STATE OF THE MINNESOTA RIVER

Summary of Surface Water Quality Monitoring

2000-2008

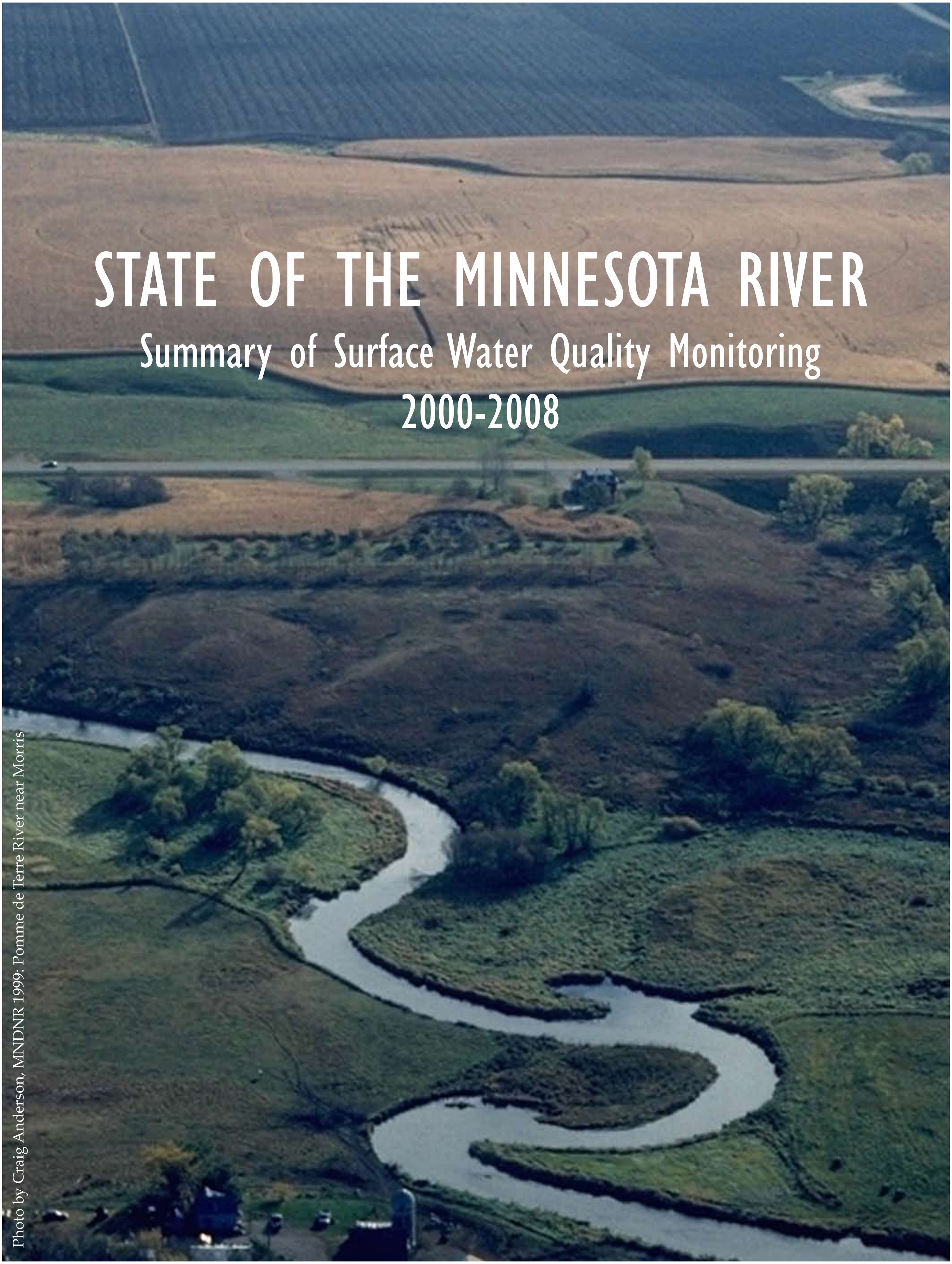

Photo by Craig Anderson, MNDNR 1999: Pomme de Terre River near Morris

STATE OF THE MINNESOTA RIVER

Summary of Surface Water Quality Monitoring 2000-2008

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ACKNOWLEDGEMENTS

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Many individuals contributed to collecting and preparing data, writing, editing, and creating maps and graphics for this report.

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United States Geological Survey: A special thanks to Greg Payne for sharing his expertise and assistance writing this document.

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Minnesota Department of Agriculture
Minnesota Pollution Control Agency
Redwood-Cottonwood Rivers Control Area
Rush River Clean Water Partnership
Watonwan River Clean Water Partnership Project
Water Resources Center at Minnesota State University, Mankato
Yellow Medicine Watershed District

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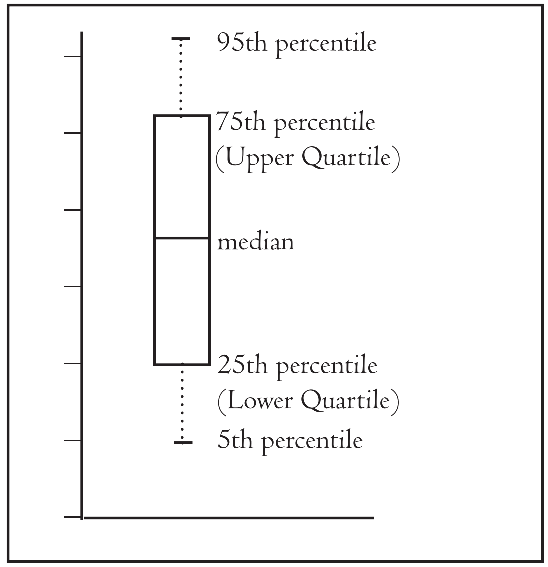
KEY TERMS

Box Plot

Box plots are used throughout this report to visually summarize data. These graphs depict the following statistical measures: median, upper and lower quartiles.

The boxplot is interpreted as follows: The box itself contains the middle 50 percent of the data. The upper edge of the box indicates the 75th percentile of the data set, and the lower edge of the box indicates the 25th percentile.

The line in the box indicates the median value of the data. If the median line within the box is not equidistant from the edges of the box, then the data are skewed.



Flow-Weighted Mean Concentration (FWMC)

FWMC is calculated by dividing the total load (mass) for the given time period by the total flow or volume. It refers to the concentration (mg/L) of a particular pollutant taking into account the volume of water passing a sampling station over the entire sampling season. Conceptually, a FWMC would be the same as routing all of the flow that passed a monitoring site during a specific time frame into a big, well-mixed pool, and collecting and analyzing one sample from the pool to give the average concentration.

Load

A load is the estimate of pollutant total amount (mass), passing a specific location on a river during a specified interval of time.

Yield

One way to assess pollutant contributions from watersheds of different sizes is to determine the “yield” or mass per unit area (such as lbs./acre) of a constituent coming out of a watershed during a given time period (monitoring season in this report). Yield normalizes mass on the basis of area, and allows for more relative comparisons of pollutant contributions to be made among watersheds. Yield is calculated by dividing the total mass or load of a constituent by the area (acres) of the watershed.

Runoff

Runoff is the part of the precipitation which appears in rivers and streams, including baseflow, storm flow, flow from ground water, and flow from point sources. Essentially, runoff is all the flow passing a particular location on the river. To calculate monitoring season runoff, the total flow volume or the amount of water which passes by the station during the monitoring period is calculated and converted to acre-inches of water. This number is then divided by the total number of watershed acres to determine the inches of runoff. Conceptually, this is equivalent to redistributing all the river flow equally over the watershed, then measuring that water depth in inches.

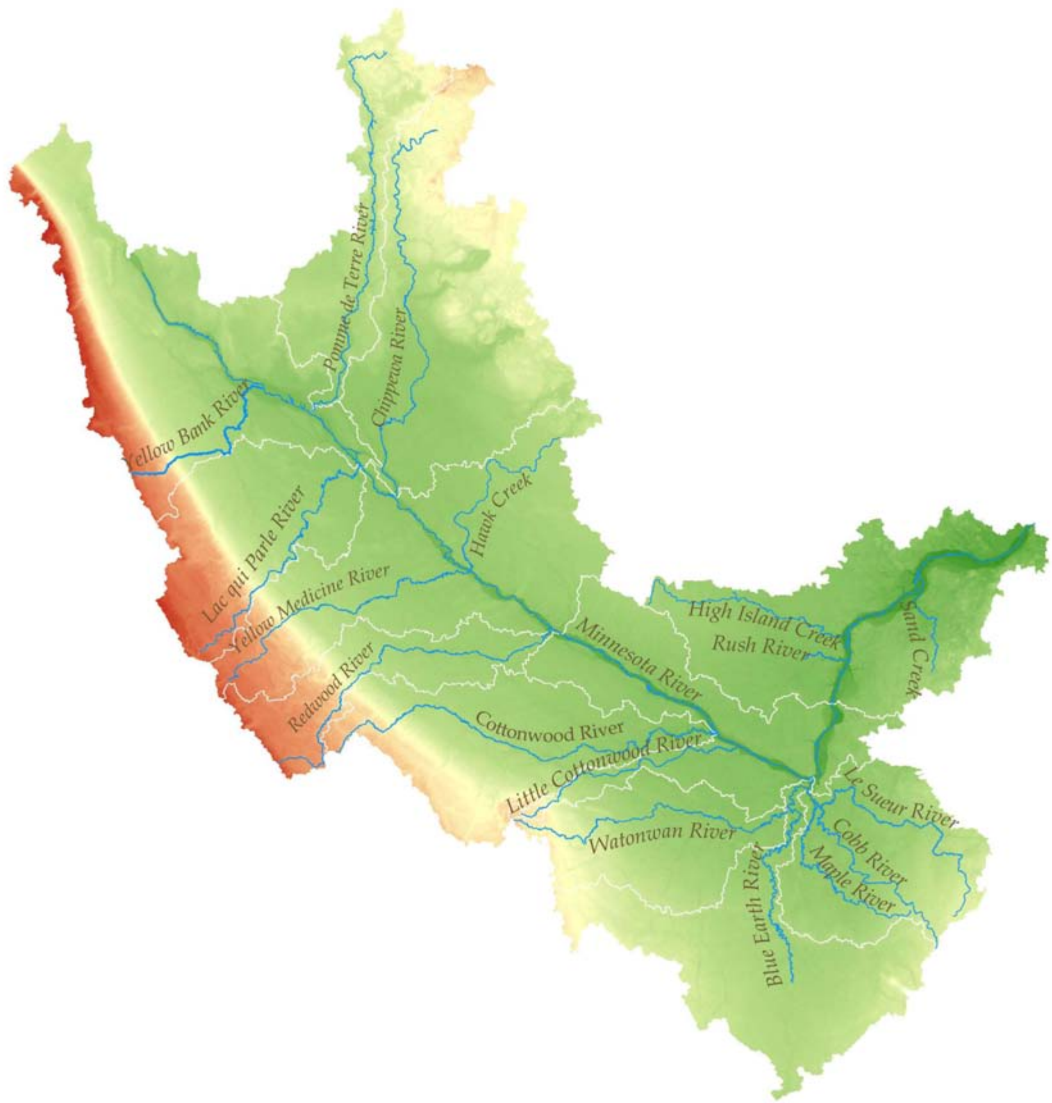
FLUX

FLUX is an interactive program developed by the U.S. Army Corps of Engineers that allows the user to estimate loadings from grab sample concentration data and continuous flow records. Most participating organizations in the Report used the FLUX program. Water quality data was derived from either composite or continuous sampling with sampling equipment, or grab sampling. These samples were paired with the flow data for that specific time period. Flow records for monitored sites were derived from continuous stage measurements.

Six alternative calculation methods are provided in the FLUX program. These calculations determine the flow/concentration relationship and estimate the associated pollutant load (mass).

ACRONYMS

MPCA - Minnesota Pollution Control Agency
MDA - Minnesota Department of Agriculture
MSU-WRC - Minnesota State University, Mankato Water Resources Center
TMDL - Total Maximum Daily Load
TSS - Total Suspended Solids
USGS - United States Geological Survey
USEPA - United States Environmental Protection Agency

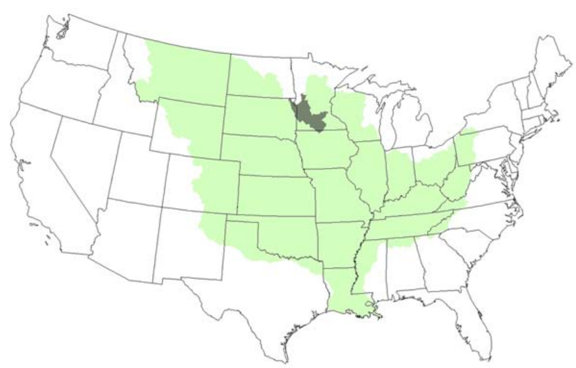


BACKGROUND

Basin Overview

The Minnesota River flows more than 335 miles from its source near the Minnesota-South Dakota border to its confluence with the Mississippi River at Minneapolis/St. Paul. It winds through diverse landscapes and drains nearly 20 percent of Minnesota (16,770 square miles total, 14,840 in Minnesota). Agriculture, primarily corn and soybean production, accounts for the majority of the basin's land use. As the river enters the Twin City Metropolitan area, the Basin is characterized by densely populated urban landscapes.

The Minnesota River has been cited as one of the most polluted rivers in the state and the nation. In 2008, it was listed on American Rivers top ten most endangered rivers in the United States. It is the focus of a major restoration effort by local, state and federal agencies, citizens and nonprofit groups. This collaborative water quality monitoring effort helps to gauge progress towards a cleaner Minnesota River.



Minnesota - Mississippi River

The Minnesota River is the state's largest tributary to the Mississippi River. When the Minnesota River flows into the Mississippi River, its flow doubles. The Minnesota River impacts downstream waters by carrying sediment and nutrients into the Mississippi River and ultimately the Gulf of Mexico.

History of Water Quality Monitoring in the Minnesota River Basin

Water-quality data have been collected throughout the Minnesota River Basin during the past 30 years, but focused attention was placed on water quality issues when the Minnesota River Assessment Project, a comprehensive study conducted 1989-94, concluded that the Minnesota River was impaired by excessive nutrient and sediment concentrations. Previous studies had found that the river did not meet standards for bacteria, turbidity, dissolved oxygen and ammonia. Subsequent to those findings, considerable attention and support have been given to clean up efforts.

On September 22, 1992, Governor Arne Carlson stood on the banks of the Minnesota River in Bloomington while holding a jar of dirty water and declared it was time to clean up this waterway. "Our goal is that within 10 years, our children will be swimming, fishing, picnicking and recreating at this river," Governor Carlson stated.

After years of neglect, citizens, government agencies and nonprofit groups began to focus on restoring, improving and protecting the Minnesota River. In recent years there has been substantial improvements in point source pollution control as well as continued adoption of best management practices to reduce non-point source pollution within the Minnesota River Basin. In the span of a decade the river was listed as one of the most Endangered Rivers in the nation, the focus of a watershed-wide study—Minnesota River Assessment Project and saw the enrollment of over 100,000 critically sensitive acres into permanent easements with the Conservation Reserve Enhancement Program (CREP).

We have passed that ten year goal and some progress has been made but more remains to be done. Cleaning up the river is much more complicated and challenging than many people realized. It took decades for the river's health to decline and and it will take some time and sustained effort to turn things around. To learn more about progress cleaning up the Minnesota River, see the Progress Report available on the Minnesota River Basin Data Center Website: http://mrbdc.mnsu.edu

Water Quality Results

This report presents selected results from water quality monitoring at four mainstem Minnesota River locations and fourteen outlets of major tributary streams (streams draining watersheds greater than 100,000 acres). The information represents results from more than 4,000 water-quality samples collected from 2000-08.

The focus of this report is the primary nonpoint pollutants of concern in the Basin: excessive sediment, phosphorus, orthophosphorus, nitrate-nitrogen, pesticide and bacteria concentrations and other environmental health concerns documented in the Minnesota River Basin. It serves as a companion document to the State of the Minnesota River, Water Quality Summary 2000 to 2008 pamphlet. All reports can be downloaded at: http://mrbdc.mnsu.edu

In accordance with the Clean Water Act, the Minnesota Pollution Control Agency (MPCA) lists water bodies within the Basin that have been designated as "impaired waters" due to pollution problems such as low dissolved oxygen, mercury, PCBs, bacteria, turbidity, and excess ammonia. In this report we have also included maps of impaired waters for comparison. For an overview of the impaired waters program, visit MPCA's website: (http://www.pca.state.mn.us/water/tmdl/index.html).

WATER QUALITY MONITORING

Monitoring the River's Condition

At present, several organizations throughout the basin have responsibility for monitoring water quality in the Minnesota River and tributary streams. A multi-agency monitoring coordination effort was initiated in 2000 to assure standardization of field and laboratory methods and comparability of results. The purpose of the monitoring is to provide annual assessments of the current status of the Minnesota River with respect to water quality standards and goals, identify problem areas, and detect changes in water quality with time. A multi-agency team reviews and evaluates water quality data annually and prepares reports (see Acknowledgements).

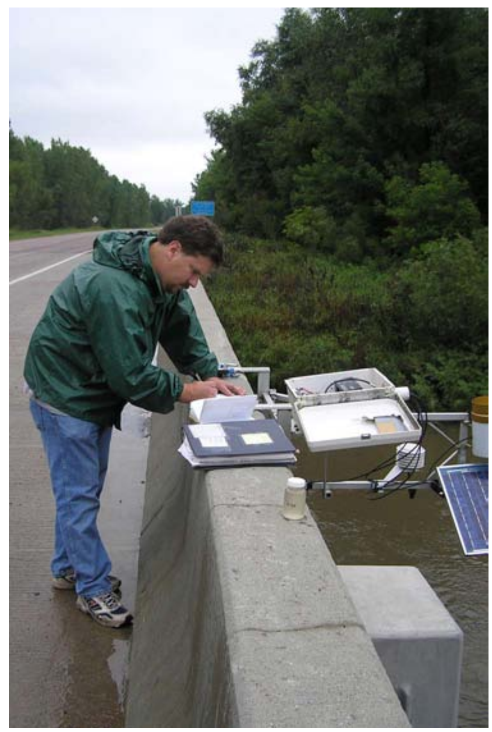
Monitoring Season

Monitoring season length is an important variable to consider when characterizing water quality and evaluating trends throughout the Minnesota River Basin. Throughout 2000-08 timeframe, monitoring season length was typically April 1 through September 30. While October flows can be substantial during some years, the April 1 (or ice out) through September 30 period typically captures the months when the majority of river flow occurs and when nutrient and sediment loads are expected to be the highest.

