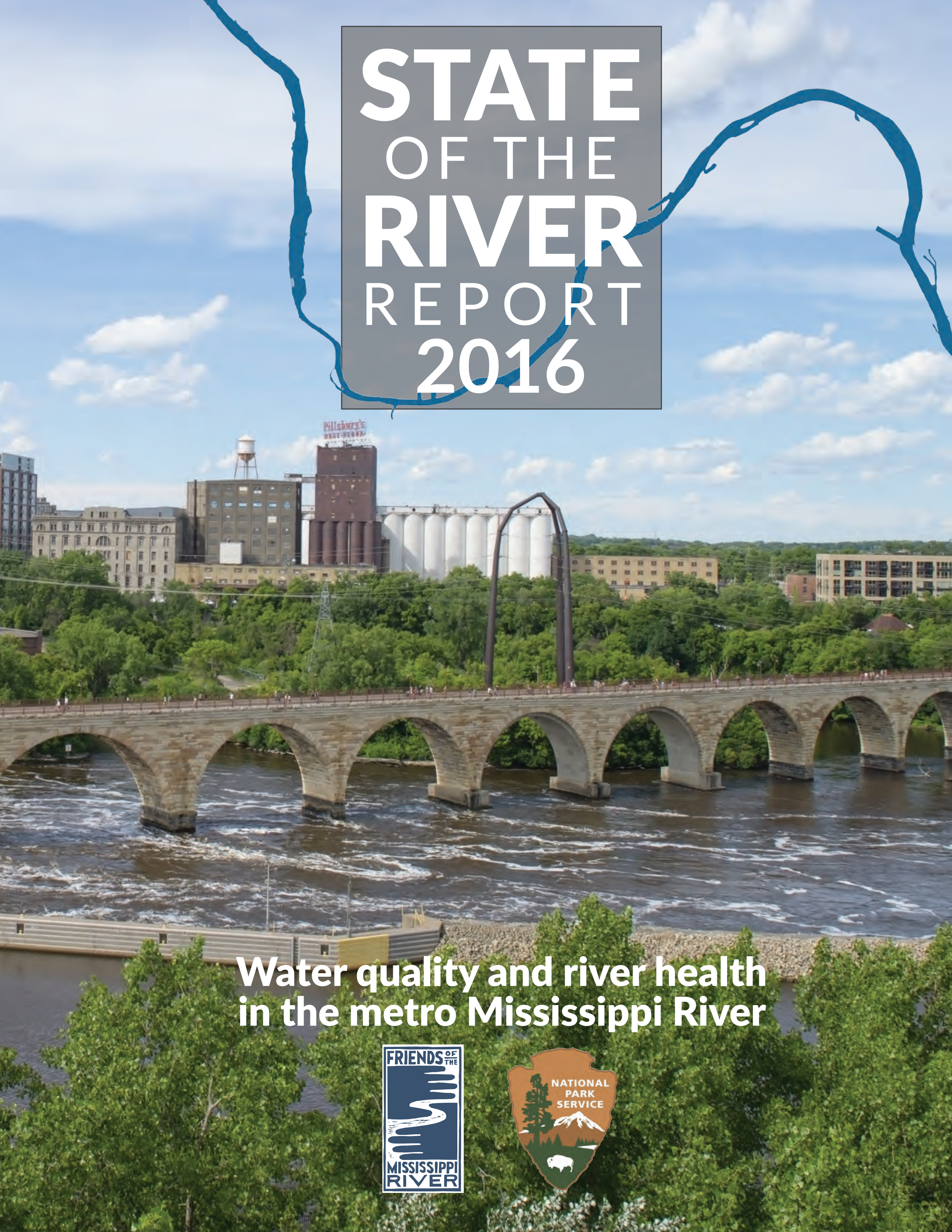

STATE OF THE RIVER REPORT 2016

Water quality and river health in the metro Mississippi River

FRIENDS OF THE MISSISSIPPI RIVER

NATIONAL PARK SERVICE

Photo credit: Irene Jones/FMR

Photo credit: Gordon Dietzman, NPS

So, how is the Mississippi River?

Friends of the Mississippi River (FMR) and the National Park Service's Mississippi National River and Recreation Area (MNRRA) are pleased to present the second edition of the *State of the River Report*.

In 2012, we partnered to develop the inagural *State of the River Report*. That report spurred a series of river management milestones, including closure of the Upper St. Anthony Lock, statewide phase-outs of triclosan and coal tar sealants, and improved targeting of state clean water funds.

For the second edition, FMR and MNRRA once again ask the question: "So, how is the Mississippi River?" The *State of the River Report* highlights 14 key indicators of river health, and presents each in a way that non-scientists can understand. The report examines the status and trends of each indicator, and highlights strategies for improvement moving forward.

In addition, we created the ***Stewardship Guide***, which provides practical steps that anyone can take in their home, yard and community to improve the health of the river.

We also created a brand-new ***Teacher's Guide*** to help teachers and students carry the lessons of the report into the classroom. FMR's ***Policy Guide*** offers priority actions that federal, state and local leaders can take to address many of the concerns raised in this report.

As individuals and as a society, we make choices that affect the river both for better or worse.

The river is cleaner today because previous generations came together and demanded something better. What will future generations say *we* did to restore our beloved Mississippi River? We hope the *State of the River Report* will guide us toward a more healthy and sustainable river, for ourselves and for generations yet to come.

For the river,

Whitney L. Clark
Executive Director, Friends of the Mississippi River

John O. Anfinson
Superintendent, National Park Service, Mississippi National River and Recreation Area

Acknowledgements

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THE McKNIGHT FOUNDATION

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QUALITY OF WATER, QUALITY OF LIFE

MISSISSIPPI PARK CONNECTION
Discover your river

Project Advisors
The *State of the River Report* would not have been possible without the generous assistance of many individuals and organizations whose research and scientific expertise form the basis of the document. They have given many hours of their time to help us interpret and characterize a variety of river data, and we are deeply grateful to them for their support and cooperation.

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www.stateoftheriver.com

The mighty Mississippi River

Photo credit: Gordon Dietzman, MNRRA

The Mississippi River flows approximately 2,350 miles from Lake Itasca to the Gulf of Mexico.

It has long been one of the defining natural features of the United States.

This great river drains all or part of 31 states and two Canadian provinces, or about 40% of the area of the lower 48 states.

The Ojibwe Indians of northern Minnesota called it "Messipi" or "Big River," and it was also known as the "Mee-zee-see-bee" or the "Father of Waters."[1]

Today, the river serves as an important environmental, cultural and recreational resource, as well as an artery of commerce and industry.

The Mississippi River watershed

Map data: ESRI, Natural Earth (naturalearthdata.com), NOAA

The river serves as a migratory flyway for more than 40% of all North American waterfowl and shorebirds. It is home to at least 260 species of fish, 50 mammal species, 145 species of amphibians and reptiles, and 38 species of mussels.[2]

The Mississippi River system is also the primary source of drinking water for about 18 million Americans in 50 U.S. cities, including roughly one million Minnesotans.[3]

The 29 locks and dams on the Mississippi River allow for navigation from St. Louis to Minneapolis. To move goods up and down the Mississippi, the U.S. Army Corps of Engineers maintains a 9-foot shipping (or navigation) channel from Baton Rouge, La., to Minneapolis.

Roughly 60% of grain exported from the U.S. is transported and shipped on the Mississippi River,[4] along with billions of dollars' worth of freight each year.

The metro Mississippi River watershed

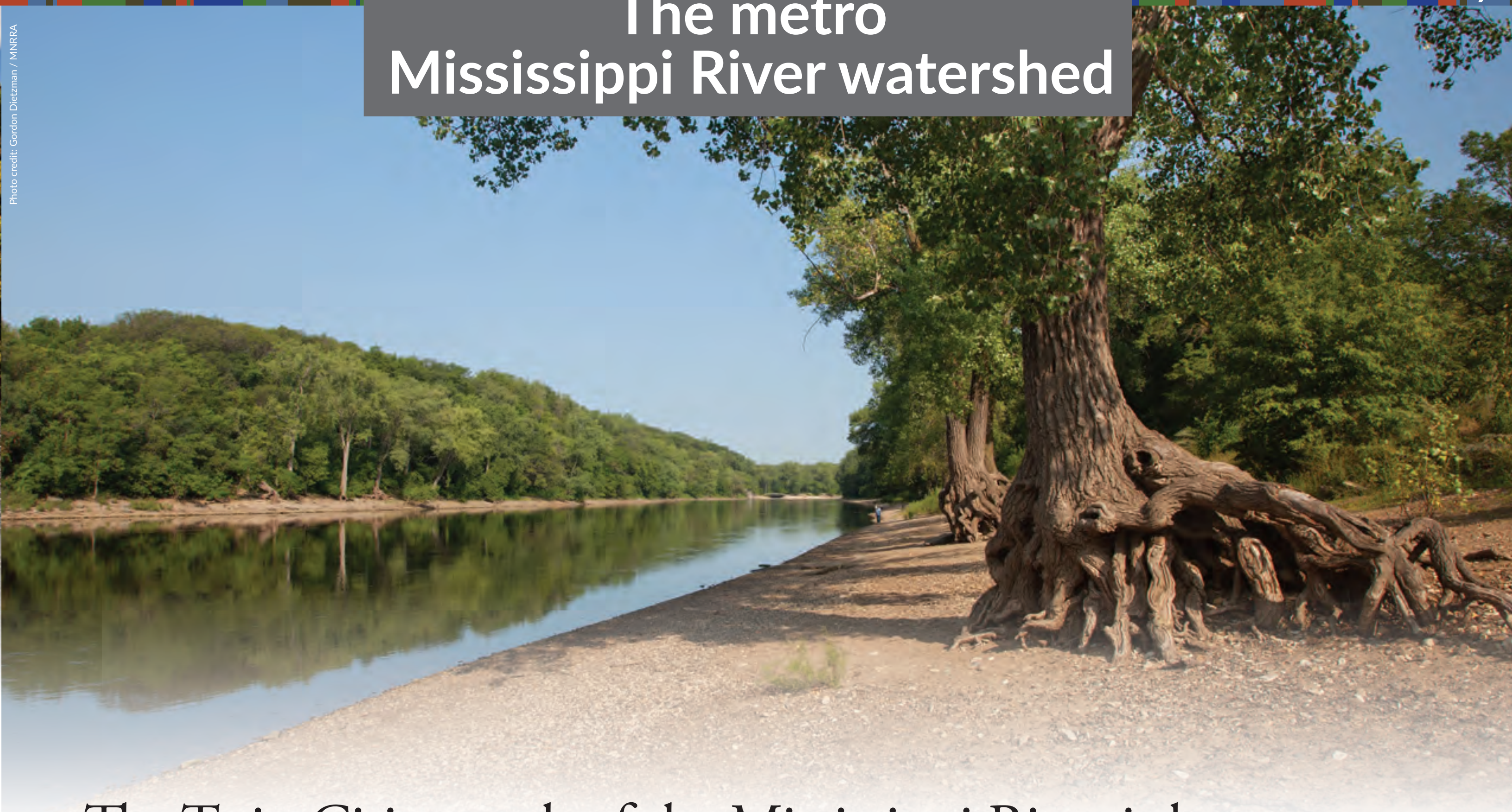


Photo credit: Gordon Dietzman / MNRRA

The Twin Cities reach of the Mississippi River is home to the confluence of three of Minnesota's great rivers: the Upper Mississippi, the Minnesota and the St. Croix.

From its start at iconic Lake Itasca State Park, the 500-mile-long Upper Mississippi River drains about 13 million acres of diverse landscapes that include mixed forests, prairie, agriculture and urban land areas.

The Minnesota River begins at Big Stone Lake on the Minnesota-South Dakota border, and drains about 10 million acres of largely agricultural lands on its 335-mile journey to its confluence with the Mississippi River in St. Paul near Fort Snelling.

The St. Croix River, portions of which are designated as a Wild and Scenic River, drains about five million acres in Minnesota and Wisconsin before joining the Mississippi River at their confluence near Prescott, Wisconsin.

Further downstream, the Mississippi flows through Lake Pepin, a natural lake on the river about 60 miles downstream of the Twin Cities. Here, the river naturally widens and slows as it moves through the lake, allowing sediment and other pollutants to settle out on the lake bottom.

Several indicators in this report, including sediment and triclosan, reference overall pollution trends in Lake Pepin, where sediment research has provided excellent insights into the history and trends of water quality and the ecological health of the Mississippi River.

Map data source: Minnesota Department of Natural Resources

Mississippi National River and Recreation Area

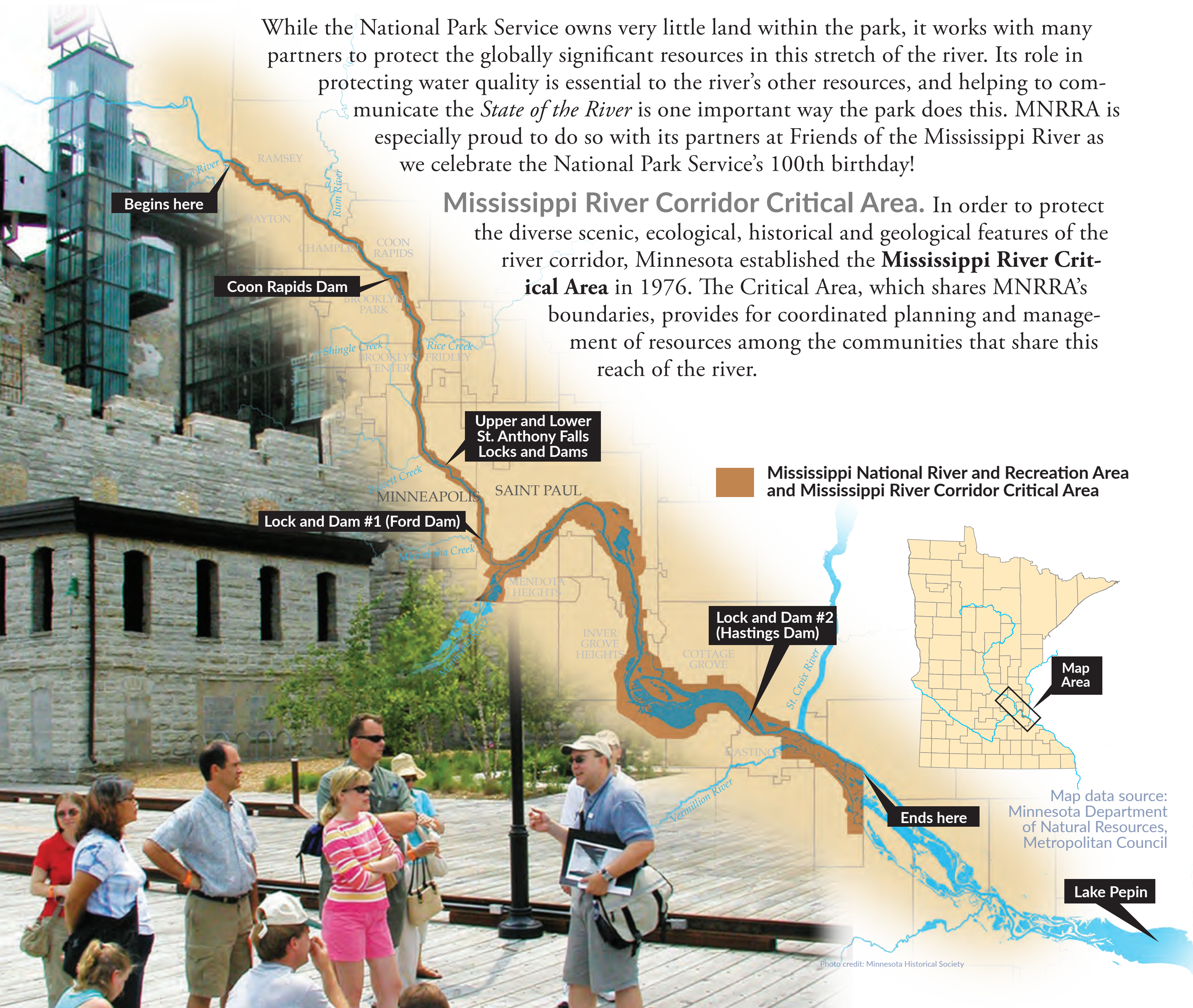
Did you know that the Mississippi River in the Twin Cities is a national park?

For 72 miles (from the Crow River confluence in Dayton and Ramsey, to just past the St. Croix River confluence near Hastings and Prescott) the Mississippi is so unique that Congress designated it a national park in 1988: the Mississippi National River and Recreation Area (MNRRA). How many times have you visited this national park, maybe without even realizing it?

The river changes character more within this park than anywhere else along its entire length. Entering the park as a modest-sized prairie river, it plunges over St. Anthony Falls (its only true waterfall) and through a deep, wooded gorge (its only true gorge), and then emerges in St. Paul as a large floodplain river before flowing 800 miles downstream to St. Louis and beyond.

While the National Park Service owns very little land within the park, it works with many partners to protect the globally significant resources in this stretch of the river. Its role in protecting water quality is essential to the river's other resources, and helping to communicate the *State of the River* is one important way the park does this. MNRRA is especially proud to do so with its partners at Friends of the Mississippi River as we celebrate the National Park Service's 100th birthday!

Mississippi River Corridor Critical Area. In order to protect the diverse scenic, ecological, historical and geological features of the river corridor, Minnesota established the **Mississippi River Critical Area** in 1976. The Critical Area, which shares MNRRA's boundaries, provides for coordinated planning and management of resources among the communities that share this reach of the river.



Indicators overview and critical terms

The Mississippi River is a complex natural system. A wide variety of factors impact water quality and aquatic life as the river moves through the Twin Cities. The river can change dramatically from year to year, and even from season to season. So how do we assess the overall *State of the River*?

This report includes 14 key indicators of water quality and ecological health in the river. These indicators were selected to explain the *State of the River* in a way that is easy to understand. These indicators address a variety of river attributes in five categories:

FLOW: Flow and hydrology

SWIMMING & RECREATION: Bacteria | Phosphorus

RIVER LIFE: Fish consumption | Fish survey | Invasive Asian carp | Bald eagles | Mussels

ECOLOGICAL HEALTH: Sediment | Nitrate | Chloride | Pesticides | Microplastics

OTHER RIVER CONTAMINANTS: Additional contaminants of concern

For each indicator, we include a brief description and highlight its role in the river system. We also provide readers with a summary of its status, and, where possible, include information on history, trends and management solutions for moving forward.

Critical terms and units

Throughout this report, we refer to several critical terms that are important to understanding the *State of the River*. Knowing the meaning of these terms will help you as you read this report.

Data is commonly presented in the units "parts per million (ppm)" or "parts per billion (ppb)." Okay, but how much is that, really?!

- **1 ppm** = about 1 drop of water in two bathtubs
- **1 ppb** = about 1 drop of water in an Olympic-size swimming pool[1]

Impaired

If a portion of the river is **"impaired,"** it means that reach of the river fails to meet state or federal standards for one or more pollutants.

Some reaches of the river are **impaired** for multiple pollutants.

Concentration

Pollution "**concentration**" refers to the *amount of a pollutant in a given volume of water,* and is important when we think of impacts on *local* river life and health.

Pollutant standards are often expressed in **concentrations**.

Load

Pollution "**load**" refers to the total amount of a pollutant moving into/through the river system.

Load helps us understand the total quantity of a pollutant, and is especially important when we think of impacts on *downstream* waters like Lake Pepin or the Gulf of Mexico.

Photo: Gordon Dietzmann/MNRRA

FLOW

This section highlights river flow and hydrology, which influence many other indicators in this report.

Flow and hydrology

Flow and hydrology

River flow has changed, affecting overall river health.

Metro river flows have increased by 24% over the last 70 years.

Recent changes in flow are linked to land use, drainage and climate.

Description and impacts. The timing, amount and intensity of rain and snow can impact river flow, which naturally varies seasonally and from year to year. High and low flows can have positive and negative effects on river health.

