Comprehensive Water Quality Assessment of Select Metropolitan Area Streams

TECHNICAL EXECUTIVE SUMMARY

METROPOLITAN COUNCIL

December 2014

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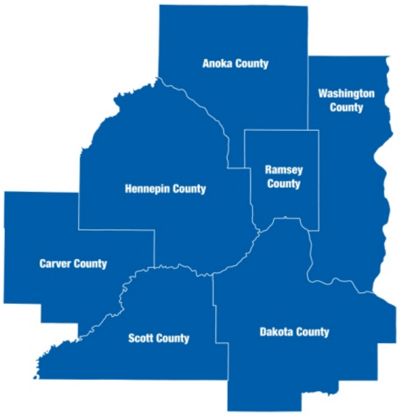

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

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Technical Executive Summary

The Twin Cities metropolitan area has a wealth of streams that traverse its landscape and ultimately flow into one of its three major rivers – the Mississippi, the Minnesota, and the St. Croix. These streams provide rich habitat for aquatic life and wildlife and enhance the recreational and aesthetic value of the metro area.

The Metropolitan Council is committed to the conscientious stewardship of the region's streams and works with its partners to maintain and improve their health and function. The foundation for these efforts is the collection and analysis of high-quality data about their condition over time.

The *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams* is a major study conducted by the Metropolitan Council that examines the water quality of 21 streams or stream segments that discharge into the metropolitan area's major rivers. Drawing upon stream data collected between 1989 and 2012, the study is one of the most extensive of its kind carried out in the seven-county metropolitan area. The results provide a base of technical information that can support sound decisions about water resources in the metro area − decisions by the Council, state agencies, watershed districts, conservation districts, and county and city governments.

All background information, methodologies, and data sources are summarized in *Introduction and Methodologies*, and a glossary and a list of acronyms are included in *Glossary and Acronyms*. Both of these, as well as individual technical sections and two page non-technical fact sheets for each of the 21 streams, are available for separate download from the report website. The staff of Metropolitan Council Environmental Services (MCES) and local cooperating organizations (for example, watershed management organizations, cities, and conservation districts) conducted the stream monitoring work, while MCES staff performed the data analyses, compiled the results and prepared the report.

This work supports the regional polices established in the Metropolitan Council's Thrive MSP 2040 and Water Resources Policy Plan to collaborate with partners to promote the long-term sustainability and health of the region's water resources, including surface water, wastewater and water supply.

Cover Photo

Minnehaha Falls, located on Minnehaha Creek near the confluence with the Mississippi River.

Recommended Citations

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The study:

- Documents those characteristics of each stream and associated watershed most likely to influence stream flow and water quality, based on a uniform dataset. Examples include land cover, elevation changes, feedlots, discharges of wastewater treatment plants (WWTPs) and potable-water treatment plants, and impaired waters as designated by the Minnesota Pollution Control Agency (MPCA).
- Presents assessments of stream flow, total suspended solids (TSS), nutrients – primarily total phosphorus (TP) and nitrate (NO_3) – chloride (Cl), and aquatic insects.
- Identifies statistical trends of flow-adjusted concentrations to identify changes in TSS, TP, and NO_3 over time.
- Draws general conclusions about possible effects of landscape features, climatological changes, human activities, and implementation of best management practices on flow and water quality.
- Compares flow and water quality of all streams within the metropolitan area monitored by MCES and partners.
- Makes general recommendations for future assessment activities, partnerships, watershed management, and other potential practices to remediate any water quality or flow concerns.

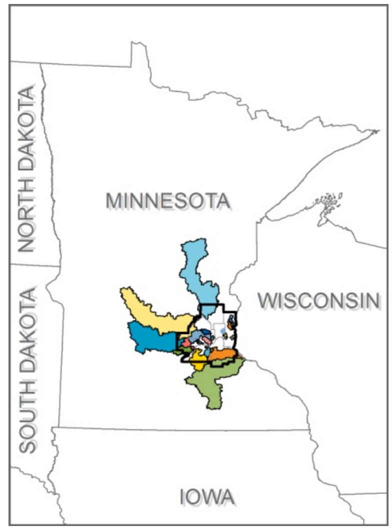
This executive summary provides an overview of flow, the main pollutants of interest (TSS, TP, NO_3, and chloride), and a summary of select technical findings, including trend analysis and macroinvertebrate (aquatic insect) assessment. Readers are directed to individual sections for each stream for comprehensive technical information and recommendations.

Streams assessed in this study include those shown in Figures 1 and 2, and are described later in this summary. Of the 21 streams, one – the Crow River − has segments that were studied separately – the Crow River South Fork and the Crow River Main Stem (which includes both North and South forks). The 21 streams vary greatly in the general characteristics of their watersheds and drainage areas. Nine can be considered primarily rural and/or agricultural; 7 urban, and 5 mixed urban and rural/agricultural. Most have headwaters in lakes, wetlands or springs, and a number are supplemented by groundwater, which tends to increase their flow and lower their water temperature, making them suitable for coldwater aquatic life such as trout. They vary greatly in length, (from 157 miles for the Crow Main Stem to 1.8 miles for Fish Creek), and their monitored watershed areas, ranging from 4.6 square miles (Fish Creek in Saint Paul) to 2,636 square miles (Crow River Main Stem).However, MCES assessed all using identical criteria, measures, and protocols.

To complete the assessments included in this study, MCES and partners collected an exceptional amount of data, including more than 13 million 15-minute flows (equivalent to 140,000 daily values or 383 years) and 9,400 water samples. The MCES lab completed approximately 52,000 analyses on the collected samples. Plus, additional data not assessed in this study, like metals concentrations, chlorophyll, and biological oxygen demand, will be included in future analyses.

The watersheds of streams monitored by MCES and its partners total 6,710 square miles (equivalent to 8% of the state of Minnesota) and extend significantly outside of the seven-county metropolitan area, ranging north to Lake Mille Lacs (headwaters of the Rum River), west to the North Fork of the Crow headwater wetlands of Pope County, south to the Straight River branch of the Cannon River in Freeborn County, and east to the St. Croix River (Figure 1).

