



SUSTAINING

MICHIGAN'S WATER HERITAGE



A Strategy for the Next Generation

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Governor's Foreword

Michigan has an unparalleled system of thousands of lakes, streams, wetlands, beaches and groundwater resources. This vast water network – combined with our unique position within the Great Lakes, the world's largest freshwater system – provides us exceptional opportunities. But, it also means we have a great responsibility to ensure the healthiest water system in the world.

Michigan's water system provides drinking water to millions of people, creates unique and pristine habitats and provides for world-class recreation opportunities found nowhere else on Earth. We rely on this system for public health, environmental, recreational and economic benefits. To sustain Michigan's future, we must manage Michigan's water resources wisely in ways that protect and enhance their value.

Michigan's Water Strategy will, for the first time in our state's history, outline a vision for the future for managing, protecting and enhancing one of our greatest natural assets: abundant freshwater resources.

This Water Strategy will guide the decision makers of our state on sound water policy and it will help align the actions of the various stakeholders involved in water resource planning with a focus on water stewardship. However, there are a few critical areas the state needs to focus on immediately. With the release of this Water Strategy, I am directing my administration to focus the state's actions on five key priorities. These priorities, under the leadership of their designated departments, will be developed in more extensive detail over the coming months. These priorities will emphasize and align the protection of public health and the sustainable use of our natural resources to enrich the quality of life and economic vitality in Michigan's local communities.



1. Ensure safe drinking water

We need to ensure Michigan has reliable water infrastructure systems in place to safeguard the public health of all residents. Sound infrastructure systems are critical to providing high-quality drinking water and optimal treatment of our sewer and storm water.

2. Achieve a 40% phosphorus reduction in the western Lake Erie basin

Reducing the amount of phosphorus in the Lake Erie Basin will help reduce harmful algal blooms and improve water quality for both drinking water and ecosystem health.

3. Prevent the introduction of new aquatic invasive species and control established populations

Invasive species are one of the most significant threats to our nation's lands and waters. The native ecosystems of the Great Lakes and Michigan's inland waters are at risk of being forever changed. Our local natural resource-based economies that depend on tourism for their livelihood are at risk of collapse if invasive species enter the Great Lakes.

4. Support investments in commercial and recreational harbors

Our harbors serve as both a recreational and economic asset for local communities, helping to create vibrant waterfronts for boaters, anglers, residents and businesses. Michigan's 80 recreational harbors also help to support the state's \$4 billion boating industry. Integrating harbors into community and economic development planning can help to prioritize and leverage capital investments necessary to improve and maintain harbor infrastructure and dredging needs.

Our commercial ports also serve a vital role in the economic vitality of our local communities and the Great Lakes Basin. Strategic investments in our ports and port infrastructure will help to enhance existing markets and create new markets to improve Michigan's position in Great Lakes maritime commerce.

5. Develop and implement a water trails system

Water trails are integral to a comprehensive statewide trail strategy. They help spur economic development along Michigan's waterways, increase access to natural resources and benefit local communities.

The details of how we will work on these five priorities will be outlined in specific implementation plans crafted by each lead state agency over the next few months. Through our combined efforts, we can provide an unparalleled quality of life for all people in Michigan. We owe this to all Michiganders now and well into the future.

Rick Snyder,

A handwritten signature in black ink, appearing to read "Rick Snyder". The signature is fluid and cursive, with a large initial "R" and "S".

Governor



VISION

As the Great Lakes State, Michigan will protect and promote wise use of its globally unique water resources to ensure healthy citizens, vibrant communities, sustainable economies and the stewardship of Michigan's water heritage.

Executive Summary

Water defines Michigan. It is deeply rooted in the state's culture, heritage and economy. With 20 percent of the world's available freshwater, four of the Great Lakes, more than 11,000 inland lakes, 76,000 miles of rivers, 6.5 million acres of wetlands and more than 3,200 miles of freshwater coastline - the longest in the world - ensuring the long-term sustainability of this treasured globally significant natural resource is critical to the integrity of the ecosystem, the well-being of nearly 10 million residents and our ability to advance Michigan's prosperity.



A deep connection to water - from the smallest trickling stream to the mighty Great Lakes - shapes the Michigan way of life. Water is a primary character in our stories from the earliest tribal histories through industrial growth to today's vacation destinations. One in five Michigan jobs are tied to our water resources;¹ they are the lifeblood supporting our health, families, values and economic opportunity. The beauty of our lakes and rivers inspires us to be better stewards of our resources and maintain them for today's communities and tomorrow's future.

Michigan's clean, plentiful freshwater is a unique and valuable resource that is growing in importance. The world population is expected to grow from 7 billion to over 9 billion people by 2050,² further increasing the growing demand for global freshwater resources. In 2015, a global risk report from the World Economic Forum identified water crises as the number one risk influencing the global economy.³

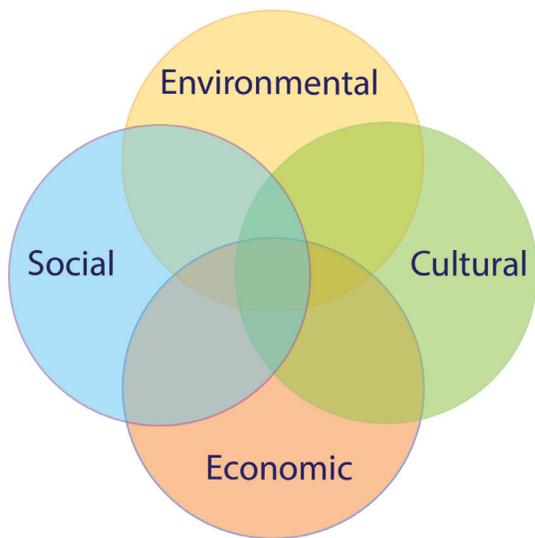
Abundant freshwater resources are at the root of why many Michiganders choose to live, work and play in the peninsula state. Michigan's surface and groundwater resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Michigan's abundant water assets and research capabilities, in addition to its highly-skilled talent, economic development expertise, innovation and invention, and powerful tourism and business marketing brand are pivotal drivers for attracting business creation and investment.

With this abundance comes a deep sense of responsibility and stewardship - but Michigan has not always treated its water with a sense of care. Today, the state is slowly returning to a level of aquatic health in many waterways and lakes necessary to fully support diverse fish and wildlife and meaningful recreation in many communities. Through longstanding public and private partnerships and tremendous investment of time and resources, communities are making progress in cleaning up legacy contamination.

But that is just the beginning. The ability to achieve Michigan's vision for its water resources depends on a strategic, collaborative ecosystem-based plan that monitors the health and condition of our water resources, invests in water-related infrastructure, uses water more thoughtfully and efficiently to grow sustainable economies, reconnects communities to water and fosters a water ethic and culture of stewardship.

Michigan's Water Strategy - An Ecosystems Approach

The forthcoming Water Strategy takes an ecosystem approach, focused on the fact that Michiganders are a part of the ecosystem in which we live and therefore have an effect on the health of our water resources. The Strategy recognizes that the core values identified with water are four fold: environmental, economic, social and cultural. All are equally important. Communities across Michigan recognize the value of water quality improvement activities supported through state and federal investments. Studies by the Brookings Institution and Grand Valley State University show that restoring water quality and shorelines respectively, result in a 3-to-1 and 6.6-to-1 return on investment in the form of increased property values, local economic development, improved ecosystem health and quality of life.



Water has immense economic and social value when paired with a healthy environment. Water use by humans is tied to the health of ecosystems and the various fish and wildlife species that occupy them. Social value is represented as how water forms a basis for activity and time with friends and family and how these uses create joy and memories. Cultural value is about identity and affinity to place: where we choose to live and why; who and what we identify with; and where our stories, myths and beliefs come from. For Michiganders, water – and especially the Great Lakes – forms a core part of identity and culture.

The approach recognizes that each of these four values needs to be addressed in balance with the others. They exist together, influence each other and may require compromise, accommodation and limits. This approach is reflected in the Strategy through its goals, outcomes and recommendations.

A Roadmap to Achieve the Vision

The Water Strategy outlines a 30-year vision shaped by a desire for high-quality, accessible water resources that are protected by and for present and future generations based on the question asked in multiple forums around the state: “What do you want Michigan and Michigan’s water resources to look like and do over the next generation?” Throughout the development of the Strategy, Michiganders said they care deeply about the Great Lakes, rivers and inland lakes, groundwater and water in general. It is this caring that ultimately drives the ability to support, choose, manage and fund the requirements of healthy water. To that end, the Strategy recognizes that decisions made now regarding infrastructure, innovation and technology, monitoring and water literacy will set the course for decades.

Great Lakes, Water and Governance

The Great Lakes and Michigan’s water have long been recognized as valuable resources fundamental to our way of life by federal and provincial governments, tribal nations and the seven other states within the basin. The Great Lakes are a global treasure and thus, protection and restoration must be considered in the context of all who share the resource. While the Strategy is Michigan-specific, coordination with the other Great Lakes states, Canadian provinces, and both the federally-recognized Indian Tribes and First Nations in the Great Lakes area is necessary to fully sustain our water heritage.

The Great Lakes region has long-standing governance and institutional structures, organizations and other formal and informal mechanisms focused on protecting, restoring and maintaining the integrity of this vast water resource. These include the International Joint Commission, Great Lakes Water Quality Agreement, Great Lakes–St. Lawrence River Water Resource Compact Agreement, Conference of Great Lakes - St. Lawrence Governors and Premiers, Great Lakes Commission, Great Lakes Fishery Commission and many others. Federal, state, and tribal laws and regulations also apply to specific water issues. The many layers of this institutional and legal framework create an ongoing need for consultation and collaboration among all of the governments and actors that seek to protect water resources.



For generations, the Indian Tribes have resided in the Great Lakes region and depended on the Great Lakes and Michigan's inland lakes, rivers, streams and groundwater for their way of life. These water resources provide food, transportation and drinking water, in addition to fulfilling many cultural purposes. The State's relationships with the federally-recognized tribes in Michigan are an important part of the governance landscape for water in the Great Lakes region. The State is a party to federal consent decrees with five tribes that govern, among other things, both inland and Great Lakes fishing to manage the fisheries and give effect to those tribes' reserved rights under treaties with the United States. Over the past two decades, Michigan and all the tribes have also worked to formalize their relationships through a variety of voluntary agreements in areas of shared interest and mutual commitment, including past agreements concerning water and climate change. The 2002 Government-to-Government Accord executed by Governor Engler and tribal leaders was a landmark agreement establishing a mechanism for consultation, collaboration and dialogue and continues to serve as the basis for a working relationship on a wide range of water issues.

Exploitation of native fisheries, wildlife and forests during Michigan's emergence as the manufacturing center of the nation created great wealth and a high quality of life, but also devastated native fish populations, impacted water quality and left a complex and costly legacy of contamination. Federal, state,

tribal and local regulation and restoration programs have made progress in addressing this legacy in many communities. These programs have been instrumental in restoring and ensuring drinkable, swimmable and fishable waters. They include progress under Michigan's Natural Resource and Environmental Protection Act, Safe Drinking Water Act, the federal Clean Water Act and cleanup statutes such as the Environmental Remediation and Leaking Underground Storage Tank Act. In addition to these efforts, recent investments by the federal government through the Great Lakes Restoration Initiative have accelerated efforts to clean up and restore our water resources and fish and wildlife populations, and to improve quality of life in many communities; however, there is more work to be done.

Government-to-government relationships, statutes, regulations and management programs all play a critical and complementary role to the actions recommended in the Water Strategy. There are many successful examples of collaboration and management of our shared waters.