- High flows can cause increased erosion, degrade habitat and carry more pollutants into the river system. However, higher flows can also restore natural floodplains and dilute concentrations of some key pollutants.
- Low flows tend to deliver less pollution to the river and can stimulate growth of healthy aquatic vegetation. However, low flows also amplify the effect of sources like wastewater treatment plants. For example, during the lowest flow periods, up to 15% of metro Mississippi River flow consists of treated wastewater released from the Metro Wastewater Treatment Plant.[1,2]

Sources. Under natural conditions, the "water cycle" is dominated by evapotranspiration (Figure 1, panel 1).[3,4] Human activities and changes in land cover can alter the natural water cycle by changing how water leaves the landscape. In **cities and towns**, hard surfaces such as roads, rooftops and driveways contribute runoff that can increase flows in nearby water bodies (Figure 1, panel 2).[5] In **agricultural areas**, row crops and artificially drained fields result in increased runoff, which typically leads to higher flows downstream (Figure 1, panel 3).[6] These seemingly small changes in runoff, spread over a large landscape, have significant impacts on river flow and hydrology.

Figure 1. Water and the landscape

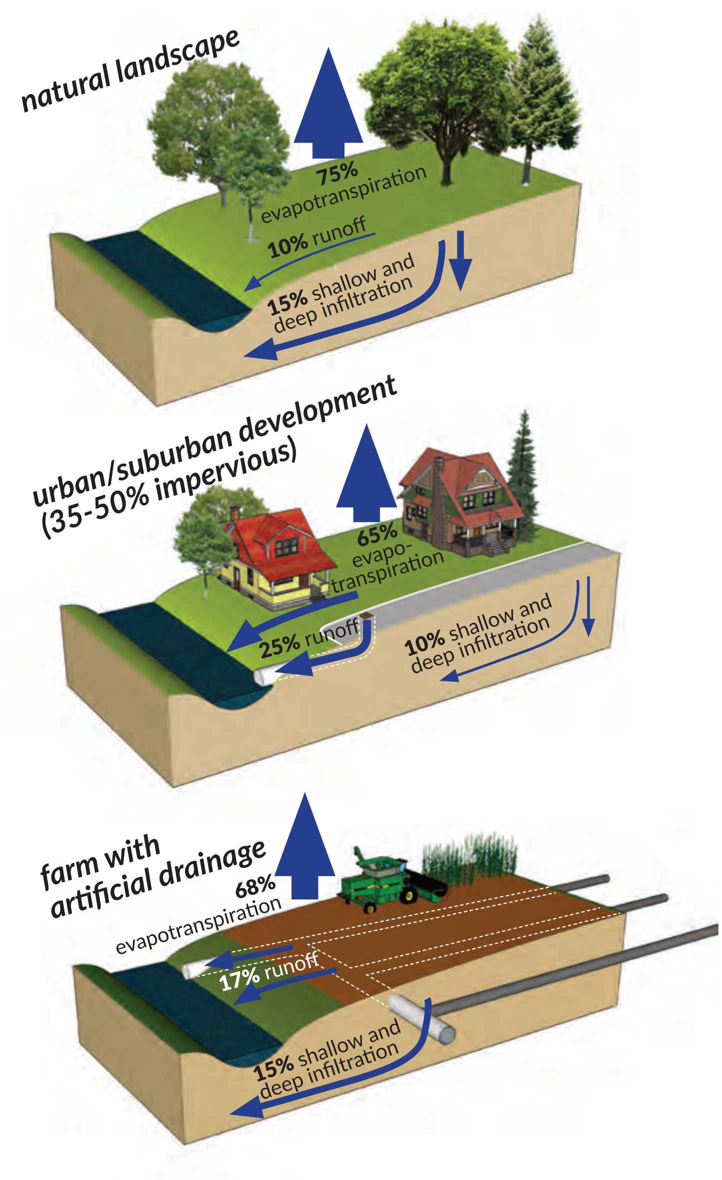
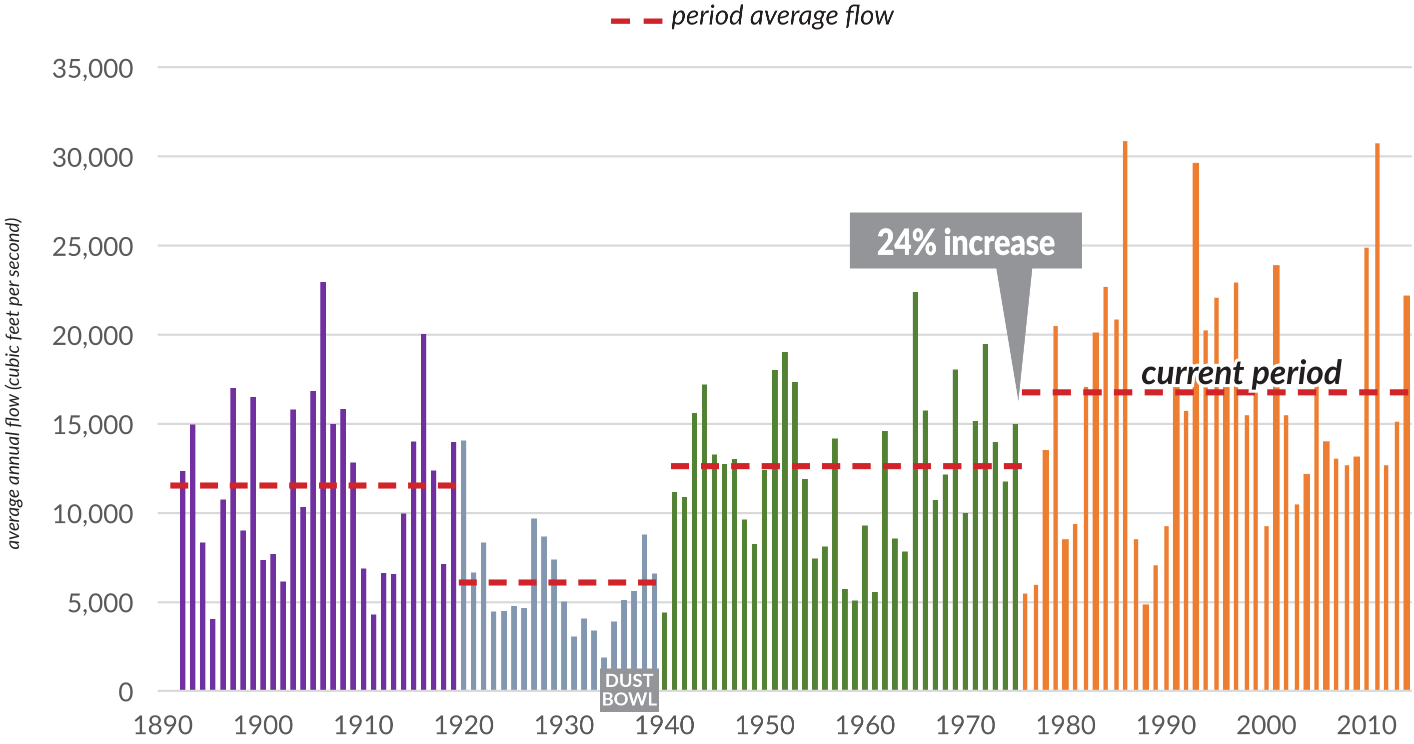


Figure 2. Long-term river flow trends in St. Paul, 1892-2014



Source: United States Geological Survey and St. Croix Watershed Research Station

Most of the metro Mississippi River's flow is from the Upper Mississippi River (59%) and Minnesota River (37%) basins, with a smaller share attributable to wastewater treatment plants (2%) and other sources (2%).[7]

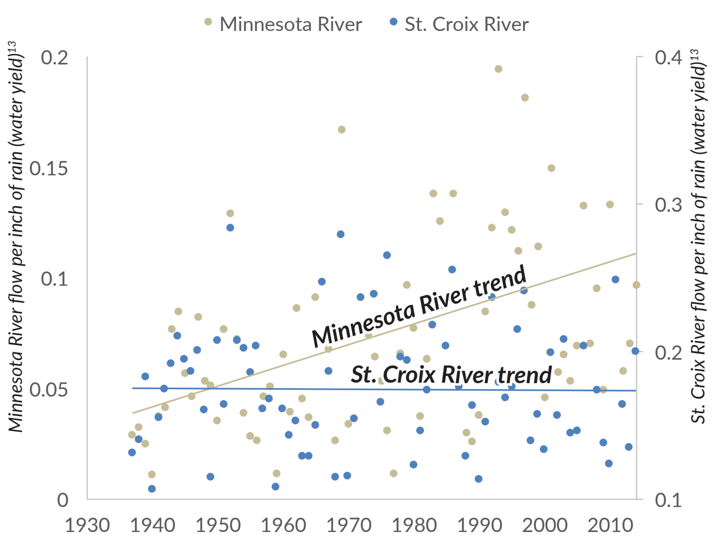
Status and trends. While recent flow trends have been relatively stable, Figure 2 above shows how recent flows compare to other periods over time. Average flows increased by 24% over the last 70 years, influenced in part by the Minnesota River, where flow has doubled over the same period.[8,9]

Why is flow changing? While flow has always been influenced by overall precipitation, the land receives and delivers water differently today than in the past. For example, the Minnesota River, an important influence on the Mississippi River, has significantly more flow per unit of precipitation now than it used to (Figure 3).[10]

The **hydrology** of the river (the movement and distribution of water) has changed over time, impacting water quality and river health. Three main factors are driving this change: land use, drainage and climate.

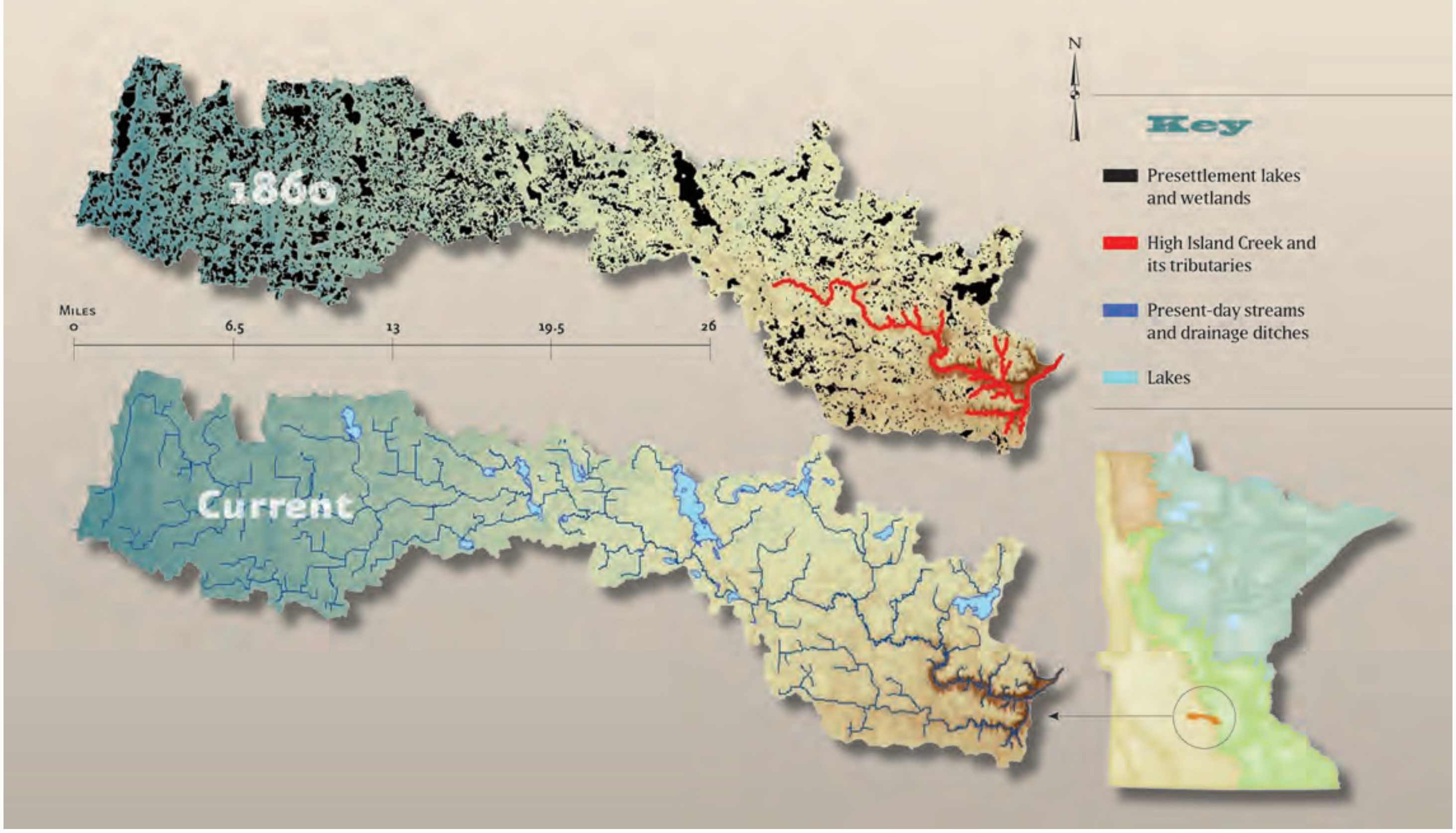
- **Land use:** Much of Minnesota's native prairies and wetlands have been converted to row crop agriculture. Whereas natural landscapes absorb and evapotranspire water effectively, annual crops only consume water during a portion of the year, allowing a greater share of annual precipitation to enter surface waters.

Figure 3. Flow per unit of precipitation in the Minnesota and St. Croix Rivers, 1937-2014



Source: United States Geological Survey, analysis provided by St. Croix Watershed Research Station

Figure 4. Landscape alteration in Minnesota



This graphic illustrates the conversion of the 238-square mile High Island Creek watershed (near Henderson, Minn.) between 1860 and today. Extensive artificial drainage has replaced many of the lakes and wetlands, which previously stored water on the landscape.

Source: DNR's Jan/Feb 2016 "MN Conservation Volunteer," pages 20-21. Jon Lore, MN DNR

- **Drainage:** Artificial agricultural drainage (which includes ditching, subsurface tiling and wetland drainage) also impacts river hydrology. Water that would have naturally ponded on the surface and evaporated is instead routed through artificial drainage and into surface waters (Figure 4).[11] As a result, less water is evaporated back into the atmosphere, while more of it drains to the river.
- **Climate:** Increases in rainfall may be responsible for a portion of recent increases in river flows.[12]

Together, these factors have fundamentally altered the ability of the land to store and evaporate water. As a result, more water enters the river with each precipitation event, making our rivers more erosive, less stable and more susceptible to runoff pollution.

Solutions. Rivers, lakes and streams fare best when runoff infiltrates naturally into the ground.

Restoring natural hydrology in agricultural areas will require a comprehensive mix of drainage water management, changes to cropping systems, and projects that hold and store more water on the land. In addition, increasing perennial vegetation on the landscape during spring and fall (before and after row crop establishment and harvest) will help restore a more natural water cycle. Such changes will require a coordinated statewide effort.

Residents can help maintain a healthy water balance by installing rain gardens, rain barrels, pervious pavers, green roofs, and by restoring native landscapes. These are proven strategies for reducing excess runoff and improving water quality in the Mississippi River.

SWIMMING & RECREATION

Photo: Gordon Dietzman/MNRRA.

This section highlights two key measures of the quality of the Mississippi River as a swimming and recreation asset.

Bacteria pose a threat to human health and can limit the recreational uses of rivers, lakes and streams.

Phosphorus contributes to algae blooms that negatively impact aquatic recreation, life and health.

Bacteria

Phosphorus

Bacteria

Portions of the river are impaired with excess bacteria, which can increase health risks for recreational users.

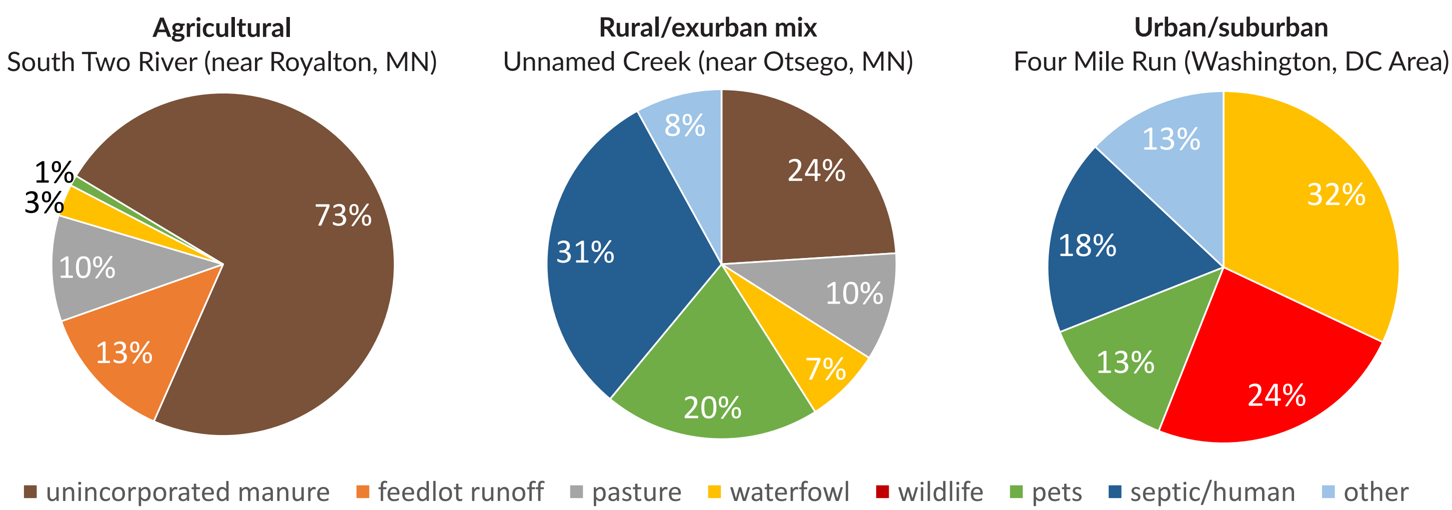
E. coli data indicate the potential presence of pathogens in the river.	Bacteria pollution comes from human and animal sources.	Swimming should be limited in impaired reaches of the river.

Description and impacts. *Escherichia coli (E. coli)* is a bacterium indicating the potential presence of waterborne pathogens that can be harmful to human health. It typically comes from human and animal feces. The river is a significant recreational resource (swimming and boating) for many Minnesotans. Contact with water with high bacteria concentrations can make recreational users sick (nausea, vomiting, fever, headache and diarrhea). To reduce the risk of people getting sick from exposure to pathogens while recreating, the state has standards for concentrations of *E. coli* in water.[1]

Sources. Bacteria pollution can be a problem in rural, suburban and urban areas. Harmful bacteria originate in the intestines of living creatures, and are generally spread when fecal matter enters the river. These bacteria come from **human sources** (septic systems, combined storm- and sanitary sewer overflows[2] and leaking sanitary sewers), **livestock** (feedlots, grazing livestock and field-applied manure), **pets** and **wildlife**.