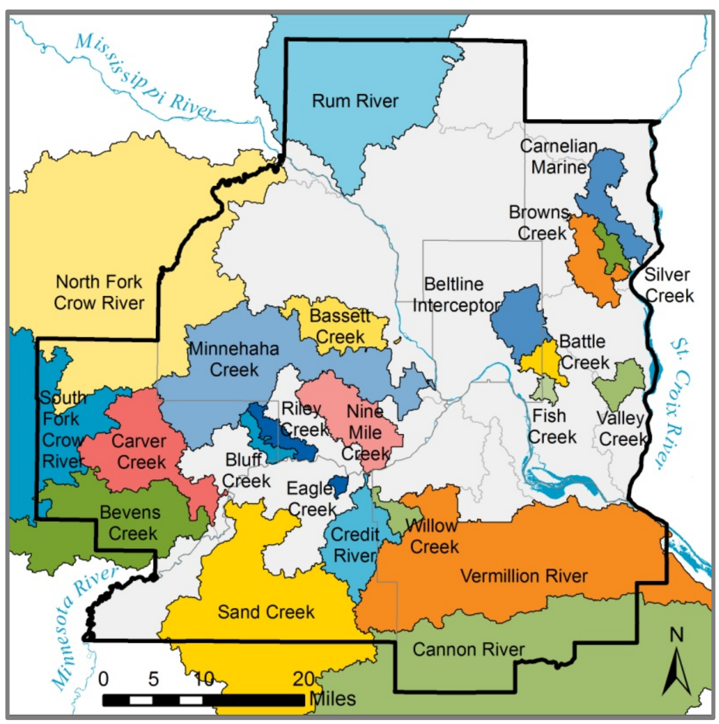
Figure 1: State-wide location of MCES watersheds.



The stream watersheds cover 50% (1,490 square miles) of the area within the seven-county metropolitan area (Figure 2). MCES does not monitor the remainder of the metropolitan area for several reasons:

- Additional portions of the metropolitan area are monitored by other organizations, such as the Three Rivers Park District (the Elm Creek watershed), Shingle Creek Water Management Organization (the Shingle Creek watershed), and Rice Creek Watershed District (the Rice Creek watershed).
- Additional streams within the metropolitan area are under the jurisdiction of organizations that have not implemented regular monitoring programs.
- Other portions of the metropolitan area include the highly urbanized downtowns of Minneapolis and Saint Paul, which are drained not by streams but by a dense network of stormsewers, with hundreds of pipes discharging directly to the major rivers. Mississippi Watershed Management Organization and Capital Region Watershed District do monitor a limited number of urban stormsewers discharging to the Mississippi River. The expense of monitoring equipment and sample laboratory analyses makes monitoring of all urban stormsewers cost-prohibitive.
- Additional portions of the metropolitan area drain directly to the major rivers by non-channelized overland flow, which is impossible to accurately monitor.
- Finally, part of the unmonitored portion of the metropolitan area is covered by floodplain forests,

Figure 2: Location of assessed watersheds in the Metropolitan Council Study.



wetlands, and bottomlands of the three major rivers. These areas are regularly flooded by the rivers, particularly during spring snowmelt and rainfall. Any monitoring equipment installed in the floodplain areas would be regularly inundated and damaged.

MCES plans to incorporate the data from those organizations that do routinely collect data within the metropolitan area in future assessments. As budgets allow, MCES will also attempt to expand its monitoring program by partnering with watershed management organizations without routine monitoring programs.

Brief summaries of the tributary streams assessed in this report include:

St. Croix River Tributaries

- **Carnelian-Marine Outlet**: Small stream system that flows between a series of lakes, including Big Marine and Big Carnelian Lakes, and outlets at Little Carnelian Lake; watershed is rural. The monitored watershed area is 27.9 square miles.
- **Silver Creek**: Small coldwater stream affected by groundwater flows; rural watershed with several rare wetlands; gorge below Fairy Falls includes several rare native plants and is owned and managed by the National Park Service. The monitored watershed area is 8.6 square miles.
- **Browns Creek**: Coldwater stream and Minnesota Department of Natural Resources (MnDNR) designated trout stream; watershed is partly developed and faces future development pressures. The monitored watershed area is 7.2 square miles. The Browns Creek state trail (to be completed in 2015) will provide cyclists and hikers views of the Browns Creek gorge.
- **Valley Creek**: Coldwater stream and a MnDNR-designated naturally-reproducing trout stream; watershed is primarily rural with small amount of agriculture; stream quality and flow is influenced by groundwater discharge. The monitored watershed area is 11.4 square miles.

Mississippi River Tributaries:

- **Crow River South Fork**: Warm water stream with large, rural watershed; primarily agricultural land use with several small communities (for example, Hutchinson, Glencoe, and Mayer) with wastewater treatment plants (WWTPs) that discharge to the stream; designated as canoe route by the MnDNR. The monitored watershed area is 1,150 square miles.
- **Crow River Main Stem (North Fork and South Fork)**: Warm water stream with large, rural watershed; primarily agricultural land use with several small communities (for example, Belgrade, Litchfield, Buffalo, and Rockford) with WWTPs that discharge to the stream; MnDNR-designated canoe route. The monitored watershed area is 2,636 square miles and includes the South Fork watershed area. The North and South Forks converge in Rockford, just upstream of the MCES monitoring station.

