

2020 State Water Plan: Water and Climate





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The Environmental Quality Board is mandated to produce a 10-year state water plan pursuant to Minnesota Statutes, 103B.151, 103A.43, 103A.204.

This report was prepared by the Environmental Quality Board with the Board of Water and Soil Resources (BWSR), Department of Agriculture (MDA), Department of Commerce, Department of Health (MDH), Department of Natural Resources (DNR), Department of Transportation (MnDOT), Metropolitan Council, Pollution Control Agency (MPCA), University of Minnesota.

Edited by Mary Hoff
Designed by Amanda Scheid

Cover photo: Two generations of MPCA volunteers monitor water clarity in Lake Harriet, Minneapolis. Citizen volunteers measure the clarity of lakes and streams, collecting valuable data the MPCA uses to make decisions on watershed protection and restoration.

Letter From the Board

Minnesota's way of life is intertwined with water. We depend on water for drinking, food production, healthy ecosystems and emotional well-being. We swim, fish, play and celebrate in and around water. Climate change is already impacting our more than 10,000 lakes, 100,000 miles of rivers and streams, abundant groundwater, and all of us. The effects of climate change are expected to accelerate in the coming decades.

In 2008, Minnesotans showed that we value water with passage of the Clean Water, Land and Legacy Amendment, creating a stable funding source for and a watershed-based approach to protection and restoration of our water resources. Since then, increased investments in monitoring, evaluation, watershed planning and implementation of projects have enabled us to do much more to protect, enhance, and restore water quality in lakes, rivers and streams and to protect groundwater from degradation. However, many challenges remain. Climate change is one, and we are only just beginning to understand how it is impacting Minnesota's waters and the challenges it will pose for the future.

The goal of this report is to shine a spotlight on actions Minnesota can take to protect our waters from climate change. In order to protect our waters, we must also take decisive action to reduce greenhouse gas emissions to curb the worst effects of climate change. We are releasing this report at a time when Minnesota is reckoning with multiple stressors, including a pandemic and the resulting economic fallout, and a legacy of economic and racial inequities. Black, Indigenous and people of color are particularly vulnerable to threats at the intersection of water and climate change. This Board, and the agencies responsible for implementing this plan, must increase our efforts to address these systemic inequities and engage with these communities openly, respectfully and transparently.

Planning for the future of Minnesota's water must include an honest appraisal of the effects our changing climate is having on this vital resource and how these changes will impact Minnesotans, wildlife, habitat and landscapes across the state. Fortunately, the actions we take to improve water quality and manage water quantity, from soil health to water storage, can also reduce greenhouse gas emissions and help us adapt to a changing climate.

What we collectively aim for and accomplish over the next 10 years will have ripple effects over the next 100 years. As a headwaters state, our actions will impact not only our neighboring states and provinces, but also the major water basins downstream, from the Gulf of Mexico to the Great Lakes to Hudson Bay. Likewise, our partnerships with local, state, regional and national governments and organizations both outside and inside our boundaries will be critical in realizing the aspirations and goals of this plan.



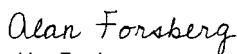
Laura Bishop, EQB Chair
Commissioner, Minnesota Pollution Control Agency



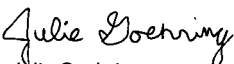
Margaret Anderson Kelliher
Commissioner, Department of Transportation



Kristen Eide-Tollefson
Public Member, Congressional District 2



Alan Forsberg
Public Member, Congressional District 1



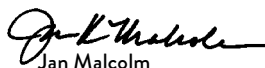
Julie Goehring
Public Member, Congressional District 7



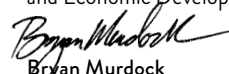
Steve Grove
Commissioner, Department of Employment
and Economic Development



Steve Kelley
Commissioner, Department of Commerce



Jan Malcolm
Commissioner, Department of Health



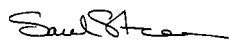
Bryan Murdoch
Public Member, Congressional District 8



Thom Petersen
Commissioner, Department of Agriculture



Alice Roberts-Davis
Commissioner, Department of Administration



Sarah Strommen
Commissioner, Department of Natural Resources



Gerald Van Amburg
Chair, Board of Water and Soil Resources



Sue Vento
Council Member, Metropolitan Council

2020 Water Plan purpose

The Minnesota Legislature has directed the Environmental Quality Board (EQB) to coordinate comprehensive long-range water resources planning and policy through a State Water Plan every 10 years ([Minnesota Statutes 103B.151](#), [103A.43](#), [103A.204](#)). This plan fulfills the legislative mandate.

The purpose of the 2020 State Water Plan is to establish a framework for aligning state agencies, legislative priorities, and local government policy, programs and actions for the coming decade. EQB developed this plan to set an agenda for tackling the stubborn and complex water problems that climate change will intensify for Minnesotans. In preparation for this report, EQB convened state agencies, met with over 250 people from 44 public and private organizations, and conducted two informal surveys to learn about concerns related to water and climate and thoughts on what actions local and state government should take. The plan defines goals, strategies and actions. It highlights key water issues related to climate, but it is not an exhaustive list of the challenges we face or the solutions to implement. Ideas set forth in this plan can help establish priorities and inform decision-making, and they underscore the need to take actions with multiple benefits across several goals to move beyond our current trajectory.



Source: DNR

A Look Back: Water Policy and Planning Highlights

- 1982:** [Metropolitan Surface Water Management Act](#) is enacted, requiring local governments in the 7-County metro region to form watershed management organizations to plan for surface water management across municipal boundaries.
- 1987:** [County Comprehensive Water Planning Program](#) is established, funding county development of water management plans.
- 1989:** The [Groundwater Protection Act](#) is enacted, creating new incentives and requirements for state and local groundwater management.
- 1991:** EQB prepares first decennial [Minnesota Water Plan: Directions for protecting and conserving Minnesota's waters](#).
- 2000:** EQB completes [Minnesota Watermarks: Gauging the flow of progress, 2000–2010](#).
- 2008:** Minnesota voters demonstrate their commitment to working together on water issues by passing the [Clean Water, Land and Legacy Amendment](#).
- 2010:** EQB completes [Minnesota Water Plan: Working together to ensure clean water and healthy ecosystems for future generations](#).
- 2011:** The University of Minnesota releases [Minnesota Water Sustainability Framework](#), a comprehensive report designed to protect and preserve Minnesota's lakes, rivers and groundwater for the 21st century and beyond.
- 2014:** [Minnesota Nutrient Reduction Strategy](#) outlines how Minnesota will reduce nutrient pollution in its lakes and streams and reduce the impact downstream. The strategy specifies goals and provides a framework for reducing phosphorus and nitrogen by an interim target date of 2025 and final date of 2040.
- 2014:** [Minnesota's Clean Water Roadmap](#) sets long-range goals for Minnesota's water resources over the 25-year life of the Clean Water, Land and Legacy Amendment (through 2034).
- 2015:** The Minnesota Legislature passes a law to protect water quality by requiring buffers on more than 100,000 acres of land adjacent to public waters and public drainage systems. EQB prepares [Beyond the Status Quo Water Policy Report](#). Legislation directs state and local governments to accomplish a ten-year transition to use a Comprehensive Watershed Approach to achieve accelerated and coordinated water management (aka [One Watershed, One Plan](#)).
- 2017:** Governor Mark Dayton asks Minnesotans for their input on how to increase the pace of progress toward clean water, setting a goal of 25% improvement by 2025.
- 2019:** Governor Walz signs [EO 19-37](#) establishing the Climate Change Subcabinet and the Governor's Advisory Council on Climate Change to promote coordinated climate change mitigation and resilience strategies.

How to use the plan

This plan is organized in three sections. The first two provide background information on water and climate connections, the importance of engaging Minnesotans to develop equitable solutions to our water challenges, and collaboration between the state and Tribal Nations in water efforts. The third section contains five goals. These goals represent focus areas for Minnesotans to become more resilient to climate change and prepare for its impacts on water in the coming decade. Each goal contains recommended strategies and actions to achieve it. The goals overlap and interrelate, so many of the strategies apply to multiple goals.

Goal 1: Ensure drinking water is safe and sufficient

Goal 2: Manage landscapes to protect and improve water quality

Goal 3: Manage built environment and infrastructure for greater resiliency

Goal 4: Manage landscapes to hold water and reduce runoff

Goal 5: Promote resiliency in quality of life

Additional resources related to the plan are available on the EQB website (eqb.state.mn.us).

Principles Underlying This Plan

Several principles and assumptions shape this plan. Some of these have shaped water policy in Minnesota for decades, while others are new, based on increasing awareness of the threats climate change poses.

- We have a responsibility to consider the needs of all natural systems, including wildlife and plants. Human impacts to water threaten many species and habitats in Minnesota. Healthy lakes, rivers, streams, wetlands, springs and aquifers are all essential for thriving ecosystems.
- We recognize the value of nature-based solutions. Promoting biodiversity and investing in the health of ecosystems is critical for our resilience to climate change. We need to protect water in areas with high biodiversity and increase biodiversity where it is lacking. As we select and implement solutions to water issues, we can choose to mimic natural systems wherever possible.
- We recognize the interconnection between land use and water quality and quantity, as well as connections between air and water. How we use and manage land affects water quality and quantity and can result in real costs, from increased drinking water treatment to repair or replacement of roads and bridges.
- We recognize that surface water and groundwater, while frequently discussed separately in this report, are interconnected and interdependent.
- We have a responsibility to consider the needs of downstream users. Minnesota sends water to three of North America's major drainage basins: the Mississippi River, the Great Lakes and the Red River of the North.
- We acknowledge that our water resources, while abundant, are not evenly distributed or unlimited and that demands on those resources are likely to increase.
- We have a responsibility to address water injustices. We recognize that the impacts of climate change on water resources will be experienced differently in different regions of the state and by different populations, and we seek equitable solutions. Existing inequities in Minnesota limit the ability of some populations to confront the impacts described throughout this report on infrastructure, water quality, recreation and more. These vulnerable populations include but are not limited to:
 - people in floodplains or at risk from localized flooding
 - residents with private wells vulnerable to contamination, with infants, children and the elderly facing the greatest risks
 - people in communities facing high water treatment costs or inadequate drinking or wastewater treatment infrastructure
 - Black, Indigenous and people of color, who already face multiple stresses that can affect resilience, from housing costs to educational inequities
 - people in poverty and those facing financial, language or educational barriers, limiting their ability to recognize and respond to threats
 - people in urban areas who lack adequate or safe access to water-based recreation.
- We have a responsibility to welcome and support culturally diverse voices and different ways of knowing and relating to water in inclusive community engagement, science, management, planning and policy.



Source: Charles Robinson

Water and climate change

Climate and water shape our lives

Minnesota is almost as famous for its climate, which swings from hot, humid summers to frigid, snowy winters, as it is for its abundant waters. Just as we cannot imagine our state without lakes and rivers, we also would not recognize a year without cold winter nights, heavy snow, summertime thunderstorms, or numerous warm and sunny days. Minnesotans depend on both climate and water for our way of life, from recreation like hunting, fishing and paddling, to our agricultural, tourism and industrial economies.

Minnesota's climate and water are closely connected in many ways:

- The amount and timing of precipitation influences how much water soaks into the ground or runs off into lakes, rivers and wetlands.
- Precipitation patterns also determine the availability and demand for water.
- Temperature patterns control the timing of snowmelt, the duration of ice cover on lakes and streams, and the beginning and end of Minnesota's growing season.
- Climate influences water temperatures, along with many of the chemical, physical and biological processes that shape aquatic resources.

Source: MPCA



What's the difference between climate and weather?

Somebody has probably said to you, "If you don't like the weather, wait five minutes," but you cannot say the same for climate. Weather and climate both describe the condition of the atmosphere in a location, but weather is short term, whereas climate refers to the effect of weather patterns averaged over seasons, years and decades. Climate shapes our expectation that it will be cold in Minnesota in the winter; weather determines what we experience on a given day.

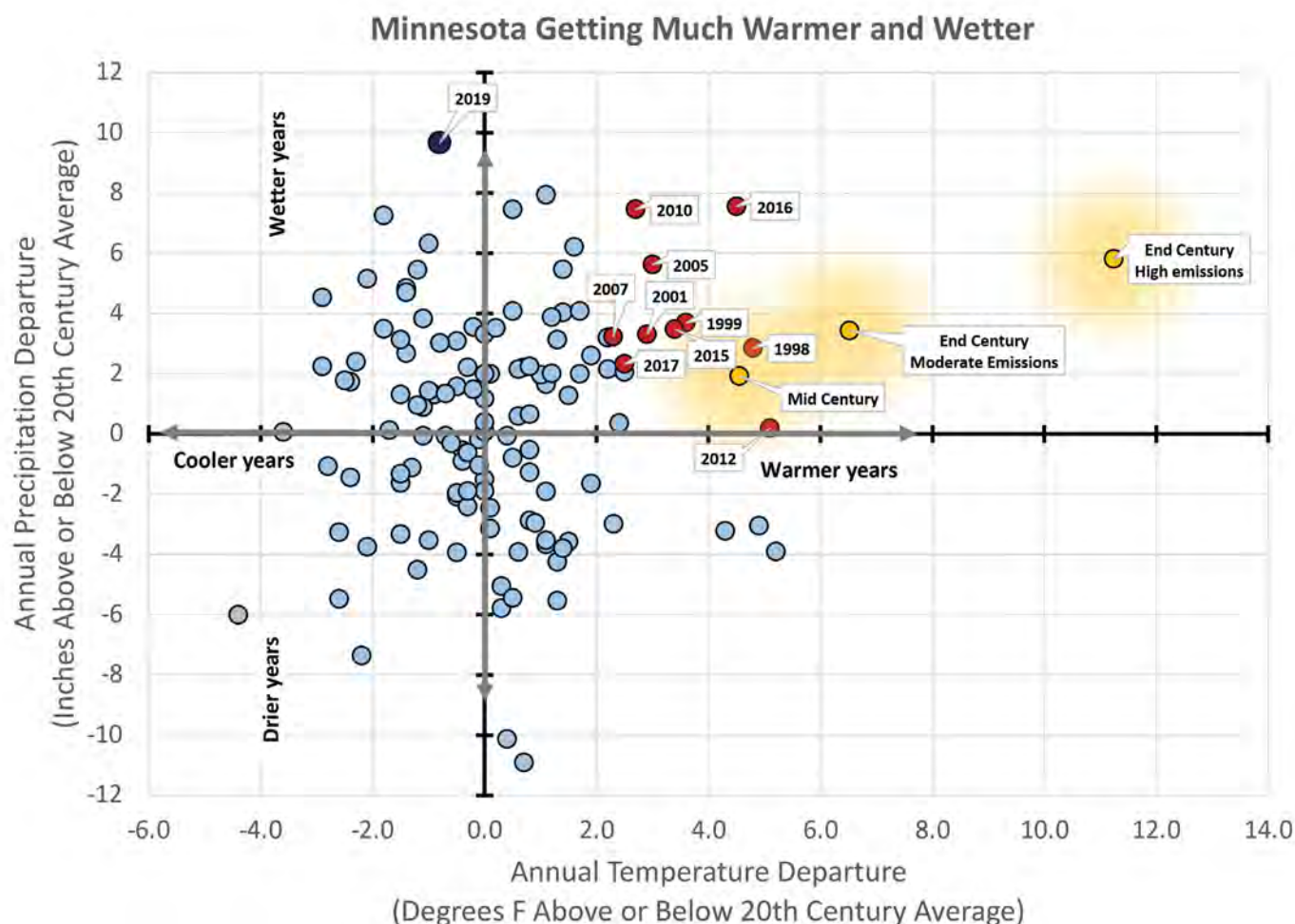


Source: MnDOT

How our climate is changing

We know that some seasons can be far warmer, colder, wetter or drier than normal. The high variability we expect from Minnesota's climate can make it difficult to notice where, when and how climate has changed in our state. However, rapid, widespread changes are already underway, and more changes are coming. In the past several decades, our state has seen substantial warming that is most pronounced during winter and at night, increased precipitation and heavier downpours.

An overwhelming base of scientific evidence projects that Minnesota's climate will see additional, significant changes through the end of this century, with even warmer winters and nights and even larger rainfalls—along with the likelihood of increased summer heat and the potential for longer dry spells. Although we will experience occasional cool or dry years, climate scientists expect these increases to continue through the 21st century.



All but two years since 1970 have been wetter and/or warmer than 20th century averages, and the 10 combined wettest and warmest years (red dots) on record all occurred from 1998 onward. Each blue and red dot represents a given year's statewide temperature and precipitation departure from 20th century averages, 1895–2019. Yellow dots represent projections for the middle and end of the 21st century with moderate and high greenhouse gas emissions, based on 20-year averages; therefore, some individual years are warmer and wetter than the values shown.

Unprecedented wetness

Minnesota's climate swings naturally from relatively dry to relatively wet periods, but wet conditions have dominated recent decades. Years with precipitation above historical averages have become increasingly frequent, and departures from those averages have grown as well, leading to sustained record-breaking precipitation surpluses. June 2014 was Minnesota's wettest month on record, with severe flooding in many areas. During 2019, more precipitation fell across the state than any other year on record back to 1895. The precipitation increases have been most pronounced in southern Minnesota. In 2016, Waseca broke Minnesota's annual precipitation record, only for Harmony and Caledonia to surpass it in 2018. Snowfall has been increasing too, with several stations setting seasonal snowfall records during the 2010s, and dozens of monthly records falling as well.

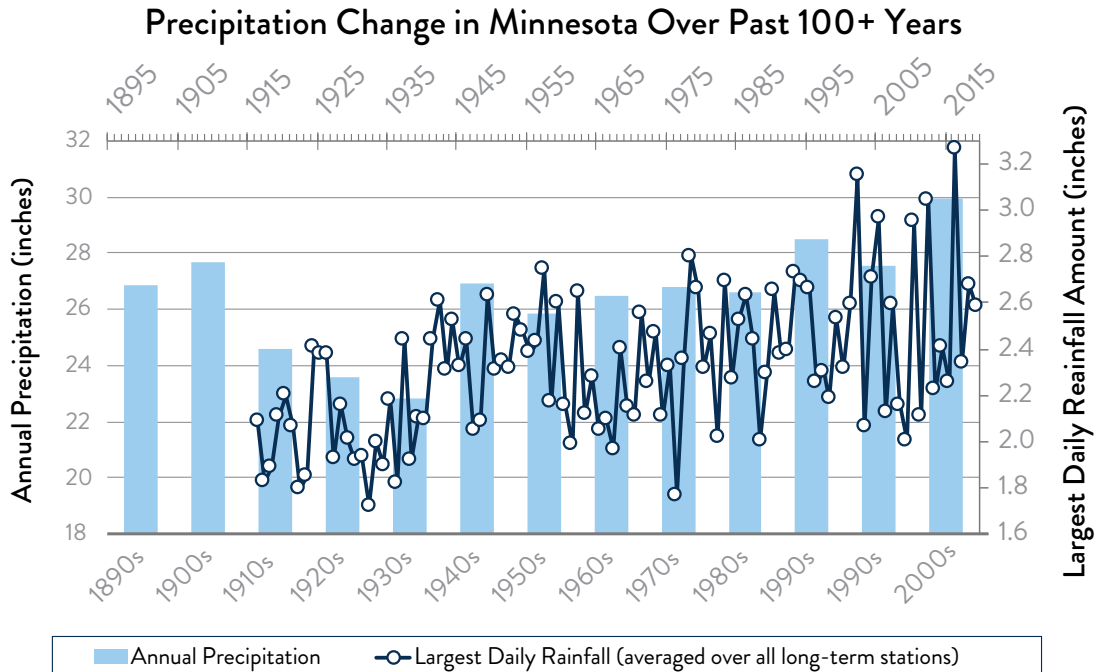
Source: MPCA





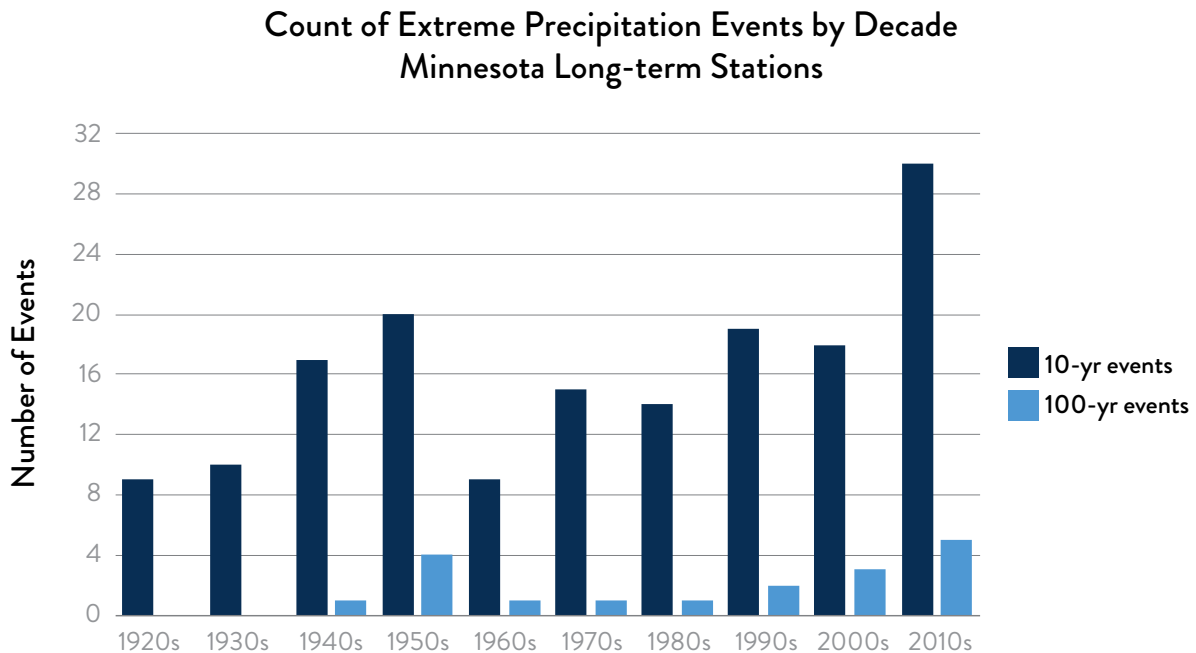
“Mega-rains”

“Mega-rains” are events in which six inches of rain covers more than 1000 square miles and the core of the event tops eight inches. Minnesota has experienced 11 mega-rains in the 20 years since 2000 (including one in July 2020), versus six in the 27 years from 1973 through 1999.



Source: DNR State Climatology Office

This chart shows changes in Minnesota’s annual precipitation, averaged by decade, along with the average value of the largest daily rainfall of the year from Minnesota’s 39 long-term weather stations. The 2010s finished as Minnesota’s wettest decade on record.



Source: DNR State Climatology Office

Minnesota’s long-term climate stations recorded more 10-year and 100-year rainfall events during the 2010s than in any other decade.

More damaging rains and heavy snowfalls

Minnesota now sees more extreme precipitation than at any other time on record. Minnesota's long-term climate stations recorded more "10-year" daily rainfall events—those exceeding 3.5 inches in the northwest and 4.5 inches in the southeast—during the 2010s than in any other decade. The annual heaviest daily rainfall total anywhere in the state now averages about 20% higher than it did historically. In August 2007, a catastrophic rainfall in southeastern Minnesota produced a 24-hour total of 15.10 inches in the town of Hokah, breaking the statewide daily rainfall record by nearly 40%. Heavy snowfall has increased during this period as well, with many stations setting all-time 24-hour records during the 2010s, and the decade setting high marks across the state for the frequency of 4-inch snowfalls.