In the areas contributing to the metro river, field-applied manure, feedlots and pastures tend to be the predominant sources of fecal bacteria in agricultural areas.[3] In suburban and urban areas, pets, wildlife and human sources tend to be the main contributors (Figure 1).[4]

Figure 1. **Estimated bacteria sources in example streams**
These graphs show estimated bacteria sources in three representative landscape types



Source: Minnesota Pollution Control Agency, Northern Virginia Regional Commission[11]

Bacteria in the metro river

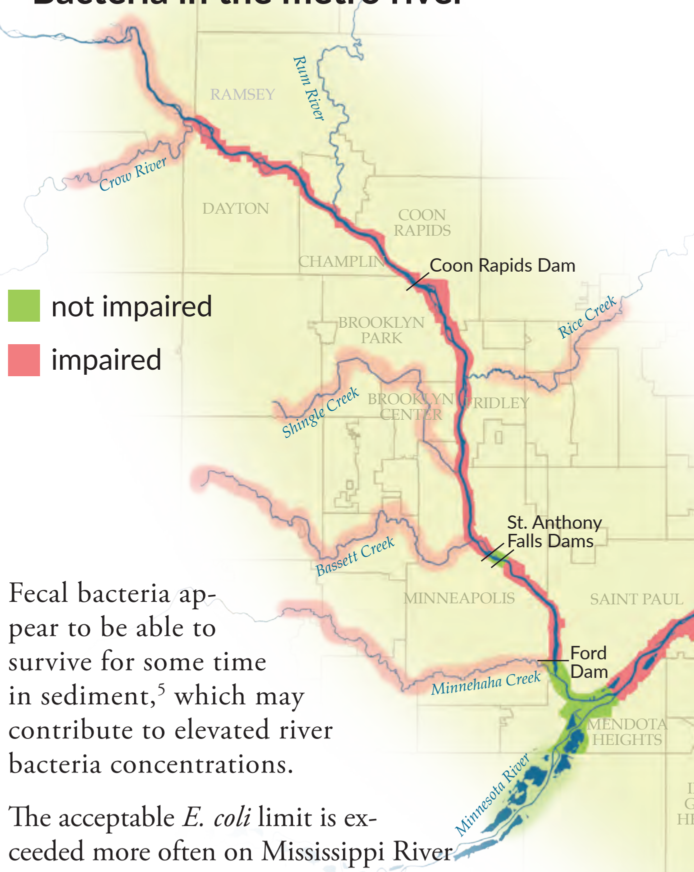
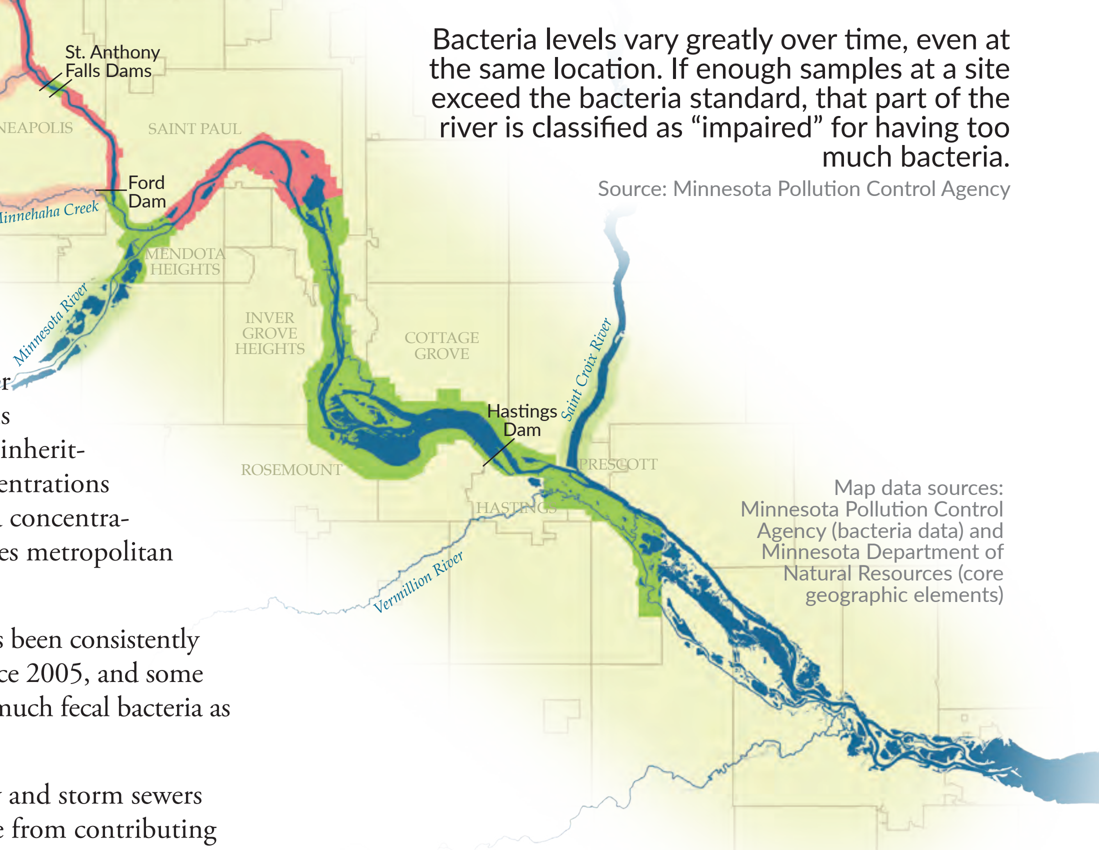
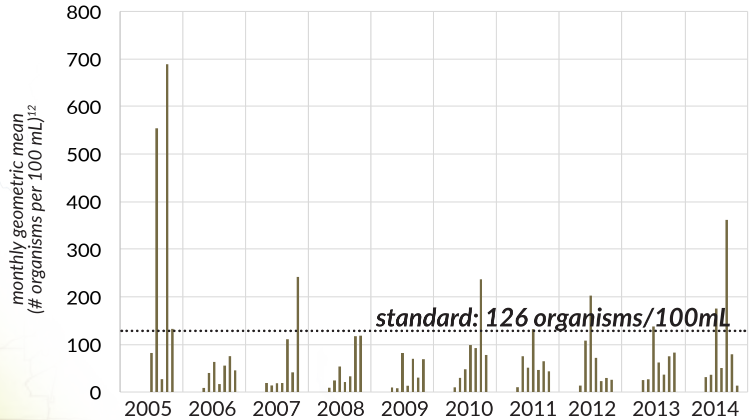



Figure 2. Bacteria levels, 2005-2014

Lower St. Anthony Falls to Ford Dam



Bacteria levels vary greatly over time, even at the same location. If enough samples at a site exceed the bacteria standard, that part of the river is classified as "impaired" for having too much bacteria.

Source: Minnesota Pollution Control Agency

Fecal bacteria appear to be able to survive for some time in sediment,[5] which may contribute to elevated river bacteria concentrations.

The acceptable *E. coli* limit is exceeded more often on Mississippi River tributaries than on the river itself.[6] This indicates that the Mississippi may be "inheriting" some of its elevated bacteria concentrations from its tributaries. The river's bacteria concentrations are highest around the Twin Cities metropolitan area.

History and trends. Bacteria data has been consistently collected in this portion of the river since 2005, and some stretches were identified as having too much fecal bacteria as early as 1996.

Since 1985, efforts to separate sanitary and storm sewers have kept millions of gallons of sewage from contributing bacteria to the river each year.[7,8]

Status. Many portions of the river from its confluence with the Crow River (in Dayton) downstream through St. Paul have average bacteria concentrations that are too high. These reaches of the river are "impaired" with excess bacteria (see map).

Can I swim in the river? It is recommended that swimming or other recreational contact be limited in impaired sections of the river and that it be avoided everywhere in the river within 48 hours of a rainstorm (including storms upstream), as this is when runoff flushes many pollutants into the river. Recreational users are advised to be especially cautious downstream of storm drain outlets and other places where runoff enters the river. Always rinse off well after swimming.

Drinking untreated river water that contains disease-causing bacteria poses a risk for animals as well as for people.[9,10] Keep this in mind if you allow your dog to swim in the river.

Solutions. The Minnesota Pollution Control Agency has completed bacteria clean-up plans for most of the Mississippi River and its tributaries in Minnesota. These plans identify the sources of bacteria pollution and propose a variety of solutions to restore these waters. The Upper Mississippi's final plan is available at http://www.pca.state.mn.us/ktqha48.

Targeted monitoring could help determine with more clarity how, when, and where elevated bacteria concentrations are delivered to the river.

You can help reduce bacteria pollution in the Mississippi River by cleaning up your pet's waste, making sure septic systems are up-to-date and reducing runoff at home and in your community.

Phosphorus

Portions of the metro river are impaired with too much phosphorus.

Excess phosphorus harms aquatic life and recreation.	Phosphorus concentrations in the metro river have decreased by 35% since 1976.	Metropolitan Council wastewater treatment plants have reduced their phosphorus output by 88% since 2000.

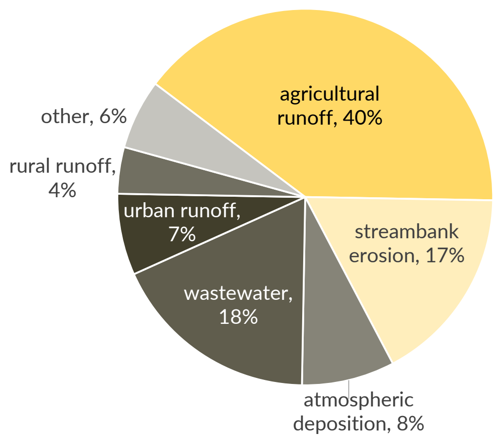
Description and impacts. Phosphorus is a common element in the environment and is essential for plant growth and health. However, too much phosphorus in waters can harm aquatic life and recreation by feeding the growth of algae, which reduce water clarity and deplete oxygen levels when they die and decompose.[1] In addition, some algae blooms (e.g., blue-green algae) can be toxic to aquatic life, humans and pets.

Sources. Major sources of phosphorus pollution include agriculture, streambank erosion and wastewater treatment plants (Figure 1).[2] Additional sources include atmospheric deposition, failing septic systems and some road salt alternatives. Sediment levels in water also affect phosphorus pollution, as phosphorus can attach to soil particles as they move through the watershed (see Sediment, page 34). Overall, about 57% of phosphorus in the metro Mississippi River comes from the Minnesota River in an average flow year.[3]

Historically, wastewater treatment plants have been significant sources of phosphorus to surface waters in Minnesota. These facilities have greatly reduced their share of phosphorus pollution. For example, Metropolitan Council wastewater treatment plants have made phosphorus reductions of 88% since implementing new phosphorus reduction technology beginning in 2000 (Figure 2).[4]

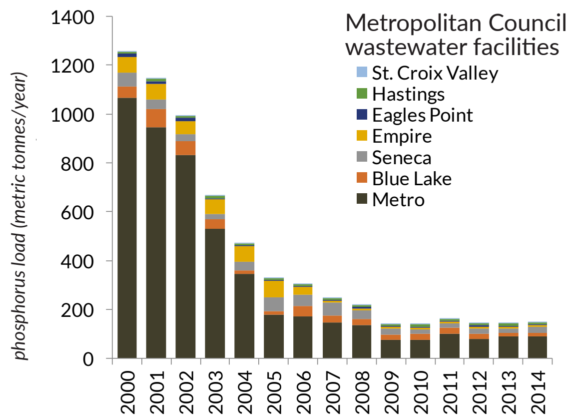
Status and trends. Minnesota established river phosphorus standards, including those for the Mississippi and Minnesota Rivers, in 2014.[5,6] The standards identify the maximum allowable amount of phosphorus in each portion of the metro river during summer months.[7] The standards also consider algae and oxygen levels that can impact

Figure 1. Sources of phosphorus to the Mississippi River in average conditions



Source: Minnesota Pollution Control Agency, 2014

Figure 2. Annual Metropolitan Council wastewater phosphorus loads



Source: Metropolitan Council Environmental Services

Phosphorus in the metro river

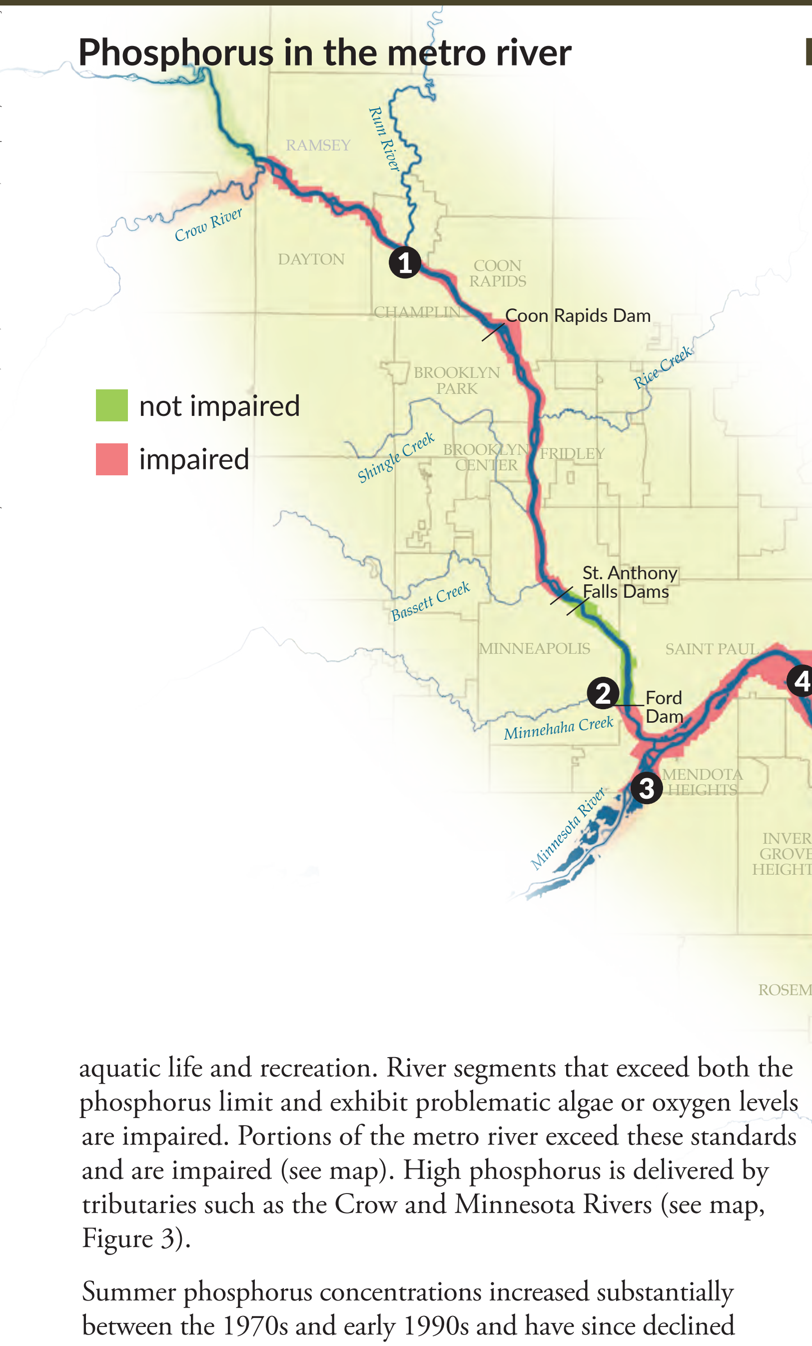
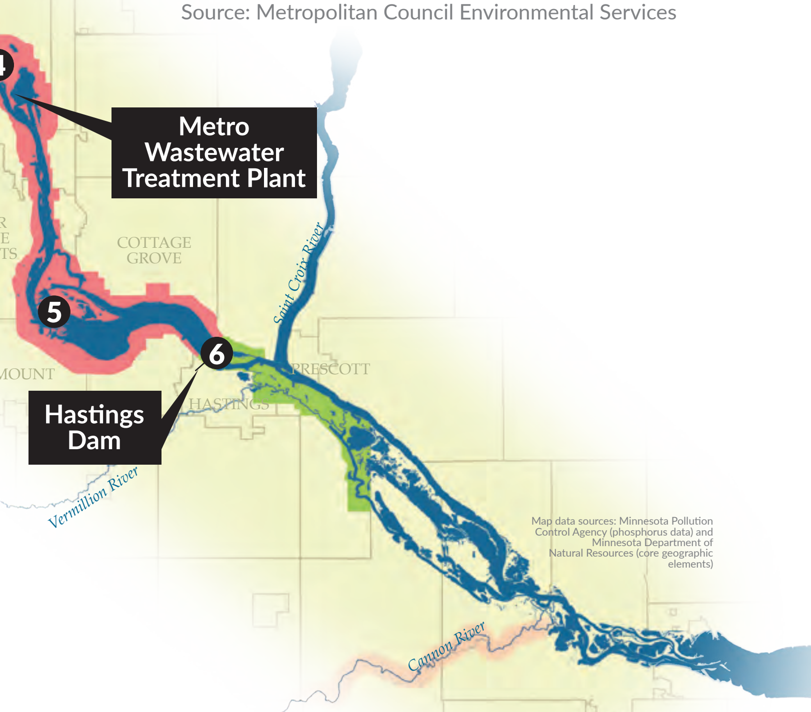
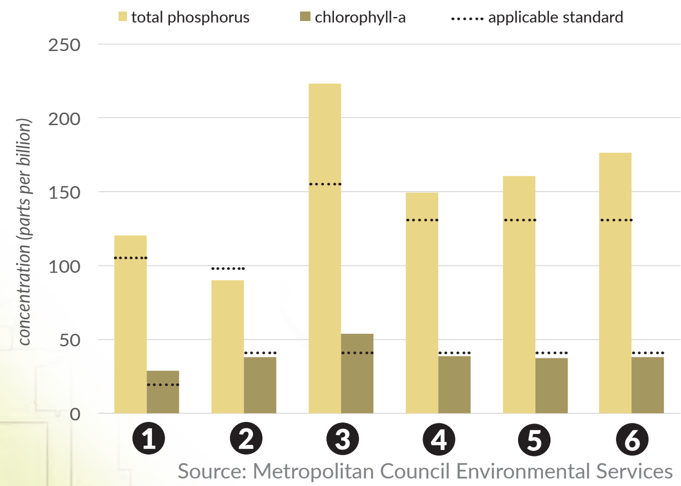



Figure 3. Average summer phosphorus and chlorophyll-a concentrations through the Twin Cities, 2005-2014



Source: Metropolitan Council Environmental Services

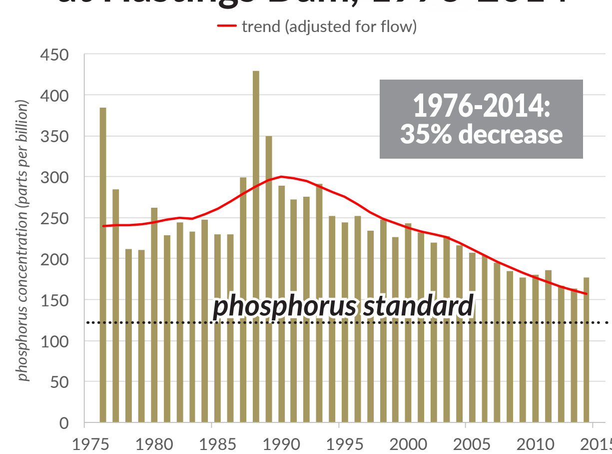
aquatic life and recreation. River segments that exceed both the phosphorus limit and exhibit problematic algae or oxygen levels are impaired. Portions of the metro river exceed these standards and are impaired (see map). High phosphorus is delivered by tributaries such as the Crow and Minnesota Rivers (see map, Figure 3).

Summer phosphorus concentrations increased substantially between the 1970s and early 1990s and have since declined notably, due largely to improvements in wastewater treatment practices. Overall, summer levels decreased by 35% between 1976 and 2014 (Figure 4).[8]

Management solutions. Recent reductions in phosphorus concentrations have been primarily due to improvements in wastewater treatment. Because remaining phosphorus pollution is linked largely to unregulated agricultural runoff, future improvements will require substantial reductions in cropland, pasture and rural runoff, along with curtailed streambank erosion.

Minnesota banned phosphorus in laundry detergents in 1977, and state law prohibits the use of fertilizers containing phosphorus on lawns and turf, except in a limited number of situations.[9,10] Residents can help by using lawn chemicals wisely, using phosphorus-free dishwashing detergents and soaps, picking up pet waste, and keeping grass clippings and leaves out of storm drains.

Figure 4. Average summer phosphorus concentrations at Hastings Dam, 1976-2014



Source: Metropolitan Council Environmental Services, St. Croix Watershed Research Station

Photo: Adam Flett/FMR.

RIVER LIFE

Photo: Gordon Dietzman/MNRRA.

This section highlights five key measures of the health of the river ecosystem.

Safe eating guidelines are in place for fish consumed from the river. Fish survey data highlight the abundance and diversity of fish species in the metro river. Invasive Asian carp threaten to destabilize river ecology.

Bald eagles and mussels are key indicators of the health and vitality of the river.

- Fish consumption
- Fish survey
- Invasive Asian carp
- Bald eagles
- Mussels

Fish consumption

Fish from the river are safe to eat if you follow the state's fish consumption advice.

Fish in the river may contain elevated levels of some contaminants.	River anglers should follow Site-Specific Safe-Eating Guidelines.	Fish consumption guidelines are based on the fish species, who you are, and how often you eat fish.

