River and Stream Water Quality

Purpose of the Report

The Metropolitan Council is charged under state law with developing a comprehensive regional development guide for the seven-county Twin Cities Metropolitan Area that minimizes the adverse impacts of growth. To help create a balance with respect to growth and adverse environmental impacts, the Minnesota Legislature has mandated the Council to assess the Metropolitan Area waters (rivers, streams and lakes) that have been polluted or that have the potential for pollution (MN Statutes 103F.721). This report assesses the metro area's ability to achieve the Council's goal of no adverse impact to water quality in 2009 by examining the river and stream water quality information collected by Metropolitan Council Environmental Services (MCES) and its partners.

This report includes summaries of the following for 2009:
- Select pollutant parameters
- Potential pollutant sources
- Mass balance of select pollutants within the Metropolitan Area for the three major drainage basins (Minnesota, Mississippi, St. Croix)
- Relative impact of tributary watersheds

Information related to assessments of the region's water supply and lake water quality can be found within supplemental Council publications 32-09-065 and 32-10-043, respectively.

Report Highlights

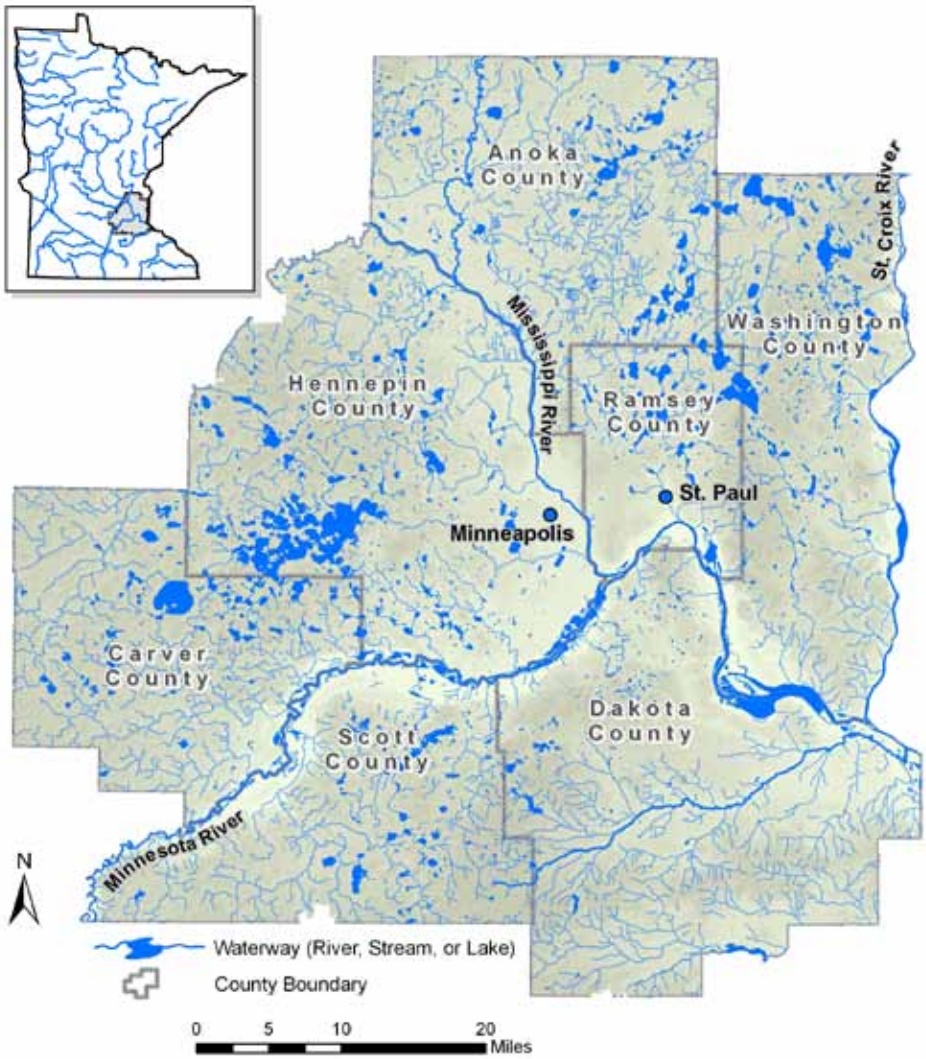
The Council's no-adverse-impact (NAI) goal states: "The quality of water leaving the Metropolitan Area is as good as the water quality entering the Metropolitan Area, and in compliance with federal and state regulations." To measure the achievement of this goal on an annual basis, water quality is expressed as an annual mass pollutant load. The total input pollutant loads, as contributed from the Mississippi River at Anoka, the Minnesota River at Jordan, and the St. Croix River at Stillwater can then be compared to the total output load from the Mississippi River near Red Wing. If the output pollutant load is less than the combined input pollutant loads, then the NAI goal is achieved. In 2009, the Council's NAI goal was met for total phosphorus, nitrate-nitrogen and total suspended solids.

When comparing the pollutant load contributions of the seven Metropolitan Council wastewater treatment plants with the contributions of the region's tributary watersheds, the influence of the treatment plants was greater in 2009, most likely due to below-normal river flows. These low flows resulted in plant effluents defining a greater share of the total flow and pollutant concentrations. Pollutant contributions from tributary watersheds were dependent on the type of pollutant and precipitation patterns across the Metropolitan Area.

In this Report:

Water Quality Partnerships & Collaboration

To achieve Metropolitan Council objectives related to surface water quality, Metropolitan Council Environmental Services (MCES) collaborates with various federal, state, and local agencies and groups to evaluate the health of the water resources. The groups include the United States Geological Survey (USGS), University of Minnesota, Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), municipalities, watershed districts, and watershed management organizations (WMOs). In addition, MCES relies on the United States Environmental Protection Agency (EPA) and MPCA to provide guidance related to federal and state wastewater treatment plant effluent regulations and limits for the Council's seven treatment plants.



Hydrologic Network within the Metropolitan Area

Table 1: State Numeric Water Quality Standards for Evaluated Parameters within Rivers & Streams

Parameter	Numeric Limit
Total Phosphorus	No 2009 River Standard MCES Wastewater Treatment Plant (WWTP) Permit Limit 1 mg/L
Nitrate-Nitrogen	No 2009 River Standard No 2009 MCES WWTP Permit Limit
Dissolved Oxygen	2009 River Standard 5 mg/L daily average MCES WWTP Permit Limit 6 - 9 mg/L depending on flow conditions
E. Coli Bacteria	2009 River Standard 10% of monthly samples cannot exceed 1,260 organisms/100ml MCES WWTP Permit Limit average monthly count of 200 organisms/100ml
Turbidity	2009 River Standard 10 NTU (Class 2A waters), 25 NTU (Class 2B waters) daily maximum MCES WWTP Permit Limit 25 NTU daily maximum
Chloride	2009 Chronic River Standard 230 mg/L (four-day average concentration) No 2009 MCES WWTP Permit Limit

Surface Water Stressors

Within the seven-county Twin Cities Metropolitan Area (Metropolitan Area), various stressors influence the health of our rivers and streams. The EPA and MPCA are responsible for enforcing water quality standards for these stressors to ensure that designated beneficial uses are met, such as drinking water, aquatic life and human recreation. The majority of water quality impairments are currently managed through Total Maximum Daily Load (TMDL) plans, which aim to identify sources and limit pollutants entering the surface waters through a watershed assessment approach. To help determine whether Metropolitan Area rivers meet water quality standards, the following parameters were evaluated by MCES in 2009:

Total Suspended Solids

Elevated total suspended solid (TSS) concentrations within surface waters can decrease water clarity, transport excess nutrients such as phosphorus, deplete oxygen levels and decrease biotic diversity. Suspended solids can come from various sources on the landscape including construction sites, lawns, agricultural fields, gullies, ravines and stream banks. Total suspended solids impairment is regulated by turbidity, but is also commonly measured as TSS. The Minnesota turbidity chronic (long-term concentration) standard for class 2A (coldwater fisheries) waters is 10 nephelometric turbidity units (NTU), while the standard for class 2B (cool or warm water fisheries) waters is 25 NTU.

Dissolved Oxygen

Dissolved oxygen (DO) in the water is necessary to support aquatic life. The two main sources of oxygen in surface water are the atmosphere and aquatic plants. Factors such as high temperature, low flow, increased pollution, or a muddy channel bottom can decrease DO levels. A daily DO concentration greater than 5 mg/l meets the current Minnesota standard.