Driving progress toward the goals and the outcomes will depend on harnessing this complex framework of governance, institutions and regulations to continue to build durable relationships and collaboration around common interests. A long-term strategy built upon local, state, federal, tribal and international collaboration that involves continued learning, open dialogue and adaptive management is critical to achieving improved water quality, sustainable groundwater resources and ensuring proper management of these shared resources.

Strategic Actions

The Water Strategy charts a course by providing recommendations and identifying strategic actions to:

Inspire Stewardship for Clean Water

Most importantly, Michigan residents need greater opportunities to learn about water. Michigan is surrounded by 20 percent of the world's fresh surface water, and with that comes a deep ethical obligation to be good and thoughtful stewards of this global treasure. A shared water ethic will guide Michigan into the future and ensure that our children and future generations will have the same or better quality of life than we have today. The durability of this Strategy and ensuring the health of our water resources for generations to come depends on creating a culture of stewardship through lifelong education about water.

Protect and Restore Aquatic Ecosystems

Michigan needs more integrated, holistic approaches to managing water on and across the landscape, including groundwater, which support healthy ecological systems and hydrologic integrity at the watershed scale.

Ensure Clean and Safe Waters

Michigan needs to protect and restore water quality to ensure ecosystem function and support current and future human uses of Michigan's surface and groundwater resources.

Invest in Water Infrastructure

Greater and consistent investments are needed in water-related infrastructure improvements to address aging and deteriorating systems that are causing water quality issues and public health concerns. Michigan needs to make investments in water infrastructure systems to realize the benefits they provide, including delivery of safe drinking water, management of stormwater and wastewater, enhanced recreational opportunities and healthy ecosystems and economies.

Create Vibrant Waterfronts

Michigan needs an emphasis on water resources as assets in state, regional and community planning efforts to create vibrant and sustainable communities, a robust recreation and tourism industry and a thriving environment and economy.

Support Water-Based Recreation

Michigan needs to create greater opportunity for access to water resources through water trails and appropriate public access.

Promote Water-Based Economies

Michigan needs to collectively build robust multi-sector and multidisciplinary public-private partnerships between business, industry, academia, private capital and government. These partnerships will link ideation; invention and innovation; research and development; capital investment and end users. This approach will bring technologies to the market to better manage and solve water challenges in Michigan and across the globe. Directed research and development to address specific water challenges should provide the basis for forming a new paradigm of collaboration.

Monitor Water Systems

Michigan needs to develop and fund a coordinated, long-term monitoring strategy to provide baseline and trend information about surface and groundwater quality and quantity. This information is necessary to base decisions and best direct actions and future investments to support healthy people, ecosystems, communities and economies.

Build Governance Tools

Michigan needs to build new models of governance at the local and regional level to address increasingly complex and intractable problems facing Michigan's water resources. Implementation efforts will require not just state agencies, but a wide array of individuals, organizations, businesses, industries and tribal and local governments across the state to continue to build on this multi-governmental and stakeholder-collaborative approach.

We call on all people of Michigan to be thoughtful and engaged stewards of our water resources.

Water Strategy Framework

The Water Strategy is organized around nine goals and outcomes designed to ensure the viability and sustainability of Michigan's water resources over time; placing Michigan on the path to achieving its water vision in a way that builds economic capacity while sustaining ecological integrity of this crucial resource for future generations.

The Water Strategy includes a series of recommendations that are a set of interconnected ideas to drive a new relationship between Michigan's communities, governments and residents to solve complex water challenges and create greater opportunities for economic and social well-being. The recommendations are designed to drive performance and behavior change, address barriers and contribute toward achieving the desired outcomes. The ability to achieve the stated goals and outcomes will require both the implementation of recommendations in the Strategy and continued implementation of the entire suite of existing water-related programs and initiatives underway at the state, regional and local level as well as across the Great Lakes Basin.

The Strategy includes recommendations paired with lead actor(s) charged with implementation and an implementation metric to measure progress toward accomplishing the recommendation. A wide host of actors and agents across the state and region, including governments, tribal nations, nonprofits, academia, industry, businesses, individuals, as well as local and regional philanthropies will need to be involved. Therefore, the Water Strategy is not a specific action plan only for government, though there are many actions that government can and should take. Rather, it is a strategy for all people of Michigan, believing that together, we can have a positive impact on the future of the State.

The Strategy includes measures of success intended to examine system response over time as a result of the collective impact of implementation of the Water Strategy recommendations and other efforts already underway by state, federal, tribal and local governments and partners to rebuild healthy aquatic systems, clean water and vibrant economies. Achieving success will require integrating planning strategies for water resources with local units of government; unifying plans between the state, regions and local units of governments and collaborating with stakeholders. Additionally, success will require an integrated process for adapting to new science and understanding of complex issues, evaluating progress, and making course corrections necessary to achieve outcomes.



Part I

Inspire Stewardship for Clean Water
Protect and Restore Aquatic Ecosystems



INSPIRE

stewardship for clean water



Stewardship is one of the most important aspects of the Water Strategy because it forms the backbone of use and enjoyment of water for generations to come. Stewardship is about supporting and maintaining what we hold dear to create valued legacy and heritage. Purposefully building stewardship for water resources requires coupling the desire for high-quality water resources with a sense of care for the water systems that provide them. Throughout the development of the Strategy, Michiganders have consistently said they care deeply about the Great Lakes, about their rivers and inland lakes, about groundwater and drinking water and water in general. This connection to place and an understanding of the context of water in communities comes from a lifelong appreciation and caring for water.

Stewardship is driven by personal values, culture and experiences, and supported through our knowledge of freshwater systems and understanding our influence on them. It is important to understand that we live in a hydrologically connected system. The Great Lakes and their watersheds (including lakes, rivers, streams and groundwater) are an integral part of the water cycle whose waterways are connected all the way to the Gulf of St. Lawrence and ultimately to the ocean.

Building stewardship for water resources requires both knowledge of freshwater systems and an understanding of their value. Personal experiences and storytelling grow connections to that value. For example, wetlands provide people with duck habitat for hunting; groundwater systems give us water to drink from; rivers provide places to canoe, fish or birdwatch. We irrigate the orchards, vineyards and fields that fill our plates and we enjoy the pure wonder of a sunset at the lakeside. All give people tangible reasons to value water resources and use them with care.

Key drivers of stewardship of water resources include water literacy, place-based education, personal experience, volunteerism and community engagement and community-based philanthropy.

Improve Water Literacy and Use of Place-Based Education

Michigan is blessed with abundant water resources, yet many citizens lack a basic understanding of fundamental water literacy principles. In recent surveys, in some counties in the State, over 60% of the people in those counties did not realize that they lived within a watershed. While the term “watershed” may not be as familiar to some - the fact remains that there

Goal

Michigan citizens are stewards of clean water and healthy aquatic ecosystems

Outcome

Individuals and communities understand their responsibility for and make informed and responsible decisions regarding water resources

Measures of Success

- Increase the number of citizens with knowledge and understanding of water literacy principles.
- Michigan citizens support funding for water and implementation of the Water Strategy.

is a distinct lack of understanding about water, water cycles and the overall connectivity of water.

The durability of this Water Strategy and the future health and condition of Michigan’s water resources many generations from now will depend on creating a system of life-long learning about water for all ages. The key audiences include K-16 students and educators, researchers, citizens, businesses, natural resource managers, city planners and legislators.

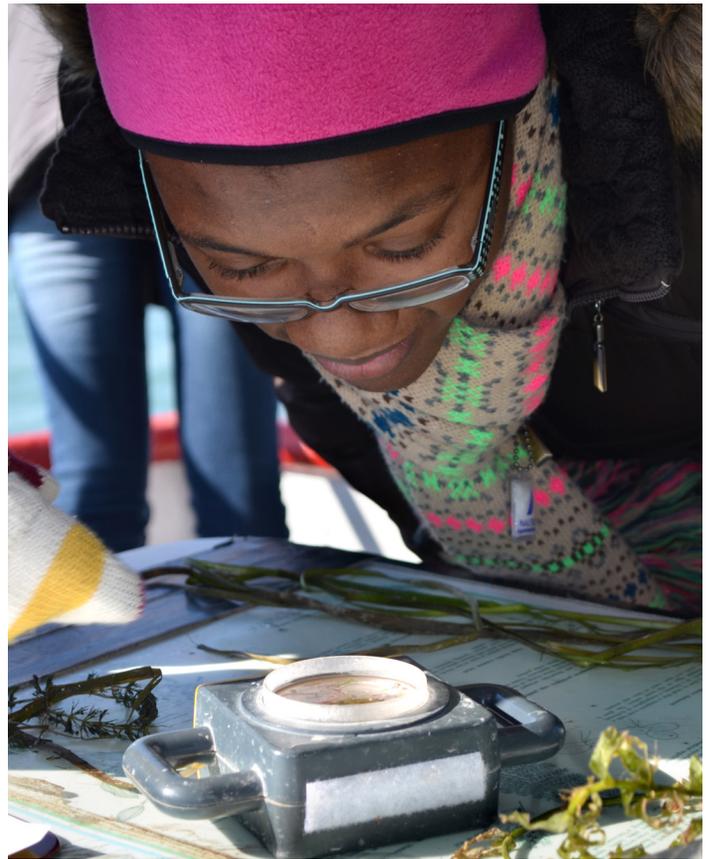
Integrating freshwater systems into place-based educational experiences is critical to building literacy and stewardship for Michigan’s water resources. Place-based education uses the key aspects and elements of local community and the local environment as a starting point for teaching and learning, emphasizes hands-on, inquiry-based, real-world experiences, and, ideally, involves direct collaboration with community partners. Learning about the world in the context of where you live through place-based education and experience creates a learning environment that engages learners in a more meaningful way. The benefits of place-based education include powerful learning, a healthy, supportive school culture, sustainable partnerships between schools and communities, a greater appreciation of the environment and more frequent and effective acts of stewardship.

Substantial work in this area is underway through independent programs and projects like the Great Lakes Stewardship Initiative (supported through the Great Lakes Fisheries Trust,) Water-On-The-Go program at Cranbrook's Institute of Science, General Motors' Global Rivers Environmental Education Network (GREEN) and the Saginaw Chippewa Indian Tribe of Michigan Environmental Education Program, working at the grassroots level in communities and watersheds across the state.

Despite these efforts, many residents across the state still lack basic knowledge about watersheds and how our water resources are affected directly by the decisions and actions of people. It is imperative that understanding of individual and collective actions needed to effectively conserve and manage water resources are understood. Existing outreach programs bring a necessary focus on water into classrooms but are not enough. As the Great Lakes state, Michigan must have a unified set of water literacy principles as part of its K-12 curriculum standards that address these deficiencies. Michigan must build a durable, connected and sustainable curriculum about water across all the grades. Educators need to be well-versed not only in critical environmental science content but how that content is most effectively taught to students. Educators need ongoing professional development to support their efforts in this arena.

Federal and state agencies govern formal K-12 education, help guide curriculum content and use testing instruments to measure knowledge retention. Educational leaders have made some efforts to build water literacy into the grade school curriculum. For instance, the K-4 science standards focus on life requirements, life cycles, and water and water movement. These content expectations span four scientific disciplines: science processes, physical science, life science and earth science. One significant challenge to increasing water literacy overall is the absence of a common focus among state government, universities, colleges, nongovernmental organizations, businesses and foundations. Collectively, Michiganders need to agree on common goals to improve water literacy, including lifelong education. A water focus, one strongly tied to STEM education, built over a child's educational life and into adulthood, can serve as the basis for place-based learning and scientific knowledge.