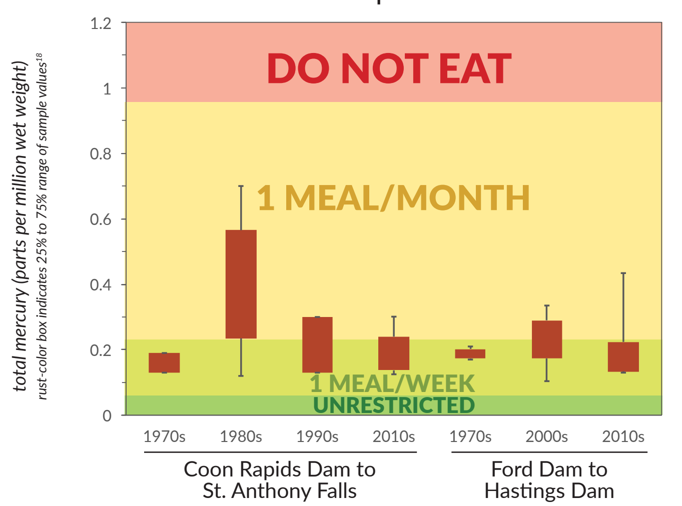
Background. Fish are rich in iron, protein and omega-3 fatty acids and are a good choice for a healthy diet. However, fish in the metro river can contain mercury, PCBs and perfluorooctane sulfonate (PFOS) that can harm human health.[1]

- Mercury is a toxic element that can impact the nervous system, particularly in children.[2] See Mercury, page 46.
- PCBs are a class of industrial chemicals linked to problems in infant development and immune, reproductive, nervous and endocrine functions.[3]
- Perfluorooctane sulfonate (PFOS) is part of a family of manufactured chemicals that accumulate in fish, persist in the environment and can pose potential risks to human health.[4] See PFOS, page 46.

History and trends. **Mercury** pollution in the environment peaked in the 1960s, and has since decreased by almost 70%.[5,6] However, while average mercury concentrations in fish vary, recent levels in and around the metro river are cause for concern (Figure 1).[7,8] Environmental contamination from **PCBs** began in the mid-1930s and peaked in the early 1970s.[9] Concentrations in fish have since declined substantially (Figure 2).[10] Locally, **PFOS**

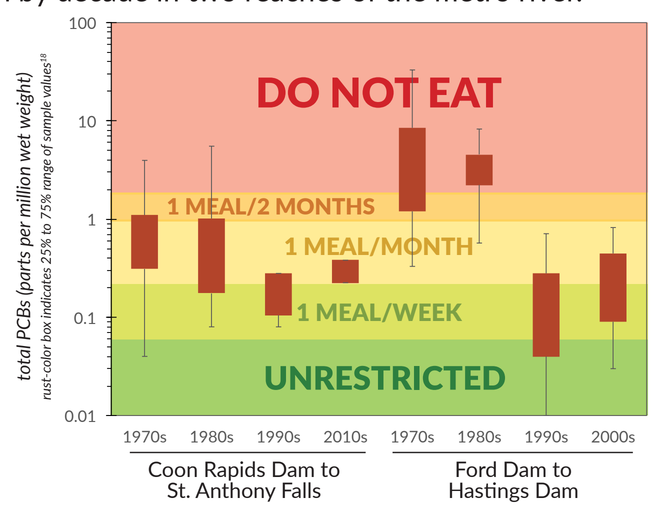
The data below show pollutant concentrations in fish by decade in two reaches of the metro river.

Figure 1. **Mercury in black bass, 1970s-2010s**
with fish consumption advice[17]



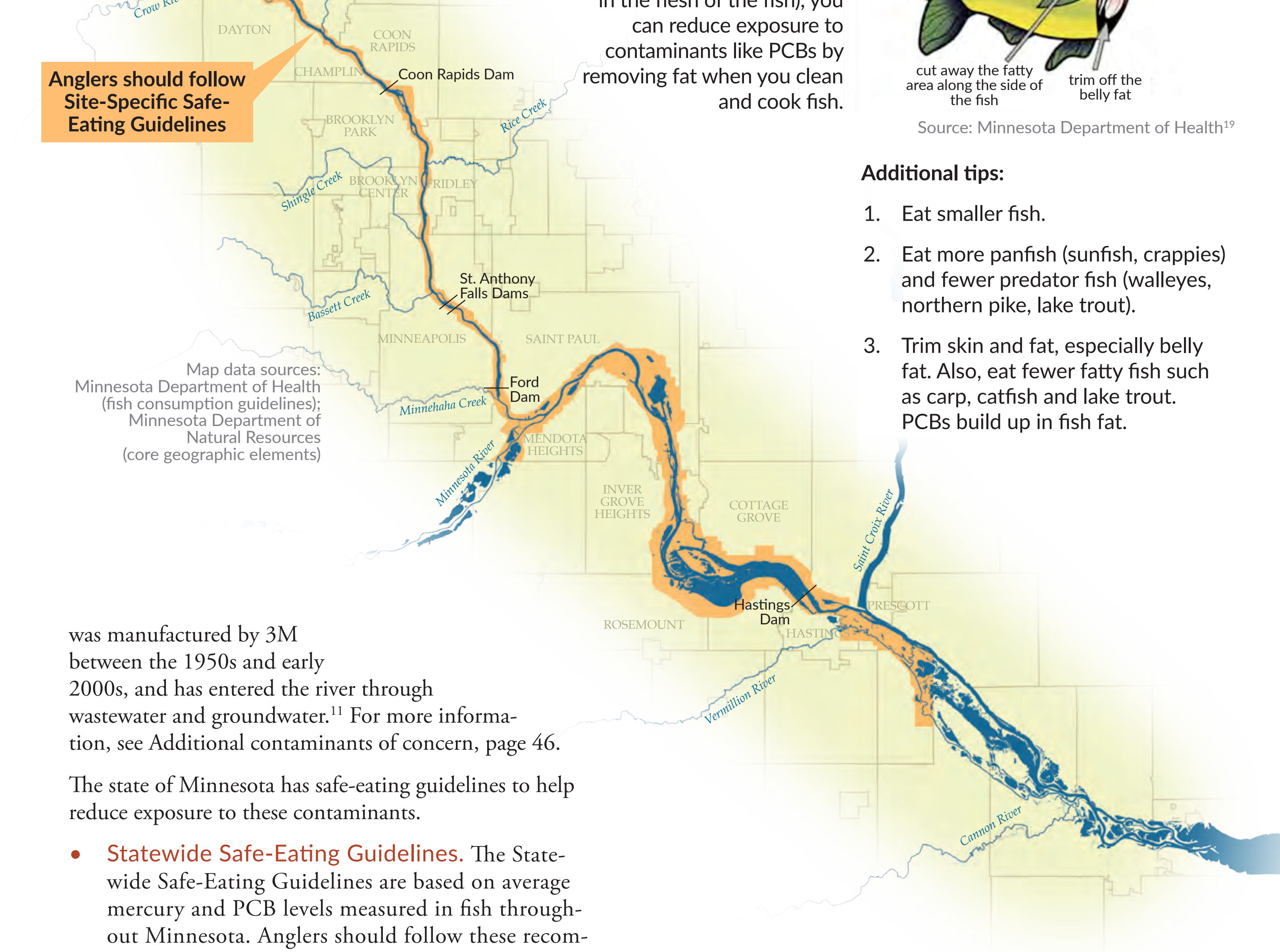
Sources: Minnesota Pollution Control Agency, Minnesota Department of Health

Figure 2. **PCBs in common carp, 1970s-2010s**
with fish consumption advice



Sources: Minnesota Pollution Control Agency, Minnesota Department of Health

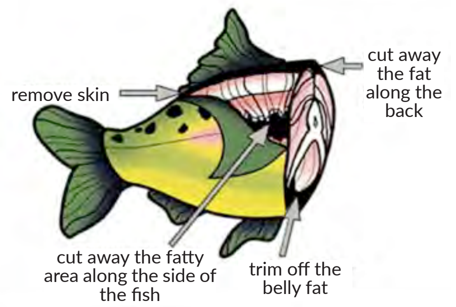
Fish consumption guidelines in the metro river



Map data sources: Minnesota Department of Health (fish consumption guidelines); Minnesota Department of Natural Resources (core geographic elements)

Tips for eating fish

While mercury and PFOS cannot be removed through cooking or cleaning (they are in the flesh of the fish), you can reduce exposure to contaminants like PCBs by removing fat when you clean and cook fish.



Source: Minnesota Department of Health[19]

Additional tips:

1. Eat smaller fish.
2. Eat more panfish (sunfish, crappies) and fewer predator fish (walleyes, northern pike, lake trout).
3. Trim skin and fat, especially belly fat. Also, eat fewer fatty fish such as carp, catfish and lake trout. PCBs build up in fish fat.

was manufactured by 3M between the 1950s and early 2000s, and has entered the river through wastewater and groundwater.[11] For more information, see Additional contaminants of concern, page 46.

The state of Minnesota has safe-eating guidelines to help reduce exposure to these contaminants.

- **Statewide Safe-Eating Guidelines.** The Statewide Safe-Eating Guidelines are based on average mercury and PCB levels measured in fish throughout Minnesota. Anglers should follow these recommendations unless Site-Specific Safe-Eating Guidelines have been established for the waterbody from which they fish.[12]
- **Site-Specific Safe-Eating Guidelines.** The State monitors contaminants from select lakes and rivers, including waters that are popular with anglers or which have known or suspected contamination issues, to determine Site-Specific Safe-Eating Guidelines. This meal advice may be more or less restrictive than the Statewide Safe-Eating Guidelines.[13]

Both categories include guidelines for the general population and separate, more protective guidelines for sensitive populations (such as pregnant women and children under 15).[14] Anglers should also note that catch-and-release regulations are in place for portions of the river; anglers may not keep or consume these fish. Fish on catch-and-release lists are excluded from Safe-Eating Guidelines.

Status. Site-Specific Safe-Eating Guidelines are in place for the metro river; people who eat fish from the river should follow these guidelines. More information is available through the Minnesota Department of Health at http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html.

Management strategies. The Minnesota Pollution Control Agency has approved a statewide mercury reduction plan that calls for a 76% reduction in mercury emissions by 2025.[15] PCB manufacture was banned in the U.S. in the late 1970s.[16] PFOS clean-up work is underway.

Fish survey

Anglers have embraced the metro river as a world-class fishery.

There has been an increase in the diversity and quality of the river's fishery, particularly smallmouth bass and walleye, since the 1970s.

Catch-and-release regulations are in place for portions of the river.

River managers lack data on species mix and trends.

Background. Historically, the river has been home to abundant populations of fish and wildlife. Scientists estimate there were nearly 120 native fish species below St. Anthony Falls and approximately 60 species above the falls, which served as a natural migration barrier.[1]

Fish populations dramatically declined following European settlement, when the river was used as a dumping ground for sewage, milling waste, stockyard waste and untreated runoff. In 1926, fish survey data showed only two living fish in the river between St. Anthony Falls and Hastings.[2]

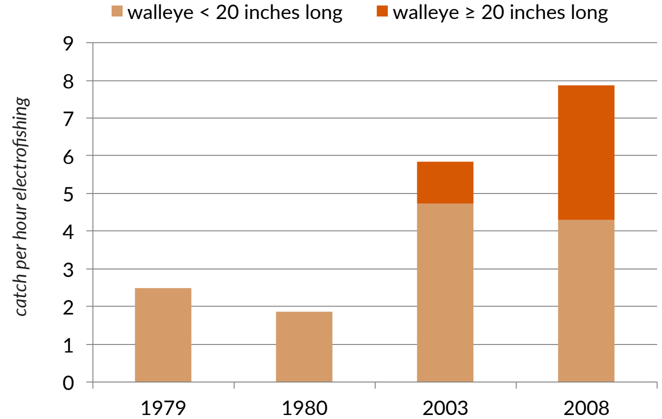
Subsequent improvements in water management, including construction of the Metro Wastewater Treatment Plant in 1938, regulation of urban and industrial pollution, and passage of the 1972 Clean Water Act, along with other factors, have resulted in improved fish populations in the river.

Locks and dams. The construction of locks and dams has played an important part in the river's ecology. Dam construction impacts river flow (converting free-flowing water to more stagnant pools), impacting some fish and floodplain vegetation. In addition, sediment accumulation behind dams can bury fish habitat at important locations.

The dams also allowed sewage, mill and stockyard waste to accumulate on the river surface, capturing public attention on the need for river clean-up - particularly during hot summer months.

In addition, lock and dam installation has altered fish migration patterns. Whereas St. Anthony Falls was a

Figure 1. Walleye catches between Ford and Hastings Dams



Source: Minnesota Department of Natural Resources

Catch-and-release regulations in the metro river

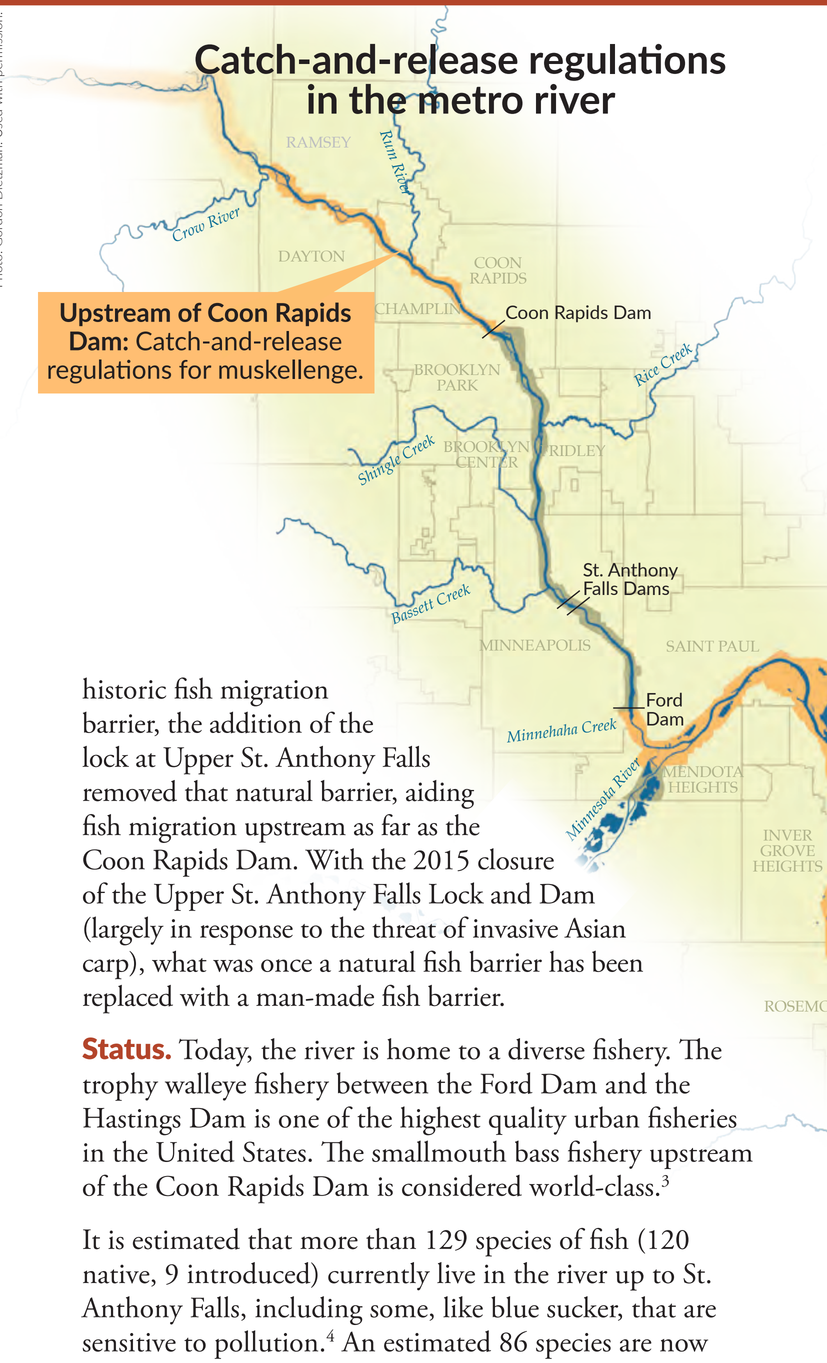
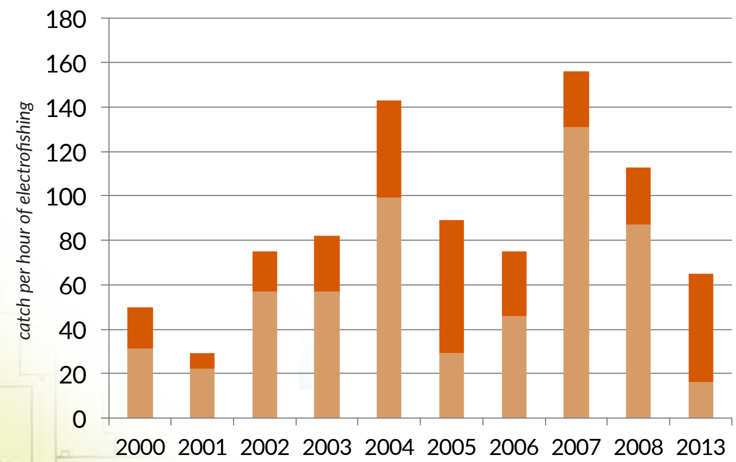


Figure 2. Smallmouth bass catches above Coon Rapids Dam



Source: Minnesota Department of Natural Resources

historic fish migration barrier, the addition of the lock at Upper St. Anthony Falls removed that natural barrier, aiding fish migration upstream as far as the Coon Rapids Dam. With the 2015 closure of the Upper St. Anthony Falls Lock and Dam (largely in response to the threat of invasive Asian carp), what was once a natural fish barrier has been replaced with a man-made fish barrier.

Status. Today, the river is home to a diverse fishery. The trophy walleye fishery between the Ford Dam and the Hastings Dam is one of the highest quality urban fisheries in the United States. The smallmouth bass fishery upstream of the Coon Rapids Dam is considered world-class.[3]

It is estimated that more than 129 species of fish (120 native, 9 introduced) currently live in the river up to St. Anthony Falls, including some, like blue sucker, that are sensitive to pollution.[4] An estimated 86 species are now found above the falls.[5]

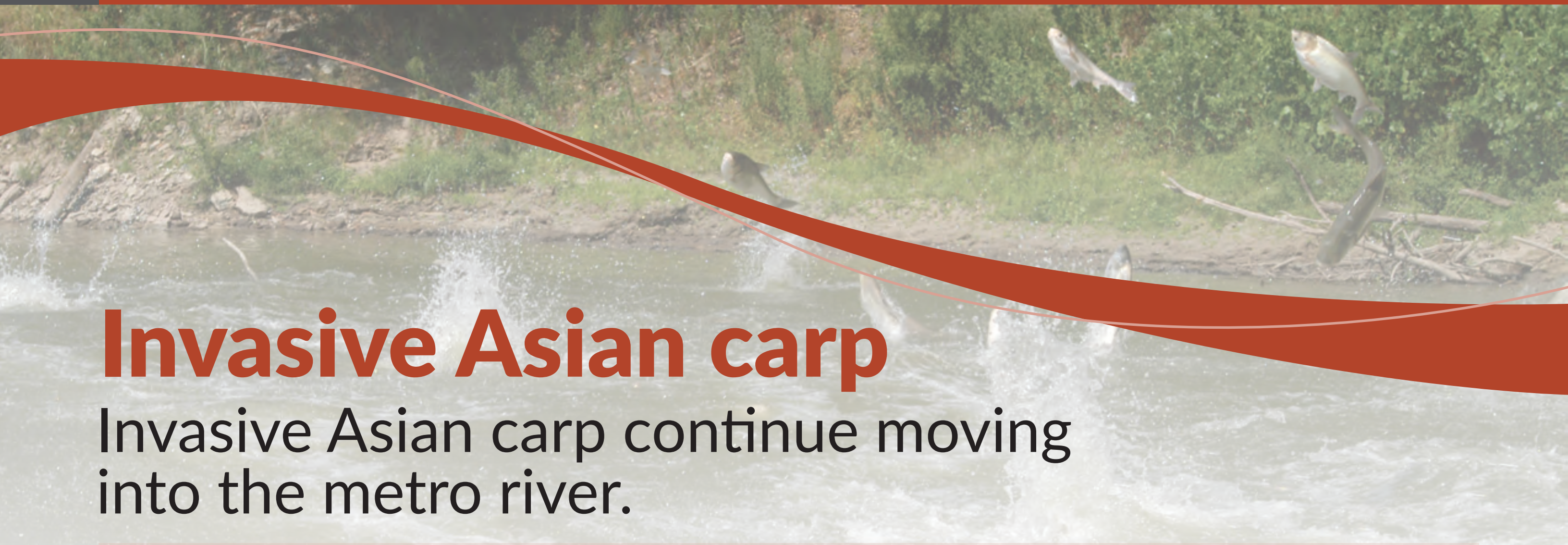
Despite these encouraging numbers, it is difficult to accurately estimate fish populations, and much remains unknown about the overall diversity and abundance of fish in the river. There have been few comprehensive surveys of aquatic life in this reach of the river.

