MINNESOTA GO

Planning Minnesota's Transportation Future

WATER QUALITY TREND ANALYSIS

CONTENTS

SUMMARY

With 11,800 lakes, 69,000 miles of rivers and streams, and 10.6 million acres of wetland, water is a major part of Minnesota's culture, economy and natural ecosystems. Water quality nationwide has been severely degraded from intense industrial activity, sprawling development and lax protections of the natural environment. In the last 30 years water quality has continued to decline overall despite policies like the Clean Water Act.

In Minnesota, today nearly 6,000 bodies of water are considered impaired by one or more pollutant or stressor (see Figure 1). Further, there has been a sharp decline in wetlands found throughout the state.[1] Wetlands are vital for storm water retention, water filtration, wildlife habitat and erosion control. The reduction in wetlands in the state has increased water quality issues as the natural protection they provided surface and ground water is no longer present in many areas of the state.

While local governments and industrial sites have taken steps to improve water quality, managing pollution from stormwater and other forms of runoff has continued to be a challenge. Transportation infrastructure and adjacent land development can increase the area impervious to water. This can result in pollutants flowing freely from these surfaces and stressing water quality. The transportation system can disrupt natural filtration systems, produce contaminants, drain polluted runoff and harm water quality in many ways. Salt used on roads and parking lots, for example, drains directly into surface water bodies demonstrating the direct role transportation plays in impacting water quality.

Both public and private sectors can innovate to minimize impacts on water quality. These efforts are collectively referred to as green infrastructure or low impact development. Examples include:

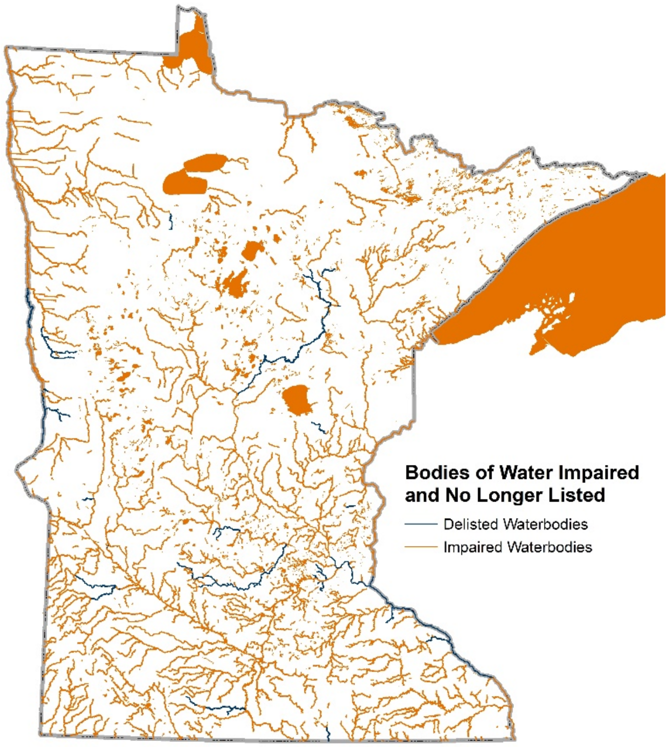
- Planting native vegetative strips around impervious surfaces[2] to capture the maximum amount of stormwater runoff
- Limiting impervious surface by narrowing roadways
- Introducing pervious surfaces and capturing water runoff on site

These are a few ways transportation can use green infrastructure or low impact development principles to help stabilize and improve Minnesota's water quality.

[1] "Draft 2020 Impaired Waters List." Minnesota's Impaired Waters List. Minnesota Pollution Control Agency, November 12, 2019. https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list

[2] Impervious surfaces are defined as mainly artificial structures, such as pavement or buildings, which are covered by water-resistant materials like asphalt, concrete or building roofs. These surfaces disrupt and divert regular water flow and can cause flooding or pollution issues for surrounding areas.