- **Rum River**: Warm water stream that originates at Lake Mille Lacs; primarily rural watershed with several small communities (for example Onamia, Milaca, and Cambridge) with WWTPs that discharge to the stream; MnDNR-designated canoe route; contains small stands of wild rice. The monitored watershed area is 1,578 square miles.
- **Bassett Creek**: Warm water stream that originates at Medicine Lake; watershed is highly urbanized and contains several major highway interchanges; below the MCES monitoring station, the creek enters a tunnel that flows under downtown Minneapolis before discharging into the Mississippi River near St. Anthony Falls. The monitored watershed area is 38.9 square miles.
- **Minnehaha Creek**: Warm water stream that originates at Lake Minnetonka; flow is highly influenced by the Gray's Bay dam in Lake Minnetonka; watershed is highly urbanized, and contains many of the lakes of the Minneapolis park system, including Calhoun, Harriet, Isles, Cedar, and Nokomis. The creek flows over Minnehaha Falls in Minnehaha Regional Park before entering the Mississippi River. The monitored watershed area is 169.6 square miles.
- **Battle Creek**: Warm water stream with a highly urbanized watershed. The creek flows through Battle Creek Regional Park before entering the Mississippi River. The monitored watershed area is 11.2 square miles.
- **Fish Creek**: Small, warm water stream with a highly urbanized watershed. The City of Saint Paul recently purchased land around the creek for preservation. The monitored watershed area is 4.6 square miles.
- **Vermillion River**: Large stream with portions designated as coldwater trout stream. Watershed ranges from highly urbanized to agricultural; MCES's Empire WWTP discharged to the river until 2008, when effluent was diverted to the Mississippi River. The monitored watershed area is 233.5 square miles.
- **Cannon River**: Large warm water stream and a MnDNR-designated canoe route; watershed is primarily agricultural with several moderately sized communities (for example, Northfield and Faribault) with WWTPs that discharge to the stream; stream flows through Lake Byllesby Regional Park. The monitored watershed area is 1,130 square miles.

Minnesota River Tributaries:

- **Bevens Creek**: Small warm water creek in southern Carver County; watershed land cover is primarily rural and agricultural. The monitored watershed area is 129.3 square miles.
- **Sand Creek**: Moderate-sized warm water creek discharging to the Minnesota near the city of Jordan. Watershed extends into Rice and LeSueur counties, and is primarily rural residential and agricultural. Several small communities (New Prague, Montgomery, and Jordan) have WWTPs that discharge to the stream. Cedar Lake Regional Park is located within the Sand Creek watershed. The monitored watershed area is 237.1 square miles.

- **Carver Creek**: Small warm water creek draining southern Carver County; watershed is primarily rural and agricultural. Carver Creek originates in Benton Township. The monitored watershed area is 82.2 square miles.
- **Bluff Creek**: Small warm water creek draining parts of Carver and Hennepin counties that discharges to the Minnesota River in the city of Chanhassen. The monitored watershed area is a mix of agricultural and urban land and is 5.6 square miles.
- **Riley Creek**: Small warm water creek in eastern Carver and western Hennepin counties; watershed is highly urbanized. The stream originates in Lake Lucy, then flows through several other small lakes before discharging into the Minnesota River in the city of Eden Prairie. The monitored watershed area is 10.4 square miles.
- **Eagle Creek**: Small coldwater creek and MnDNR-designated trout stream. The stream originates at the Boiling Springs, an artesian spring approximately one mile upstream of the MCES monitoring station. The creek is highly influenced by large amounts of groundwater discharge and therefore has a flow disproportionate to its watershed size. The monitored watershed area, which is primarily urban and forest land, is 1.7 square miles, although the groundwater that discharges to the stream likely flows from a much larger area.
- **Credit River**: A small warm water creek; watershed is a mix of agricultural, forest, open space, and wetlands in the upper part of the watershed, and developed urban land in the lower part of the watershed. It discharges to the Minnesota River in the city of Savage. The monitored watershed area is 46.9 square miles.
- **Willow Cree**k: A warm water creek that originates at the outlet of Sunset Pond before flowing to the Minnesota River near the Kraemer Quarry in the city of Burnsville. The watershed is completely urbanized and the lower part of the stream is inside a large box culvert. The monitored watershed area is 10.1 square miles.
- **Nine Mile Creek**: A warm water creek that originates in the cities of Minnetonka and Hopkins. It flows through a series of lakes and wetlands before discharging to the Minnesota River in the city of Bloomington. The watershed is completely urbanized. The monitored watershed area is 45 square miles.

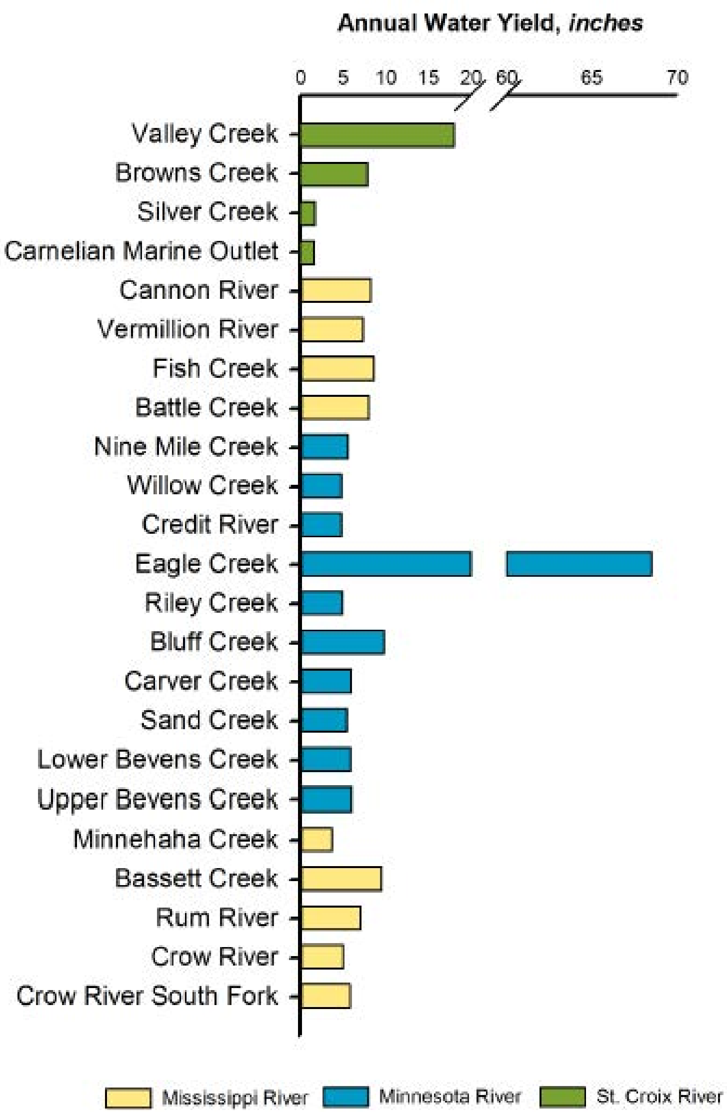
Select Findings

Flow

Stream flow can refer to both the rate of water flowing in a stream at any particular time (cubic feet per second, and gallons per second) or the total amount of water delivered by a stream into a larger body of water (gallons per year). Excessively high stream flows lead to flooding, cause erosion, and transport pollution. Both high and low stream flows can stress aquatic life.