Warmer, but not yet hotter

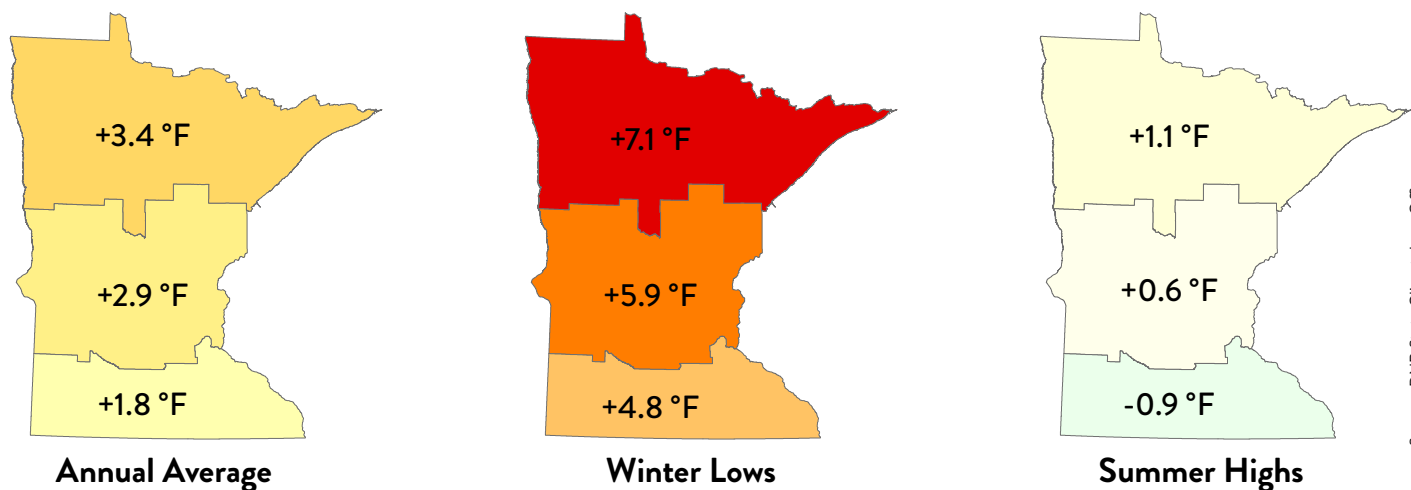
Minnesota has warmed considerably, but mostly during nights and winter. Annual temperatures have climbed 2.9 °F since 1895, but winter low temperatures have increased by 6.1 °F, with only modest increases or even slight decreases in summer high temperatures. Winter cold extremes have become less frequent and less severe across the state, but we have observed no change in the frequency or severity of heat extremes. Over 85% of Minnesota's warming occurred since 1970, indicating that the state is currently facing rapid climatic changes.



Daily precipitation increases

At climate stations with over 100 years of observation, daily precipitation totals of 1, 2 and 3 inches have increased by an average of 21%, 31% and 62%, respectively.

Total temperature change, 1895–2019



Since 1895, winter lows in northern Minnesota have increased 40% faster than in southern Minnesota.

Source: DNR State Climatology Office

"[Someone once asked], 'You've lived here your whole life, when is the skiing reliable?' and I said 'Oh, by Thanksgiving, no question.' ... And now, I mean, Thanksgiving we're still paddling."

–North Shore interviewee

Minnesota's future climates

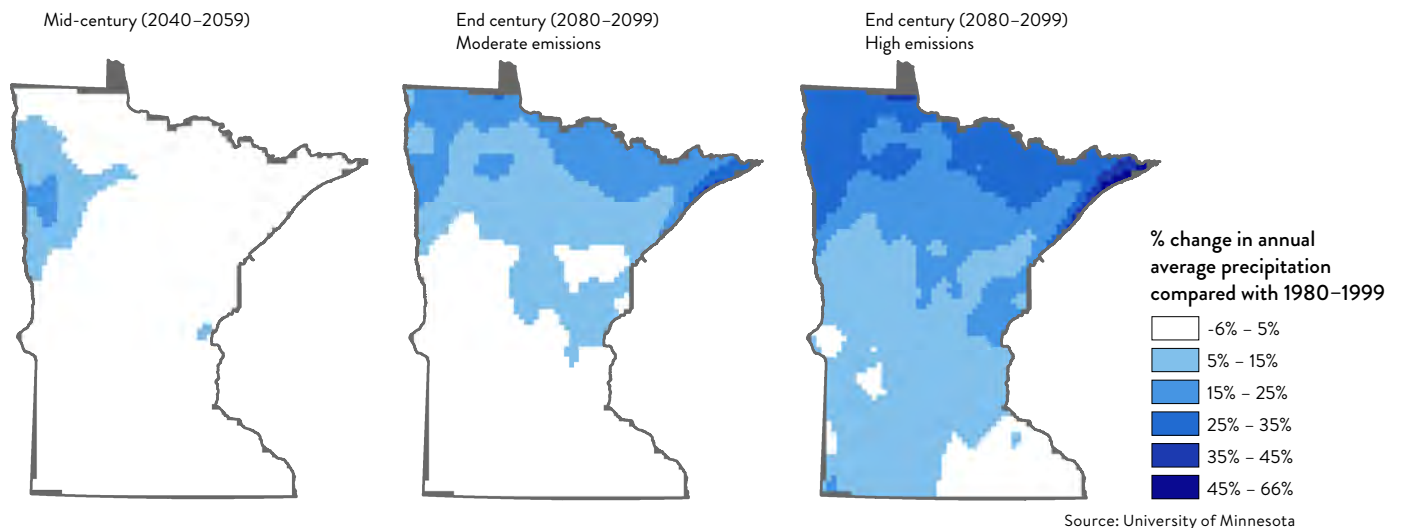
Located in the middle of a continent, halfway between the equator and the North Pole, Minnesota is highly sensitive to large-scale climatic changes, and since 1970 has warmed 40% faster than the global average. With continued global temperature increases expected, virtually all climate model scenarios at a wide variety of scales project that Minnesota will get much warmer in the decades ahead, including during the summer, with increased heat extremes by the middle of this century, if not sooner.

Precipitation is slightly more complicated because the extra moisture resulting from rising temperatures is distributed unevenly by global wind and weather patterns, leading to a range of slightly dry to very wet projections.

Climate model projections made specifically for Minnesota generally suggest we will see more precipitation by the end of this century, with continued increases in heavy rainfall and longer intervening dry spells. The projections favor wetter spring months, followed by drier late-summer conditions. Under a high greenhouse gas emissions scenario, the wettest day in a typical year at the end of this century is projected to be 20% wetter than during the 1990s. Individual years may have even larger increases in extreme precipitation. Even as the amount of precipitation increases, we expect the longest time between precipitation events to increase, indicating more precipitation is coming in fewer events.

With aggressive reductions in greenhouse gas emissions, we can avoid the more drastic climate changes represented by the high emissions projections in the following maps.

Modeling Minnesota's Future Climate: Annual Precipitation



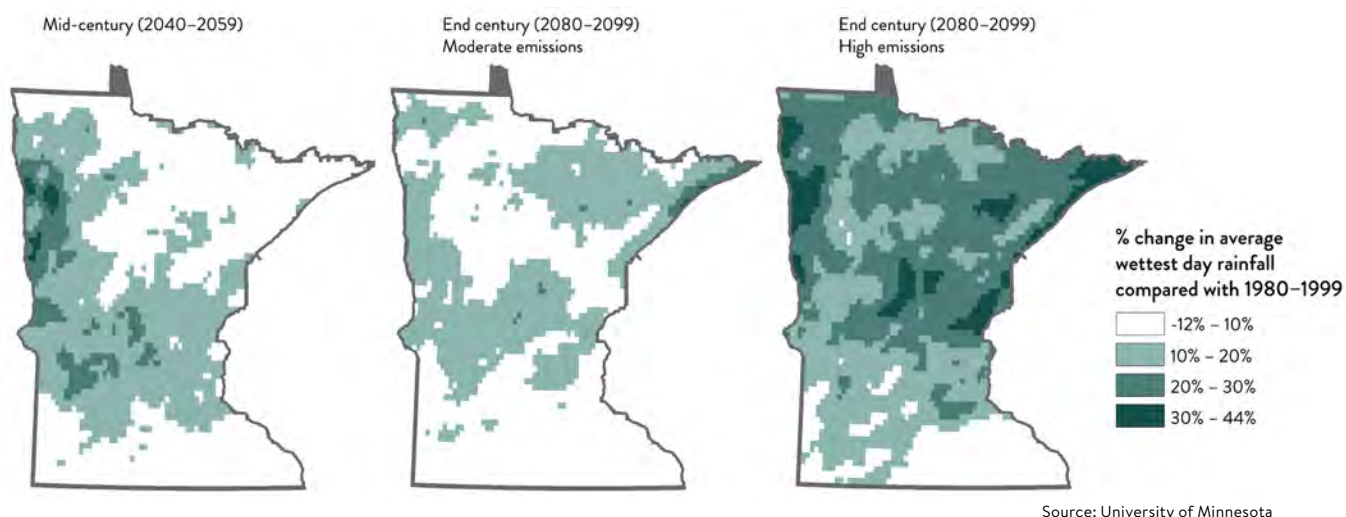
Background on Modeling: Looking at Minnesota in the Future

Climate scientists have produced numerous global and national climate model data sets, but until recently, none had been specific to Minnesota. University of Minnesota scientists, however, have used supercomputers and physical equations to “downscale.” The modelers used the average of seven global models to produce localized climate projections for the state. This report uses the averages of those models to represent future climate scenarios in Minnesota.

The models cover changes relative to baseline climate data for 1980–1999 for two future periods—“mid-century” (2040–2059) and “end century” (2080–2099).

The mid-century model shows a single scenario. Two end-of-century projections represent moderate and high greenhouse gas emission scenarios. It is clear from these two that society can still avoid more drastic long-term changes in climate by reducing emissions in the near term.

Modeling Minnesota’s Future Climate: Wettest Day Rainfall



Data were produced by the University of Minnesota under the direction of Tracy Twine, Department of Soil, Water, and Climate, with analysis support from Ryan Noe, Humphrey School of Public Affairs. Funding was provided by the Environment and Natural Resources Trust Fund and Minnesota Invasive Terrestrial Plants and Pests Center.

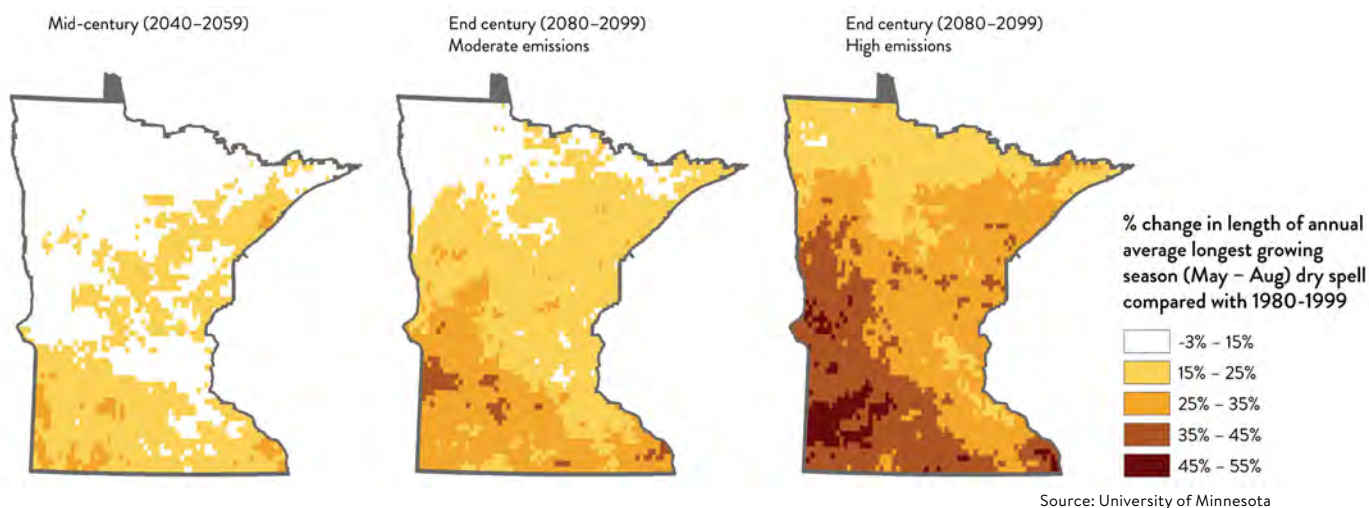
“I’ve been living here 25 years, and I do feel like the climate has changed since I’ve been here. ... [T]he moisture patterns, the way we get snow, the way it comes our way, the temperatures—I feel like that’s a very natural assumption to make.”

–Duluth area interviewee

Don't count drought out

Minnesota has not seen increased drought severity, duration or geographic coverage over the past few decades. Although not equivalent to drought, climate projections suggest that the length of the longest dry spell in the growing season may increase. Minnesota should expect at least occasional episodes of severe drought, even with a wetter climate.

Modeling Minnesota's Future Climate: Growing Season Dry Spell



Protecting water together

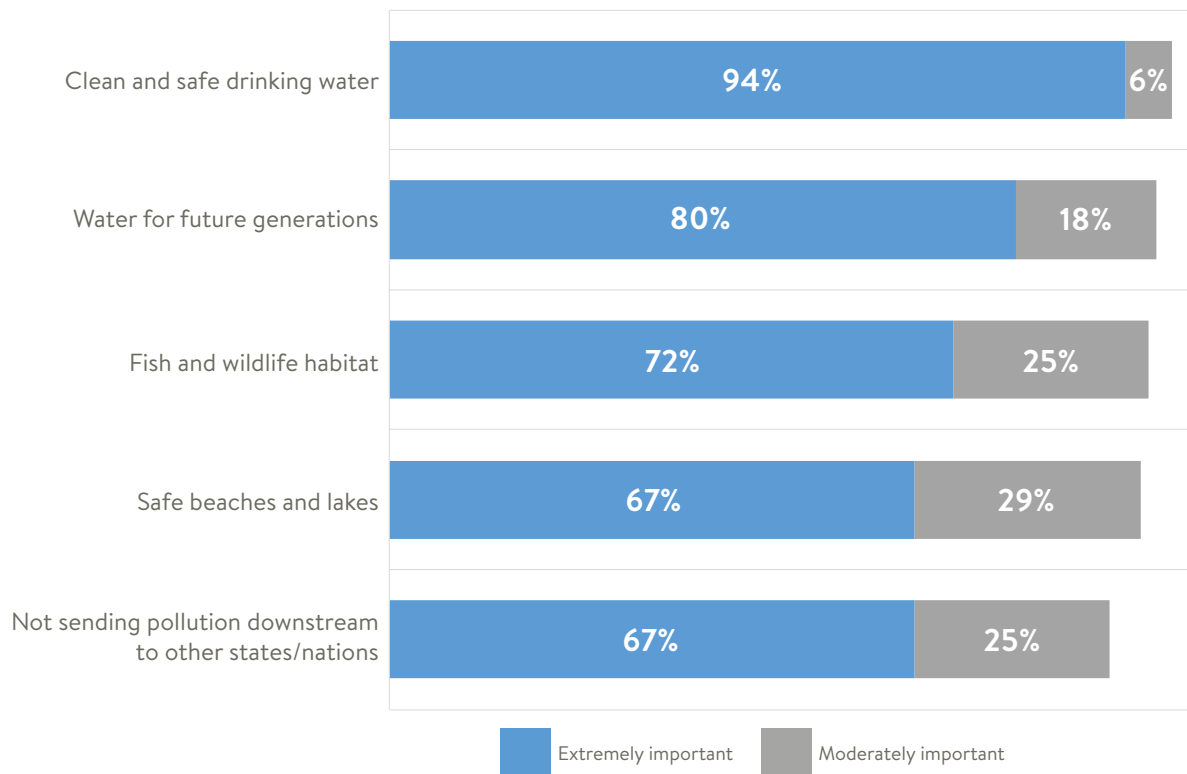
Protecting and improving water quality in Minnesota in the face of climate change will yield important rewards: clean drinking water, resilient landscapes, fishable and swimmable surface waters, and more. However, it will be a complex, challenging, and long-term process that requires “all hands on deck,” with EQB agencies, Tribal Nations, local governments, businesses, communities, NGOs/nonprofits and individuals working together.

Fortunately, Minnesotans care deeply about water and are concerned about the impacts of climate change. To successfully collaborate and produce equitable results, decision makers must engage a diversity of voices that reflect the priorities and values of communities across Minnesota. Investment in environmental literacy is essential to develop the understanding, skills and motivation to enact informed strategies for managing water and climate.

Source: DNR



What water values are most important to Minnesotans?



Source: Davenport et. al. 2019, University of Minnesota

Minnesotans value water

Understanding shared and diverse values can help decision makers align policies, practices and programs with the interests and values of area residents.

A 2018 University of Minnesota statewide survey of more than 1,400 residents affirmed that Minnesotans value clean water. Respondents most valued:

1. clean and safe drinking water
2. water for future generations
3. fish and wildlife habitat
4. safe swimming beaches and lakes
5. not sending pollution downstream to other states or nations.

More than 90% of Minnesotans surveyed believe drinking water is extremely important, with women tending to rate many values more highly than men. A smaller Twin Cities metro area study found that Black, Indigenous and people of color value equitable access to water and using water for gardening and cultural or religious practices in addition to drinking water.

More than 75% of Minnesotans surveyed believe water resources in the state need better protection. Minnesotans are worried about impacts of degraded or depleted water resources on human health, future generations and aquatic life.

Source: DNR



More than 80% of respondents support multiple actions to protect and restore water, including:

- conserving household water
- monitoring the health of Minnesota waters
- increasing water education and outreach
- enforcing existing land use laws and regulations.

Source: MPCA



Minnesotans believe the climate is changing

Minnesotans are concerned about climate change. According to a 2019 Yale University nationwide telephone poll, 66% of Minnesota residents believe the climate is changing. This is slightly lower than the national average of 70%. University of Minnesota survey research documented higher proportions of Minnesotans who believe climate change is occurring.

- More than 80% of residents on the North Shore of Lake Superior in Cook and Lake counties believed climate change is happening.
- When asked what concerns them most about climate-related impacts to the North Shore, effects on fish, wildlife and forest health were among the top concerns. Only 13% of North Shore residents said their communities are prepared for climate change.

“I am concerned. For instance, if we keep having years with these bad windstorms, or droughts, or floods, the more damage that’s happening to our natural environment here, the more impact it’s going to have on our tourism.”

–North Shore interviewee



Source: USFWS

- Of Central Minnesota farmers surveyed in a 2019 University of Minnesota study, 73% believe the climate is changing, and 42% believe their farm operations will be harmed by climate-related impacts in the future. These farmers' biggest concerns for the next 10 years are:
 - o decreased groundwater access
 - o more frequent dry periods and droughts
 - o increased heat stress on crops.
- A survey of people in the Twin Cities metropolitan area found that more than 90% believe that the climate is changing. The vast majority (89%) are at least moderately concerned about climate change impacts, including:
 - o drinking water contamination
 - o degradation of lake and stream water quality
 - o unequal access to public waters.

Building local capacity

Local governments will play a key role in building resilient communities. In 2020, EQB conducted an informal survey of local government staff and other water professionals to gauge their capacity, concern and readiness. Most respondents (83%) are moderately or extremely concerned about the effects of climate change on water issues in the communities they serve. However, fewer than half of respondents report that their organization has water plans or planning efforts underway that specifically address climate change.

Source: MPCA



Three statewide surveys of local government staff conducted by the University of Minnesota identified capacity-building needs for two climate-related challenges: managing stormwater and protecting groundwater. While 93% of survey respondents reported beliefs that climate change is occurring, only 15% believed their communities are prepared to address climate change impacts. In addition, 78% of staff viewed an increase in the frequency and intensity of storm events as a significant challenge. This group also identified flooding, aging or insufficient stormwater infrastructure, and road salting or deicing practices as significant problems. While the staff surveyed felt prepared to develop long-term plans to address water issues from a technical and educational perspective, they felt least effective at regulating existing land uses and restoring hydrology for stormwater management. These communities need resources and assistance to move forward with resilience planning, including increased capacity for community member engagement.

Engagement, equity and education

The goals and strategies that appear in this report can all be strengthened by increasing the level of public engagement and education and keeping equity top of mind.

Source: USFWS



CASE STUDY: We Are Water Minnesota

We Are Water MN is a traveling exhibit and community engagement initiative that explores the science, history, story, culture and relationships of water in Minnesota. It's a successful and proven model for building strong local and statewide networks to promote positive social norms and enable the development of a communitywide vision for water stewardship.

The 2018–2019 cohort, which included eight host sites, achieved the following:

- Over 34,000 people attended the exhibit, including 1,500 school children. A large percentage of 457 attendees surveyed spoke to the value of the exhibit:
 - 51% identified that they learned something new from the exhibit
 - 54% expressed they felt a greater responsibility to water resources as a result of visiting the exhibit
 - 48% felt motivated to take personal action regarding the personal use of water.
- Communities gathered together. Over 9,000 individuals attended 28 community events. These events strengthen informal social bonds, facilitated knowledge exchange and provided a shared sense of community and responsibility.
- There were 240 partnerships across eight sites to plan and promote the exhibit. We know these networks are new and different than before the project—30% were described as new relationships and nearly 40% were described as relationships with an organization or community not normally represented in the host site's work.

We Are Water MN is supported by a unique collaboration among the Minnesota Humanities Center, MPCA, the Minnesota Historical Society, MDA, MDH and DNR.

Source: MPCA



Minnesota's existing targets for watershed restoration and protection require significant resources and strong strategies to achieve. Investments like the Legacy Amendment and the Clean Water Fund it established have allowed us to create a strong base of knowledge about water quality in Minnesota. Yet progress to restore and protect our water is slow and difficult because of complex challenges and uncertainties due to climate change, development and other factors.

One of the biggest challenges is the social dimension. Sustainable water management must go beyond a purely technical approach and consider human beliefs and behaviors, including social norms, emotional connections to people and places, and beliefs about one's ability to make change. Engagement can help ensure that:

- a diversity of perspectives informs all policies, programs and processes
- solutions are co-created with the public and aligned to local values and needs.

Public engagement is key to protecting and improving Minnesota's water resources. Currently, local water plans tend to focus on conservation rather than outreach and engagement, despite significant social barriers to success. In addition, staff capacity, funding and lack of expertise limit the ability of local government staff to include outreach and engagement in efforts to protect water.

Water professionals need to build capacity for engagement, outreach and education in agencies, local governments, universities and other organizations. They also need to provide locally relevant and community-driven education and outreach to elected officials to build support and buy-in for plans.



Minnesota's water protection planning and programs must include multiple ways of knowing water and represent a broad range of experiences. Experiences with water differ across race, gender, ethnicity, place of origin, socioeconomic status, religion, profession and hobbies. State agencies and others working on water quality goals will be most successful when people of many different backgrounds see themselves in the work and actively participate in planning.