Nutrients

Nitrate nitrogen and phosphorus are nutrients that are necessary for aquatic growth; however, excessive nutrient contributions can accelerate plant growth in our rivers and streams, leading to over-enrichment or eutrophication. Eutrophication can lead to algal blooms, decreased oxygen levels, and fish kills. Currently there are no numeric standards for phosphorus and nitrate in rivers and streams; however, numeric phosphorus limits do exist for most WWTP effluent. Nutrients are currently managed through a watershed assessment approach, which aims to quantify and limit nutrients entering the surface waters.

Pathogens

Pathogens are organisms found in human or animal fecal matter. Sources can include failing septic tanks, untreated wastewater, livestock, pets and wildlife. The pathogen that is commonly measured is E. coli bacteria, and an average monthly E. coli count greater than 126 organisms per 100 ml exceeds the regulatory standard between April 1 and October 31.

Chloride

Elevated concentrations in rivers and streams can be toxic to aquatic and terrestrial organisms. The main sources of chloride – road deicing and water softeners – are typically found in the urban environment. A Minnesota stream is deemed impaired if the chronic (four-day average) chloride concentration is greater than 230 mg/L and/or the instantaneous one-hour average concentration is greater than 860 mg/L, the levels that are toxic to aquatic life.

Emerging Contaminants

Emerging contaminants, such as pharmaceuticals, personal care products, and perfluorooctane sulfonates (PFOS) are a relatively new concern within the region's rivers and streams. Pharmaceuticals and personal care products can be routed into rivers and streams through wastewater effluent. These are often introduced into the wastewater through human consumption and disposal. Concentrations of pharmaceuticals from wastewater effluent have been found in small concentrations and can cause reproductive problems in aquatic life. Another concern is PFOS, a fluorinated compound that originates from industrial chemicals and has the tendency to build up within fish tissue. The EPA cites PFOS as carcinogenic to animals. The impact that pharmaceuticals, personal care products, and PFOS have on human and aquatic health is being actively researched throughout the United States. No data, analysis, or standards related to emerging contaminants are provided in this report.

Potential Sources of Water Pollution

Sources of water quality pollution vary throughout the Metropolitan Area. For regulatory purposes as defined by the federal Clean Water Act, the source of water pollution is categorized as point or non-point.

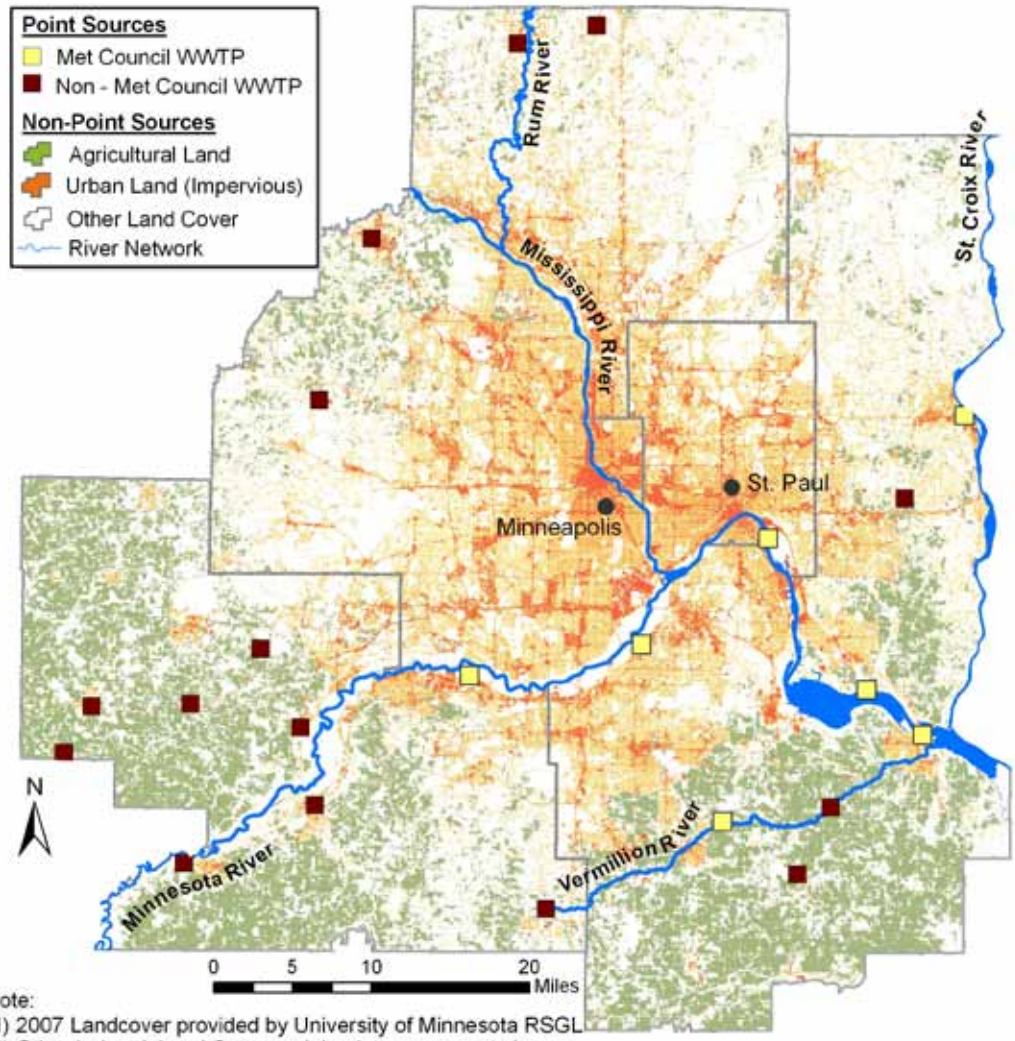
Point-source Pollution

Point-source pollution originates from an identifiable end-of-pipe source, typically treated or untreated wastewater, called effluent, from wastewater treatment plants or industrial facilities. MCES owns and operates the region's seven largest treatment plants, which discharge treated effluent into the Mississippi, Minnesota and St. Croix rivers. Additionally, there are approximately 200 other MPCA permitted point sources such as industrial facilities and small municipal WWTPs throughout the Metropolitan Area.

Nonpoint source (NPS) Pollution

NPS pollution is the transport of pollutants across the landscape via runoff into waterways. NPS pollution begins with the alteration of the landscape caused by agricultural production and urban development. NPS pollution can originate from diffuse sources such as stormwater runoff from parking lots and lawns, and erosion from farm fields, construction areas, and highways.

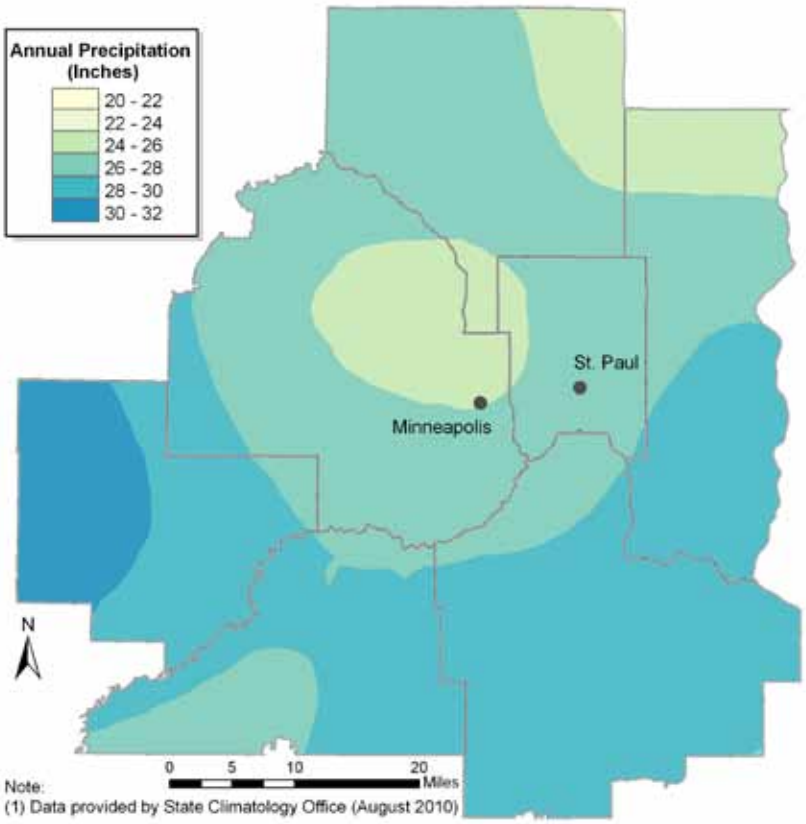
Point Source (Wastewater Treatment Effluent) and Potential Non-Point Lands within the Metropolitan Area



Note:
(1) 2007 Landcover provided by University of Minnesota RSGL
(2) Other Industrial and Commercial point sources not shown

Factors Affecting Water Quality in 2009

The origins of water pollution are dependent on multiple variables including precipitation, topography, land management and population throughout the region.