Figure 1. Waterbodies considered impaired by one or more pollutants in Minnesota and those which are no longer considered impaired and are now delisted in 2020.[3]



WATER QUALITY IN MINNESOTA

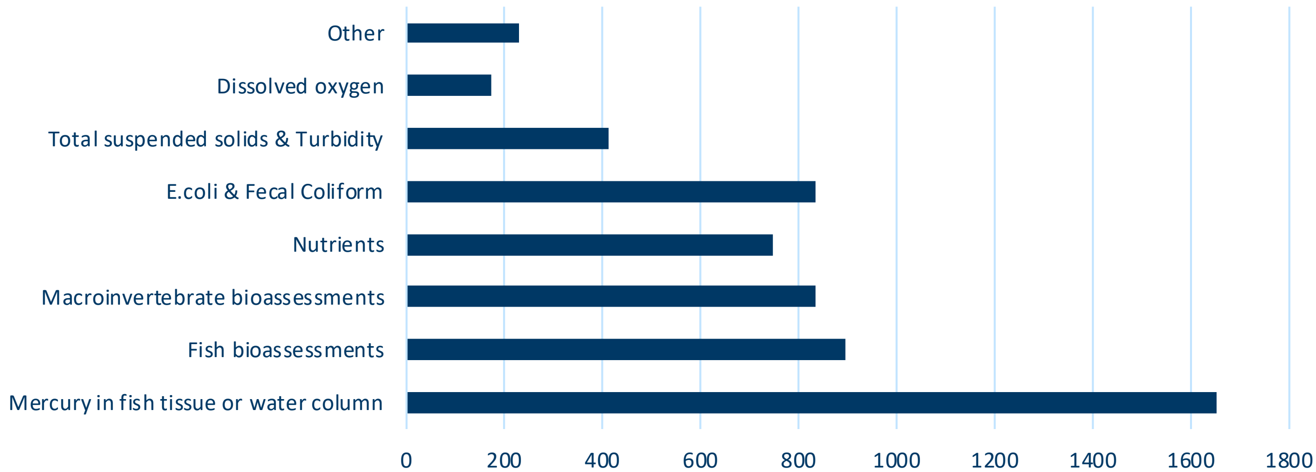
Water quality in Minnesota's lakes, rivers, groundwater, wetlands and watersheds is impacted by both human activity and natural sources. A Minnesota Pollution Control Agency (MPCA) study found that human activity is polluting water bodies faster than existing programs and strategies are improving water quality.[4] Figure 2 lists the pollutants or stressors found in Minnesota water. Phosphorus and nitrogen, high bacteria levels and mercury contamination continue to be problems in many of Minnesota's lakes, rivers and streams, but are only small fraction of the many ways in which Minnesota's waters are impaired. These pollutants, which are typically the product of urban and agricultural land runoff, have left many bodies of water unfit for human consumption or use and aquatic life. Currently, 31% of the state's waters are listed as polluted or otherwise impaired.[5]

[3] Impaired waterbodies are defined as a body of water which fails to meet one or more water quality standards by the Minnesota Pollution Control Agency. A delisted body of water is one which was once considered impaired but is no longer. This can be from a multitude of reasons; natural process, human activity or new and more detailed data which indicates a false impairment.

[4] "Swimmable, Fishable, Fixable?" Featured Stories. Minnesota Pollution Control Agency, April 2015. https://www.pca.state.mn.us/sites/default/files/wq-ws1-07.pdf.

[5] "Draft 2020 Impaired Waters List." Minnesota Pollution Control Agency.

Figure 2. 2020 inventory of the most common stressors impairing Minnesota water bodies. For full list see MPCA impaired waters list.[6]



WATER POLLUTANTS

PHOSPHORUS, NITROGEN AND BACTERIA

As seen in Figure 2, many different pollutants can harm water quality and impair surface water. Phosphorus from wastewater and agricultural activities can create algae blooms that are harmful to aquatic life and human recreation.[7] Bacteria from untreated human and animal waste, nitrate from agricultural activities and sediment from natural or human activities all have similar harmful impacts on water quality. These pollutants all spread out in fresh water quicker and in more abundance when water washes them off roads and other impervious surfaces. When runoff goes directly into ditches and streams it doesn't go through a natural filtration process which removes these pollutants. This unfiltered runoff from roads and other impervious surfaces contribute to polluted watersheds. Watersheds are vitally important to the quality of rivers and streams as a watershed represents an area of land that drains all rainfall and streams within it to a common outlet.[8]