Fishing catch-and-release rules. There are catch-and-release regulations for the river between the Ford and Hastings Dams for walleye, sauger, largemouth bass and smallmouth bass, as well as for muskellunge above the Coon Rapids Dam. These fish may be caught, but must be returned alive to the water. These guidelines were established to protect and maintain high quality fish populations.

Invasive Asian carp. These large fish can destabilize the aquatic food web and outcompete native fish for food. Monitoring for the presence of Asian carp in the river is ongoing, and the lock at Upper St. Anthony Falls was permanently closed in 2015, largely to prevent further upstream migration of these fish. For additional information, see Invasive Asian carp, page 26.

Management tools. Several important fishery management tools, including catch-and-release rules and commercial and recreational angling regulations, are currently in place.

While the fishery as a whole appears healthy, fishery managers lack clear data on species mix and trends throughout this reach of the river. Research to establish baseline fish populations and the impact of lock closure on fish is underway. Once this information is gathered, strategic management options can be more effectively identified.



Invasive Asian carp

Invasive Asian carp continue moving into the metro river.

Asian carp are invasive fish that pose a serious threat to river recreation and ecosystem health.	At least 19 grass, bighead and silver carp have been caught in Lake Pepin and the metro Mississippi River since 2011.	Changes in management of navigational locks have been made to slow the migration of Asian carp.

About Asian carp. Asian carp are a group of invasive fish consisting of four species: bighead, black, grass and silver carp. With large appetites, these voracious feeders can severely disrupt aquatic ecosystems as they outcompete native fish species and outgrow natural predators. Black, bighead and grass carp can all grow to over 100 pounds. Elsewhere on the river, established Asian carp populations have severely degraded boating, fishing and other recreation activities. Silver carp, which commonly grow to 20-40 pounds and leap as high as 10 feet from the water when disturbed, have caused injuries and boat damage in other states.[1]

History and background. Asian carp were originally imported to the southern U.S. from China to control aquatic vegetation and parasites in fish farms. The carp escaped to the Mississippi River and its tributaries in the 1970s, and populations were well established in southern river states by the 1980s.[2] Their populations and ranges have increased dramatically in recent years, and the fish have reached states throughout the upper Mississippi River, including Minnesota (see map). In portions of the Illinois River where the infestation is extreme, over 60% of the weight of all the fish in the river is Asian carp.[3]

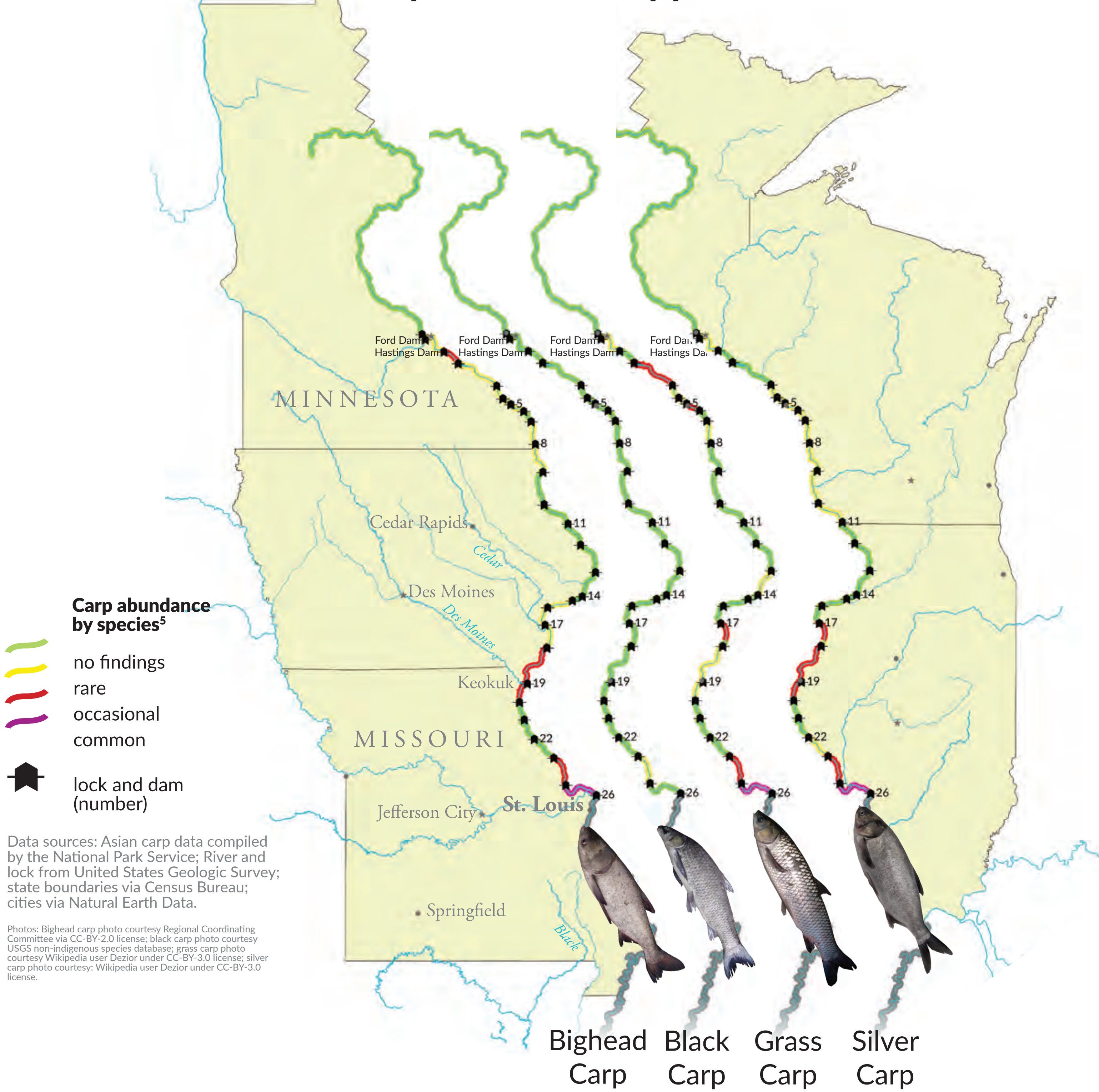
Status and trends. In Minnesota, over 76 bighead, silver and grass carp have been caught from the Mississippi and St. Croix Rivers since 1996, including at least 19 catches upstream of Winona since 2011.[4] A 47-pound bighead caught in Lake Pepin in November 2012 is the largest carp caught to-date in Minnesota. Two silver carp were caught between the Hastings Dam and the Ford Dam in 2014. Grass and bighead carp were also caught in the Minnesota River near New Ulm in December 2015 and February 2016. While no reproducing populations of Asian carp are known to exist in Minnesota, these data suggest the fish are present in the metro river area.

Solutions. Because they can move upstream when locks are opened, the recent closure of the Upper St. Anthony Falls Lock and reduced hours of operation at the Ford Lock (Lock and Dam 1) may help prevent the further spread of Asian carp into Minnesota.

Preventing the establishment of Asian carp in Minnesota's waters will require the following:

- **Deterrent technology:** Continue to research how modifying flow through dam gates and installing carp-deterrent technologies such as bubble, electric and acoustic barriers in the locks can be most effective.
- **Lock operations:** Modify lock operations to reduce recreational traffic wherever feasible. Manage lock operations to incorporate our growing understanding of Asian carp behavior, migration patterns and biology.
- **Research and biological control:** Enhance long-term funding for research into the behavior and biology of Asian carp.
- **Education and outreach:** Educate the public about the risks of Asian carp to build support for the

The march of Asian carp up the Mississippi River



strategies and practices necessary to prevent their establishment in the metro river.

Minnesotans can help prevent upstream Asian carp migration by minimizing their use of Mississippi River locks and by not moving bait from water to water.

Improvements to water quality and aquatic habitat in the river will support healthy native fish populations, which will be more resilient in the face of competition from invasive Asian carp.

To learn more, visit www.asiancarp.us or www.stopcarp.org.

Bald eagles

The metro river is home to a resilient population of bald eagles.

Eagles along the river have made a dramatic comeback from near-extinction.	Lead levels in nestlings are higher in the metro river corridor than elsewhere in the region.	Levels of several contaminants are declining, but remain cause for concern.

Background. In 1963, only 417 bald eagle pairs nested in the lower 48 states. Today, nearly 10,000 pairs live in the lower 48 states, including over 1,300 in Minnesota.[1] This extraordinary recovery is linked to protections offered by the Bald Eagle Protection Act (1940),[2] the Clean Water Act (1972),[3] a national ban on DDT (1972),[4] and the Endangered Species Act (1973).[5]

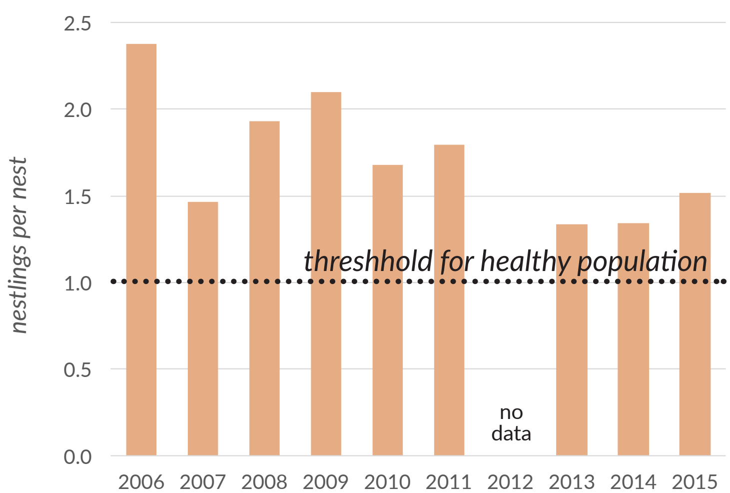
Eagles feed primarily on aquatic prey and are susceptible to contaminants present in fish and other wildlife. Young bald eagles ("nestlings") are particularly vulnerable to these contaminants, and can help us understand overall ecosystem health.

Population status. Currently, the metro river is home to approximately 55 active nesting sites. This is approximately a 35% increase since 2011, indicating a strong and stable bald eagle population. Research is tracking this productive eagle population, which averages about one and a half nestlings per nest, well over the threshold for a healthy population (Figure 1).[6] Though the reproductive rate has varied over the years, it remains high relative to other areas monitored by the National Park Service.

Nestling health status. From 2006 through 2015, the National Park Service visited nests annually to take samples to measure levels of targeted contaminants, including:

- **PFCs.** Perfluorinated chemicals (PFCs) are a family of manufactured compounds widely used in stain-, grease- and water-resistant products. High levels of PFCs in humans are associated with obesity, diabetes and early menopause in women. PFCs, including PFOS (see PFOS, page 46), also contribute to fish consumption advisories in the metro river (see Fish consumption, page 22). Overall concentrations of PFCs declined in nestlings between 2006 and 2014. However, compared to upriver nestlings, PFC levels were nearly twice as high in the lower portion of the metro river, including record levels in a nestling near Hastings (Figure 2).[7]
- **Lead.** Lead is a neurotoxin with potentially harmful impacts to eagle nestlings and other wildlife. It is introduced into the environment via industrial uses, fishing tackle,

Figure 1. Nestlings per nest



Source: National Park Service

Figure 2. Eagle nest locations and nestling blood lead levels along the metro river

ammunition and atmospheric deposition.[8] Research has documented the presence of lead in eagles throughout the river corridor (Figure 2). These concentrations are higher than the levels found in other national parks sampled in the region.[9] Two nestlings monitored in 2015 had some of the highest levels yet recorded: more than 160 parts per billion (ppb) and more than 260 ppb (Figure 2). The Raptor Center has established a threshold of 200 ppb for an adult bald eagle to need treatment for lead poisoning.

- **PBDEs.** Polybrominated diphenyl ethers (PBDEs) are a common flame retardant used in plastics, electronics, fabrics and other commercial products.[10] There is concern over their environmental toxicity and persistence in the food chain.[11] Studies on humans and laboratory animals show PBDE exposure can interfere with immune and thyroid function, and alter human infant behavior.[12]

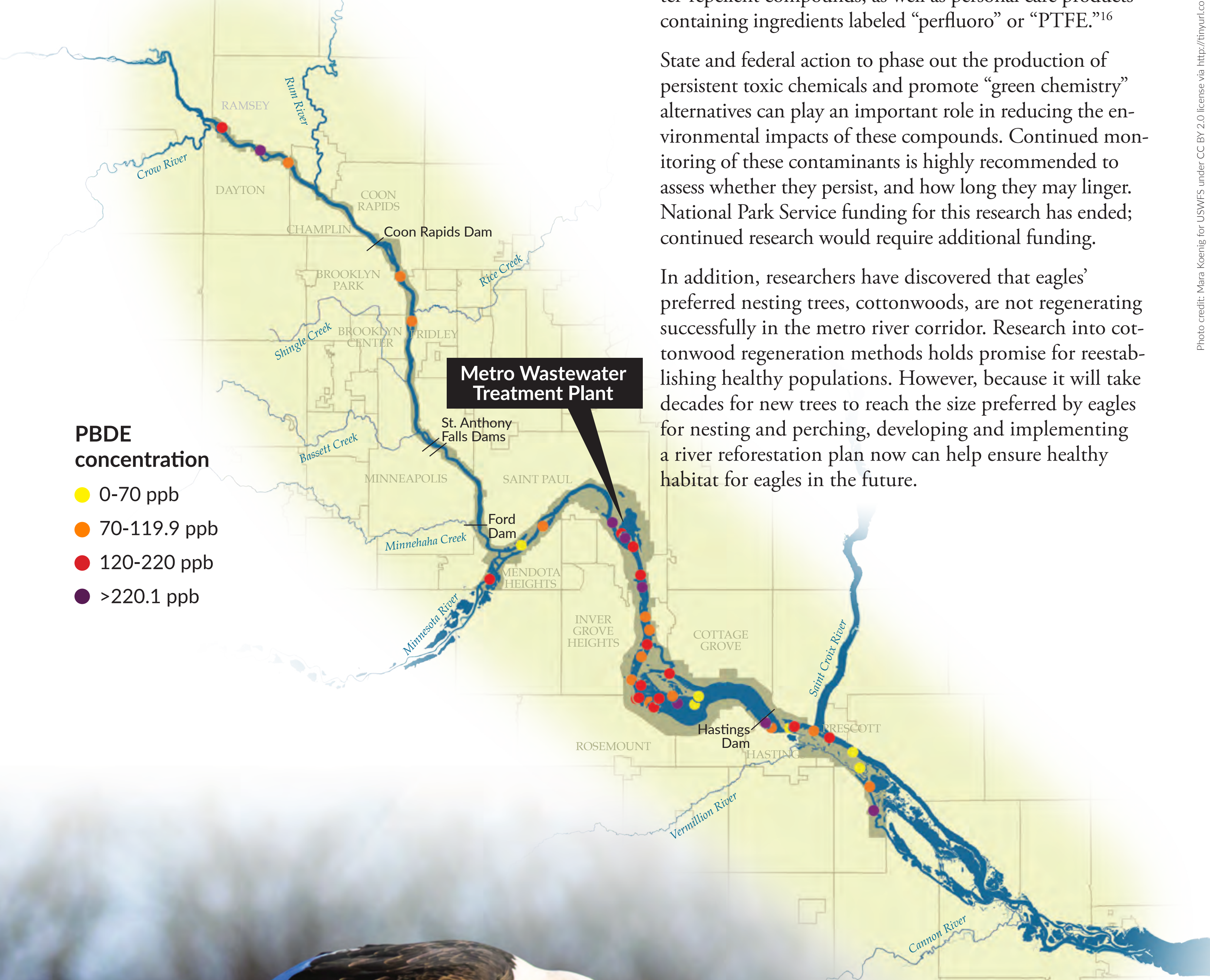
  Between 2006 and 2011, levels of PBDEs in metro river eagles declined by 10% overall.[13] However, compared to upstream nestlings, concentrations were twice as high in nestlings downstream of the Metro Wastewater Treatment Plant with further increases downstream of our study area (Figure 3, page 30).[14]

Solutions. Hunters and anglers can help reduce lead in the environment by using non-toxic ammunition and fishing tackle, and asking bait and tackle stores to stock unleaded sinkers. If using lead ammunition, recover and remove all shot game from the field.

Consumers wishing to reduce their contribution of PBDEs in wastewater can do so by purchasing products made without PBDE-based flame retardants. Legislation banning several forms of PBDEs has passed at the national and state levels, including one in Minnesota in 2015.[15]

Consumers can help prevent PFC pollution by avoiding products treated with PFC-based grease-, stain-, or wa-

Figure 3. PBDEs in nestlings



ter-repellent compounds, as well as personal care products containing ingredients labeled "perfluoro" or "PTFE."[16]

State and federal action to phase out the production of persistent toxic chemicals and promote "green chemistry" alternatives can play an important role in reducing the environmental impacts of these compounds. Continued monitoring of these contaminants is highly recommended to assess whether they persist, and how long they may linger. National Park Service funding for this research has ended; continued research would require additional funding.

In addition, researchers have discovered that eagles' preferred nesting trees, cottonwoods, are not regenerating successfully in the metro river corridor. Research into cottonwood regeneration methods holds promise for reestablishing healthy populations. However, because it will take decades for new trees to reach the size preferred by eagles for nesting and perching, developing and implementing a river reforestation plan now can help ensure healthy habitat for eagles in the future.

Mussels

Some native mussels are gradually being reestablished in the metro river.

The presence of mussels is a good biological indicator of river health.	River pollution eliminated mussels from much of the metro river in the early 1900s.	Mussel habitat is degraded below the confluence with the Minnesota River.

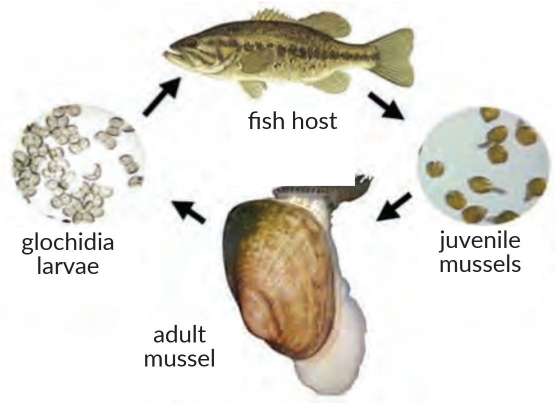
About mussels. Native mussels perform important functions in water bodies, and their presence is a good biological indicator of overall river health. Minnesota's native mussels filter solid material like plant debris, bacteria and runoff from the water, and excrete nutrients used by plants and other animals.[1]

Health and lifecycle. Mussels spend their lives partially or fully buried in mud, sand or gravel in lakes, rivers and streams. They require a stable surface, dissolved oxygen, and a food supply of organic matter to filter from the water passing over them. Mussels reproduce by releasing larvae that attach to a host animal, usually fish (Figure 1). Once attached to their host, the larvae metamorphose into adults, leave the host, and take up life in the river bottom.[2]

Status. Because they can't swim away, mussels are directly impacted by river contaminants. The discharge of untreated waste to the river through the early 1900s eliminated the mussel population downstream of St. Anthony Falls.[3,4] Since then, mussels have responded favorably to improved sewage treatment, the separation of storm sewers from sanitary sewers, and other water quality improvements.[5]

Mussel habitat downstream of the confluence with the Minnesota River is degraded, most likely due to high loads of sediment and other pollutants. However, some mussel species have returned and this lower reach of the river now supports 28 of the original 43 native mussel species.[6] Upstream of St. Anthony Falls, where lock construction aided host fish passage and mussel migration, there are 18 native mussel species.[7] Upstream of the Coon Rapids Dam, seven of nine historical native species are present.[8]

Figure 1. The lifecycle of a mussel



Source: Water Resources Center at Minnesota State University, Mankato

Management solutions. Reducing pollution is critical to improving mussel abundance in the river. Efforts to remove fish migration barriers like dams would also benefit mussel populations, but would need to be coordinated with efforts to control the spread of invasive Asian carp. In addition, ongoing efforts to reintroduce native mussels into the metro river will be important to their continued recovery.