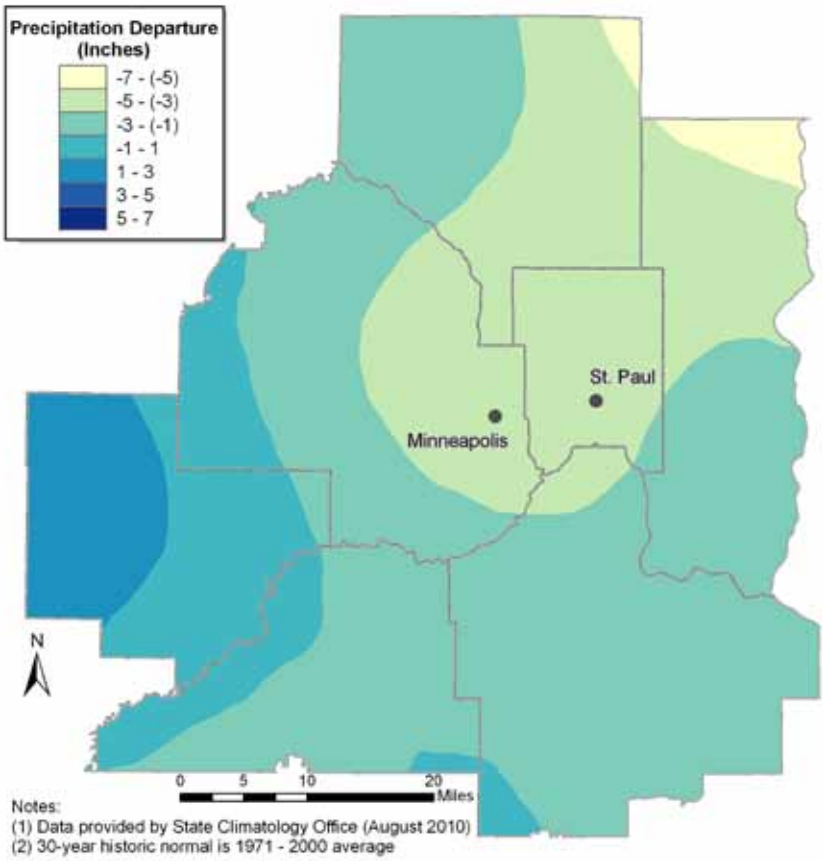


2009 Annual Precipitation Distribution within the Metropolitan Area

Precipitation

The transport of pollutants to rivers and streams is mainly driven by precipitation. The amount, intensity and timing of precipitation influences water quality. For example, heavy rainfall or rapid snowmelt events increase the risk of water pollution from agricultural and urban runoff. During dry years, river and stream flows decline and water quality deterioration may occur when nutrients and contaminants become more concentrated in reduced volumes.

In 2009, the Metropolitan Area experienced below-normal annual precipitation, with only 25 inches recorded at the Minneapolis-St. Paul International Airport (MSP), compared to the 30-year annual average of 30.20 inches. Much of the Metropolitan Area measured 2009 annual and monthly precipitation totals below the 30-year averages. Of the 25 inches recorded at MSP in 2009, the majority (48%) of the precipitation fell in August and October. A two-day event in August recorded 3.06 inches of rain (12% of the annual total). The condensed timing of the rainfall events in August and October leads to increased runoff potential.



2009 Annual Precipitation Departure from 30-year Normal within the Metropolitan Area

Topography

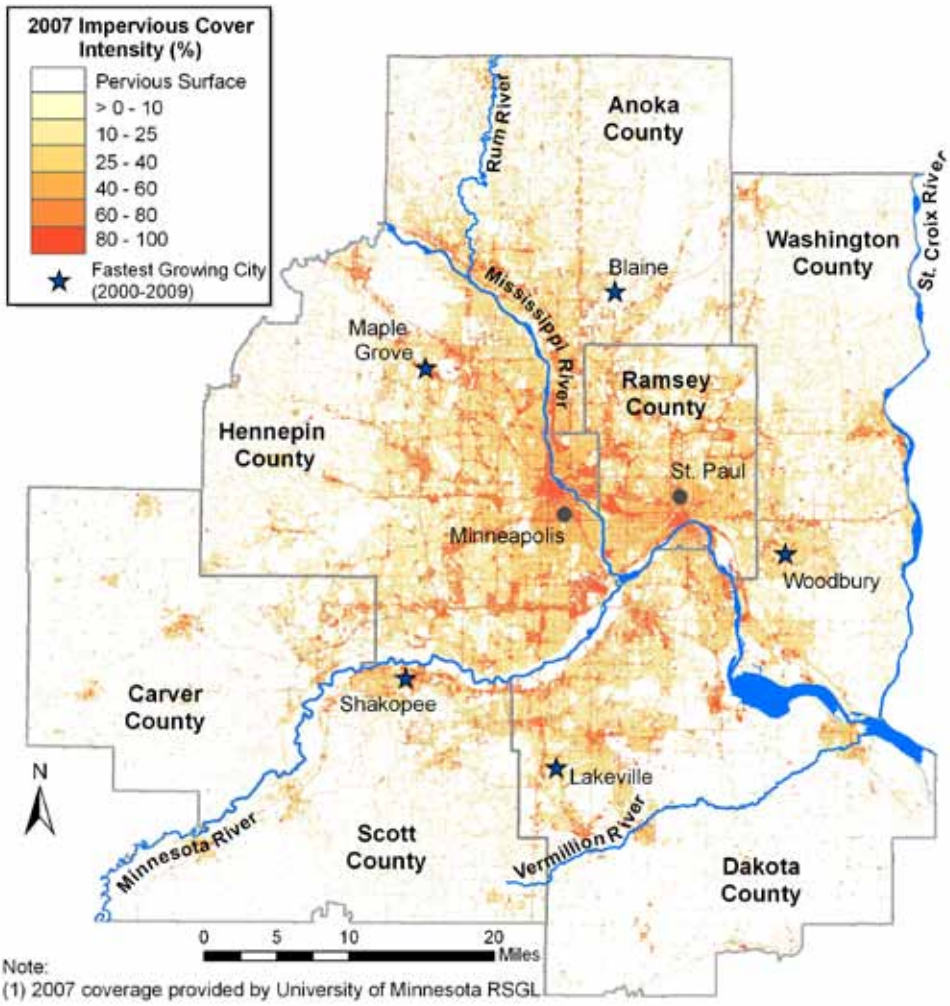
Increased slopes can lead to greater runoff and erosion potential because water can travel more quickly down a steeper slope. When coupled with an impervious land surface such as a street, the amount of runoff entering streams and rivers increases, as does erosion along the stream and river banks. Within the Metropolitan Area, steep gradients can be found within the major river valleys as well as within stream sections prior to entering the major rivers.

Land Use

The pressure of population growth and economic development on the Metropolitan Area's landscape influences runoff, wastewater effluent volumes, and ultimately the pollution loads entering the rivers and streams. The modification of the landscape to accommodate city streets, new subdivisions, and tilled agricultural land can change the hydrologic balance. Rain that falls onto grassland or forests infiltrates into the ground and contributes to the groundwater supply. Infiltration is less prevalent on tilled, agricultural lands or in urban areas with impervious surfaces such as traditional parking lots or roofs. The runoff water from agricultural and impervious lands concentrates and carries a large number of pollutants that would otherwise remain on the landscape if the rainwater were able to infiltrate into the ground.