Sample Collection Methods

Two primary methods of storm event sampling are used by projects in the Basin. Grab Sampling is the collection of a discrete individual sample, either by manual means or with an autosampler. Flow-based composite sampling is the collection of a composite sample over all or part of a storm event, using an autosampler. An autosampler is a battery operated sampling device that collects samples once a stream has reached a certain stage after a storm event. Autosamplers can be set to collect samples at specific time intervals or stages after they are triggered. Autosamplers can make collection of storm samples much easier, especially for very flashy streams where sample collection during the rising limb of the hydrograph could be missed.

Le Sueur shelter with samples



Downloading flow - Rush River

Water Sample Analysis

Water quality testing for this report focused on four major parameters: Total suspended solids (TSS), Nitrate-nitrogen (NO3-N), total phosphorus (TP), and orthophosphorus (OP). Although not included in this report, dissolved oxygen, pH, biological oxygen demand, temperature, flow and other water quality parameters also are tested in some waterways. Water quality analysis was performed by many different water testing laboratories across the basin throughout the 2000-2008 monitoring season.

Scott Matteson, High Island Creek

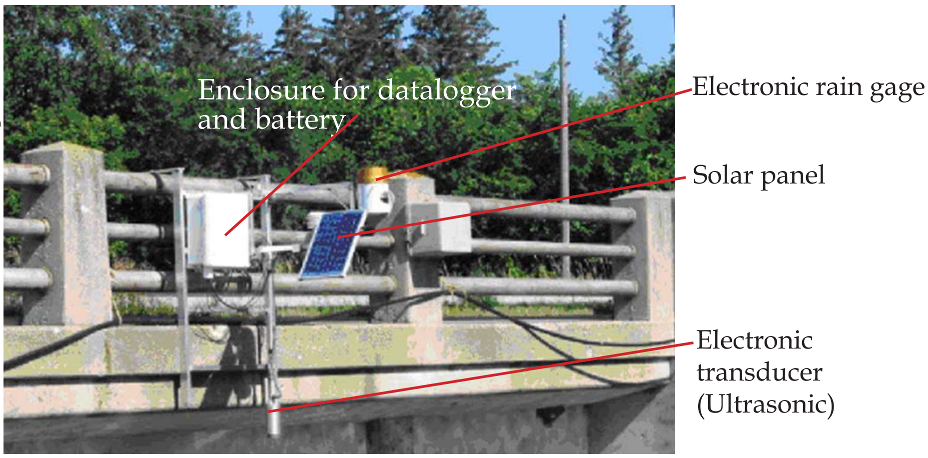


Photo shows flow and precipitation monitoring equipment that was mounted to a bridge in High Island Creek Watershed.

Transparency tube and Maple River

Taking a grab sample

Data Available

There are many calculations used to describe water quality. The 2000-08 dataset has been summarized into loads, yields, and concentrations. This summary focuses on two calculations: Flow-weighted mean concentration (FWMC) and yield. FWMC is calculated by dividing the total load (mass) for the given time period by the total flow or volume. It refers to the concentration (mg/L) of a particular pollutant taking into account the volume of water passing a sampling station over the entire sampling season. A yield shows mass per unit area (such as lbs./acre) of a constituent coming out of a watershed during a given time period. Yield is calculated by dividing the total mass or load of a constituent by the area (acres) of the watershed (see key terms for more information). Loads, yields, FWMCs are summarized in barcharts and boxplots and included in Appendix A and B. All of the data collected for these sites are included as an excel spreadsheet in Appendix C.

Cottonwood River

MONITORING SITES

Mainstem, Major and Minor Tributary Monitoring Sites in the Minnesota River Basin

Although water quality monitoring data have been compiled and analyzed for sites throughout the Minnesota River Basin, this report focuses on Minnesota River mainstem and Major Tributary (greater than 100,000 acres) sites. Data for these and other monitoring sites are available on the DNR/MPCA Cooperative Stream Gaging website: http://www.dnr.state.mn.us/waters/csg/index.html

Mainstem

Minnesota River at Judson
Minnesota River at St. Peter
Minnesota River at Jordan
Minnesota River at Fort Snelling

Major Tributary

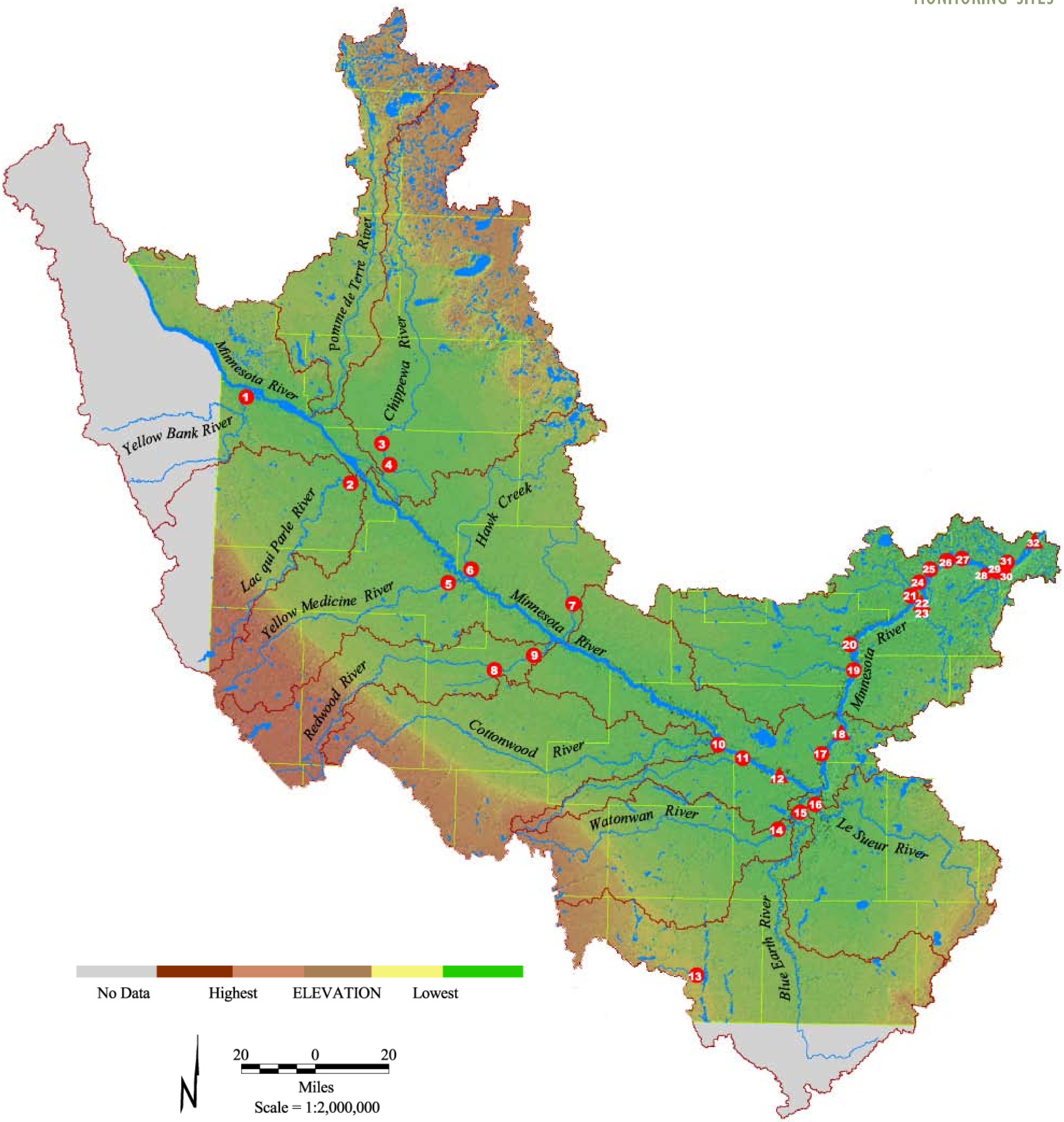
>100,000 acres
Yellow Bank River
Lac qui Parle River
Chippewa River
Yellow Medicine River
Hawk Creek
Redwood River
Cottonwood River
Little Cottonwood River
Watonwan River
Blue Earth River
Le Sueur River
Rush River
High Island Creek
Sand Creek

Minor Tributary

<100,000 acres
Dry Weather Creek
WF Beaver Creek
Clear Creek
Dutch Creek
Seven Mile Creek
Bevens Creek
Chaska Creek
Carver Creek
Bluff Creek
Riley Creek
Eagle River
Credit River
Willow Creek
Nine Mile Creek

SELECT MINNESOTA RIVER MONITORING SITES 2000-2008

1	Yellow Bank River near Odessa	LQPYB-MPCA
2	Lac qui Parle River near Lac qui Parle	LQPYB-USGS-MPCA
3	Chippewa River near Milan	CRWP-USGS
4	Dry Weather Creek near Watson	CRWP
5	Yellow Medicine River near Granite Falls	YMRW-USGS-MPCA
6	Hawk Creek and County Road 52	HCWP-DNR
7	West Fork Beaver Creek Henryville Twp	HCWP
8	Clear Creek near Seaforth	RCRCA
9	Redwood River near Redwood Falls	RCRCA-USGS
10	Cottonwood River near New Ulm	RCRCA-USGS
11	Little Cottonwood River near Courtland	BNC-USGS
12	Minnesota River at Judson	MCES-MDA-MSUWRC-DNR
13	Dutch Creek near Fairmont	MARTIN CO
14	Watonwan River near Garden City	WATONWAN CO-MPCA-USGS
15	Blue Earth River at Dam in Rapidan Twp	MCES-MDA-USGS-MSUWRC
16	Le Sueur River at Hwy 66 in South Bend Twp	MCES-MDA-MSUWRC
17	Seven Mile Creek near St. Peter	BNC-DNR
18	Minnesota River at St. Peter	MCES-MSUWRC
19	Rush River at Hwy 93 near Henderson	SIBLEY-DNR
20	High Island Creek near Henderson	SIBLEY-USGS
21	Bevens Creek at Co Rd 40 Bridge	MCES
22	Minnesota River near Jordan	MCES-USGS
23	Sand Creek at 2nd St in Jordan	MCES
24	Carver Creek at Co Rd 40	MCES
25	Chaska Creek at Co Rd 10	MDA
26	Bluff Creek at Flying Cloud Drive	MCES
27	Riley Creek at Hwy 169 in Eden Prairie	MCES
28	Eagle Creek 50 m up from 126th Street	MCES
29	Credit River at 123rd St Bridge in Savage	MCES
30	Willow Creek 300 m down from 106th St	MCES
31	Nine Mile Creek 500 m down from 106th St	MCES
32	Minnesota River at Fort Snelling State Park	MCES-USGS

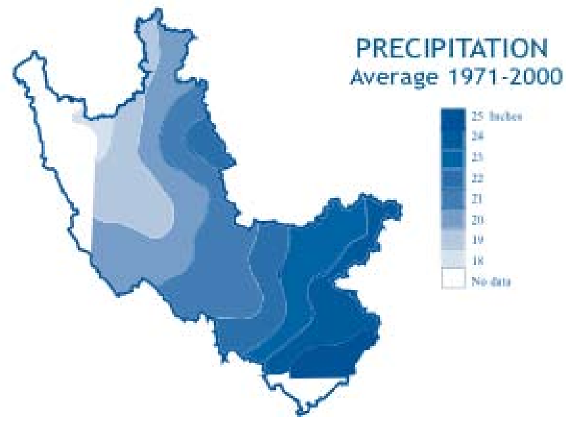


Contributors: Barr Engineering, Brown-Nicollet-Cottonwood Water Quality Board (BNC); Chippewa River Watershed Project (CRWP); Hawk Creek Watershed Project (HCWP); High Island Creek Clean Water Partnership (HCCWP); Lac qui Parle-Yellow Bank Watershed Project; Martin SWCD; Metropolitan Council Environmental Services Program (MCES); Minnesota Department of Agriculture (MDA); Minnesota Pollution Control Agency (MPCA); Minnesota State University, Mankato Water Resources Center (MSUWRC); Redwood-Cottonwood Rivers Control Area (RCRCA); Rush River Clean Water Partnership (RRCWP); U.S. Geological Survey (USGS); Watonwan River Clean Water Partnership (WRCWP); Yellow Medicine River Watershed (YMRW).

PRECIPITATION AND RUNOFF

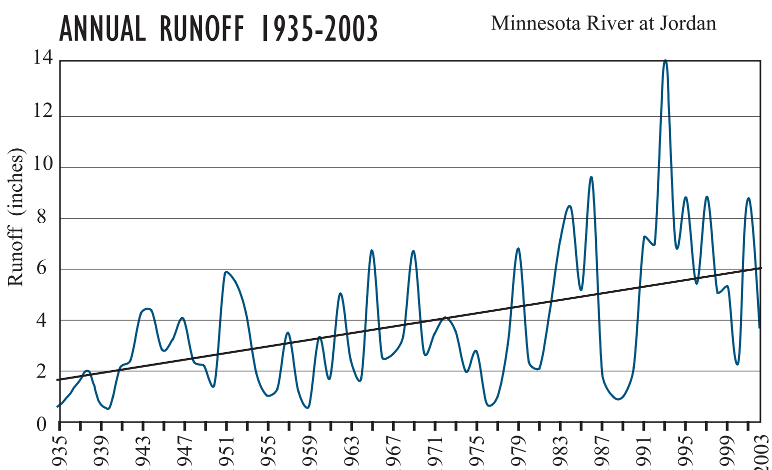
Precipitation

Across the basin, the amount of precipitation varies geographically, seasonally and from year to year. In general, the eastern portion of the basin receives more rain than the western portion. Data in this report show that watershed yields of key water quality pollutants also follow a general pattern of increasing yield from west-to-east across the basin.



Runoff

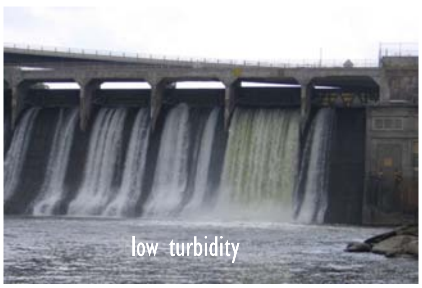
Runoff is the part of the precipitation that appears in rivers and streams, including baseflow, stormflow, flow from ground water, and flow from point sources. Typically, the more precipitation that occurs in a watershed, the more runoff there will be. However, the timing and intensity of precipitation, relative wetness or dryness of soil moisture conditions, soil types, land slopes, land use, as well as other factors, can dramatically influence the seasonal or annual final runoff number. In the Minnesota River Basin, runoff tends to increase from the western portion of the Basin to the eastern portion due to geographical differences in precipitation (see map above).

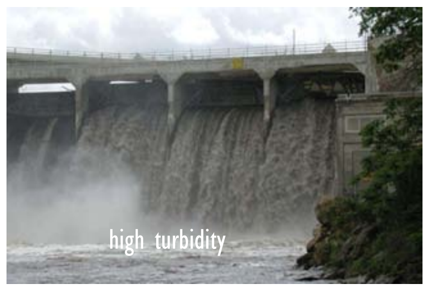


The annual runoff 1935-2003 graph from the Minnesota River at Jordan illustrates the trend of increasing runoff volume over the past several decades. There is highly variable runoff from one year to another.

EXCESS SEDIMENT

Excessive amounts of sediment degrade the ecological health and aesthetics of the Minnesota River and its tributaries. When suspended sediment, measured by TSS (total suspended solids), is elevated, turbidity increases, water clarity decreases, and light penetration is reduced. Reduced light penetration shifts stream productivity away from beneficial periphyton (mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems) and favors undesirable floating algae. An overabundance of floating algae (phytoplankton) further increases turbidity, compounding the problem. Fine-grained sediments that settle on stream beds cover and degrade the desirable rock and gravel substrates that form essential habitats for invertebrates and fish. During periods of high turbidity, streams take on a murky brownish-green cast, greatly reducing their appeal to people who enjoy water-based recreational activities such as boating, fishing, or swimming.





Pat Baskfield. MPCA

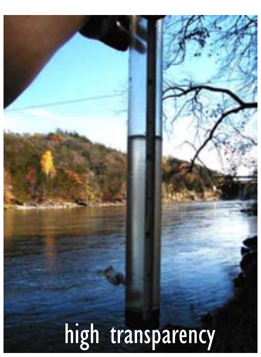
The Blue Earth River at the Rapidan Dam is shown (above) during low and high turbidity.

What is Turbidity?

Turbidity refers to how clear the water is. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity.

Chetomba Creek
Hawk Creek Watershed Project

The photos above show the dramatic increase in turbidity that often occurs when heavy rains fall on unprotected soils. Upon impact, raindrops dislodge soil particles while runoff waters easily transport fine particles of silt and clay across fields or through drainage systems to ditches and tributary streams throughout the Minnesota River Basin.



The photos of the Blue Earth River at left show a transparency tube. It is a tool for measuring stream water clarity: how much sediment, algae, and other materials are suspended in the water. This 60 cm long tube has a black and white disk at the bottom for measuring the depth at which the disk is visible.

What are Total Suspended Solids?

The transport of sediment is a natural function of rivers. Modification of the landscape has accelerated the rate of erosion of soil into waterways. Increased runoff has resulted in stream bank erosion. Elevated sediment (suspended soil particles) has many impacts. It makes rivers look muddy, affecting aesthetics and swimming. Sediment carries nutrients, pesticides, and other chemicals into the river that may impact fish and wildlife species. Sedimentation can restrict the areas where fish spawn, limit biological diversity, and keep river water cloudy, reducing the potential for growth of beneficial plant species.