"I think women of color and people of color in natural environments are a lot less rare than people think. Representation is definitely a huge part of the problem of whiteness in the outdoors. And, you know, it's self-perpetuating; people don't see folks that look like them represented and they don't think that the outdoors is a place for them. So that's a big part of the reason that I've been motivated to continue working in the outdoors and doing this work that I do, because as a marketer I can help shape that narrative and that representation—or lack thereof, rather."

— Alora Jones
We Are Water MN program, 2018

Working with people is key to solving water challenges. It includes not only understanding environmental issues and natural systems, but also developing skills to address environmental problems as well as active participation in civic life for the benefit of the environment and others.

We develop our relationship with water through home and family life, school, and a variety of lifelong opportunities. Minnesotans need regular access to information, conversations, experiences and skill-building to support this growth. Expanding opportunities to learn about water is important in achieving the level of participation needed to address the challenges we face.

Education can include:

- experiential learning opportunities in nature
- building relationships that increase resiliency and shared understanding
- boosting a sense of efficacy and mental health through volunteer opportunities
- encouraging participation in creating goals, policies and plans.



Source: DNR

Potential Pathways in Education

The Minnesota GreenStep Schools pilot program supports K–12 climate and water education. Free and voluntary, the program offers a beginner-friendly framework building on the successful model of Minnesota GreenStep Cities and the nationally recognized Green Ribbon Schools program. Minnesota [GreenStep Schools](https://www.mngreenstepschools.org) connects public and private experts with schools and districts to share best practices for reducing environmental impacts and costs, improving health and well-being of students and staff, and providing effective environmental and sustainability education. www.mngreenstepschools.org



Tribal Nations, Water and Climate Change

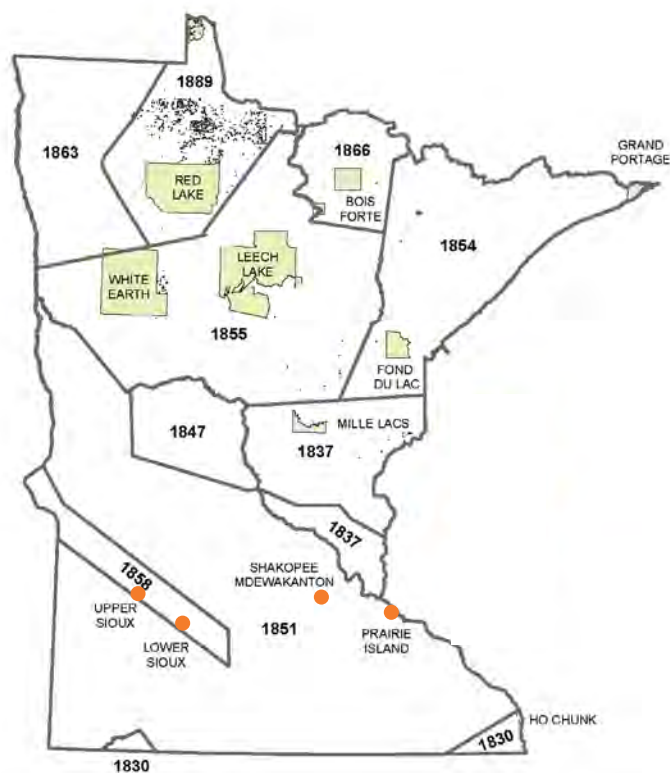
Tribal Nations depend on clean water for healthy communities, economic security and cultural survival. Water is central to Ojibwe and Dakota cultures and has been since long before the state was established.

Climate change threatens the waters and ecosystems tribes depend on. Species with aquatic habitats such as wild rice, black ash and walleye are important for health, sustainability and cultural well-being. These species are also highly sensitive to climate change. Tribes are actively studying the challenges climate change brings to the lands and waters of Minnesota. Learning from tribes and collaborating on solutions is essential for protecting Minnesota's waters from climate change.



Source: Tina Shaw/USFWS

Minnesota Indian Tribal Land



- Anishinaabe Reservations
- Dakota Communities
- Treaty-Ceded Territories

Source: MnDOT

Tribes in Minnesota

Minnesota is home to 12 federally recognized Tribal Nations:

- seven Anishinaabe (Chippewa, Ojibwe) reservations
- four Dakota (Sioux) communities
- the Minnesota Chippewa Tribe, composed of the Bois Forte, Fond du Lac, Grand Portage, Leech Lake, Mille Lacs and White Earth reservations.

Each is a separate sovereign nation with its own government and is distinct from all other federally recognized tribes.

Reservations and communities are segments of land that were retained or reserved by American Indian tribes after ceding large portions of their original homelands to the United States through treaty agreements. Boundaries of these lands have changed over time and across the United States, with some still under dispute today.

While treaties with the United States set aside reservations as tribes' permanent homes, in Minnesota, the Ojibwe reserved the right to hunt, fish and harvest natural resources from ceded lands and waters. The ability to exercise those treaty rights depends on clean water and healthy ecosystems.

Treaty rights, environmental health and tribal culture are all interconnected. Tribal members remain connected to ancestral generations through subsistence living, maintaining cultural practices, and exercising treaty rights to hunt, fish and harvest natural resources. Tribal Nations manage lands, resources and economies; protect people; and build a more secure future for generations to come.¹

¹ Portions of text courtesy of Fond du Lac Resource Management Division

Water: More than a resource

A 2016 report on climate change developed through a collaboration among the Bois Forte, Fond du Lac and Grand Portage Bands and the 1854 Treaty Authority opens:

To the Ojibwe, natural resources are cultural resources. There is no separation between how the bands manage and interact with a resource and how their culture endures: one is dependent on the other. Climate change, however, is threatening the very viability of many natural resources important to the Ojibwe.²

The fundamental relationship between ecosystems and cultural survival is central to how Minnesota tribes approach science and management of water resources. *Why Treaties Matter*³ points out that for Ojibwe and Dakota people, environmental values center on an ethic of responsibility, rights and relationships. They view themselves as *participants* in the natural world, continually in relationship with everything that surrounds them. The natural world has intrinsic rights that humans have responsibility to uphold. Beings in the natural world are connected to humans through familial relations. Ojibwe language reflects this: *nibi*, the word for water, means *life-giving force*. This worldview contrasts with economic and political systems that value private property and often view land and water as commodities to buy, sell and use.

Disproportionate impacts

Impacts to water from climate change will disproportionately affect Minnesota tribes. Increased risk of flooding and extreme weather could place additional burdens on reservations already struggling with infrastructure challenges. For subsistence and cultural survival, tribes also depend on native species with aquatic habitats that are vulnerable to the effects of rising temperatures and increased precipitation. Loss of these species could harm health and well-being.

The Prairie Island Indian Community is an example of a Tribal Nation that is vulnerable to increased precipitation from climate change. The community is located on the shores of the Mississippi and Vermillion Rivers between Hastings and Red Wing. The tribe has long dealt with flooding that causes everything from washed out roads to evacuations, and it has invested in flood mitigation infrastructure. Climate change could make flooding more frequent and severe, putting additional strain on community resources.



Aquatic habitat species that tribes depend on for subsistence and cultural survival are also at risk from climate change, which disproportionately impacts tribal health and well-being. As the 1854 Treaty Authority points out in its climate change vulnerability and adaptation plan,⁴ the boundaries of reservations, communities and ceded territories are geographically defined. Tribes cannot follow shifts in natural resources that may come with climate change, and might lose access to culturally, economically and nutritionally important species. Many health issues American Indians face today can be traced to historic displacement from traditional foods and healthy cultural practices. Climate change could cause yet more displacement from these foods and practices.

²Stults, M., Petersen, S., Bell, J., Baule, W., Nasser, E., Gibbons, E., & Fougerat., M. (2016). *Climate Change Vulnerability Assessment and Adaptation Plan 1854 Ceded Territory Including the Bois Forte, Fond du Lac, and Grand Portage Reservations*. 146.

³*Why Treaties Matter*. <http://treatiesmatter.org/exhibit/> accessed July 15, 2020.

⁴Stults, M., Petersen, S., Bell, J., Baule, W., Nasser, E., Gibbons, E., & Fougerat., M. (2016). *Climate Change Vulnerability Assessment and Adaptation Plan 1854 Ceded Territory Including the Bois Forte, Fond du Lac, and Grand Portage Reservations*.

WILD RICE

Wild rice (*manoomin*-Ojibwe, *psij*-Dakota) has been central to the lives and identity of Dakota and Ojibwe for centuries. Today, it is used in religious practices and ceremonies, and hand harvesting is an important ritual that builds community and helps tribes remain culturally resilient. Wild rice is also critical for the health and subsistence of tribes. Harvesting and consuming wild rice promotes health and enhances tribal food sovereignty.⁵

Minnesota has the largest concentration of wild rice remaining in the United States. Still, wild rice occupies only a fraction of its historic range. Dakota and Ojibwe people are actively working to restore and preserve this resource on tribal waters and in ceded territories. Meanwhile, wild rice faces multiple threats, including altered hydrology, water quality issues and invasive species. Climate change is making these threats worse. Impacts to wild rice could bring cascading effects because rice wetlands provide habitat and food for waterfowl, fish and other wildlife.



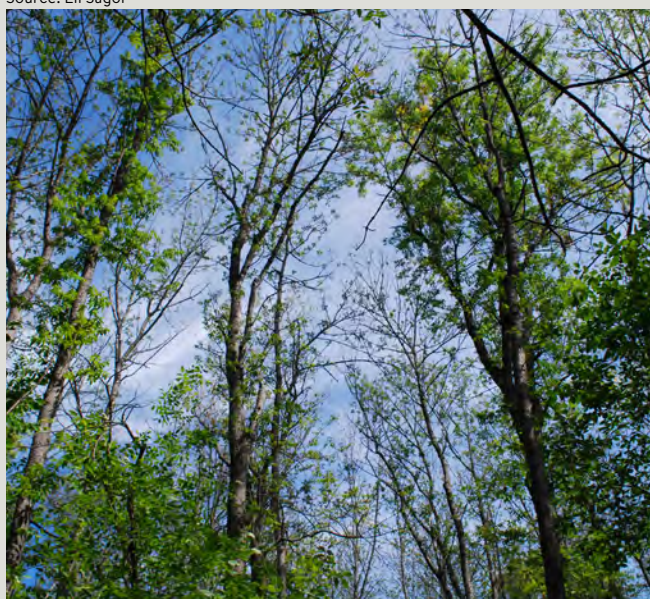
Source: MPCA

Food sovereignty

Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems.

– Declaration of Nyéléni, the first global forum on food sovereignty, Mali, 2007

Source: Eli Sagor



BLACK ASH

Black ash (*baapaagimaak*) is a tree that thrives in swamps, floodplains, ravines and small, poorly drained areas with high water tables. For the Ojibwe, black ash is important for crafting traditional baskets and snowshoes.

Increasing temperatures and disruptions to hydrology are altering the ecological conditions that black ash depends on to survive. In addition, emerald ash borer (EAB), an invasive insect, threatens black ash. Climate change is impairing efforts to slow EAB's spread. Minnesota has 1 million acres of black ash-dominated forests, and EAB threatens all of them. Black ash trees act like water pumps—without them, water accumulates on the land. Losing black ash means overlapping impacts to tribal culture, wetland ecosystems and water storage on the land.

⁵Minnesota Tribal Wild Rice Task Force. (2018) 2018 Tribal Wild Rice Task Force Report.

Fond du Lac Band of Lake Superior Chippewa. (2018). *Expanding the Narrative of Tribal Health: The Effects of Wild Rice Water Quality Rule Changes on Tribal Health. Health Impact Assessment.*

WALLEYE

Walleye (*ogaa*), native to most of Minnesota, is an important source of food for American Indians. Fishing for walleye is also an important cultural activity. Climate change, management practices and invasive species have contributed to recent population declines in the Mille Lacs Lake area, part of the 1837 ceded territory.

Warming water temperatures have led to an expansion of walleye habitat in Lake Superior. However,

temperature increases will likely create competition from warmer water fish species in southern and shallow lakes and reduce populations of prey species such as cisco. Later freeze-ups and ice-out dates on lakes could also affect walleye spawning. The complex interactions among these factors make it difficult to assess the vulnerability of walleye to climate change.

Source: Joe Ferguson



Mercury and climate change

Mercury can accumulate in fish to levels toxic to the fish and to those who eat them. Fish provide an important food source for Minnesota tribes and other subsistence anglers, but many fish species have consumption advisories due to contamination from mercury. Mercury is a [neurotoxin](#) to humans and can cause a range of health effects.

Almost all the mercury in Minnesota's lakes and rivers comes from outside the state and is delivered by the atmosphere. Mercury moves from air to land and water by attaching to vegetation or washing out with rain and

snow. Bacteria transform some into methylmercury, a substance that can accumulate in animals.

Despite a decline in mercury emissions over the past three decades, average mercury levels in northern pike and walleye have increased. Scientists believe this is because there are existing stores of mercury in water bodies, and increasing temperature and precipitation is causing more uptake of methylmercury in animals.

Tribes are decision makers

Under the federal Clean Water Act (CWA), tribes are eligible to implement programs that protect water quality and prevent pollution. The Fond du Lac and Grand Portage Bands have established an environmental regulatory program under the CWA. This means they set water quality standards for tribal waters, which the U.S. Environmental Protection Agency (EPA) approves. These tribes periodically review their standards and propose changes based on science and public input.

Tribes also have management authorities on tribal waters and in ceded territories, and they view their treaty rights as a responsibility to manage resources to ensure their future use. Tribal environmental departments carry out monitoring, water treatment, infrastructure development, pollution prevention, habitat restoration, invasive species control and other activities. Tribes regularly work together to set priorities, share best practices and influence policy. Tribes also collaborate with other jurisdictions such as cities, counties and the state to manage water resources.

The United States and the State of Minnesota have a unique legal relationship with federally recognized tribes, which is set forth in the Constitution of the United States, treaties, statutes, Executive Orders, administrative rules and regulations, and judicial decisions.

In Minnesota, Executive Order 19-24 directs state agencies to conduct government-to-government consultation with tribes and to look for mutually beneficial solutions. Similar federal executive orders affirming tribal sovereignty have been issued under multiple presidents including Clinton, G.W. Bush and Obama. Complex issues like protecting waters from climate change will require ongoing consultation with Tribal Nations in Minnesota.

Tribal knowledge and experience

Tribes hold extensive scientific expertise about managing waters and ecosystems that is critical for sustainable water management in the face of climate change. They also offer perspectives from Indigenous knowledge systems, which are perhaps an even more significant asset for addressing climate change. Indigenous ways of knowing that have been passed down through generations are sensitive to subtle changes and attuned to unique qualities of a place. Moreover, tribes have already survived and adapted to centuries of environmental, cultural and political change. They have much to offer as Minnesotans work to protect waters from the impacts of climate change.

The goals and strategies that appear in this report can all be strengthened with deliberate attention to the knowledge, priorities and needs of tribes in Minnesota. Specifically, advancing goals 1–5 in this plan should involve:

- government-to-government consultation with Tribal Nations:
 - Follow Executive Order 19-24, which directs state agencies to recognize the unique legal relationship between the State of Minnesota and Minnesota Tribal Nations and to “accord Tribal Governments the same respect accorded to other governments.”
 - Initiate government-to-government consultation at the beginning of policy or program development and not in the final stages when decisions have already been made.
 - Work with tribal liaisons to distinguish between consultation, collaboration and cooperation and engage with Tribal Nations at the appropriate level.
- integration of tribal knowledge and expertise into state strategies and actions:
 - Value Tribal Ecological Knowledge on equal footing with other forms of scientific knowledge.
 - Integrate tribal knowledge early in planning and policy development processes.
 - Seek to engage tribal knowledge in multiple ways and look beyond usual sources of information. Tribal knowledge may be represented in a variety of formats and venues, including consultation and coordination with Tribal natural resource departments and technical staff, oral histories, published papers and reports, white papers, blogs, works of art, historical documents, undergraduate and graduate research reports, and more.
- collaboration with tribes to protect culturally important water habitats and species that are vulnerable to climate change:
 - Recognize that species and habitats have multiple benefits for Minnesota tribes, including economic, cultural, nutritional and ecological benefits.
 - Consider the presence of culturally important habitats and species within ceded territories, reservations, allotments and land that is federally supervised and set aside for the use of tribes, (usually found on trust land).
 - Consider opportunities to restore culturally important species and habitats in areas where they have been lost or degraded.



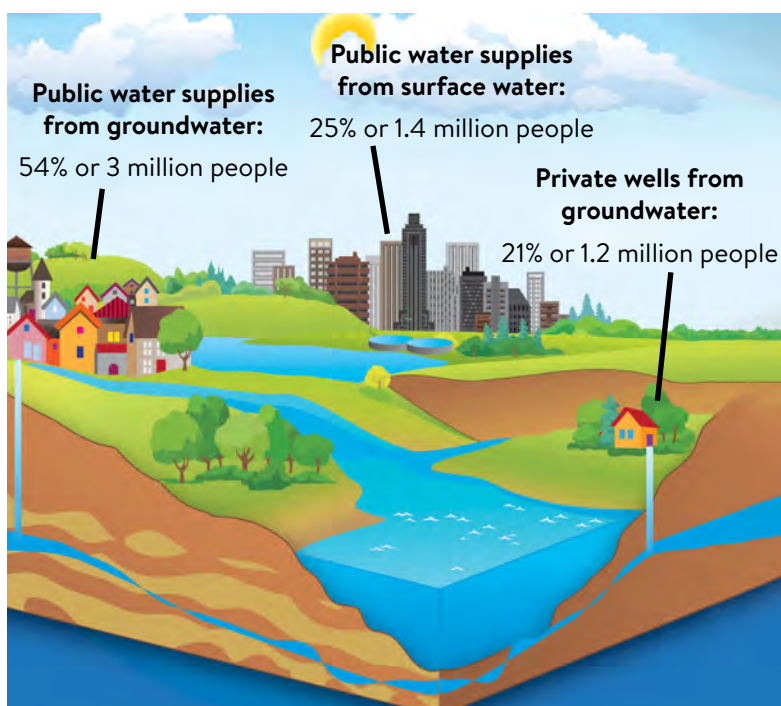
Source: DNR

GOAL 1:

Ensure drinking water is safe and sufficient

Minnesota's demand for water continues to grow along with our population and economy. By 2030, Minnesota's population of 5.6 million is expected to grow to more than 6 million. As Minnesota's population and economy grow, so does the need to protect drinking water. And as Minnesota's climate changes, bringing more intense and frequent precipitation, the challenge of protecting that water is becoming more complex than ever.

Climate is a primary driver of Minnesota's drinking water supply, influencing precipitation, evapotranspiration, runoff and groundwater recharge. Climate change is bringing more intense and frequent precipitation, which can lead to fluctuations in drinking water quality and quantity.



Source Water in Minnesota

"Source water" refers to surface waters (streams, rivers, lakes) and groundwater that provide drinking water for public water systems and private wells. Some 79% of Minnesotans get their drinking water from a community public water supply, while 21% use private wells.

In many parts of Minnesota, drinking water is vulnerable to contamination from the land surface. Increased precipitation and runoff due to climate change can increase the amount of nutrients, pesticides and other contaminants in drinking water. Warmer and wetter conditions can increase growth of toxin-producing algal blooms in source waters. Flooding can wash pathogens from the land into public and private wells.

Nitrate contamination of drinking water can pose serious health concerns, especially for infants and pregnant women. Although nitrate occurs naturally, it can also come from human-made sources such as human waste, animal manure and commercial fertilizer. One of the main sources of nitrate is fertilizer used to grow annual row crops like corn. Nitrate not used by crops easily moves by water through the soil into groundwater in areas dominated by coarse soils or underlain by eroded limestone (karst), which forms underground drainage systems.

Increases in precipitation are likely to move more nitrate into drinking water sources. Increasing the acreage of perennial crops such as alfalfa can reduce nitrate leaching. However, these crops must be economically viable for farmers to grow.

STRATEGY 1: Accelerate source water protection for community water systems.

Action 1.1: Prioritize protection of the 400,000 acres of vulnerable land in DWSMAs.

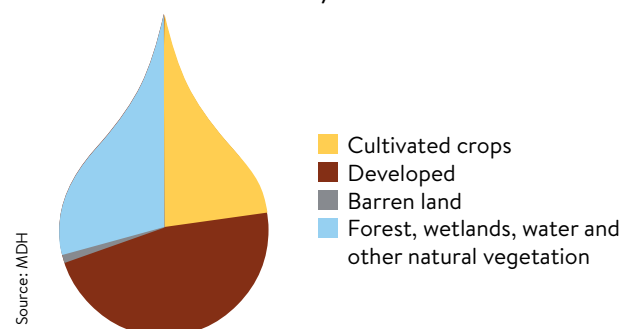


Source: MDH

Out of approximately 1.2 million acres of land in Drinking Water Supply Management Areas (DWSMAs) in Minnesota, 36% (about 400,000 acres) is considered vulnerable to contamination. Public water systems have limited ability to influence management of private land within DWSMAs, especially land outside city boundaries, so public-private partnerships are important.

- Where feasible, protect vulnerable areas in DWSMAs with easements or grants for permanent changes in land use from row crops to prairie/woodland/wetland. Currently, roughly 9,000 DWSMA acres are permanently protected through easements.
- Where permanent protection is not immediately feasible or desirable, use tools such as cover crops, conservation crop rotations, perennial crops and advanced nitrogen management practices.
- Provide incentives where high-level protection requires land use changes that pose economic barriers for landowners.
- Use the statewide [Source Water Protection Collaborative](#) to provide local resource managers and community members a nexus for long-term collaboration, collective learning and strategic planning aimed at protecting source water.

Drinking Water Supply Management Areas (DWSMAs) are defined as areas surrounding public water supply wells from which a contaminant can travel to the well within 10 years.



Approximately 30% of land in DWSMAs has a protective land use such as forestry or wetlands.

Action 1.2: Assess and monitor the safety and resiliency of surface DWSMAs.

- Prioritize drinking water protection activities for the 23 community public water suppliers that rely on surface water for drinking water. Point source management is most critical closest to the intake, whereas nonpoint source management is important throughout the watershed. Land use, physical settings and potential contaminant sources vary, and interventions should be specific to local needs.
- Prioritize watershed management plan creation and implementation in watersheds upstream from surface water intakes. Thirty-eight watersheds include surface water intakes or are upstream from an intake. These watersheds should have plans in the works or in place by 2025.

Action 1.3: Protect, restore, and increase perennial cover in the highest priority areas of the Mississippi River watershed.

- Identify protection strategies for those lands most vulnerable to contamination within the Mississippi watershed drinking water supply area. Thousands of square miles upstream of St. Cloud and Minneapolis–St. Paul contribute to the seven-county Twin Cities metro area drinking water supplies. Many land uses in the watershed are associated with potential contaminants that can travel downstream and affect drinking water quality. Forests in the watershed are being converted to irrigated agriculture. The largest proportion of these conversions occurred in critical water supply source areas for St. Cloud and Twin Cities metro area communities.

STRATEGY 2: Emphasize source water protection in watershed management.



Over a decade ago, Minnesota began transitioning to managing water on a major watershed basis.

The state has a goal of completing comprehensive watershed management plans through the [One Watershed One Plan](#) (1W1P) program by 2025. These plans, as well as Twin Cities metro area watershed management plans (in place since the 1980s), address protection and restoration of surface and groundwater quality (including source water) as well as other issues such as flooding and habitat.