CHLORIDE

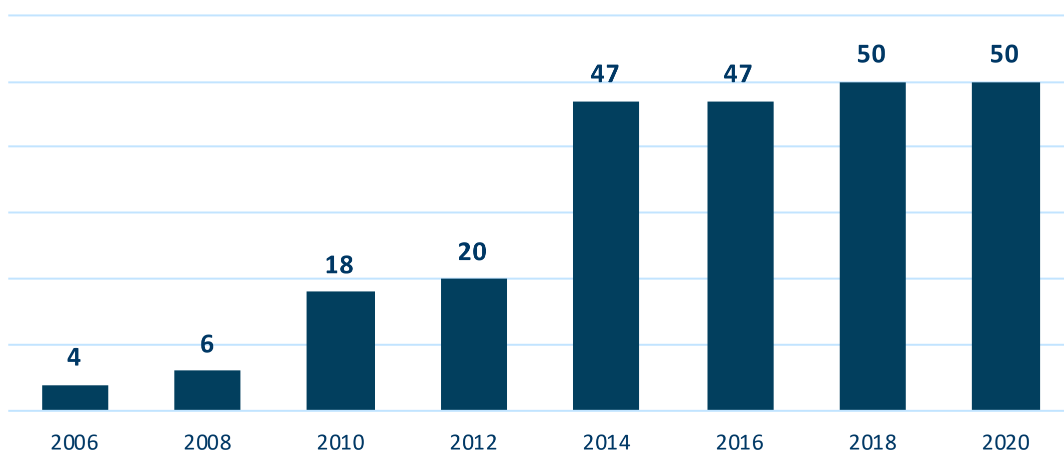
Chloride is another pollutant that can cause poor water quality in lakes and rivers. Once chloride gets into a water source it is very difficult and impractical to remove. Since chloride is easily spread and does not biodegrade, it has long lasting effects on soil, vegetation, water and air. Long-term chloride build up in soil can reduce the fertility of the land and cause drought-like stresses on plant life, which cause stunted growth, brown leaves and premature plant growth.[9] Groundwater in Minnesota is polluted with chloride from deicing salts used on roadways, sidewalks and parking lots throughout the state. Twenty-seven percent of groundwater aquifers in urban areas in

[6] "Draft 2020 Impaired Waters List." MPCA.
[7] "Our Upper Mississippi River." Minnesota Pollution Control Agency, January 2017. https://www.pca.state.mn.us/sites/default/files/wq-iw8-08ab.pdf.
[8] "Watersheds and Drainage Basins." Water Science School. United States Geological Survey, n.d. https://www.usgs.gov/special-topic/water-science-school/science/watersheds-and-drainage-basins?qt-science_center_objects=0#qt-science_center_objects.
[9] "Environmental Impacts of Road Salt and Other De-Icing Chemicals." Minnesota Stormwater Manual. Minnesota Pollution Control Agency, May 15, 2017.

Minnesota are worse than statewide standards set for chloride levels.[10] The impact is also seen in surface waters where a small amount of salt can harm aquatic life. One teaspoon of salt can pollute five gallons of fresh water to the point it becomes toxic to fish, plants and insects.[11] The MPCA tracks pollution impaired water bi-annually. In the 2020 report, 50 bodies of water are known to be polluted with chloride.[12] As seen in Figure 3, this number saw a significant increase from 2012 to 2014, but has stabilized since, only rising from 47 to 50 from 2014 to 2020. Although the harm is significant to the environment, current levels of chloride are not believed to be toxic to humans. However, high concentrations give water a salty taste.[13]

There are two major sources of chloride pollution today. The first is from salt that runs off of impervious surfaces like roads, sidewalks and parking lots into nearby fresh water. Salt is used to make roads and sidewalks safe for travel during icy periods in the winter, but once snow and ice melt, the salt then washes into nearby lakes, streams, wetlands and groundwater.[14] Road salt is generally washed into stormwater sewers which go directly into lakes, rivers and streams without being treated.[15] Another major source of salt is from water softeners in homes and businesses. Most wastewater treatment facilities were not designed to remove salt from water and end up flushing the salt directly into surface water. Due to the difficulty of removing chloride once it is in waterbodies, it is an encouraging sign that the alarming rise in chloride impaired waters has slowed significantly, but continued work is needed to maintain and eventually reverse this trend.