The streams assessed by MCES have vastly different watershed areas. Streams with larger watershed areas (for example, the Rum River) generally have larger flows and a greater annual volume of flow than those with smaller watershed areas (for example, Silver Creek). MCES converted the annual volume to water yield (by dividing the annual volume by the watershed area) to allow direct comparison between the watersheds. The water yield, expressed in inches,

Figure 3: MCES Streams Median Annual Water Yields, 2003-2012



is simply the amount of stream flow produced per acre of watershed area, and varies greatly across the streams (Figure 3).

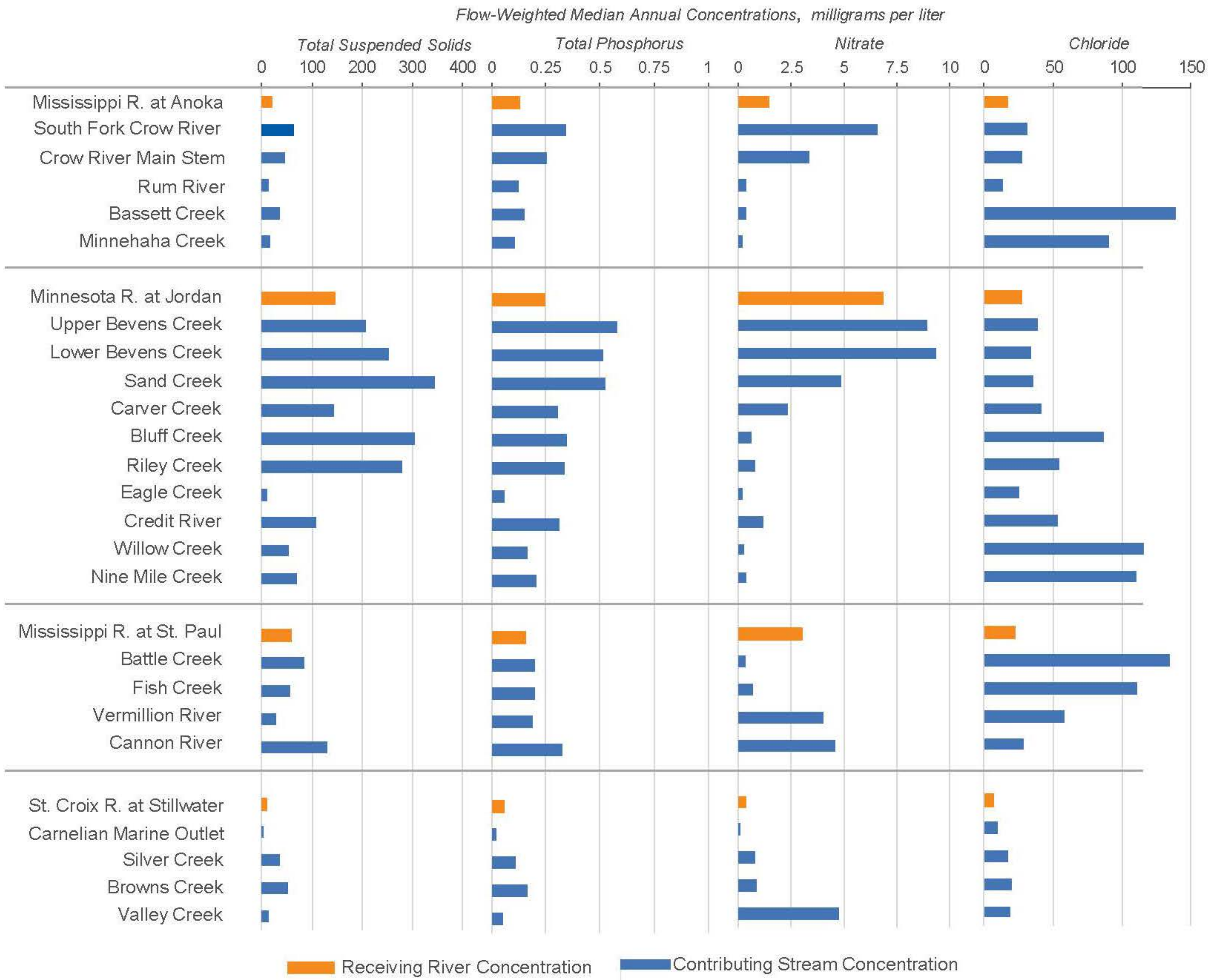
In general, the streams with the greatest water yield, thus producing the most stream flow per acre of watershed, are those with high groundwater contributions, including Eagle Creek, Valley Creek, the Vermillion River and Browns Creek. These streams are also MnDNR-designated trout streams, indicating the clean, cold nature of the water flowing within the stream.

Other streams with relatively high water yields include those with highly urbanized watersheds, including Fish Creek, Battle Creek, Bluff Creek, and Bassett Creek. Rainfall and snowmelt from rooftops, paved areas, and roadways traditionally have been diverted directly to streams to quickly drain the landscape. More recent innovative stormwater practices, like rain gardens and infiltration basins, allow rainfall and snowmelt to drain through soil to shallow groundwater and aquifers. As more of these practices are installed in these watersheds, one would expect the water yields to decrease in the future.