Based on 2007 satellite imagery processed by the University of Minnesota, the Metropolitan Area is influenced by an impervious, urbanized landscape (33% of the region) and agriculture (20% of the region). The remaining land is generally characterized as grassland, forests, wetlands and open water. As an indicator of landscape changes, population estimates within the seven-county Metropolitan Area show an average annual increase of 13,357 households between 2000 and 2009; however, the growth in 2009 slowed to 8,546 additional households. The communities that have experienced the greatest population growth during the past 10 years include Shakopee, Blaine, Woodbury, Lakeville, and Maple Grove. Regionally, Hennepin County noted the greatest population increase, followed by Dakota and Scott counties in the southern Metropolitan Area.

Impervious Cover Percentage and Population Growth within the Metropolitan Council Area



MCES Water Quality Data

MCES and its partners have an extensive network of river and stream monitoring sites to detect seasonal and annual changes in water quality throughout the Metropolitan Area.

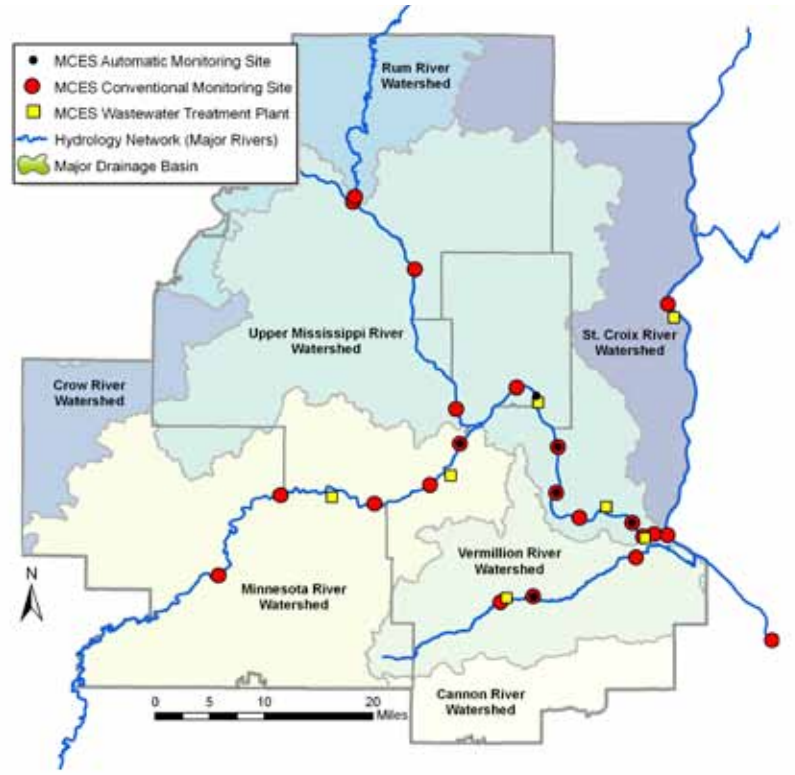
The river monitoring program began in 1927 after the Mississippi River was declared a public health hazard. Today the river monitoring program serves a wide array of needs, including:

- Collection of water quality data to meet National Pollutant Discharge Elimination System (NPDES) permit requirements for MCES treatment plants
- Assessment of the performance and effectiveness of MCES treatment plants
- Measurement of compliance with state water quality standards and criteria

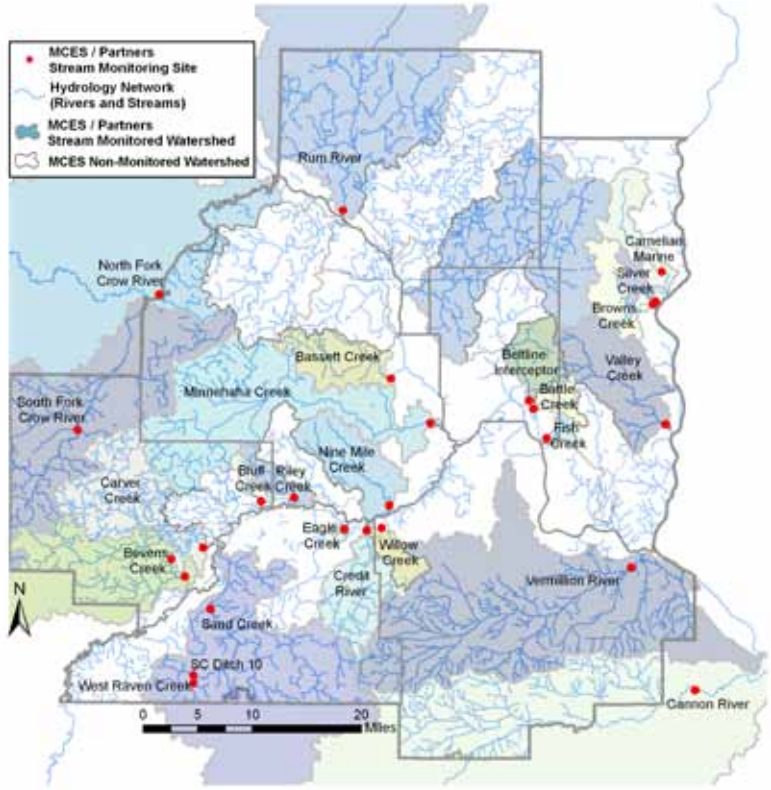
The river monitoring sites are placed at locations where the rivers enter and exit the Metropolitan Area, as well as upstream and downstream of the MCES treatment plants. The stations identify the pollutants within the three major river drainages: the Minnesota, Mississippi, and St. Croix. In 2009, the health of these rivers was evaluated through automatic water quality monitoring at six sites and collection of conventional water quality samples at 23 sites.

The smaller tributary streams that contribute to the river water quality are monitored for three reasons. The first is to determine the extent of nonpoint-source pollution loading from tributaries to the Mississippi, Minnesota and St. Croix rivers, as required by Minnesota Statute 103F.721. The second is to assist the MPCA and watershed districts or watershed management organizations by providing the information necessary for the development of total maximum daily loads (TMDLs) for these tributary watersheds, required by Minnesota Statute 473.157. The third reason is to evaluate the effectiveness of watershed management practices for reducing nonpoint-source pollution and improving water quality in streams and rivers. In 2009, flow and various water quality parameters were monitored at 26 stations on 25 Metropolitan Area streams.

MCES River Monitoring Stations within the Metropolitan Area



MCES Stream Monitoring Stations within the Metropolitan Area



Did the Metropolitan Area achieve the Council's goal of no adverse impact (NAI) in 2009?

The Council's no-adverse-impact (NAI) goal states: "The quality of water leaving the Metropolitan Area is as good as the water quality entering the Metropolitan Area, and in compliance with federal and state regulations." To measure the achievement of this goal on an annual basis, water quality is expressed as an annual mass pollutant load. The total input pollutant loads, as contributed from the Mississippi River at Anoka, the Minnesota River at Jordan, and the St. Croix River at Stillwater can then be compared to the total output load from the Mississippi River near Red Wing. If the output pollutant load is less than the combined input pollutant loads, then the NAI goal is achieved. In 2009, the Council's NAI goal was met for total phosphorus, nitrate-nitrogen and total suspended solids. Note that the pollutant loads can vary from year to year due to annual differences in precipitation (e.g., drought years versus flood years), land-use changes, and in-river processes. In addition, watersheds within the region where pollutant reductions are occurring may be offset by other watersheds contributing more.