Ample coursework and curriculum about water resources is already available, but unlike other critical areas of knowledge, is not required of all students



nor is it linked to their place or community. The Great Lakes state should have a water-based curriculum linked to STEM concepts and the life sciences should be a basic requirement throughout the science curriculum, beginning in kindergarten. Knowledge of local water systems, like watersheds, flow, rivers and discharges, provide a relevant and place-based context for learning. Weaving water into school curricula is crucial to fostering future water stewards, leaders and decision makers.

Increase Volunteerism and Community Engagement

One key aspect of stewardship within a community is whether residents are willing and able to volunteer their time to better their own local water resources. Examples include maintenance of healthy rivers through activities such as river cleanup days, invasive species management along the shore, and water conservation. Communities that exhibit strong stewardship characteristics have more individuals and groups engaged with the community and also tend to financially support measures that drive good management practices such as environmental cleanups and funding programs. The focus on building stewardship and care can translate directly into heightened engagement and long-term benefits to the community, the state and water resources.

Michigan has a diverse and passionate portfolio of nonprofit organizations including some of the oldest organizations in the country working to increase volunteerism and community engagement in natural resource management and conservation. Conservation and watershed-based organizations, as well as local volunteer programs such as the Michigan Clean Water Corps (MiCorps) program, play an important role in supporting and contributing to state water management programs and achieving long-term outcomes.

Implementation of stewardship activities should be coordinated with other grassroots efforts and must address social and cultural gaps in access and opportunities to experience water. Studies have shown that people are more likely to engage in stewardship of natural resources if they have had an opportunity to personally experience nature. Long-term sustainable funding mechanisms are needed to continue this important work at the grassroots and community-based level.

Studies show that people are more likely to engage in stewardship activities if they have had an opportunity to experience nature

Community-based philanthropy

Another act of stewardship within a community, similar to volunteerism, is philanthropy and giving. How people choose to spend their money is a deep reflection of what they value. Every county in Michigan is covered by a community foundation in some fashion, and many of these have education funds, environmental funds and other funds that focus on water and environmental issues. There are also a myriad large and small family foundations, corporate foundations and independent foundations. In addition to more formal philanthropic structures, there are vast networks of nonprofit organizations supported through private giving. The Foundation Center of New York reports that grant making for environmental and animal welfare issues was \$56.8 million in Michigan from 2011-12. This category consistently makes up six to seven percent of total grant making for foundations that make grants of at least \$10,000.



Organized philanthropy in the state join together periodically on environmental issues through the Council of Michigan Foundations in issue-specific groups, such as the Green and Blue Network, and the Land Use Funders. There are no readily available statistics on the amount individuals give to support environmental and water-related interests, but individual philanthropy combined with foundation philanthropy is in excess of \$60 million annually for the state.

Local and individual philanthropy can have a direct impact on a community's ability to achieve Water Strategy goals. Further alignment is needed amongst private foundations and community based philanthropy to support key elements of the Strategy.

Goal: Michigan Citizens are Stewards of Clean Water and Healthy Aquatic Ecosystems

Outcome: Individuals and Communities Understand Their Responsibility for and make Informed and Responsible Decisions Regarding Water Resources

#	Recommendation	Implementation Metric	Lead Actor
1	Integrate water literacy principles into place-based education and state of Michigan curriculum standards tied to Science, Technology, Engineering and Math (STEM) across all grade levels and coordinate, deliver and support ongoing freshwater-focused professional development for Michigan K-12 educators.	By 2017, develop a strategy to integrate freshwater literacy principles into place-based education, state curriculum standards and professional development for K-12 educators.	Department of Education, MDEQ, MDNR and State Board of Education, Non-governmental organizations (NGOs), Local units of government, Public and private educational institutions, Watershed councils
2	The State, working with stakeholders, will develop a public outreach campaign that highlights stewardship practices and encourages actions that sustain water resources.	By 2017, develop and implement a communication strategy focused on connecting economic, environmental, social and cultural values to Water Strategy outcomes. Utilize survey tools and data collected to assess behaviors and attitudes toward Michigan’s water resources to assess changes over time to measure: <ul style="list-style-type: none"> • Michigan’s residents willingness to fund water quality infrastructure • Community’s connection to local water assets • Michigan’s residents knowledge of and affinity for local waters • Volunteerism and local philanthropy that support a community’s vision for water and water-related assets. 	MDNR, MDEQ, MTED, Local units of government, NGOs
3	Work with existing volunteer, community-based and statewide conservation organizations to promote and expand opportunities to engage citizen volunteers to achieve the Water Strategy goals and outcomes, such as the Michigan Clean Water Corps program.	By 2017, develop a list of participants and define engagement levels. Track progress toward increasing engagement levels. By 2018, secure long-term funding for the MiCorps program and evaluate opportunities to expand the scope of monitoring activities.	MDEQ, MDNR, NGOs
4	Work with the Council of Michigan Foundations to assess the potential for further alignment of strategic funding with philanthropy towards implementation of Water Strategy goals.	By the end of 2016, convene, through the Council of Michigan Foundations, a funder’s summit for Community Foundations and Donor Advised Fund managers. Assess the potential for a pooled Great Lakes social equity fund, supported by private philanthropy that would support Great Lakes restoration and management.	MDEQ, Council of Michigan Foundations



PROTECT

and restore aquatic ecosystems

Healthy, functional ecosystems purify air and water, provide habitat for fish and wildlife, serve as buffers from flooding and support natural resource-based economies. All long-term, sustainable uses of water depend on intact ecological and hydrologic systems. Ecosystems link living organisms with the non-living components of their environment like the water, soil and air. While the Water Strategy focuses on the water component of ecosystems, it recognizes that changes in the make-up or distribution of organisms and disturbances on the land or in the air also impact water, and that hydrologic management across the landscape directly affects those systems.

For example, the introduction of aquatic invasive species (AIS) in the Great Lakes region has been a major challenge to the resiliency and diversity of aquatic ecosystems. The presence of invasive species combined with nutrient runoff can have devastating impacts on fisheries and other aquatic life, disrupt the ecology of lakes and streams, and contribute to nuisance aquatic plant growth and algae blooms. In a few areas of the Great Lakes, nuisance algal growths have been associated with botulism outbreaks, “muck” (organic debris), washing up on beaches and impacts to drinking water systems. Some nuisance algal growths have also been characterized as toxic, harmful algal blooms (HABs).

The practice of moving water off the landscape as quickly as possible has resulted in both positive and negative consequences. Since the mid-1800s, Michigan has developed more than 35,000 miles of public drains, serving more than 17 million acres of agricultural and urban lands and roadways. These drains provide benefits by removing excess stormwater; preventing damage from flooding; improving soil productivity and enabling residential and commercial development. However, these extensive drainage systems were designed without consideration of the long-term consequences of modifying natural hydrology.

In addition, other hydrologic modifications like storm drains and extensive impervious surfaces like parking lots, contribute to less infiltration and increased surface water runoff and flow, resulting in increasingly “flashy” streams. These cause stream bank erosion and increase sediment loads, transporting nutrients that impair aquatic life. The excess surface water runoff, combined with sediment and nutrient loading, leads to water quality degradation such as decreased dissolved oxygen and sediment deposition within the stream channels.

Goal

Michigan’s aquatic ecosystems are healthy and functional

Outcome

Aquatic systems are resilient and diverse

Measures of Success

- No net loss of primary indicator species such as steelhead, brook trout, sturgeon and lake trout, from baseline levels.
- Natural salmon and trout populations are thriving due to enhanced river connectivity and removal of impediments to migration.
- Reduction in nuisance and harmful blue-green algal blooms.
- Waters of the state meet Water Quality Standards.
- Reduction in annual volume of untreated sewage discharges.
- Reduction in the number of designated use impairments due to wet weather discharges.

These changes in the water quality lead to a decline in the benthic population on which the fish population is dependent, evidenced in recent losses of cold water indicator invertebrates that sustain trout populations.

The loss of infiltration can reduce vital aquifer recharge and reduce base flow to streams. In rural areas, infiltration to deeper depths is interrupted by tile drains designed to conduct water away from fields. These hydrologic changes can pollute receiving waters, impact aquatic life that depends on groundwater-fed streams during summer months and affect human use of groundwater.⁴

Growing conversations in the international community regarding climate change recognize that changing climatic conditions throughout the world are causing social, ecological and economic impacts.

While Michigan's climate future is unclear, climate change can lead to significant impacts to water resources, particularly through the variability and intensity of extreme weather (severe storm events and drought), more rapid runoff, greater flashiness in streams, sediment loadings, pollutants in runoff and flooding events. In the Great Lakes region, variability in precipitation from year-to-year is large. Total annual precipitation has increased in the Great Lakes basin by 4.5 inches from 1915 to 2004, with 4.2 of those inches occurring from 1955 to 2004.⁵ Michigan's current infrastructure capacity was not designed to effectively handle increased volume and intensity of extreme weather events, leading to potential challenges in flood management zones and hazard mitigation planning and implementation.

Climate change can also lead to changes in seasonality of significant precipitation, natural community composition, species ranges (including invasive species) and degradation of habitat. Changes in water levels and temperature can impact culturally significant species such as whitefish, sturgeon and wild rice, important for ecological balance, subsistence economies and cultural purposes in tribal communities. Changing climatic conditions will require Michigan to be proactive in its use of adaptive management approaches to water management to mitigate impacts to ecological, economic, social and cultural resources, including designing infrastructure to effectively handle extreme weather events. The Water Strategy focuses on adaptive management approaches to reduce threats to aquatic ecosystems and implementation of watershed-based approaches to restore hydrologic integrity and improve aquatic ecosystem and community resiliency. Holistic watershed-based approaches that slow the movement of water across the landscape; increase infiltration capacity; reduce erosion, sediment, nutrient flow and wastewater discharges; and increase aquifer recharge are needed for long-term preservation of Michigan's hydrology. These approaches are critical to ensure healthy functional ecosystems that wildlife and human populations depend on.

Prevent Introduction of and Manage Aquatic Invasive Species

Since the 1800s, more than 182 nonindigenous aquatic organisms, including animals, plants, bacteria and viruses, have colonized the Great Lakes ecosystem, forever altering its ecology. The introduction of AIS into the Great Lakes and inland waters has caused significant damage to the state's natural resources and beneficial uses by humans.

Detriments include Eurasian water milfoil clogging inland lakes and the devastating effects of sea lamprey on fish communities. In addition, other negative impacts include round gobies eating fish eggs and larvae and serving as a vector for botulism poisoning in wildlife and water fleas snagging fishing lines and changing the zooplankton community. Of particular note, invasive mussels have disrupted the energy flow, nutrient cycling and food web which has altered fish communities and affected top predators in the Great Lakes such as lake trout. The intensive filtering activities of zebra and quagga mussels have greatly increased water clarity, allowing the long filamentous algae known as *Cladophora*, as well as other types of algae, to grow to nuisance levels in areas where it previously did not occur. When *Cladophora* dies and breaks loose, it creates conditions ripe for the production of the botulinum toxin in Great Lakes sediments by creating the very low oxygen conditions required by Type E botulism spores to become active. Type E botulism outbreaks have resulted in fish kills and the death of waterbirds.