Local governments have begun to implement high-priority actions from their comprehensive watershed management plans. Implementing activities in vulnerable source water areas within watersheds can help protect drinking water.

Action 2.1: Emphasize source water protection in implementing watershed management plans.

Watershed management plans developed under the 1W1P program, as well as many of the Twin Cities metro area and other watershed management plans, already identify vulnerable acres within public and private well supply areas for improved management.

- Private wells: Prioritize watershed management plan implementation for townships in which private wells exceed the health risk limit of 10 milligrams per liter (mg/L) for nitrate. Statewide, approximately 9% of private wells tested by the [MDA township testing](#) program exceed this limit.
- Public water systems: Prioritize watershed management plan implementation for vulnerable areas within groundwater DWSMAs. Conservation practices within the 400,000 vulnerable acres can yield immediate benefits for drinking water quality and long-term gains for groundwater quality.

Action 2.2: Leverage the use of state dollars to protect drinking water.

- Use funding programs such as [BWSR's Watershed Based Implementation Funding](#), [Projects and Practices Drinking Water Grants](#) and [Wellhead Protection Partner Grants](#) to protect vulnerable land near public and private drinking water wells.

Action 2.3: Increase routine testing of private well water.

MDH recommends that private well owners test their wells at least once for lead, arsenic and manganese; every year for coliform bacteria; and every other year for nitrate.

- Promote nitrate testing kits and educate well owners as part of implementation of watershed plans; this may increase private well testing.
- Provide free nitrate testing kits to households with infants.

Source: MDH

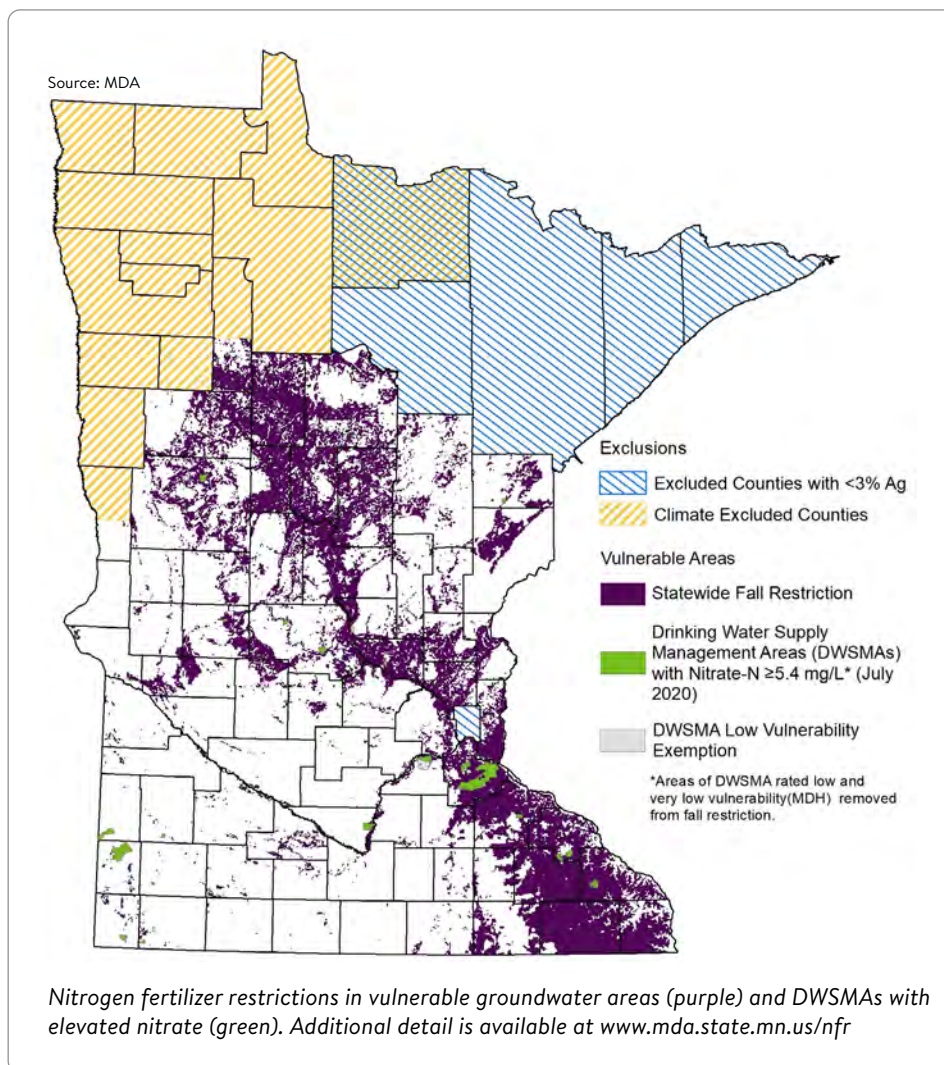


STRATEGY 3: Prevent nitrate contamination of drinking water and groundwater.

The [Nitrogen Fertilizer Management Plan](#) (NFMP) is the state's blueprint for minimizing impacts of nitrogen fertilizer on groundwater. The NFMP process includes forming local advisory teams, using computer modeling to identify and target high-priority practices, monitoring groundwater for long-term trends, and implementing groundwater-protecting practices.

The [Groundwater Protection Rule](#) (GPR) restricts the application of nitrogen fertilizer in the fall and on frozen soils in areas vulnerable to contamination, increases the adoption of nitrogen fertilizer BMPs, involves farmers in adopting practices that reduce nitrate in groundwater, and reduces the severity of nitrate pollution in DWSMAs where nitrate in public water supply wells is equal to or greater than 5.4 mg/L.

While the GPR process is designed for use in DWSMAs of public water supplies, the NFMP applies this process to private wells in townships. In combination, the NFMP and GPR provide a comprehensive effort to address nitrate in groundwater through voluntary adoption of practices and regulation if necessary.



Action 3.1: Fully implement Minnesota GPR in DWSMAs with nitrate concentrations above defined thresholds.

- Focus implementation funding on ensuring that no additional public water supply wells exceed the drinking water standard for nitrate. The rule includes regulatory and voluntary measures to work with farmers to adopt nitrogen fertilizer BMPs and other practices such as vegetative cover, to address nitrate in groundwater within DWSMAs.
- Use new modeling techniques being developed by University of Minnesota researchers and MDA to forecast water quality outcomes of potential implementation activities.

Action 3.2: Implement the NFMP in vulnerable areas as defined by township testing results.

NFMP implementation is voluntary and prioritizes private wells in townships where more than 10% of wells have nitrate concentrations over 10 mg/L. Perennial crops and cover crops are important components of the NFMP.

- Work with farmers to voluntarily adopt practices to reduce nitrate contamination of groundwater.

Action 3.3: Ensure compliance with the Minnesota Feedlot Rule.

Improper manure management can contaminate water and lead to harmful algae blooms. [MPCA's Feedlot Program](#) monitors animal feedlots and land application of manure to ensure compliance with the Minnesota Feedlot Rules ([Chapter 7020](#)) protecting groundwater and surface water. The Feedlot Program also issues permits that ensure that rules governing manure storage system construction and design standards are met.

GOAL 1: Ensure drinking water is safe and sufficient

[Federal National Pollutant Discharge Elimination System](#) (NPDES) and [State Disposal System](#) (SDS) permits are issued to the larger feedlots in Minnesota for construction and operation. Proposed revisions to the 2021–2026 Feedlot General NPDES/SDS permit are intended to mitigate nitrate leaching from manure application and to prevent manure-contaminated runoff by requiring the use of additional BMPs and imposing seasonal restrictions on manure application.

- Strengthen and prioritize MPCA's regulatory oversight of these permits and rules in areas that receive high precipitation.



Source: MDA

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is designed to accelerate adoption of on-farm practices that protect Minnesota's waters.

Kernza®



Source: Courtesy of the Land Institute (landinstitute.org)

Kernza® grain is the world's first commercially viable perennial grain crop. Kernza grain is harvested from intermediate wheatgrass, a forage crop that is being domesticated for grain production and human consumption by [The Land Institute](#) in Salina, Kansas, and the [Forever Green Initiative](#) at the University of Minnesota. As a crop with a deep, dense root system that provides year-round living cover, [Intermediate Wheat Grass](#) has been shown to reduce nitrate leaching to groundwater and reduce soil erosion and may increase carbon storage compared with annual crops. Research on these benefits is ongoing. Kernza has attracted increasing interest from growers, processors and food manufacturers. Early uses of Kernza include brewing, crackers, baked goods, cereals and other food products. Kernza can be managed as a dual-use crop for grain and forage to reduce risk and support grower profitability.

The first Kernza variety, MN-Clearwater™, was released by University of Minnesota in 2019, and seed supplies will allow about 1,000 acres to be planted in fall 2020. Regional seed and grain processing capacity is currently limited to several local seed companies, a promising Minnesota-based start-up business, and a processor in North Dakota. However, demand for cleaning, dehulling, milling and malting Kernza is increasing, and Kernza production, supply chains, and markets are poised to scale quickly in the coming years.



Source: MPCA

Increased intensity and duration of rain due to climate change can reduce surface and groundwater quality by increasing nutrient and sediment runoff. Water quantity is also expected to be impacted, with more erosion and flooding (see Goal 4). Healthy soil provides many benefits:

- It contains organic matter that retains water, reducing runoff and the need for structural water storage.
- It increases the availability of water to plants, which can increase yield and improve resilience to dry spells, reduce the need for supplemental irrigation, reduce the speed and volume of runoff, and reduce nutrient losses into surface water and groundwater.
- It can store large amounts of carbon, which means that soil health improvements have great potential to reduce greenhouse gas emissions across Minnesota's 20 million acres of cropland.

Agricultural BMPs that contribute to soil health include no till or reduced tillage, cover crops, crop rotations that include perennials, responsible manure application and installation of vegetative buffers along streambanks and lakeshores. [Minnesota's Nutrient Reduction Strategy](#) calls for one or more of these practices to be newly adopted on approximately one-third of cultivated lands to achieve interim goals for surface water quality.

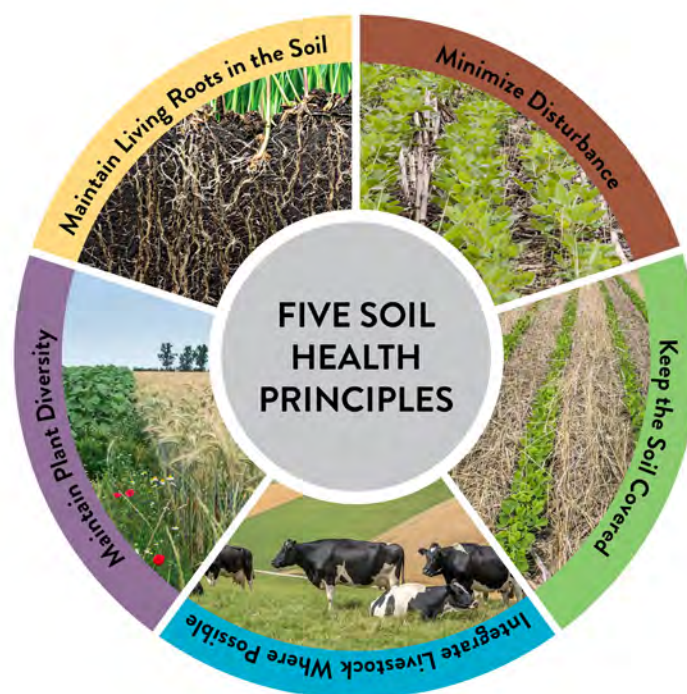
While public investment may be needed to incentivize practices that boost soil health, such practices should eventually begin to pay for themselves because they are marketable, add value to the product or service provided, and can result in higher yields and/or lower inputs.

GOAL 2:

Manage landscapes to protect and improve water quality



Source: Courtney Celley/USFWS



"I think agriculture has really evolved. In my father's and grandfather's time, you plowed the soil and planted your crop. I think due to technology and what we've learned, we can practice no-till, strip-till, vertical tillage, where we're leaving more residue on the soil. We don't need to leave it exposed. We can use cover crops so we have the ability to retain and keep that soil in place so that we don't have runoff. So we keep the nitrogen and nutrients in place to make sure that our surface water does stay clean."

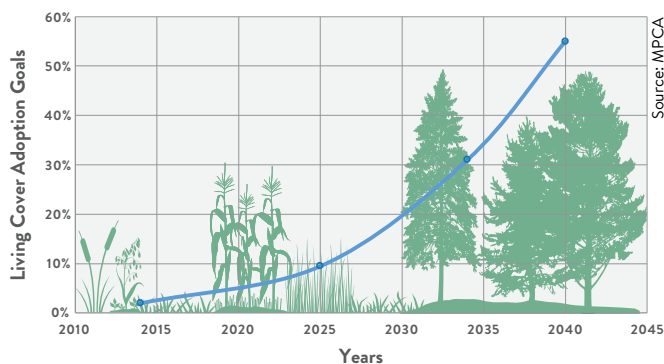
—Randy Spronk, Edgerton

STRATEGY 1: Increase soil health.

Action 1.1: Work to meet state goals for expanding the acreage of cover crops and continuous living cover.

- Keep fields covered with vegetation for much of the year. Practices such as cover cropping and incorporation of perennial vegetation (known as continuous living cover) protect soil from water and wind erosion and reduce nutrient loss to surface and groundwater. However, cover crops are grown mainly for soil health purposes rather than as a primary commodity crop and can take time and resources to establish. USDA farm census data indicate that less than 2% of Minnesota producers use cover crops on their land. The [Clean Water Council Strategic Plan](#) identifies a goal of 5 million acres of row crop agriculture using cover crops or continuous living cover by 2034. Minnesota's [Nutrient Reduction Strategy](#) scenarios identify cover crop needs of 1.9 million new acres by 2025 and over 10 million acres by 2040. When combined, goals for escalating these “living cover” practices in Minnesota look like the curve below.

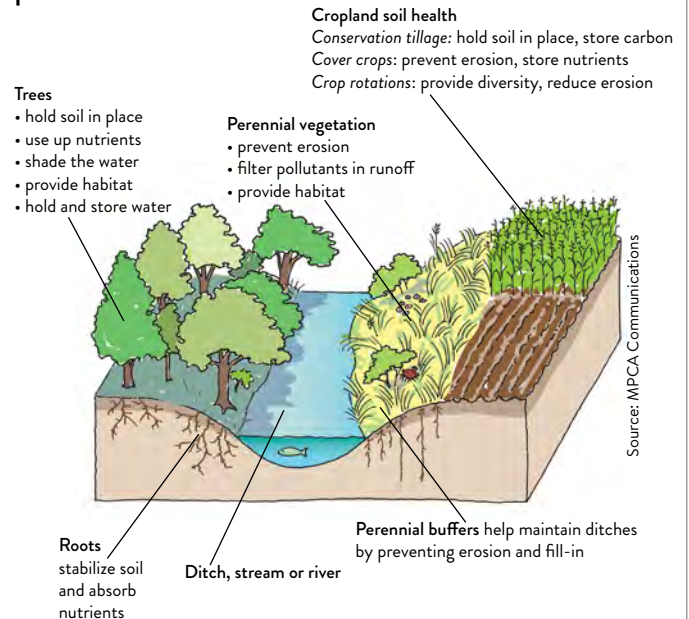
Living Cover Adoption Goals
Nutrient Strategy and CWC Strategy



Less than 2% of Minnesota producers currently use cover crops on their land. The “living cover” adoption goals aims to increase the percentage of cropland by the year 2040.

- Accelerate existing grant and cost-share programs (see next page). Priority lands should include:
 - drinking water source areas, as discussed under Goal 1
 - sloping land and highly erodible soils
 - subwatersheds or other areas identified as priorities in local watershed plans.

How continuous living cover protects water



Action 1.2: Improve monitoring and metrics for soil health based on statewide research and modeling.

- Work with the [Minnesota Office for Soil Health \(MOSH\)](#) at the University of Minnesota to monitor and evaluate soil health statewide.
- Work with MOSH to develop standard metrics for soil health under a range of climate and soil conditions, including both laboratory tests (e.g., organic matter, biological activity) and in-field measurements (e.g., soil properties, earthworms).
- Increase resources for on-farm and regionally specific research on and demonstrations of conservation tillage, cover crop systems, crop rotations, management intensive grazing and other conservation practices in order to generate more regionally specific data.
- Determine how much the improvement of soil health at a subwatershed scale can reduce the need for water retention structures to hold water on the landscape.

Programs That Support Soil Health

In addition to the many federal funding options available through the [National Resource Conservation Service](#), Minnesota has established a number of pioneering programs supporting agricultural BMPs that advance soil health.

- The [MAWQCP](#) is a national demonstration project developed with the [USDA](#) in partnership with public and private collaborators, including Soil and Water Conservation Districts (SWCDs), BWSR, MDA, DNR, MPCA and private industry. Certification systematically identifies and mitigates risks to water quality on a field-by-field basis. Participants receive individualized technical and financial assistance to implement practices and improve soil health and may further obtain a soil health endorsement for exemplary management.
- BWSR's [State Cost Share Program](#) provides funds to SWCDs to share costs of conservation practices with producers for high-priority erosion, sedimentation or water quality problems. Structural or vegetative practices must be designed and maintained for a minimum effective life of 10 years.
- The [Projects and Practices](#) grant is a competitive grant supported by the [Clean Water Fund](#) that invests in projects and practices that will protect or restore surface water quality or protect groundwater or drinking water. Eligible activities include many agricultural BMPs that promote soil health.
- A [Cover Crop Demonstration Grant program](#) established in 2019 provides funds to five SWCDs to offer technical and financial assistance to new adopters of cover crops.
- The [AgBMP Loan Program](#) provides low-interest loans to farmers, rural landowners and agriculture supply businesses to encourage agricultural BMPs that prevent or reduce runoff from feedlots or farm fields and other pollution problems identified in local water plans.
- The [Nutrient Management Initiative](#) promotes cover cropping, manure crediting and other practices for corn and wheat producers. Participating farmers work with crop advisers to set up field trials.
- The [Clean Water Research Program](#) recently provided funds to MOSH to develop a guide for establishing cover crops in Minnesota based on local data. The program has also funded research on cover crop establishment and water quality benefits.
- [Sustainable Agricultural Research and Education](#) grants combine federal and state funds to help MDA, SWCDs and growers collaboratively assess the impact of cover crops on soil health.

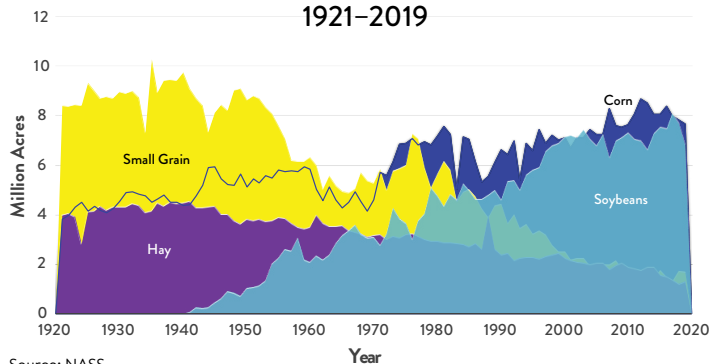


Source: BWSR

Examples of crops used as a living cover to support soil health.

Action 1.3: Diversify crops and agricultural practices that support soil health.

Long-Term Trends for Corn, Hay, Soybeans and Small Grains 1921–2019



Source: NASS

- Since about 50% of agricultural land is rented, target both landowners and producers with outreach and assistance on conservation contracts (including [MAWQCP](#) comprehensive conservation management contracts) to reflect the value of soil health practices and increase adoption.
- Promote the reintroduction of small grains—wheat, oats, barley and rye, which were once staple crops in Minnesota. Such short-season crops make it much easier to establish cover crops than is the case for corn and soybeans, and they can provide other soil health benefits. However, markets and supply chains for small grains need further development and support to make these crops economically viable.
- As discussed under Goal 1, continue to build markets and supply chains for crops that provide continuous living cover, such as those developed through the University of Minnesota's [Forever Green Initiative](#). Emerging perennial crops, notably Kernza, and winter annual cover crops (camelina and pennycress) provide soil health and water quality benefits and are beginning to gain footholds in the marketplace.

Action 1.4: Reduce social and financial barriers to implementation of soil health practices.

- Encourage and support programs such as the [Minnesota Soil Health Coalition](#) that offer farmer-to-farmer communication and mentorship to help farmers successfully transition to conservation-tillage and cover-crop systems, crop rotations, continuous living cover crops, and other soil health practices.
- Support the establishment and work of local soil health teams and networks. Numerous teams are providing demonstrations and field days at county, multi-county or watershed scales, but they need further financial and personnel support.

- Invest in regional equipment purchasing and sharing programs for agricultural cooperatives or SWCDs to reduce the burden of investing in cover crop and perennial/small grain planting and harvesting equipment.

Action 1.5: Establish soil health demonstration watersheds.

- Fund incentives, local promotion and water monitoring related to intensively adopting soil health practices in selected small subwatersheds to identify how barriers can be overcome and demonstrate multiple benefits.
- Use demonstration watersheds to promote soil health and living cover practices to other watersheds.
- Facilitate farmer-to-farmer sharing of learning experiences and ways to overcome technical, financial and social barriers.

CASE STUDY: Statewide Soil Health Database

The [Mower](#) and [Stearns](#) county soil and water conservation districts (SWCDs) are collaborating with the University of Minnesota on a [statewide soil health project](#) measuring soil properties under contrasting management systems. The project, which is funded by a [Conservation Innovation Grant](#) from the NRCS, will collect soil health indicator data from 26 working farms in Mower County, the Minnesota River Valley, Stearns County and the Red River Valley. At the end of the project, the partners will have a database of regional soil health measurements, a suite of case studies highlighting farmers who have adopted soil health practices, and a detailed economic analysis of soil health management systems on 10 farms.



Source: MDA

STRATEGY 2: Expand opportunities to participate in ecosystem services markets.

Offset markets, which offer compensation for providing ecosystem services, can help landowners finance sustainable practices. Offsets fall into two primary “buckets”: carbon and water quality.

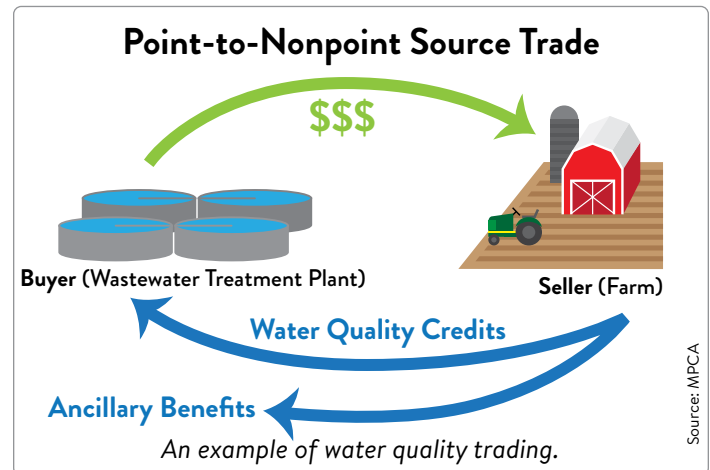
- 1) Carbon offsets, which fund projects that sequester carbon (e.g., reforestation, improved forest management, avoided conversion, improved land management) have been traded in voluntary markets for decades. Primary markets include the [California Compliance Offset program](#) and voluntary markets for activities such as reforestation and regenerative agricultural practices.
- 2) Water quality offsets typically take the form of water quality trading. An entity facing high costs to control a pollutant trades with another entity paying lower costs for pollution control. Part of the permittee’s required reduction in pollutant load is offset by improvements made elsewhere in the watershed. The watershed still benefits from the reduction in the surface water pollutant—it just comes from a different source. For example, an upstream landowner implements agricultural BMPs that reduce pollution or nutrients to levels below legal requirements. Once those nutrient reductions are verified, they are translated into credits that may be sold in water quality trading markets. Downstream cities or industries can then purchase those credits to reduce the cost of compliance with their pollutant load reduction requirements.