Figure 3. Number of bodies of water impaired by chloride in Minnesota.



STORMWATER

When rain or snow falls onto impervious surfaces, like roadways, it is considered stormwater. Stormwater collects on and around impervious surfaces like roads, parking lots and building rooftops. Naturally, stormwater **is filtered**

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[10] Ibid.

[11] Marohn, Kristi. "MnDOT Cuts Back Road Salt Use to Save Money, Protect Water." MPR news. Minnesota Public Radio, March 31, 2017. https://www.mprnews.org/story/2017/03/31/mndot-cutting-back-road-salt.

[12] "Draft 2020 Impaired Waters List." Minnesota Pollution Control Agency.

[13] Adams, Byron, Sharon Kroenig, Andrew Streitz, Doug Hanson, and Paul Hoff. "Groundwater Protection Recommendations Report" Minnesota Pollution Control Agency, January 2016. https://www.pca.state.mn.us/sites/default/files/lrwq-gw-1sy16.pdf.

[14] "Minnesota Waters Need a Low-Salt Diet." Chloride 101. Minnesota Pollution Control Agency, n.d. https://www.pca.state.mn.us/water/chloride-101.

[15] ibid

through the earth as it soaks into and through the ground where it will eventually subside into the water table. Development of impervious surfaces breaks this natural cycle and diverts stormwater directly into surface water likes lakes, rivers and streams. When stormwater runs off from these surfaces into pervious surfaces and bodies of water, it can pick up and carry harmful chemicals like lead, cleaning solvents, chloride, phosphorus, pesticides, bacteria, viruses and more into the watershed.

Stormwater has long been a risk to transportation infrastructure and private property, in addition to natural systems. This is because as more impervious surfaces are constructed, higher rates of stormwater runoff are created which in turn exacerbates flooding and pollution issues. Environmental issues related to stormwater are becoming more important, especially in terms of pollutant control and infiltration. When water collects on road surfaces it can be contaminated by pollutants from vehicles, deicing materials or other chemicals from surrounding land uses like agriculture, yard fertilizers, failing septic systems or animal waste and eventually flow into nearby surface water without being treated by treatment facilities or the natural infiltration process. Urban areas have a large percentage of impervious surfaces. This causes faster and larger quantities of water runoff to flow into watersheds with higher quantities of pollutants and makes these areas much more susceptible to flooding events. The Metropolitan Council has found that creeks in the seven-county metro area where surrounding land use had a higher percentage of impervious surface also had poorer water quality.[16]

One of the most effective ways to improve water quality in the state is to improve stormwater management practices.[17] There are a few general strategies to minimize negative impacts of stormwater:

- Control the flow of stormwater to reduce flooding
- Treat runoff before it reaches nearby lakes, streams, or rivers
- Reduce materials before they can enter flowing stormwater

Conventional stormwater management detains water in ponds, underground storage tanks or constructed wetlands to control release rates and to prevent sediments and other pollutants from reaching freshwater lakes and rivers. These controls also help to alleviate major flood risks from large rain events. Other than the higher cost and higher impact interventions listed, there are many lower cost means to achieve similar goals and which are also more environmentally sustainable. These low-impact development ideas to control stormwater include green roofs, bioswales or rain gardens, curb cuts, catch basins, pervious pavements and increased tree planting. These interventions have become more affordable over time and accessible to developers while development standards for stormwater runoff continue to strengthen in many states and communities. Although these principals are becoming more widespread, more bodies of water in the state continue to become impaired every year.

ROAD SALT USE

Depending on the temperature, salt can be used to prevent snow and ice from bonding to roads and sidewalks, to breakup ice and snow pack and to melt black ice that has formed on traveling surfaces.[18] MnDOT is the single

[16] "Water Resources Policy Plan." Thrive MSP 2040. Metropolitan Council, May 2015. https://metrocouncil.org/Wastewater-Water/Planning/Water-Resources-Management-Policy-Plan/WATER-RESOURCES-POLICIES/Water-Resources-Policy-Plan.aspx.