Primary Sources of Sediment

Bluffs, ravines, gullies, streambanks, and upland runoff contribute sediment to the streams and rivers in the Minnesota River Basin. Urban stormwater and construction sites also contribute sediment.

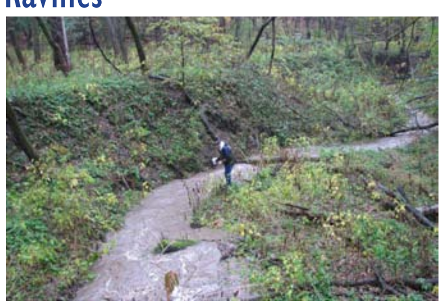
Primary sources of sediment illustrated on a digital elevation model of a portion of the Le Sueur River watershed.
Source: Wilcock, 2009

Le Sueur River water quality samples (above) collected throughout the 2002 monitoring season. This illustrates the variability in turbidity throughout the year.

Streambanks

Bluffs like this one in the Le Sueur River Watershed contribute sediment to waterways in the Basin.

Ravines



Ravines are another source of sediment.

Uplands

Soil erosion in farm fields also contributes sediment to streams and rivers. Soils are most vulnerable during the post planting period when residue is minimal and crops have not formed a protective canopy.

Tributaries are displayed in downstream order from left to right (west to east) on Figure 1. The tributaries in the middle and downstream parts of the Minnesota River Basin have, in general, greater flow weighted mean concentrations (FWMC) and greater year-to-year variability than tributaries in the western, upstream, part of the basin. The horizontal line indicates threshold level (58 mg/L and 66 mg/L) established by Minnesota Pollution Control Agency for streams in the Western Corn Belt Plains and Glaciated Plains ecoregion (MPCA, 1993). The Total Suspended Solids (TSS) FWMC values are indicators of the condition of the tributary streams and are a measure of their potential to affect water quality in the Minnesota River (Figure 2). FWMC are calculated on a monitoring season basis (approximately April through September).

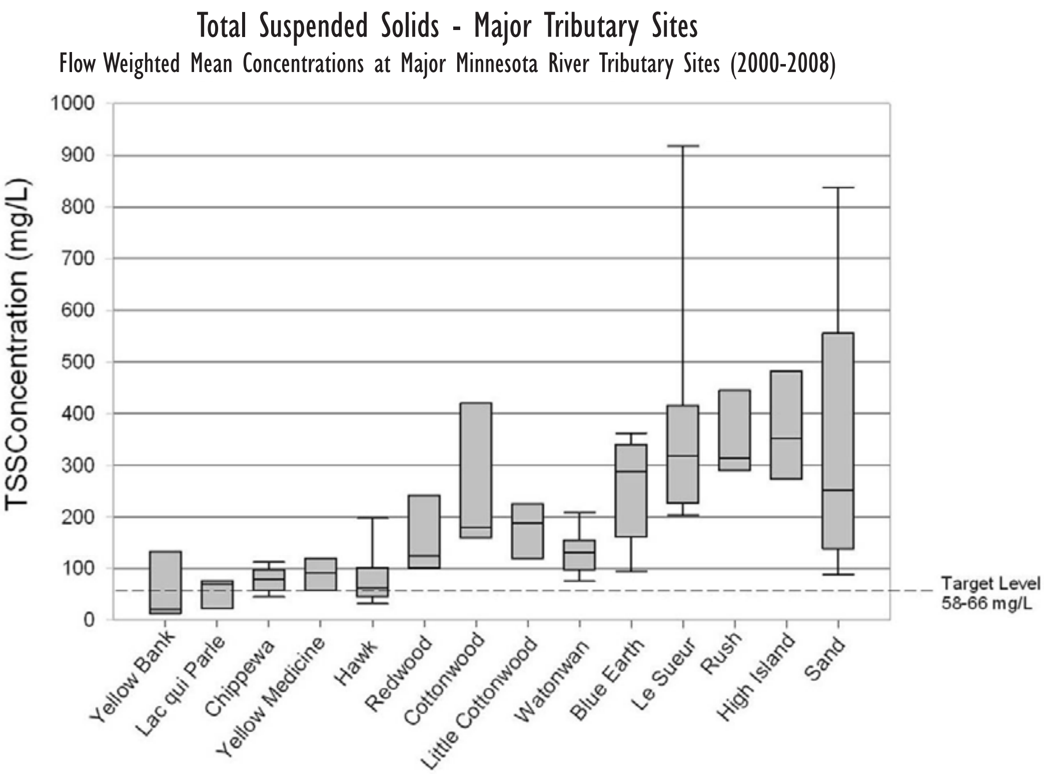


Figure 1.
Boxplot showing the monitoring season (approximately April through September) total suspended solids FWMC for major Minnesota River tributary streams in the Minnesota River Basin.

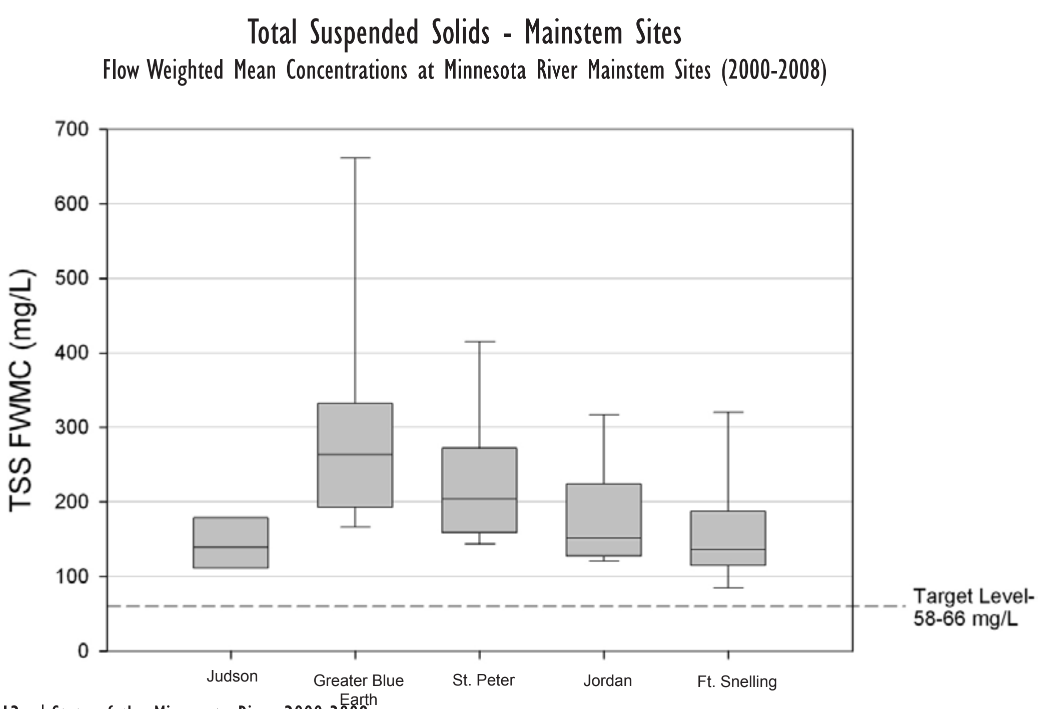


Figure 2.
Boxplot showing monitoring season total suspended solids FWMC for Minnesota River and Greater Blue Earth River sampling sites. The median FWMC's clearly show a decrease in TSS from St. Peter to Jordan to Fort Snelling. After examining a sediment "budget" for the lower Minnesota reach, researchers hypothesize that deposition may account for the apparent sediment "loss", especially in years that the River accesses its floodplain.

Yields, shown as pounds of sediment delivered per watershed acre, are indicators of the severity of erosion in each tributary watershed. Figures 3 and 4 show that sediment yields generally increase from west to east across the Minnesota River Basin and that watersheds in the eastern, downstream, part of the Basin have greater year-to year variability in sediment yield. Tributary streams that have greater yields and large watersheds like the Le Sueur have the greatest potential to affect water quality in the Minnesota River mainstem. Figure 3 illustrates four broad data categories across the basin: 1) <100 pounds per acre (western Basin), 2) 100-200 pounds per acre (middle Basin), 3) 400 pounds per acre (Blue Earth & Le Sueur sub-basin), and 4) 300 pounds per acre (lower basin). These results may reflect four combination sets of geomorphology, management practices, and climate variables that define water quality in each of the geographical areas.

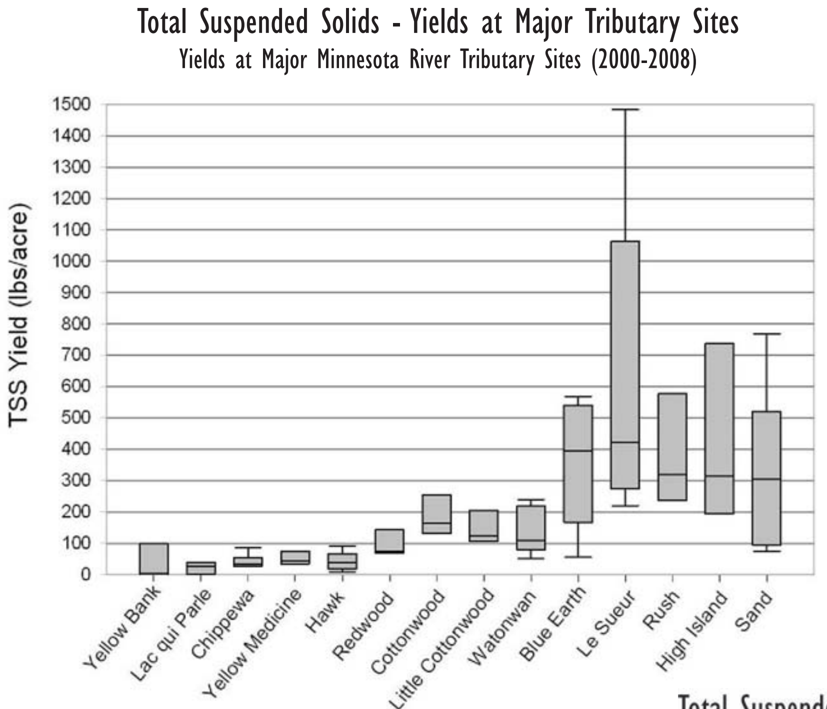


Figure 3. Boxplot showing monitoring season TSS yields for major tributary streams in the Minnesota River Basin.

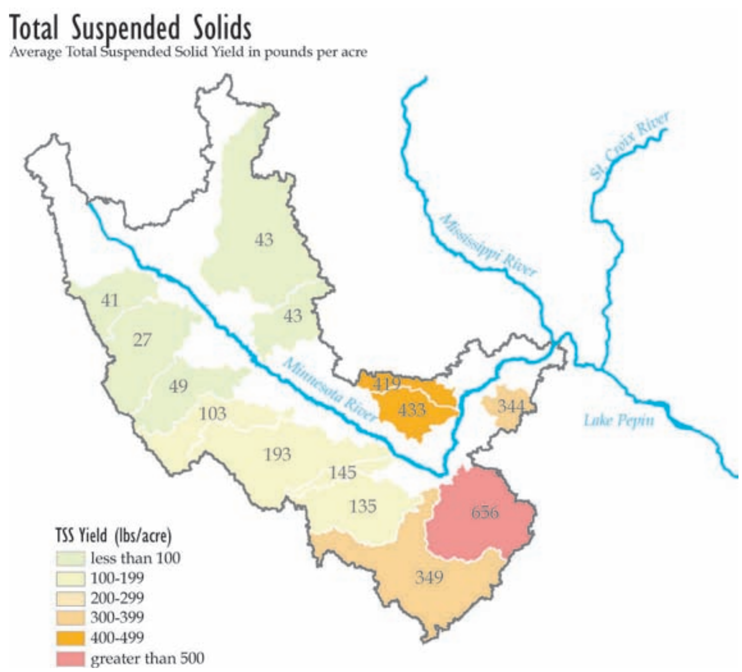
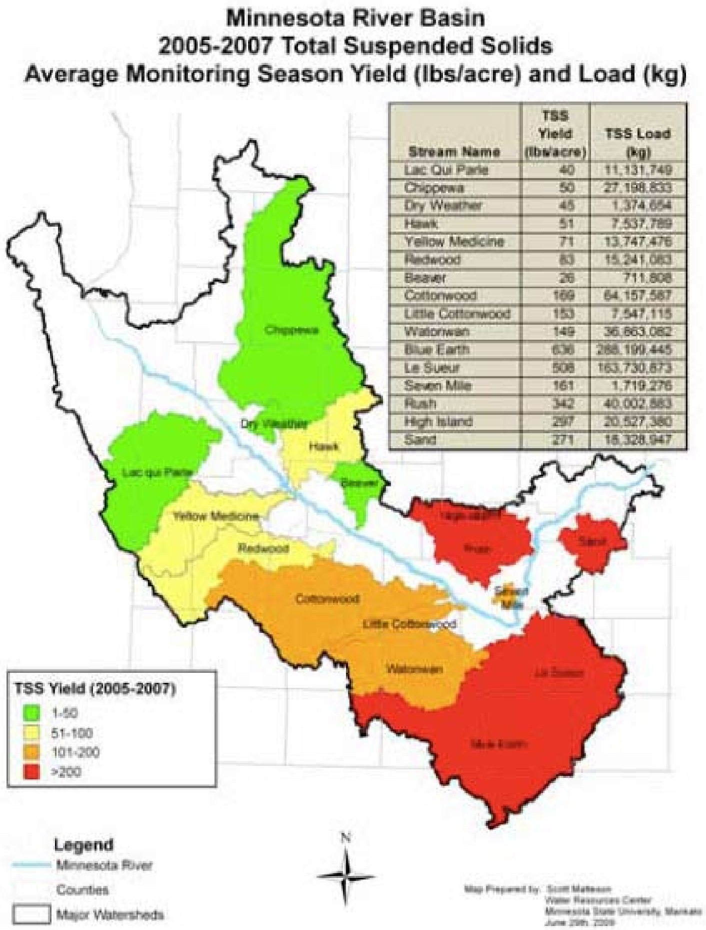


Figure 4 displays the pattern of the nine year yields (2000-08) indicating the disproportionate contribution from the watersheds in the eastern part of the basin. Locations not colored did not have available information.



Stream Name	TSS Yield (lbs/acre)	TSS Load (kg)
Lac Qui Parle	40	11,131,749
Chippewa	50	27,198,833
Dry Weather	45	1,374,654
Hawk	51	7,537,789
Yellow Medicine	71	13,747,476
Redwood	83	15,241,083
Beaver	26	711,808
Cottonwood	169	64,157,587
Little Cottonwood	153	7,547,115
Watonwan	149	36,863,082
Blue Earth	636	288,199,445
Le Sueur	508	163,730,873
Seven Mile	161	1,719,276
Rush	342	40,002,883
High Island	297	20,527,380
Sand	271	18,328,947

Figure 5. Map of Minnesota River Basin showing annual TSS yield (lbs/acre). Total annual TSS load in kg is given in the inset table.

Sources Contributing to Yields

Erosional processes in fields, streambanks, bluffs, and ravines all contribute to sediment yield. In the western part of the Minnesota River Basin, field erosion and streambanks are the predominant sediment sources. Further east in the Basin, the Minnesota River and its tributaries are more deeply incised resulting in steep bluff areas and ravines. Areas containing bluffs and ravines are located in the downstream reaches of the tributaries where the streams approach their confluence with the Minnesota River. The yields (figures 3 and 4), were gathered from downstream monitoring stations near stream mouths, and thus reflect the influence of bluff and ravine erosion in those tributaries where incised terrain features are extensive. Paired monitoring stations, placed upstream and downstream of incised terrain in seven of the tributary watersheds, have clearly shown that sediment yield is greater in the incised areas of those watersheds. Wilcock (2009) summarized findings presented to the Minnesota River Sediment Colloquium concerning these and other sediment sources.

Loads

"For a five year period starting in 2002, the TSS load was 1.8 million tons at Judson and 5.4 million tons at St. Peter, a 300% increase. Nearly all of the increased load can be attributed to the TSS supply from the Blue Earth and Le Sueur Rivers, which discharge into the Minnesota between the two gauges. The 2002-2006 TSS load of these rivers was measured as 3.2 million tons" (Wilcock, 2009).