Photo: Gordon Dietzman/MNRRA

ECOLOGICAL HEALTH

Photo: Gordon Dietzman/MNRRA.

This section highlights five indicators of water quality and river health.

Sediment and nitrate are important measures of water quality that affect aquatic life and habitat throughout the river corridor. Chloride runoff is affecting river tributaries and poses a long-term threat to water quality and aquatic life.

Pesticides can harm aquatic life and beneficial pollinators. Microplastics are an emerging contaminant of concern found in river water, sediment and fish and mussels.

Sediment

Nitrate

Chloride

Pesticides

Microplastics

Sediment

The lower portion of the metro river is impaired due to excess sediment.

Excess sediment can harm aquatic plants and habitat for fish and other wildlife.

About 76% of the river's sediment comes from the Minnesota River basin.

The metro river is carrying sediment at nine times its natural rate.

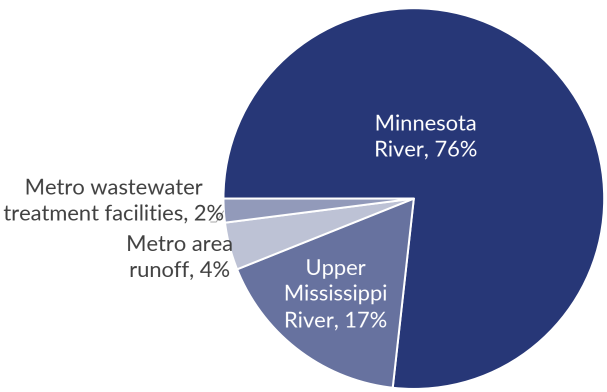
Description and impacts. Sediment pollution includes tiny particles of soil and organic matter that are suspended in the river's water. Excess sediment makes the water murky, harming aquatic plants and habitat for fish and other wildlife. In addition, other pollutants like phosphorus can attach to sediment and be carried downstream. Excess sediment is also rapidly filling in Lake Pepin, a natural lake on the Mississippi River 60 miles downstream of the Twin Cities.

Sources. About three-quarters of the sediment load flowing into this portion of the river comes from the Minnesota River basin (Figure 1), where eroding river bluffs, stream banks and farm fields are the primary sources of sediment pollution.[1] The remainder comes from the upper Mississippi River, Cannon River and other smaller tributaries. Metro-area urban runoff contributes roughly 4% of the total sediment load.[2]

Sediment loads to the river are greatly influenced by flow and hydrology (see Flow and hydrology, page 12). Increased flows generally create a more erosive system capable of delivering additional sediment to the river.

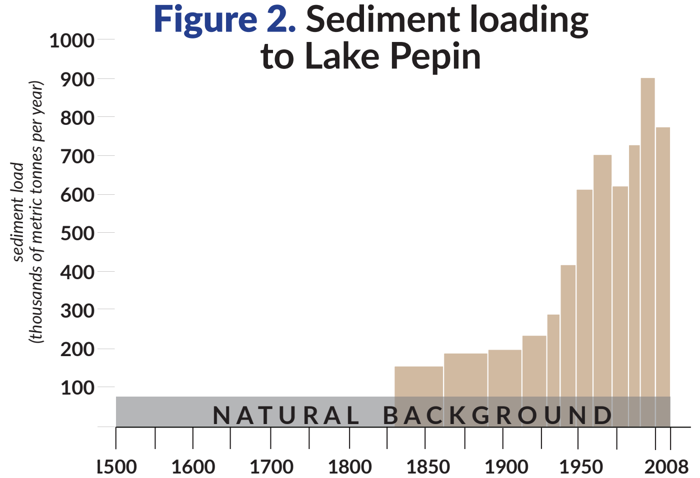
History and trends. Sediment core research in Lake Pepin documents how sediment inputs to the river have changed over time. As European settlement displaced native landscapes and people, widespread changes in land use produced dramatic increases in sediment pollution.[3] From the 1930s to 1960s, sediment loads to Lake Pepin roughly doubled (Figure 2).[4] Sediment loads peaked in the early 1990s (when river flows were especially high) and remain at roughly nine times pre-European levels.[5] The river currently delivers approximately 71,000 dump trucks' worth of sediment every year to Lake Pepin – one every seven and a half minutes.[6]

Figure 1. Sources of sediment to the metro river in average conditions



Source: Minnesota Pollution Control Agency

Figure 2. Sediment loading to Lake Pepin



Source: Minnesota Pollution Control Agency

Sediment in the metro river

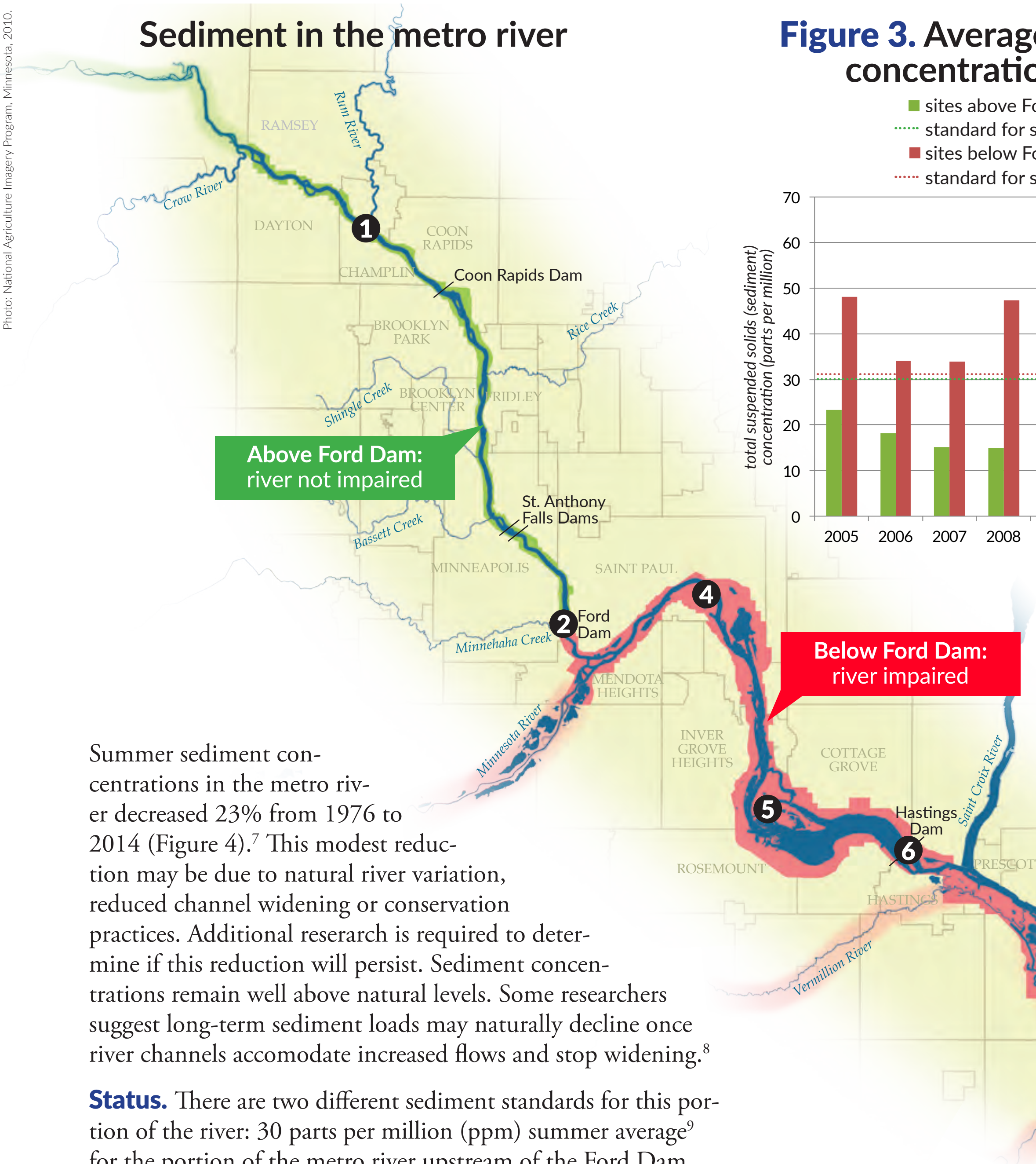
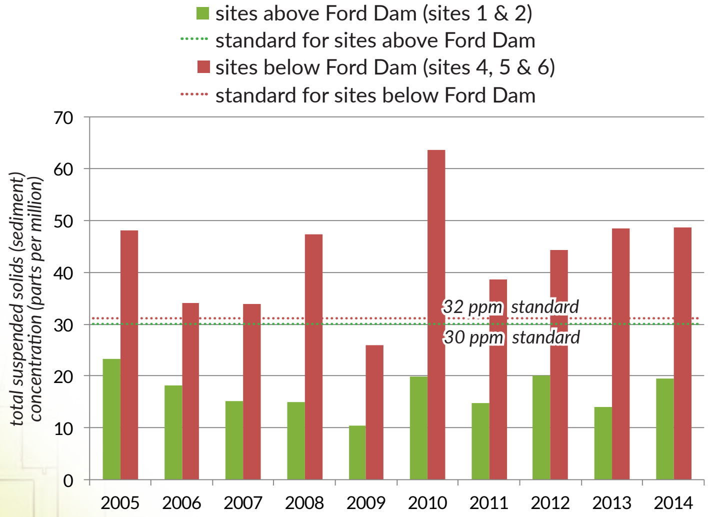


Photo: National Agriculture Imagery Program, Minnesota, 2010.

Figure 3. Average summer sediment concentrations, 2005-2014



This graphic illustrates sediment concentrations upstream and downstream of the Ford Dam.
Source: Metropolitan Council Environmental Services

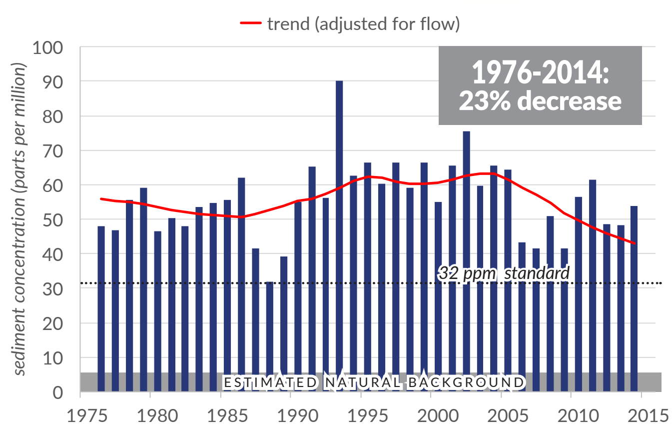
Summer sediment concentrations in the metro river decreased 23% from 1976 to 2014 (Figure 4).[7] This modest reduction may be due to natural river variation, reduced channel widening or conservation practices. Additional research is required to determine if this reduction will persist. Sediment concentrations remain well above natural levels. Some researchers suggest long-term sediment loads may naturally decline once river channels accomodate increased flows and stop widening.[8]

Status. There are two different sediment standards for this portion of the river: 30 parts per million (ppm) summer average[9] for the portion of the metro river upstream of the Ford Dam, and 32 ppm summer average downstream of the dam.[10, 11] The river is currently impaired for excess sediment below the Ford Dam (Figure 3). These conditions make it difficult for native aquatic plants, fish and wildlife to thrive.[12]

Solutions. The Minnesota Pollution Control Agency adopted a clean-up plan calling for major reductions in sediment loads, including 50-60% reductions from the Minnesota River, 20% from the Upper Mississippi River and 25% from metro-area urban runoff.[13, 14]

Continued progress toward these goals will require substantial changes in how we use land, including improved agricultural conservation, drainage management and widespread conversion to perennial crops. Practices that reduce peak flows, especially in the spring (when banks are most susceptible to erosion) are essential, particularly in the Minnesota River basin.

Figure 4. Average summer sediment concentrations at Hastings Dam, 1976-2014



Source: Metropolitan Council Environmental Services, St. Croix Watershed Research Station

In 2015, the Gulf of Mexico dead zone covered approximately 6,475 square miles.

Nitrate

Overall nitrate pollution to the river has increased substantially.

Excess nitrate threatens human health and aquatic life, and is a primary contributor to the Gulf of Mexico "dead zone."	Nitrate concentrations in the river increased by 44% from 1976-2014.	The river meets drinking water standards for nitrate, but Minnesota lacks standards to protect aquatic life in the river.

Description and impacts. Nitrate is an important form of nitrogen for plant life, but too much in waters can be harmful to fish and other aquatic life.[1] Human activities can greatly increase nitrate levels, which are typically low in undisturbed landscapes.[2] Excess nitrate can quickly enter surface waters and groundwater, where it presents three primary challenges:

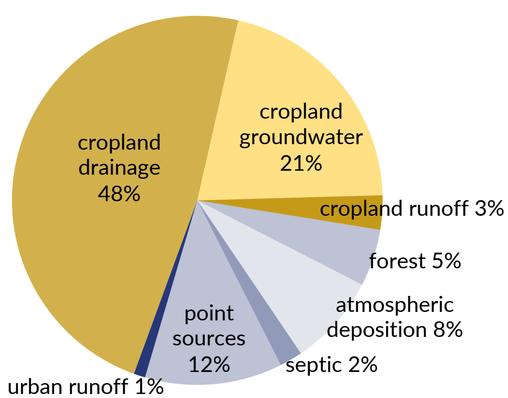
- **Human health.** Nitrate levels above drinking water standards (10 parts per million) can pose human health risks, including the potentially fatal "blue baby syndrome" in infants.[3]
- **Aquatic life.** Excess nitrate in surface waters interferes with the healthy growth and development of aquatic life.[4]
- **Hypoxia and the Gulf dead zone.** Further downstream, surplus nitrate contributes to the "dead zone" in the Gulf of Mexico, where excess nitrogen feeds massive algae blooms each year. When the algae die and sink, their decomposition robs bottom water of oxygen (a condition called "hypoxia"), suffocating marine life that is unable to escape.[5]

Sources. In Minnesota, cropland is the dominant source of nitrogen, contributing 72% of the load to the Mississippi River:[6]

- 48% of nitrogen comes from farm drainage systems.
- 21% is from cropland runoff leaching to groundwater and moving underground until it reaches streams.
- 3% is from cropland surface runoff.[7, 8]

Other sources include atmospheric deposition, wastewater, forests and urban runoff (Figure 1).[9] Total nitrogen loads to the river are influenced by flow; large volumes of water can move more nitrogen through the river system.

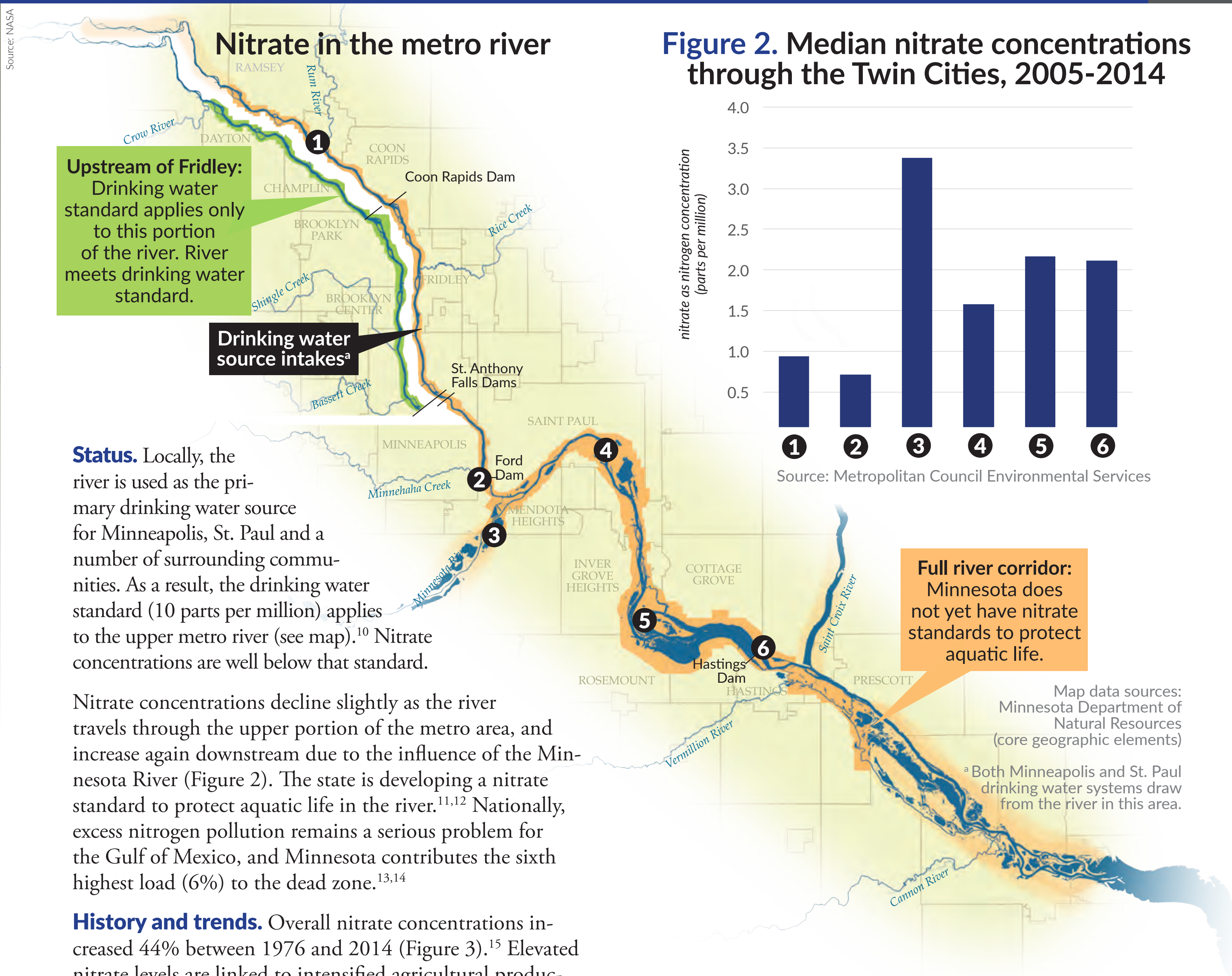
Figure 1. Sources of nitrogen to the Mississippi River in Minnesota in average conditions



Source: Minnesota Pollution Control Agency, Nitrogen in Minnesota Surface Waters

Source: NASA

Nitrate in the metro river



Map data sources: Minnesota Department of Natural Resources (core geographic elements)

[a] Both Minneapolis and St. Paul drinking water systems draw from the river in this area.

Figure 2. Median nitrate concentrations through the Twin Cities, 2005-2014

Source: Metropolitan Council Environmental Services

Status. Locally, the river is used as the primary drinking water source for Minneapolis, St. Paul and a number of surrounding communities. As a result, the drinking water standard (10 parts per million) applies to the upper metro river (see map).[10] Nitrate concentrations are well below that standard.

