watershed strategies. The Milwaukee Metropolitan Sewerage District has captured and cleaned 98.3% of all the water and wastewater that has entered the regional sewer system since its inline storage system known as the Deep Tunnel began operation in 1994.[50]

Aquatic Ecosystems

- NR 40 was adopted in 2009 to regulate the transportation, possession, transfer, and introduction of invasive species and encourage widespread public education efforts by agencies and nonprofit organizations.[51]
- Under the federal Great Lakes Restoration Initiative (launched in 2010), significant

clean-up projects have reduced contaminants such as PCBs, PAHs, and heavy metals in many sites identified as Areas of Concern in the Great Lakes Water Quality Agreement. In Wisconsin these include the Milwaukee Estuary, Sheboygan River and Harbor, Fox River and Lower Green Bay, Lower Menominee River, Kinnickinnic River, and St. Louis River. In addition, the Initiative has helped to restore wetlands and other coastal habitats along the Great Lakes.[52]

- Representative examples of naturally occurring aquatic communities within high-functioning ecosystems, such as important wetlands, have been protected by the DNR's State Natural Area program for the enjoyment, study, and stewardship of biological diversity. The state currently has 675 natural areas, encompassing over 380,000 acres.[53]
- Wetland and aquatic habitat restoration projects were advanced in many key watersheds throughout the state, due to major investments in Wisconsin by the U.S. Department of Agriculture's Wetland Reserve Program[54] and various U.S. Fish & Wildlife Service programs.[55]
- The Wisconsin State Legislature and U.S. Congress both enacted policies to ban plastic microbeads in personal care products.[56]

Setbacks

There have also been setbacks in water policy and environmental conditions since 2003.

Water Supply

- In 2011 the Wisconsin State Legislature enacted Act 21, which made changes to Wisconsin law, rendering it more difficult to promulgate administrative rules (Wisconsin Statutes Chap. 227.10).* At the request of the State Legislature, Attorney General Brad Schimel issued in May of 2016 a legal decision interpreting Act 21 language, declaring that, when issuing high-capacity well permits, the DNR cannot take into account the cumulative impacts those wells would have on other wells or waterways.[57] In June 2016, the DNR decided to follow the attorney general's interpretation of the law.[58]

Water Quality

- Changes by the State Legislature to the process for promulgating administrative rules (see bullet under "Water Supply") have also hampered the DNR's ability to address serious problems in Clean Water Act permitting programs within the timeline set by the U.S. Environmental Protection Agency (EPA) (see chapter IV, page 53).
- In 2013, state mining policy was modified to relax and/or exempt the practice of iron (ferrous) mining from long-standing regulations that protect streams, lakes, and wetlands (2013

* For example, the fastest that a new rule can be adopted by the DNR in Wisconsin is 2.5 years. According to a 2011 *Wisconsin Lawyer* article, "Act 21 appears to proscribe an agency's authority to act in a number of ways. For example, an agency may not impose any standard, requirement, or threshold, in a rule or a license condition, unless the standard, requirement, or threshold is explicitly required or permitted by statute or by another properly promulgated rule." See: Ronald Sklansky, "Changing the Rules on Rule-making," *Wisconsin Lawyer* 84, no. 8, August 2011, http://www.wisbar.org/newspublications/wisconsinlawyer/pages/article.aspx?Volume=84&Issue=8&ArticleID=2092. See also: David Strifling, "Is Wisconsin's Public Trust Doctrine Eroding?" Marquette University Law School Faculty Blog, January 7, 2016, http://law.marquette.edu/facultyblog/2016/01/07/is-wisconsins-public-trust-doctrine-eroding.

Wisconsin Act 1). The new law also relaxed groundwater protections for the proposed open-pit taconite mine in the Penokee Hills. Although the mining project was abandoned in March 2015, the law remains in place.[59]

- Monitoring capacity to assess surface-water flow and water quality (with the exceptions of those gains listed under "Gains: Water Supply") has decreased.[60]
- The number of waterways listed under EPA's "Impaired"* status more than doubled from 2004 to 2016, due in part to the fact that the number of waterways assessed has increased (for example, between 2008 and 2016, there has been an 85% increase in assessed river and stream miles) and standards have changed. Yet, many waters remain un-assessed.[61] Improved analytical advances have played a role in detecting pollutants and other signs of impairment, adding waterways to the EPA list that are now classified as "Impaired."**
- Chlorides from road salts, de-icing chemicals, and water softeners continue to increase the salinity of Wisconsin waters, impairing aquatic ecosystems and drinking water quality.***
- Bacteria, including fecal coliform, have become serious groundwater contaminants in areas such as Kewaunee County (see In Focus, pages 48).[62]
- The Livestock Facility Siting Law (2004) and the 2006 rules established by the Wisconsin Department of Agriculture, Trade and Consumer Protection (ATCP 51) limit local control for siting concentrated animal feeding operations (CAFOs), making it difficult for local communities to prevent the siting of CAFOs that may have negative impacts on local water quality or water use.[63]

Aquatic Ecosystems

Promising advances in ecological restoration have been offset by state regulatory changes and budget cuts or restrictions in recent years.[64] These include:

- Loss of wetlands protections through modifications to existing policy, including:
  1. The 2011 Wisconsin Act 118;
  2. 2013 changes to the state's metallic mining law;

* According to the U.S. EPA, under Section 303(d) of the U.S. Clean Water Act, "States, territories and authorized tribes (included in the term 'State') are required to submit lists of 'impaired' waters. These are waters that are too polluted or otherwise degraded to meet water quality standards. The law requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters." TMDLs are "pollution budgets," as defined by the Clean Water Act, which represent the maximum amount of a given pollutant that can occur in a water body. See: U.S. Environmental Protection Agency, "Implementing Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)," last modified June 7, 2016, https://www.epa.gov/tmdl.

** We cannot automatically conclude that this indicates an overall increase in polluted waterways. The increase in number of waters listed as "impaired" might be due to changes in analytical technologies and areas tested rather than an actual increase in waters that constitute "impaired." That said, recent cuts in DNR staffing might mean that fewer reviews and less analysis are taking place.

*** "Current levels of salt use cannot be sustained without degrading our drinking and surface waters. Forty years of salt use reduction efforts have not produced meaningful results, but there are signs of progress. The detrimental effects of road salt are now widely recognized. Practical, user-level information is becoming commonplace. Madison is exploring salt reduction options in well recharge zones, too. Surely, these are positive steps toward reducing the negative impacts of deicing salt." See: Public Health Department of Madison & Dane County, Road Salt Report (Madison: Public Health Department of Madison & Dane County, 2016), January 6, 2016, https://www.publichealthmdc.com/publications/documents/RoadSaltRpt2015.pdf.

3. The 2013 Wetlands Reform Bill; and
4. The 2015 Wisconsin Act 387.

These modifications increase risks to wild rice habitat and coastal wetlands by relaxing or removing previously required wetland-dredging permits for development, among other changes.[65]

- Loss of local authority to protect waters and shoreland zoning through local regulations. Act 55 in the 2015–17 state budget weakened the previous state law allowing counties to adopt stricter protections for shoreland development (waterfront developments must now be constructed using the state's minimum requirements, even if local ordinances were once stricter).[66]
- Loss of state tax funding support for state parks. The 2015–17 state budget ended all tax-based funding to Wisconsin State Parks, which resulted in an increase in park user fees.[67]

In addition, hydrological changes, a changing climate, and the emergence of invasive species are growing sources of ecological stress in aquatic of ecosystems. Specific setbacks include:

- Wetland degradation from sediments, nutrients, and other pollutants as well as nearby development.[68]
- Increasing stresses from related to climate change, including those from warming waters, intense storms, and other factors (see In Focus, page 21).
- Increased ecological damage from invasive species, causing degraded habitat for native species, exacerbated algal blooms, and alterations in aquatic food webs in the Great Lakes and inland waters (see chapter II, page 22, and chapter IV, page 56).

Continuing Challenges

Water Quality and Supply

Many challenges to the integrity of Wisconsin's waters that were identified as concerns in the 2003 report are still concerns today. Some are at a larger scale with wider impacts; others are issues that remain unresolved.

Nutrient pollution remains one of the most intractable challenges of our time. While phosphorus has been the predominant concern, nitrogen is a growing concern as well. Impacts from nutrient pollution (such as eutrophication and algal blooms) may be exacerbated by increases in extreme rain events that accelerate the transport of nutrients from agricultural and urban areas to our waters (see chapter IV, page 46).

The dead zone in the Bay of Green Bay remains a particular challenge. The bay has experienced numerous hypoxic (low-oxygen) episodes in the last several years (see In Focus, page 51).

State groundwater protection remains inadequate. Indeed, the pace and scale of high-capacity well expansion have eclipsed protections in the Groundwater Protection Act (Act 310). Although Act 310 was an important first step in protecting groundwater quantity, there have been significant challenges in safeguarding groundwater supply and addressing well contamination since 2003, including the following:

- Groundwater supply has become a major concern in some areas, particularly in the Central Sands region, where local surface waters have been depleted in some years due to large-volume withdrawals (see chapter IV, page 43).
- Well contamination is a threat to public health in many areas. Nitrate contamination is a serious concern across Wisconsin, as are harmful bacteria—especially in Kewaunee County (see In Focus, pages 47–49).

Wisconsin fish advisories (the state's guidelines for safe human consumption of fish) remain in effect throughout the state, with mercury in particular continuing to be a regional and global contaminant.* However, public education about these risks has declined over the last decade, as have resources for analysis and monitoring for food web contaminants. People who fish for sustenance are more at risk than the general public, especially those who face language barriers and may not have access to information about possible contaminants.[69]

Wisconsin lacks a plan for climate change resilience. The drought of 2007 and the drought and floods of 2012 illustrate the effects of extreme weather on our communities and waters alike. These events underscore our limited preparedness for potential climate change impacts. Wisconsin needs to prepare for a wide range of adaptation challenges as well as strengthen community resilience for intense rain events, warmer water and air temperatures, and other climate-influenced factors that will affect public health and safety as well as agriculture and industry in Wisconsin.