Downstream Impacts

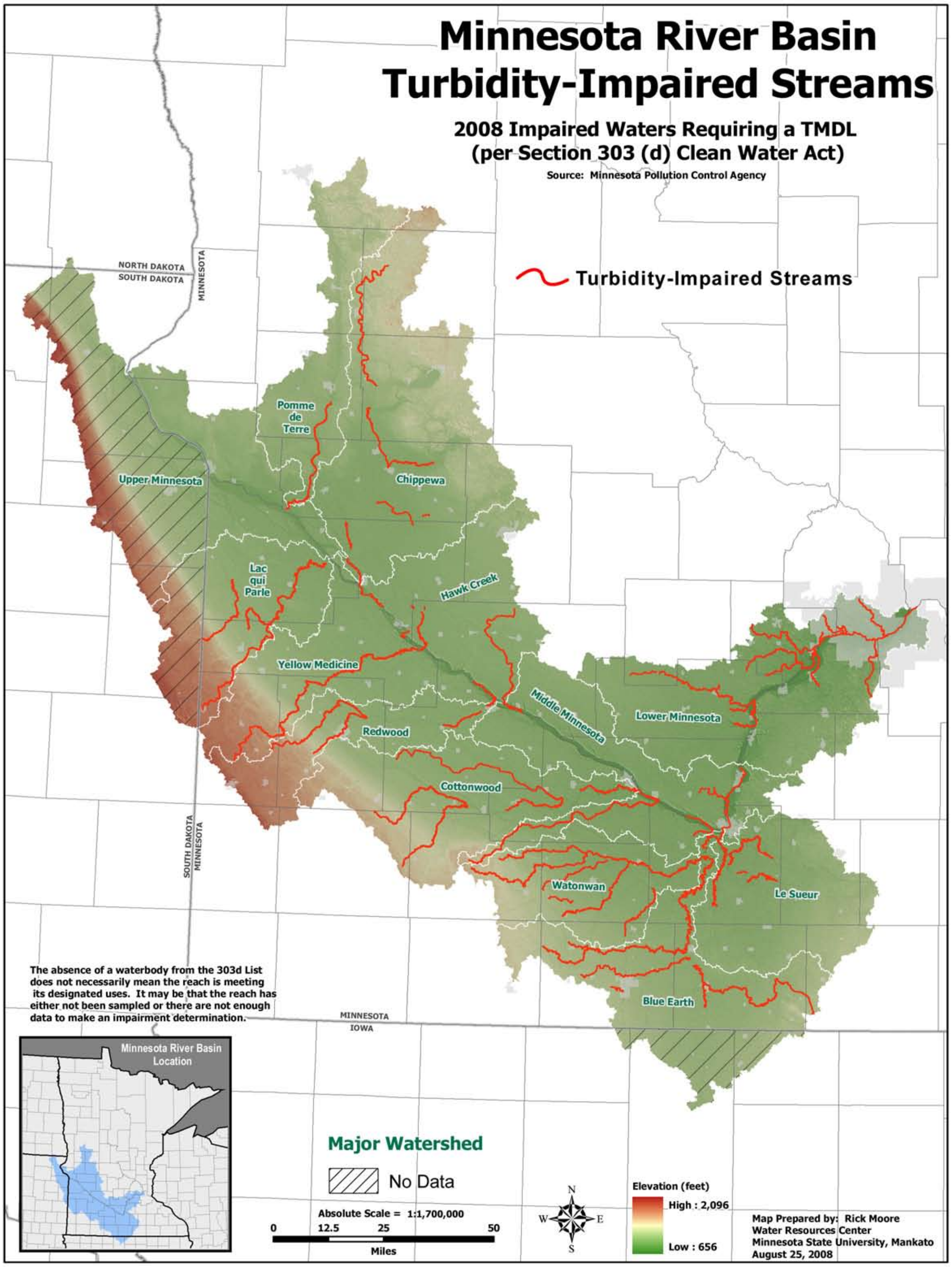
Met Council Environmental Services

The sediment laden Minnesota River (left) flows into the Mississippi River (right). When the Minnesota River meets the Mississippi River it carries elevated sediment and nutrient concentrations.

Explore Minnesota Tourism

Lake Pepin is a natural impoundment along the Upper Mississippi River just downstream of St. Paul. The Mississippi River carries sediment downstream and it settles in Lake Pepin. Most of Lake Pepin's sediment is coming from the Minnesota River.

Recent studies have indicated an approximate ten fold increase in post-settlement sedimentation rates in Lake Pepin. The Minnesota River, while only accounting for 25% of the flow into the lake is responsible for 88% of the sediment load. The lake is filling in at 10 times its natural rate (Engstrom and Almendinger, 1997).



The "Minnesota River Basin Turbidity-Impaired Streams" map above shows assessed water bodies that do not meet Minnesota water quality standards for turbidity and are therefore listed on the Minnesota's Impaired Waters 303(d) List. Learn more about impaired waters on the MPCA website:
http://www.pca.state.mn.us/water/tmdl/tmdl-303dlist.html

Phosphorus-enriched streams are commonplace in the Minnesota River Basin. Phosphorus stimulates the growth of algae and elevated phosphorus concentrations often lead to eutrophy, which is characterized by undesirably high levels of algal growth. An overabundance of algae and sediment contributes to increased turbidity and reduced light penetration. Water clarity is greatly reduced under these conditions, impairing recreational use and aesthetics of the river environment. Furthermore, algal cells eventually die and their subsequent decomposition consumes in-stream oxygen. This oxygen demand can lower dissolved oxygen in the streams and impair the stream's ability to support aquatic life. Some outbreaks of highly elevated algal growth, termed algal blooms, release toxins into the water. Instances of this have occurred within the Minnesota River Basin and resulted in the death of animals (including pets) that ingested these toxins. Phosphorus arises from both point (e.g. municipal and industrial discharges) and non-point (e.g. runoff from agricultural lands and urban areas) sources.

Total Phosphorus (TP) concentrations in the tributaries show substantial variation across the Basin. During 2000 to 2008, the median TP concentration in the Minnesota River mainstem reach from Judson to Fort Snelling was 0.31 mg/L. Concentrations in the major tributary streams are shown in Figure 7. The horizontal lines in Figures 6 and 7 show the TP threshold value of 0.26 mg/L. Data analysis (MPCA, 1997) has indicated that a reduction in undesirable algal growth cannot be expected unless mainstem TP concentrations are brought below that threshold. Figure 7 and Figure 8 indicates that few of the tributaries meet that criterion.

MPCA

Watonwan River algal bloom.

MPCA

Blue Earth River algal bloom.

MCES

Lake Pepin algal bloom. The lake is accumulating phosphorus at 15 times the natural rate.

What is Phosphorus?

Phosphorus is an important nutrient for plant growth. Total phosphorus is the measure of the total concentration of phosphorus present in a water sample. Excess phosphorus in the river is a concern because it can stimulate the growth of algae. Excessive algae growth, death, and decay can severely deplete the oxygen supply in the river, endangering fish and other forms of aquatic life. Low dissolved oxygen concentrations are a concern particularly during low-flow times or in slow-flowing areas such as reservoirs and the lower reaches of the Minnesota River. Large total phosphorus loads can have major impacts both locally and on downstream receiving waters such as Lake Pepin.

Phosphorus Sources

Point-source phosphorus comes mainly from municipal and industrial discharges to surface waters. Nonpoint-source phosphorus comes from runoff from urban areas, construction sites, agricultural lands, manure transported in runoff from feedlots and agricultural fields, and human waste from noncompliant septic systems.

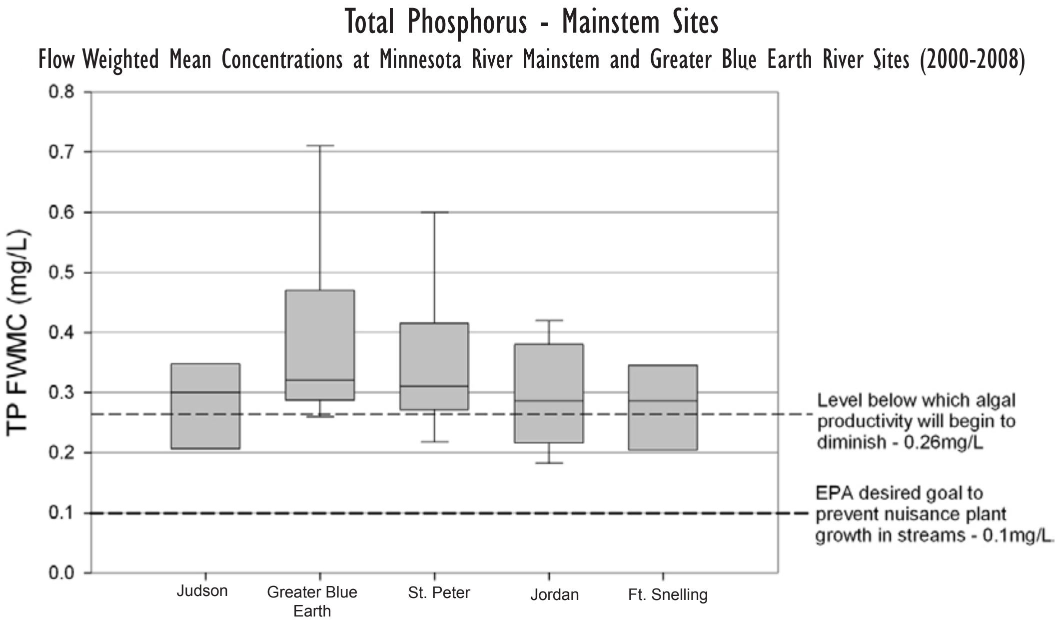


Figure 6.
Boxplots showing monitoring season total phosphorus (TP) flow-weighted mean concentrations (FWMC) at Minnesota River and Greater Blue Earth River sampling sites. Researchers noted a staircasing decrease in TP FWMC moving through the reach Judson to Fort Snelling, further supporting the concept of loss of P through sedimentation.

The boxplots in figure 7 were compared to similar plots prepared for the last report (2000-05). Moderating (decreasing) TP concentrations across much of the Basin were evident in the new data added for the 2006-08 sampling seasons. The effect was a substantial lowering of median TP values for several sites. Medians for the Cottonwood, Little Cottonwood and Watonwan Rivers decreased substantially and are now at the 0.26 mg/L threshold. Medians for the Blue Earth and Le Sueur Rivers also have decreased, with the Blue Earth median now just under 0.3 mg/L and the Le Sueur decreasing from 0.5 mg/L to close to 0.4 mg/L. Rush River and High Island medians show decreases as well. High Island now is at about 0.35 mg/L, down from a median of more than 0.5 mg/L in the last report. The median TP FWMC for Sand Creek, however, remains greater than 0.5 mg/L. Substantial effort has been made to reduce both point and non-point sources of phosphorus across the basin. Linkage between those efforts and improved water quality (decreased TP) will require continued monitoring and consideration of other factors such as recent weather events and climate trends, but these results are encouraging.

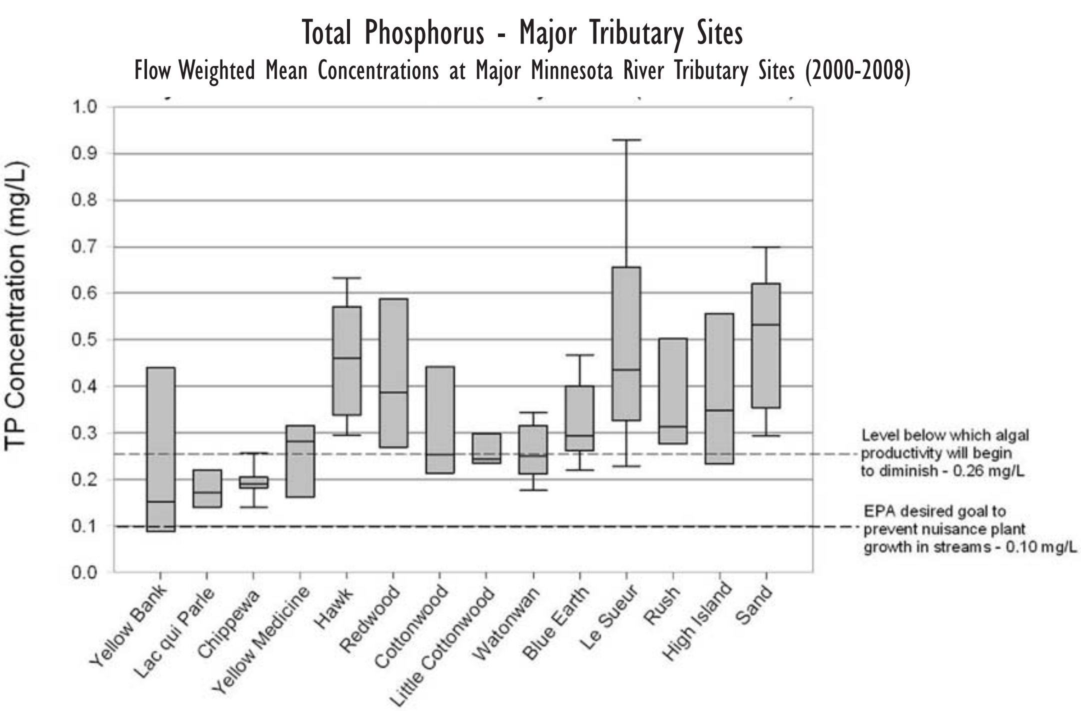


Figure 7.
Boxplots showing monitoring season TP FWMC in major tributary streams in the Minnesota River Basin. The boxplots illustrate the substantial differences in TP concentrations among the major tributaries. Resolving the causes, both natural and human-induced, for these differences remains one of the challenges for researchers in the Minnesota River Basin.

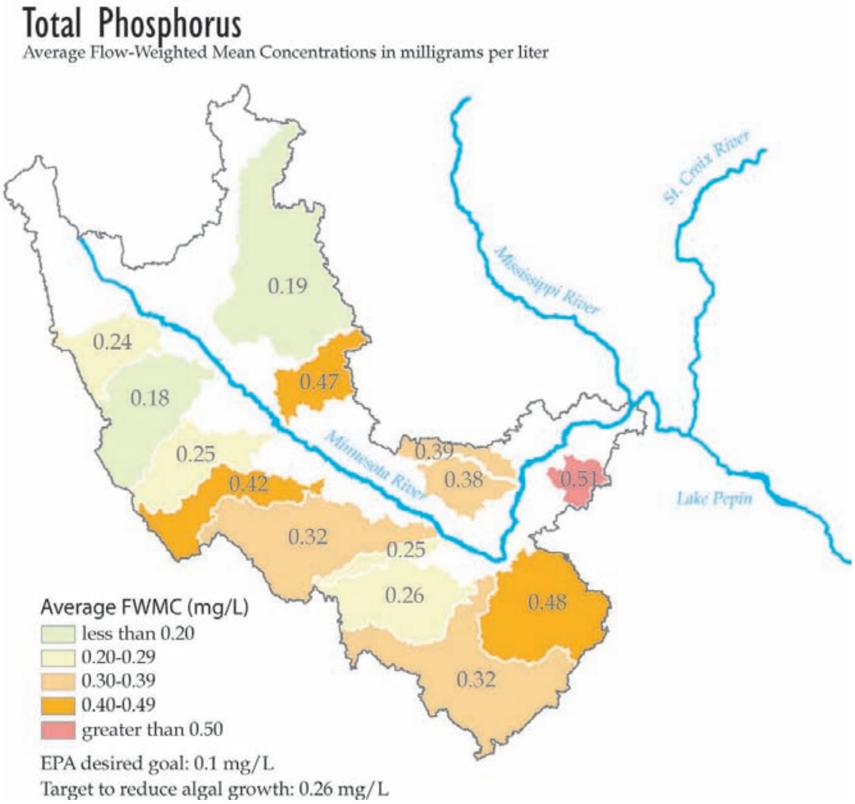


Figure 8.
2000 to 2008 average monitoring season Total Phosphorus FWMC for major tributary streams in the Minnesota River Basin.

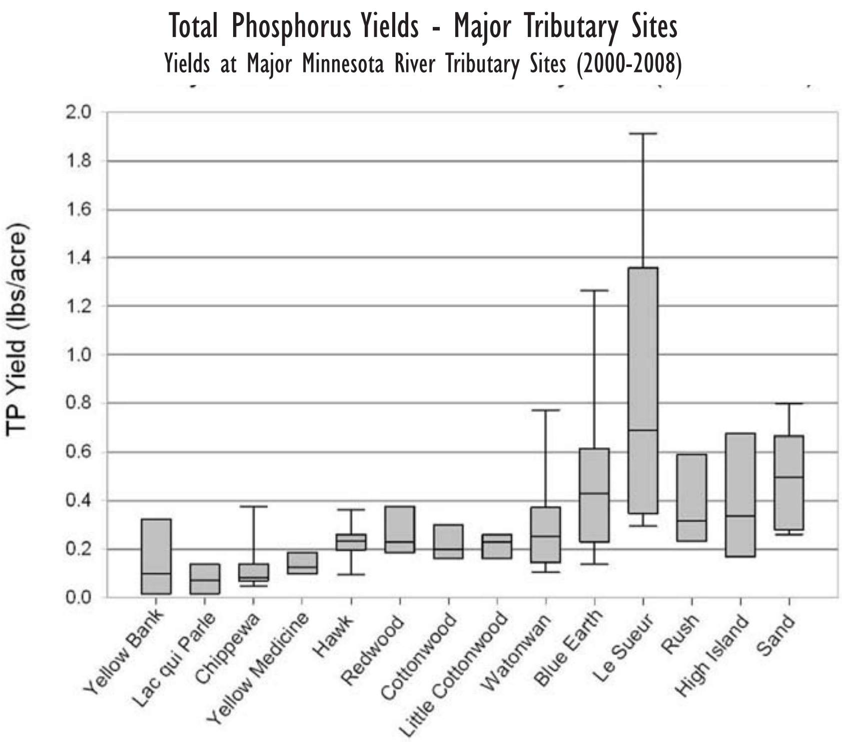


Figure 9. Boxplots showing total phosphorus (TP) yields from major tributary watersheds in the Minnesota River Basin.

The boxplots in Figure 9 appear in downstream order, left to right (west to east) across the basin. The yields, expressed in pounds of TP delivered per watershed acre, show the variation in TP yields from each major watershed. Watersheds in the eastern part of the basin yield more TP per acre compared to watersheds in the western part. The range of yields is greater in the eastern part of the basin.

What is Orthophosphorus?

Under natural conditions, phosphorus is typically scarce in the aquatic environment. Human activities, however, have resulted in excessive loading of phosphorus into many freshwater systems. A portion of the total phosphorus concentration in surface waters is available to plants to support their growth. Phosphorus exists in water in either a dissolved phase or a particulate phase. Dissolved inorganic phosphate (orthophosphate) is the form required by plants for growth.

OP is of particular concern for lakes and streams. Orthophosphates are immediately available in the aquatic environment for algal uptake. OP is a soluable form of phosphorus that is readily available to algae (bioavailable). A particular concern is that under certain conditions it can stimulate excess algae growth leading to subsequent depletion of dissolved oxygen.

Orthophosphorus Sources

Natural processes produce orthophosphates, but major man-influenced sources include: partially treated and untreated sewage; runoff from agricultural sites; and application of some lawn fertilizers. Orthophosphate concentrations in a water body vary widely over short periods of time as plants take it up and release it.

Figure 10 illustrates boxplots of major tributary Orthophosphorus levels from 2000-08. These can be broadly organized into three groups. The first is the Upper Basin sites that have median Orthphosphorus Flow Weighted Mean Concentrations (OP FWMC) below 0.1 mg/L. The second group is Hawk Creek and Redwood River which stand out with medians are nearly three times greater than other Upper Basin sites. The final group is the Middle and Lower Basin sites where medians are between 0.1 and 0.15 mg/L. The Blue Earth stands out with lower OP concentrations in this group. Similar to Total Phosphorus, there is a substantial difference between the Blue Earth and Le Sueur River watersheds. In the case of OP, the lower values for Blue Earth River may come about because there is algal uptake of OP in the Rapidan Reservoir, especially during summer low flow when the residence time is greater.