Pollutants in Each Stream

The primary pollutants assessed in the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams* are sediment, nutrients (phosphorus and nitrogen), and chloride. Pollutant content in a stream is measured by MCES in two ways. The concentration is the amount of pollutant in a specified volume of stream water and is usually expressed as milligrams per liter. The concentration value is important as it is typically compared to water quality standards set by the Minnesota Pollution Control Agency (MPCA) to determine if the stream is impaired for that pollutant. In addition, if the stream concentration is greater than the major river into which it discharges, the stream discharge may cause a decline in the river's water quality.

Figure 4: Flow-Weighted Median Annual TSS, TP, NO_3, and Chloride Concentrations, 2003-2012

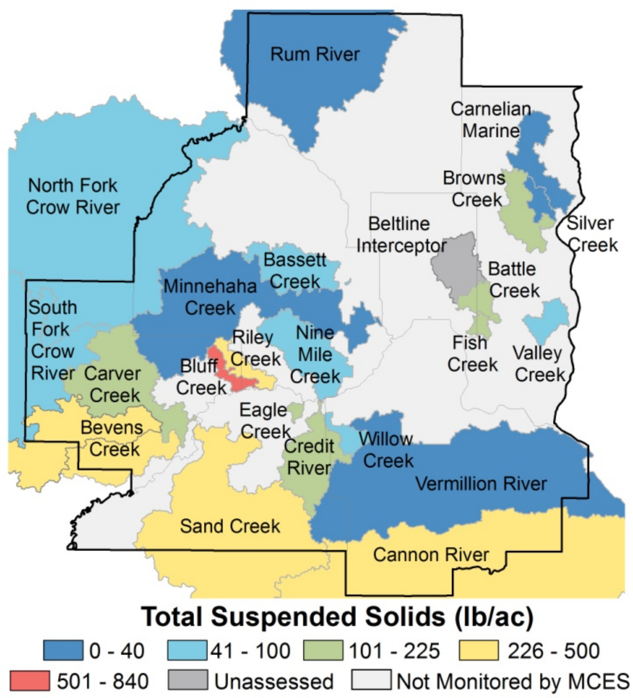


The load is the total mass of pollutant carried by the stream each year and discharged to one of the three major rivers. The load is calculated using the concentration and the stream flow and is typically expressed in pounds or kilograms per year. The watersheds monitored by MCES vary greatly in size, thus producing a wide range of pollutant loads. Consequently, MCES divided each load by the watershed area, thus allowing direct comparison of the pollutant yield per acre of watershed. The pollutant yield is expressed in units of pounds per acre.

Total Suspended Solids (Sediment)

Sediment is made up of sand, silt, or clay particles and is naturally present in all streams. Excessive sediment can enter a stream from poorly managed construction sites or eroded stream banks and gullies. In the MCES monitoring program, sediment is measured as TSS. Excess sediment in a stream decreases the light available for plant growth, increases water temperature, clogs gills of fish, and smothers the habitat of valuable aquatic insects.

Figure 5: Total Suspended Solids Annual Yield, 2003-2012



The highest TSS concentrations were observed in the Minnesota River tributaries: Bevens Creek, Sand Creek, Riley Creek, and Bluff Creek (Figure 4). This is not unexpected, as the Minnesota River landscape is still stabilizing from changes caused by the last ice age. The unstable terrain and steep elevation drops lead to easily erodible soils and high levels of sediment delivered to the streams.

Not surprisingly, the highest TSS yields (Figure 5) are observed in the same streams, as well as in the Cannon River. The Cannon River, while not in the Minnesota River watershed, is largely agricultural with a number of eroded side channels. Coupled with its high water yield, the Cannon delivers a relatively large load of sediment to the Mississippi River.

Nutrients

The most common nutrients are nitrogen (often measured as nitrate, NO_3) and phosphorus (typically measured as total phosphorus, TP). Low levels of nutrients do occur naturally and are important for stream health. However, too many nutrients from lawn or agricultural fertilizers, malfunctioning septic systems, grass clippings, and manure and pet wastes can be harmful to stream health. Excess nutrients in our waters can cause severe algae growth and lower the amount of oxygen in the water. This makes it unpleasant for swimming or fishing and unsuitable for aquatic life. Large amounts of nutrients in our region's rivers can travel all the way to the Gulf of Mexico and contribute to the "dead zone."

Figure 6: Total Phosphorus Annual Yield, 2003-2012

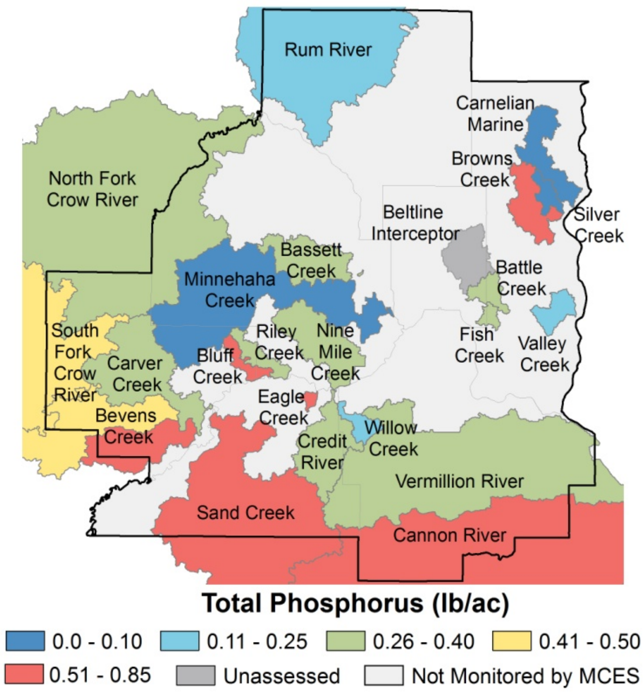
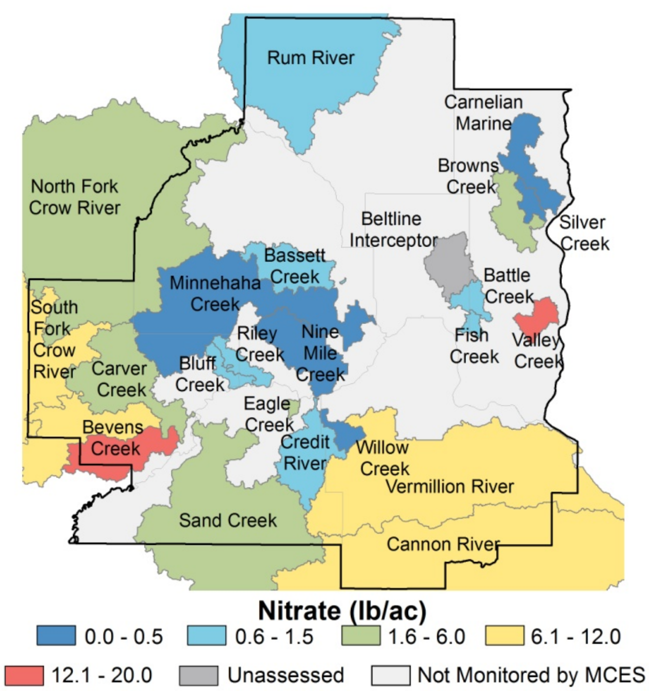