Changing Policy Context

The cumulative impacts of legislative and administrative action—or inaction—are reducing the state's capacity to anticipate and respond to emerging environmental challenges (see chapter V for a deeper exploration of this topic):

- Since 2010, the State Legislature has actively pursued efforts to relax existing protections for shorelines, wetlands, and groundwater, as well as taken actions to reduce or remove local government authority to enact local protections (see chapter II, page 19, as well as "Setbacks: Aquatic Ecosystems").
- Legislative action (such the changes to Administrative Law code brought about by Act 21 in 2011) has explicitly constrained the DNR's authority to act and its discretion to respond to emerging needs (see "Setbacks: Water Supply" and "Setbacks: Water Quality").
- The DNR's capacity for scientific research, monitoring, and reporting has been dramatically reduced by cuts to budgets and staff, diminishing the role of science in informed public decision-making (see chapter V, page 67).
- Staffing reductions and many retirements at the DNR have resulted in significant loss of institutional memory and expertise in a wide range of regulatory areas as well as monitoring, research, and other scientific analysis in Wisconsin state agencies (see chapter V, page 67).
- Environmental education has lost funding and institutional support from the state, depriving many Wisconsin children of a fundamental understanding of ecological systems and how they support life, economy, and culture.[70]

* A 2015 report from the International Joint Commission notes that "after many years of declining mercury levels in fish and other Great Lakes biota, concentrations have generally leveled off or slowly increased in some species in some locations." The largest source of mercury to Wisconsin's waters is the atmosphere, and the largest source to the atmosphere is coal-burning power plants. While atmospheric emissions come from around the world, Wisconsin is also a source of these emissions. The majority of Wisconsin's electricity—55.9%—is produced by coal-burning plants. See: International Joint Commission, Atmospheric Deposition of Mercury in the Great Lakes Basin (Washington, DC: IJC, 2015), http://ijc.org/files/tinymce/uploaded/documents/Atmospheric-Deposition-of-Mercury-in-the-Great-Lakes-Basin-December-2015.pdf, p. 2.

Emerging Challenges

Pharmaceutical & Cosmetic Pollutants

Over the last decade, scientists have helped raise awareness of the many compounds and materials from pharmaceutical, personal care, and other consumer products that end up in our water. Many of these were largely "under the radar" in previous decades. Compounds from hypertension and diabetes medications, contraceptives, and antidepressants are some of the most common found in wastewater effluent and receiving lakes and streams. A 2013 study led by Rebecca Klaper, a scientist at the UW–Milwaukee School of Freshwater Sciences, found 32 chemicals (from pharmaceuticals and personal care products) in an analysis of Lake Michigan water. The four most frequently found compounds were caffeine, an antidiabetic drug called metformin, the antibiotic sulfamethoxazole, and the antibacterial and antifungal agent triclosan, which is often found in soaps, toothpastes, and other consumer products.[71] Currently, wastewater treatment systems do not have the technology to adequately treat or eliminate pharmaceutical and cosmetic compounds or microplastics.

Fossil Fuel Transport

Shipments of Bakken crude oil and Alberta tar sands crude oil by train, barge, and pipeline have grown rapidly in Wisconsin over the last decade. While accidents and spills are rare, there have been several notable and significant pipeline leaks and rail accidents in Wisconsin and the Great Lakes Region in the last decade. Enbridge has proposed a major new 42-inch pipeline to transport tar sands crude oil across the state, running parallel to its existing pipeline route across many of the state's major rivers.[72] The primary rail routes for oil shipment in Wisconsin also cross multiple waterways, and spills could cause lasting and widespread damage to water quality, as has been the case with the 2010 Kalamazoo River spill in Michigan.* Concerns about accident risks prompted Dane County to require accident insurance from Enbridge, but the Wisconsin Legislature pre-empted this example of local authority through legislation enacted in the 2015–17 Wisconsin state budget (see chapter II, page 19).[73]

Privatization of Water

A trend toward privatizing water is a growing concern. Water is *the* ultimate public good. Entrusting a public good to private interests raises many questions, including whether privatizing infrastructure (as has been proposed in some communities) can lead to private ownership of a public resource and subsequent commodification. For example, a bill proposed in early 2016 (Assembly Bill 554) would change existing law to make it easier to sell municipal water supplies to private corporations. The bill was introduced at the request of the Pennsylvania company Aqua America Inc., which already owns water systems in eight states. Local governments, municipality utility groups, and environmental organizations voiced strong opposition to the legislation. Although the bill passed the Assembly in January 2016, the State Senate canceled its vote on its version of the bill in February.[74]

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* As of publication, $1.2 billion has already been spent on the Kalamazoo River cleanup, and work remains to be completed. See: Garret Ellison, "New Price Tag for Kalamazoo River Oil Spill Cleanup: Enbridge Says $1.2 Billion," MLive.com, November 5, 2014, http://www.mlive.com/news/grand-rapids/index.ssf/2014/11/2010_oil_spill_cost_enbridge_1.html; U.S. Environmental Protection Agency, "EPA Response to Enbridge Spill in Michigan," last modified, July 21, 2016, https://www.epa.gov/enbridge-spill-michigan.

Whether private or public, water infrastructure in the state and the region is at risk due to a lack of funding. Wisconsin has no formal strategy to deal with aging and inadequate infrastructure and the related implications for public investment in—and oversight of—healthy drinking water supplies.

Notes

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EXPLORING THE MAJOR CHALLENGES

Exploring the Major Challenges

This chapter explores several of the larger water-related challenges Wisconsin faces now and will continue to face in the coming decade. These include achieving sustainable water management to safeguard our water supplies, strengthening prevention and restoration efforts to improve and protect water quality, and developing the capacity to protect and restore aquatic ecosystems.

Water Supply

Wisconsin uses an average of more than 1.95 trillion gallons of water every year,[75] and more than 70% of Wisconsin residents rely on groundwater for their drinking water supply.[76] While we are a water-rich state in comparison to many others, we do have areas with water shortages and many aquifers that have been severely drawn down or pumped to depths where salt, radionuclides (most commonly radium), or other contaminants render the supply unsuitable for drinking water. Drought years like 2012 have a pronounced impact on agricultural productivity and ecological health; they alert us that we cannot take abundant water supplies for granted.[77]

The 2003 Waters of Wisconsin (WOW) report stressed the need for developing a water management framework that integrated strategies within and across the state's Great Lakes Basin and Mississippi River Basin, as well as both groundwater and surface water management. While there was initial progress in this direction with the enactment of the Groundwater Protection Act in 2003, which recognizes the link between surface water and groundwater, and also through the adoption of the Great Lakes Compact in 2008, implementation has been piecemeal. The lack of an integrated, systemic approach threatens to undermine progress toward a truly comprehensive framework that can address the complex water management needs of the state.

Wisconsin needs long-term strategies to manage and conserve water supply. Great Lakes Compact conservation requirements and high-capacity well regulation are two areas where decisions in Wisconsin are likely to have long-term implications for our water resources.

Great Lakes Compact

Public concern about water supply and the health of the Great Lakes provided the momentum needed for Wisconsin to enter into the Great Lakes Compact to safeguard the Great Lakes from unregulated withdrawals or diversions.

In 2008, Congress passed the Great Lakes–St. Lawrence River Basin Water Resources Compact (otherwise known as the Great Lakes Compact)—the first "consensus-based, basin-wide" compact to protect the water supply of the Great Lakes.[78] A parallel agreement exists between the St. Lawrence Seaway and the two Canadian provinces that border the Great Lakes, Ontario and Quebec. The compact established a consensus-based approach to conserving the waters of the Great Lakes. It developed the following guidelines, as described by the Great Lakes–St. Lawrence River Basin Water Resources Council:

- Economic development will be fostered through sustainable use and responsible management of Basin waters.
- In general, there is a ban on new diversions of water from the Basin but limited exceptions could be allowed in communities near the Basin when rigorous standards are met.

- Communities that apply for an exception have a clear, predictable decision-making process; standards to be met; and, opportunities to appeal decisions.
- The States will use a consistent standard to review proposed uses of Basin water. The States have flexibility regarding their water management programs and how to apply this standard.
- Regional goals and objectives for water conservation and efficiency have been developed, and they will be reviewed every five years. Each State will develop and implement a water conservation and efficiency program that may be voluntary or mandatory.
- There is a strong commitment to continued public involvement in the implementation of the Compact.[79]

According to the Alliance for the Great Lakes, the U.S. parties (the eight Great Lakes states) and Canadian parties (the provinces of Ontario and Quebec) are tasked with "developing their own water conservation policies" so long as those are "in keeping with the Compact's goals" as listed above (Wisconsin's conservation and management plan is described in this chapter and in the In Focus section on page 44).[80]

The Waukesha Diversion

In December 2015, the Wisconsin Department of Natural Resources (DNR) submitted an application to the Great Lakes–St. Lawrence River Water Resources Regional Body (the compact's governing body) recommending approval of Waukesha's request for a permit under the terms of the compact to shift its water supply to Lake Michigan. The application cited the compromised conditions and capacity of its current groundwater source.[81] In June 2016, the Compact Council voted unanimously to approve the City of Waukesha's application to obtain its drinking water from Lake Michigan (decisions to approve new diversions of any kind require unanimous consent from the eight Great Lakes states represented on the council). The historic decision marked the first time a U.S. city outside of the Great Lakes Basin received approval for an application under the compact.[82]

Citizens groups disagree on whether the approved application meets the terms and requirements necessary for an approved diversion under the compact.[83]

Great Lakes Compact
Water Conservation & Management Plans

As discussed earlier in this section, all parties to the Compact (all eight Great Lakes states and two Canadian provinces that span the Great Lakes Basin) are required under the compact to implement a water conservation and management plan that includes goals and objectives consistent with the agreement. Each entity is required to evaluate its plan every five years (see In Focus, page 44).

In contrast to the plans of other states, Wisconsin's water conservation plan for the compact does not apply to the entire state, only to the Great Lakes Basin. The Upper Mississippi Basin is not protected by a similar compact. Thus, Wisconsin lacks an integrated, statewide plan for managing both surface and groundwater use.