Orthophosphorus - Major Tributary Sites

Flow Weighted Mean Concentrations at Major Minnesota River Tributary Sites (2000-2008)

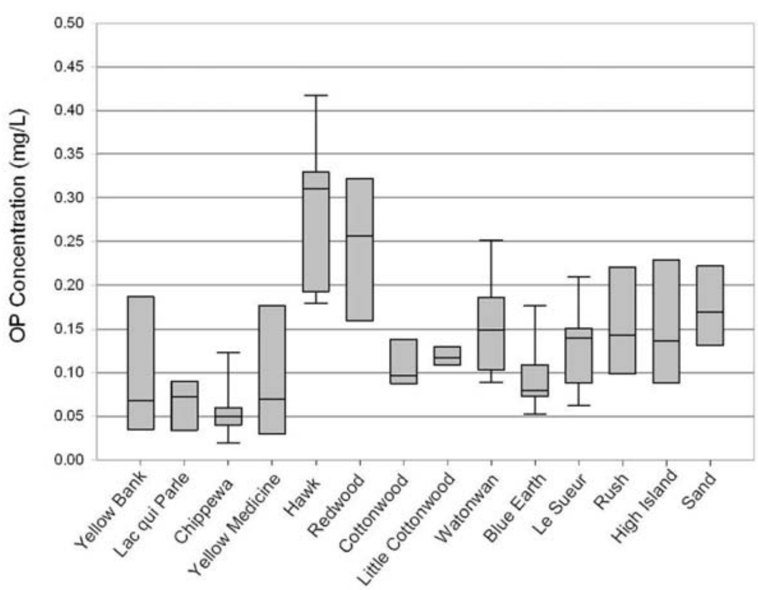


Figure 10.
Boxplots showing monitoring season orthophosphorus in major tributary streams in the Minnesota River Basin. The elevated OP concentrations in Hawk Creek and the Redwood River are a cause for concern. Orthophosphorus concentrations are especially elevated at low flow and OP:TP ratios are greater than those in nearby tributaries. This suggests point-source inputs of OP. Efforts are currently underway to upgrade wastewater treatment in these two watersheds.

Figure 11 illustrates that orthophosphorus concentrations are stable from site to site on the mainstem, probably as a consequence of rapid uptake and utilization, and possibly, adsorption to sediment particles. On the negative side, the position of the lower whiskers on the plots suggests that about 0.06 mg/L of orthophosphorus is available approximately 90 percent of the time. This is a concern because an excess of bioavailable phosphorus in freshwater systems can result in accelerated algal growth.

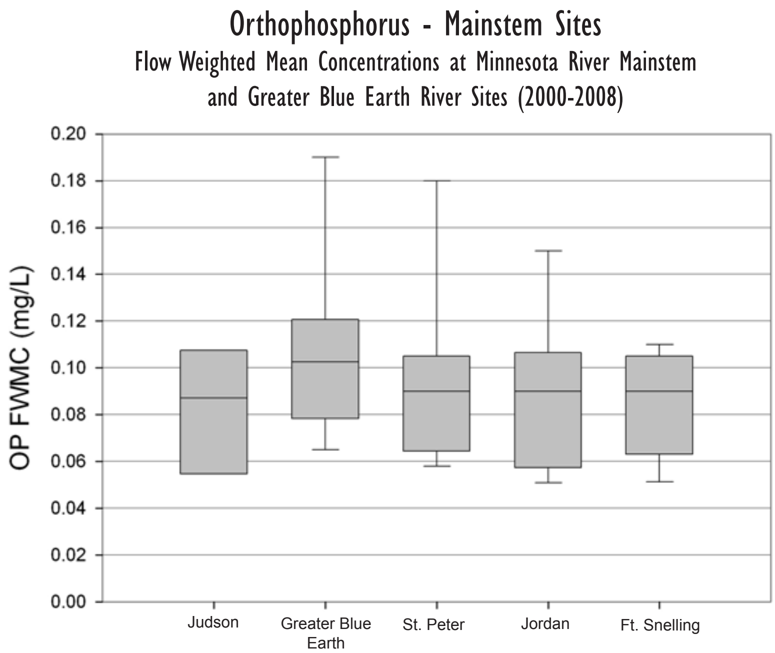


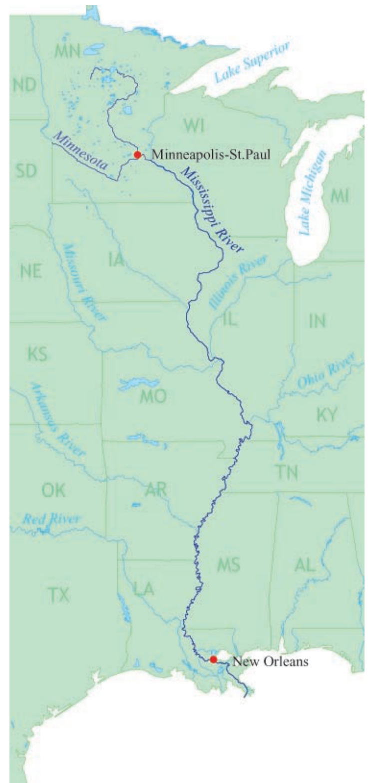
Figure 11. Boxplots showing monitoring season orthophosphorus (OP) flow-weighted mean concentrations (FWMC) at Minnesota River mainstem and Greater Blue Earth River sampling sites.

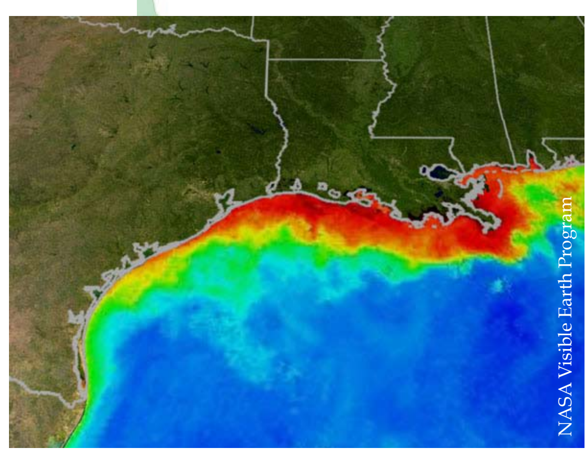
Nitrate-nitrogen is important because it is biologically available and is the most abundant form of nitrogen in Minnesota River Basin streams. Like phosphorus, nitrate can stimulate excessive and undesirable levels of algal growth in waterbodies. In recent years, this problem has been particularly severe in the Gulf of Mexico where development of a hypoxia zone (hypoxia means "low oxygen") has been linked to excessive amounts of nitrate carried to the Gulf by the Mississippi River. Reduced oxygen levels in the hypoxic zone, brought on by decomposition of algae, have damaged the shellfish industry and threaten the aquatic ecosystem of the Gulf Region. The Minnesota River has been identified as a substantial contributor of excess nitrate to the Mississippi River and the Gulf Region. In addition to over-stimulation of algae, elevated levels of nitrate in drinking water can cause methemoglobinemia, or blue-baby syndrome in infants.

What are Nitrates?

Nitrogen exists in the environment in many forms. Nitrate is the oxidized form of Nitrogen that is commonly found in the rivers and streams of the Minnesota River Basin. Because it is highly mobile, and biologically available, it is of special concern for aquatic systems.

In recent decades, there has been a substantial increase in nitrogen fertilizer use. Elevated nitrate-N in the Minnesota River can pollute aquifers it recharges. Therefore, nitrogen can affect drinking water. At high enough concentrations, nitrate-N can cause infants who drink the water to become sick and even die (methemoglobinemia) (see Drinking Water: Nitrates section). Downstream, nitrate-N from the Minnesota River contributes to hypoxia (low levels of dissolved oxygen) in the Gulf of Mexico by stimulating the growth of algae which, through death and decay, consume large amounts of dissolved oxygen and thereby threaten aquatic life.





This image shows the hypoxic zone (sometimes referred to as the dead zone) in the Gulf of Mexico. Reds and oranges indicate areas of low oxygen concentration. In July 2008, the hypoxic zone was mapped at 7,988 square miles—the second largest on record since measurements began in 1985. This is larger than the land area of the state of Massachusetts.

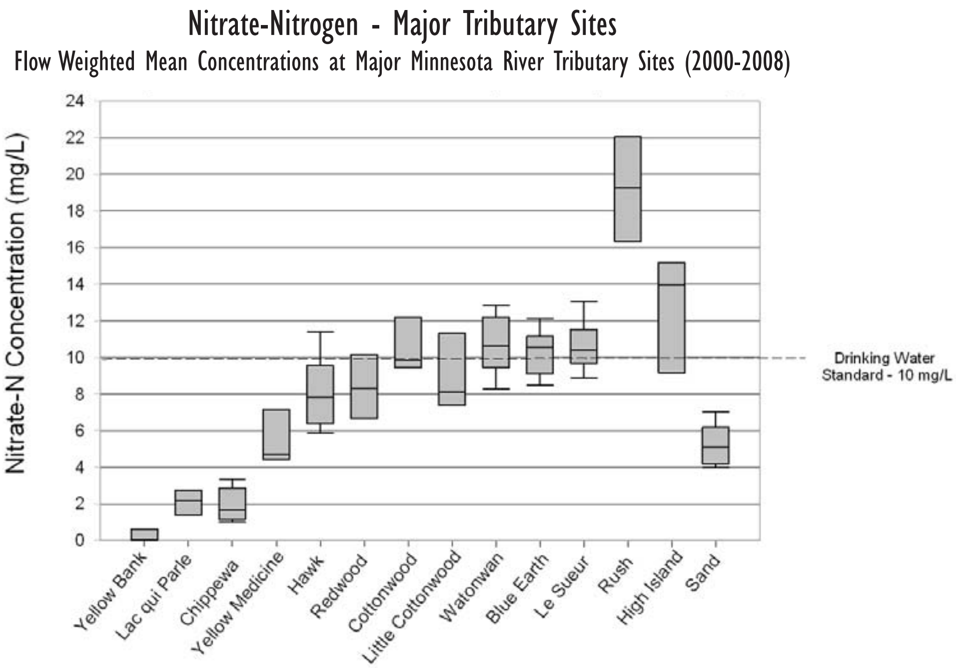


Figure 12. Boxplots showing monitoring season nitrate-nitrogen flow-weighted mean concentrations (FWMC) in major tributary streams, Minnesota River Basin, 2000-08.

The boxplots in Figure 12 show the variability in nitrate concentrations in major tributary streams. The sites are arranged in downstream order, west to east, in the graphic. The dashed horizontal line shows the drinking water standard for nitrate (10 mg/L). Flow-weighted mean nitrate concentrations, in general, are greater in the central and eastern parts of the Minnesota River Basin. Ecoregions are areas with similar physical landscape characteristics. Average ecoregion values for minimally impacted rivers in the Minnesota River Basin can be used for comparison with major tributary FWMC Nitrate-N concentrations.The ecoregion target values for these rivers includes Nitrate-N concentrations in the 0.9 to 6.5 mg/L range.

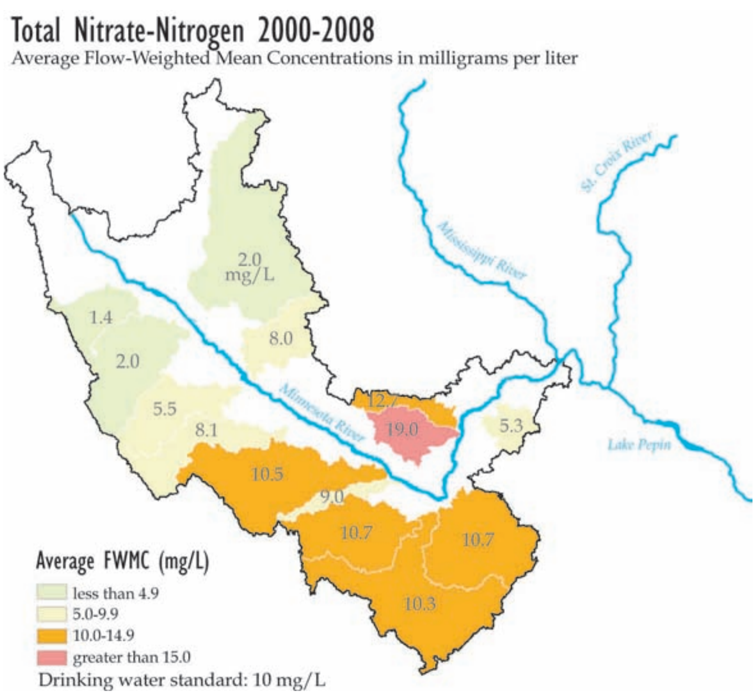


Figure 13 illustrates nitrate concentrations across the basin. The watersheds shown in orange and red have concentrations that exceed the drinking water standard (10 mg/L). Most of the nitrate in the Minnesota River comes from agricultural drainage.

The Greater Blue Earth River (GBE) system stands out (Blue Earth, Watonwan and Le Sueur River Watersheds) as a region with elevated nitrate concentrations. The GBE comprises 22 percent of the total drainage area but contributes a significant portion of the total nitrate-N load.

Five of the major tributaries have median FWMC greater than the drinking water standard (see Figure 12. Seasonal FWMC's in nine of the major tributaries have exceeded the ecoregion target value goal (6.5 mg/L) during the 2000-08 monitoring period.

For the mainstem, the overall nitrate-N pattern is that the Upper and Middle-Basin mainstem is within the drinking water standard and also within the surface water ecoregion target level (6.5 mg/L) most of the time, while the Lower-Basin mainstem is not attaining the surface-water goal in most years. The seasonal FWMC for GBE exceeded the drinking water standard during three of the last nine years and was greater than 8.0 mg/L during all years.

Yields of nitrate nitrogen vary substantially across the Minnesota River Basin (Figure 14) and are generally greater in streams that drain watersheds in the central and eastern part of the basin. Streams that have greater yields also have greater year-to-year variability in yields. The east to west increase in yield coincides with a gradient of increased rainfall and runoff, west to east, across the basin.

In addition to yield variability associated with natural rainfall variability, agricultural practices affect nitrate yield. Gowda and others (2007) modeled nitrate losses from the Bevens Creek and Sand Creek Watersheds in the eastern part of the basin. These watersheds receive similar average rainfall amounts, but differ in nitrate load and yield. The calibrated models showed that nitrate losses were sensitive to fertilizer application rates, timing of fertilizer application (fall vs. spring), and the percentage of cropped land drained by subsurface tile. The model results show that nitrate losses increase with increased application rates, fall applications, and increases in subsurface drainage.

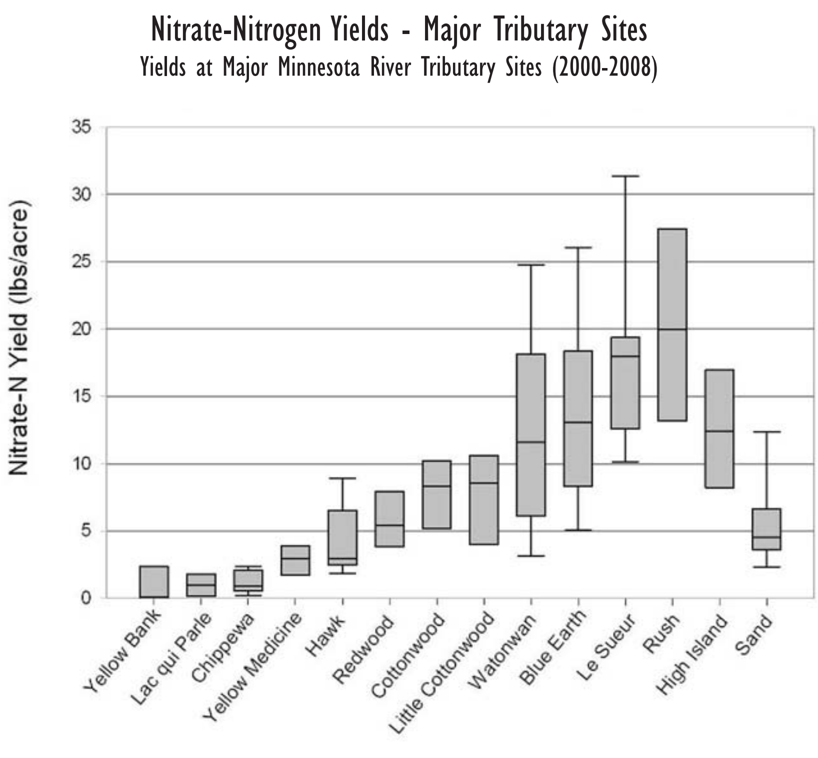


Figure 14. Boxplots showing nitrate-nitrogen monitoring season yields in major tributary streams, Minnesota River Basin, 2000-08. Nitrate is soluble and thus mobilized when rainfall infiltrates through soil profiles. Tile, ditches, and natural streams capture this nitrate laden water and deliver it to the major tributaries and Minnesota River Mainstem.

DRINKING WATER: NITRATES

Nitrates in Drinking Water

To comply with the federal Safe Drinking Water Act, the Minnesota Department of Health (MDH) is responsible for assuring the compliance of community water supply systems. Minnesota Groundwater Protection Act and the federal Safe Drinking Water Act require public water suppliers to develop Wellhead Protection Plans.

Standard/Criteria

Both State and Federal regulations limit nitrate in drinking water to 10 parts per million (ppm) to protect prenatal and infant children. Elevated levels of nitrate in drinking water can cause methemoglobinemia, or blue-baby syndrome. Methemoglobinemia is a blood disorder in which an abnormal amount of hemoglobin builds up in the blood. Hemoglobin is the oxygen-carrying molecule found in red blood cells. This can result in the hemoglobin being unable to carry oxygen effectively to body tissues.

Findings

During the 2000 to 2008 monitoring period, several tributary streams in the Minnesota River Basin periodically exceeded the 10 ppm standard. The City of Mankato draws drinking water from a shallow aquifer that is connected to, and partially recharged by, the Blue Earth River. Nitrate-N levels in the Blue Earth River strongly influence nitrate levels in Mankato's water intake supply.