Nitrate concentrations decline slightly as the river travels through the upper portion of the metro area, and increase again downstream due to the influence of the Minnesota River (Figure 2). The state is developing a nitrate standard to protect aquatic life in the river.[11,12] Nationally, excess nitrogen pollution remains a serious problem for the Gulf of Mexico, and Minnesota contributes the sixth highest load (6%) to the dead zone.[13,14]

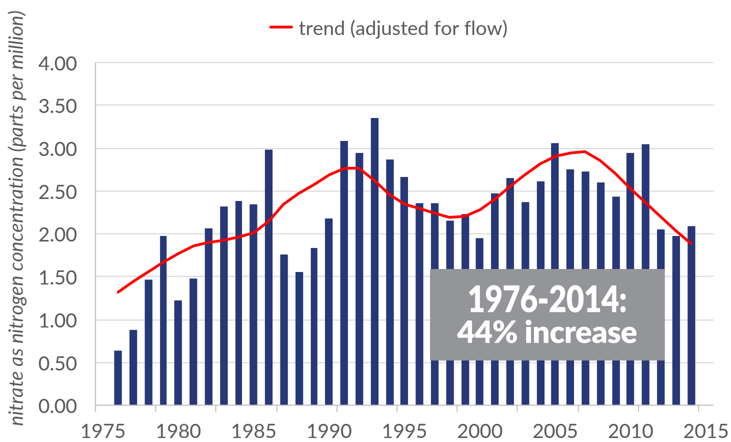
History and trends. Overall nitrate concentrations increased 44% between 1976 and 2014 (Figure 3).[15] Elevated nitrate levels are linked to intensified agricultural production, fertilizer application, farm drainage systems and higher overall river flows.[16] Other factors, including population growth and changes in how wastewater is managed, also impact river nitrate levels.

Solutions. Establishing a state nitrate standard to protect aquatic life is an important next step in managing the impacts of excess nitrate in Minnesota.

To reduce the state's contribution of nitrate to the annual Gulf of Mexico dead zone, Minnesota set a goal to reduce nitrogen inputs to the Mississippi River by 45% by 2040.[17]

Achieving these reductions will require widespread improvements in agricultural drainage, fertilizer-use efficiency, and converting to more perennial crops. In addition, reductions in urban runoff, wastewater treatment plant loads and air emissions will help protect the river and restore the Gulf of Mexico for future generations.

Figure 3. Average annual nitrate concentrations at Hastings Dam, 1976-2014



Source: Metropolitan Council Environmental Services, St. Croix Watershed Research Station

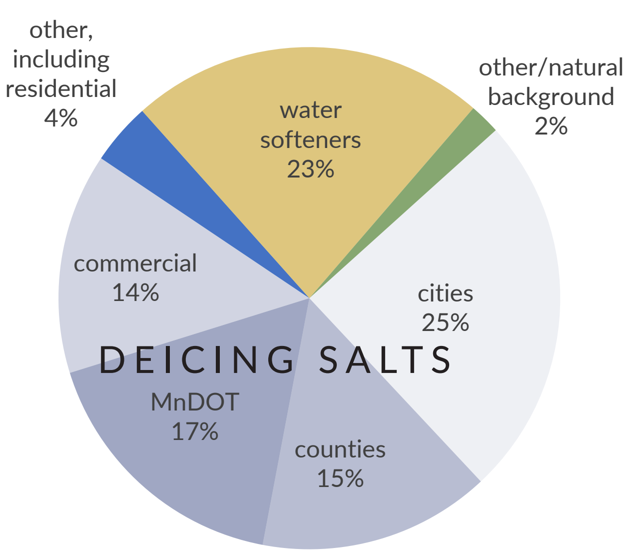
Chloride

The river meets standards for chloride, but levels are increasing throughout the metro area.

Chloride comes primarily from road deicing salt and water softeners.	1 teaspoon of salt is enough to permanently pollute 5 gallons of water.	39 local water bodies are impaired by excess chloride, including several river tributaries.

Description and impacts. Chloride is an element that naturally occurs at low levels in Minnesota lakes and streams. However, at high concentrations, it can be toxic to aquatic life.[1] High chloride levels can also affect groundwater and drinking water supplies, vehicles, infrastructure, soil and plants, pets and wildlife.[2] Chloride is a permanent pollutant; it does not degrade over time, so it cannot be feasibly removed from surface waters.[3]

Figure 1. Sources of chloride to metro area waters



Source: Minnesota Pollution Control Agency

Sources. Winter road deicers are the primary source of chloride to Minnesota's waters; approximately 350,000 tons of deicing chemicals are applied in the metro area each year.[4] Seventy-eight percent of chloride applied in the Twin Cities area is retained in local surface and groundwater.[5] Water softeners, which discharge chloride to septic systems or wastewater treatment facilities (which do not remove chloride), are another important source. Other sources include fertilizers, dust suppressants, and landfill leachate (Figure 1).

Status. The river is currently well below the state's chloride standards to protect aquatic life. However, many local tributaries, lakes and wetlands fail to meet these standards (see map and Figure 2). Of tested metro area water bodies, 39 are impaired for excess chloride with another 38 close to exceeding state standards.[6] Monitoring data also show high chloride concentrations in area groundwater. Twenty-seven percent of the metro area sand and gravel wells exceed federal guidelines, as compared to 1% of non-metro wells.[7,8]

History and trends. Chloride levels in the metro river increased by 81% from 1985 to 2014 (Figure 3). Chloride concentrations are also increasing in metro area surface waters and groundwater.

Cyanide formation. Some deicing salts may contain iron-cyanide compounds to prevent caking when exposed to moisture. These compounds can break down when exposed to sunlight to form free cyanide, which can be toxic

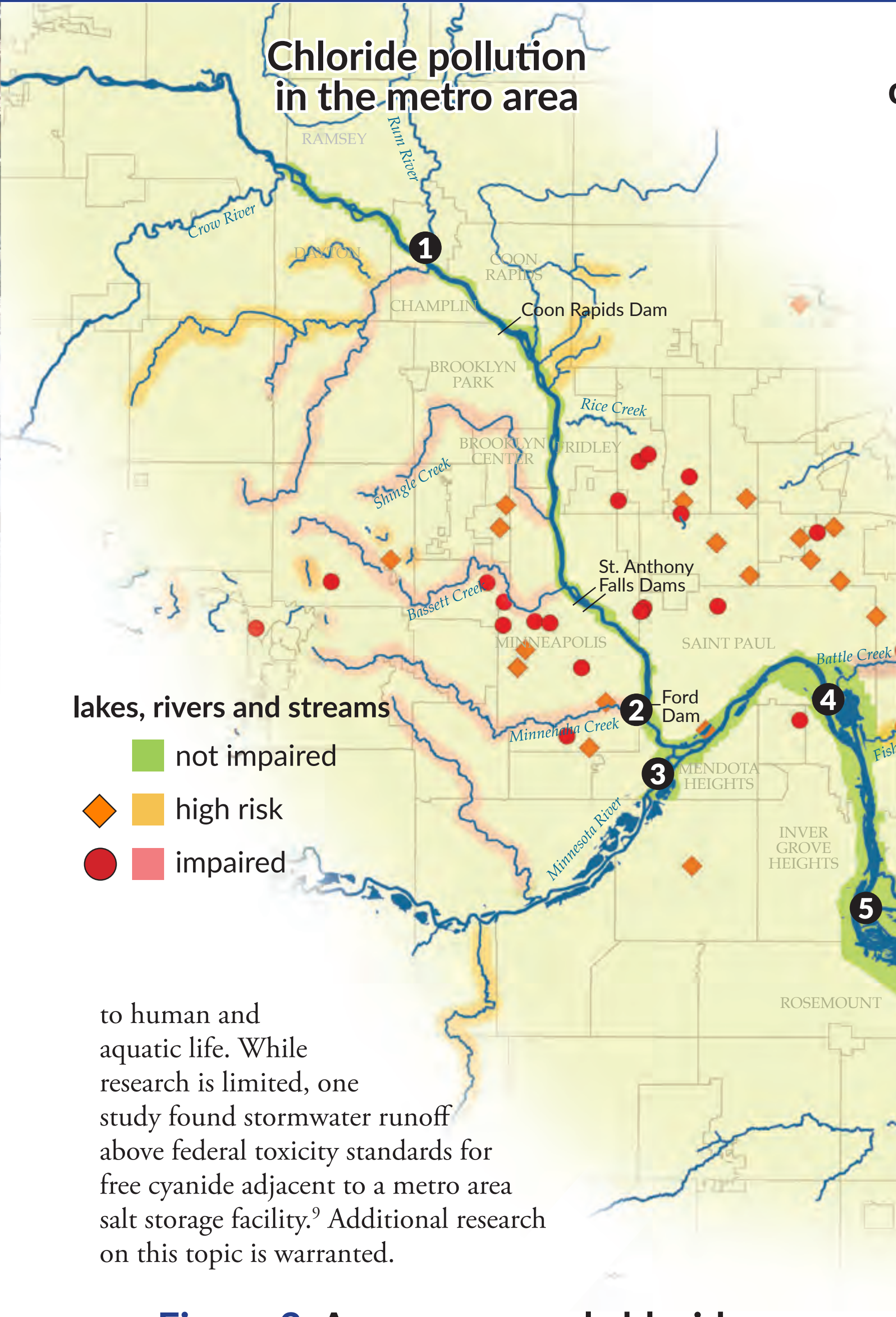
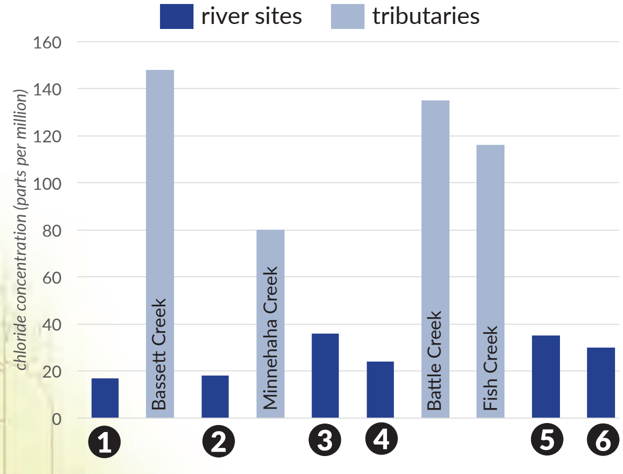


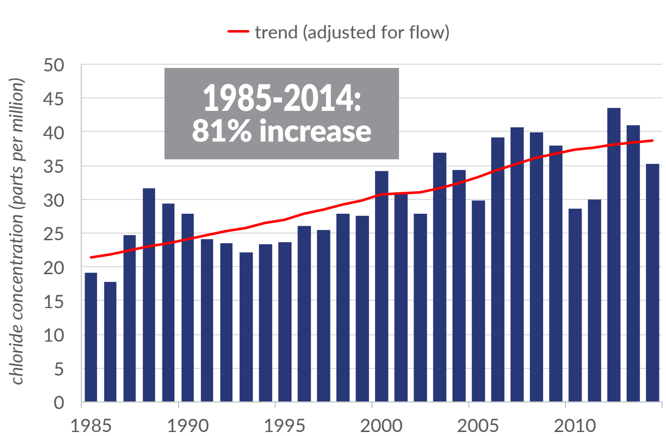
Figure 2. Median chloride concentrations in the metro river and tributaries, 2005-2014[10]



Source: Metropolitan Council Environmental Services

to human and aquatic life. While research is limited, one study found stormwater runoff above federal toxicity standards for free cyanide adjacent to a metro area salt storage facility.[9] Additional research on this topic is warranted.

Figure 3. Average annual chloride concentrations at Hastings Dam, 1985-2014



Source: Metropolitan Council Environmental Services, St. Croix Watershed Research Station

Solutions. While deicers are important public safety tools, their use should be well managed to minimize their negative environmental impacts and reduce maintenance costs.

The state's recently adopted chloride management plan identifies methods for reducing chloride use in the metro area without impacting public safety. Solutions include enhanced chloride monitoring, improved salt storage, "smart salt applicator" certification of commercial applicators, and precision application technology for winter maintenance crews. Minnesota could also reduce slip-and-fall liability for private applicators who attend "smart salt trainings."

Residents can do their part by using deicing chemicals sparingly and not applying traditional rock salt in temperatures below 15ºF, when it is no longer effective. More information on smart winter maintenance is available at https://www.pca.state.mn.us/water/follow-these-simple-tips-protect-our-water.

Pesticides

The metro river meets standards for pesticides.

Pesticides are used to control unwanted insects, weeds and other pests.	At elevated levels, pesticides can harm aquatic life and beneficial pollinators.	Herbicides 2,4-D, acetochlor, atrazine and metolachlor are frequently detected at levels well below state standards.

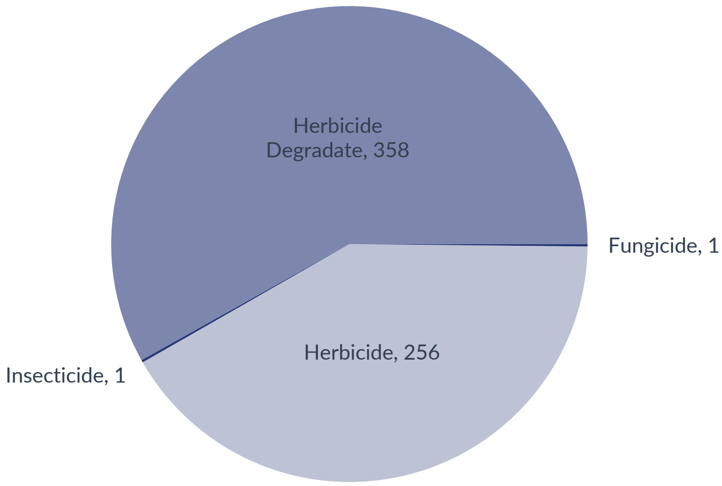
Description and impacts. Pesticides are used to control unwanted insects, plants, rodents, fungi, mold or bacteria. Pesticides are applied in both agricultural and urban areas, and can move into waterbodies through runoff, groundwater discharge and wind. Pesticide detections in waterbodies are dependent on pesticide use, river flow and season.[1]

The Minnesota Department of Agriculture (MDA) monitors for pesticides in surface waters. Statewide the MDA has identified three compounds as surface water pesticides of concern: acetochlor and atrazine (both herbicides) and chlorpyrifos (insecticide).[2]

- **Atrazine** was introduced in 1954 for weed control in corn production, and has possible links to prostate and other cancers in humans and to reproductive deformities in frogs.[3] It has been found in groundwater and surface waters across Minnesota.[4] Farm operators may not apply atrazine within 66 feet of waterbodies.[5]
- **Acetochlor** used primarily in corn and soybean production, was introduced in 1994, and is classified as a "probable human carcinogen."[6] Farm operators are encouraged not to apply acetochlor within 66 feet of waterbodies.[7]
- **Chlorpyrifos** has been used since 1965 to control pests.[8] It can be toxic to birds, fish and insects, including bees.[9] Farm operators may not apply chlorpyrifos within 25 feet (ground application) or 150 feet (aerial application) of water bodies.[10]

Metolachlor is a widely used agricultural herbicide, and 2,4-D is a broadly used herbicide in both agricultural and developed areas. The MDA also monitors for six neonicotinoid compounds. Neonicotinoids are a group of insecticides that are used widely on farms and in urban and suburban landscapes. Insects including bees and butterflies, as well as earthworms, can be harmed by neonicotinoids.[11] Pollinators may become sick or die if they visit plants treated with neonicotinoids.[12]

Figure 1. Pesticide detections by type at Grey Cloud Island, 2010-2015[13]



Source: Minnesota Department of Agriculture

Pesticides in the metro river

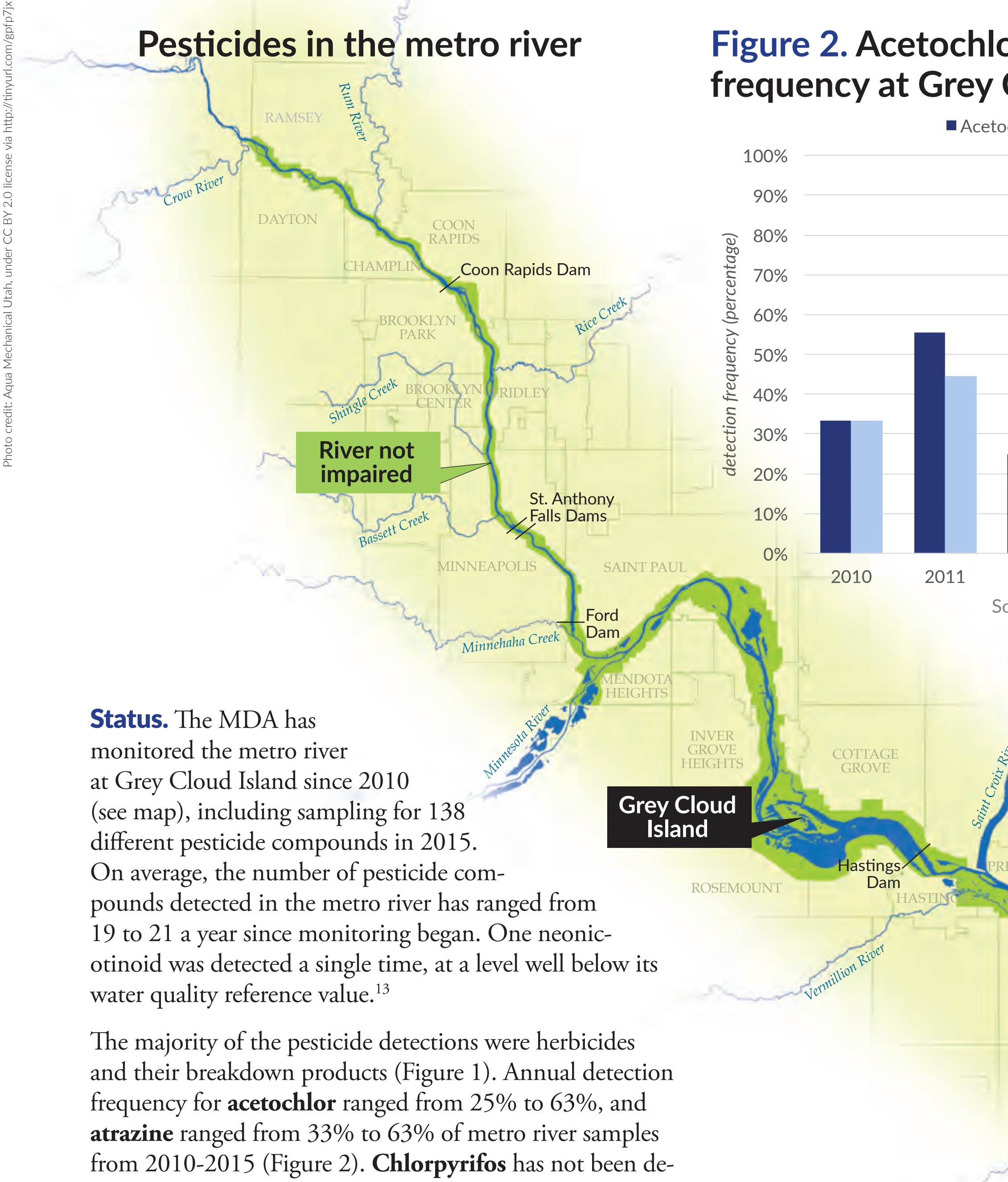
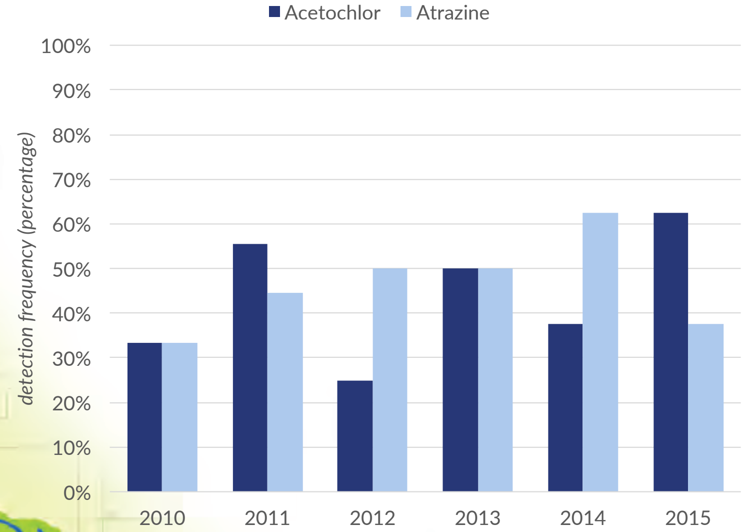


Figure 2. Acetochlor and atrazine detection frequency at Grey Cloud Island, 2010-2015



Source: Minnesota Department of Agriculture

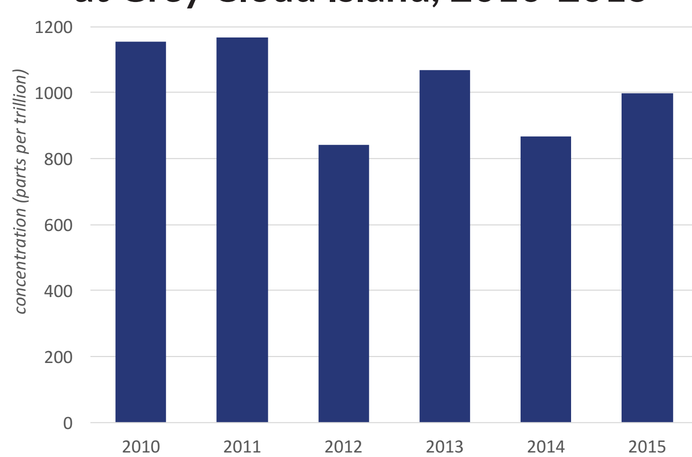
Status. The MDA has monitored the metro river at Grey Cloud Island since 2010 (see map), including sampling for 138 different pesticide compounds in 2015. On average, the number of pesticide compounds detected in the metro river has ranged from 19 to 21 a year since monitoring began. One neonicotinoid was detected a single time, at a level well below its water quality reference value.[13]

The majority of the pesticide detections were herbicides and their breakdown products (Figure 1). Annual detection frequency for **acetochlor** ranged from 25% to 63%, and **atrazine** ranged from 33% to 63% of metro river samples from 2010-2015 (Figure 2). **Chlorpyrifos** has not been detected in the metro river. Breakdown products of acetochlor, atrazine and metolachlor were found in at least 90% of the samples. Detections of fungicides and insecticides are rare.