Groundwater

Groundwater and high-capacity wells were a concern for many Wisconsin residents in 2003 and remain so today. The Academy's 2003 WOW report highlighted the need for more forward-looking groundwater management. In 2004, Wisconsin governor Jim Doyle signed the Groundwater Protection Act into law (passed by the State Legislature as Act 310 in 2003). This legislation

GREAT LAKES COMPACT: WISCONSIN WATER USE PROGRAM

Much of this language was pulled from a 2014 report published on the Great Lakes–St. Lawrence River Water Resources Regional Body (see below for citation):

> The Wisconsin Department of Natural Resources (DNR) developed the Water Use Program to implement the Great Lakes–St. Lawrence River Basin Sustainable Water Resources Agreement, and to focus on sustainable and efficient water use. Wisconsin's Compact implementing legislation (2007 Wisconsin Act 227) and related regulatory case law provide the foundation for the Water Use Program. While most of the program applies statewide, there are specific requirements for water users in the Great Lakes Basin. The components of the Water Use Program include:
>
> - Documenting and monitoring water use through registration and reporting;
> - Implementing the Compact through water use permitting and regulating diversions of Great Lakes Basin waters;
> - Helping communities plan water supply needs;
> - Reviewing the construction and impact of high capacity wells;
> - Building a statewide water conservation and efficiency program; and
> - Developing and maintaining a statewide water resources inventory, including a better understanding of water loss and consumptive use in Wisconsin.

Sources:

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sought to regulate the quantity of groundwater being pumped by high-capacity wells—wells that extract more than 100,000 gallons per day from one property.[84] The Groundwater Protection Act gave the DNR the authority to consider environmental impacts from high-capacity well pumping within its permitting process, and, though limited in scope, it was an important first step in Wisconsin's groundwater management practices. The legislation also led to increased staffing at the DNR for groundwater monitoring.[85]

However, groundwater policy has not kept pace with the rising demand for groundwater use. This has been particularly evident in the groundwater use controversies in Wisconsin's Central Sands region. The first few high-capacity wells were established in the 1950s. Today, Wisconsin has more than 11,000 high-capacity wells; each well has the capacity (and permission from the state) to pump up to 100,000 gallons per day. Groundwater withdrawals for municipal public water supplies account for the largest proportion (43%) of groundwater use in the state, with agricultural irrigation coming in second at 35%.[86] There are over 3,000 high-capacity wells in the Central Sands region.[87] The primary use of this water is for agricultural irrigation. Groundwater withdrawals in the Central Sands region have diminished—and in some cases eliminated—stream flow, such as in the Little Plover River. The highest impacts occur during the peak growing (and thus irrigation) season.[88]

High-capacity well permit fees have not increased since 2004. In addition, permit fees for concentrated animal feeding operations (CAFOs) have not increased since the mid-1990s. These permit fees have not kept pace with growth and do not supply the state with funds to sufficiently monitor both high-capacity wells and associated CAFOs. As of 2014, there are around 260 permits that regulate 296 CAFO operations in the state of Wisconsin.[89] These large livestock operations represent a small portion of the state's overall high-capacity well users, but large groundwater withdrawals by CAFOs can still have significant local impacts.

Not all aquifers are the same across the state; some have plentiful supplies, but some aquifers are nearly depleted. Some have significant contamination (such as nitrates, arsenic, or radionuclides); others have high-quality waters. Thus, any comprehensive strategy needs to not only address the full scope of impacts across the state, but also respond to local conditions. However, in the absence of an integrated management strategy that addresses the Great Lakes and Mississippi River Basin as well as all surface water and groundwater, Wisconsin will fall short of providing a long-term framework for conserving its water resources and ensuring their sustainable use. Michigan and Minnesota both have more rigorous water management and allocation policies than Wisconsin, and Wisconsin could gain insights from these policies as it wrestles with its future strategies.

Water Quality

Clean water is a priority for public health and healthy ecosystems alike. Yet Wisconsin faces significant hurdles in providing safe drinking water for its citizens as well as sustaining healthy aquatic ecosystems that support Wisconsin's economy.

Drinking Water

Many Wisconsin residents do not have reliable access to safe drinking water, or are dependent on drinking water supplies that are vulnerable to contamination risks. Through its recent (and on-

going) series "Failure at the Faucet," the Wisconsin Center for Investigative Journalism (WCIJ) found that "hundreds of thousands of Wisconsin's 5.8 million residents are at risk of consuming drinking water tainted with substances including lead, nitrate, disease-causing bacteria and viruses, naturally occurring heavy metals and other contaminants." These high instances of contamination are due to "flawed agricultural practices, development patterns that damage water quality, geologic deposits of harmful chemicals, porous karst and sand landscapes," as well as aging or poorly maintained infrastructure, unregulated wells, and untreated water systems.[90] In fact, an estimated 1.7 million people in the state drink from unregulated private wells, and tens of thousands of residents derive their drinking water from systems that do not treat it for possible disease-causing viruses.[91]

While some water systems are contaminated by naturally occurring chemical elements such as radium, arsenic, and molybdenum in the aquifer, others are subject to contamination through aging water infrastructure. Wisconsin residents in some areas are at risk of exposure to lead in drinking water from lead pipes still in use, especially cities with older systems such as Milwaukee and Wausau, with heightened risk in homes built before 1950. The WCIJ estimates that at least 176,000 Wisconsin homes and businesses receive their water by lead service lines.[92] It should also be noted that in April 2016, the Wisconsin DNR announced an $11.8 million investment in new grants to help low-income regions of Wisconsin replace aging lead pipes.[93]

Agricultural and industrial sources can contaminate municipal and private wells with atrazine, nitrates, and bacteria as well as chlorides from road de-icers and water softeners (see In Focus, pages 47–49). According to a 2012 survey of Wisconsin municipal systems, "47 systems have had raw water samples that exceeded the nitrate Environmental Standard [safe nitrate levels]," which was up from 14 systems in 1999.[94]

Groundwater Pollution and Well Contamination

Growth in large livestock operations and their concentration in vulnerable geological regions have outpaced the capacity to manage manure and other wastes from these facilities in ways that safeguard water quality and drinking water safety. Well contamination in Kewaunee County highlights the challenge of protecting groundwater in areas with shallow soils and karst (pocketed) bedrock in the face of exponential growth in CAFOs. More than one-third of the wells in the county do not meet health standards for nitrates or bacteria.[95] In addition, overall monitoring and enforcement capacity has shrunk with cuts in personnel and budgets, making it more difficult to keep up with well testing and ensure well water quality (see chapter V, pages 67 and 69).[96]

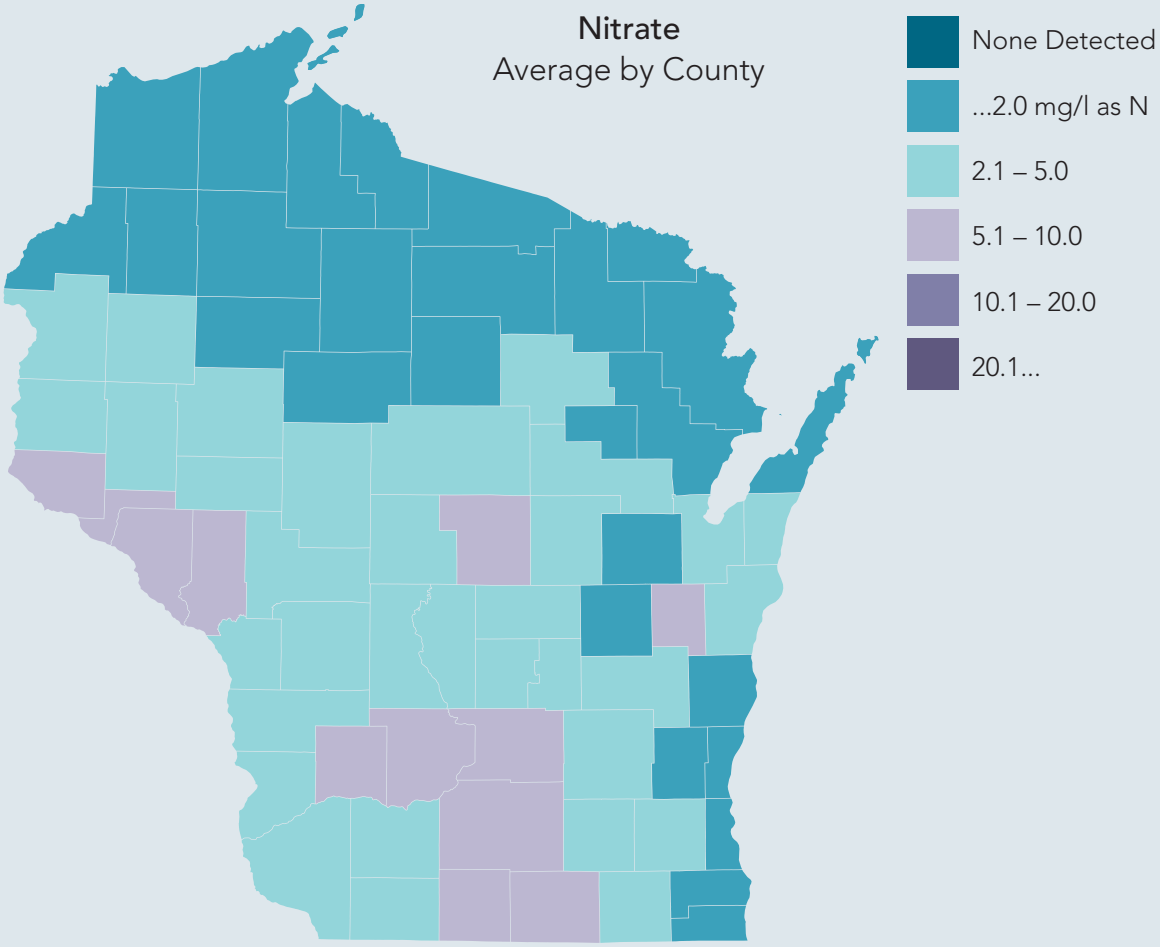
Surface Waters:
Rivers, Lakes, and Coastal Waters

Phosphorus, Algal Blooms, Cyanobacteria

One of Wisconsin's long-standing challenges to water quality is nutrient pollution, particularly phosphorus pollution. As a natural element essential to plant growth, phosphorus is a major component of commercial fertilizers. Phosphorus is also released into the environment from manure, decomposing crop waste, leaves, grass clippings, and other organic matter, including treated wastewater. We see the impacts of excessive phosphorus in our waters reflected in harmful algal blooms and the related impacts on water quality, including low oxygen (hypoxia) in the water, or the absence of oxygen (anoxia), which have resulted in "dead zones" in Green Bay.[97] Since testing began in 1986, there have