The protection of ground and surface water from which all of us get our drinking water from is an important health issue. Approximately 10 percent of Minnesota's 2,400 community supply wells show at least some contamination resulting from human activities. Fortunately, most contaminant levels are below safe drinking water limits.

Municipal Systems - MDH

Municipal systems are monitored closely by MDH to meet health standards. Their source water protection program is designed to help prevent contaminants from entering public water sources. The program includes wellhead protection (capture zone for the well), source water assessments (description of water source), and where needed protection of surface water intakes.

Major Pollutants: Nitrates & Arsenic

Major groundwater pollutants of concern in the basin include nitrates and arsenic. Nitrate is a common contaminant found in many wells throughout Minnesota. Wells most vulnerable to nitrate contamination include shallow wells, dug wells, and wells with damaged or leaking casings. Major sources of nitrate contamination can be from fertilizers, animal waste, and human sewage. Arsenic occurs naturally in some soil and rock and can leach into groundwater. Almost all arsenic in drinking water is from underground deposits of naturally occurring arsenic. Statewide arsenic sampling in Minnesota indicates that a significant area of the state has detectable concentrations of arsenic in ground water (MCPA, 1995), with approximately 14% of sampled wells exceeding the standard of 10 µg/l. Arsenic is particularly concentrated in western Minnesota where over 50% of the 900 sampled private drinking water wells had arsenic over 10 µg/l (MDA, 2001).

Public Water Supply Systems

A 2007 Report by the Minnesota Department of Health provides insight into the status of drinking water across the state. "Public water supply systems" are defined: a water supply system must have its own water source and provide water to 25 or more people, or have 15 or more service connections. Minnesota's community water supply systems are routinely tested for more than 100 different pesticides and industrial contaminants. Findings from the 2007 report are summarized below.

Nitrate/Nitrite
Community water supply systems in Minnesota are tested once a year for nitrate. No community systems exceeded the standard for nitrate by the end of 2007.
Bacterial Contamination
Statewide twenty community systems, including 17 municipal systems, tested positive for bacterial contamination in 2007.
Arsenic
Statewide, approximately 11 community water systems had arsenic levels above 10 parts per billion.

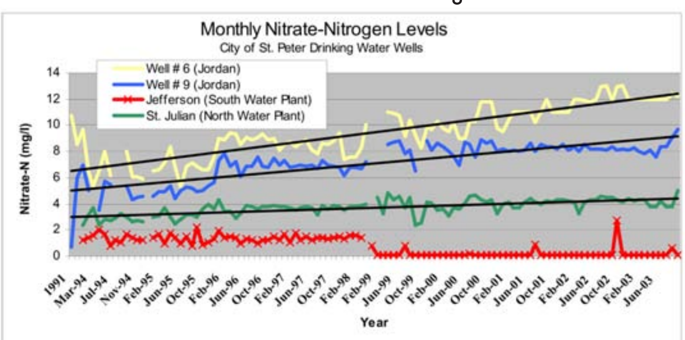
Wellhead Protection Program

Wellhead Protection activities prevent well contamination by managing potential contaminant sources in the land area that contributes water to the well. Public water suppliers are required to develop Wellhead Protection Plans as stated in the Minnesota Groundwater Protection Act and the federal Safe Drinking Water Act.

St. Peter Wellhead Protection Program

A case study example in the Basin includes in St. Peter Wellhead Protection Program where nitrate is the primary contaminant of concern. The graph (below) shows nitrate concentrations steadily increasing from 1991-2003. The city blends water from different wells to stay within public health guidelines (BNC, 2003).

St. Peter Wellhead Nitrate-Nitrogen Levels

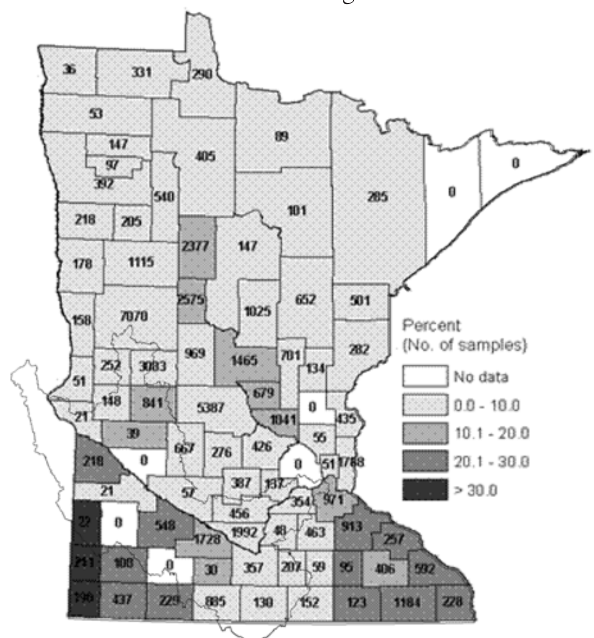


cawaterkeepers.org

Private Wells

The MDH conducts ground water monitoring in order to regulate public and private water supply wells and public water supplies, and evaluate the risk to human health from contaminants in groundwater. Approximately one million Minnesotans rely on private wells and 70 percent of all Minnesotans rely on groundwater as their primary source of drinking water. Nitrate is a common contaminant found in many wells in Minnesota. MDH suggests testing your well every year or two for nitrate and at least once for arsenic. Contact you county MDH official for more information.

Nitrate Water Testing Program 1995-2005
Percent of Wells Exceeding Nitrate-N Standard



The map above presents results from the Minnesota Department of Agriculture's (MDA) Nitrate Water Testing Program 1995-2005. Based on 52,000 wells, it illustrates the percent of wells exceeding the 10 mg/L Nitrate-N Standard. The dark grey color indicates greater than 30 percent of samples exceeded the standard. Overall statewide, ten percent exceeded the standard (Birr et al., 2008).

How Safe is My Drinking Water?

National Tap Water Quality Database. Environmental Working Group
    http://www.ewg.org/tapwater/findings.php
US EPA Local Drinking Water Information
    http://www.epa.gov/safewater/dwinfo/index.html
Minnesota Department of Health
    http://www.health.state.mn.us/divs/eh/water/index.html
Minnesota Department of Health - Nitrates
    http://www.health.state.mn.us/divs/eh/wells/waterquality/nitrate.html
Minnesota Department of Agriculture - Drinking Water Protection in Agricultural Areas -
    http://www.mda.state.mn.us/protecting/waterprotection/drinkingwater.htm

MERCURY AND FISH

Mercury and Fish Consumption

The primary contaminants of concern in the Minnesota River Basin are mercury and polychlorinated biphenyls, or PCBs. In Minnesota, mercury contamination of fish is a well-documented problem. Mercury is tightly bound to proteins in all fish tissue, including muscle. There is no way to reduce the amount of mercury in a fish through cooking or cleaning it.

Current consumption advice for the Minnesota River shows minimum recommended restrictions for the upper portion of the basin (above Minnesota Falls) primarily due to mercury in fish. Below Minnesota Falls, fish are more likely to be contaminated with PCBs and carry more stringent consumption advice than the upper portion of the basin.

Fish Consumption Advisories

The Minnesota Department of Health (MDH) advises people to restrict their fish consumption due to mercury accumulation in sport fish from lakes and rivers. Large amounts of mercury in your body may harm your nervous system. The MDH issues fish consumption advisories for lakes and streams in Minnesota where fish have been tested. The advisories contain recommended rates of consumption based on contaminant levels in the fish. The Minnesota Department of Health provides two types of advice on how often fish

Is it Safe to Eat Fish?

Fish caught in the Minnesota River Basin may have elevated levels of mercury. The Department of Health website is your best resource to learn more about fish caught in particular rivers, streams, and lakes.

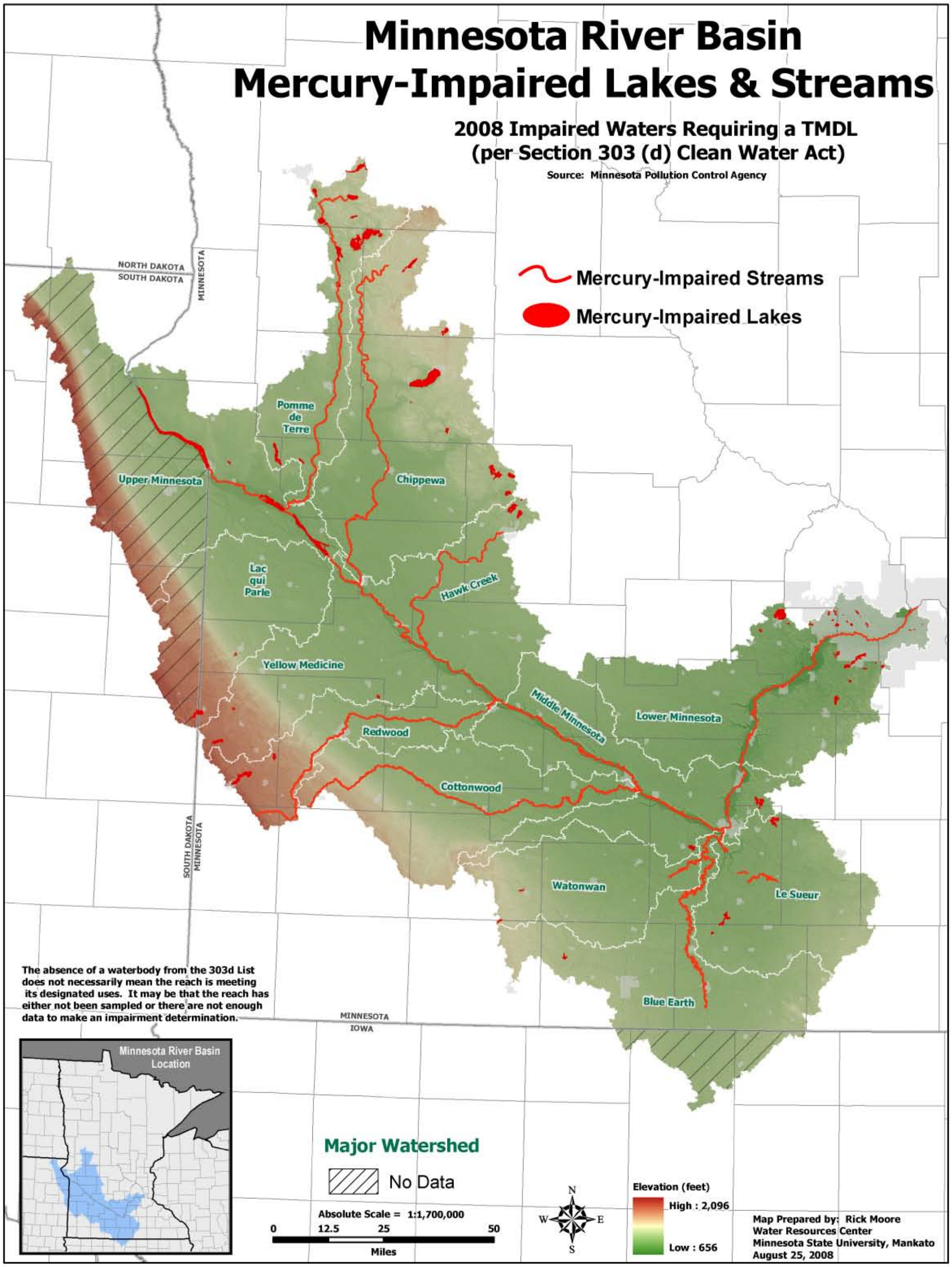
For more information: Minnesota Department of Health's fish consumption guidelines: http://www.health.state.mn.us/divs/eh/fish/index.html Consumption guidelines are also searchable by lake on the Department of Natural Resources Lake Finder website. http://www.dnr.state.mn.us/lakefind/index.html

Don't Eat

MDH advises avoiding Minnesota caught walleye longer than 20 inches, northern pike longer than 30 inches, and muskellunge. Nearly all fish and shellfish contain traces of methylmercury. However, larger fish that have lived longer have the highest levels of methylmercury because they've had more time to accumulate it. On the other hand, MDH advises that it is safe to eat Minnesota caught: sunfish, crappie, yellow perch, bullheads (one meal per week).

What is Mercury?

Mercury is a highly toxic element that is found both naturally and as an introduced contaminant in the environment. Mercury falls from the air and can accumulate in streams and oceans and is turned into methylmercury in the water. Although concentrations in water are very low, mercury accumulates through the aquatic food chain, resulting in high concentrations in fish that can threaten the health of people and wildlife. Fish absorb the methylmercury as they feed in these waters and so it builds up in them. It builds up more in some types of fish and shellfish than others, depending on what the fish eat, which is why the levels vary. Methylmercury can be especially harmful to unborn babies and young children. Sources of Mercury: The Mercury in Minnesota's fish comes almost entirely from atmospheric deposition, with approximately 90 percent originating outside the state. It comes from local, regional and global sources. Most of the mercury in the environment originates from human activities, including burning coal to produce electricity, processing taconite, and using mercury in products such as fluorescent lights, dental fillings, and some types of thermostats and switches.



The “Mercury Impaired Lakes and Streams” map above shows assessed water bodies that do not meet Minnesota water quality standards for mercury and are therefore listed on the Minnesota’s Impaired Waters 303(d) List. Learn more about impaired waters on the MPCA website: http://www.pca.state.mn.us/water/tmdl/tmdl-303dlist.html

What are E. coli Bacteria?

Escherichia coli (abbreviated as *E. coli*) are a large and diverse group of bacteria. *E. coli* is a type of fecal coliform bacteria which are associated with human or animal wastes. They are commonly found in the intestines of animals and humans. The presence of *E. coli* in water is a strong indication of sewage or animal waste contamination.

Redwood River, Ron Bolduan

E. coli are used as markers for water contamination. There are hundreds of strains of the bacterium *E. coli* and most strains are harmless and live in the intestines of healthy humans and animals. However, others can make you sick. Some kinds of *E. coli* can cause diarrhea, while others cause urinary tract infections, respiratory illness and pneumonia, and other illnesses. According to the EPA, E. coli O157:H7 is an emerging cause of foodborne and waterborne illness. This strain produces a powerful toxin and can cause severe illness.

For more information see, the Center for Disease Control and Prevention and EPA websites:
http://www.cdc.gov/nczved/dfbmd/disease_listing/stec_gi.html
EPA Drinking Water Contaminants
http://www.epa.gov/safewater/contaminants/ecoli.html

Sources of E. coli

Fecal coliform and *E. coli* bacteria found in rivers and streams comes from human, livestock, pet, and wildlife waste. Bacteria can be directly transferred to surface waters from noncompliant septic systems, wastewater treatment facility discharge points and urban stormwater systems. Sources include spills or runoff from feedlots or manure storage facilities, runoff from agricultural lands that receive manure applications, and direct deposition into waterways by wildlife or grazing animals. Statewide, amounts tend to be lower in the forested and wetland-rich areas of northern Minnesota, and higher in agricultural and more heavily populated areas (MPCA, 2008).

Standard/Criteria

State water quality standards for bacteria are designated by law to support full or partial body contact recreational uses such as swimming, wading, boating, and fishing. Per USEPA's suggestion, Minnesota recently changed its bacteria standard from fecal coliform to the *E. coli* standard. The rule revision replaced the fecal coliform with an *E. coli* standard. Minnesota's water quality standard for *E. coli* bacteria in streams states: "not to exceed 126 organisms per 100 milliliters (as a geometric mean of not less than 5 samples representative of conditions within any calendar month), nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters." The standards apply April 1 through October 31. When they are exceeded, the water is considered impaired and not fully supporting the designated use. People using impaired waters for recreation are at risk for exposure to pathogens.

Seven Mile Creek, Kimberly Musser

Bacteria Levels and Swimming

Disease-causing organisms (pathogens) in water bodies are difficult to measure, so indicators like *E. coli* bacteria are used to illustrate the likelihood that a water body contains pathogens. Although viruses and protozoa cause many of the illnesses associated with swimming in polluted water, monitoring for *E. coli* will tend to indicate fecal contamination. Untreated sewage or livestock waste released into the water can expose swimmers to bacteria, viruses, and protozoa. Children, the elderly, and people with weakened immune systems are most likely to develop illnesses or infections after swimming in polluted water. The most common illness associated with swimming in water polluted by sewage is gastroenteritis. The illness can have one or more of the following symptoms: nausea, vomiting, stomachache, diarrhea, headache, and fever. Other minor illnesses associated with swimming include ear, eye, nose, and throat infections.

Findings

In the Minnesota River Basin, streams monitored for *E. coli* are often found to exceed water quality standards. *E. coli* levels are elevated across the entire Minnesota River Basin with over 90 percent of monitored streams exceeding health standards (126 cfu/100 ml for *E. coli)*. Data show the highest concentrations in the eastern portion of the Basin. Many streams require a 80 to 90 percent reduction in bacteria levels to meet standards. Many of the rivers and streams across the basin have been listed as "impaired waters" and not suitable for swimming because they exceed water quality standards for bacteria (see the "Minnesota River Fecal Coliform Bacteria Impaired Streams" Map).