Since the 1800s, more than 182 nonindigenous aquatic organisms have made their way to the Great Lakes

Michigan has led the region for decades in focusing on prevention of new introductions and minimizing impacts of established invasive species. To combat the introduction of new AIS and minimize the impacts of established ones, Michigan developed the second state AIS management plan in 1996, later updating it in 2013. It provides a comprehensive strategy outlining new actions and enhancing existing efforts to prevent and control AIS in Michigan waters, including continued support for separation of the Great Lakes and Mississippi watersheds. In addition, the Michigan Department of Natural Resource's Fisheries Division Strategic Plan, *Charting the Course: Fisheries Division's Framework for Managing Aquatic Resources*, provides specific actions to support healthy aquatic ecosystems and sustainable fish populations. It also provides strategic assessments and tools to inform decision-making. However, more is needed. Long-term mandates for the prevention of new invasive species into the basin will depend on a collaborative approach.

Reduce Occurrence and Impacts of Harmful and Nuisance Algal Blooms

Nuisance algal blooms are increasingly a problem in the Great Lakes and have been documented in some inland waters. Some algal blooms are dominated by blue-green algae also known as cyanobacteria that produce harmful toxins; these blooms are characterized as harmful algal blooms (HABs) based on concentrations of toxins produced. The most common algal toxins are Microcystin, Anatoxin-a, Cylindrospermopsin and Saxitoxin. For example, the toxin Microcystin is produced by the cyanobacteria *Microcystis*. HABs occur when Microcystin exceeds the World Health Organization's non-drinking water guideline of 20 ug/l or drinking water criteria of 1 ug/l in water bodies with drinking water intakes. However, state agencies will likely adopt new criteria as additional information becomes available.

The presence of these toxins is known to impact human health and can cause closures of drinking water systems and beaches, including a well-publicized HAB in western Lake Erie in 2014 that prompted officials to shut down the drinking water system in Toledo and a few areas in Michigan. Health symptoms commonly associated with algal toxin exposure include nausea, skin rashes, gastro-intestinal distress, numbness and fatigue.⁶ These toxins can also kill fish and other aquatic life. The most commonly monitored algal toxin in Michigan is Microcystin; however, MDEQ is evaluating monitoring protocols for other toxins.

Algal blooms are caused by many factors, including excessive inputs of nutrients, usually phosphorus and to a lesser extent nitrogen. Meteorological conditions can also play a role in determining algal bloom severity and seasonal dynamics. For example, the occurrence and duration of extreme weather events, such as heavy rainfall and droughts, may influence the development of algal blooms by intensifying the magnitude and timing of nutrient delivery from the watershed.⁷ In addition, changes in the food web caused by the introduction of invasive species can change the way nutrients are partitioned in the environment or change environmental conditions enough to trigger algal blooms. Physical factors affecting water temperature, light penetration and water column mixing may also contribute to create potentially favorable conditions for algal blooms.

One step to combating HABs is to address agricultural point and nonpoint sources of sediment and nutrients that have been identified as a major source of the pollutants in recent western Lake Erie Basin studies conducted in both Michigan and Ohio. These opportunities include promoting changes in the use of phosphorus through mechanisms like the 4R Program (Right Source, Right Rate, Right Time, Right Place), implementation of the Michigan Agriculture Environmental Assurance Program (MAEAP) suite of practices, restoration of grasslands and wetlands, use of vegetative filter strips, use of technologies like precision farming and implementing no-till and conservation tillage techniques to reduce run-off.

The biggest challenge posed is the lack of a comprehensive understanding of the cause of HABs in Michigan's waters. For example, HABs that are capable of producing toxins are not limited to nutrient rich waters and can be found in nutrient poor waters like oligotrophic lakes. It is not possible to tell visually (including via satellite), by taste or by odor whether a bloom is a HAB. Additional work must be done in order for state, federal and local partners to make strategic decisions to determine best possible solutions to address the problem. A strategy to prevent HABs should be developed, involving a broad set of state, federal and local partners and include conducting additional monitoring, data collection and research to improve the understanding of the cause of HABs and inform models and actions to achieve the desired water quality and public health outcomes.

Integrate Water Knowledge into Local Land-Use Planning

Land-use planning is inextricably linked to healthy aquatic ecosystems, a clean and available water supply and protection from natural occurrences that can damage property. In Michigan, decisions about how the land can be used are made at the local level through master planning and zoning ordinances. Communities use these tools to plan and guide the character of the community and influence the local economy.

However, local community and economic development planning is based on political boundaries and jurisdictions, not along watershed boundaries. To be effective, these planning tools should consider activities that adversely affect water quality and quantity, such as extreme weather events, throughout their watershed and incorporate best management practices into transportation, infrastructure and zoning regulations

and other community development planning to minimize impacts on local water resources. In addition, planning across municipal boundaries, sharing of information and services at the watershed scale is needed to achieve desired water quality and quantity outcomes.

Build Resiliency into Riparian Systems

One of the most direct ways to positively influence water quality and aquatic habitat is to restore, create and improve riparian areas. Riparian areas, or land area adjacent to a stream or lake, provide critical ecosystem services and benefits for lakes and rivers, including:

- Reducing runoff by acting as a barrier and protecting against erosion and nonpoint source pollution
- Absorbing contaminants
- Moderating water temperature through shading
- Serving as a greenway corridor for birds, mammals, amphibians and reptiles
- Contributing leaves, woody debris and other organic matter as foundation for the food web and providing in-stream habitat for fish and other aquatic organisms
- Providing pleasing recreational corridors or views

Accelerated erosion and sedimentation problems occur in rivers and lakes throughout Michigan as a result of lack of riparian management. Hardening of the riparian zones, lack of shade due to deforestation and a lack of continuity in riparian areas all contribute to increased stream temperatures, resulting in declines of fish and wildlife habitat. In some watersheds, lack of upstream riparian filter strips or buffers results in the need for increased downstream dredging at river mouths for boat access and international shipping. Upstream riparian management of soils is an essential tool that can reduce the quantity of sediments and also improve quality of sediment. Sediment that is higher in



quality will improve opportunities for beneficial uses of dredged materials and reduce the need for costly dredge disposal.

Currently, a patchwork of regulatory and non-regulatory approaches are used to manage riparian zones, including watershed management plans, best management practices, state programs and landowner incentives. The success of many voluntary programs, however, is contingent on a well-informed and cooperative landowner. To maximize benefits, a more holistic watershed approach is needed for riparian area management. Taking a broad approach that considers the hydrologic function upstream and downstream for riparian management can have comprehensive impacts on aquatic ecosystems, international shipping, and river recreation. In addition, the interest in waterfront development combined with the need to decrease management costs (dredging) and reduce impacts of extreme weather events provides an opportunity to better define science-based actions and consciously manage riparian areas throughout Michigan.

Protect and Restore Wetland Function

Wetlands are among the most productive ecosystems and play a vital role in recreation, tourism and the economy. Michigan is home to a broad variety of wetland types, including deciduous swamps, wet meadows, emergent marshes, conifer swamps, lake plain prairies, shrub-scrub swamps, vernal pools, fens and bogs. These wetlands are a significant factor in the health and existence of other natural resources of the state and their hydrologic capacity provides flood control. They provide nesting, breeding and cover areas for many types of aquatic and terrestrial wildlife. They recharge our groundwater supplies and serve as natural filters for pollutants and sediment. Wetlands habitats also include diverse plant communities that have ecological, social, cultural and economic value such as wild rice.

Approximately 40 percent of Michigan's wetlands have been lost over time due to development and land use changes. The State has established a long-term goal of restoring 500,000 acres of wetlands. Partnerships are needed to develop innovative strategies to protect existing wetlands, and enhance wetland restoration and green infrastructure efforts that contribute to improving resiliency and diversity of aquatic resources. This is critical to sustaining Michigan's aquatic ecosystems and our urban and rural communities. Native wetland plant species such as the two native

species of wild rice (*Zizania spp.*), tend to grow in high-quality wetland areas and may be looked upon as an indicator species of climate change and water quality. Some species are listed as threatened. Fish and wildlife utilize wild rice beds and other native vegetation for spawning, brood rearing and as an important food source.



Wild rice was once present throughout the state in lakes, bays and river systems. However, threats from development and invasive species like *Phragmites* have competed with historic and restored stands of wild rice.

Wild rice is an integral part of Michigan's Indian heritage. Michigan tribes have expressed the significance of wild rice to their spiritual, historical, cultural, ceremonial, social values and relationships, food systems and economies. The tribes view themselves as caretakers, responsible for protecting wild rice. Some Michigan tribes initiated rice restoration efforts beginning in the late 1980s, while other tribes have joined this effort more recently with additional restoration projects. Successfully restored sites would benefit from increased public recognition and an adequate level of protection from threats like invasive species and other impacts.

To address both the ecological and tribal importance of wild rice, effective coordination, planning and implementation for control of threats such as invasive species, along with adequate protection within wetland habitats must be given a high priority from state, federal and tribal governments.

Restore Hydrologic Connectivity

Michigan has more than 2,500 dams, the majority of which are nearing or have exceeded their design life. Federal, state and local governments as well as conservation organizations are removing dams that provide little to no natural resource value to reconnect streams and rivers. However, challenges exist including ownership questions (74 percent of dams are privately owned), financial burdens, social views on dam removal and value of impoundments behind dams. Additionally, careful considerations must be made to

prevent the upstream movement of unwanted invasive species and downstream movement of contaminated sediment trapped behind dams.

Despite these challenges, federal, state and locally funded efforts have achieved progress in restoring connectivity. As examples, dam removal and river restoration projects are re-envisioning the role of the Boardman, Cass and Huron Rivers. These restoration efforts create greater opportunity for recreation and economic development by connecting water and place within communities.

Manage Groundwater Withdrawals

Michigan's water resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Despite the large volumes of surface and groundwater in Michigan – more than one quadrillion gallons by some estimates – there is growing concern about its use and about groundwater withdrawal effects on environmental function and integrity. Groundwater use and value is increasing, and the state must invest in the information and decision systems to realize groundwater's full value, promote its wise use and protect its hydrological and ecological integrity.

Groundwater is an important resource for commercial, industrial, domestic and public supply purposes. Most of Michigan's large groundwater withdrawals are for agricultural irrigation. More than 2,500 high-capacity irrigation groundwater wells have been registered for installation during the past four years. These wells greatly enhance economic development (in particular agricultural productivity), ensure against drought conditions and augment high-value crop production. However, as farmers and others develop more high-capacity irrigation wells, the odds of interfering with nearby domestic wells and surface water systems like rivers and lakes also increase. Responsible management of groundwater recharge is an issue of growing importance for ensuring sustainable groundwater resources and supporting demands for agriculture and other human uses.

Michigan has developed the Michigan's Water Withdrawal Assessment Tool to help the State manage groundwater withdrawals. A new or increased high-capacity well must be evaluated using the groundwater tool before installation. The Groundwater Tool is specifically designed to assess the likelihood

of an adverse impact of withdrawals on nearby streams, rivers and fish communities. Michigan's Water Use Advisory Council, established by MDEQ in 2012, completed its assessment of Michigan's water management framework, including the Water Withdrawal Assessment Tool, and issued a series of recommendations to MDEQ in December 2014. The MDEQ has since reviewed and assessed the recommendations and developed an implementation plan to address priority recommendations. The Water Withdrawal Tool creates publicly (and easily) accessible streamflow and groundwater elevation data, along with the total quantity of permitted withdrawals. The development of a robust and effective water management program for the state will be an ongoing, iterative process and the insights and recommendations such as the ones in the Council's report will continue to help shape the development of that process.