Action 2.1: Develop accounting protocols and data foundations for ecosystem services trading.

- Evaluate agriculture and forestry-based BMPs to establish consistent protocols for an ecosystem services trading system that includes both carbon and water quality elements. Useful resources include MPCA’s [Greenhouse Gas Reduction Potential of Agricultural Best Management Practices](#) and the [Minnesota Nutrient Reduction Strategy](#).



Source: BWSR



Action 2.2: Pursue emerging options for ecosystem service markets using water quality trading as a starting point.

- Participate in a pilot project launched by the [Ecosystem Services Market Consortium](#) (ESMC), a collaboration of members from across the agricultural supply chain and value chain working to build a viable, scalable and cost-effective ecosystem service marketplace. The ESMC views “soil health as the nexus through which they can most effectively address climate change, water quality degradation, and water scarcity.” ESMC is currently engaged in research and development of pilot projects leading up to a projected 2022 full-scale market launch. A Minnesota pilot project is being launched in the [Sauk River watershed](#).
- Expand the water quality trading program managed by the MPCA. The MPCA allows water quality trading on a case-by-case basis as a voluntary part of the permitting process for pollutant discharges. Trades have been conducted in several ways in Minnesota:
 - Point-to-point: trades between two or more point sources such as wastewater treatment plants. For example, in 2014 the City of Redwood Falls entered into a trading agreement with the City of New Ulm to offset part of the phosphorus discharge from its wastewater treatment facility to the Minnesota River, a trade that remains in effect.
 - Point-to-nonpoint: trades between a point source and one or more nonpoint sources. For example, Rahr Malting in Shakopee implemented five trades with four sites on the Minnesota River and its tributaries, mainly focused on streambank revegetation and bluff stabilization, to offset increased wastewater discharges. The Southern Minnesota Beet Sugar Cooperative in Renville County implemented trades with multiple sites that include cover crops planted on beet fields to offset increased discharges to a county ditch.

CASE STUDY: The Shell Rock River Watershed District



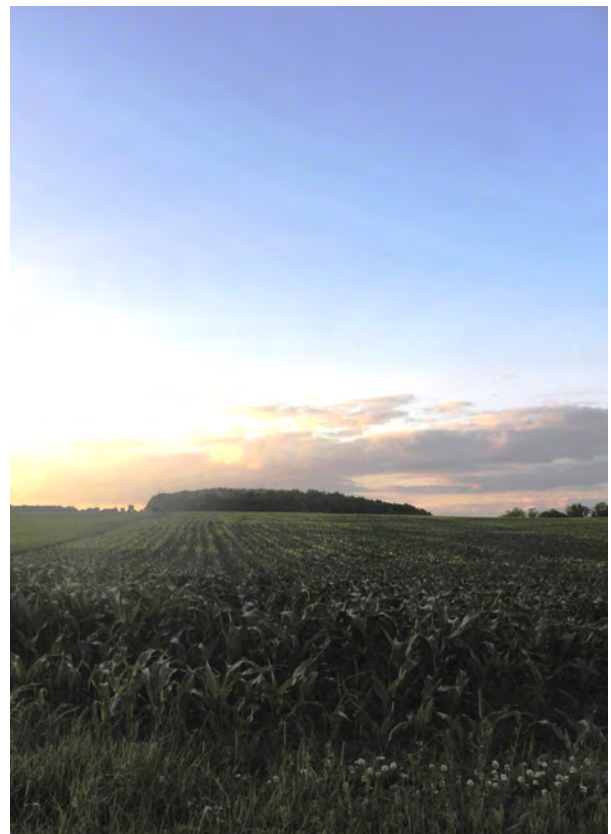
Source: MPCA

Shell Rock River

The [Shell Rock River Watershed District](#), located in Freeborn County, forms the headwaters for the Cedar and Upper Iowa rivers. The watershed, located in and around Albert Lea, includes several impaired lakes and stream segments. Fountain Lake, a major recreational amenity in the city, is impaired by excess nutrients such as phosphorus from both urban and agricultural sources. While phosphorus reduction projects in a developed city are very expensive, there are ample opportunities to reduce phosphorus in the surrounding agricultural parts of the watershed. In 2018, the [Legislative-Citizen Commission on Minnesota Resources](#) (LCCMR) provided funding to develop a pilot credit trading system for stormwater. The program will establish an approach to sediment and nutrient credit trading for stormwater permits that could be used across Minnesota.

CASE STUDY: Wisconsin's Water Quality Trading and Adaptive Management Programs

[Wisconsin's Water Quality Trading](#) and [Adaptive Management](#) programs help Wisconsin Pollutant Discharge Elimination System permit holders meet water quality-based effluent limitations through water quality trading between point sources and nonpoint sources within the same watershed. It is implemented through an agreement between government agencies rather than a credit transaction. One large-scale example aims to reduce phosphorus in the Yahara River Watershed, which surrounds the capital city of Madison. All sources of phosphorus in the watershed collaborate to reduce phosphorus. Partners pool their resources and fund practices that reduce nutrient runoff. [Yahara Pride Farms](#), a farmer-led, not-for-profit organization, acts as a technical service provider, engaging farmers to implement BMPs and track progress. The work began in 2012 and, following a four-year pilot effort, has transitioned to full-scale implementation over 20 years.



Source: Yahara Pride Farms



Source: MDA

Pictured is ForageScape Farm LLC (<https://www.foragescape.com>)



The Minnesota Agricultural Water Quality Certification Program

The [MAWQCP](#) is a noteworthy example of the two Goal 2 strategies in action.

With respect to the strategy aimed at increasing soil health, MAWQCP implements soil health practices across more than 600,000 certified acres under 10-year contracts. MAWQCP also offers a soil health endorsement developed with the [Minnesota Soil Health Coalition](#), [MOSH](#) and others.

Since April 2019, MAWQCP has worked with MPCA to estimate greenhouse gas emission reductions from 21 practices related to changing land use, cropping practices and nutrient reduction. Between 50% and 60% of new water quality practices implemented by MAWQCP-certified growers are among the [21 climate practices identified by MPCA](#), including increased perennial cover and cover crops, nutrient management, and reduced tillage. The average emission reduction is 37 tons of greenhouse gas (CO₂-equivalent) emissions per practice per year.

Related to expanding opportunities to participate in environmental services markets, the MAWQCP, as a partner to the [ESMC](#) Minnesota pilot project, helps lay the groundwork needed for a functional market-based water quality trading system. First, MAWQCP's certification process establishes a baseline assessment of water quality risks associated with the management and practices for every crop grown on a farm. Second, it documents improvements above baseline of new clean water and climate-specific practices and management activities under a 10-year contract. Third, certification is a documented demonstration by growers of comprehensive management and practices achieving superior stewardship across their entire farm.



Source: MPCA

In the past, we built stormwater infrastructure while only considering its main job—moving water away from developed areas to prevent flooding—and not accounting for the associated harms. We now know that the way we have developed our built environment has disrupted the natural water cycle and led to flooding and water pollution. Aging wastewater collection systems are vulnerable to inflow and infiltration of clear water, potentially overwhelming infrastructure like lift stations and treatment plants and causing sewer backups. In addition, much of the drinking water infrastructure in Minnesota is old and outdated and may not address future needs for capacity or treatment.

Climate change threatens to make these problems worse, with higher annual precipitation and more frequent, heavier rainstorms as well as extended dry periods. Much stormwater, drinking water and wastewater infrastructure needs rehabilitation or replacement to handle more extreme conditions. While this is a clear financial challenge, it is also an opportunity to invest in infrastructure built for climate resiliency. Appropriately sized gray infrastructure built to work with green infrastructure can be designed to provide multiple benefits related to stormwater management, air quality, urban heat island mitigation, greenhouse gas reduction and overall quality of life. However, communities need better support in the form of funding and data in order to achieve these goals.

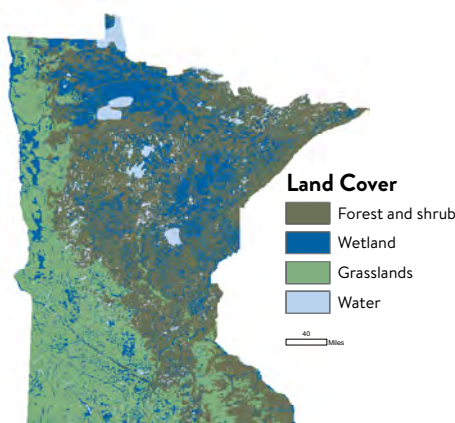
GOAL 3:

Manage built environments and infrastructure for greater resiliency

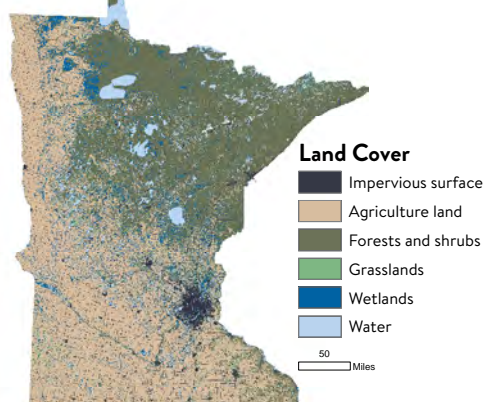


Source: MPCA

Pre-European settlement

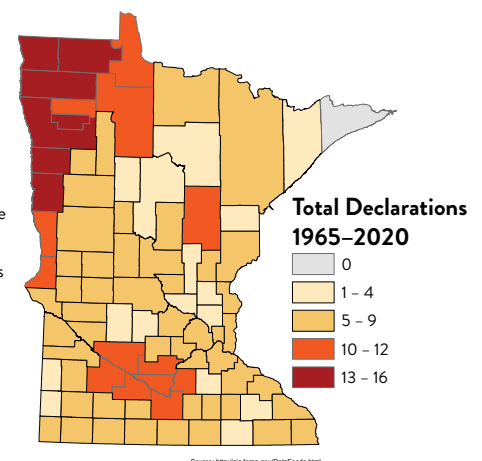


Today's land cover



Minnesota has experienced numerous floods
Number of flood disasters by county (1965–2020)

Source: HSEM/DPS



Minnesota's land cover has changed dramatically since European settlement. Loss of wetlands, increasing impervious surface, and the alteration of natural hydrology in both urban and rural settings create vulnerability to flooding.

STRATEGY 1: Improve data sources and modeling.

Minnesota needs accurate climate data to assess vulnerabilities to the changing climate and guide planning for new and replacement infrastructure. Climate change means that models based on past data must be coupled with tools incorporating current conditions and future projections. Several agencies are using remote sensing to determine where to put infrastructure, what kind of pollutant load a water body may experience or which areas of a city have the greatest risk for flooding. Large-scale models and data sets exist for climate projections and for remote sensing but do not provide enough detail to understand local impacts. We have the technology we need to obtain finer-scale data; however, agencies, organizations and communities require funding and resources to use it.

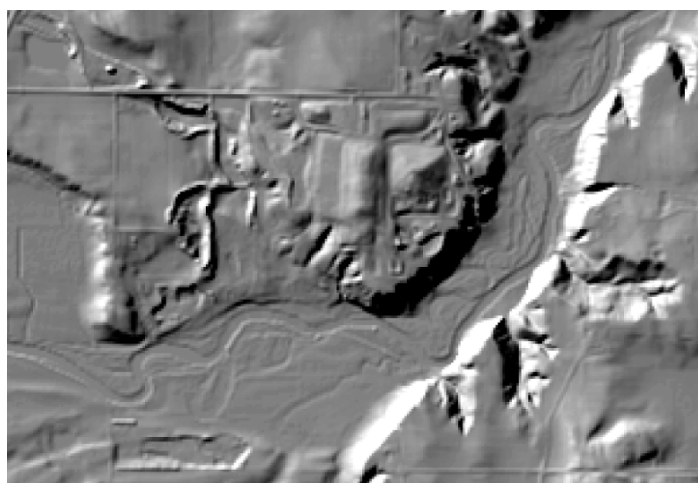
Action 1.1: Pursue and fund next-generation LiDAR.

LiDAR creates detailed models of an area by sending out laser pulses from a transmitter and receiving light particles that bounce back. We can use LiDAR to identify the size of depressions and estimate how much water they can hold. Minnesota's LiDAR data are at or approaching 10 years old.

- Initiate a five-year-plus effort to acquire higher resolution LiDAR data to reflect the reality of our landscapes, following the Minnesota Geospatial Advisory Council's plan for capturing LiDAR data across the state.
 - Submit a cost-share grant request to the federal government through the U.S. Geological Survey (USGS) each year.
 - Acquire data from all land in Minnesota.
- Engage partners at all levels of government, tribal nations, academia, nonprofit and private sectors to contribute to planning and funding.
- Consider the [Minnesota Geospatial Information Office](#) (MnGeo) as the likely aggregator and distributor for the data products generated.



30-meter DEM



10-meter DEM



1-meter DEM continuing into aerial photos

Source: MnGeo

LiDAR becomes increasingly useful to gather data as we increase the resolution. In the 30-meter digital elevation model (DEM), you can barely make out that it's a landscape, but as we move to 1-meter DEM, you can see the details in topography even more clearly than in the aerial photo.

CASE STUDY: New Models to Determine Flooding Risk

As part of its [Climate Vulnerability Assessment](#), the Metropolitan Council used the Danish Road Institute's [Blue Spot model](#) along with the state's LiDAR data to identify low-lying areas in the Twin Cities metro area that could fill with water and cause localized flooding. The Blue Spot assessment evaluates risk to public transportation, wastewater treatment plants and other infrastructure. The Metropolitan Council staff could strengthen the Blue Spot assessment with updated LiDAR data, standardized stormwater information, and inclusion of current stormwater infrastructure and BMPs. Communities across the state could adopt this methodology to create their own models.

A similar predictive model was released by the [First Street Foundation](#) in 2020. Unlike typical flood models, which are based purely on statistical analysis of historical records of rainfall and stream gages, the foundation's flood risk model projects future climate scenarios and incorporates local adaptation projects such as levees and green infrastructure. The model shows [localized flooding potential](#) and projections of increased flood threats due to climate change over the next 30 years.



Metropolitan Council's outward-facing [Localized Flood Map Screening Tool](#) uses the Blue Spot assessment technique to provide communities with an opportunity to determine which of their assets and areas may experience localized flooding risks during short-term, extreme rain events.

COMMUNITY HIGHLIGHTS:

Improving Watershed Resilience by Leveraging Advances in Monitoring and Data Science

Changes in the frequency and intensity of rainfall due to climate change are increasingly stressing the capacity of hydrologic systems. The flooding and high-water issues that result have wide-reaching impacts on water quality, ecology, infrastructure, property and recreation.

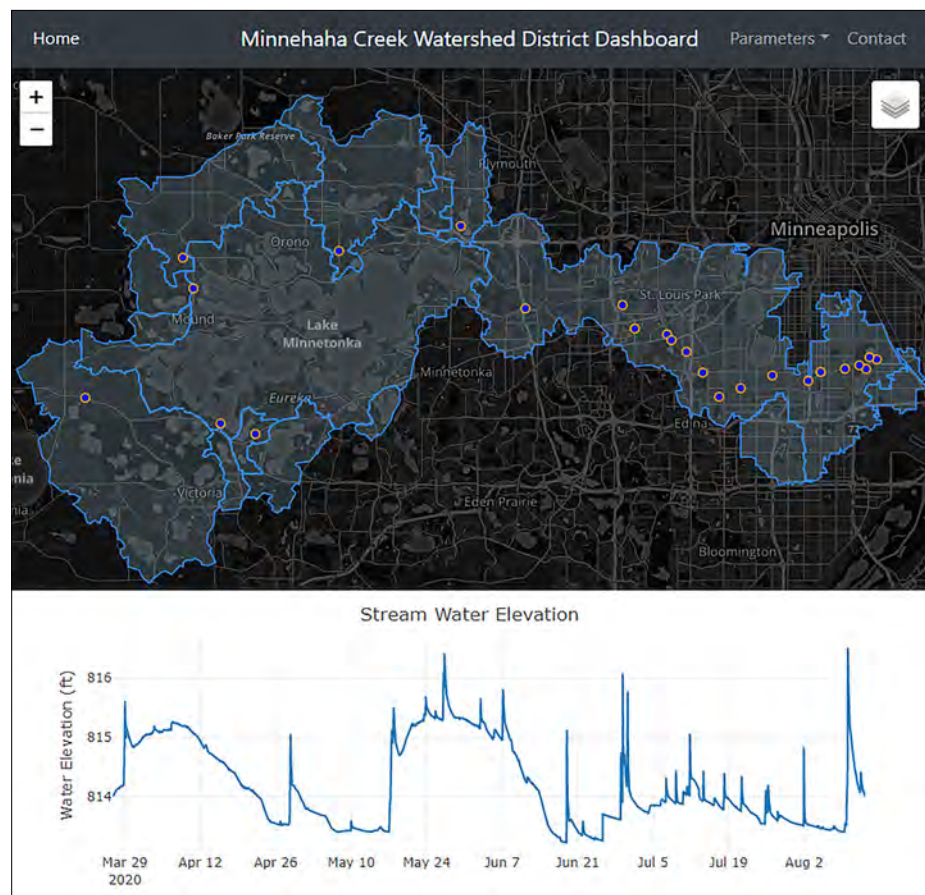
Recognizing the need to maximize existing storage capacity in its systems, the [Minnehaha Creek Watershed District](#) (MCWD) formed a multi-agency partnership with the National Weather Service (NWS), USGS and Hennepin County to leverage advances in remote sensing, machine learning and modeling to better predict, observe, manage and communicate about water levels across the Minnehaha Creek watershed.

The NWS provides seven-day precipitation forecasts, in six-hour increments, tailored to the watershed. The NWS also provides data from its hydrologic model to predict how this precipitation will impact Lake Minnetonka's water level. Hennepin County provides data from seven weather stations across the watershed that track real-time precipitation, soil moisture and other weather conditions. USGS sensors at the outlet of Lake Minnetonka and along Minnehaha Creek provide real-time water level data. MCWD's own real-time sensor network of more than 20 water-level sensors supplements the USGS sensors to gauge how the watershed responds to rain events in real time.

This information allows MCWD to optimize how it operates the Gray's Bay dam, which controls flow from Lake Minnetonka into Minnehaha Creek, in order to maximize capacity in both water bodies and reduce flood risk. It also allows MCWD to proactively communicate flood risk to its communities and residents. In 2021, MCWD will begin developing a new machine-learning model and a two-dimensional model using the large and growing data sets

on both predicted and measured rainfall and watershed response. The robust machine-learning model will further refine dam operations and improve flood forecasting and emergency response, and the two-dimensional model will improve project planning.

By leveraging the unique expertise and combined data sets of these agencies and deploying advances in monitoring and data science, this multi-agency partnership has increased the resiliency of the watershed in a changing climate. Since the partnership formed after historic floods in 2014, there has not been significant flooding in the watershed, despite experiencing the wettest six-year period on record. Like many data-driven solutions, the benefits of this system are likely to compound over time as the data sets grow and the tools improve.



MCWD's Real-Time Sensor Network (RESNET) allows them to control flow from Lake Minnetonka into Minnehaha Creek through Gray's Bay Dam in response to changes in stream and lake water elevations.

Action 1.2: Obtain dynamically downscaled climate projections.

Agencies and local partners currently rely on historical weather trends to make decisions, which are less useful as climate changes. New and innovative modeling methods make it possible to downscale climate projections from global models to project local changes. Such projections are valuable for planning and implementing strategies for maintaining and protecting the natural environment, built infrastructure, economy and public health. Perhaps most importantly, they will help agencies and communities model hydrology and hydraulics, identify vulnerabilities in wastewater treatment plants and stormwater management systems, develop feedlot runoff storage pond standards, enhance soil and water BMPs, and understand how climate change may affect human health. Reliable, local climate projections will help communities plan and prioritize adaptation and resiliency practices.

- Produce high-resolution (areas equivalent to a quarter of a township) climate model projections for the entire state.
- Create a publicly accessible web-based portal for viewing and using the projection data.
- Provide educational resources and training materials for professionals on using the projections to plan and adapt.

Source: MnDOT



Action 1.3: Support modeling efforts and risk management that consider climate change impacts.

[The Federal Emergency Management Administration's \(FEMA\)](#) floodplain maps have been the standard for land use planners for over 50 years. Municipalities, townships and counties use them in land use planning and culvert and bridge design. Historically, developers of these maps have not considered land use changes or climate change when determining the 1%-annual-chance (100-year) floodplain. Recently, FEMA has required that all models used for mapping incorporate the 1%-plus storm event, which takes into account any potential errors when calculating the hydrology for a stream or river. This 1%-plus event can also be used to evaluate areas that are now more likely to flood due to land use or climate change.

- Communities can compare the 1%-annual-chance floodplain to the 1%-plus floodplain to find areas more vulnerable to climate change.
- Communities can compare the 1%-annual-chance-floodplain to the [Flood Factor](#) model for any specific location—by checking properties at risk on the Score Map, and by looking at projected flood risk at 1% flooding likelihood using the Flood Risk Explorer—to find areas now more likely to flood due to climate change.
- DNR can assist communities learning to use FEMA's other new products, such as depth grids or velocity grids, to identify potential erosion or additional hazard areas.

For many individuals and businesses, insurance functions as a risk management tool. Improved climate data provides a more accurate assessment of risk and better inputs for developing effective insurance products.

- Expand communication with residents and businesses about understanding their baseline insurance coverage for water and flood damage.
- Improve access to risk mitigation for flood and water damage by encouraging the development of new insurance products that rely on improved, data-driven flood risk mapping.

Accounting for climate risk in municipal bond markets

While financial incentives in the commercial and residential insurance industry integrate climate data, municipal bond markets have not absorbed these climate-data signals. Without accounting for climate data, there is little financial incentive to manage climate risk.

However, credit-rating agencies are beginning to take climate risk more seriously, with bond rating agencies considering the impacts of climate change in their credit quality evaluations. In addition, buyers of municipal bonds are beginning to ask about how municipalities and water utilities are considering climate and extreme weather risks in their planning and operations.

Expanded integration of climate data into financial risk assessment for public infrastructure will help drive informed decision-making and risk mitigation.

STRATEGY 2: Support communities with asset management and resiliency planning for wastewater, stormwater and drinking water infrastructure.

Much of the water-related infrastructure in Minnesota is old, inadequate for meeting future needs and increasingly vulnerable to climate change.



Source: MPCA

Drinking water and wastewater treatment plants and the infrastructure networks that convey treated and untreated water are complex, expensive and necessary systems. Much of this infrastructure across Minnesota needs repair or replacement in the next 20 years

Asset management is a method that public water and wastewater systems can use to assess their infrastructure, evaluate vulnerabilities, and plan for long-term maintenance and protection. An asset management inventory should include all water infrastructure and consider source water vulnerability and protection needs. As weather patterns change and storms intensify, asset management becomes increasingly important in planning and preparing for potential emergencies.