MCES River Assessment Sites within the Metropolitan Area

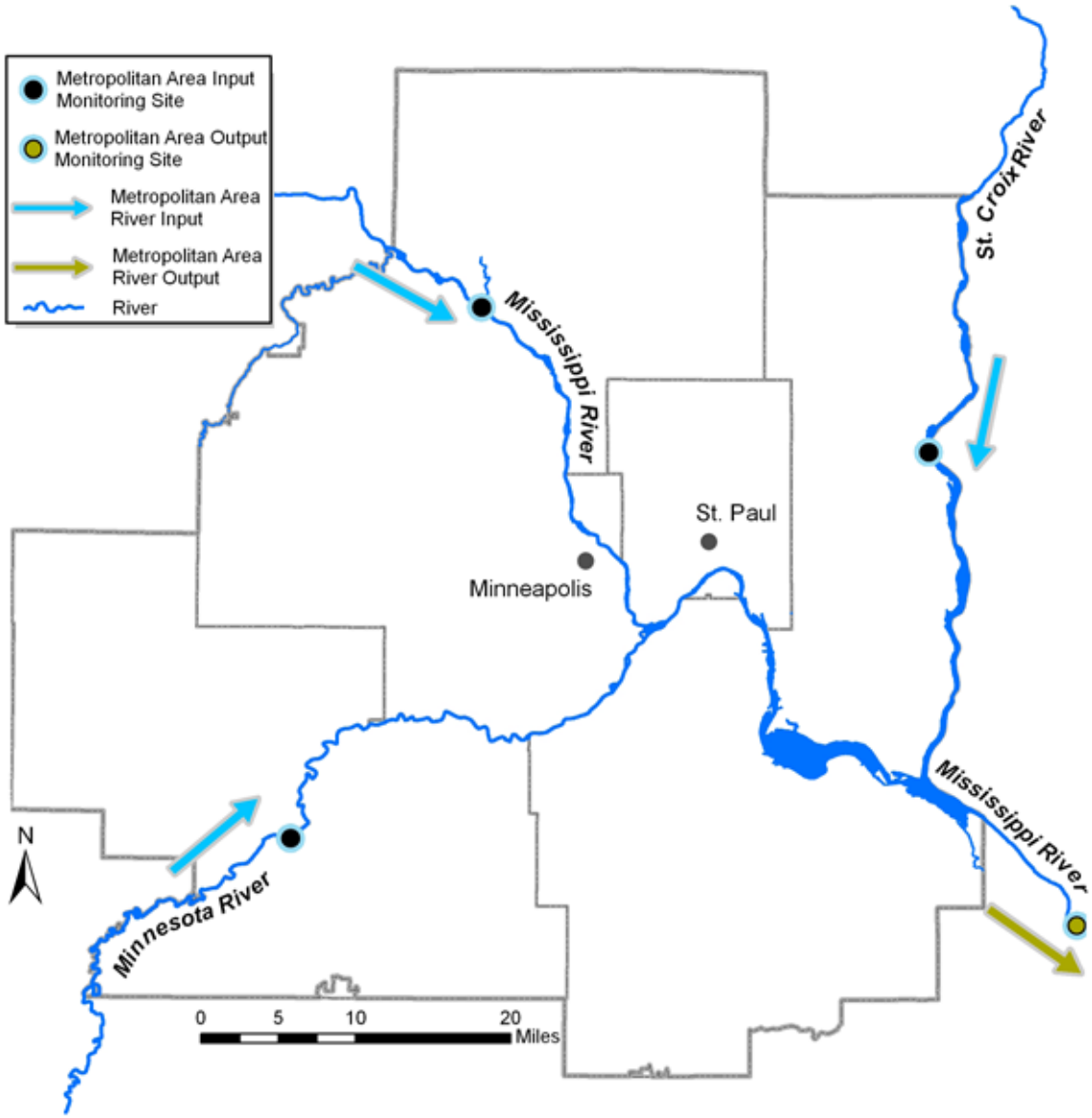


Table 2: Nutrient Loads (tons) Entering and Leaving the Metropolitan Area in 2009

	Metropolitan Area Inputs				**Metropolitan Area Output**	
Parameter	Mississippi River at Anoka	Minnesota River at Jordan	St. Croix River at Stillwater	Total Input	Mississippi River above Red Wing	2009 Net Change (%) (Output–Input)
Total Phosphorus (% Contribution)	**778** 42%	**929** 50%	**157** 8%	**1,864**	**1,874**	0 %
Nitrate-Nitrogen (% Contribution)	**9,465** 35%	**16,753** 61%	**1,027** 4%	**27,245**	**27,069**	-1 %
Total Suspended Solids (% Contribution)	**122,631** 19%	**483,937** 76%	**28,863** 5%	**635,431**	**558,455**	-12 %

In general, there has been a decreasing trend in Metropolitan Area total phosphorus (TP) contributions over the past 20 years. In 2009, there was approximately an equal amount of TP leaving the Metropolitan Area as entering. Of the three basins contributing to the Metropolitan Area, the Minnesota River Basin contributed the greatest amount of TP (50%). The NAI goal for TP was reached in 2009; however, below-normal precipitation and in-river deposition within the Metropolitan Area may have assisted in the achievement.

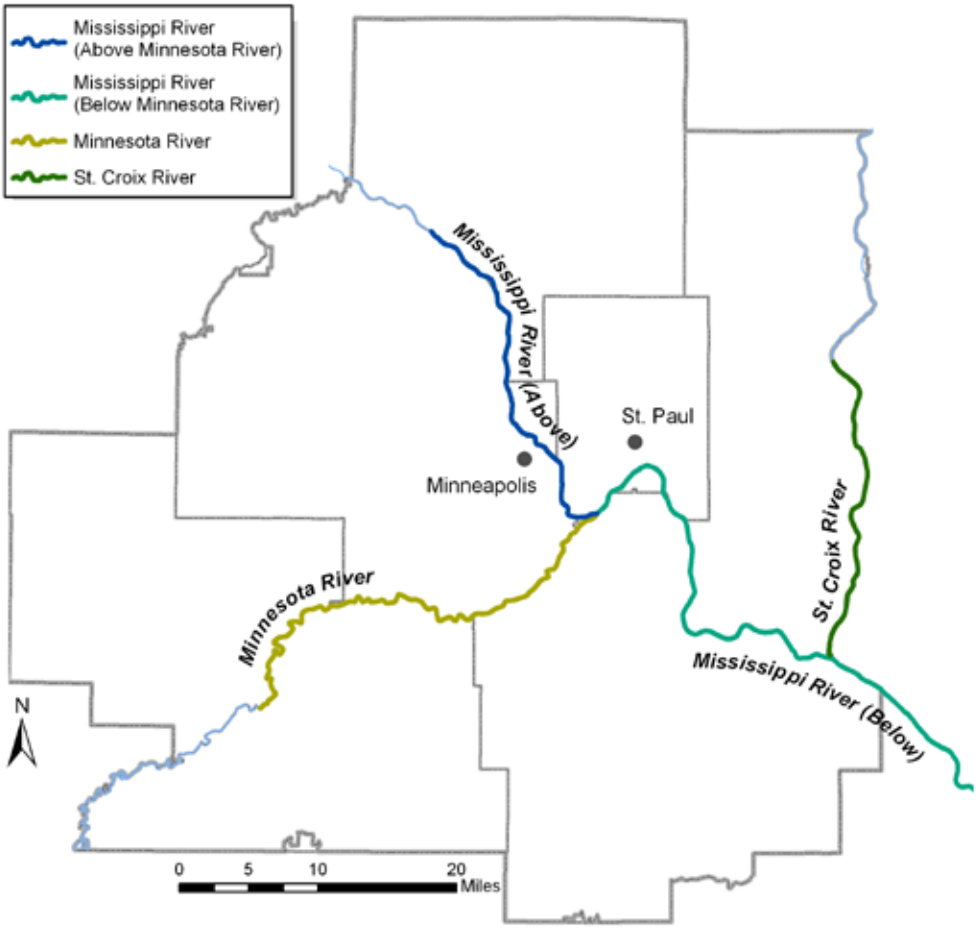
There has been a static trend in Metropolitan Area nitrate-nitrogen contributions over the past 20 years. In 2009, there was approximately an equal amount of nitrate leaving the Metropolitan Area as entering. Of the three basins contributing to the Metropolitan Area, the Minnesota River Basin contributed the greatest amount of nitrate (61%). The NAI goal for nitrate was reached in 2009; however, below-normal precipitation and denitrification within the Metropolitan Area may have assisted in the achievement.

There has been a decreasing trend in Metropolitan Area suspended sediment contributions over the past 20 years and the NAI goal has been achieved for the majority of the years during that time. As with phosphorus and nitrate, the Minnesota River Basin contributed the greatest amount of total suspended sediment (76%). The decrease in total suspended sediment leaving the Metropolitan Area is likely a combined result of improved management practices and the process of deposition within the river system, particularly in the pooled areas upstream of the lock and dams.

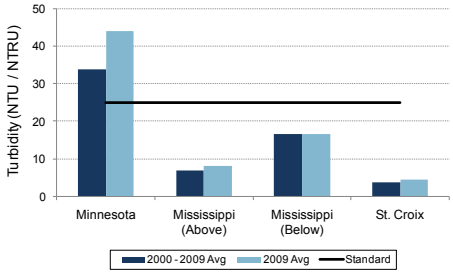
Did Metropolitan Area rivers meet state water quality standards in 2009?