Improve Water Management in Urban Landscapes

In urban areas, impervious surfaces like roads, buildings and parking lots prevent rainfall from penetrating the soil. As natural vegetation is removed and these surfaces increase, the amount of evapotranspiration and groundwater recharge decreases. This causes increased runoff, stream channel erosion, buried river bottoms due to silt and sediment, reduced or lost habitat and aquatic species decline. Aging infrastructure and ill-managed or improperly managed stormwater runoff also contributes to sewer overflows, affecting water quality, ecological systems, creating human health risks and negatively impacting the enjoyment of water resources.

As municipalities struggle to address aging infrastructure and capacity issues, opportunities exist to transition away from grey to green infrastructure. Green infrastructure can increase a community's resiliency to severe weather events by increasing



infiltration and absorption of water. This reduces flooding risk, decreases surface runoff into lakes and streams and reduces impacts of aging systems. Many communities are considering developing green infrastructure such as wetlands, green spaces and buffer strips, as well as man-made infrastructure like rain gardens and bioswales. In addition, incorporating green infrastructure into transportation projects and placemaking initiatives can improve stormwater management and reduce pressure on existing water infrastructure. Overcoming barriers to green infrastructure such as limited funding mechanisms, regulatory and permitting requirements, institutional and organizational capacity and lack of understanding of design and maintenance requirements will be necessary to improve water management and address stormwater.

Improve Water Management in Rural Landscapes

Michigan's \$5.5 billion drainage infrastructure sustains some of the most productive agricultural land in the world and became a key component in developing land for residential, commercial, industrial and transportation purposes. However, the historical land changes that led to this productivity, such as the draining of wetlands, dredging and straightening of rivers and streams, converting streams to drains and deforestation have resulted in degraded water quality and aquatic ecosystems.

The agricultural community understands the importance of water resource conservation and is continuously considering new methods for managing water, including restoring hydrology, enhancing soil's capacity to retain and infiltrate rainfall and allowing for aquifer recharge. New science and technological advancements are also impacting agricultural water management with research in areas such as identifying the most efficient irrigation timing and amounts for crops in dry weather conditions, water reuse for irrigation and reducing nutrient loss via tile lines.

The federal Agriculture Act of 2014 commonly known as the Farm Bill is also providing resources to enhance conservation practice implementation in Michigan to address nutrients and sediment. Other initiatives are underway such as the newly formed regional and community-led Healthy Waters Working Farms initiative that combines conservation practices and farmland preservation to keep Michigan's rivers and lakes clean while keeping the best farmland working.

It is critical that governments, academia and industry collaborate to develop new tools, processes and systems to help local officials, landowners, agricultural producers and others who impact the rural landscape to take actions to improve water resources. The Natural Resource Working Group has concluded that the establishment of collaborative partnerships to support learning and adaptation is needed to foster community-based natural resource management. Engaging the rural community as a whole in deciding what behaviors should change to maintain and improve water quality and determine what actions would be necessary to encourage behavior change are necessary to drive performance toward desired outcomes on the landscape.

Goal: Michigan's Aquatic Ecosystems are Healthy and Functional.			
Outcome: Aquatic Ecosystems are Resilient and Diverse.			
#	Recommendation	Implementation Metric	Lead Actor
1	Prevent the introduction of new aquatic invasive species and control existing populations of AIS in accordance with the Michigan Aquatic Invasive Species Management Plan	By 2020, studies have been completed on a system of control points in the Chicago Area Waterways System to prevent the interbasin transfer of aquaic invasive species. By 2022, construction has been initiated at the Brandon Road Lock and Dam in Joliet, Illinois to prevent further upstream movement of invasive carp.	State and federal agencies, Tribal governments, Nongovernmental organizations (NGOs), Local units of governments, and individuals.
2	Work with other Great Lakes states and provinces to harmonize aquatic invasive species prevention, early detection processes and response actions across the Great Lakes region.	By 2017, implement a pilot project with Ontario and interested states to evaluate and pursue areas of harmonization.	State agencies, Province of Ontario
3	Accelerate research and solutions to identify mechanisms of food web disruption and changes of nutrient flows in the Great Lakes with a focus on the effects of invasive species.	By 2017, a minimum of three new research projects will be established for the purposes of evaluating nutrient shifts in Great Lakes food webs to help focus appropriate management, social, and economic responses.	Universities
4	Develop a comprehensive strategy to prevent nuisance and harmful blue green algal blooms.	By 2017, develop a strategy to prevent harmful algal blooms and HABs based on desired outcomes.	MDEQ, MDARD, MDHHS, Local health departments
5	Achieve a 40% phosphorus reduction in the western Lake Erie basin.	Develop and execute implementation plans to achieve a reduction in phosphorus loads from the Western Lake Erie Basin of 20% by 2020 and 40% by 2025.	MDEQ, MDARD
6	Develop harmful algal toxin water quality criteria and implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by harmful algae.	By 2020, increase by 20% the number of people served by drinking water suppliers using surface water sources with real-time monitoring equipment installed to provide early warning of potential public health threats. By 2020, develop harmful algal toxin assessment criteria. By 2020, implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by HABs.	MDEQ, MDHHS

#	Recommendation	Implementation Metric	Lead Actor
7	Support the development of a national drinking water advisory or action level target for harmful algal toxins.	Work with federal agencies to develop a national advisory target.	MDEQ, MDHHS
8	Incorporate planning for wet weather extremes, droughts and increased seasonal variability of precipitation into state, regional and community planning and infrastructure design to mitigate impacts to ecological, economic, social and cultural resources.	Best management practices are reviewed every five years and updated (if necessary) to reflect climatic changes such as changes in rainfall frequency, duration or intensity.	State, Regional governmental entities, Communities, NGOs
9	Provide technical assistance and develop technical tools and training programs for communities, local officials and stakeholders to inform and improve their water literacy and help them integrate water impacts into local land-use planning and decisions.	By 2020, develop a public official water literacy measurement tool. By 2020, develop a training module for local elected officials and decision-makers on the connection between land-use planning and zoning and the siting and approval of new projects. By 2020, develop a training module for local elected officials and decision-makers on the merits and benefits of asset management planning.	Universities, Regional government and planning organizations, NGOs, MDEQ
10	Develop tools and guidance related to shoreline and riparian ecology and management and provide necessary technical support and training to municipalities, watershed-based organizations and landowners to achieve full benefits of riparian areas.	By 2020, develop a baseline for the current research and educational capacities. <ul style="list-style-type: none"> • Coordinate to pinpoint areas of capacity expansion. • Develop tools, guidance and training on best practices. • Determine need to update guidance and training materials. 	MDNR, MDEQ, NGOs, Watershed organizations, Michigan Natural Shoreline Partnership
11	The State, working with tribal governments and stakeholders, will establish new partnerships to develop innovative strategies to enhance wetland restoration and green infrastructure efforts in Michigan. The tribes will work with the State to elevate the recognition, protection and restoration of native wild rice stands throughout the state.	By 2018, state agencies and stakeholders will work together to establish partnerships that develop innovative strategies to enhance wetland restoration and green infrastructure efforts. The tribes will work with the State to elevate the recognition, protection and restoration of native wild rice stands throughout the State.	MDEQ, MDNR, MDARD, Tribal governments, Local units of government, NGOs
12	Remove or improve dams that are no longer safe or ecologically, economically or socially viable to protect public safety and create healthy, connected aquatic systems.	By 2020, address all dams classified by MDEQ as high hazard facilities in unsatisfactory condition.	MDEQ, MDNR, Local communities, Dam owners

#	Recommendation	Implementation Metric	Lead Actor
13	Focus river and stream restoration efforts on addressing small hydrological impediments like culverts to enhance connectivity and restore stream stability.	By 2020, increase the number of small hydrologic impediments that are restored over a baseline established in 2016.	NGOs, Tribal governments and local units of governments
14	Refine and improve the water withdrawal assessment process and model to ensure sustainable use of water resources and that high priority is given to incorporating existing and new data to better represent local and regional water resources and surface water/groundwater interactions.	By 2020, initiate priority Water Use Advisory Council recommendations as identified in the implementation plan.	MDEQ, MDNR, MDARD
15	Provide technical and financial support to communities and their partners to plan and implement green infrastructure techniques and low-impact development while preserving natural spaces that contribute to water quality, including application of these techniques in the design of new developments, redevelopments and road projects to ensure stormwater management, improved hydrology and overall water quality.	By 2020, increase the number of attendees to green infrastructure conferences, applications for projects, amount of grant dollars awarded to projects incorporating green infrastructure or low-impact development, and number of programs incentivizing green infrastructure projects and the number of Michigan communities that are recognized for green infrastructure projects and strategies over a baseline established in 2016.	MDEQ, MDOT, MDNR, MEDC
16	Modernize road and highway planning and infrastructure and integrate with watershed planning to effectively accommodate storm water runoff and infiltration needs, thereby reducing the costs and impacts of flooding.	By 2020, increase the number of Michigan's new road and highway projects designed to better accommodate storm water runoff and infiltration needs over a baseline established in 2016.	MDOT, Local road and highway commissions, Watershed and regional planning organizations
17	Enhance financial and technical support of local stakeholder efforts to develop and implement watershed management plans to restore impaired waters, protect high quality waters and develop and utilize local water resource assets.	By 2018, increase the number of grants, training and educational opportunities that support the development and implementation of watershed management plans over a baseline established in 2016.	MDEQ

#	Recommendation	Implementation Metric	Lead Actor
18	Use existing authority to work with local units of government with storm water discharge or storm water-related hydrologic impairments in their waterways to establish Phase II storm water plans for impaired water bodies.	By 2020, increase the number of water bodies with storm water plans in place to address designated use impairments caused by storm water discharges and hydrologic impairments over a baseline established in 2016.	MDEQ, MDNR
19	Eliminate impairments in priority watersheds that have degraded water quality and/or aquatic ecosystems due to nutrient runoff and soil erosion. Engage landowners through a collaborative and adaptive community-based natural resource management process to identify local actions to change behaviors and develop solutions to achieve desired outcomes within established timeframes.	By 2018, identify priority watersheds. Develop performance standards to cover statewide land-use activities. Agricultural land-use will directly follow MAEAP guidelines and participation criteria to remain consistent with the state's recent efforts. By 2018, develop Regional Action Teams (RATS) through MAEAP with protocols for working with landowners. Educate collaborative teams on existing regulations and enforcement mechanisms allowed in their regions. Through RATS, identify additional required actions if demonstrable outcomes are not achieved within established timeframes.	MDEQ, MDARD

Part II

Create Vibrant Waterfronts

Support Water-Based Recreation

Promote Water-Based Economies



CREATE

vibrant waterfronts

Michigan's abundant water resources, including its coasts, ports and harbors, rivers, lakes and streams, make many communities desirable places to live, work and play. Historically, Michigan's waterfronts supported industries such as shipbuilding, power production, lumber yards, tanneries and chemical production. Many communities developed commercial centers with their backs to the water. As industries abandoned the waterfront, many became eyesores and the public's connection to water as a community asset was lost.

Initiatives such as the federal Clean Water Act, corresponding state water regulations, strong local champions, and recent investments from the GLRI have turned polluted waters into thriving systems. As a result, communities began to rediscover their waterfronts and reimagine their communities focusing on their water resources. Water is once again playing a pivotal role in transforming communities' economies and is reflected in their values and desires.

Integrate Water Assets into All Planning Initiatives

Including water assets in community development reestablishes the connection between citizens and the outdoors, building a sense of place and improving overall quality of life. The way people relate to water in their community can drive ecological, economic and social outcomes. A stronger understanding of this relationship is needed to assist communities with economic and community development through proper land-use planning and form-based design.

By understanding this relationship, communities can more effectively integrate water as a strategic asset, maximize economic and social capital, strengthen the relationship people have to water, and avoid potential challenges with conflicting or unaligned policies or actions. Ultimately, creating greater opportunities to interact with local water resources can help foster a water conservation ethic in individuals and the community.