Figure 7: Nitrate Annual Yield, 2003-2012



The highest TP concentrations were observed in Minnesota River tributaries, particularly Bevens Creek and Sand Creek (Figure 4). Both of these creeks have large areas of agricultural activity, so have a high likelihood of delivering high nutrient runoff from farm fields and drain tiles to the streams. The Cannon and Crow rivers also exhibit relatively high TP concentrations; again, each has a high level of agricultural activity in their watersheds.

The highest TP yields were observed in Bevens, Bluff, and Sand Creeks, the Cannon River, and Browns Creek (Figure 6). The Browns Creek TP yield may be influenced by the rapid rate of urbanization taking place in the watershed. To its credit, the Browns Creek Watershed District is proactively installing a large number of remediation projects, including rain gardens, iron-sand filters, and stream channel and stream bank restorations.

Not surprisingly, the highest nitrate concentrations were observed in the most agricultural watersheds: Bevens and Sand creeks, the Crow River (Main Stem and South Branch), and the Cannon River (Figure 4). The high nitrate concentration in the Vermillion River was likely affected by treated effluent discharged from the Empire WWTP. The WWTP effluent was diverted to the Mississippi River in 2008; thus, future assessments will likely show lower nitrate in the stream. Valley Creek has historically had unusually high nitrate concentrations, likely caused by discharge of high-nitrate groundwater into the stream.

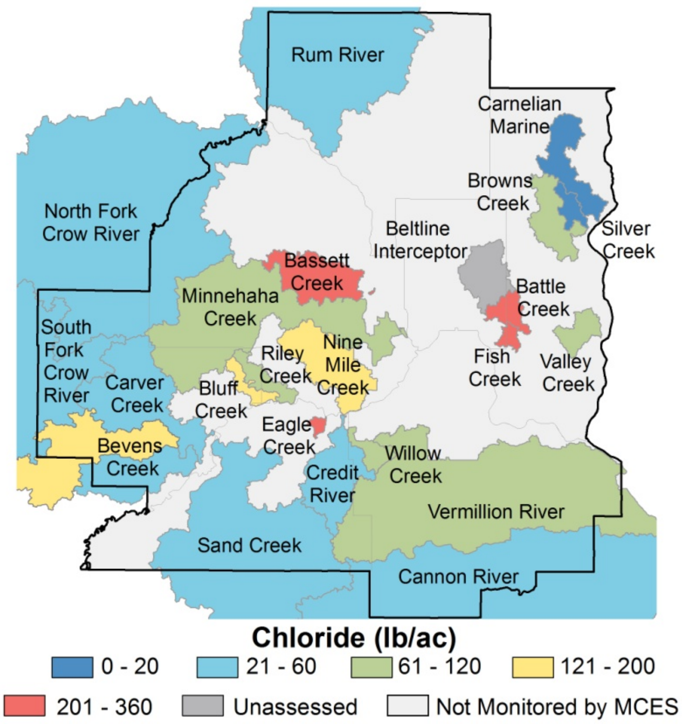
The nitrate watershed yields follow a similar pattern as the concentrations, with the highest yields exhibited by Bevens Creek, the South Crow River, the Cannon River, the Vermillion River, and Valley Creek (Figure 7).

Chloride

Chloride is a chemical commonly used in winter ice removal salts and home water softening products. When the snow and ice melt off the roads, parking lots, and sidewalks, the chloride is carried into our streams. High concentrations of chloride can be harmful to aquatic life.

As one may expect, both the highest chloride concentrations and highest chloride yields were observed in the streams with the most urbanized watersheds, with large paved areas and roadways applied with salt as a winter de-icer, including Bassett Creek, Battle Creek, Minnehaha Creek, Fish Creek, Bluff Creek, Willow Creek and Nine Mile Creek (Figure 4 and Figure 8).