Small communities often lack the staff needed to thoroughly inventory their water system assets. MDH and the [Minnesota Rural Water Association](#) (MRWA) can help smaller public water

systems inventory their assets and identify vulnerabilities. However, MRWA assistance is limited by funding constraints. Priority funding is needed to support asset management in small community drinking water systems.

Action 2.1: Fund a comprehensive asset management program across Minnesota.

- Provide funding so small public water systems can develop asset management plans and assess potential climate change impacts on infrastructure and source water. Funding can also be used to aid other utilities during disasters through the [Minnesota Water/Wastewater Utilities Agency Response Network](#) (MnWARN).

Action 2.2: Provide training and technical assistance to smaller communities on tools to assess risk and vulnerability.

- Evaluate and adopt elements of [CREAT](#), a tool developed by EPA to help wastewater, stormwater and drinking water utilities plan for and adapt to extreme weather, and to help small water and wastewater systems track inventory items, assess critical infrastructure, and evaluate vulnerabilities to climate change and extreme weather.
- Communities can use CREAT or similar tools to evaluate stress on their equipment, assess risk of equipment failure, and identify and compare costs of risks and mitigation measures. They can also incorporate climate projections from CREAT into aquifer models to understand climate change impacts on water availability.

Action 2.3: Adopt a stormwater data standard and fund digitization.

Cities, townships, counties and other municipal separate storm sewer system (MS4) permit holders must have their stormwater system mapped. However, data collection is not standardized across municipalities, so it is difficult to include infrastructure in wider watershed-based modeling and assessments. In 2019, [MnGeo's Standards Committee](#) approved a draft standard for exchange of stormwater system data that provides a clear method to digitize maps and data collection for ease of sharing, but is expensive and time-consuming and requires specialized skills.

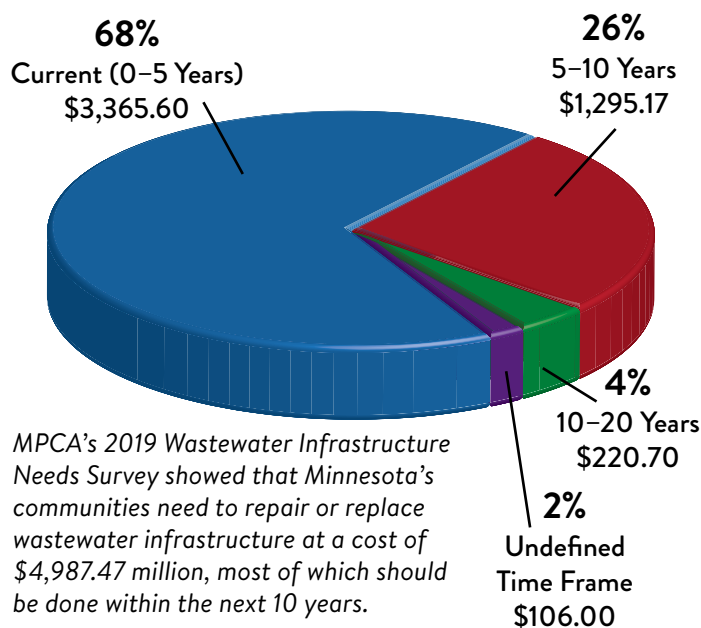
- Provide grants to MS4 permit holders to digitize their maps. With standardized data across the state, planners will have more access to create vulnerability assessments, model pollutant loads, determine the best places for BMP installations and build more resilient communities.

STRATEGY 3: Develop new and updated resiliency financing mechanisms.

As precipitation increases and becomes more extreme and dry periods lengthen, communities need to modify how they manage water. Infrastructure is expensive, and communities lack funding to move forward with assessments and planning, especially for wastewater, stormwater and drinking water utilities. We need to develop consistent and stable

funding for local governments and other entities responsible for infrastructure so they can develop climate vulnerability assessments and/or climate adaptation and resiliency plans to help with prioritization, budgeting and applications for funding resilient infrastructure.

Statewide wastewater infrastructure needs by time frame (millions)



Action 3.1: Develop and fund climate planning grants to communities for drinking water, wastewater and stormwater infrastructure.

- Develop an MPCA-administered grant program with a 50% match by the local unit of government to support local planning to help prepare for and recover from climate change risks. Initiatives could include vulnerability studies, asset management, training and data development, or implementing tools from EPA or nongovernmental organizations.
- Award grants on a competitive basis through an application process. Local governments that are participating in climate vulnerability assessments, or developing climate adaptation and resiliency plans, updating existing plans to address climate adaptation, or that have adopted a regional climate adaptation plan, would be eligible to apply.
- Provide additional funding to address identified needs.
- Update the [Wastewater Infrastructure Needs Survey](#) to include consideration of climate resiliency needs. This will help agencies determine future needs for programmatic funding and infrastructure bonding.

CASE STUDY:

South Washington Watershed District Climate Resiliency Plan

The [South Washington Watershed District](#) (SWWD) worked with a consultant to develop information strategies and implement climate adaptation practices that increased the District's climate resilience. The District completed a risk analysis of over 24,000 stormwater pipes and promoted groundwater protection, ravine stabilization and reduction in chloride loading. In addition to directing district resiliency activities, the plan broadens eligibility for projects funded with a 50% cost share through the [Coordinated Capital Improvement Program](#). Resiliency projects identified in the plan are eligible for funding that was previously available only to municipal projects enhancing water quality benefits.



SWWD conducted workshops with city officials, state and local government staff, and members of the public to identify climate risks and vulnerabilities and develop strategies for mitigation.

Action 3.2: Authorize and fund Public Facilities Authority (PFA) programs to support resilient infrastructure projects.

Minnesota municipalities lack comprehensive funding to address water quantity. The PFA has programs to help finance wastewater, drinking water and stormwater infrastructure, but they do not fully address climate resiliency.

- Provide a new funding stream at PFA for stormwater work so cities can address sanitary sewer, storm sewer and drinking water improvements at the same time. A large share of PFA funding goes to help cities replace aging sanitary sewer and water mains. Cities often want to make storm sewer improvements when they replace or repair drinking water and wastewater utilities, but currently must fund that portion on their own.
- Include climate resiliency criteria in PFA funding considerations. PFA eligibilities and project priorities are based on public health and water quality but do not directly address water quantity or climate resiliency issues. It is important for climate change resiliency projects related to water quantity, like stormwater storage or infiltration, to be planned and implemented in a coordinated fashion with traditional gray infrastructure.

Action 3.3: Expand the Minnesota Property-Assessed Clean Energy (MinnPACE) program to include water conservation and hazard mitigation projects.

[MinnPACE](#) currently funds energy conservation and renewable energy projects by providing funding to commercial property owners while the local government adds a corresponding assessment to the tax rolls. Similar programs in some other states also finance upgrades that help conserve water and/or protect against storm damage.

- Provide statutory authorization of MinnPACE financing for water efficiency and storm protection projects on private property.

Climate Resiliency Grant Program

An appropriation would allow MPCA and PFA to administer a program to help communities boost climate resiliency. A pilot program would prioritize stormwater infrastructure, including creating stormwater storage, improving infiltration and increasing conveyance capacity.

Under a permanent program, eligible projects could also include energy-saving retrofits and construction, public infrastructure retrofits or replacements, and resilient energy projects. The pilot would seek to fund five to 10 pilot projects with bond appropriations and a 25–50% match from the grant recipients.



Source: Metropolitan Council

STRATEGY 4: Design transportation infrastructure in floodplains for long-term resiliency.

Minnesota has over 65,000 culverts that allow natural rivers and streams to flow under roadways, and many more at intermittent channels. Inadequately sized culverts harm both the natural watercourse and the road. As climate change alters precipitation frequency and severity, it is important to address long-term resiliency of both the watercourse and roadway when replacing infrastructure. The DNR encourages the geomorphic approach to culvert design to reduce impacts to roadways from extreme rainfall and enhance channel and floodplain connectivity. Despite increased up-front costs compared with traditional designs, the DNR expects long-term benefits to outweigh added costs.



Source: MnDOT

Action 4.1: Design culverts with future climate conditions in mind.

- Apply the geomorphic approach to culvert design where appropriate to reduce impacts to roadways from extreme rainfall and enhance channel and floodplain connectivity.
- Maintain natural flows and habitat connectivity. Traditional culvert design limits flow to a channel alone, but the geomorphic approach allows floods to spread across a natural floodplain, creating the potential for a more natural flow, to reduce erosion and property damage, increase resiliency and improve aquatic and terrestrial habitat connectivity while addressing public safety and compliance with local, state and federal floodplain requirements.
- Continue MnDOT efforts to train culvert designers and implement stream connectivity measures from the [Minnesota Guide for Stream Connectivity and Aquatic Organism Passage Through Culverts](#).
- Provide funding to allow DNR, MnDOT and public road authorities to cooperatively implement pilot projects that test and demonstrate the effectiveness of this approach. DNR would be responsible for monitoring the success of these pilot projects and developing future project guidance and selection.
- Select appropriate pilot project sites based on multiple factors, including impacts to adjacent landowners, culvert owner liability and resource impacts.



Source: MnDOT

Action 4.2 Prioritize climate adaptation actions across Minnesota's road systems.

- Prioritize adaptation measures so investments minimize life-cycle and road-user costs. MnDOT has used the [Federal Highway Administration's Climate Change and Extreme Weather Vulnerability Assessment Framework](#) in northeastern and southeastern Minnesota to identify facilities at greatest risk of flash flooding damage. In 2019, it also began a study to develop methodology for characterizing the vulnerability of the entire state's bridges, large culverts and pipes to flooding.

More Green, Less Gray

Under natural conditions, precipitation filters through soil to the water table and returns to the air as plants release it through their tissues. Impervious surfaces alter this cycle in ways climate change exacerbates. We need to implement all of the tools that we have for resiliency, using green and gray infrastructure in tandem.

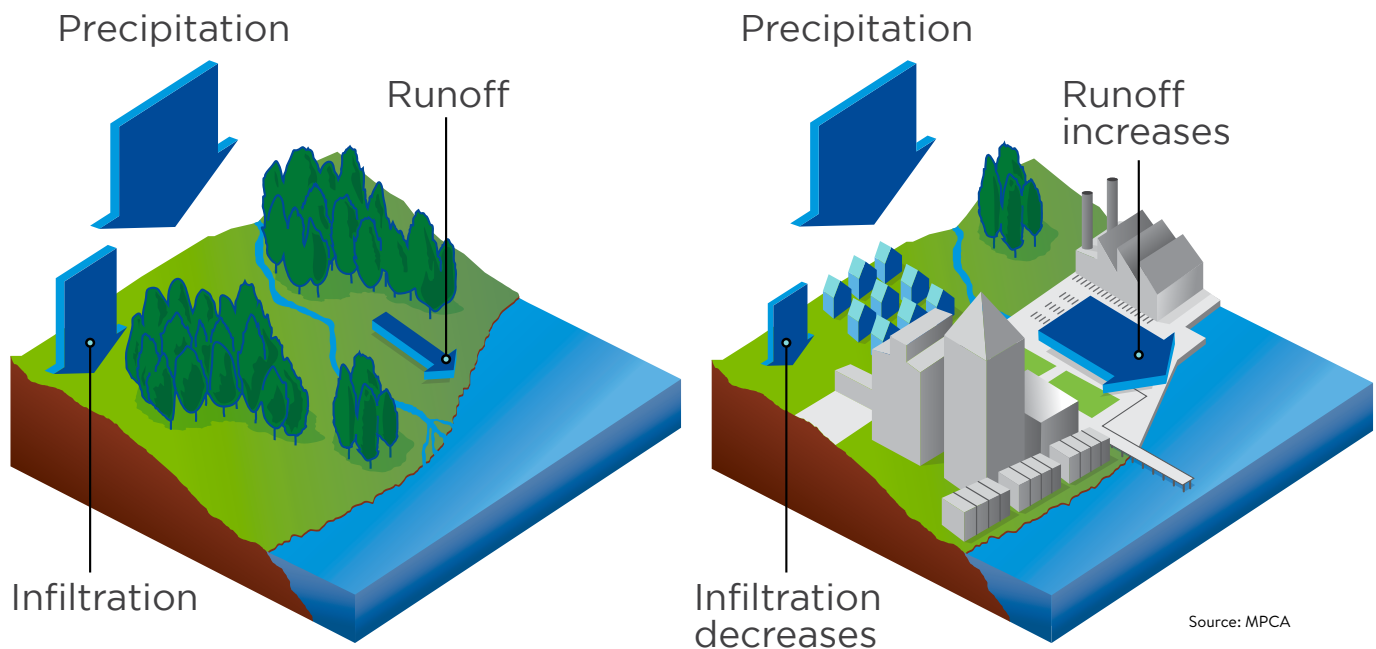
With more frequent intense rainfalls, green infrastructure is a key component in climate resiliency planning for infrastructure. However, we need to think beyond engineered BMPs. Creating and maintaining natural areas, especially in cities and in areas vulnerable to localized flooding, can lower risks of damage to property and human health.

Programs like [Milwaukee Metropolitan Sewerage District's Greenseams](#) have proven this method effective in preventing problems like sewage system backups or overflows. Greenseams buys undeveloped private properties containing open space along streams, shorelines and wetlands in areas with projected major growth over the next 20 years.

While BWSR has similar programs in predominantly agricultural areas, a program like this could be useful in suburban and exurban areas experiencing rapid growth.

Cost is always a concern for developments and for infrastructure. Green infrastructure generally complements a gray infrastructure system to improve water quality outcomes. While green infrastructure cost and implementation is site-specific, it is often more expensive up front than gray infrastructure. However, it comes with additional benefits lacking in gray infrastructure. Green infrastructure often includes a variety of vegetation, which can provide water quality improvements, water retention and storage, urban heat island effect and energy use reductions, and CO₂ sequestration, among other benefits. EPA and the [Minnesota Stormwater Manual](#) include case studies and information about costs and benefits of green infrastructure projects. Additionally, several tools exist for cost-benefit analysis and potential siting of green infrastructure, including but not limited to:

- [Metropolitan Council's Surface With Purpose tool](#)
- [Green Roofs for Healthy Cities Green Roof Energy Calculator](#)
- [Natural Capital Project's Urban InVest calculator](#)
- [Center for Neighborhood Technology's National Green Values™ Calculator](#)



Increasing impervious surfaces causes more water to run off into water bodies when it cannot infiltrate into the ground. The increased volume of water also tends to bring pollutants like sediment, phosphorus and nitrogen that it picks up over paved and built surfaces.



Source: MPCA

Climate change increases extreme rainfall events, which in turn increase the volume and speed of runoff, resulting in more erosion and damage to roads, bridges and other infrastructure. More rain, combined with increased surface and subsurface drainage, also moves more pollutants from land to waterways. By enhancing the ability of land to hold water and slow runoff, we can reduce erosion, damage to infrastructure and water pollution.



Source: MPCA

GOAL 4:

Manage landscapes to hold water and reduce runoff



Source: MDA

STRATEGY 1: Identify opportunities to retain and store water and manage drainage.

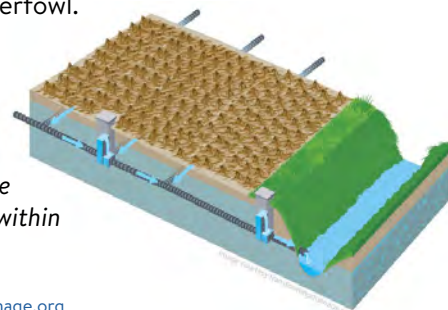
The Minnesota River Valley has been particularly hard hit by increases in rainfall and streamflow. The river's flows have increased 75% during the past two decades compared with the previous six decades. One of Mankato's drinking water supply wells now sits within 8 feet of the river's edge, and nearby roads and homes have been undermined by high flows.

For the Minnesota River and other agriculture-dominated watersheds, achieving state water quality standards for nutrients and sediment will require investment in water storage that increases infiltration, removes nitrate, and reduces runoff volume contributing to high river flows and bluff erosion. Surface water storage can be increased through water impoundments, grass waterways, vegetated buffers, controlled drainage outlets and wetlands. Soil water storage capacity can be increased through improved soil health and drainage water management.

According to the U.S. Army Corps of Engineers 2020 [Minnesota River Basin Interagency Study](#), "the most critical needs are for actions to store water on the landscape using BMPs, build soil health and stabilize ravine erosion." Impoundment structures and reservoirs can provide large-scale water storage. "Basin-wide improvements in soil health and water storage will require ongoing partnerships between landowners, governments, and private organizations."

Action 1.1: Identify and pursue opportunities for temporary and permanent water storage across agricultural landscapes.

- Identify opportunities to store water on the landscape, including storage basins and wetlands, managed drainage, saturated buffers, and other conservation practices that improve soil health.
- Establish landscape priority areas such as former wetlands that could be restored.
- Implement multipurpose drainage methods such as two-stage ditches, control devices near tile outlets and upland storage to reduce flooding.
- Investigate and test existing and novel approaches to water storage and test other strategies for temporarily storing runoff water. Consider multipurpose benefits of storage, such as crop irrigation and creating habitat for migrating waterfowl.



Controlled drainage stores more water within the soil profile.

Source: [Transformingdrainage.org](https://transformingdrainage.org)

Action 1.2: Establish standards for technology, flow reduction, detention locations and sizing, drainage system design, culvert sizing, and flood staging.

- Develop design standards and practices to reduce peak flows, including strategic metering of flows in drainage systems, to address water quantity issues and consider downstream impacts. Developing these standards will require further study by the multi-stakeholder Drainage Work Group (see page 48) and all agencies working with drainage issues.
- Study distributed detention as a new approach to determine where storage will reduce runoff and flood peaks to meet watershed goals. Examples include on-channel or off-channel storage, large- and small-scale retention and/or detention in restored or created wetlands and impoundments, and private in-field constructed storage.
- Invest in technology such as LiDAR and hydro-conditioning that can better identify flood risk areas and guide management of water resources.

- Combine updated statewide LiDAR with Blue Spot analysis (see Goal 3) to identify high-risk flooding locations outside of FEMA regulatory floodplains. This will be particularly valuable for locations that intersect transportation infrastructure.
- Expand the Central Minnesota Ag Weather Network from 12 stations in central Minnesota and Dakota County to provide statewide coverage. Enhanced coverage will allow for better water management and climate data collection.

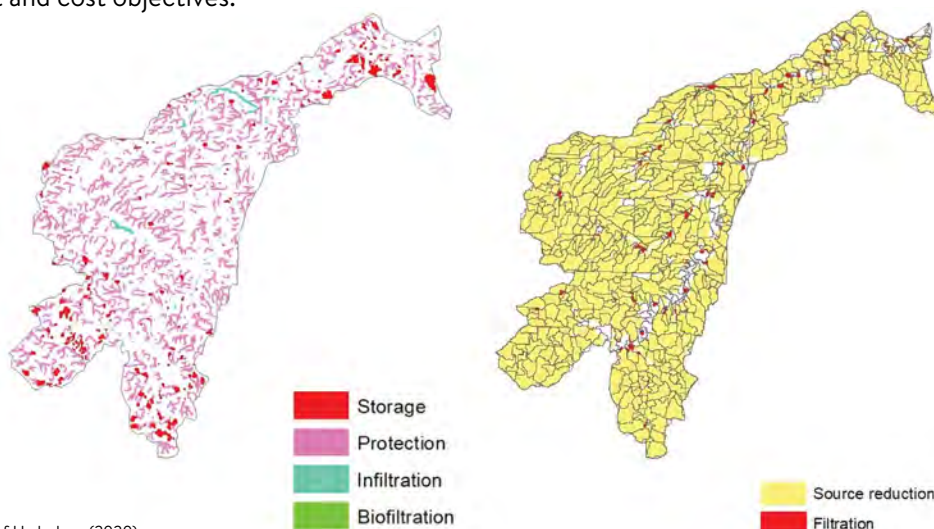
Action 1.3: Investigate and develop mechanisms to pay for water retention and detention.

- Determine the costs of the most cost-effective water storage that meets water quantity and quality goals while determining the technical feasibility and regulatory constraints of practice installations.
- Develop funding mechanisms to pay for water retention and detention. Define regional legal entities that can serve as fiscal agents and hold permits and easements for water storage and impoundment structures. (Note that watershed districts, where present, have the authority to establish a water management district that can collect revenue to fund water storage projects.)

Combining Multiple Models to Site Conservation Practices

There are multiple models for siting conservation practices in places on the landscape where they will be most effective, identified by acronyms such as [ACPF](#), [PTMApp](#), and [HSPF-SAM](#). Each model focuses on different scales, from the individual field to the catchment to the stream and watershed. Research from the University of Minnesota and BWSR integrates aspects of these models to identify multiple opportunities for structural practices, such as multistage ditches or water and sediment control basins, and nonstructural practices, such as cover crops or stream buffers, in a single small watershed. The combined model also factors in costs and pollutant reductions of each practice and can incorporate landowner preferences. Local conservation partners can use the model to balance soil health, water quality, habitat and cost objectives.

The study site is the Plum Creek watershed in Cottonwood County. Plum Creek is a tributary of the Cottonwood River.



Source: Srinivas, Drewitz and Magner, Journal of Hydrology (2020)

How Is Drainage Managed in Minnesota?

The first drainage laws in Minnesota go back as early as 1883 and were enacted to effectively drain low, wet areas for agricultural production. Minnesota has approximately 19,150 miles of drainage ditches and untallied miles of subsurface tile installed and maintained under drainage law ([Minnesota Statutes, chapter 103E. Drainage](#)).

Drainage law enables multiple landowners to collectively construct, improve and repair drainage systems across property boundaries and governmental boundaries. These systems are managed by public drainage authorities. Drainage authorities include county boards, joint county boards and watershed district boards with jurisdiction over a drainage system or project. Private drainage, such as tile drainage on individual properties, is managed by private landowners.

Beginning in the late 1990s, drainage projects increased substantially as existing drainage systems needed major repairs, land prices increased and subsurface tiling became more economical. As systems expanded, water quality concerns grew. In 2014, drainage law was modified to include consideration of water quality and multipurpose drainage management options for drainage projects.

State agencies have limited authority over drainage systems, largely focused on oversight of buffer requirements and review of projects that affect public waters. Several interagency and stakeholder groups play important advisory roles in drainage management:

- The interagency [Drainage Management Team](#) (DMT) includes state and federal agencies, the University of Minnesota, and the Minnesota State University, Mankato, Water Resources Center. The DMT coordinates and shares relevant scientific and technical information on agricultural drainage management.
- The [Drainage Work Group](#) (DWG) is an advisory body comprising representatives of state agencies, research institutions, agricultural organizations, watershed districts, engineering firms, environmental groups and other stakeholders. The DWG works to foster science-based understanding about drainage topics and to recommend best practices for drainage system management, as well as updates to drainage law.
- The Local Government Water Roundtable is an affiliation of three local government associations, the [Association of Minnesota Counties](#), [Minnesota Association of Soil and Water Conservation Districts](#) and [Minnesota Association of Watershed Districts](#). The roundtable helped develop the 1W1P program and advises state agencies on other watershed funding and related management issues.
- Consultants to drainage authorities, including engineering and legal consultants, also play important advisory roles.



Source: MPCA

STRATEGY 2: Develop multipurpose drainage water management standards, guidelines and incentives.