Research shows people are willing to pay more to locate to areas with access to clean water and good environmental quality. Residents drawn to these environmentally attractive places help communities create more wealth and more jobs. Studies by the Brookings Institution and Grand Valley State University show a 3-to-1 and 6.6-to-1 return, respectively, on investments in restoring water quality and shorelines in the form of increased property values and local economic development.¹

Goal

Michigan communities use water as a strategic asset for community and economic development

Outcome

Economic and community development plans and efforts fully leverage water assets to create great places to live, work and play

Measure of Success

- All community and economic development plans integrate water resource assets.

Foster Community Leadership to Reconnect Communities to Water

Fully leveraging water assets will require fostering community leadership and local champions. These leaders, both inside and outside of government, should fashion a comprehensive, community-informed vision, strategy and implementation plan for stitching water into the fabric of their communities. The strategy and implementation plan must balance economic opportunities, environmental protection and human well-being to ensure sustainability. Communities such as Alpena have embraced their maritime heritage with partnerships between the community and the National Oceanic and Atmospheric Administration's Thunder Bay Sanctuary. Grand Rapids is reimagining its relationship with the Grand River through its plans to reinstate its namesake rapids. The magnificent Detroit River transformation has been developing for nearly a decade under the leadership of the Detroit Riverfront Conservancy. Many other communities including Marquette, Flint, Kalamazoo, Battle Creek, Traverse City, Boyne City and Petoskey have also refocused the role that their waterfronts play in their community's vibrancy. Their experiences provide powerful case studies to share with other Michigan communities.

Goal: Michigan Communities Use Water as a Strategic Asset for Community and Economic Development.

Outcome: Economic and Community Development Plans and Efforts Fully Leverage Water Assets to Create Great Places to Live, Work and Play.

#	Recommendation	Implementation Metric	Lead Actor
1	Emphasize water resources as assets in state, regional and community planning efforts to provide appropriate, sustainable protection and to fully leverage community-based economic opportunities.	Increase number of communities participating in the Redevelopment Ready Communities® program and those who work through the Waterfront Best Practices.	MEDC, MDEQ, MDNR, Regional governments and planning organizations, Local units of government
2	Support an annual mayor’s summit focused on creating high-quality communities that leverage strategic water assets.	Increase in property values as a result of increased economic activity and investment on or near water in a community, watershed or region.	Mayors
3	Provide in-depth technical assistance to support communities with developing and implementing community visions and strategies for waterfront redevelopment, access and use.	Increase number of communities participating in the Redevelopment Ready Communities® program and those who work through the Waterfront Best Practices.	Regional and interagency teams, Michigan Municipal League; County and Township Associations; Local economic development organizations, and Regional councils
4	Prioritize investments around strategic economic assets of commercial harbors and long-term, sustainable infrastructure.	By 2020, increase the volume of cargo handled at marine terminals receiving public funding for infrastructure projects.	MDOT, MEDC, MDNR, MDEQ’s Office of the Great Lakes, Governor’s Office of Public-Private Partnerships, Commercial maritime interests, Industry, Local planning professionals



SUPPORT

water-based recreation



Michigan's four Great Lakes, 11,000 inland lakes, 76,000 miles of rivers and streams and 3,200 miles of freshwater coastline provide abundant water-based recreation opportunities, making Michigan a great place to live and play while supporting a thriving tourism industry. Tourism is one of the largest industries in Michigan, generating \$17.7 billion of direct spending, \$995 million in state taxes and 200,000 jobs in 2011.³ Water-based tourism and recreation attracts and retains people who want to live, work and play and is an important part of growing a sustainable water-based economy in Michigan. However, challenges and opportunities exist in sustaining and expanding the state's water-based recreational opportunities.

Maintaining access to water resources while simultaneously preserving their integrity is critical to their long-term sustainability and integral to conserving the quality of life that makes Michigan a great place to live and a premier travel destination.

Improve Beach Health

Beach days are among the fondest memories of Michiganders' summer vacations, but pathogens such as E. coli threaten this treasured asset. The Great Lakes and inland public beaches are monitored for pathogens on a voluntary basis by local health departments, supported by MDEQ which awards grants for this purpose. In 2015, 98 beaches reported 212 incidents of E. coli exceeding accepted water quality standards. While the durations were typically short, (usually one or two days) any closure impacts recreation and tarnishes the state's image.

Causes of beach contamination include releases from wastewater treatment plants, sewer overflows, leaking septic systems, runoff from agricultural operations, and excessive wildlife on beaches. These causes are addressed in other sections of the Water Strategy; however, additional real-time beach monitoring data is also needed to provide timely advisories that protect public health.

Address Fish Consumption Guidelines

Michigan continues to need guidelines detailing safe fish consumption amounts due to ongoing and historical deposition of persistent, bio-accumulative toxic (PBTs) pollutants like perfluorooctane sulfonate (PFOS), mercury, PCBs and banned pesticides such as DDT. Addressing sources of ongoing deposition and sites of legacy contamination is critical to restore human use and enjoyment of fishery resources.

Goal

Michigan's water resources support quality natural resources, recreation and cultural opportunities

Outcome

Waters of the State are world-renowned for recreational pursuits such as hunting, fishing, boating, and swimming

Measures of Success

- Increase in water-based recreation and tourism.
 - 90% of the population has convenient access to swimmable and fishable water.
-

In some cases, global sources are contributing to atmospheric deposition of mercury and other PBTs and will require a state, regional and national approach to reduce emissions. Michigan's participation in national and regional efforts to eliminate anthropogenic (human-caused) mercury use and releases from fuels or raw materials, or from uses in products or industrial processes, is critical to having an impact on this global problem. The MDEQ's 2008 Mercury Strategy Report estimated most of the mercury released into the environment is released into the air, with a smaller amount being released directly to water and land. A 2002 inventory estimated about 7,000 pounds of mercury were emitted into the air in Michigan that year. About 37 percent was from coal combustion and about 30 percent was from the use of mercury in manufacturing and industry. This estimate has been used to establish a baseline for measuring progress toward reducing emissions. Between 2002 and 2011, ongoing pollution prevention activities, permitting and regulations resulted in mercury air emission reductions of 1,000 to 2,000 pounds of mercury. Coal-fired power plant retirements and use of additional coal combustion control equipment may eventually reduce mercury emissions in Michigan by 80 to 90 percent.

Although atmospheric deposition of mercury, PCBs and other PBTs contribute contaminants to fish in most Michigan water bodies, the highest concentrations measured are associated with legacy contamination

S	Smaller fish are better. They tend to have fewer chemicals.
a	Avoid large predator fish & bottom-feeders. Always check the <i>Eat Safe Fish Guide</i> before eating these fish.
f	Fat should be removed. Some chemicals are stored in the fat of the fish.
e	Eat fish that have been broiled or grilled on a rack. More fat can drip away during cooking.

MDHHS “Eat Safe Fish” guidelines inform communities about best practices regarding fish consumption

sites. For example, the “do not eat” guideline covers all species of fish on the Kalamazoo River between Morrow Dam and Lake Allegan because of past practices at paper mills. In several Areas of Concern (AOC), the fish consumption beneficial use impairment (BUI) designation has been removed due to restoration efforts over the last several decades. Although improved, fish consumption guidelines will continue to be in place for the undetermined future at these sites – even after BUI removal and AOC delisting – due to lingering (although lessened) contamination in the sediment, as well as ongoing air deposition. The GLRI has enabled rapid progress toward restoring human uses of fishery resources, and sustained support for the GLRI is needed to continue progress.

Monitoring of fish for legacy and emerging contaminants is important to protect public health. In 2014, perfluorooctane sulfonate (PFOS), a key ingredient in fire-fighting foam, first appeared in Michigan Department of Health and Human Service’s Eat Safe Fish Guide as a chemical of concern for fish consumption for the Au Sable River near the decommissioned Wurtsmith Air Force Base in Oscoda. In 2015, PFOS fish consumption guidelines were also included for the Flint River, Rogue River and St. Joseph River. Michigan must continue to prioritize and institutionalize the continued monitoring of legacy and emerging contaminants in order to ensure that Michigan maintains its status within the Great Lakes as a leader in the adoption and implementation of best available science to protect public health.

Ensure Sustainable Recreational Harbors

Michigan has more than 80 recreational harbors that contribute significantly to the quality of life and economic vitality of host communities. In addition, harbors help support Michigan’s \$4 billion boating industry.⁴ Unfortunately, many harbors are in poor or failing condition and limited financial resources hamper sustainability.

The Michigan Department of Natural Resources completed an inventory and condition assessment of recreational harbor infrastructure in 2014. Additional research, planning and prioritization is needed to identify critical sources of sediment that diminish the value of the harbor and increase maintenance costs, prioritize long-term capital investment needs, and create strategies to market harbors.

Too often, communities have not realized the full economic and social value of their harbors; they are rarely integrated into community and economic development plans

A multi-agency and university partnership is also conducting assessments to evaluate the complexity of the issues facing harbors while developing community guidance to ensure sustainability. Too often, communities have not realized the full economic and social value of their harbors; they are rarely integrated into community and economic development plans. This integration is necessary for prioritizing and leveraging capital investments. Variable lake levels, infrastructure condition and depreciation, access, boating trends and future use of the harbor all need to be considered to ensure harbor and marina sustainability.



Increase Access to Lakes, Rivers and the Great Lakes

Since water plays such a pivotal role in many Michiganders' lives, access has always been a priority. In 1939, the Legislature first earmarked funds to purchase water frontage to improve access for fishing and boating. Since then, more than 1,200 public launching sites have been developed for boaters. The Natural Resource Trust Fund remains an important part of providing recreational opportunities, including access to Michigan's waters, but with more than 11,000 lakes and thousands of miles of rivers, streams and Great Lakes coastline, significant gaps in access remain. The 2013 Michigan Department of Natural Resources Managed Public Lands Strategy and the Great Lakes Water Trail Plan both recognized this need. When addressing access gaps, protection of ecologically sensitive areas needs to remain foremost, and increasing access for people of all abilities to experience and enjoy Michigan's water resources should be a priority.



Designate Water Trails

Michigan has endless opportunities for establishing a spectacular water trail system. Much of the framework for such a system already exists, and some water trails have recently been developed on several rivers using existing access sites, harbors of refuge and waterside campsites. Statewide criteria for designating a trail is needed, including level of difficulty, distance between access sites, and trail amenities such as nearby campgrounds, restaurants and restrooms. Ensuring these areas are accessible by transit and non-motorized systems is important to creating a statewide water trails system.