Figure 8: Chloride Annual Yield, 2003-2012



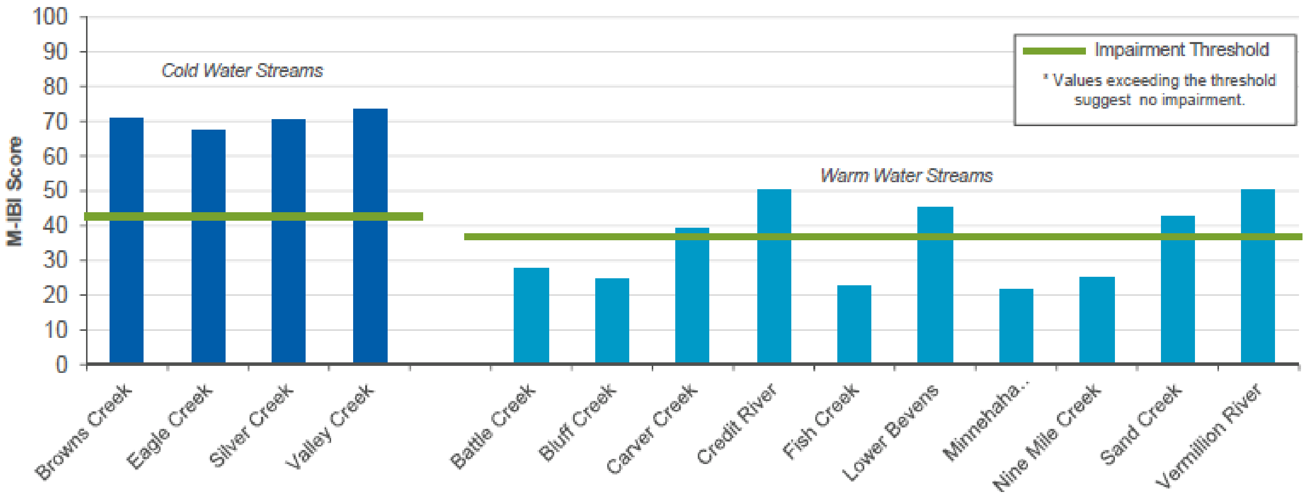
Aquatic Insects (Macroinvertebrates)

Aquatic insects are bugs that spend a large portion of their lives in the stream. Aquatic insects are an important part of the food chain for fish, birds, and other wildlife. In addition, these insects are highly sensitive to pollution in the water. The variety and health of insects found in a stream can be used as a measure of overall stream health, and is reflected in a value known as an M-IBI score (Macroinvertebrate Index of Biological Integrity). A high score indicates a healthy number and variety of insects, while a low score indicates an impaired stream habitat unable to support a varied population of insects.

MCES has assessed the varieties and numbers of aquatic insects at most of the stream monitoring stations (Figure 9). MCES has been limited by available staff time from adding more streams to the macroinvertebrate monitoring program. Monitoring of additional streams will be considered as staffing allows.

In general, the cold water streams, which include Browns Creek, Eagle Creek, Silver Creek, and Valley Creek, exhibit high M-IBI numbers, indicating healthy insect populations and low impairment by pollutants. The M-IBI values for the warm water streams are more varied. Carver Creek, Credit River, Bevens Creek, Sand Creek, and the Vermillion River have M-IBI values above the impairment threshold, indicating low impairment of aquatic insects by water-borne pollutants. The M-IBI values for Battle Creek, Bluff Creek, Fish Creek, Minnehaha Creek, and Nine Mile Creek were below the impairment threshold, indicating the population and variety of aquatic insects are likely affected by pollutants. Interestingly, these streams are the most highly urbanized of those monitored by MCES.

Figure 9: Median M-IBI Scores, 2004-2011



Have Our Streams Improved or Declined?

Whether the water quality of metropolitan area streams has been improving or declining is of primary importance to MCES and its partners. The challenge is to present a coherent picture of water quality trends while accounting for all the varying factors that affect the underlying pollutant concentrations and stream flow. For example, year-to-year variation in rainfall and snow amounts leads to annual variation in stream flow and pollutant concentrations. Additionally, pollutant concentrations often vary from season to season. As a result, it is almost impossible to identify changes in pollutant concentration from simple graphs of those data.

To deal with the issue, MCES used the statistical tool QWTREND and followed the same methodology as the U.S. Geological Survey (USGS) and the MPCA for the state-wide nitrogen study completed in 2013 (*Nitrogen in Minnesota Surface Waters*, MPCA, 2013, document no. wq-s6-26a). QWTREND removes both the effects of annual flow variation and seasonal variation from the data, creating a smoothed curve designating improving or declining water quality based on pollutant flow-adjusted concentration. The resulting detailed trend plots are included in each stream section of the study. The following includes general conclusions about concentration trends over the past five years.

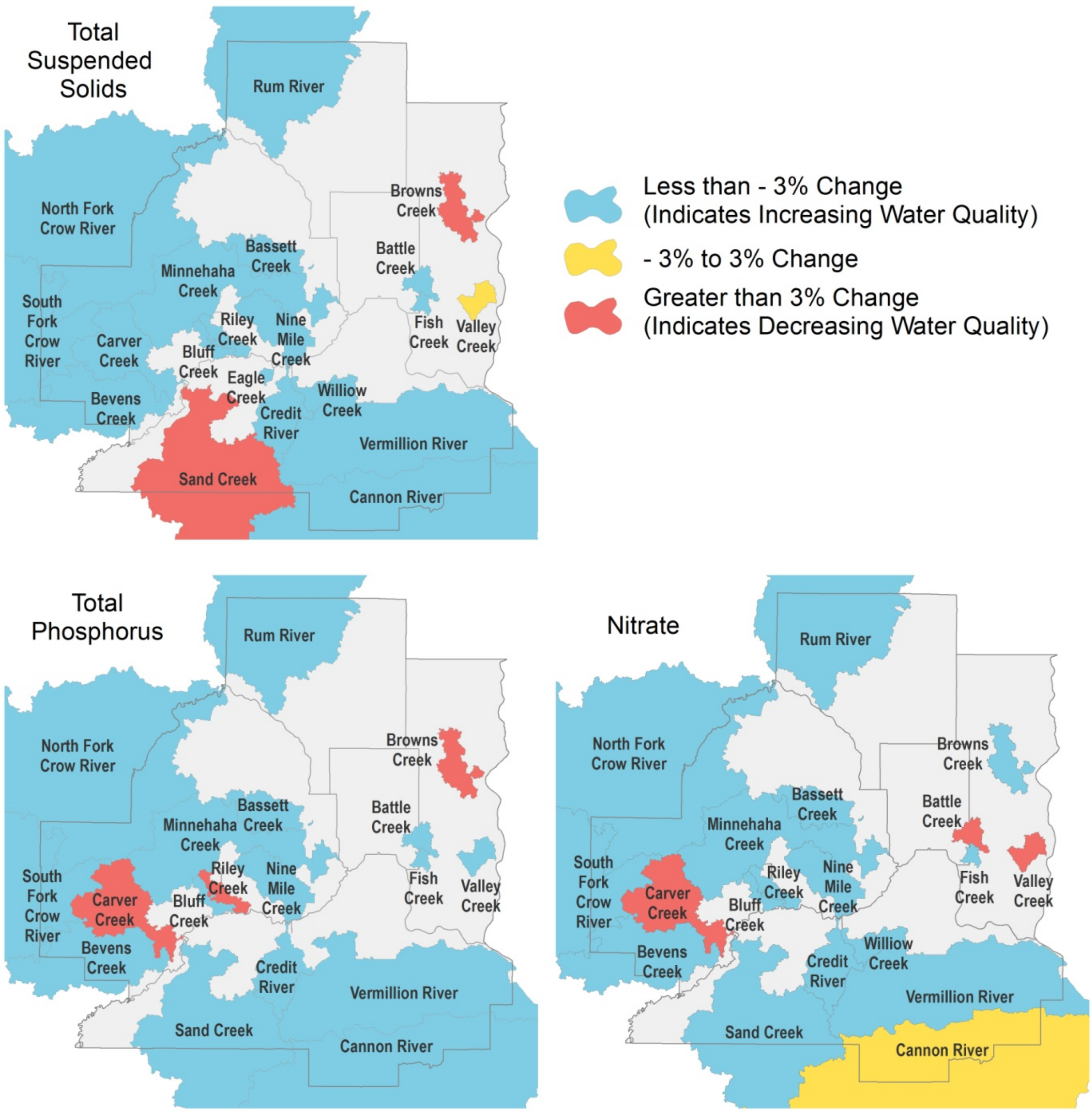
Total Suspended Solids (TSS)