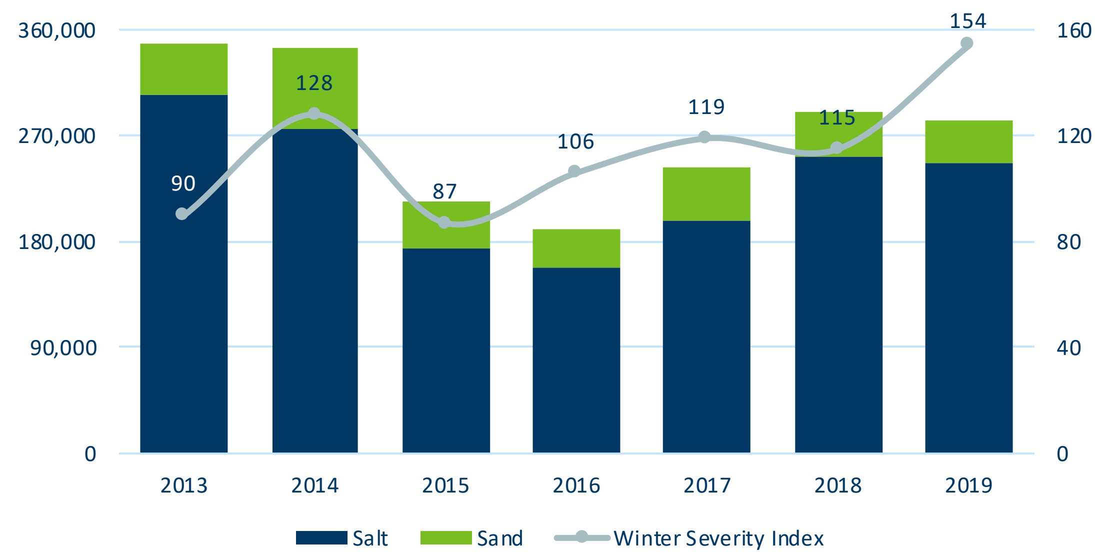
[17] "General Stormwater Information." Minnesota Stormwater Manual. Minnesota Pollution Control Agency, May 29, 2019. https://stormwater.pca.state.mn.us/index.php?title=General_stormwater_information

[18] "Frequently Asked Questions." Maintaining Minnesota's Highways. Minnesota Department of Transportation, n.d. http://www.dot.state.mn.us/maintenance/faq.html.

largest user of road salt in Minnesota and has applied approximately 150,000 to 300,000 tons annually to state roads throughout Minnesota in recent years, as seen in Figure 2. MnDOT is not the only organization using salt to aid in winter maintenance efforts. Many other entities including county and city road authorities, private snow-clearing companies and individual homeowners use salt to keep roads, sidewalks and parking lots ice free throughout the winter.

The amount of salt used is dependent on weather. Generally, when there is more snow and ice throughout a winter season, more salt is used. MnDOT has developed a "winter severity index" which takes into account nine weather factors[19] to create a single aggregate number to quantify the relative severity of a given winter.[20] The index takes into account more factors than just precipitation and so is not a perfect representation of road salt required in a given winter. The index does provide a consistent metric for MnDOT to track road salt usage relative to winter weather. MnDOT, through policies and maintenance practices, is making an effort to reduce its salt use and has had some success. Figure 4 shows that though the winter severity index has ebbed and flowed, hitting a peak in 2019, road salt usage has generally declined over the decade. The noticeable rise in 2018 and 2019 was due primarily to heavy snow precipitation in which the state saw approximately 30 more inches of snow than the ten-year average.[21]

Figure 4. MnDOT Salt and Sand Usage Compared to Winter Severity.[22]



Road salt is known to pollute surface water, but where the majority of excess road salt ends up is not known. Only about 30% of the road salt applied in the seven-county metro area has been observed to be carried away and dissolved in the Mississippi River. The remaining 70% of road salt remains unaccounted for. Data has shown sodium and chloride levels in state lakes and groundwater tables have grown with the increase in road salt usage and these levels increase during winter and decline over summer months, but studies have not conclusively

[19] The nine factors are; dew point/relative humidity, wind speed, gusts and direction, frost or black ice, precipitation type, duration and amounts, air temperature, road temperature, cloud cover, blowing snow and surface air pressure.