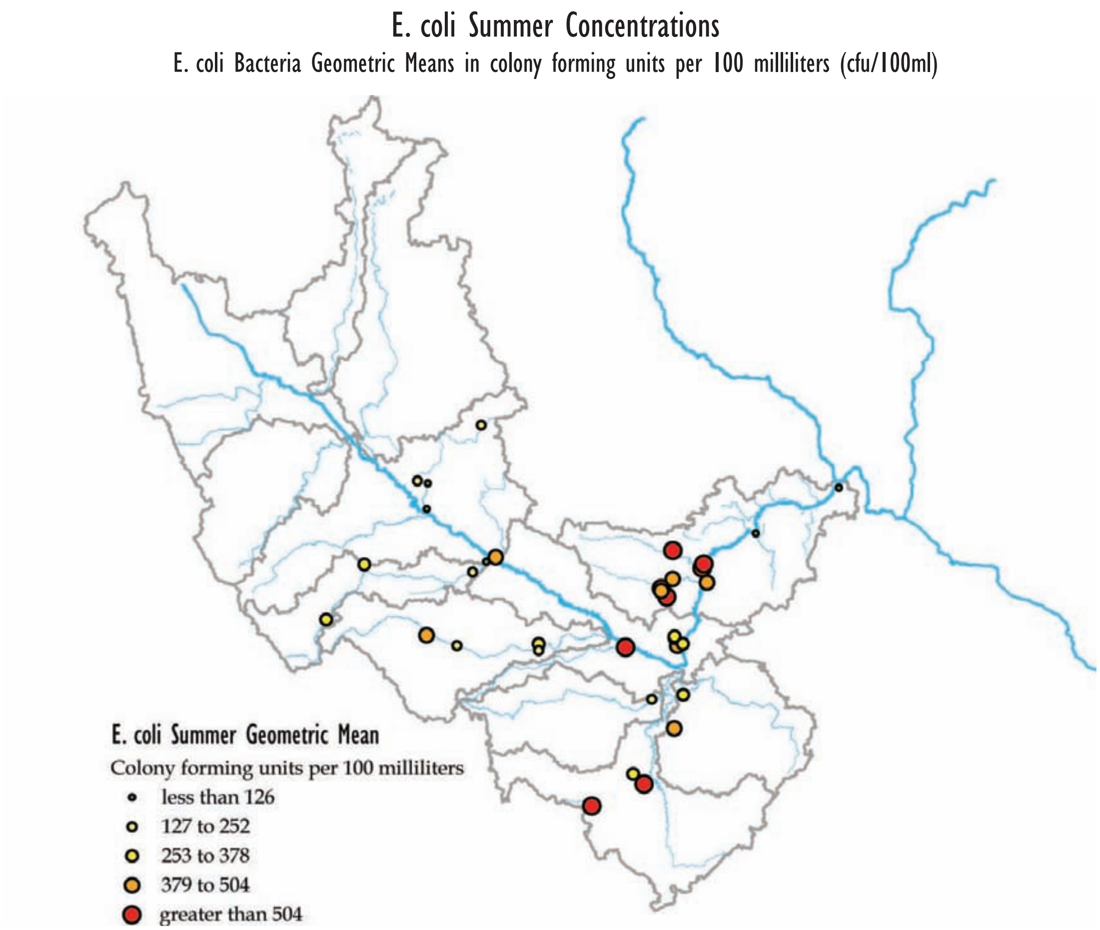


Figure 15. The map at left shows summer E. coli concentrations (geometric mean) across the basin for sites with at least 20 samples. The water quality standard for E. coli is 126 cfu/100ml. Monitoring data show the majority of reaches sampled exceed the standard.

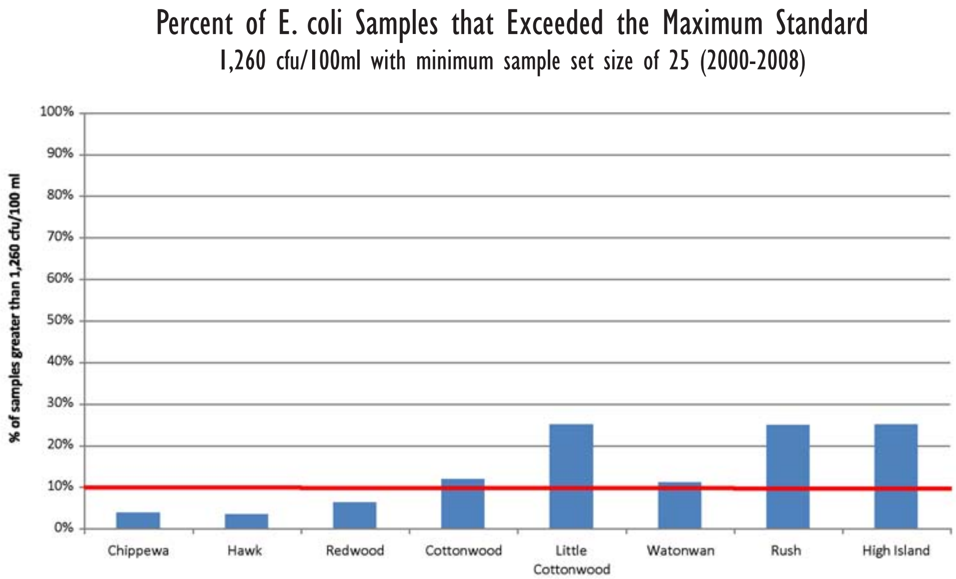


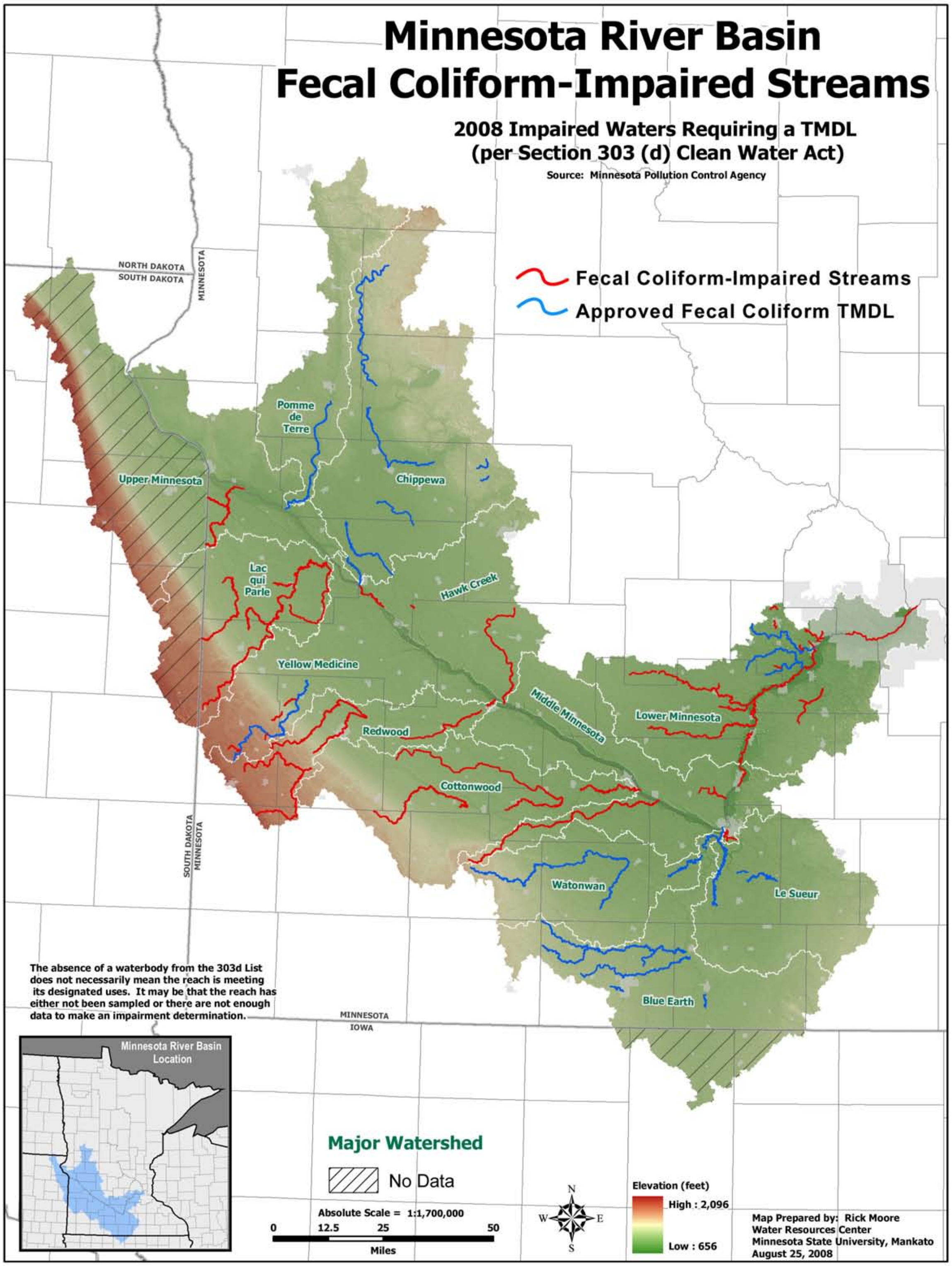
Figure 16. The graph above depicts the percent of *E. coli* samples that exceeded the maximum water quality standard of 1,260 colony forming units per 100 mL. The general pattern is less exceedences in the western portion of the Basin than the eastern. Little Cottonwood, Rush and High Island have an average of over 20 percent of samples exceeding the maximum standard. The water quality standard is exceeded if more than ten percent (indicated by red line) of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters.

E. coli Monthly Geometric Means - Major Tributary Sites

Monthly E. coli Bacteria Geometric Means

Stream	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Sum GM	# Samples	Years
Chippewa		30			82			144	26	2007-08
Hawk	119	38	152		87	143	293	110	58	2007-08
Redwood	51	80	101	39	151	143	194	84	64	2000-08
Cottonwood	76	55	359		39	47	879	74	42	2006-07
Little Cottonwood	77	190	1,139	445	360	1,214	267	734	100	2002-2008
Watonwan	51	136	235	160	207	256	267	202	126	2001-2008
Blue Earth	42							86	18	2008
Le Sueur	62							116	21	2008
Rush	86	178	525	325	300	261	1,382	416	141	2003-2008

Figure 17. The table above shows monthly geometric means for E. coli bacteria at tributary sites with data available. Yellow indicates below the standard of 126 cfu/100mL. Red indicates over the standard. For many months, monitoring sites have well-exceeded the standard.



The "Fecal Coliform-Impaired Streams" map above shows assessed water bodies that do not meet Minnesota water quality standards for bacteria and are therefore listed on the Minnesota's Impaired Waters 303(d) List. Learn more about impaired waters on the MPCA website: http://www.pca.state.mn.us/water/tmdl/tmdl-303dlist.html

Note: The 2008 listing includes fecal coliform but the MPCA recently changed the bacterial water quality standard from fecal coliform to E. coli bacteria.

PESTICIDES

Pesticides Detected in Lakes, Rivers and Streams

The Minnesota Department of Agriculture (MDA) is the lead state agency for most aspects of pesticide and fertilizer regulatory functions. The MDA Monitoring Unit collects pesticide samples from multiple stream locations in the Minnesota River Basin. Pesticide monitoring data indicate the seasonal presence of several chemicals sometimes at levels of concern. The most commonly detected pesticides in the Minnesota River Basin are delineated in the table below.

Commonly Detected Pesticides (Analytes)	Pesticide Type	Trade Name Examples
Acetochlor	Herbicide	Surpass, Harness
Atrazine	Herbicide	Atrazine, Aatrex
s-Metolachlor	Herbicide	Dual, Brawl

In order to evaluate the presence of commonly used pesticides in the rivers and streams, the MDA conducts an annual statewide survey of selected surface water sites. These studies are organized by Pesticide Monitoring Region (PMR). The Minnesota River Basin roughly lies within PMR 6. 8. and 10.

Source: MDA, 2008

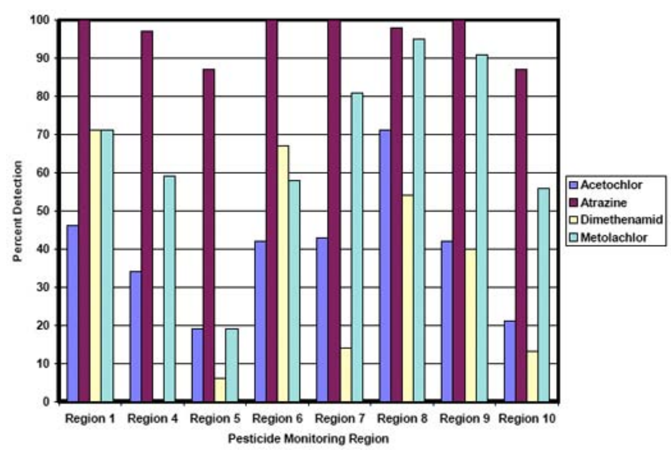
Minnesota Department of Agriculture

What are Pesticides?

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Although often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator.

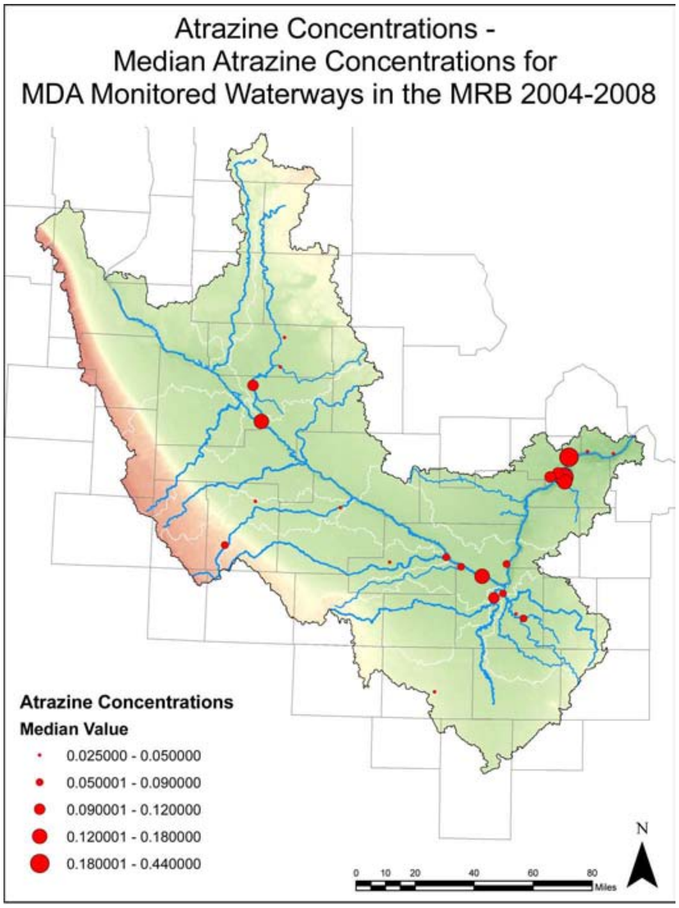
Health Risks & Pesticides

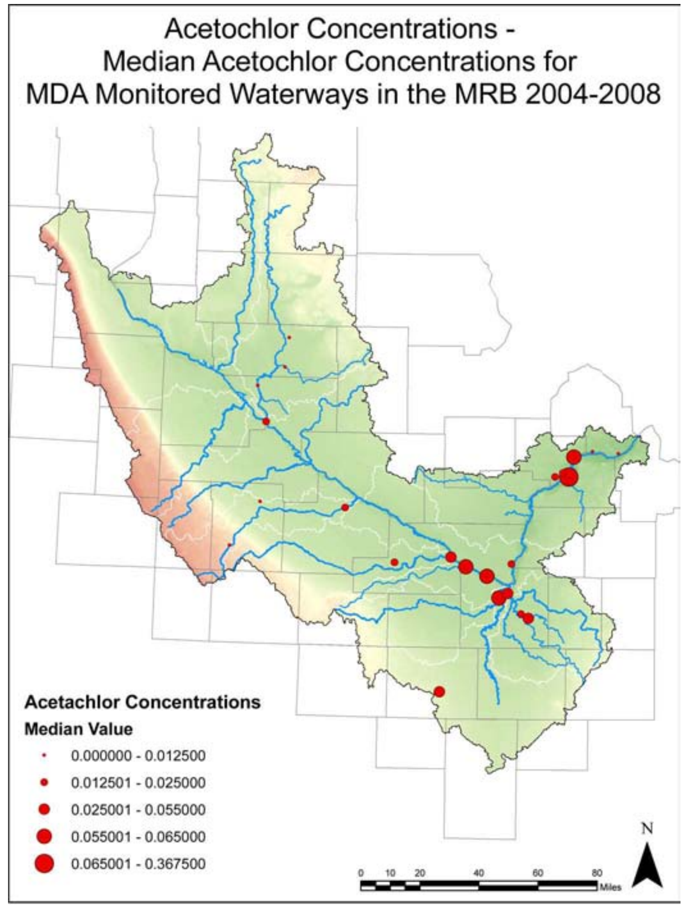
You can learn more by visiting the National Pesticide Information Center (NPIC): http://npic.orst.edu/az.html#G
NPIC provides objective, science-based information about pesticides and pesticide-related topics to enable people to make informed decisions about pesticides and their use.

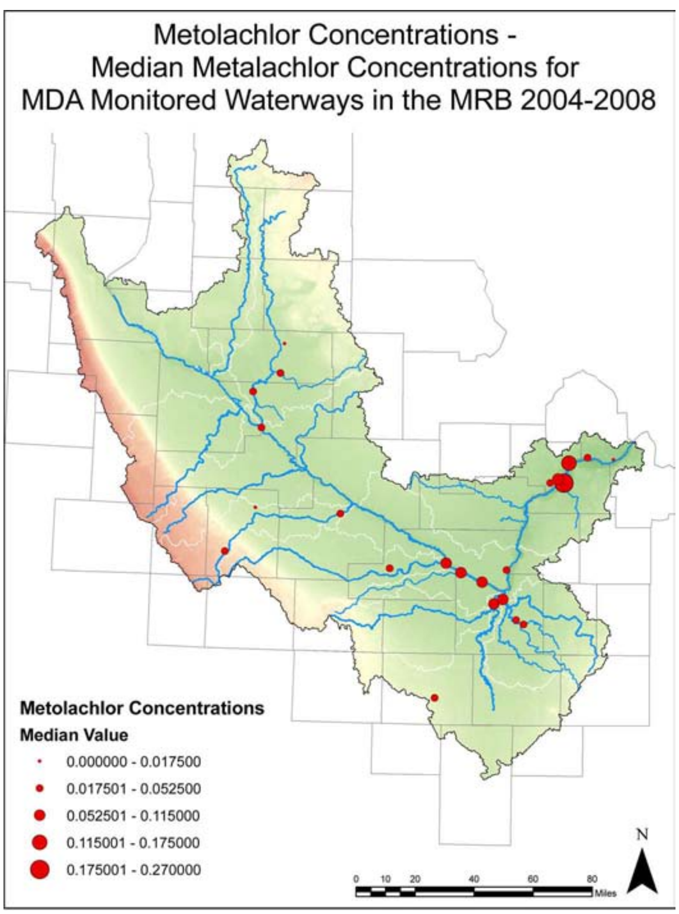


Source: MDA, 2008

Figure 18. The chart above shows detection patterns by Pesticide Monitoring Region (PMR) based on 57 sites in 2008. Atrazine was detected in virtually all samples and Metolachlor also had a high detection rate followed by Acetochlor.