Results of trend analysis for 2008-2012 indicate lower TSS flow-adjusted concentrations and thus improving water quality for all watersheds except Sand Creek and Browns Creek (Figure 10, top map). Each of these exhibited improving water quality until 2011 and 2012, and may have been affected by a number of intense rain events that occurred across the metropolitan area during those years.

Total Phosphorus (TP)

Trend analysis results for 2008-2012 indicated lower TP flow-adjusted concentrations and thus improving water quality for all watersheds but Carver Creek, Riley Creek, and Browns Creek (Figure 10, lower left map).

Figure 10: Regional Maps of Estimated Flow-Adjusted Concentration Trends, 2008-2012



Nitrate (NO_3)

Trend analysis results for 2008-2012 indicated lower nitrate flow-adjusted concentrations and thus improving water quality for all watersheds but Carver Creek, Battle Creek, and Valley Creek (Figure 10, lower right map).

The trend results indicate improvements in water quality in the majority of monitored streams during 2008-2012 based on reductions in sediment, phosphorus, and nitrate flow-adjusted concentrations. However, the trend analysis does not identify which actions, projects, structures, or practices have caused the improvements (or declines). More detailed and costly studies would be necessary to precisely identify which factors have affected stream water quality and flow.

While MCES staff have assessed monitoring data and trend analysis statistics, more work is needed to assign causative actions to the trend analysis results. TSS and TP chemistry, delivery, transport and remediation are complicated, although fairly well-understood. Identifying contributing events, implementation practices, and other causative actions is expected to be somewhat straightforward for these two parameters.

NO_3 chemistry and transport dynamics within the natural environmental are significantly more complicated. The NO_3 trends for most of 21 streams assessed in this study showed periods of both rising and falling flow-adjusted concentrations. NO_3 concentrations may be affected by periods of saturated and unsaturated soil conditions related to precipitation patterns, by agricultural crop rotations, by changing levels of fertilizer applications, or other unidentified causative variables, rather than true long-term improvement in concentrations based on intentional implementation of best management practices.

MCES staff will repeat the trend analysis in 5 or 10 years. In the meantime, MCES will continue to investigate the $NO_{3,}$ TSS, and TP dynamics in streams entering the metropolitan area with local partners and state agency staff.

It is likely that water quality improvements have occurred due to multiple projects and actions, implemented over time. Over the past several decades, metropolitan area cities, watershed districts and water management organizations, state agencies, farmers, business owners, and private citizens have implemented a vast number of water quality improvement practices. Some examples include continued actions prompted by passage of the federal Clean Water Act, such as:

- Establishment of water quality standards and implementation of projects intended to achieve MPCA requirements for Total Maximum Daily Load (TMDL) studies.
- Implementation of state-wide reductions in phosphorus discharges from wastewater treatment plants.
- Passage of the Minnesota Phosphorus Lawn Fertilizer law, which prohibited the sale and use of lawn fertilizer containing phosphorus.
- Implementation of numerous educational programs
- Formation and subsequent actions of multiple environmentally-based nonprofit organizations.
- Changes in agricultural practices, including conservation tillage and manure management.
- Creation of multiple grant programs -- for example, the Minnesota Clean Water, Land and Legacy Amendment -- to fund water quality improvement projects.
- Construction of numerous structural practices on the landscape to remove pollutants from runoff or to stabilize the stream channels, including raingarden installations, green roof installations, pervious pavement installations, streambank stabilizations and restorations, prairie restorations, and many others.

MCES staff will be presenting results of the overall study and the trend analyses to each partner organization, with a focus on discussing future partnerships and actions necessary to continue water quality improvements or reverse declines.

Recommendations

Even though the MCES assessments indicate water quality in many watersheds has been improving, there is still work to be done. In each stream section, MCES staff have identified a number of stream-specific recommendations focused on additional studies, potential improvement actions, and partnership projects with watershed management organizations, counties, and cities − all with a goal to continue water quality improvements or to help achieve improvement in those streams with declining water quality.

Recommendations identified by MCES for all streams include:

- Work with partners (including watershed management organizations, counties, and cities) to document past projects and management activities. This information will aid in interpreting MCES's next analysis of water quality trends, scheduled for approximately 2019.
- Educate local water management organizations about the identification of vulnerable streams and lakes that have heightened potential to be impacted by groundwater withdrawals.
- Continue participation by MCES staff on local water management organizations and state agency technical advisory committees to continue the planning and implementation of projects to improve stream water quality.

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