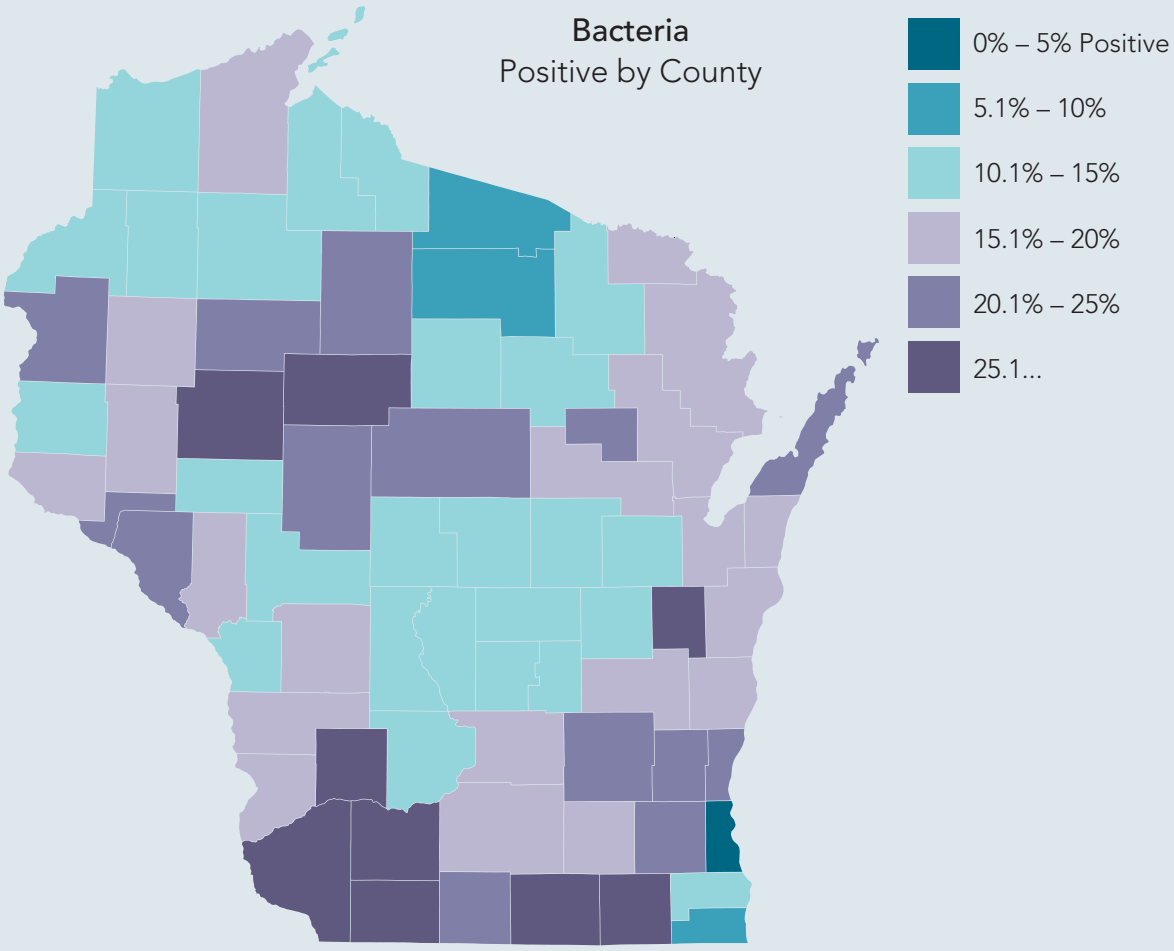
WHAT'S IN YOUR WATER?

More than 900,000 Wisconsin households rely on private wells for their drinking water, making well water—and, more broadly, groundwater—a major public health issue. In order to keep the public better informed about groundwater contamination, the University of Wisconsin–Stevens Point and University of Wisconsin–Extension developed "Wisconsin Well Water View," an interactive, online map that shows collected data on levels of certain water contaminates. Map data has been voluntarily submitted from homeowners and collected by state agencies and county health departments over the past 25 years. Learn more at http://www.uwsp.edu/cnr-ap/watershed/Pages/WellWaterViewer.aspx.



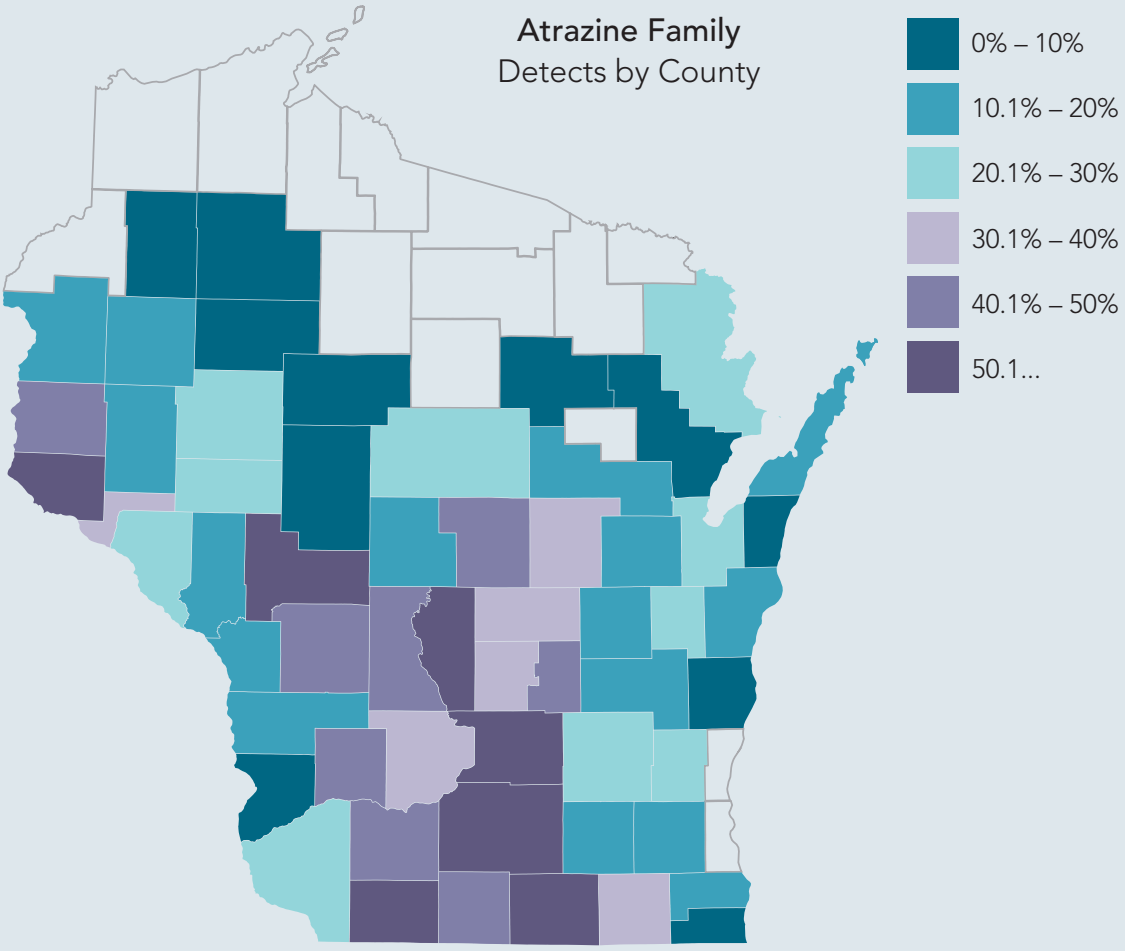
The results above show the average level of nitrates for all samples taken in a given county in milligrams per liter. While no averages by county currently exceed the U.S. Environmental Protection Agency's (EPA) maximum contaminant level of 10.0 mg/L (the level at which nitrates may put human health at risk, particularly through 'blue-baby syndrome'). The township-level map, available on the Wisconsin Well Water View website, does show areas that exceed risk levels throughout the Central Sands region and southern-central part of the state. Counties that appear blank in these maps lack sufficient data.

While nitrates occur naturally in groundwater, levels above 3 mg/L typically indicate outside contamination. Nitrates in well water originate from any number of sources. The most prominent sources include run-off from nitrogen-based fertilizers or manure applied to fields, leaking septic systems or sewerage lines, and others.



These results show results of a "total coliform test"—a common test for drinking water that is used to detect the bacteria fecal coliform. Ultimately, the test is an indicator of a sanitary water supply.

This map indicates the percentage of positive tests (that is, the rate of instances that water tested indicated detectable signs of fecal coliform bacteria) out of all samples tested. In Wisconsin, the average rate of positive results is about 15%. Those areas that test above that rate typically indicate outside contamination, perhaps due to a loose well cap, susceptible area geology, or other reasons.



Like the Bacteria Map, these results show the percentage of those tests that came back positive for detectable levels of atrazine and its breakdown components. The results do not indicate those samples that came back with levels of atrazine above the U.S. EPA's maximum contaminant level.

Atrazine is a common herbicide, widely used in Wisconsin. While the U.S. does not ban the use of atrazine, the European Union does.

Sources:

Kevin Masarik, telephone interview by Meredith Keller, Wisconsin Academy of Sciences, Arts & Letters office, Madison, WI, September 13, 2016.

University of Wisconsin-Stevens Point, "Well Water Quality Viewer: Private Well Data for Wisconsin," accessed August 10, 2016, http://www.uwsp.edu/cnr-ap/watershed/Pages/WellWaterViewer.aspx.

U.S. Environmental Protection Agency, "Estimated Nitrate Concentrations in Groundwater Used for Drinking," last updated December 24, 2015, https://www.epa.gov/nutrient-policy-data/estimated-nitrate-concentrations-groundwater-used-drinking.

been numerous hypoxia and anoxia (dead zone) incidents in Green Bay.[98] The Yahara watershed lakes in Madison, as well as Lake Winnebago, Green Bay, and many other inland lakes, have been plagued with massive summer algal blooms for at least the last decade. Following the torrential rains in northwest Wisconsin in 2012, the Wisconsin shores of Lake Superior from Cornucopia to Little Sand Bay in the Apostle Islands National Lakeshore experienced a rare, if not unprecedented, blue-green algal bloom in July of that year.[99]

The most hazardous water quality conditions are caused by blooms of cyanobacteria, also called blue-green algae (although cyanobacteria are not true algae). The toxins in cyanobacteria can be dangerous to pets and people, and in some cases can render drinking water unsafe for consumption, as was the case for the Toledo, Ohio, water utility in western Lake Erie's summer 2014 outbreak of the bacteria that produced microcystins (a class of toxins produced by certain types of cyanobacteria). Although phosphorus is one of the controlling factors for harmful algal blooms, sunlight, higher water temperatures, and some invasive species may also play a role.[100]

Reducing polluted runoff was a key recommendation of WOW in 2003. In 2010, building on more than a decade of efforts to curb nutrient and sediment pollution in water, the DNR adopted a new suite of administrative rules aimed at reducing phosphorus loading in the form of the Phosphorus Rule.