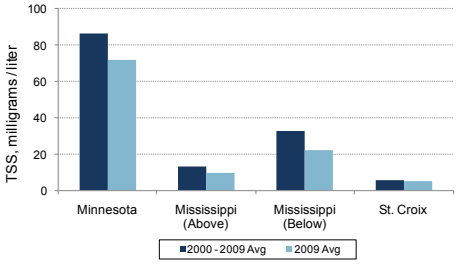
The results shown below are indicative of the 2009 and 10-year average (2000-2009) concentrations of several water quality variables within four separate river reaches (Mississippi River above Minnesota River confluence, Mississippi River below Minnesota River confluence, Minnesota River, and the St. Croix River). Concentrations of these variables can be compared to state numeric water quality standards where applicable. The variables examined include total suspended solids, dissolved oxygen, total phosphorus, nitrate-nitrogen, bacteria and chloride. Although annual and long-term average concentrations of these variables are presented, extreme conditions (i.e. storm events or droughts) can cause concentrations to fluctuate greatly.

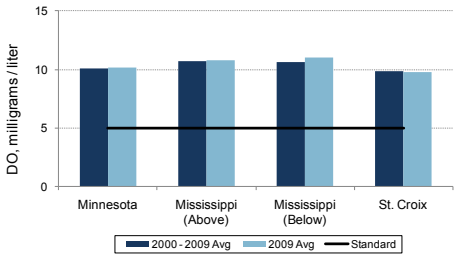
MCES River Assessment Reaches within the Metropolitan Area



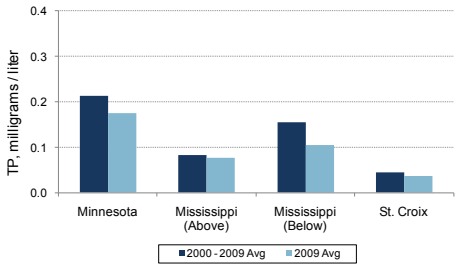
Turbidity / Total Suspended Solids (TSS) – The 2009 average daily turbidity levels within the four river reaches monitored were at or above the 10-year average level. Only the Minnesota River exceeded the daily turbidity water quality standard of 25 NTU. The average daily TSS concentrations were lower than the 10-year average, likely a result of below-normal precipitation and river flows. The Minnesota River is the primary TSS contributor within the Metropolitan Area. Currently there is no statewide water quality standard for TSS.



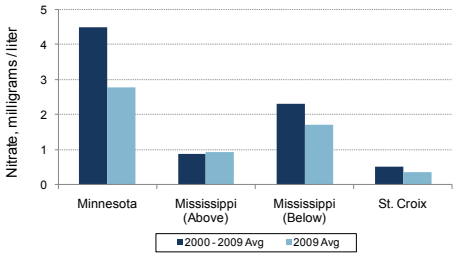




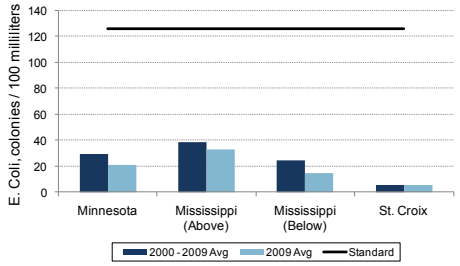
Dissolved Oxygen (DO) - The 2009 average daily DO concentrations met the 5 mg/L daily minimum concentration standard and were comparable to the 10-year average concentrations for the four river segments. Of the 631 river DO measurements in 2009, only four late summer daily samples from the Minnesota River were below the 5 mg/L threshold.



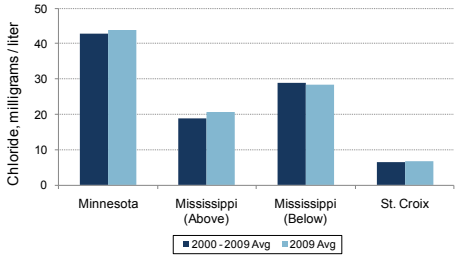
Total Phosphorus (TP) - The average 2009 TP concentrations for the four river reaches were below the 10-year averages for these river reaches. An overall river water quality standard for total phosphorus does not exist; however, a site-specific standard for Metropolitan Area rivers is currently being established through the Lake Pepin TMDL process.



Nitrate - In general, 2009 nitrate-nitrogen concentrations were at or below the 10-year average concentrations for the river reaches within the Metropolitan Area. An overall river water quality standard for nitrate does not exist; however, if the water source is directly used for drinking water, the nitrate concentration must not exceed 10 mg/L.



Bacteria - Average monthly 2009 concentrations of Escherichia coli (E. coli) bacteria were well below the average monthly water quality standard of 126 organisms per 100 ml, indicating favorable conditions for recreational use at these locations. Of the 385 samples collected in 2009, only one sample from the Minnesota River at Jordan exceeded the daily standard of 1,260 organisms per 100 ml.



Chloride - Average daily 2009 chloride concentrations were near the 10-year average daily concentration. The 2009 and 10-year average chloride concentrations were well below the chronic water quality standard of 230 mg/L.

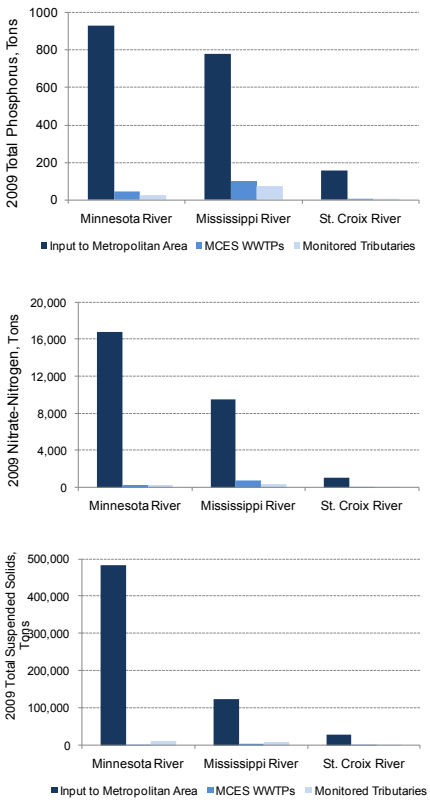
How did MCES treatment plant pollutant load contributions compare to watershed pollutant load contributions in 2009?

In addition to determining if Metropolitan Area rivers achieved no-adverse-impact goals and met water quality standards in 2009, an assessment of the Metropolitan Area pollutant loads contributing to the river reaches was conducted to help identify potential corrective actions. Two pollution categories were examined: the point-source pollutant loads from the seven MCES wastewater treatment plants, and the pollutant loads contributed by Metropolitan Area tributaries, as defined by a combination of non-point and point-source pollution. In addition, the respective river assessment reach load input was shown for comparison to the Metropolitan Area MCES treatment plant and tributary inputs.

Of the 31 tributary watersheds that are monitored in the Metropolitan Area, 24 tributary watershed contributions, with a total area of 3,252 mi^2, are within the confines of the three major river assessment reaches. In 2009, 2,957 mi^2 (91%) of these contributing tributaries were monitored by MCES or its partners. The other 9% of the Metropolitan Area tributaries were located within the river corridor (beige colored areas on map) and were not monitored. The seven treatment plants discharge effluent into the major rivers of the Metropolitan Area. Two of the plants contribute effluent to the Minnesota River, four to the Mississippi River, and one to the St. Croix River.

The influence of the MCES treatment plants was greater than usual in 2009, most likely due to below-normal river flows, which resulted in treatment plant effluents defining a greater percentage of the total flow and pollutant concentrations. In addition, tributaries within the river corridor were not monitored, likely resulting in an underestimation of the total tributary input. In 2009, total phosphorus and nitrate loads from MCES treatment plants exceeded the respective load contributions from Metropolitan Area tributaries, with the exception of nitrate loads in the Minnesota and St. Croix rivers. The total suspended solids loads were much higher from tributary sources than from the treatment plants. Historically the treatment plants TSS contributions have been minimal in comparison to the contributions from tributary watersheds.