[20] "2018-2019 Winter Maintenance Report." Maintaining Minnesota's Highways. Minnesota Department of Transportation, 2019. http://www.dot.state.mn.us/maintenance/pdf/2019-winter-maintenance-report.pdf.

[21] "2018-2019 Winter Maintenance Report." Minnesota Department of Transportation.

[22] Ibid.

linked these observed trends directly to road salt use.[23] However, road salting activity can be inferred to play a role in the pollution of Minnesota's lakes, rivers, streams and groundwater. Accordingly, MnDOT has begun to implement strategies to limit road salt usage on state roads. Some strategies used to reduce the amount of salt used on roads during the winter include:

- New technology to optimize the treatment and use of salt on roads
- Liquid chemical deicers use instead of salt or sand
- Underbody plows to reduce the amount of salt needed
- Driver training to teach new snow plowing techniques
- Pursuit of chemical and equipment innovations not currently used at MnDOT

SNOW FENCES

MnDOT designs rural highways to limit snow and ice buildup on the road surface, but snow and ice buildup cannot be eliminated by design alone. Landowners near highways can help limit the amount of snow plowing and salt used on state highways. Living snow fences are used across Minnesota to limit the amount of snow that drifts onto a highway, especially in Greater Minnesota. Living snow fences are trees, shrubs, native grasses and wildflowers located on roadsides. Farmers also leave corn rows and hay bales near roads to control blowing snow. MnDOT also installs fencing along some highways to act as snow fence in-lieu of living snow fence strategies. See Figure 5 for an example of a living snow fence in Greater Minnesota.

Figure 5. Stacked hay bales to serve as a snow fence along a MnDOT highway.

MnDOT, through its living snow fence program, provides funding opportunities for landowners to convert private land adjacent to state highways into snow fencing. This program has resulted in 145 miles of living and structural snow fencing and standing corn rows at the end of 2019.[24] The miles of standing corn rows have more than doubled since 2011 and should continue to grow in the future. If the opportunity for a living snow fence isn't

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[23] Stefan, Heinz, Omid Mohseni, Eric Novotny, and Andrew Sandor. "Study of Environmental Effects of De-Icing Salt on Water Quality in the Twin Cities Metropolitan Area." Minneapolis, MN: University of Minnesota, 2008. https://conservancy.umn.edu/bitstream/handle/11299/151669/MN_RC2008-42.pdf?sequence=1&isAllowed=y.

[24] "Sustainability Report 2019." Minnesota Department of Transportation, July 2020. http://www.dot.state.mn.us/sustainability/docs/2019-sustainability-report.pdf.

available, some landowners have chosen to construct a structural snow fence with wood and metal posts. MnDOT also has begun constructing structural snow fencing with certain projects in Greater Minnesota. There are many benefits to these barriers, including:[25]

- Preventing dangerous conditions from snow drifts and icy roads
- Improving driver visibility and reducing vehicle accidents
- Reducing shipping delays for goods and services
- Reducing public money spent on plow time and heavy vehicle usage
- Controlling soil erosion and reducing spring flooding by maintaining proper drainage
- Lessening environmental impact due to less salt use, fewer truck trips and less fuel consumption
- Increasing crop yields by 10% or more
- Improving grassland habitats for nesting birds and pollinators