Adoption of the Phosphorus Rule took a concerted effort from clean water advocates, and experts consider it one of the most significant accomplishments for clean water in Wisconsin in the last decade. These rules were designed to enable point sources, such as wastewater treatment plants and industrial sources, to enter into agreements with land-based sources (e.g., farms) in the same local watershed to reduce overall loads of phosphorus. Through land-based practices such as streamside buffers, cover crops, and eliminating winter manure spreading, point and nonpoint partners work together to meet federal Clean Water Act water quality goals for lakes and streams (see In Focus, page 54).

Under the original Phosphorus Rule, point sources would have three permit terms (five years each) to comply with water quality standards (NR 102). The land-based strategies are often described as the adaptive management option.[101] An alternative approach is called phosphorus trading, where point sources "purchase" specific reductions from other sources. In 2013, the Great Lakes Commission and the U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) launched a phosphorus trading initiative in the Lower Fox River Valley.[102]

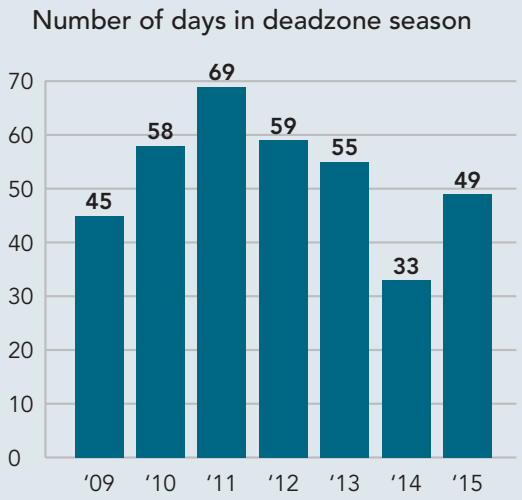
When it was first implemented in 2010, the Phosphorus Rule was considered a game-changing strategy to support flexible partnerships and non-technological strategies to meet a common goal while applying resources to the most promising solutions. Three watersheds have developed major initiatives around watershed-scale adaptive management strategies.* These include the Yahara River watershed, the Oconomowoc River watershed, as well as various projects in the

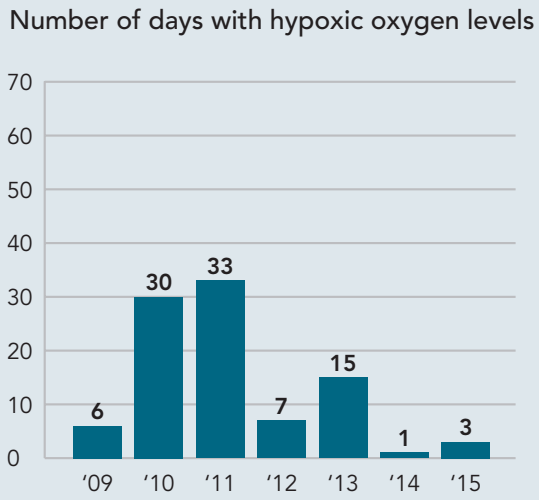
* It is important to note that the concept of adaptive management generally used in the context of the Phosphorus Rule is a narrower definition than the broader concept of adaptive management outlined in chapter I on page 2. For Phosphorus Rule compliance, the adaptive management approach refers to agreements between point sources and landowners to reduce overall loadings in a specific watershed or river segment over a set time period. Unlike formal trading, there is no structured market, and water quality compliance requirements are different for the two approaches.

THE GREEN BAY DEAD ZONE

The Dead Zone Season

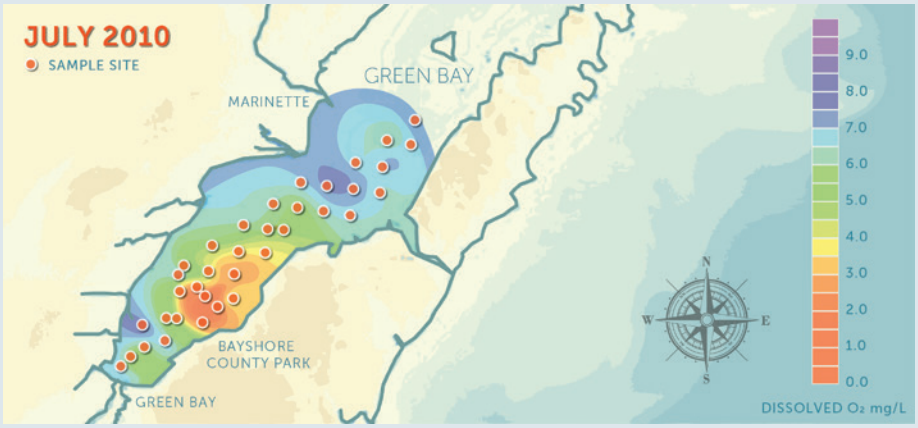
According to the *Milwaukee Journal Sentinel* article, "The dead zone season is the period from the first to the last day when oxygen levels in Green Bay are very low. In recent years, the actual number of such days has been down. Scientists attribute this to the weather—not to the volume of runoff entering the bay." A dead zone occurs when "dissolved oxygen is less than 2 milligrams per liter and does not support aquatic life."





Hypoxic Areas

The image below of samples taken at various points in Green Bay during July 2010 shows the outline of the dead zone. Note the hypoxic area of concern with five or fewer milligrams of dissolved oxygen per liter, which can comprise 30% of bay waters.



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Lower Fox River watershed.[103] Each community is pursuing strategies tailored to its particular needs and the scale of its respective challenges. Practices include planting agricultural cover crops, banning winter manure spreading or diverting manure to biodigesters, encouraging low-till or no-till crop management, building stream buffers, expanding green infrastructure that captures and slows rainwater runoff, building detention and retention ponds to capture runoff, as well as a range of other options.[104]

Because many of these are new—and in some ways experimental—approaches to phosphorus management, early pioneers find themselves inventing and evaluating the implementation strategies as they move forward.

In 2014, however, the Wisconsin State Legislature took action to change the Phosphorus Rule and established a statewide multi-discharger variance* (via 2013 Wisconsin Act 378).[105] The jury is still out as to the impact of these changes. On March 30, 2016, the DNR submitted the final multi-discharger variance package to the U.S. Environmental Protection Agency (EPA) for approval; as of publication, the DNR is awaiting approval.[106] Proponents saw advantages in provisions for funding mechanisms for local governments; opponents expressed concern that compliance with the Clean Water Act could be delayed until 2025 or later, and that the option to simply pay a fee for phosphorus loadings could undermine commitments to adaptive management strategies on surrounding landscapes.[107]

Even with the Phosphorus Rule in place, nutrient-reduction projects throughout troubled watersheds may not be large or comprehensive enough to address their respective issues—nor are many of them likely to be implemented in enough time to meet the water quality goals outlined in the Clean Water Act. Moreover, although some watershed communities have access to resources, technical skills, and collaborative processes that support responsive actions, others do not. The lack of access to expertise and resources to implement practices and strategies is a significant barrier to progress.

For wider adoption of the Phosphorus Rule over the coming years, more resources and training for local authorities and landowners are needed to develop the capacity to successfully broker and implement land-based water quality improvements.

In the larger context, scientists and water quality advocates have expressed concerns that, without fundamental changes in agricultural practices, even widely adopted best practices in local watersheds will be insufficient to reduce phosphorus loadings to levels that will improve and sustain water quality—that is, levels the law requires and the public desires. Without changes at the systemic scale—such as the Farm Bill and other structures that shape farm practices—Wisconsin is likely to continue to be a net importer of phosphorus for fertilizer and feed, and the result is that our waterways will continue to be overburdened with nutrients for the foreseeable future.

* A multi-discharger variance (MDV) applies to many point-source dischargers, and not just an individual permit holder. For the Wisconsin Phosphorus rules, the MDV provides a time extension for point sources facing compliance with phosphorus limits. They may use a variety of approaches over the life of their twenty-year state (WPDES) discharge permit to comply. See: Wisconsin Department of Natural Resources, Multi-Discharger Phosphorus Variance (Madison: Wisconsin Department of Natural Resources, 2015), http://dnr.wi.gov/topic/SurfaceWater/documents/Phosphorus/MDV_Factsheet_562015.pdf.

Clean Water Act Enforcement

The Clean Water Act has been the bedrock of water quality protection since it was enacted by Congress in 1972.[108] Its overall goal is to ensure fishable, swimmable, and drinkable water for the entire U.S. Its primary mechanism for achieving this is through setting water quality standards for surface waters (rivers, lakes, and streams) and by regulating direct discharges into these waters, such as from industrial facilities and sewage treatment plants. The law does not regulate indirect sources, such as nonpoint runoff from farms or city streets. When waters are polluted at levels that are above the federal standards, they are considered "out of compliance." Inadequate permits or permit violations, incidents such as bacteria loadings from combined sewer overflows, and high levels of polluted runoff in local or upstream landscapes can all contribute to noncompliance.[109]

Most states, including Wisconsin, were given authority by the EPA to regulate Clean Water Act enforcement through their state conservation or environmental quality agencies. In 2011, the EPA sent a letter to the Wisconsin DNR outlining 75 "omissions and deviations from federal requirements" with regard to Wisconsin's Clean Water Act implementation program. In October 2015, an EPA spokesman said the DNR reported 40 of the 75 issues were resolved, although the EPA has not confirmed this actually ocurred.[110] Clearly, there is a gap between what the federal standards prescribe and what Wisconsin's Clean Water Act programs are delivering.