The maps on this page show the median concentration of Atrazine, Metolachlor, and Acetochlor for sites MDA monitored in the Basin from 2004-2008. The increasing west-to-east gradient is especially visible in the acetochlor and metolachlor maps.

Pesticide concentration for most compounds typically peak in May and June in the rivers of south central Minnesota, although it is not unusual to see peak metolachlor concentrations earlier in the year (March or April) because the product is commonly applied in the fall.

Criteria/Standard

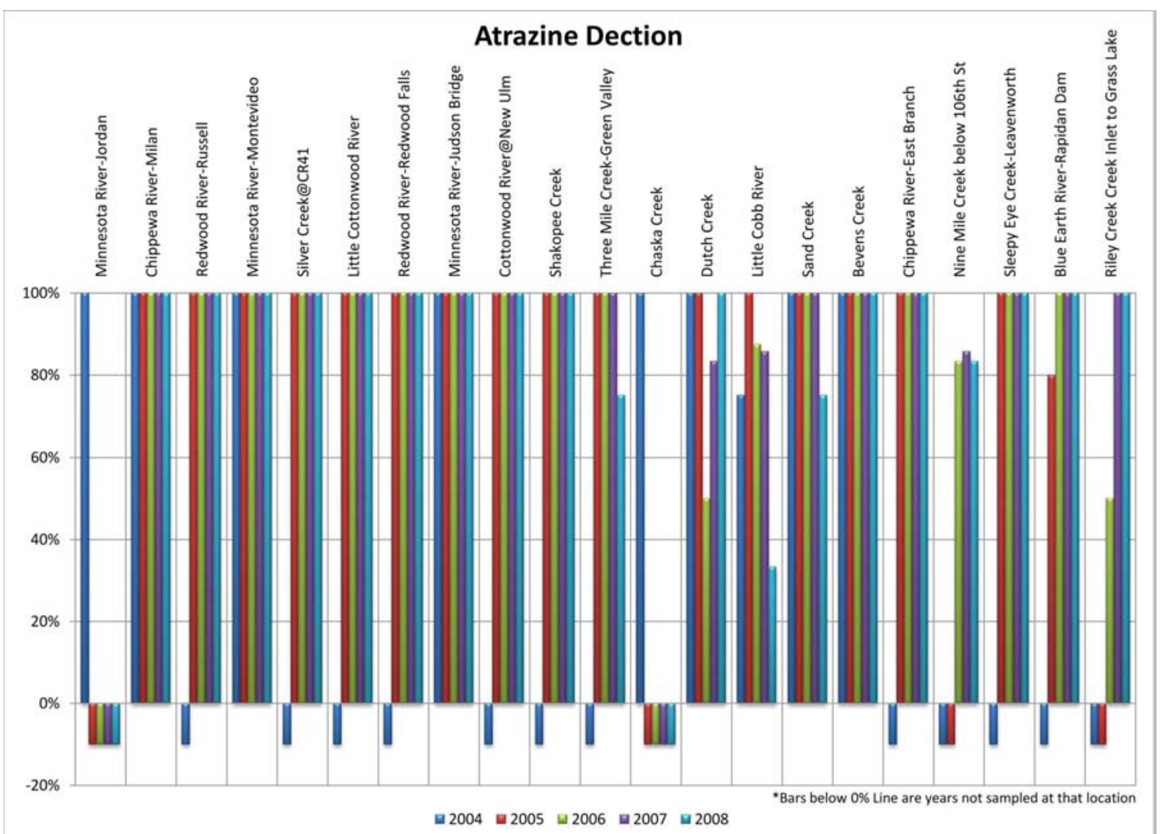
	Pesticide Reference Value
Acetochlor	3.6 ug/L (2008 standard; 4-day aquatic toxicity)
Atrazine	10 ug/L standard (4-day aquatic toxicity)
Metolachlor	23 ug/L (2008 standard; 4-day aquatic toxicity)

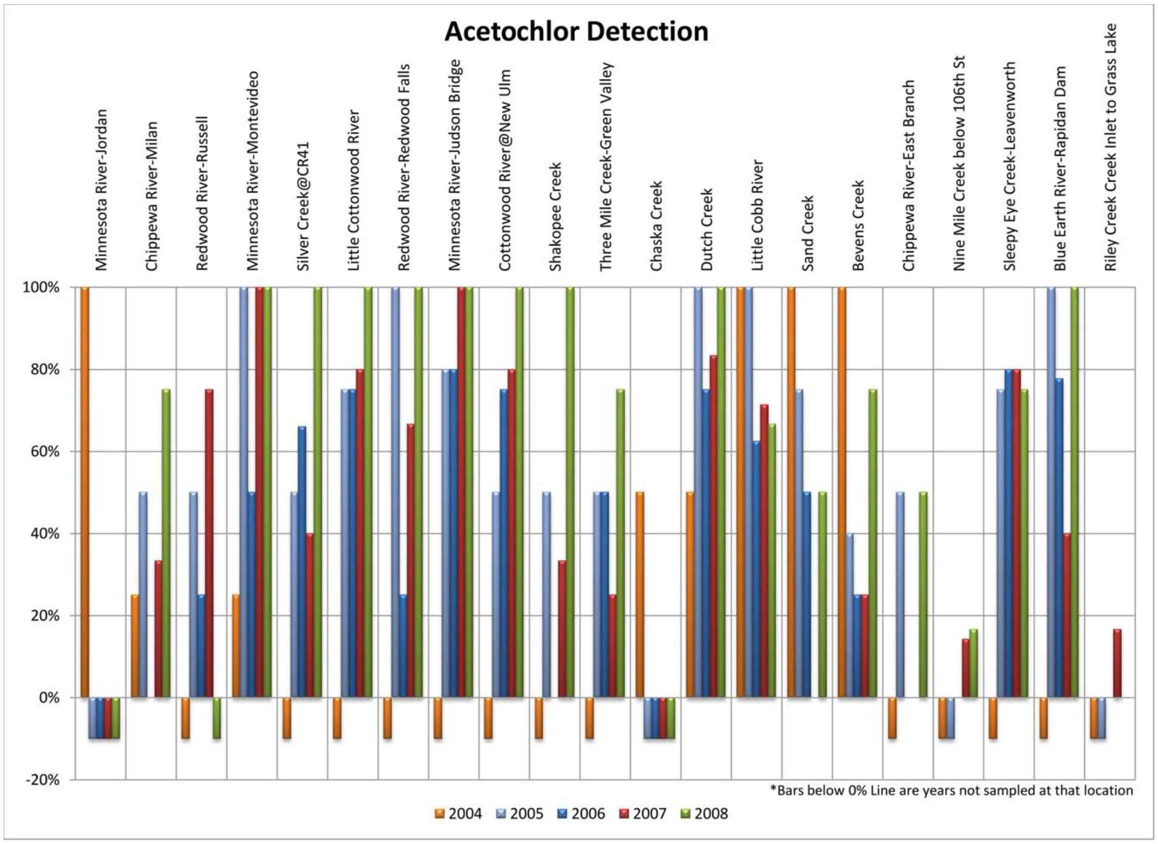
The following table is an excerpt from The Minnesota Department of Agriculture's (MDA) *2008 Water Quality Monitoring Report.* The report presents ground and surface water quality data for pesticides and fertilizers. Summary data for the Le Sueur River sampling for Acetochlor, Atrazine, and Metolachlor are presented below.

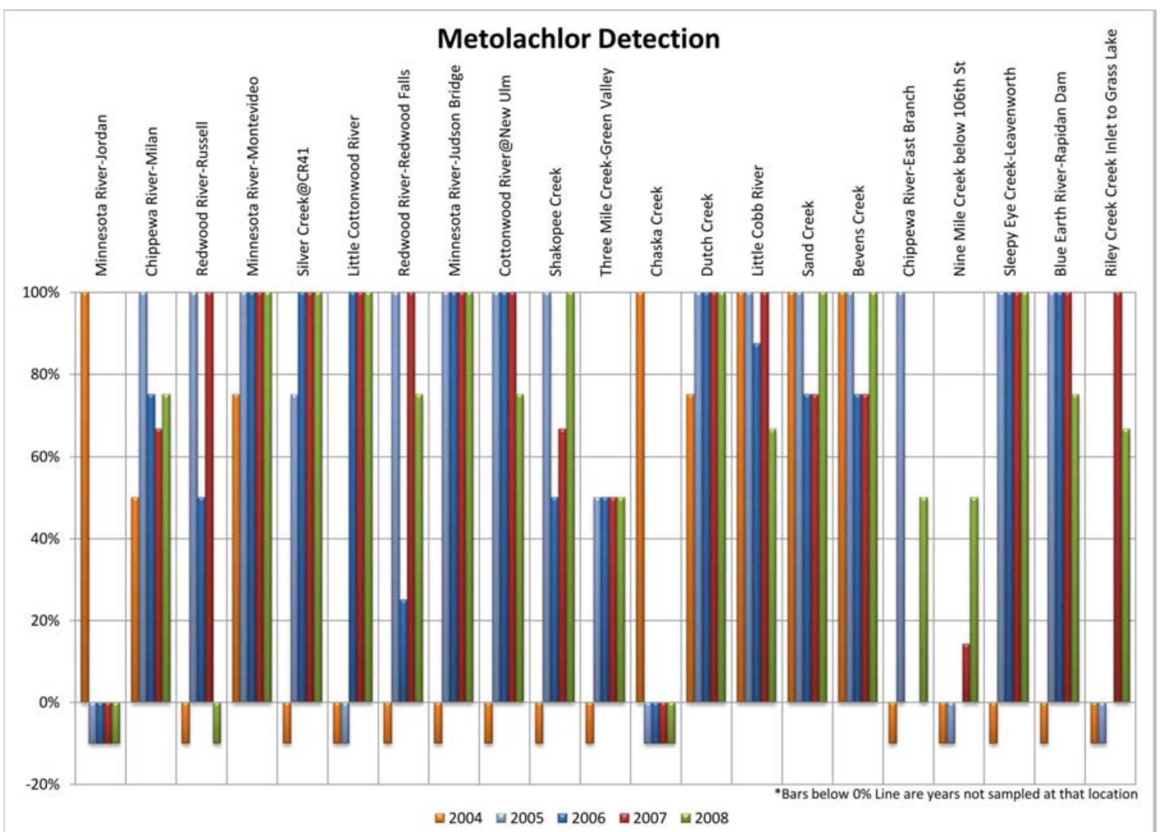
Le Sueur River

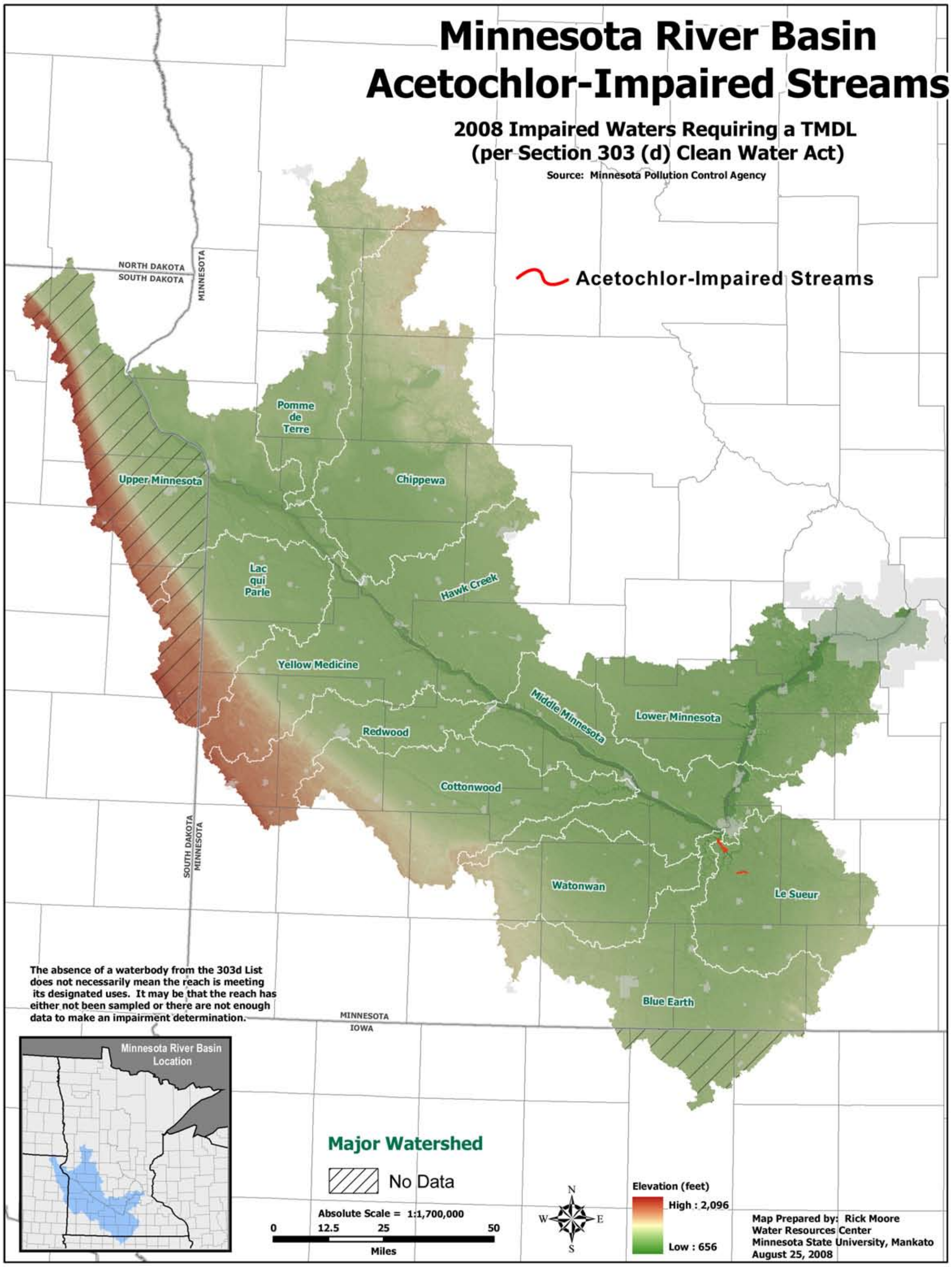
	Acetochlor (ug/L)			**Atrazine (ug/L)**			**Metolachlor (ug/L)**		
Year	Maxi-mum	Median	Mean	Maxi-mum	Median	Mean	Maxi-mum	Median	Mean
1999	3.63	0.09	0.45	2.04	0.04	0.30	0.70	0.13	0.19
2000	3.55	0.11	0.58	2.80	0.48	0.61	1.41	0.21	0.29
2001	9.00	0.13	1.02	3.80	0.10	0.48	1.44	0.22	0.38
2002	7.10	0.08	0.48	2.97	0.24	0.64	0.65	0.10	0.15
2003	2.38	0.09	0.34	0.43	0.07	0.11	0.68	0.08	0.16
2004	1.52	0.06	0.28	1.95	0.22	0.40	1.30	0.11	0.20
2005	5.30	P	0.40	0.72	0.07	0.14	0.98	0.07	0.16
2006	1.24	0.13	0.25	0.29	0.05	0.07	0.24	P	0.07
2007	1.50	P	0.24	0.47	0.08	0.12	0.57	P	0.11
2008	2.05	P	0.27	0.66	P	0.09	1.54	0.10	0.22

Atrazine is commonly detected in streams and rivers around the state. The Atrazine Detection graph below depicts MDA monitored sites in the basin from 2004-2008. The Acetochlor and Metolachlor Detect graphs on the following page are also based on MDA 2004-2008 data.




Acetochlor Detection
Minnesota River-Jordan
Chippewa River-Milan
Redwood River-Russell
Minnesota River-Montevideo
Silver Creek@CR41
Little Cottonwood River
Redwood River-Redwood Falls
Minnesota River-Judson Bridge
Cottonwood River@New Ulm
Shakopee Creek
Three Mile Creek-Green Valley
Chaska Creek
Dutch Creek
Little Cobb River
Sand Creek
Bevens Creek
Chippewa River-East Branch
Nine Mile Creek below 106th St
Sleepy Eye Creek-Leavenworth
Blue Earth River-Rapidan Dam
Riley Creek Creek Inlet to Grass Lake
100%
80%
60%
40%
20%
0%
-20%
*Bars below 0% Line are years not sampled at that location
2004
2005
2006
2007
2008


Metolachlor Detection
Minnesota River-Jordan
Chippewa River-Milan
Redwood River-Russell
Minnesota River-Montevideo
Silver Creek@CR41
Little Cottonwood River
Redwood River-Redwood Falls
Minnesota River-Judson Bridge
Cottonwood River@New Ulm
Shakopee Creek
Three Mile Creek-Green Valley
Chaska Creek
Dutch Creek
Little Cobb River
Sand Creek
Bevens Creek
Chippewa River-East Branch
Nine Mile Creek below 106th St
Sleepy Eye Creek-Leavenworth
Blue Earth River-Rapidan Dam
Riley Creek Creek Inlet to Grass Lake
100%
80%
60%
40%
20%
0%
-20%
*Bars below 0% Line are years not sampled at that location
2004
2005
2006
2007
2008



Two streams, the Le Sueur River and the Little Beauford Ditch, violated the Minnesota Pollution Control Agency (MPCA) Chronic Surface Water Quality Standard for Acetochlor and are included on the Minnesota 2008 Impaired waters list (also known as the 303(d) list). These streams violated the Acetochlor surface water standard of an average Acetochlor concentration exceeding 3.6 µg/L over four days (96 hours). Learn more about impaired waters on the MPCA website:
http://www.pca.state.mn.us/water/tmdl/tmdl-303dlist.html

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State of the River reports and executive summaries are available online at:
http://mrbdc.mnsu.edu