In many parts of Minnesota, drainage is critical for agricultural production and protection of roads and other infrastructure. However, practices must now also accommodate increasing precipitation amounts and intensity of individual rainfall events.

Drainage can affect water quality and quantity by increasing annual flows, peak flows and nutrient transport. Increases in peak runoff flows upstream can contribute to downstream erosion and flooding. Future drainage should simultaneously support agricultural production, protect water quality, reduce flood damage and protect habitat.

Drainage in Minnesota is managed primarily by county and multi-county drainage authorities and watershed districts (see previous page) and private landowners. State agencies can advise drainage authorities, provide incentives such as funding and offer technical assistance. Therefore, the following actions will require a collective effort among state, local, academic and private entities.

Action 2.1: Develop mechanisms to incentivize drainage BMPs.

Financial and technical assistance is available for drainage water management (DWM) plans and a variety of drainage BMPs, including control structures, biofilters and saturated buffers. However, adoption of drainage BMPs is not widespread. State assistance should be directed to:

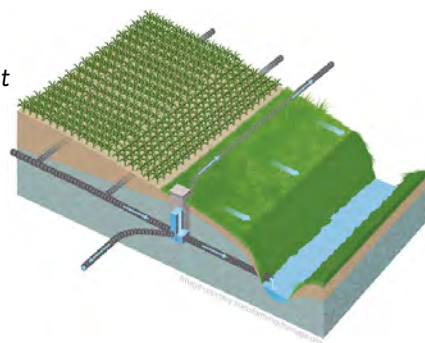
- identify and evaluate benefits and socioeconomic barriers to adoption of on-farm water storage
- support a position with University of Minnesota Extension for DWM outreach and education
- develop a DWM endorsement within the [Minnesota Agricultural Water Quality Certification Program](#) to include administrative, regulatory or other benefits for local drainage authorities and landowners.

Action 2.2: Develop/expand technical and financial assistance.

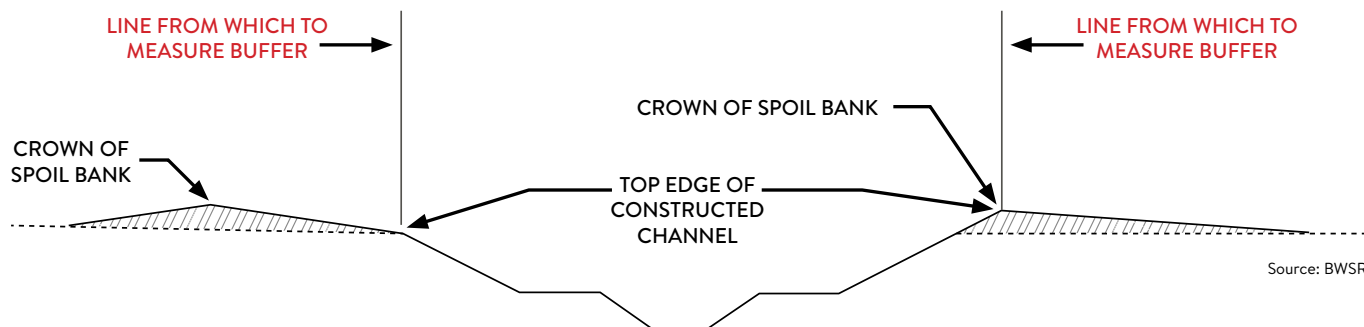
- Incentivize drainage authorities, watershed managers, farmers and landowners to use DWM practices through grants and technical assistance.
- Work with drainage authorities (counties, watershed districts) and private-sector engineers and contractors to provide technical assistance.

A saturated buffer delays water movement from a subsurface drainage system.

Source: Transformingdrainage.org



BUFFER LAW AND DRAINAGE LAW TWO-STAGE PUBLIC DRAINAGE DITCH



Source: BWSR

A two-stage drainage ditch meeting the requirements of buffer law.

Action 2.3: Establish a consistent approach to drainage system design.

Other than voluntary guidance provided by the [Red River Basin Technical and Scientific Advisory Committee](#), guidance to drainage authorities regarding pattern tile or surface drainage is not standardized. The [Drainage Management Team](#) (DMT, see page 48) should work to establish standards and guidance for drainage authorities on the following topics, with review by the [Drainage Work Group](#) (DWG), Local Government Water Roundtable and other stakeholders:

- water storage opportunities designed to ensure adequate outlets (potentially including estimating drainage tile coverage, focusing on locations where tile may not be functioning well)
- consistent regional approaches to ditch design and culvert sizing
- establishment of standards for drainage coefficients, which measure the capacity of a drainage system and can be used during design to quantify or measure discharge at a watershed scale

- practices for overall system management during floods or times of high flow
- best practices for developing systemwide culvert inventories, using methods developed by DNR and local drainage authorities
- best practices for outreach to landowners and other stakeholders.

Action 2.4: Increase the number of research and demonstration sites.

- Establish additional sites to facilitate implementation of DWM practices, show projects to landowners, monitor and assess water quantity and quality impacts, and evaluate management, cost and agronomic impacts. For example, [Discovery Farms Minnesota](#) paired watershed comparisons continue to generate new information on the interactions among farm management, seasonal weather conditions and drainage water quality.
- Provide funding to recruit more growers to test new drainage practices under different combinations of dominant soils and crop production in Minnesota.



STRATEGY 3: Incorporate drainage water management into local water planning

Without watershed or basin-wide planning, it is challenging to coordinate across scales and develop funding mechanisms. A potential solution includes creation of standards specific to major watersheds. Some watershed organizations are already doing this.

Action 3.1: Use the [One Watershed One Plan \(1W1P\)](#) process to establish watershed-scale standards.

The 1W1P approach brings stakeholders together on a watershed basis, facilitating multipurpose water management.

Such cooperation can build the support of citizens and agencies, achieve water quality and quantity goals, and produce environmental benefits that healthy watersheds provide while preserving a vibrant agricultural economy.

- Develop and apply flow reduction and water retention goals across all watersheds using watershed district law ([MS 103D](#)) and public drainage system law ([103E](#)) to subsidize and incentivize planning.

CASE STUDY: Long-Term Flood Solutions for the Red River Basin

The [Red River Basin](#) is an international watershed of 45,000 square miles, with 80% of the basin in the United States and 20% in Canada. Eighteen Minnesota counties and 22 North Dakota counties lie wholly or partially in the basin. Faced with recurring and increasing flooding, including record floods in 1997 and 2009, the [Red River Basin Commission](#) developed long-term flood solutions for the Red River and its tributaries.

The study established a 20% peak flow reduction goal for the main stem of the Red River across the entire basin. It is up to local watershed organizations to implement practices that can achieve this goal. Practices can include retention and detention ponds and metering of ditch and tile drainage runoff via control structures and pumps.

Within the Red River Basin, the [Bois de Sioux Watershed District](#) implements the 20% goal by restricting tile drainage projects to a $\frac{1}{4}$ -inch-per-day drainage coefficient at the outlet, unless the system has storage offsets or can be controlled in case of downstream flooding. The district requires tile pump and gate closures during spring snowmelt based on regional and local conditions.

Several other activities of Red River Basin water management agencies are worth highlighting:

- Since the late 1970s, the [Red River Watershed Management Board](#) has helped fund approximately 181,588 acre-feet of storage in the Minnesota portion of the [Red River Basin](#), consisting mainly of constructed flood impoundments ranging from a few hundred to thousands of acre-feet. Some of the storage is gated to allow for detention times on the order of weeks, reducing flood volume during peak flow periods.

- The [Red River Basin Technical and Scientific Advisory Committee](#) has established best practice recommendations with the goal of balancing the positive and negative effects of agricultural surface drainage. Most crops grown in the Red River Basin can tolerate standing water for 24–48 hours. The primary objective of the design guidance is to remove water from a 10-year summer rainfall before it damages crops. During larger events, some longer inundation is expected, but damage would be distributed as equitably as possible. The design guidance is implemented by sizing culverts, adding floodwater storage (preferably gated) and avoiding drainage of non-contributing areas. While voluntary, the best practices have been adopted by several watershed districts. The guidance works best on relatively flat drainage systems and on systems smaller than 10 square miles.



Source: Two Rivers Watershed District

Ross Impoundment Project storing approximately 3,400 acre-feet during the 2019 fall flood. Project details:

- total storage to emergency spillway—3,611 acre-feet
- water surface area to emergency spillway—1,312 acres

CASE STUDY: Blue Earth County Ditch No. 57

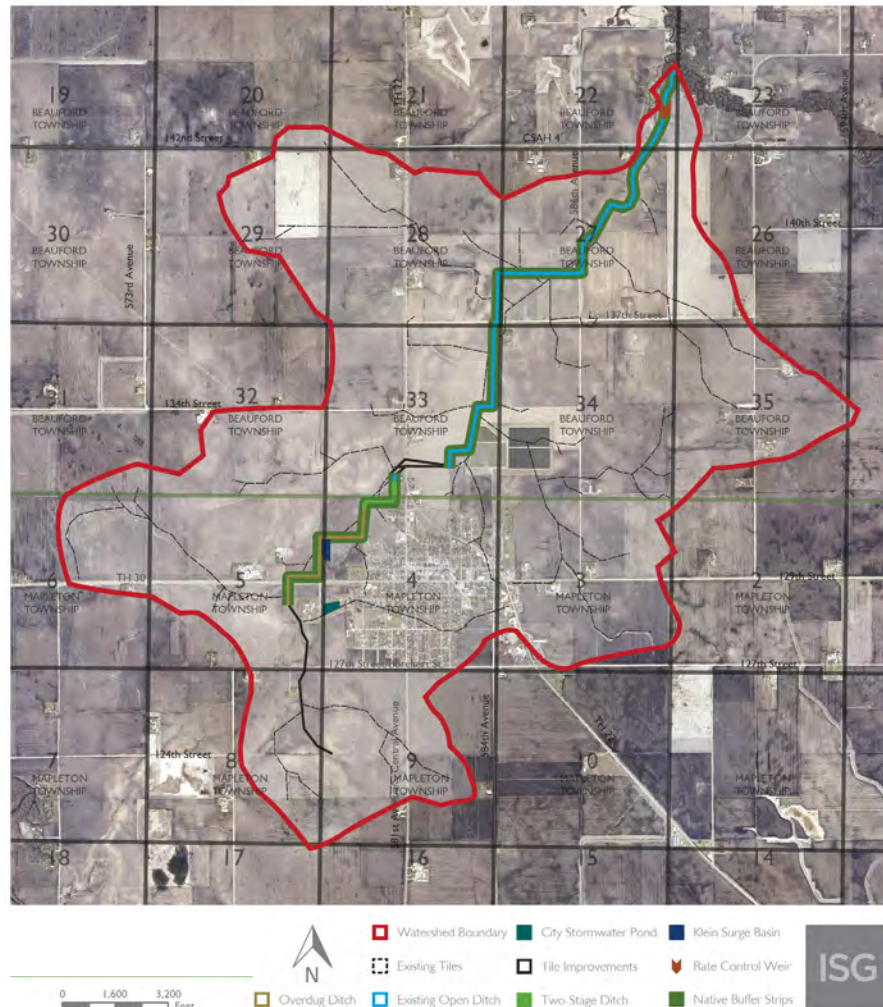
Blue Earth County has over 100 county-administered drainage systems, with over 160 miles of open ditches and over 500 miles of tile systems. Approximately 50% of all the land in Blue Earth County drains to a county ditch. The remaining land drains to natural drainage systems such as rivers or streams. [Blue Earth County Ditch No. 57](#) (CD 57), a public drainage system near Mapleton, exemplifies a successful multipurpose approach to drainage water management.

The CD 57 drainage system is a 6,041-acre watershed comprising farmland and the city of Mapleton. The system has been public since 1921, with some portions installed privately prior to 1900 and the only repairs completed in the mid-1970s. By 2007, portions of the system had failed, and landowners petitioned the drainage authority for repairs. As the petition was being developed, downstream landowners voiced flooding concerns. By implementing a range of water storage methods, the [Blue Earth County Drainage Authority](#) and its partners were able to meet the needs of

both upstream and downstream landowners. The project design included:

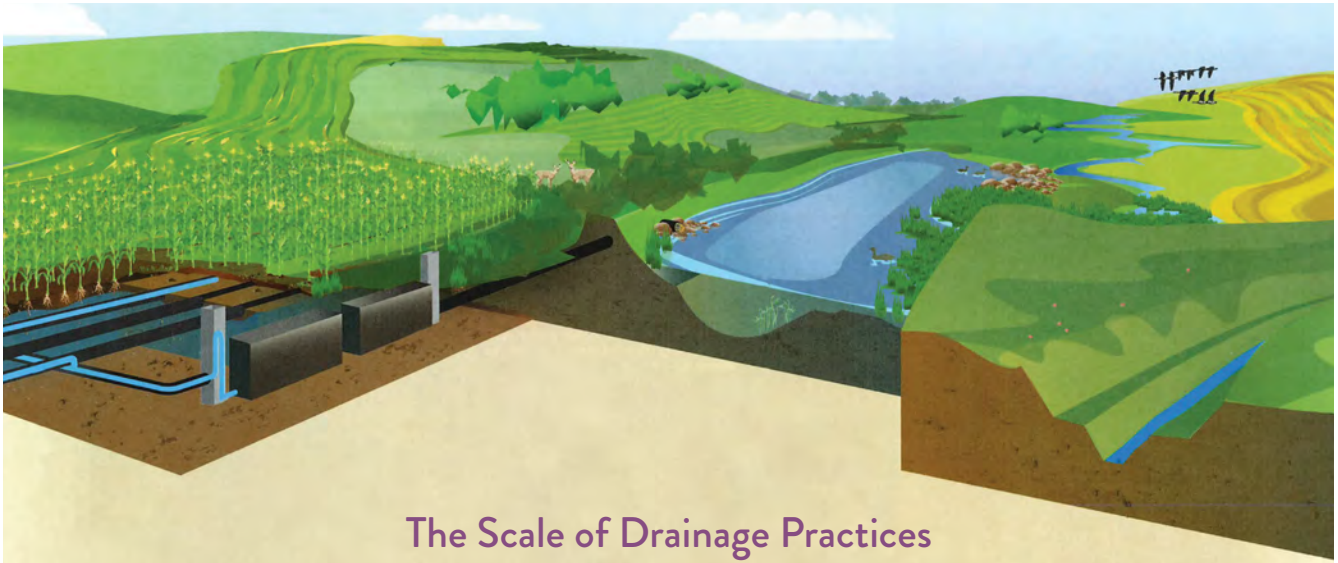
- surge basins, also known as sediment or storage ponds, that provide storage with a reduced outlet size
- a two-stage ditch (an open ditch designed to maintain flow that mimics that of natural streams)
- an over-dug ditch (a widened ditch with a lowered bottom to allow sediment to settle)
- buffer strips along open ditches, planted with deep-rooted native vegetation to provide wildlife habitat and increase erosion protection
- a rate-control weir at the outlet of the ditch system to create temporary ponding.

Source: ISG



The CD 57 reconstruction is an extremely successful project, providing increased agricultural production and crop yields while decreasing downstream flooding and levels of sediment and nutrients. Pollutant (nutrient) reductions have been as high as 50%, with averages near 25%. Over 70 dump-truck loads of sediment have been kept out of public waters.

Source: ISG, Mankato, MN



The Scale of Drainage Practices

Drainage practices can be considered at multiple scales, beginning with managing the rain where it falls and then as it moves to the drainage system and into the broader watershed.

- At the field scale, consider soil health practices, grassed waterways, water and sediment basins, and other surface drainage practices. Managed drainage practices may include saturated buffers, water capture and reuse, alternative surface inlets, and bioreactors. A few field-scale examples include the [Red River Valley Drainage Water Management](#) project and the [Clay County drainage site](#).
- If field-scale practices are insufficient, the focus moves outward to the drainage system—the ditch/watercourse scale. Practices such as filter strips, two-stage ditches, side inlets and check dams can slow flows and reduce erosion. The County Ditch No. 57 case study is a good example of coordinated drainage system management.
- At the watershed or subwatershed scale, practices such as wetland construction and restoration, stream bank and shoreline protection, restoring stream channel meanders, and creating short- and long-term water storage can alleviate flooding and erosion problems. Watershed management plans offer opportunities to consider these larger-scale solutions.



Source: BWSR



Source: Courtney Celley/USFWS

Water is vital for meeting basic human needs such as drinking, washing and growing food. But water provides benefits beyond basic needs—it enhances our quality of life. Water is part of Minnesota’s identity and is integral to the recreation, livelihoods, spirituality and sense of well-being of many Minnesotans.



Source: DNR

Outdoor recreation is an essential part of Minnesota culture and contributes nearly [\\$17 billion](#) to Minnesota’s economy. Climate change is altering fishing, skiing, hunting, boating, swimming and other activities. For example:

- Winter activities such as cross-country skiing, ice skating, snowshoeing, ice fishing and snowmobiling face shorter seasons and more inconsistent conditions.
- Some outdoor activities attract more participants as temperatures warm more quickly in the spring and stay warm longer in the fall, straining capacity on popular water bodies and recreation areas.
- Trails, beaches and other recreational facilities face increased wind and flood damage from storms.
- Erosion along rivers and slope destabilization from heavy precipitation can damage rare plant and animal communities and cultural resources.
- Invasive species are becoming more prevalent and new species are arriving, threatening native plant and animal communities.
- Higher water temperatures increase the likelihood of harmful algal blooms and levels of bacteria in recreational waters.
- Changes to animal populations affect fishing, hunting and wildlife watching.

GOAL 5:

Promote resiliency in quality of life



More changes are expected; additional research is needed to understand how climate change will affect winter and summer recreational opportunities and the economic and social benefits they bring.

Changes in precipitation and water quality due to climate change are also affecting plant communities, wildlife and diverse landscapes across Minnesota. This in turn affects the mental and spiritual health benefits we receive from nature.

Many Minnesotans feel connected to a specific body of water and have traditions and memories associated with it. Changing seasons provide a signal for certain subsistence, recreational and economic activities, such as the beginning and end of the ice-fishing season, planting and harvesting times, and tourism to ski areas. Our attachment to places—and the environments, traditions and customs tied to these places—are very deep and part of our identity.

For this reason, disruptions in our sense of place from environmental changes and natural disasters can be distressing. These feelings and experiences of loss can contribute to emotional distress, strain relationships and weaken community cohesion.

STRATEGY 1: Adapt and mitigate infrastructure planning, design and development for recreational needs.

In order to support recreational activities, recreation infrastructure will need to withstand Minnesota's changing climate. Design of new recreation infrastructure must take new realities of climate change into account. Funding will be required to deal with repairs, closures and cleanup following extreme weather damage at existing facilities.

At the same time climate is changing, Minnesota is seeing increased interest in water-based recreation. Motorized water activities and fishing are projected to increase more than [20% between now and 2060](#). This has the potential to further stress water resources.

Climate change and increasing recreational demands will have profound impacts on how agencies, resource managers and recreational providers handle infrastructure, manage natural landscapes and provide outdoor opportunities. Additionally, travel, tourism, sport and adventure education industries will need information and support to help prepare for these changes. Planning, design, and development must become more inclusive to address cultural needs, including identity, recreational and subsistence activities.

Action 1.1: Incorporate the ability to withstand greater rainfall and wind events into infrastructure design and construction (e.g., docks, marinas, shelters), consulting climate projection data for local areas.

Action 1.2: For existing facilities, anticipate the need for funding to deal with emergency repairs, closures and cleanup following damage from more frequent and unpredictable extreme weather events.

Action 1.3: Minimize the introduction and spread of invasive species through appropriate protective strategies and infrastructure utilizing existing programs, such as the DNR Watercraft Inspection Program.



STRATEGY 2: Improve monitoring and public communication regarding water quality and safety of beaches.

Climate change threatens the quality of Minnesota's beaches and recreational waters. Warmer temperatures are more conducive to the growth of algae and bacteria. With more frequent, intense rainfall events, increased stormwater runoff can wash more bacteria from the land surface into recreational waters. Some beaches are experiencing high numbers of closures in wet years due

to increased bacterial levels in the water. Harmful algal blooms are a particular concern because they produce cyanotoxins, which can make humans and animals sick.

Minnesota state law does not require beach monitoring. However, some local public health departments or cities regularly monitor beach water quality, providing periodic snapshots of water conditions.



Source: DNR

No single entity tracks public beach monitoring or closures statewide. An online statewide recreational water testing portal would give Minnesotans convenient access to information on recreational water monitoring, beach closures and dangers such as harmful algal blooms or major pollution events. Similarly, there is no dedicated funding to monitor algal toxins in Minnesota. Understanding which algal toxins are present in Minnesota waters, and when and where they occur, will help state and local officials protect the public. Algal toxin monitoring can also warn cities that draw drinking water from surface water sources when they may be vulnerable to contamination.

Action 2.1: Develop state web portal and activation of beach alerts system.

Action 2.2: Develop dedicated funding for increased monitoring of algal toxins.



Source: MDH

Not all algal blooms are toxic, and not all harmful algal blooms are visible to the naked eye. These are additional reasons more algal toxin monitoring is needed.

STRATEGY 3: Manage fish and aquatic habitat for resilience.

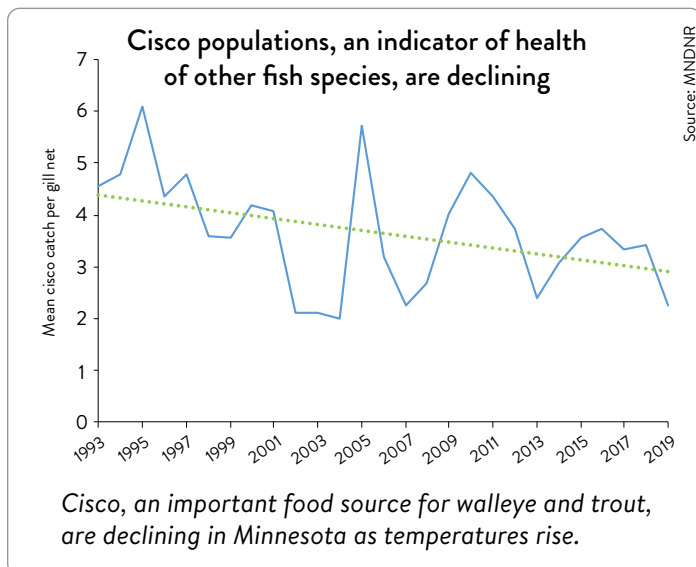
Fishing connects Minnesotans to the water for both sustenance and recreation, reinforcing seasonal cultural traditions. Climate change is altering fisheries in Minnesota due to warming waters, increasing heavy rain events, and shorter and milder winters. This could mean more fish harvest opportunities for some species but fewer opportunities for others. Furthermore, climate change exacerbates existing issues such as excessive nutrients and invasive species.



Source: Courtney Celley/USFWS

Climate change impacts to fishing include:

- displacement of cold-water and cool-water fish by fish species that tolerate warmer waters
- lower reproductive success of some species
- changes to habitats and fish behavior
- decreased fishing opportunities due to flooding
- reduced ice fishing due to diminished ice cover and ice quality.



Fishery managers will need to alter fish and habitat management based on current and future conditions.

Mercury contamination leading to consumption advisories is another issue affecting fishing. Mercury levels in fish depend on fish species, their size and the water bodies in which they live. More research is needed to understand why mercury isn't declining in some water bodies despite lower emissions, and how climate change and other factors may affect mercury contamination in fish.