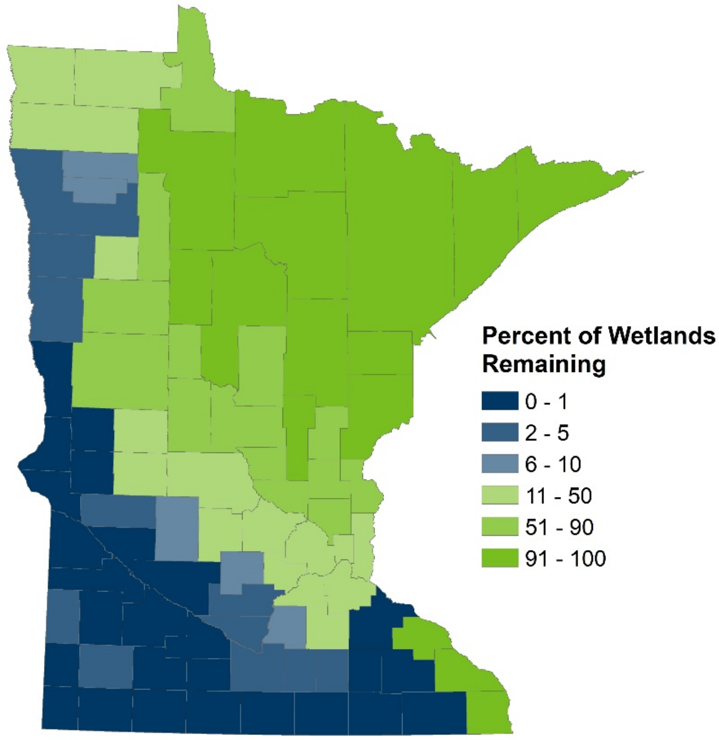
WETLANDS

Wetlands provide an important ecological role, including wildlife habitat, water filtration and recycling, water quality protection, erosion control for lakes and streams and flood mitigation by providing retention of stormwater runoff. A wetland is defined as the land that is a transition from aquatic habitat to dry solid ground. These can take the form of bogs, marshes, shallow open water, swamps, wet meadows or seasonally flooded wetlands. Wetland water levels are less than seven feet deep and some can be dry for much of the year. Due to the impracticality of attaining precise data of wetlands which have been eliminated by human activity, estimates of wetland loss vary. However, Minnesota is estimated to have lost anywhere from 40 to 60% of the state's wetland inventory in less than 200 years.[26] As seen in figure 6, wetland loss varies significantly by county, with counties in the southeast losing almost all wetland acreage and those in the northeast retaining nearly all pre-settlement wetland acreage. This dramatic loss of wetland has increased the risk of flooding around impervious surfaces like roads, buildings and sidewalks on account of the ability of wetlands to retain and slow stormwater runoff.[27] The loss of wetland also negatively impacts water quality in the state as wetlands act as natural filtration for stormwater runoff before it reenters watersheds.

[25] "Living Snow Fences." Environment. Minnesota Department of Transportation, n.d. https://www.dot.state.mn.us/environment/livingsnowfence/index.html.
[26] Dahl, T.E. 1990. *Wetlands Losses in the United States 1780's to 1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C. Minnesota Wetlands Conservation Plan, Version 1.02, 1997, Minnesota Department of Natural Resources, St. Paul, Minnesota.

[27] "Why Are Wetlands Important?" Wetlands. United States Environmental Protection Agency, June 13, 2018. https://www.epa.gov/wetlands/why-are-wetlands-important.

Figure 6. Estimated wetland loss by county from pre-settlement to 1984.[28]



A wetland inventory was undertaken by the Minnesota Department of Natural Resources from 2009 to 2014 which found approximately 11 million acres of wetlands of various types in Minnesota.[29] This data shows wetland loss has been largely halted and potentially even reversed since the previous estimates from the 1980s and 1990s, seen in figure 6. Overall data for the state indicated the remaining wetlands are generally in good or excellent condition (67%). This high-quality wetland stock is concentrated in the northeast area of the state where development and cultivation is far less intense. Remaining wetland in the central and southwest areas of the state has been impacted greatly from development and agriculture. Of the remaining wetland in these areas, only 18% is considered in good or excellent condition.[30]

While transportation projects are not a major direct source of wetland loss in Minnesota, freeway construction and expansion has supported increased urban and suburban development often resulting in the loss of wetlands throughout the state.[31] Recognizing the importance of wetlands, the Minnesota Legislature passed the Wetland Conservation Act in 1991 to protect the state's remaining wetlands from being drained, filled or in some cases excavated.