**Goal: Michigan's Water Resources Support Quality Natural Resources,
Recreation, and Cultural Opportunities.**

**Outcome: Waters of the State are World Renowned for Recreational Pursuits
such as Hunting, Fishing, Boating, and Swimming.**

#	Recommendation	Implementation Metric	Lead Actor
1	Expand the use of real-time monitoring and source tracking techniques at high risk beaches by local health departments, counties, communities and universities, and address sources of beach contamination.	By 2020, all of Michigan's water meets total and partial body contact designated uses with no closures or advisories. Real-time monitoring is in place at all high-risk beaches.	MDEQ, Local health departments, Local units of government, Universities
2	Continue national, regional and state coordination of mercury reduction activities including implementation of the Great Lakes Mercury in Products Phase-Down Strategy, the Great Lakes Emissions Reduction Strategy and MDEQ's mercury regulations and pollution prevention activities.	Reduce the mercury levels in edible portions of fish from the Great Lakes, inland lakes and streams to below 0.35 parts per million by 2020.	MDEQ, MDHHS
3	Prioritize and institutionalize the continued monitoring of fish for legacy and emerging contaminants to protect public health.	By 2018, fund and continue to support monitoring of fish for legacy and emerging contaminants.	MDEQ, MDHHS, MDNR, Legislature
4	Prioritize infrastructure needs for repair and upgrade of public recreational harbors and their landside access. Support investments in communities involved in long-term harbor sustainability planning and implementation that integrate community, economic development and watershed and resiliency planning.	By 2017, develop a prioritized list of infrastructure needs. By 2020, increase the number of communities that integrate harbors as a strategic asset in community, economic development, watershed and resiliency planning over a baseline established in 2016.	MDNR, Waterways Commission, MDEQ, MDOT, ACOE, MEDC
5	Establish a harbor town program and improve marketing of harbors. The program should work with MDEQ to address sources of upstream sediment, sediment reduction and relocation strategies.	By 2017, establish a Harbor Town program. Work with stakeholders to address sources of upstream sediment, sediment reduction and relocation strategies.	MDNR, MDEQ Local units of government
6	Work with local partners to provide public access every five miles on the Great Lakes, on all priority lakes over 100 acres in size and on every five miles of navigable water, as environmentally appropriate.	Establish public access every five miles on the Great Lakes and on all priority inland lakes larger than 100 acres.	MDNR, Local units of government, Lake Associations, NGOs
7	Work with stakeholders to develop and implement a designated water trail system for inland waterways and along the coast and market water-based recreational opportunities.	By 2020, a designated water trail system has been established by the MDNR.	MDNR, Local units of governments, NGOs



PROMOTE

water-based economies

Michigan's water and Great Lakes, in general, have played a defining role in the state's economy starting with fur trading and continuing across time through the lumber boom, agriculture, manufacturing and more recently with tourism. Michigan should build off these past experiences by highlighting and marketing its strategic advantages as the Great Lakes state, growing leadership and harnessing talent in research and development, accelerating innovation in water technology and optimizing water efficiency. This could represent a whole new chapter of the state's long-standing water-centric economic history. However, rather than degrading our water in exchange for economic growth as we have in the past, we can create pioneering solutions for growing water-based economies that improve community stewardship and sense of place simultaneous with economy growth.

Michigan and other places across the globe face severe and complex challenges in water quality and quantity. The state is well-positioned through its research, talent, innovation, industrial design, capital, fabrication and deep manufacturing expertise to be a powerhouse for solving these challenges and growing its economic opportunities around water and to do so in a manner that ensures sustainable use and stewardship of the resource. Opportunities for collaboration abound among industry, governments, economic developers and academia (in Michigan and the region's neighboring states and Canada) to direct water research and support new technologies and innovation.

Market Michigan's Strategic Advantages

Currently, Michigan hosts about 350 companies that provide technology, goods and services related to the supply, treatment, distribution, storage, transport, recycling, rehabilitation and conservation of water. As a 2014 University Research Corridor analysis highlighted, more than one out of five jobs in the state are strongly linked to water, a number that does not include outdoor recreation and tourism.⁵

The understanding of the importance of water as central to public health, healthy ecological systems, people and economies is growing. Electric utilities, mining, steel manufacturing and the food and agricultural sector face increasingly higher costs as a result of water scarcity across the nation. Water-intensive companies in water-stressed areas are at the highest risk of experiencing production disruptions, stranded assets, increased capital costs and community conflicts over shared resources.

Goal

Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies

Outcome

Policy, innovative practices and technologies are developed and adopted to grow sustainable water-based economies

Measures of Success

- Michigan is recognized as a place to invest and locate a business due to its support of sustainable water technologies, water conservation, and high quality of life.
- Increase in percentage of economic output per gallon of water utilized.
- Increase in water sector employment and earnings at the statewide and county level.

Water is a key factor in the economic health of many corporations and therefore a significant and knowable element in overall corporate stock price and volatility. In a 2015 survey, the World Economic Forum ranked water crises first as a critical risk to the global economy.⁶ According to a Pacific Vox survey of 50 Fortune 500 companies from a broad cross-section of industries nationwide, concern about water scarcity has grown dramatically during the past five years. By 2018, 86 percent of the companies expect to consider water availability in their site selection, up from 37 percent in 2008.⁷

Water is now seen as an increasing factor in the investment decisions affecting the deployment of trillions of dollars of capital. Researchers, financial managers, investors and corporations are beginning to fully understand how water contributes to or mitigates risks throughout the business cycle. Risks are not just within how a company operates but also in how suppliers and business partners manage that risk as well throughout the supply chain. A key challenge that investors face is how to quantify and value financial risks from regulatory, physical and reputational impacts from water. The University of Michigan is conducting innovative research about water risk and corporate behavior, but further research is needed about the value the state's water resources can add to managing water-related risk, stock price volatility and overall financial performance.

Optimize Efficient Use of Water in Business, Utilities and Municipalities

If Michigan's abundant clean water supply is efficiently managed, the state's economic capacity can grow while ensuring water stewardship. In a state with generally abundant water resources, it is difficult to appreciate that water is not disposable and that every drop is valuable. However, there are some areas of the state experiencing localized water scarcity due to increasing demands from groundwater withdrawals. An appreciation for efficient use of water needs to spread across the state to ensure the sustainability of this precious resource. All Michiganders have an obligation to be good and thoughtful stewards of this global treasure by using water more thoughtfully and efficiently.

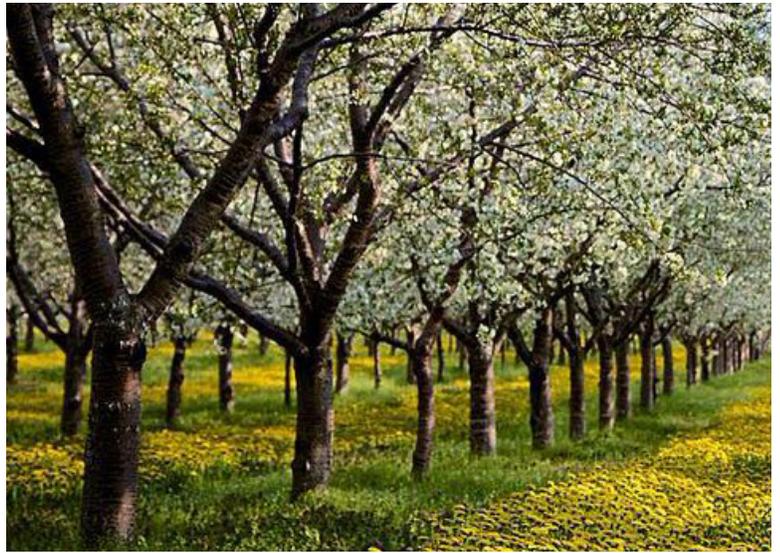
Under the Great Lakes Compact Agreement, each state is required to establish water conservation measures for each water use sector; however, limited data is available on current water use for each sector beyond gross numbers and anecdotal information. Without goals or objectives, we cannot evaluate progress in reducing water use impacts and determine if improvements are needed.

Michigan's residential, industrial, and commercial sectors are all showing increases in water conservation.

In 2012, the State formed the Water Use Advisory Council and tasked it with providing insight and advice to the State on Michigan's Water Use Program which includes the Great Lakes Compact, water withdrawal and water use conflict. One specific charge to the Water Use Advisory Council was to provide advice on water conservation and efficiency goals, objectives and voluntary measures. Recommendations from this Council were issued in December of 2014 and initially were not part of the draft language in the Water Strategy.⁸

A host of the recommendations in the report related to water conservation – twenty three in all - have now been incorporated into the implementation plan for the Water Strategy. Two recommendations from that report in particular bear repeating here.

1. "Michigan should improve its water use-related data management program. This includes improving the quality of current water use reporting, the



capacity to track water usage, the result of conservation measures, and the development of water demand analysis for individual water use sectors. In particular, each water use sector should design the appropriate data sets in order to track water use, progress on water efficiency and conservation, and develop demand analysis.

Development of these data sets must balance the need to be generally applicable to a sector or sub-sector and the ability to be tracked over time with the complexities of the circumstances faced by each particular user. The state-specific outcomes described in Recommendation WC 5.1 can inform the development of these data sets. Ideally, these data sets could be recommended for Great Lakes Basin-wide use."

2. "The MDEQ should incentivize water conservation and efficiency in the public sector by rewarding the implementation of water conservation and efficiency measures when applying for State funding for water infrastructure projects. This could be accomplished by providing significant points to project plans from water systems that already have a water conservation and efficiency plan, thereby increasing the likelihood that the project will be funded."

Progress toward increasing water conservation in Michigan is underway. Residential, industrial, and commercial sectors are all showing increases in conservation, as is agriculture. While agricultural use of water, and in particular agricultural use of groundwater is increasing, the efficient use of that water for irrigation purposes is also increasing through the deployment of technology and information systems. Businesses are focusing efforts around

water sustainability to improve their bottom line and to further comply with environmental standards. Others are recognizing the importance of water globally and are beginning to work more holistically outside corporate walls. For example, major Michigan corporations like Ford Motor Company, Consumers Energy, General Mills, Whirlpool, Amway and Dow, among others, are all heavily engaged in water management as part of their corporate sustainability and operational programs. Many of these companies have set aggressive water efficiency targets. For instance, Consumers Energy has set a water reduction target of 20 percent between 2012 and 2020. Ford Motor Company set a goal of reducing its water footprint by cutting the amount of water used per vehicle by 30 percent globally between 2009 and 2015.

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) also urged cities to participate in the GLSLCI Water Conservation Framework to help meet its commitment of reducing water use within city limits by 15 percent in total water usage by 2015 using 2009 water consumption levels as a baseline.

Conservation makes not just social sense, but business sense. Water is heavy, requiring a significant amount of energy to move through the system. Measureable water loss can be attributed to leaking and poorly maintained municipal infrastructure. In addition, cleaning and purifying water for drinking water, manufacturing and discharge is very costly. Nationally, between 4 and 13 percent of all energy is used to pump and treat water for waste management or for industrial and commercial processes.

For businesses and industries that require water use as a core part of their operations, energy (and cost) savings can happen in two ways: increasing the efficiency of pumping and treating water, or by reducing the total use of water per capita, per industrial or municipal process. Capital asset management planning and infrastructure upgrades should reflect these goals.

Wastewater reuse through energy generation also provides economic opportunities. Innovative solutions to wastewater management can minimize water and energy footprints. Firms like Moore and Bruggink have reengineered Greenville's wastewater treatment facility to produce its own energy, reducing costs and energy consumption by more than 30 percent.⁹

In addition to using less water through efficiency measures, water reuse should be explored in situations where potable water quality is not required and risk for cross-contamination is low. This must be done with critical attention to public health and infrastructure. Michigan should develop standards, protocols and strategies to protect public health and preserve surface water and groundwater resources while facilitating rain and grey water reuse in appropriate situations.

Optimize Water Sustainability Practices for Agriculture

Agriculture is another example of a major water user in Michigan that has made significant advancements to improve efficiency. Water, energy and food are inextricably linked. Growing populations, improving technologies, high crop prices and specialty crops like seed corn have led to expansion of irrigation and agriculture production into regions of the state where it was once unfeasible. Biotechnology advances, especially shorter-season crop varieties, and climatological and meteorological changes with accompanying longer growing seasons make farming in the northern part of the state a more viable opportunity.