Wisconsin Challenges with CWA Enforcement

Over the last fifteen years, the State Legislature has repeatedly cut regulatory and enforcement capacity in the DNR (see chapter V, page 67). At the same time, the DNR has seen a rapid increase in applications for high-capacity well and CAFO permits (specifically, the Wisconsin Pollutant Discharge Elimination System—or WPDES—permits), as well as permits related to a proposed iron ore mine. The agency also has been challenged to address the minimal regulatory framework for the frac sand mining industry in the state. These new demands, in addition to the existing load of industrial and other point source permit applications and reviews, have led to a backlog of discharge permit applications, limited time and resources for permit review, and limited capacity of the DNR to perform routine inspections or required triennial reviews.[111] Monitoring programs that can detect problems have also been reduced due to lack of funding and/or staff, with a few notable exceptions in 2015 and 2016 (see chapter V, page 66).

In 2015, sixteen Wisconsin residents, along with the nonprofit Midwest Environmental Advocates, filed a Petition for Corrective Action requesting that the EPA compel the DNR to correct its Clean Water Act implementation program (the WPDES permitting process) and bring the program into compliance with federal law, or de-delegate the program if the state fails to comply. De-delegation would mean that the EPA would step in and take over enforcement of the Clean Water Act in Wisconsin. The primary aim of the Petition, however, is to avoid de-delegation by requiring the DNR to better protect public health and water quality and promptly resolve deficiencies in the WPDES permitting program.

Over the fall of 2016, the EPA plans to conduct in-person file reviews and meetings with the DNR to follow up on the 75 points of deficiency outlined in its letter to the DNR in 2011.These reviews will build upon the EPA's preliminary determinations, as made in summer

WISCONSIN PHOSPHORUS POLLUTION

There are two primary sources for the phosphorus that ends up in Wisconsin's waters. *Point source pollution* from sewage treatment plants, paper mills, and CAFOs (among other sources) is specifically regulated by the Clean Water Act. *Nonpoint source pollution* from agricultural lands, such as phosphorus-laden runoff, is not regulated by the Clean Water Act. The distinctions between point and nonpoint source pollution are important for regulatory strategies to manage phosphorus.

Point & Nonpoint Source Pollution

Point source pollution originates from a single, traceable source, "including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged." Point sources do not include "agricultural stormwater discharges and return flows from irrigated agriculture." For more, see Section 502(14) of the Clean Water Act.

In contrast, nonpoint source pollution originates from "many different sources" rather than a single identifiable point. Nonpoint source pollution is typically "caused by rainfall or snowmelt moving over and through the ground. As water is being transported, it picks up and carries away natural and human-made pollutants, finally delivering them into lakes, rivers, wetlands, coastal waters and ground waters."

For a specific definition, see section 502(14) of the Clean Water Act.

Wisconsin's Phosphorus Rule

Collectively, these three rules are referred to as the Phosphorus Rule:

- NR 102, which sets water quality standards for total phosphorus allowed in surface water.
- NR 217, which establishes procedures for point sources (e.g., industrial and municipal wastewater systems) to implement water quality standards through their discharge permits; this rule allows for flexible strategies and partnerships among sources such as municipal wastewater dischargers, farms, industries, and other sources to meet water quality goals.
- NR 151, which is designed to reduce pollution from nonpoint sources (land-based runoff) through agricultural performance standards.

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Kimberlee Wright, interview with Jane Elder, Wisconsin Academy of Sciences, Arts & Letters, March 2016.

2016, regarding what the DNR must do to bring Wisconsin back into compliance with basic federal water protection laws.[112]

Healthy Aquatic Ecosystems

Headwaters, crystalline lakes, thriving natural wetlands, trout streams, coastal spawning beds, and other highly valued habitat represent the best of our freshwater ecosystems in Wisconsin. Our long practice of conserving unspoiled places provides scientific benchmarks to guide us as we sustain natural systems on our public and private lands. We know all too well that what happens on the land influences water quality. The quality of these special waters is one of the measures of how well our conservation and protection strategies are working. Wisconsin's conservation history is a living example of the Wisconsin Idea in action.

At the same time, restoration of degraded watersheds and waters is another measure of our investments in wider ecological vitality and its benefits to people. In addition to conserving high-quality areas, over the last fifteen years, state, tribal, and federal agencies working in Wisconsin have invested substantial public and private resources and countless hours of volunteer time to protect and restore important waters. These actions include:

- *Gains in water quality and habitat improvement through the Great Lakes Water Quality Agreement (GLWQA, first signed in 1972 and amended in 1978, 1987, and 2012), and the Great Lakes Restoration Initiative (GLRI, launched in 2010.)* The GLWQA provided the framework to facilitate the removal and/or treatment of large volumes of legacy pollutants such as PCBs, PAHs, and heavy metals from and within sites designated as Great Lakes Areas of Concern (AOC) defined under the agreement. The GLRI has provided funds to launch those removal, treatment, and restoration projects.[113] Such efforts have improved water quality, and thus ecological functions and natural habitat. As discussed in chapter III, the GLRI has provided funding for several restoration projects to clean up AOCs in Wisconsin, including in the Milwaukee Estuary, Sheboygan River and Harbor, Fox River and Lower Green Bay, Lower Menominee River, Kinnickinnic River, and St. Louis River.[114]
- *Restoration of trout streams and other river and wetland and coastal habitat.* Projects include myriad examples, such as pike habitat restoration in the Green Bay watershed, thousands of acres of wild rice habitat restoration in northern lakes, numerous projects in the Driftless Area, and other watersheds to restore habitat and reduce erosion and polluted runoff.[115]

However, in recent years, progress in both conservation and restoration has been hampered by state regulatory changes, budget cuts, and restrictions as noted in chapters III and V. Volunteer efforts and federal programs cannot carry the full restoration challenge for Wisconsin's freshwater ecosystems, and the State needs to be a full partner in safeguarding and sustaining these essential systems for the future.

Overarching Challenges to Aquatic Ecosystems

As we look to the coming decades, Wisconsin's aquatic ecosystems face threats from large-scale drivers discussed in chapter II and, in particular, from hydrological changes, climate change, and invasive species, discussed in chapter III.

Hydrology

Water management at the watershed scale is inadequate, such that in many areas wetlands are in poor condition due to historic disturbance and development. Hydrology has been altered, with less water being retained in headwaters and upstream systems, and more water being flushed through watersheds and flooding downstream wetlands. Faster water flushes more sediment and nutrients into waterways and carries water and pollutants downstream. In combination, this degrades downstream wetlands and supports weed infestations.[116] To protect and restore Wisconsin's waters, Wisconsin needs a strategic approach to restoring wetlands across the landscape, as well as watershed-scale management.

Climate Change

As noted in chapters II and III, a changing climate will influence the health and resilience of all our waters. Climate change is putting Wisconsin's coldwater fishes at risk, and we are already seeing the results. As the state's average air temperature increases, so will the temperature of its waters, compromising coldwater and coolwater fishes that are uniquely sensitive to subtle temperature changes. In chapter II, we discussed that recent scientific models from the WICCI have shown that a five-degree-Fahrenheit increase in water temperature could eliminate 95% of Wisconsin's brook trout and 88% of the state's brown trout populations.[117] Other similar fishes are also at risk. The cisco (or lake herring) is declining in the inland lakes of Wisconsin and nearby states. Their decline may also be negatively affecting the food sources for lake trout and possibly walleye.[118] An associated issue of concern is the decline of walleye in inland lakes and their potential replacement by largemouth bass. Future scenarios for streams indicate a decline in all of Wisconsin's coldwater fishes in streams, most importantly trout, and also of all cool-water fishes, including walleye and coolwater northern pike.[119] This is just one example of the kinds of changes a warming and more turbulent climate will impose on Wisconsin lakes and streams.

Climate change may increase and intensify polluted runoff, erosion (and thus sedimentation), and overall nutrient loading in Wisconsin waterways.[120] Shoreline and other aquatic habitats will be less stable and resilient, and some may disappear altogether.

With no climate resilience or adaptation strategy in place for Wisconsin's waters, our waters are likely to be at higher risk than in those states and provinces that are engaged in active planning to optimize water quality and ecosystem health under the conditions of a rapidly changing climate.

Invasive Species

As discussed in chapter II, the continuing arrivals of new species entering our inland waters are a major destabilizing influence on our aquatic fish communities. These invasive species include fishes, mussels, snails, and small aquatic organisms such as the spiny water flea. Already, waters of the Great Lakes have been significantly altered, with major losses in recreational and commercial species over the years.[121] Warmer waters enable non-native species from more southerly areas to expand their territory, thus increasing pressures on already fragile ecosystems.[122]

Strategies to address all of these challenges will need to take into consideration the decision-making frameworks noted in chapter I. In the following chapter we discuss changes in those frameworks and the implications for Wisconsin's waters.

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5

STATUS OF DECISION-MAKING FRAMEWORKS

Status of Decision-Making Frameworks

As we discussed in chapter I, we perceive water and water policy through multiple frameworks or lenses that influence the way we observe the world—and the way we react when problems arise. These frameworks include science, economics, ethics, and governance. In addition to the chemical, physical, and biological changes in our waters, our decision-making and management frameworks have been changing as well. In this chapter we discuss progress and setbacks in the decision-making frameworks and the implications for Wisconsin's waters.

Changes in the Role of Science

In the realm of science, there has been notable growth in freshwater research investments in the academic sector over the last decade. In addition to ongoing work at the long-established Center for Limnology at UW–Madison:

- UW–Milwaukee has established and grown its School of Freshwater Sciences and Center for Freshwater Policy;
- Northland College established its Mary Griggs Burke Center for Freshwater Innovation;
- Marquette University has grown its Water Quality Center and also supports a research collaboration at Milwaukee's Global Water Center, and a Law and Water Policy Initiative; and
- UW–Whitewater has grown its Institute for Water Business and established its new Integrated Science/Business Water Emphasis.

Other notable centers include UW–Extension's Lakes program at UW–Stevens Point, and various sustainability programs throughout the UW System. However, these gains are being offset by cuts to agencies and universities that play a critical role in water research.[123]

Analytical Advances

New technologies have improved water quality analysis and water management capabilities in the last decade. These include significant advances in the sophistication of data gathering and analysis. For example, today we have the capability to pinpoint sources of nutrient-laden runoff to specific farms and fields, and to detect and analyze pharmaceutical and nanoparticle pollutants in water as well as trace amounts of many other contaminants.