Though most of the mercury deposited in Minnesota comes from outside the state, we can do our part to reduce mercury emissions. Sources of mercury emissions in Minnesota include energy production (mostly burning coal), taconite processing, other industrial processes and forest fires. For larger predatory fish to be safer to eat, MPCA scientists say that we must reduce mercury emissions to 789 pounds per year, a 76% reduction from 2005 levels. Working with stakeholders, the MPCA has developed a plan to meet this goal by 2025.



Source: DNR

Action 3.1: Manage fisheries to recognize and adapt to climate change trends, including altering fish stocking programs and harvest opportunities based on current and expected future conditions.

Action 3.2: Manage aquatic ecosystems to create, promote and maintain quality habitat, climate refuges and habitat connectivity.

Action 3.3: Monitor and research aquatic wildlife populations over time in variable conditions.

Action 3.4: Continue efforts to reduce mercury emissions and conduct research to better understand how climate change affects mercury contamination in fish.

STRATEGY 4: Conduct research and engagement to address impacts of changing water resources and ecosystems on mental health and well-being.

Emerging research seeks to better understand the psychological and emotional impacts of climate change. As climate change impacts water resources, Minnesotans may experience a sense of loss, anxiety or despair linked to these impacts, including:

- loss of habitat for native plants and wildlife
- water shortage and drought
- loss of livelihood for those whose career depends on stable and expected climate conditions (e.g., farming, tourism)
- threats to cultural or family traditions tied to water, such as wild rice harvesting, ice fishing or skiing
- loss of property or possessions due to a disaster, such as flooding.

As our communities face increasing strain from climate change, we need to consider mental health and well-being as we work to find solutions.



Action 4.1: Research the mental and emotional impacts of changing water resources and ecosystems due to climate change, particularly among those who may be uniquely impacted (e.g., Indigenous persons, farmers and subsistence anglers), and identify strategies and resources to support psychological resiliency.

Action 4.2: Research community values and beliefs surrounding water, including those of particularly vulnerable communities, and work to integrate those values and beliefs into water resource planning.

Action 4.3: Strengthen networks and build community around water resources through cultural activities and community science (also known as “citizen science”).

Action 4.4: Improve coordination between state and local emergency managers to identify communities impacted by climate-related water hazards, and better target resources to reduce physical, emotional and mental stressors.



Spotlight on Lake Superior

Minnesota borders one of the most beautiful and extraordinary ecosystems on Earth: Lake Superior. This global gem contains 10% of the world's surface fresh water and is in the best ecological condition of all the Great Lakes. Minnesotans depend on Lake Superior for benefits such as drinking water, recreation, transportation, commerce, and the iconic views and vistas that characterize the North Shore.

Today the lake and its basin face direct and indirect impacts from climate change. The direct impacts from warming temperatures, increased precipitation and frequent storm events have numerous indirect effects. These include increased flood risks, reduced ice cover, altered shoreline habitats and intensified nonpoint source pollution. These changes threaten this magnificent and complex ecosystem.



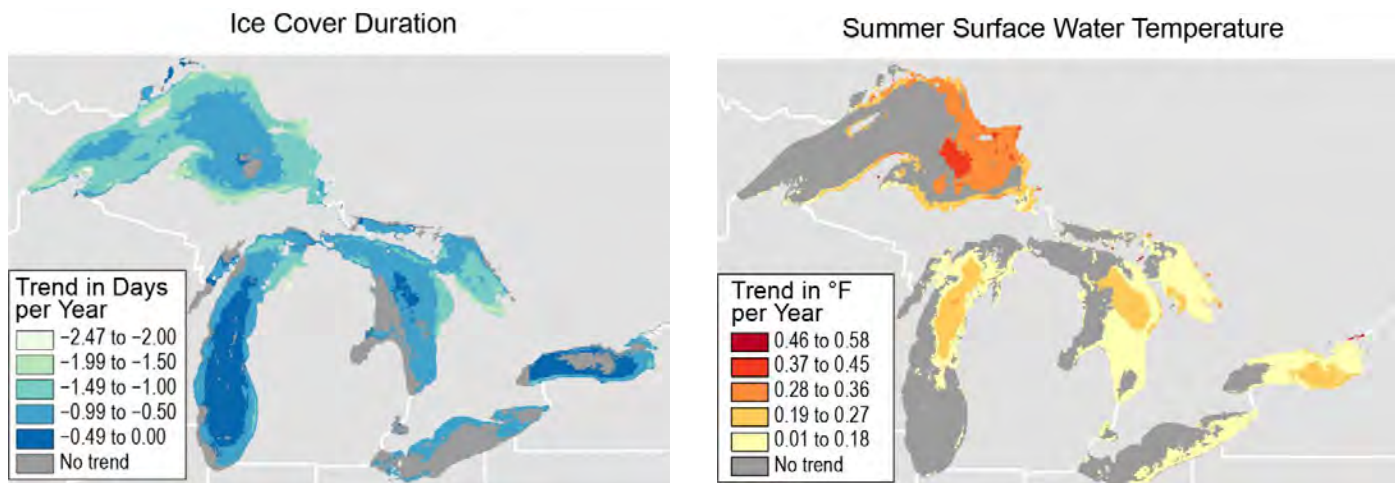
Minnesota's rugged Lake Superior coast.

Source: DNR

Climate change impacts and forecasts

Climate change is expected to produce increased air and water temperatures, decreased extent and duration of ice cover, and more frequent storm events across the Lake Superior basin. Recent studies forecast increased annual precipitation and more frequent large precipitation events in northeastern Minnesota throughout the 21st century, bringing significant impacts on local hydrology and Lake Superior water levels.

These climate effects will impact Lake Superior's complex ecosystem and the services it provides. Temperature changes, for example, could favor aquatic invasive species such as the sea lamprey, alter plankton communities that sustain the entire food web and threaten cold-water fish communities. Warmer water temperatures, more frequent storms and pollution may increase the likelihood of harmful algal blooms, which could degrade water quality, hurt local tourism-dependent economies and negatively affect human health.



Source: U.S. Federal Government, 2018: "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II" [Online] nca2018.globalchange.gov.

Trends in ice cover duration (1973–2013) and summer surface water temperatures (1994–2013) across the Great Lakes

Lake Superior hydrology and water levels

Lake Superior water levels have fluctuated dramatically over the past 50 years, as demonstrated by a 6-foot increase in water levels between 2013 and 2019. Water levels largely reflect changes in precipitation and evaporation rates, since the lake's only outlet at the Soo Locks provides only moderate regulation.

Fluctuating water levels affect coastal and near-shore environments and public and private infrastructure. They also increase vulnerability to coastal storms and flooding. Models predict highly variable water fluctuations in the future.

Community planning and adaptive management

It is vital to recognize the interaction between community planning and natural resource management within the context of climate change. Deliberate decision-making is necessary in response to more frequent and intense precipitation events, storm damages, and ongoing development pressures. Local communities benefit from guidance and support in adaptively managing their infrastructure, water resources and recreational amenities.

Current efforts in community planning, hazard mitigation and natural resource management at state and local levels identify existing concerns and recommendations for improving community resilience. Existing regional management plans, such as the [Lake Superior Lakewide Action Management Plan](#) and the State of Minnesota Hazard Mitigation Plan, can guide science-based adaptive management of coastal areas. In conjunction with local community level plans, these regional plans help identify shared priorities to protect the Lake Superior ecosystem.



Source: DNR

Larger and more frequent storm events along Lake Superior shoreline have caused significant damage.

Example collaboration:

St. Louis River area of concern

The [St. Louis River Area of Concern \(AOC\)](#), encompassing over 1,000 square miles of the river's estuary and tributaries in Minnesota and Wisconsin, has been the focus of years of collaborative restoration efforts by federal, state, tribal and local partners. The AOC is a long-term effort to address past industrial pollution and contamination and restore degraded habitat. While the AOC program focuses on historical disturbance, partners are now looking at adapting these habitats toward conditions that are more resilient to projected climatic and hydrologic changes.



Source: DNR via Richard Hamilton Smith

St. Louis River Estuary, looking upstream toward the Fond du Lac neighborhood of Duluth.

Highlighted Resources and Programs

- [The Chester Creek Project](#) highlights the economic and environmental benefits of using green infrastructure to reduce flooding risks in the Chester Creek watershed in Duluth.
- [Duluth Urban Watershed Advisory Committee \(DUWAC\)](#) brings together local governments and researchers to collectively manage urban watersheds, protect water quality and reduce flooding risks.
- [Minnesota's Lake Superior Coastal Program](#) supports local planning and coastal management that balance community needs with sustainable use and protection of natural resources.
- [Minnesota Sea Grant](#) provides a wealth of climate-related resources, including brochures, an interactive map and a "Climate Conversations" series on topics affecting the Twin Ports.

Implementation of the 2020 State Water Plan and state agencies involved.

The purpose of this table is to summarize the types of actions needed to implement strategies in the 2020 State Water Plan. Primary state agencies involved are identified, recognizing that multiple agencies and many local and

regional partners are also involved in each action and may be the parties implementing them. As these strategies evolve, this table will be updated periodically over the 10-year lifespan of this plan.

Strategy	Statute change	Rule change	Policy change	Additional funding/reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
GOAL 1: Ensure drinking water is safe and sufficient									
Strategy 1: Accelerate source water protection for community water systems.									
Action 1.1: Prioritize protection of the 400,000 acres of vulnerable land in DWSMAs.			●	●	●		●		MDH, BWSR, MDA
Action 1.2: Assess and monitor the safety and resiliency of surface DWSMAs.			●	●	●		●		MDH, MPCA
Action 1.3: Protect, restore, and increase perennial cover in the highest priority areas of the Mississippi River watershed.			●	●	●		●		MDH, BWSR, MDA
Strategy 2: Emphasize source water protection in watershed management.									
Action 2.1: Emphasize source water protection in implementing watershed management plans.				●	●				BWSR, Met Council, MDH
Action 2.2: Leverage the use of state dollars to protect drinking water.			●	●					BWSR
Action 2.3: Increase routine testing of private well water.				●	●	●	●		MDH
Strategy 3: Prevent nitrate contamination of drinking water and groundwater.									
Action 3.1: Fully implement Minnesota GPR in DWSMAs with nitrate concentrations above defined thresholds.		●		●	●		●		MDA
Action 3.2: Implement the NFMP in vulnerable areas as defined by township testing results.			●	●	●	●	●		MDA
Action 3.3: Ensure compliance with the Minnesota Feedlot Rule.			●	●	●		●	Permit renewal	MPCA

Implementation of the 2020 State Water Plan and state agencies involved.

The purpose of this table is to summarize the types of actions needed to implement strategies in the 2020 State Water Plan. Primary state agencies involved are identified, recognizing that multiple agencies and many local and

regional partners are also involved in each action and may be the parties implementing them. As these strategies evolve, this table will be updated periodically over the 10-year lifespan of this plan.

Strategy	Statute change	Rule change	Policy change	Additional funding/reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
GOAL 2: Manage landscapes to protect and improve water quality									
Strategy 1: Increase soil health									
Action 1.1: Work to meet state goals for expanding the acreage of cover crops and continuous living cover.					●	●	●		BWSR, MDA, MPCA
Action 1.2: Improve monitoring and metrics for soil health based on statewide research and modeling.			●	●	●	●	●		BWSR, MDA
Action 1.3: Diversify crops and agricultural practices that support soil health.				●	●	●	●		MDA, BWSR
Action 1.4: Reduce social and financial barriers to implementation of soil health practices.				●		●	●		BWSR, MDA, MPCA
Action 1.5: Establish soil health demonstration watersheds.				●	●	●	●		MDA, BWSR
Strategy 2: Expand opportunities to participate in ecosystem services markets									
Action 2.1: Develop accounting protocols and data foundations for ecosystem services trading.	●		●	●	●		●		MDA, BWSR, MPCA
Action 2.2: Pursue emerging options for ecosystem service markets using water quality trading as a starting point.				●	●	●	●		MDA, BWSR, MPCA

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Strategy	Statute change	Rule change	Policy change	Additional funding/reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
Goal 3: Manage built environments and infrastructure for greater resiliency									
Strategy 1: Improve data sources and modeling.									
Action 1.1: Pursue and fund next-generation LiDAR.				●			●		DNR
Action 1.2: Obtain dynamically downscaled climate projections.				●	●		●		All state agencies
Action 1.3: Support modeling efforts and risk management that consider climate change impacts.				●		●			All state agencies
Strategy 2: Support communities with asset management and resiliency planning for wastewater, stormwater and drinking water infrastructure.									
Action 2.1: Fund a comprehensive asset management program across Minnesota.	●			●	●		●		MPCA, MDH
Action 2.2: Provide training and technical assistance to smaller communities on tools to assess risk and vulnerability.				●	●		●		MDH, MPCA
Action 2.3: Adopt a stormwater data standard and fund digitization.				●	●		●		MPCA
Strategy 3: Develop new and updated resiliency financing mechanisms.									
Action 3.1: Develop and fund climate planning grants to communities for wastewater and stormwater infrastructure.	●			●					MPCA, MDH, Met Council
Action 3.2: Authorize and fund Public Facilities Authority (PFA) programs to support resilient infrastructure projects.	●	●		●	●		●		PFA, MPCA, MDH
Action 3.3: Expand the Minnesota Property-Assessed Clean Energy (MinnPACE) program to include water conservation and hazard mitigation projects.	●		●				●		Commerce
Strategy 4: Design transportation infrastructure in floodplains for long-term resiliency.									
Activity 4.1: Design culverts with future climate conditions in mind.	●			●	●	●	●		DNR, MnDOT
Activity 4.2 Prioritize climate adaptation actions across Minnesota's road systems.						●			MnDOT

Implementation of the 2020 State Water Plan and state agencies involved.

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regional partners are also involved in each action and may be the parties implementing them. As these strategies evolve, this table will be updated periodically over the 10-year lifespan of this plan.













Strategy	Statute change	Rule change	Policy change	Additional funding/reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
GOAL 4: Manage landscapes to hold water and reduce runoff									
Strategy 1: Identify opportunities to retain and store water and manage drainage.									
Action 1.1: Identify and pursue opportunities for temporary and permanent water storage across agricultural landscapes.									BWSR, DNR
Action 1.2: Establish standards for technology, flow reduction, detention locations and sizing, drainage system design, culvert sizing, and flood staging.									BWSR, DNR
Action 1.3: Investigate and develop mechanisms to pay for water retention and detention.									BWSR
Strategy 2: Develop multipurpose drainage water management standards, guidelines and incentives.									
Action 2.1: Develop mechanisms to incentivize drainage BMPs.									BWSR, DNR, MDA
Action 2.2: Develop/expand technical and financial assistance.									BWSR
Action 2.3: Establish a consistent approach to drainage system design and permitting.									BWSR
Action 2.4: Increase the number of research and demonstration sites.									MDA, BWSR
Strategy 3: Incorporate drainage water management into local water planning.									
Action 3.1: Use the 1W1P process to establish watershed-scale standards.									BWSR, MPCA, DNR

Implementation of the 2020 State Water Plan and state agencies involved.

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regional partners are also involved in each action and may be the parties implementing them. As these strategies evolve, this table will be updated periodically over the 10-year lifespan of this plan.

Strategy	Statute change	Rule change	Policy change	Additional funding/reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
GOAL 5: Promote resiliency in quality of life									
Strategy 1: Adapt and mitigate infrastructure planning, design and development for recreational needs.									
Action 1.1: Incorporate the ability to withstand greater rainfall into infrastructure design and construction (e.g., docks, marinas, shelters).				●	●				DNR, MnDOT
Action 1.2: For existing facilities, anticipate the need for funding to deal with emergency repairs, closures and cleanup following damage from more frequent and unpredictable extreme weather events.				●	●				DNR
Action 1.3: Minimize the introduction and spread of invasive species through appropriate protective strategies and infrastructure utilizing existing programs such as the DNR Watercraft Inspection Program.			●		●	●	●		DNR
Strategy 2: Improve monitoring and public communication regarding water quality and safety of beaches.									
Action 2.1: Develop state web portal and activation of beach alerts system.				●	●	●	●		MDH
Action 2.2: Develop dedicated funding for increased monitoring of algal toxins.				●	●	●			MPCA, MDH
Strategy 3: Manage fish and aquatic habitat for resilience.									
Action 3.1: Manage fisheries to recognize and adapt to climate change trends, including altering fish stocking programs and harvest opportunities based on current and expected future conditions.					●	●			DNR
Action 3.2: Manage aquatic ecosystems to create, promote and maintain quality habitat, climate refuges and habitat connectivity.				●	●	●	●		DNR
Action 3.3: Monitor and research wildlife populations over time in variable conditions.				●	●	●	●		DNR, MPCA
Action 3.4: Continue efforts to reduce mercury emissions and conduct research to better understand how climate change affects mercury contamination in fish.				●	●	●	●		DNR, MPCA, MDH

Strategy	Statute change	Rule change	Policy change	Additional funding/ reallocation	Planning	Research	Education and awareness	Other	Primary state agencies
GOAL 5: Promote resiliency in quality of life (continued)									
Strategy 4: Conduct research and engagement to address impacts of changing water resources and ecosystems on mental health and well-being.									
Action 4.1: Research the mental and emotional impacts of changing water resources and ecosystems due to climate change, particularly among those who are vulnerable to the effects of climate change (e.g., farmers and Indigenous persons), and identify potential strategies and resources that support mental health.									All state agencies
Action 4.2: Research community values and beliefs surrounding water, including those of particularly vulnerable communities, and work to integrate those values and beliefs into water resource planning.									All state agencies
Action 4.3: Strengthen networks and build community around water resources through cultural activities and citizen resource monitoring opportunities.									All state agencies
Action 4.4: Improve coordination between state and local emergency managers to identify communities impacted by climate-related water hazards to better target resources and reduce associated physical, emotional and mental stressors.									All state agencies

Water Governance in Minnesota

Water management in Minnesota is complex. Various state, local and federal agencies play roles in every aspect of water management, from water quality to water use to drinking water safety. At the state level, different agencies are charged with distinct but interactive water management roles. These differing purposes (public health, natural resource conservation, pollution prevention, etc.) sometimes overlap and occasionally conflict.

The Clean Water Legacy Act of 2006, which established the Clean Water Fund and the Clean Water Council, and the 2008 Clean Water, Land and Legacy Amendment have served as powerful incentives for state agencies to collaborate and improve the integration of their programs. Collaboration is yielding results in areas as diverse as

watershed planning, wetlands management and drinking water protection. However, the sheer number of programs and permit requirements, including those of federal agencies and local governments, can still result in confusion and frustration.

The following chart is a generalized overview of the major water-related programs and authorities of the primary state water management agencies, the Public Facilities Authority (multi-agency) and the Metropolitan Council. Many programs are collaborative efforts among state and federal agencies and local government partners, and funding is frequently passed through to these local partners. The table only shows the primary state agency “home” of each program.

AGENCY	PROGRAM TYPE							
	Education, Outreach	Financial Planning	Technical Assistance	Training	Oversight	Monitoring	Regulation, Enforcement	Acquisition, Development
Board of Water & Soil Resources								
Wetland Conservation Act	●	●		●	●	●	●	●
Watershed District and SWCD Oversight, Funding	●		●	●	●			
Watershed Planning (1W1P, Metro, etc.)	●	●	●	●	●			
Conservation Easements			●			●		●
Multipurpose Drainage Management	●		●	●				
Buffer Program	●		●			●	●	
Environmental Quality Board (EQB)								
State Water Policy Coordination	●	●						
Department of Agriculture (MDA)								
Groundwater Protection Rule	●	●			●		●	
Nitrogen Fertilizer Management Plan	●	●	●	●		●		●
MN Ag Water Quality Certification Program	●		●		●			
Minnesota Water Research Digital Library (MnWRL)	●							
Water Quality Monitoring (Surface and Groundwater) for Agricultural Chemicals	●	●				●		
CWF Technical Assistance and Research	●	●	●	●	●			●
AgBMP Loan Program			●		●			

	Education, Outreach	Financial Assistance	Technical Training	Oversight	Monitoring	Regulation, Enforcement	Acquisition, Development	Research	
AGENCY	PROGRAM TYPE								
Department of Health (MDH)									
Source Water Protection Programs	●	●	●	●		●	●	●	
Community and Noncommunity Public Water Supply Programs				●	●	●	●	●	
Groundwater Restoration and Protection Strategies	●	●		●				●	
Well Management Program	●		●	●	●	●	●	●	
Health Risk Assessment Program	●		●	●			●	●	
Minnesota Lake Superior Beach Monitoring Program	●					●			
Waterborne Diseases Program	●				●	●		●	
Department of Natural Resources (DNR)									
Water Use (Appropriation)	●	●		●	●		●		
Work in Public Waters (Permitting)	●				●		●		
Invasive Species Management	●	●	●	●	●	●	●	●	
Floodplain Management, Dam Safety	●	●	●		●	●	●	●	
Shoreland and River-Related Management	●	●		●	●				
Climate Monitoring and Research	●	●		●		●		●	
Groundwater Hydrology Programs	●	●	●	●	●	●		●	
Surface Water Hydrology Programs	●			●	●	●		●	
Lake Superior Coastal Program (Federal-State-Local)	●	●		●	●				
Water Recreation Programs (Fisheries, Waterfowl, Etc.)	●	●	●	●					
Aquatic Habitat Restoration Programs	●		●	●					
Metropolitan Council									
Water Quality Monitoring and Assessment of Metro Area Lakes, Rivers and Streams				●		●		●	
Water Supply Planning (Regional Research and Planning, Review of Local Water Supply Plans)	●	●	●	●	●			●	
Local Surface Water Management and Planning (Review of City and Township Local Surface Water Management Plans)	●	●		●	●				
Wastewater Treatment	●	●		●			●	●	
Watershed Planning (Review and Comment on Local Watershed Management Plans)		●		●					

	Education, Outreach	Financial Assistance	Technical Training	Oversight	Monitoring	Regulation, Enforcement	Acquisition, Development	Research	
AGENCY	PROGRAM TYPE								
Pollution Control Agency (MPCA)									
Water Quality Standards	●					●		●	
TMDLs, Watershed Restoration and Protection Strategies (WRAPS)	●	●	●	●	●	●	●	●	
Stormwater Program (MS4, Construction, Industrial Permitting)				●	●		●		
Wastewater Program, Septic Systems (SSTS)		●		●	●		●		
Feedlot Program				●	●		●		
Water Quality Monitoring and Assessment of Surface Water and Groundwater		●	●	●		●			
Nutrient Reduction Strategy		●			●				
Clean Water Council (Multi-agency)		●	●						
Federal 319 Nonpoint Source Pollution Program			●		●				
Clean Water Partnership Loan Program			●		●				
Chloride Reduction and Prevention	●	●		●					
St. Louis River Area of Concern Lake Superior Lakewide Action and Management Plan (LAMP) (with DNR)	●	●			●	●		●	
Public Facilities Authority (PFA) – DEED/MPCA									
Public Facilities Authority (PFA) – DEED/MPCA			●						
Clean Water Revolving Fund			●						
Drinking Water Revolving Fund (PFA/MDH)			●						
Wastewater Infrastructure Fund			●						
Small Communities Wastewater Treatment Program			●						
TMDL Funds			●						
Phosphorus Reduction Grants			●						



Source: MPCA

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Source: MPCA

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