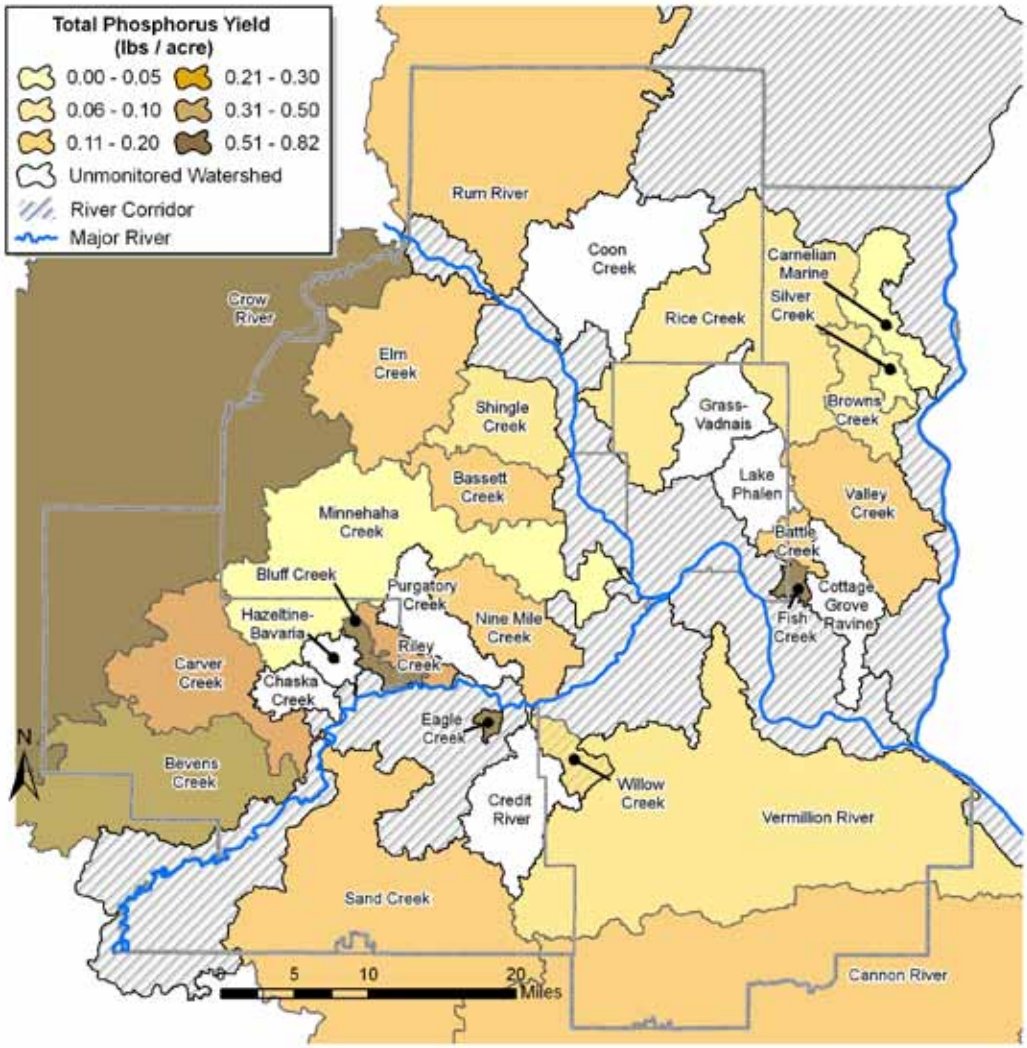
Tributary and MCES WWTP Contributions within the Metropolitan Area



Which Metropolitan Area tributaries yielded the largest contribution of TP, TSS, NO3, and Cl in 2009?

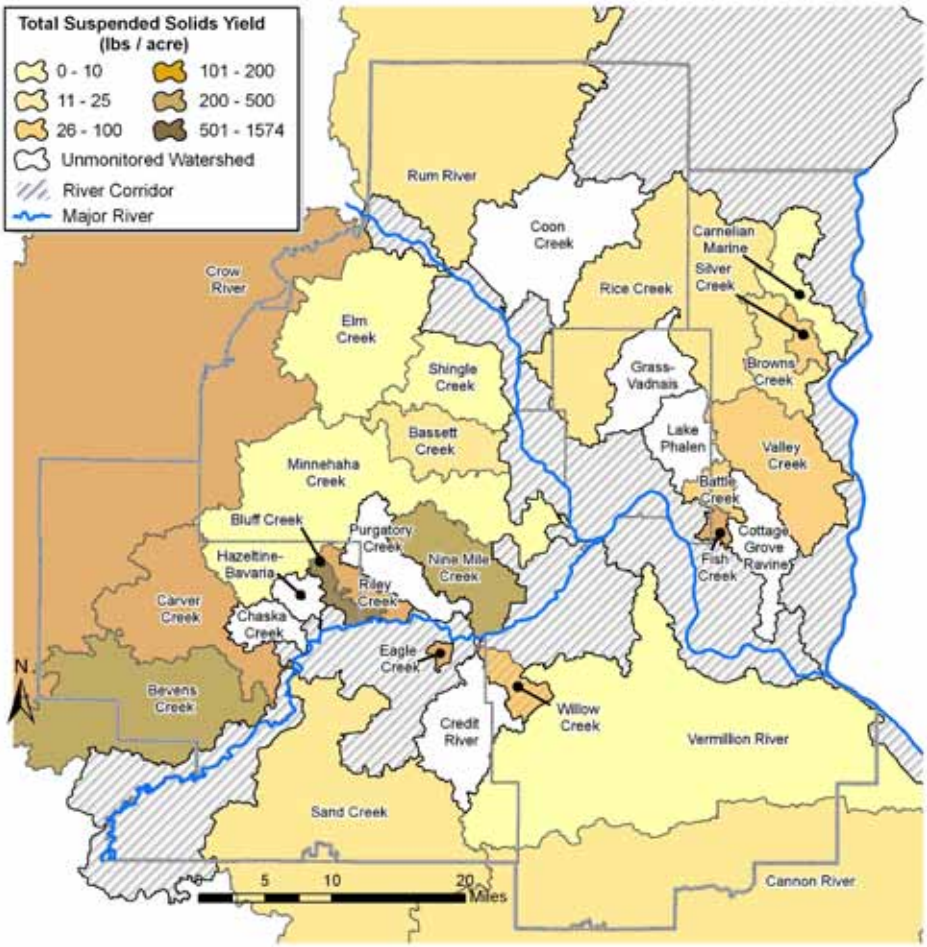
Of the 31 tributary watersheds that extend into the Metropolitan Area, 23 had adequate monitoring data for the calculation and evaluation of pollutant yields in 2009. A pollutant yield is determined by dividing the pollutant load (mass) by the contributing watershed area, allowing a relative comparison to be made between watersheds. Pollutant yields are primarily a function of soil type, land use, landscape characteristics, and the amount, timing, and intensity of precipitation. Due to below-normal precipitation in 2009, the 2009 pollutant yields are likely not representative of the long-term average yields.