Advances in time and spatial analysis, such as geographic information systems (GIS) and remote sensing, are enabling us to examine lake and watershed issues across geographical areas, beyond former constraints limited by lake-by-lake, stream-segment, or single-wetland analysis. These advances provide tools to better assess a wide range of water management challenges, from developing dam removal strategies to understanding the ways water flows from farm fields in heavy rains. Long-term statewide databases have added depth to analysis, and improvements in science theory are strengthening research. Access to these tools through UW–Extension, the Wisconsin Department of Natural Resources (DNR), U.S. Geological Survey (USGS), and other public agencies has empowered local governments and other groups to map watersheds, understand how water moves through them, and better manage severe weather and flood risks.[124]

Monitoring, too, is an essential component of water science. Groundwater-level (as opposed to water quality) monitoring capacity is beginning to rebound after years of declining resources. Within the last year new funds from the DNR and USGS are helping the Statewide Groundwater Monitor-

ing Network (a partnership between the USGS and the Wisconsin Geological & Natural History Survey) grow and improve Wisconsin's capacity to assess and safeguard groundwater levels.[125]

Investments in scientific modeling have advanced our understanding of climate change impacts in Wisconsin. In particular, as noted in chapter II, the Wisconsin Initiative on Climate Change Impacts (WICCI) has played a leading role with its 2011 report. The WICCI report provides extensive insights, based on models that forecast water (and other) impacts, which are important for planning and adaptive strategies.[126]

Funding Cuts

At the same time, funding for both the collection of basic data and for wider research has become more competitive over the last two decades when federal and state budgets have been increasingly constrained. Ironically, as freshwater sciences become more sophisticated and our body of knowledge grows, the capacity to collect and analyze data and apply subsequent knowledge to solve real-world problems faces constraints.

Through budget and personnel cuts to the Wisconsin DNR and UW System, limited deliberative processes, and even explicit disregard, the value of evidence, data, and scientific perspectives appears less salient in Wisconsin's policy-making than in the past. Since 2000, under the leadership of both Democratic and Republican administrations, Wisconsin's DNR staff has been reduced by 15%. The largest cut came in 2015 with the 2015–17 Wisconsin state budget provision that removed the Science Services Bureau (charged with scientific research that informs decisions on the state's natural resources, such as wildlife and waterways) and cut over 90 positions from the agency—a measure opposed by the State Conservation Congress.[127] According to the nonpartisan Legislative Fiscal Bureau, the Walker administration indicated that "the science services positions no longer serve the core mission of the agency and should be deleted."[128]

In 2015, one in five positions were vacant at the DNR—an all-time high over the last fourteen years.[129]

Economic Influences & Impacts

The Water Council in Milwaukee has seized the opportunity to link economic growth to water by growing a "globally connected epicenter for freshwater research, innovation, education and business development."[130] Founded in 2009 by Milwaukee-area business, education, and government leaders, the Water Council works to align the regional freshwater research community with water-related industries. In 2016, more than 200 water companies are affiliated with the Water Council. They see this work as a means of responding to the global need for access to clean, fresh water. Closer to home, the Water Council notes that 79% of U.S. companies currently face water challenges, making the case that

> water will take center stage as the forces of global economic growth continue to collide with the forces of global resource scarcity. We need solutions now. That's why water technology innovators, who can help people and companies better use their water resources, have an opportunity—right now—to become key players in the global economy.[131]

Developing water-related technologies is one way that Wisconsin can benefit economically from its water expertise while providing national and global leadership.

Water resource management has economic implications, and as such must incorporate conflicting views on values and valuation. One of the greatest concerns participants expressed in developing this report is that Wisconsin's historic land and water stewardship and conservation values are being displaced by short-term, market-driven choices with little regard for the long-term economic and environmental consequences. This fundamental shift can be seen in:

- The clash of values involving the proposal for a Penokee Hills iron mine;
- Concerns about winners and losers (and who is responsible for remediation) from any potential impacts related to frac sand mining and oil transportation across the state;
- Disregard for the cumulative impacts of high-capacity wells on local water resources and long-term aquifer management in the Central Sands region; and
- Conflicts related to beneficiaries and costs for crop production for food versus ethanol.

Wisconsin would be well served to engage economists to investigate the long-term economic risks of this fundamental shift and explain to public audiences the potentially irreversible and highly damaging impacts to the state's greatest economic asset—our waters. Understanding the full spectrum of economic costs, benefits, and externalities—long- and short-term—can help citizens and policy-makers craft informed decisions.

Changes in Governance

Over the last decade, Wisconsin citizens have seen significant changes in how they engage in—and their platforms for—policy-making in the state. Local governments and citizens' organizations are stepping up to enact important policies and provide crucial resources for water stewardship.

Shifts in Public Engagement

Until recently, water has been a point of collaboration in Wisconsin, but that culture of collaboration has slipped away at the state policy level, and in some cases the federal level as well. Wisconsin's political climate has grown increasingly polarized, and civil deliberation and compromise in policy debates are no longer the norm.[132]

In contrast, at the local level, where many communities are coming together to address water problems, evidence shows some positive signs of traditional cooperative and collaborative processes that are still working in Wisconsin. For example:

- Volunteer stewardship activities have grown across the state. These include local restoration and cleanup projects, local "friends" organizations and coalitions to protect lakes and watersheds, and citizen science projects, many of which incorporate sophisticated water sampling to monitor local water quality.
- The land trust movement has grown across the state, protecting land and water resources through easements and land purchases and community-based land restoration and management.
- Tribal natural resource management programs have grown and are addressing water quality, resource management, and restoration projects.
- Watershed-scale strategies have been embraced in many areas, integrating scientific tools such as GIS and data from the DNR Water Action Volunteers stream-monitoring program. These are changing how local

decision-making around watersheds works at the community level.

Local Strategies to Address Water Impacts from Climate Change

While the state does not have a climate adaptation or mitigation plan, many local governments, businesses, and tribal governments are pursuing aspects of climate change adaptation.

- The village of Gays Mills developed a plan to relocate portions of the town to higher ground after the devastation of massive floods in August 2007 and June 2008.[133]
- The Bad River Band of Lake Superior Chippewa has developed a climate change adaptation project, noting "climatic and environmental conditions that have already affected key cultural resources, such as wild rice. A changing climate is expected to aggravate existing stressors on ecosystems, as well as introduce new challenges to management."[134]
- The Milwaukee Metropolitan Sewerage District has undertaken a significant investment in green infrastructure through its GreenSeams project to help reduce stormwater-related flooding (exacerbated by extreme precipitation in a changing climate) and combined sewer overflows.[135]
- La Crosse undertook a community adaptation study completed in 2013 to determine local vulnerability, needs, and potential measures such as innovative flood and floodplain management to provide areas for detention of large storm event runoff that could help the community adapt to changes.[136]

These and many other climate adaptation activities around the state indicate a growing awareness of the need to prepare for climate change influences on water and water infrastructure, forestry and agriculture, and public health. These individual strategies and assessments could benefit from a more cohesive statewide strategy.

Capacities & Resources

Two major economic downturns have affected federal and state budgets since the Waters of Wisconsin project began its work in 2000. When coupled with a new set of economic strategies to drastically shrink the role and influence of government, some of the recent losses have been extreme. This has played out in many ways, including the loss of key scientific and regulatory personnel in public agencies and universities (including UW–Extension services), and, with them, institutional memory and professional expertise. Overall, funding has been reduced for technical assistance, monitoring, and enforcement of environmental laws, and many environmental education programs have been cut.

For the majority of its history, the DNR has been the big ship that pulls many boats forward in its steady wake of conservation leadership. Our DNR has been a place where many interests come together to balance the wants of today with the needs of the future. However, the agency has undergone significant changes in recent years:

- Since 2000, state resources allocated to the DNR have steadily declined, with staff being reduced by 15%—the largest cut being in 2015 (see under "Changes in the Role of Science: Funding Cuts").[137]
- In the same timeframe, water-intensive industries requiring regulatory oversight have grown rapidly. Concentrated animal feeding operations (CAFOs), frac sand mines, and irrigation-dependent farm operations have

increased regional concentration of high-capacity wells (see chapters II, III, and IV). The DNR has inadequate resources to study the cumulative impacts of these wells and has been discouraged from doing so by Wisconsin Attorney General Brad Schimel, as noted in chapter III, page 31. These changes have shifted the costs and burdens of assessing impacts to citizens (instead of permit seekers) who must be willing to pay for independent experts to review decisions that will likely affect their families.[138]

Enforcement

Environmental advocates have decried the DNR's lack of enforcement of laws, brought to light by the 2016 Legislative Audit Bureau Report, which concluded that the agency has been challenged by high staff turnover and has not conducted inspections on the agency's own schedule, and that enforcement actions are down. For example, over the last decade, the DNR failed 94% of the time to issue notifications of violations (the first step in the state's enforcement process guidance) to municipal wastewater treatment plants, industrial wastewater treatment facilities, and CAFOs. In response, the DNR (as well as the audit itself) has pointed to a slashed budget for personnel and other expenses that constrain its ability to respond to needs.[139] Lax enforcement increases the risk of pollution from point sources such as CAFOs and places human and animal health in jeopardy.[140]

State reductions in technical assistance to land managers and water discharge managers make it more difficult to comply with existing law. However, over the last decade, federal programs such as the Mississippi River Basin Initiative and the Great Lakes Restoration Initiative have provided critical financial support for water quality improvement projects (see chapters III and IV for more information).

Ethical Considerations and Concerns

Perhaps the largest ethical concern facing Wisconsin is the erosion of the Public Trust Doctrine, in terms of water being held in common by the people of the state of Wisconsin. Trends toward privatization could signal a fundamental shift in water rights, use, and management in Wisconsin and other historically riparian-rights-based states.*

* According to the Mountain-Prairie Region of the U.S. Fish & Wildlife Service, the riparian doctrine "applies to all bodies of water including streams, lakes, ponds, and marshes, and grants to all riparian owners the right to make reasonable use of the water so long as the water use does not interfere with the reasonable use of water by other riparian users. Disputes over what constitutes reasonable use are generally resolved by the courts. The fundamental principles of this doctrine are: ownership of land along a body of water (riparian ownership) is essential to the existence of a right to that water; and each riparian owner has an equal right to make use of the water in its natural state (no storage), no matter when use of the water was initiated; thus, shortages are shared." From: Water Resources Division of U.S. Fish & Wildlife Service Mountain-Prairie Region, "Water Rights Definitions," accessed July 31, 2016, https://www.fws.gov/mountain-prairie/wtr/water_rights_def.htm.