As agriculture continues to grow in Michigan, there will be more pressure on aquifers and greater potential for use conflicts. More intensive use of land will require greater management of water. While total agricultural water use is increasing, the efficiency of the transformation of water into crops is also increasing. There are opportunities for agriculture to use more sophisticated irrigation delivery and water management systems to minimize overall water use per unit output. Continued efforts to increase efficiency can reduce conflicts in localized areas that have water shortages, reduce related energy costs, and reduce water use impacts. There are many synergies and trade-offs between water and energy use and food production. The goal is not necessarily to reduce water use, but to reduce the impacts of agricultural water use on ecological systems and to use it more judiciously.

Aquaculture is another area that could thrive based on Michigan's plentiful water supply and high water quality. In a world demanding ever-increasing amounts of high-quality fish and protein, growing the state's aquaculture industry will require significant innovation in water technology to ensure sustainability and protection of water quality and the health of current fisheries. In particular, industry and the state should continue to support closed loop or recirculating

systems. Working together to create models and incentives for lowering energy costs of production, improving water filtration and strengthening supply chains for commercial aquaculture systems will enable the industry to grow substantially in an ecologically responsible fashion.

Efficient use of water also affects the processing and manufacturing supply chain. Companies like Kellogg, MillerCoors and General Mills are focusing efforts around water sustainability by working with the agricultural community to implement best practices such as efficient delivery of water to crops, efficient use of water, and impact accountability. In areas with water scarcity issues like Texas, Colorado and other western states, technological advancements are reducing pressure on aquifers with inadequate recharge. Establishing targets for water efficiency in areas with localized water stress may reduce the potential for conflict.

Another recommendation from the Water Use Advisory Council's report is pertinent to the agriculture sector. "Based on the water use trends, more focus needs to be placed on conservation and efficiency in the Irrigation Sector. MDARD has developed comprehensive guidance in the form of Generally Accepted Agricultural and Management Practices (GAAMPs), which includes guidance in preparing a water conservation and efficiency plan. MDARD and Michigan State University (MSU) Cooperative Extension should continue to provide and expand training and outreach to the Irrigation Sector to increase the use of these GAAMPs."

Accelerate Innovation and Technologies to Solve Water Challenges

Michigan has opportunities to advance the technology, science, research and education required to improve water management. These water technologies can be an economic driver for the state. To capture its share of the global water technology sector predicted to reach \$1 trillion annually by 2020, Michigan must nurture an environment that fosters water entrepreneurs, supports a high-performing water technology sector, and leverages the state's innovation, research, development and extensive manufacturing capabilities.

Michigan faces a number of complex challenges regarding water quality and quantity but the state also has a history of developing innovative water technologies to help meet those challenges while exporting those technologies to global markets.



Different water sectors – municipal, agriculture, manufacturing and industry – all have specific needs requiring technological solutions such as maximizing water efficiency, minimizing water loss, meeting more rigorous discharge standards, and dealing with new forms of contamination from emerging chemicals and pharmaceutical products. A recent report on Michigan's Blue Economy by the Michigan Economic Center and Grand Valley State University Annis Water Resources Institute highlights examples of successful efforts to develop and deploy cutting-edge water technologies to address some of these needs and challenges.¹⁰

Michigan has the ideas and research; academia, businesses, and end users need to align goals and desired outcomes for technologies to actually reach the market. In addition, Michigan community colleges provide a mechanism for needed job training to expand water-related industry sectors. Focusing on innovation in water technologies does not represent a philosophical change to the state's approach to economic development but rather recognizes the importance of aligning interests, making clear statements about priorities, and connecting the pieces together to drive entrepreneurial innovation. By building robust public-private partnerships, Michigan can link innovation, research and development, capital investment, entrepreneurialism, and end users to achieve desired environmental, economic and social outcomes. When an accelerator of public and private funding is combined, ideas can move more quickly from design to deployment and markets.

Goal: Michigan has a Strategic Focus on Water Technology and Innovation to Grow Sustainable Water-Based Economies.

Outcome: Policy, Innovative Practices, and Technologies are Developed and Adopted to Grow Sustainable Water-Based Economies.

#	Recommendation	Implementation Metric	Lead Actor
1	Highlight the State’s competitive advantage as a highly attractive place for business creation and investment because of our abundant natural water assets, water research capabilities, highly skilled talent, economic development expertise, manufacturing expertise and powerful tourism and business-marketing brand.	Increase the number of water-dependent companies and investments including water dependent tourism companies locating in Michigan. Specifically track aquaculture flow through and recirculating technology and related opportunities.	MEDC, MDNR, MDARD, Academia
2	Conduct a comprehensive review of all state and local laws, regulations and rules which impact water to remove barriers, inconsistencies, overlaps and reduce regulatory process to improve and facilitate investment in sustainable water-based economies in Michigan.	By 2017, complete a comprehensive review of all state and local laws, regulations and rules which impact water to identify barriers, inconsistencies, overlaps and reduce regulatory process to improve and facilitate investment in sustainable water-based economies in Michigan.	LARA, MDEQ, MDARD, DNR, MEDC
3	Establish voluntary water efficiency targets for all major water sectors to reduce water use impacts and costs.	By 2020, develop a baseline for water usage, data collection and definitions to inform development of water conservation goals and objectives. Collect data for two years. Increase by 20% the number of businesses, industries, and municipalities with water efficiency within their water management plans.	MDEQ, MDARD
4	Promote innovative technologies that reduce cost and water loss or convert waste products to usable materials.	By 2020, increase the number of new, innovative and cost-effective technologies, pilot projects, and startups that are commercialized, come to market and result in connections with end users to reduce costs and water consumption, or convert waste products to usable materials and produce energy over a baseline established in 2016.	MDEQ, MDARD, MEDC
5	Develop a water conservation and reuse strategy for the State, local governments and public and private facilities that incorporates the use of green infrastructure, grey water systems and energy production that includes recognition programs.	By 2018, develop a water conservation and reuse strategy that identifies major sectors by water use and their locations.	MDEQ, MDARD, MDOT, NGOs

6	<p>Fund a pilot project, through a competitive bid process, for the initiation and evaluation of a new model for wastewater management. This pilot program will assess the opportunities and barriers to creating a “Water Resources Utility of the Future,” focused on:</p> <ul style="list-style-type: none"> • Reclaiming and reusing water • Extracting and finding commercial uses for nutrients and other constituents • Capturing waste heat and latent energy in biosolids and liquid streams • Generating renewable energy using its land and other assets • Using green infrastructure to manage storm water and improve urban quality of life 	By 2017, pilot project is funded.	Legislature
7	<p>Define measures of agriculture water conservation and establish voluntary targets for utilizing best management practices (BMPs) that reflect conformance with the Irrigation Water Use Generally Accepted Agricultural and Management Practices in areas of existing or potential water stress.</p>	By 2017, using information collected in the water use reporting tool, develop a baseline for the number of farms with irrigation systems utilizing best management practices (BMPs). Increase the number of producers located in water stressed regions that are utilizing BMPs and are considered in conformance with the Irrigation Water Use Generally Accepted Agricultural and Management Practices by 2020.	MDARD, Universities, Water use sectors
8	<p>Enhance voluntary water conservation measures through technology and outreach for agriculture to optimize water use while reducing impacts and costs.</p>	By 2017, develop a baseline for water usage, data collection and definitions to inform development of water optimization goals and objectives. Increase the number of agricultural sectors that have water efficiency plans and water optimization targets by 2020.	MDARD
9	<p>Create a strategic focus on water innovation to attract and accelerate new technologies to market through a business-led council comprised of private investors, entrepreneurs, corporations, public agencies and universities, and nongovernmental organizations to better manage water challenges in Michigan and worldwide.</p>	By 2020, increase the number of new, innovative and cost effective technologies, pilot projects, and startups that are commercialized, come to market and result in connections with end users to solve water problems over a baseline established in 2016.	MDEQ, MEDC, MDNR, MDARD
10	<p>Create strategic focus through the State’s existing public and private research and development assets, the Universities’ Water Centers and Institutions, and community colleges on education, innovation, talent development and research focused especially on critical water challenges.</p>	By 2017, conduct an assessment of Water Centers and research institutions’ current focus on water challenges and water related research areas. Convene leadership from these public and private institutions to develop a set of shared strategic goals to address critical water challenges.	MDEQ, MDNR, MDARD, Water centers, Universities, Community colleges

Definitions and Acronyms

- AIS - Aquatic Invasive Species - An invasive species is defined as a species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health.
- AOC - Areas of Concern - Federally designated places where numerous beneficial uses of the areas (fishing, swimming, hunting, drinking water) have been impaired due to historical contamination.
- CAWS – Chicago Area Waterways System
- DDT - A commonly used pesticide (Dichlorodiphenyltrichloroethane) that was banned in 1972 that has contributed to fish consumption advisories in the Great Lakes ecosystem.
- Evapotranspiration - How water is transferred from land to the atmosphere by evaporation from the soil and transpiration from plants.
- Flashiness - The ability of a stream to quickly reach flood stage after a snowmelt or rainfall event.
- MDEQ – Michigan Department of Environmental Quality
- MDNR – Michigan Department of Natural Resources
- Ecosystem - The complex set of relationships among living resources and their habitat
- Food web - The system of interlocking and interdependent food chains
- GLITTH – Great Lakes International Trade and Transport Hub
- GLRI - Great Lakes Restoration Initiative
- GLSLCI – Great Lakes and St. Lawrence Cities Initiative
- Grey infrastructure - Impervious surfaces like roads, buildings, and parking lots which prevent rainfall from penetrating the soil.
- Grey water - The relatively clean wastewater from sinks, baths, and washing machines.
- HAB – Harmful Algal Bloom - Algal blooms that produce concentrations of harmful toxins such as blue green algae or cyanobacteria.
- Impaired waters – Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes.
- Implementation metric – A tactical metric to measure progress toward accomplishing the recommendation.
- LARA – Michigan Department of Licensing and Regulatory Affairs
- MAEAP - The Michigan Agriculture Environmental Assessment Program is an innovative, proactive, and voluntary program that helps farms of all sizes and all commodities voluntarily prevent or minimize agricultural pollution risks administered by the Michigan Department of Agriculture.
- MDARD – Michigan Department of Agriculture and Rural Development

MDHHS – Michigan Department of Health and Human Services

Measures of Success – A measure of the improvement in environment, social or economic conditions over time as a result of multiple actions.

MEDC – Michigan Economic Development Corporation

Nonindigenous - Fish or wildlife not native to a place.

Nonpoint source pollution- Pollution that comes from snowmelt and stormwater that flows over impervious surfaces, collecting pollutants, and eventually drains into a body of water.

NREPA – Natural Resources and Environmental Protection Act

Outcomes - The desired final end results.

PBT – Persistent Bio-accumulative Toxin

PCB - Polychlorinated Bi-Phenyl

Point source pollution- Pollution from industrial and sewage treatment plants that is directly deposited into the water.

Redevelopment Ready Communities Program- A statewide certification program that helps communities adopt innovative redevelopment programs and become economically competitive.

Stormwater- Water from precipitation events that runs off impervious surfaces and collects pollutants.

Sustainable- Able to be maintained indefinitely without significant depletion of resources.

URC - University Research Corridor - The formally created research cooperative comprised of the University of Michigan, Michigan State University and Wayne State University.

U.S. EPA – United States Environmental Protection Agency

Water literacy principles - The understanding of water's influence on the individual and the individuals influence on water. An example of a water literacy principle is that bodies of fresh water are connected to each other and to the world.

Watershed- The area of land from which water drains into a receiving body of water.

WHO – World Health Organization

WLEB - Western Lake Erie Basin

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