2009 Total Phosphorus Contributions by Tributary Watersheds within the Metropolitan Area

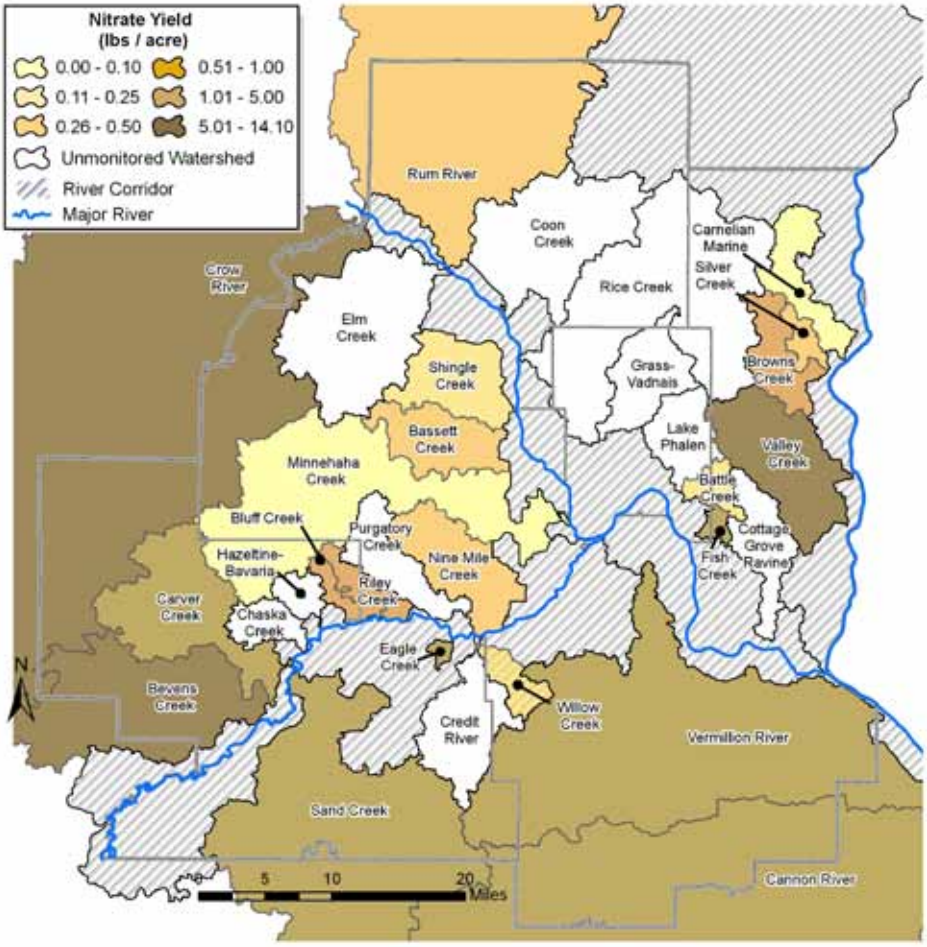


Total phosphorus yields in 2009 ranged from 0.02 lbs per acre in the Minnehaha Creek watershed to 0.52 lbs per acre in the Bluff Creek watershed. Total phosphorus yields in 2009 were highest in the Bluff, Eagle and Fish Creek watersheds relative to the other 20 tributary watersheds. Total suspended solids (TSS) yields ranged from 2 lbs per acre in the Minnehaha Creek watershed to 1,574 lbs per acre in the Bluff Creek watershed. By yield, the highest TSS contributors included the Bluff, Bevens and Nine Mile Creek watersheds in the Minnesota River Basin. Nitrate yields ranged from 0.03 lbs per acre in the Minnehaha Creek watershed to 14 lbs per acre in the Valley Creek watershed. By yield, the highest nitrate contributors included the Valley Creek, Bevens Creek and Crow River watersheds. Elm Creek and Rice Creek watersheds were not monitored for nitrate. Chloride yields in 2009 ranged from 5.72 lbs per acre in the Silver Creek watershed to 452 lbs per acre in the Eagle Creek watershed. The highest chloride contributors in 2009 included the Eagle Creek, Fish Creek and Bluff Creek watersheds. It is important to note that some watersheds, such as Eagle Creek, receive a large amount of their flow from groundwater, resulting in a relatively large contributing area compared to what was used to determine the pollutant yield cited in this report.

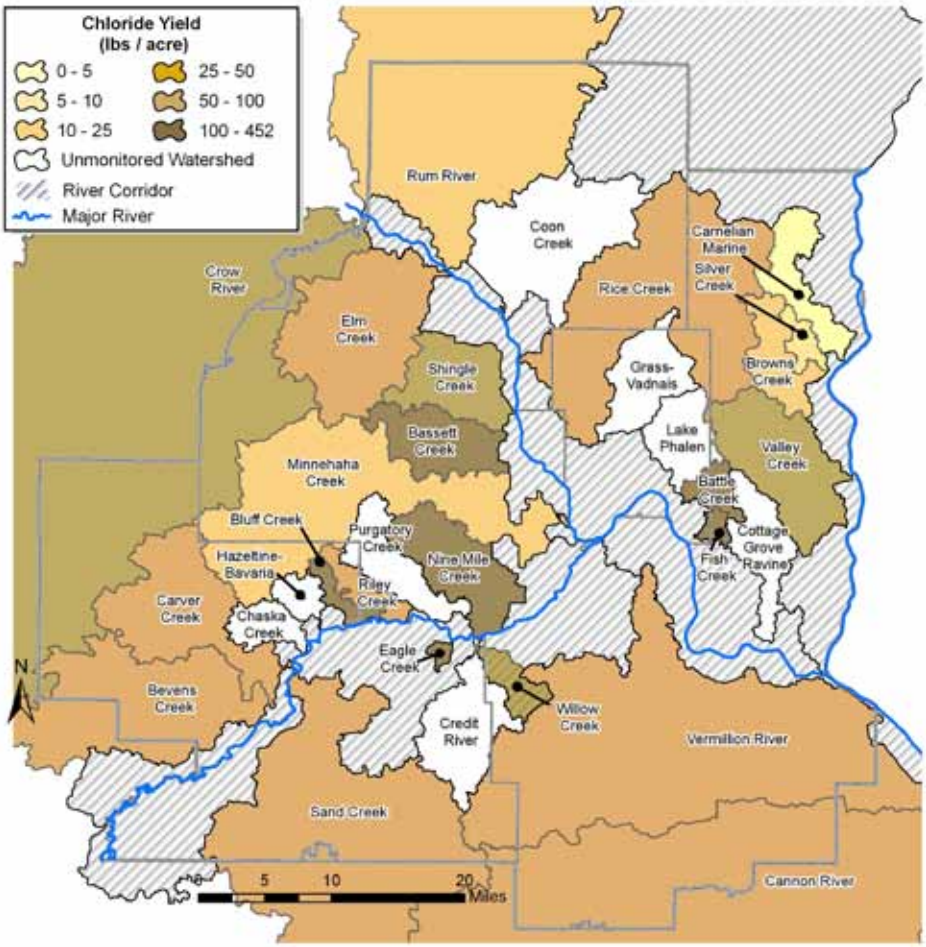
2009 Total Suspended Solids Contributions by Tributary Watersheds within the Metropolitan Area



2009 Nitrate Contributions by Tributary Watersheds within the Metropolitan Area



2009 Choloride Contributions by Tributary Watersheds within the Metropolitan Area



Upcoming MCES Water Resource Reports

The MCES Water Resources Assessment Section plans to release several reports related to the Metropolitan Area's river and stream water quality during 2011. These include:

- Historic annual pollutant loads dataset for rivers (1980 – Present)
- Historic annual pollutant loads dataset for streams (Site Inception – Present)
- Metropolitan Area Stream Trends Analysis (Site Inception – Present)

Report Data Sources

The 2009 MCES River and Stream Assessment Report relied on several information resources. Monitoring data, including flow and water chemistry, originated from MCES and its partners, the USGS, the Elm Creek and Shingle Creek watershed management organizations, and the Rice Creek Watershed District. The watersheds cited in this report were delineated by the DNR and watershed areas were calculated by MCES staff to reflect the area contributing to the monitoring site. The spatial definition of the Metropolitan Area impervious areas was provided by the University of Minnesota.

Information related to water quality and standards was provided by the EPA and MPCA. Information related to data and the analysis methodology used in development of this report can be obtained from the MCES Water Resources Assessment Section Manager **Judy Sventek (judy.sventek@metc.state.mn.us).**

About the Metropolitan Council

The Metropolitan Council was established by the Minnesota Legislature in 1967 to provide policy for regional growth for the seven-county Minneapolis-St. Paul Metropolitan Area. The mission of the Metropolitan Council is to develop, in cooperation with local communities, a comprehensive regional planning framework, focusing on wastewater, transportation, parks and aviation systems, that guides the efficient growth of the Metropolitan Area. The Council operates wastewater and transit services and administers housing and other grant programs.

The Metropolitan Council consists of a chair and 16 members appointed by the Minnesota governor representing 16 geographic districts:

Susan Haigh	Chair
Roger Scherer	District 1
Tony Pistilli	District 2
Robert McFarlin	District 3
Craig Peterson	District 4
Polly Bowles	District 5
Peggy Leppik	District 6
Annette Meeks	District 7
Lynette Wittsack	District 8
Natalie Haas Steffen	District 9
Kris Sanda	District 10
Georgeanne Hilker	District 11
Sherry Broecker	District 12
Rick Aguilar	District 13
Kristin Sersland Beach	District 14
Daniel Wolter	District 15
Wendy Wulff	District 16

Visit **www.metrocouncil.org** for more information about the Council.

Metropolitan Council
390 Robert Street North
St. Paul, MN 55101-1805
(651) 602-1000
www.metrocouncil.org

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