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    - UW–Extension resources: http://clean-water.uwex.edu
    - DNR resources: http://dnr.wi.gov/topic/surfacewater/monitoring.html
    - USGS tools: http://water.usgs.gov/ogw/data.html

125. Charles Dunning (supervisory hydrologist and groundwater specialist with U.S. Geological Survey Wisconsin Water Science Center), interview with Erin Olshefski, Wisconsin Academy of Sciences, Arts & Letters office, Madison, WI, November 9, 2015.

126. View the full report at WICCI, *Wisconsin's Changing Climate*, at http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf. More information and supporting reports are also available at the WICCI website, http://www.wicci.wisc.edu.

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RECOMMENDATIONS

Recommendations

From its inception, the Wisconsin Academy's Waters of Wisconsin (WOW) Initiative has brought together people from across the state, and from varied fields and areas of interest, to address challenges and seize opportunities related to our precious waters. It has done so as a matter of both principle and practical reality: the state of our waters reflects the ways we interact not only with them, but with one another and our institutions. The WOW project has aimed to provide guidance for Wisconsin citizens in sustaining the health of our water resources and aquatic ecosystems over the long term. The specific recommendations we offer below continue this effort, resting upon a set of broad values that must underlie a sustainable water future in Wisconsin:

We recognize and honor Wisconsin's unique array of water resources and aquatic ecosystems, our history of both exploitation and recovery, and our evolving set of values and ethics with regard to water. In particular, we honor the Public Trust Doctrine, which ensures that our waters are held in trust for all citizens by the State of Wisconsin.

We are committed to science-based management and stewardship of all our waters. Science does not, and cannot by itself, determine appropriate management actions. But it plays an essential role in informing sound decision-making, providing the "sideboards" on uncertainty, and monitoring the effectiveness of our management actions and interventions.

We are committed to a more integrated and comprehensive approach to water management. As our waters are connected, so are our water problems and water stewardship opportunities. Fragmented, incremental, and piecemeal approaches to the interconnected waters of our state inevitably detract from sound management and invite inefficiencies. Our water resources and systems can be sustained only if we move toward this integrated approach, based on whole watersheds and entire ecosystems, including our human economy and the communities within it.

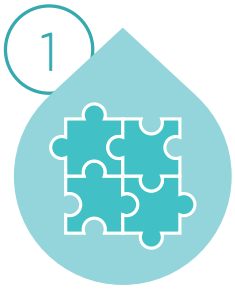
We embrace a commitment to sustainable and long-term water management approaches, as opposed to short-term "fixes" to immediate crises. Such crises are not just problems in themselves; they are symptoms of larger-scale and longer-term problems.

We are dedicated to intelligent adaptive management as a means to meet our long-term water stewardship responsibilities. This must be built into our water management approach as we plan actions and interventions, monitor outcomes, and adjust and adapt management going forward. Our water systems are dynamic, and so must be our efforts to work well with and within them.

We honor and welcome our Wisconsin tradition of citizen engagement in water stewardship—in our communities, businesses, organizations, and governmental bodies. A fundamental aspect of this is the assurance of transparency in governmental decisions affecting all our citizens.

We challenge all our fellow citizens to be effective water stewards, to make every effort to anticipate and shape our water future as active and informed participants in our communities, our watersheds, and Wisconsin as a whole. Merely reacting to unwelcome change is not enough; we aim to engage in informed planning and cooperative caretaking of our shared waters—for ourselves, for future generations, and for all that depend on clean, abundant, and self-replenishing water in Wisconsin.

In this context, we recommend the following actions:



DEVELOP AN INTEGRATED WATER MANAGEMENT FRAMEWORK

Water issues inherently involve connections and continuity, yet our water policies remain fragmented across the landscape and in our institutions. To defend against inequities and to safeguard freshwater ecosystems, Wisconsin needs to bring its water management strategies up to date, learning from examples in neighboring states and provinces. As we recommended in 2003, Wisconsin still needs an integrated water management strategy that acknowledges and addresses the connections between ground and surface water systems, and the common and unique challenges in both the Great Lakes and Mississippi watersheds. This strategy should include:

- A statewide water conservation plan (fulfilling and building upon the requirement for a Wisconsin water conservation plan under the Great Lakes Compact);
- Enhanced groundwater protections that anticipate, assess, and mitigate the cumulative impacts of high-capacity wells;
- Steps to redress data collection gaps, specifically for monitoring wells;
- Steps to fully engage the scientific and technical community to ensure a management framework that is based on sound science and one that can also be supported by reliable technical capacities; and
- A plan to protect and restore ecological and hydrological systems that are critical for our state's groundwater recharge, water filtration, and flood prevention and for sustaining resilient and diverse aquatic habitat.

SAFEGUARD DRINKING WATER

Wisconsin must take steps to reinvigorate water quality protections for drinking water and the healthy ecosystems that provide it through active prevention and also through restorative measures (wherever possible). This includes:

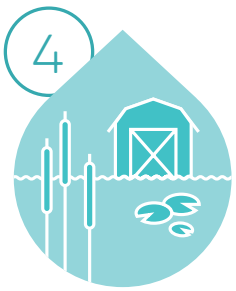
- Anticipating and regulating land-based as well as surface-water sources of pollution to sensitive aquifers such as the karst region or the Central Sands;
- Reducing pesticide applications across the state (consider developing a state-level nutrient and pesticide reduction strategy that engages stakeholders in developing practices and solutions and sets targets for reductions in both the Great Lakes and Mississippi Basins); and
- Increasing groundwater monitoring and reporting on quality as well as quantity.

In addition, Wisconsin needs to work with communities where the municipal drinking water systems still include lead service lines to ensure that those people who are dependent on those systems are not at risk, and work to determine long-term strategies to remove lead pipes or reduce risks from them.

CONTROL NUTRIENT POLLUTION

Wisconsin needs to invest in the implementation of the Wisconsin Phosphorus Rule by providing communities with technical support and resources, and documenting and sharing successful practices that advance effective adaptive management. It should do this specifically, by:

- Examining existing best practices and finding ways to improve them;
- Exploring applicable strategies from other complex governing initiatives, such as the Great Lakes Compact, that may integrate local and regional approaches;
- Identifying progress, successes, and lessons learned on nutrient reduction and erosion control through the Mississippi River Basin Initiative and the Clean Water Act Total Maximum Daily Load assessments and resulting strategies; and
- Evaluating the water impact of Wisconsin's 30 x 20 Initiative (an effort to produce 30 billion pounds of dairy products in Wisconsin annually by 2020), and evaluating how farm policy is influencing net nutrient inputs in Wisconsin.



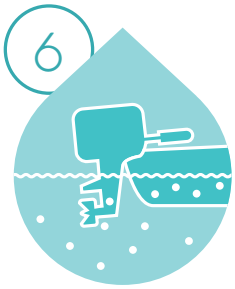
APPLY WATERSHED-SCALE STRATEGIES

As an investment in Wisconsin's long-term health and natural assets, Wisconsin should commit to wetland, shoreline, and streamside (riparian) conservation practices and work with local communities and watershed organizations to develop strategies to restore and sustain hydrological and ecological functions that enhance water quality, groundwater recharge, and habitat for native aquatic species.

PLAN FOR CLIMATE CHANGE

Wisconsin needs a game plan for addressing climate change and its impacts on the state's waters. Building on the excellent work of the Wisconsin Initiative on Climate Change Impacts (WICCI), we recommend developing and implementing a Wisconsin Climate Action Plan that includes:

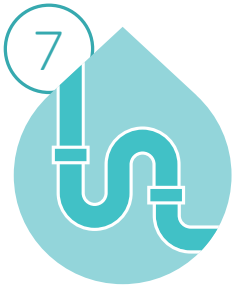
- Expanding Wisconsin's capacity to reduce its carbon emissions and enhance natural carbon storage in natural and farmed landscapes;
- Building freshwater adaptation capacity and resilience, both ecologically and within human systems and infrastructure through local and regional planning, coupled with conservation and restoration strategies;
- Increasing public understanding of the limits to adaptation and how to anticipate irreversible consequences; and
- Disseminating information about climate change impacts on Wisconsin's waters to planners and decision-makers for water infrastructure (both drinking water and wastewater systems), habitat management, municipalities, regional planning authorities, and other water managers.



MANAGE INVASIVE SPECIES

Wisconsin must control, slow, and eliminate the spread of aquatic invasive species. Some strategies include:

- Considering support for opportunities to ecologically separate the Lake Michigan and Mississippi Basin watersheds in cooperation with other Great Lakes states;
- Expanding educational efforts to raise awareness among commercial shippers, boaters, and others to prevent the further spread of aquatic invasive species; and
- Supporting research on the effect of the spread of invasives, the reasons why some bodies of water are more susceptible to invasion than others, and alternative means of controlling their spread.



MODERNIZE WATER INFRASTRUCTURE

Wisconsin water management and planning agencies should work with municipalities, drinking water and wastewater utilities, sewerage districts, and other units of local governments to identify urgent needs for maintenance and new construction to reduce exposure to drinking water contaminants and modernize sewage treatment capacities. With priorities identified, local governments should work with state and federal governments to secure a plan and funding mechanisms to address both urgent and routine maintenance.

COMMIT TO TRANSPARENCY AND PUBLIC PARTICIPATION

Citizens, communities, organizations, and businesses throughout Wisconsin have a strong stake in water policy decisions. Yet our public dialogue has been marked by polarization, lack of access to critical information and ideas, and constrained and abbreviated approaches to public engagement and deliberation. We urge those engaged in setting and implementing policy to examine public engagement processes and reinvigorate efforts to provide citizens of the state with meaningful mechanisms to deliberate, shape, and implement water policies through open dialogue, transparency, and timely response to queries and requests for information.

INVEST IN WATER LITERACY

Reaffirming the recommendations from the first WOW report, we need to better articulate the pressing and emerging water concerns in Wisconsin and help people understand the economic, environmental, and social consequences of our decisions about water. Education and public engagement strategies should include concerted efforts to educate all Wisconsinites, from elementary students to policy-makers, about basic water science and social science, water history and water ethics, the role of water in our economy, the policy-making process for water, and the Public Trust Doctrine and what it means for our water resources.

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