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[28] Anderson, J.P. and Craig, W.J. 1984. Growing Energy Crops on Minnesota Wetlands: The Land Use Perspective. Publication CURA 84-3, Center for Urban and Regional Affairs, University of Minnesota, Minneapolis, MN.

[29] "National Wetland Inventory for Minnesota." Minnesota Geospatial Commons, May 23, 2019. https://gisdata.mn.gov/dataset/water-nat-wetlands-inv-2009-2014.

[30] Minnesota Pollution Control Agency 2015. "Status and Trends of Wetlands in Minnesota: Vegetation Quality Baseline". wq-bwm-1-09. Minnesota Pollution Control Agency, St. Paul, MN.

[31] Brody, S. (2013) The Characteristics, Causes, and Consequences of Sprawling Development Patterns in the United States. Nature Education Knowledge 4(5):2

The Minnesota Wetland Conservation Act requires entities to:

- Achieve no net loss in the quantity, quality and biological diversity of Minnesota's existing wetlands
- Increase the quantity, quality and biological diversity of Minnesota's wetlands by restoring or enhancing degraded or drained wetlands

In following the regulations set forth in the act, MnDOT, for example, is required to replace wetlands at an average of one and a half acres for each acre impacted. This legislation slowed the dramatic draining of wetlands in the state.

Generally, the wetlands created as substitution are not of the same quality as what was replaced. Results from other studies on wetlands in Minnesota show that wetlands that have been drained from 2006 to 2011 were replaced with an equal amount of replacement wetland, as they are required to do, but these wetlands were cultivated and don't exhibit the same characteristics of native wetlands that they replaced.[32] Research shows that of the wetlands gained in Minnesota, 67% are classified as ponds, which lack characteristics necessary to fully support wildlife. While they were established to replace permanent wetlands, many of these ponds are more temporary in nature than natural wetlands.[33] Wetlands need to be restored to their native setting in order to perform their full range of essential ecological services.

CONCLUSION

Water quality is vital for the health of Minnesota's environment and the health of its residents. Minnesota is rich in water, whether it is its tens of thousands of lakes, the many large rivers or ample wetlands, but the quality and quantity of this water is threatened. Transportation infrastructure has a direct negative impact on the quality of Minnesota's water, as in the case of road salt and other pollutants which wash into lakes, streams and groundwater. It also has an indirect effect as in the case of loss of vital native wetlands from increased development and cultivation pressure in south and central Minnesota spurred in part from transportation investments made in the past. This wide-ranging impact presents an opportunity for MnDOT to have a meaningful effect on the quality of Minnesota's water through changes in operation and investments.

Minnesota GO, MnDOT's 50-year statewide vision, calls for MnDOT to design a system which minimizes resource use and pollution generation and is compatible with Minnesota's natural systems.[34] With Minnesota GO guiding MnDOT's planning and operations since 2011, it has begun to rectify damaging past practices and is continuing to work on further improvements. However, continued and increased action is needed to maintain a healthy and vibrant water system that supports Minnesota's natural systems and its residents.

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[32] Minnesota Department of Natural Resources 2013. "Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006-2011". Minnesota Department of Natural Resources, St. Paul, MN.
[33] Ibid.
[34] "Minnesota GO: Crafting a Transportation Vision for Generations." Minnesota Department of Transportation, November 2011. http://minnesotago.org/application/files/9114/9858/0225/minnesotagovision-nov2011.pdf.

RELATED TRENDS

- Air Quality
- Biodiversity
- Climate Change
- Health and Transportation

Minnesota's vision for transportation is known as Minnesota GO. The aim is that the multimodal transportation system maximizes the health of people, the environment and our economy. A transportation vision for generations, Minnesota GO guides a comprehensive planning effort for all people using the transportation system and for all modes of travel. Learn more at MinnesotaGO.org.

REVISION HISTORY

Date	Summary of revisions
November 2015	Original paper (part of Environmental Quality trend analysis).
January 2018	Updated to reflect new data and separated into Water Quality-specific trend analysis.
April 2021	Updated to reflect new data and information.