Overall pesticide concentrations have remained relatively stable from 2010-2015 (Figure 3). Pesticides are generally found at low levels, and no individual detections were greater than 50% of any applicable water quality reference value.

Solutions. While pesticides have not been found at levels of concern in the metro river, continued monitoring of their presence and research into their potential impacts on wildlife, including pollinators, is warranted. Consumers concerned about the potential impacts of lawn and garden chemicals should limit their use or use safe alternatives. Residents can help enhance pollinator health by planting pollinator-friendly landscapes. Additional information is available at www.xerces.org or www.beelab.umn.edu.

Figure 3. Median annual total pesticide concentration at Grey Cloud Island, 2010-2015



Source: Minnesota Department of Agriculture

Microplastics

Fibers are the most common microplastic in the metro river.

Microplastics are tiny pieces of plastic that are abundant in the environment.	Microplastics present potential risks to wildlife and human health.	Research is underway to better understand the presence of microplastics in the metro river.

Background. Microplastics are tiny pieces of plastic that end up in the environment through the breakdown of litter, car tire wear, or after plastics in clothing and consumer products are washed down the drain.[1] These persistent environmental pollutants build up in organisms that ingest them, and move up the food chain.[2]

Sources. Microplastics are found in different shapes - beads, fibers, foams, films and fragments - which provide clues about their origins.[3] When consumers wash products containing microplastics down the drain (for example, via cosmetics or washing clothing), some of the plastics make their way through wastewater treatment plants and into surface waters. Microplastics can also enter surface waters via runoff, or when plastic litter breaks down in the environment.

Consumers may be most familiar with **microbeads**, which manufacturers began adding to facial washes, toothpastes and other products as an abrasive agent in the late 1990s. Researchers began discovering them in surface waters by the mid-2000s.[4] While microbeads have captured the attention of consumer advocates and lawmakers, it is fibers rather than microbeads that are the primary source of microplastic pollution in the metro river.[5]

Microplastic fibers come from synthetic fabrics (e.g., microfleece, polyester, nylon) and are shed during machine washing, as well as transported through atmospheric deposition.[6,7] Many fibers are dense enough that they tend to sink, especially in low-velocity waters.[8]

Risks. Microplastics are found in water bodies, the stomachs of marine animals, and sediment around the world - including ocean sediment as much as three miles below the surface.[9,10] While additional research is required, there are a number of potential risks associated with microplastic pollution in the environment:

- **Physical effects on wildlife:** River life such as invertebrates, fish, mussels and birds are known to consume microplastics either via gill exposure or ingestion. Once ingested, microplastics can block or damage feeding apparatus, digestive tracts and circulatory systems, and create other physical harm.[11,12] Studies have documented liver stress, early tumor formation and potential reduction in feeding (or false satiation) in fish that have consumed microplastics.[13]
- **Chemical effects on wildlife:** Microplastics carry chemicals used in their production, as well as other

contaminants that attach to the plastic's surface in water. As microplastics are ingested by wildlife, these chemicals can pose risks throughout the aquatic food chain.[14,15,16] Exposure to microplastics has been shown to inhibit hatching, decrease growth rates and increase predator-induced mortality in fish.[17] Oysters that have ingested microplastics may produce fewer and less-healthy offspring.[18,19]

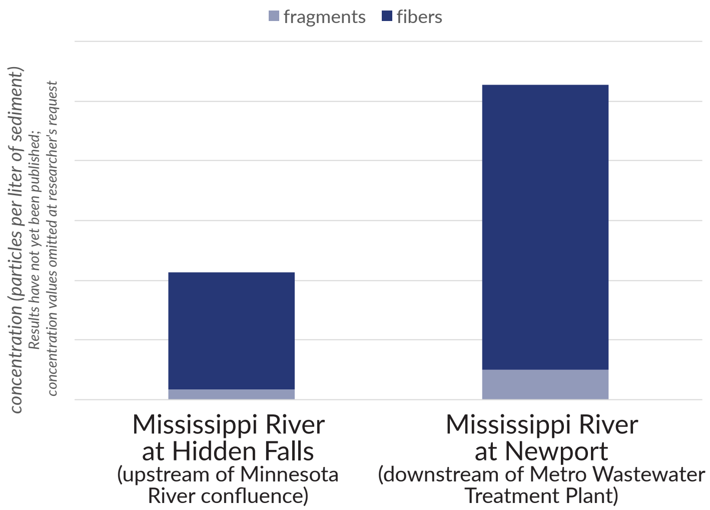
- **Human health:** Studies in humans and other mammals indicate that exposure to microplastics may lead to intestinal inflammation and adverse effects on gut microflora and the immune system.[20] Ingestion of particles smaller than 0.15 millimeters may result in particle uptake in lymph and circulatory systems, and some extremely small particles could pass through placental tissue.[21,22] Because microplastics have been found in samples of fish, beer, sugar, honey and table salt, human exposure via seafood and other food sources may be a concern.[23,24]

Microplastics are a relatively new phenomenon in the environment. Additional research will continue to shed light on the extent of their impacts on humans and wildlife, but existing research indicates cause for concern.

Status and trends. Recently, the U.S. Geological Survey, in partnership with the National Park Service, began sampling river water, sediment, and fish and mussel tissue for microplastics in the metro river. Preliminary results indicate that fibers are the dominant type of microplastic in these samples. For example, fibers represent about 90% of the microplastics accumulating in metro river sediment (Figure 1). Because wastewater facilities are not specifically designed to remove these contaminants, concentrations increase downstream of the Metro Wastewater Treatment Plant.[25,26,27]

Management solutions. In December 2015, the U.S. Congress passed legislation to phase out plastic microbeads

Figure 1. Relative concentrations (by type) of microplastics in metro river sediment



Source: U.S. Geological Survey, 2016

from personal care products, effective on July 1, 2017.[28] Until then, consumers concerned about the potential environmental impacts of microbeads and other microplastics can help reduce microplastic pollution.

- **Microbeads:** Download the smartphone app from www.beatthemicrobead.org, which allows consumers to scan product labels and determine whether they contain microbeads.[29]
- **Other microplastics:** Choose clothing made from natural fibers, avoid single-use plastics such as plastic bags and take-out containers, and remain careful not to litter or flush plastic materials down the toilet.[30]

Source: NOAA Marine Debris Program

Photo: Gordon Dietzman/MNRRA

OTHER RIVER CONTAMINANTS

Photo: Bob Spaulding.

This section highlights additional contaminants of concern.

Pharmaceuticals in the river may negatively impact the health of fish and other aquatic life.

Mercury and PFOS contamination can impact river life, and contribute to fish consumption advisories.

Triclosan can contribute to dioxin formation in the river environment.

Additional contaminants of concern

Additional contaminants of concern

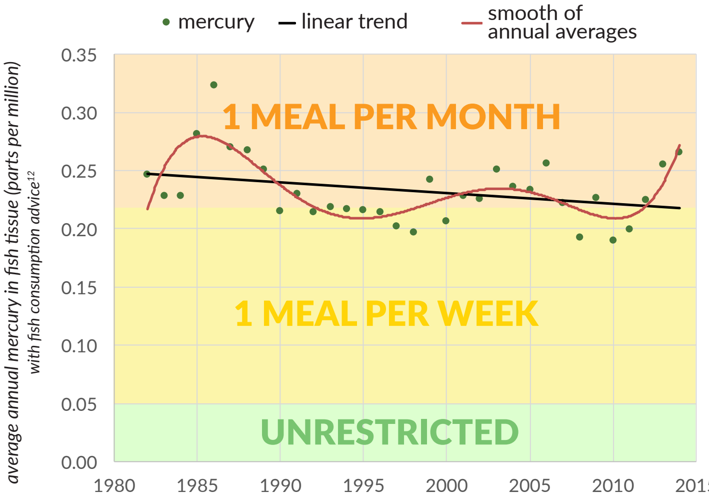
Additional contaminants of concern may negatively impact the health of the metro river.

Pharmaceuticals are repeatedly detected in Minnesota rivers and streams.	Mercury and PFOS contribute to fish consumption advisories in the metro river.	Triclosan-derived dioxins have increased by 200-300% in Lake Pepin sediment.

Mercury. The entire river is impaired for mercury in fish tissue, and the lower portion is impaired for mercury in the water.[1] Mercury is a naturally occurring element that can damage the central nervous system of animals and people, especially children.[2] About 70% of mercury air emissions result from coal combustion, mining and incineration of mercury-containing products.[3] Mercury pollution in the river peaked in the 1960s.[4] By the early 1990s, annual accumulation rates had decreased by almost 70%.[5]

Mercury can bioaccumulate in fish and pose risks for human consumption. Research indicates a mixed trend in mercury in Minnesota fish. Mercury levels decreased 37% from 1982 to 1992, but increased 15% between 1996 and 2006.[6,7] While overall mercury trends show a modest long-term reduction (see figure), recent increases in some fish are cause for concern.

Mercury trends in northern pike and walleye in Minnesota lakes, 1982-2014



Source: Minnesota Pollution Control Agency, Minnesota Department of Health

Minnesotans who eat fish from the Mississippi River should follow Minnesota Department of Health Site-Specific Safe-Eating Guidelines (Fish consumption, page 22).[8]

A state-approved mercury reduction plan calls for a 76% reduction in mercury emissions from Minnesota sources by 2025.[9,10] However, because roughly 90% of atmospheric mercury deposition in Minnesota comes from out of state, significant reductions in U.S. and global emissions will be required to meet these goals.[11]

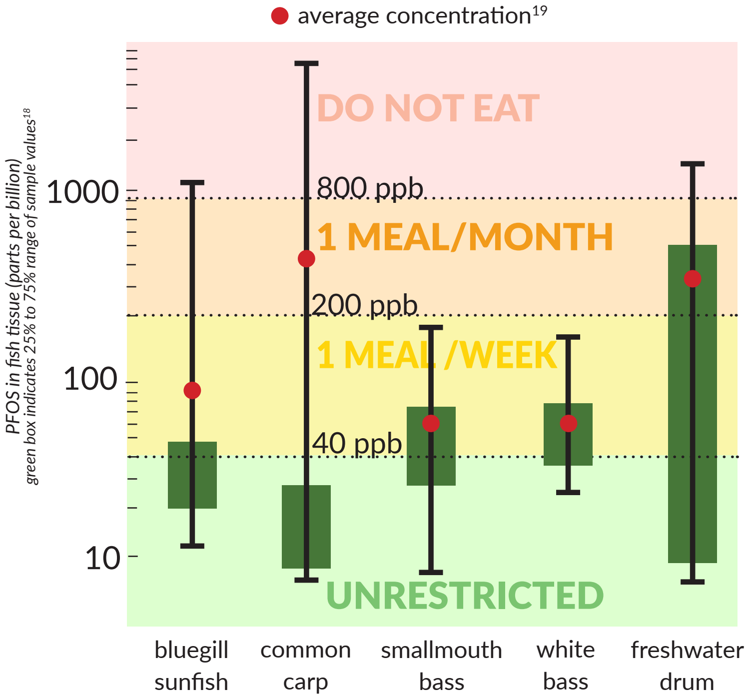
PFOS. PFOS (perfluorooctane sulfonate) is part of a family of synthetic compounds known as PFCs (perfluorochemicals), which persist in the environment, and can be found in the blood of humans and animals worldwide.[13] PFOS was manufactured locally by 3M from around 1950 to 2002 and used in stain-resistant fabric, nonstick cookware, food packaging and fire-fighting foam.

The Minnesota Department of Health has determined that PFOS in fish tissue and drinking water could pose risks to human health if ingested.[14] The river from near Inver Grove Heights to the Hastings Dam is impaired for PFOS contamination of the water and fish tissue.[15,16] PFOS levels in fish vary (see figure), but are generally highest in the southernmost portion of the metro river. Anglers should

Photo credit: Oregon Tom Bell

PFOS in fish above Hastings Dam, 2012

with fish consumption advice



Sources: Minnesota Pollution Control Agency (2012) and Minnesota Department of Health

follow fish consumption guidelines (Fish consumption, page 22).

The state, local governments and 3M have conducted clean-up at several sites in the east metro.[17] Additional work remains on containing, pumping and treating contaminated groundwater, and monitoring treatment effectiveness over time.

Pharmaceuticals. Nationally, over four billion prescriptions were dispensed in 2015.[20] Medications in human waste, along with expired and unwanted medications, are often disposed of down the drain. Wastewater treatment systems are not specifically designed to remove pharmaceuticals, so many are discharged back into surface waters.[21]

Several pharmaceuticals, including antidepressants, antibiotics and a variety of other medications, are repeatedly detected in rivers and streams around the state and are widespread in our aquatic environment.[22,23,24,25]

Pharmaceuticals can have impacts on fish and other aquatic wildlife. Some drugs, such as anti-depressants and beta-blockers, reduce fertility or affect spawning in some aquatic organisms.[26] Others may act as endocrine active compounds (EACs). EACs mimic or alter hormone systems and can interfere with reproductive, developmental and other biological functions and can lead to reproductive mutations in aquatic organisms.[27] A recent study found 73% of male smallmouth bass at a site in Lake Pepin showed signs of sex mutation.[28]

Unused medications should never be flushed down the drain. For information on household hazardous wastes and collection programs, contact your county's solid waste office or the Minnesota Pollution Control Agency.

Triclosan. Triclosan is an antimicrobial agent developed in the 1960s and added to a variety of consumer products including liquid soaps, toothpastes, cosmetics and sportswear.

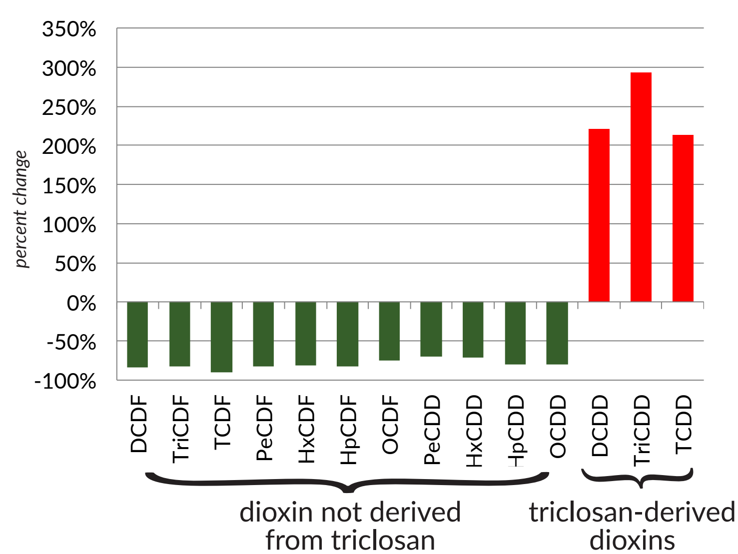
Triclosan has been found in 58% of U.S. rivers and streams, including the metro river.[29] Triclosan enters the river primarily through wastewater treatment systems. When exposed to chlorine and sunlight, it can break down into potentially harmful dioxins and other carcinogens.[30,31,32] Since the 1960s, triclosan-derived dioxins have increased by 200-300% in Lake Pepin sediment, while levels of other dioxins decreased by 73-90% (see figure).[33,34]

Minnesota adopted legislation prohibiting the sale of triclosan-based consumer soaps and cleaning products, effective in 2017.[35] Several manufacturers are voluntarily phasing out triclosan.[36]

There is no evidence that triclosan provides any benefit over washing hands with normal soap and water.[37] Consumers concerned about the potential impacts of triclosan can follow the recommendations of the Minnesota Department of Health by not using products containing triclosan unless instructed to do so by a health care provider.[38] For more information on products containing triclosan, look in the "Drug Facts" box and ingredients list, or visit http://www.ewg.org/skindeep/ingredient/706623/TRICLOSAN/.

Triclosan-derived dioxin trends in Lake Pepin

triclosan-derived dioxins vs. non-triclosan-derived dioxins in Lake Pepin sediment cores since the 1960s



Source: Buth et. al.

Photo credit: Amy Kilgore/FMR

Summary & conclusion

Photo credit: FMR

The Mississippi River is a complex natural system, with many factors affecting its overall health and vitality. While some aspects of the metro river have improved over time, other indicators of water quality and river health are cause for concern.

- The river is once again home to healthy **bald eagle**, **mussel**, and **fish** populations. As pollution has been cleaned up and habitat restored, wildlife has rebounded. These are symbols of our shared ability to rejuvenate the Mississippi River, and are an inspiration for future success.
- While the river meets standards for **pesticides** and **chloride**, vigilance is required to minimize the potential impacts of these pollutants over time.
- Several indicators are cause for concern. The river is impaired by excess **sediment**, **bacteria** and **phosphorus**, degrading aquatic habitat and recreation. **Fish consumption** guidelines are in place throughout the river due to elevated levels of contaminants like **PFOS** and **mercury**. While we remain optimistic, it is clear that much more work remains to resolve these problems.
- Other indicators are cause for alarm. **River flows** have multiplied to worrisome levels, destabilizing the river system and delivering large amounts of pollution. **Nitrate** concentrations have increased substantially. **Invasive Asian carp** continue to move upstream, with potentially devastating consequences to aquatic life and recreation. The solutions to these problems require new tools and determined public action before they move beyond our reach.
- **Microplastic** fibers, **pharmaceuticals** and **triclosan**-derived dioxins in the metro river pose uncertain risks to aquatic life and health. Additional research and collective action are required to mitigate their potential long-term impacts.

While the challenges we face are complex and daunting, the river today is healthier thanks to the actions of previous generations. The return of abundant wildlife to a once-troubled river is evidence that restoring the Mississippi is possible through shared commitment and decisive public action. We remain hopeful that with strong leadership and vocal support from river lovers across our state and nation, we, too, can pass a cleaner, healthier and more vibrant Mississippi River on to future generations.

To learn more about what you can do in your home, yard and community to help protect the river, consult the *State of the River Report* ***Stewardship Guide***. You can also learn more about priority actions that federal, state and local leaders can take for the river in Friends of the Mississippi River's *State of the River Report* ***Policy Guide***. Parents and educators can help pass the lessons of this report on to the next generation of river stewards through our *State of the River Report* ***Teacher's Guide***. Find out more at **www.stateoftheriver.com**.

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