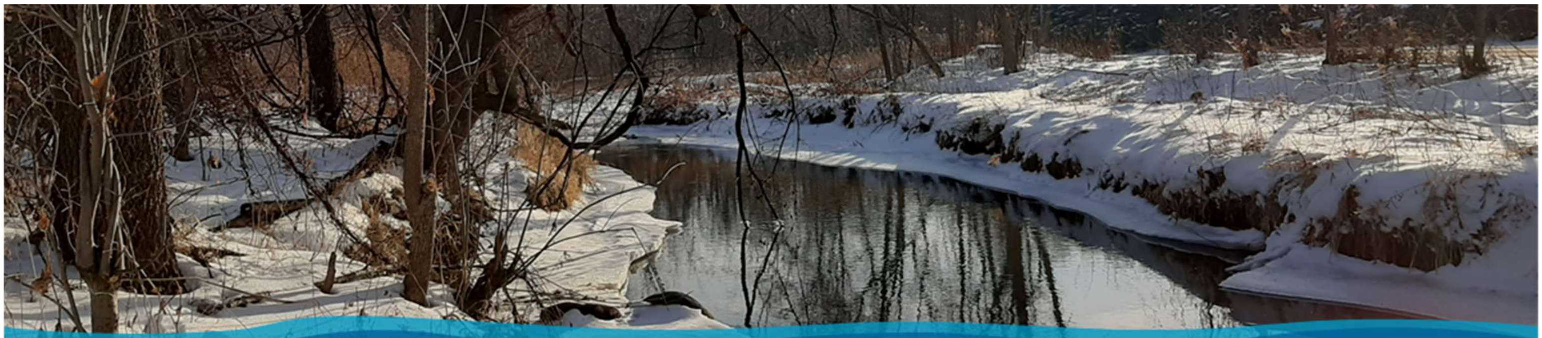

Credit River CHLORIDE

KEY FINDINGS

Chloride increased in Credit River from 1999-2012, then remained relatively stable through 2019. During this steady period in 2018, the lower segment of the stream was added to the impaired waters list.

De-icing salt and water softening are likely to be the primary sources of chloride in Credit River, though contributions from fertilizer application are poorly understood and should be investigated.

INTRODUCTION

The Metropolitan Council Environmental Services (MCES) is committed to stewardship of Twin Cities streams and tributary rivers and works with its partners to maintain and improve waterbody health and function. These efforts are supported by the collection and analysis of high-quality, long-term data.

In 2014, *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams* described statistical water quality trends for streams and tributary rivers in the Twin Cities. At that time, data were insufficient to analyze chloride trends. By 2019, our monitoring work provided sufficient data for statistical trend analysis. Meanwhile, concern about chloride pollution has increased for watershed managers and the general public. This memo includes information about chloride sources and timing of chloride runoff and addresses the following questions:

- How has in-stream chloride changed over time?
- How have upland watershed activities impacted in-stream chloride over time?
- What can monitoring data tell us about chloride sources and pathways in the watershed?

During the analysis period of 1999-2019, Scott County, Scott SWCD, and local governments through the Scott Clean Water Education Program (SCWEP), have partnered on education efforts regarding chloride and deicing salt application throughout Scott County, including the Credit River watershed.[1]

This memo provides data and analyses from Credit River with state and regional context about chloride pollution. This information has prompted questions from MCES staff and will likely prompt questions from readers. This memo is intended to initiate a dialog about regional chloride dynamics and inspire action to alleviate chloride pollution. Please contact us to discuss potential future partnerships if you are interested in continuing this work.

CHLORIDE POLLUTION IN TWIN CITIES WATERS

Chloride concentrations have been rapidly rising in many Twin Cities waterbodies over the past two decades. In the Twin Cities, 40 lakes and streams are impaired for aquatic life due to chloride contamination and an additional 41 waterbodies are high risk for chloride impairment.[2] A recent study by MCES indicated an increasing trend for chloride concentrations in the Mississippi, Minnesota, and St. Croix Rivers during the recent 30 years.[3] Thirty percent of Twin Cities shallow aquifer monitoring wells have chloride concentrations that exceed the Minnesota state water quality standard.[4]

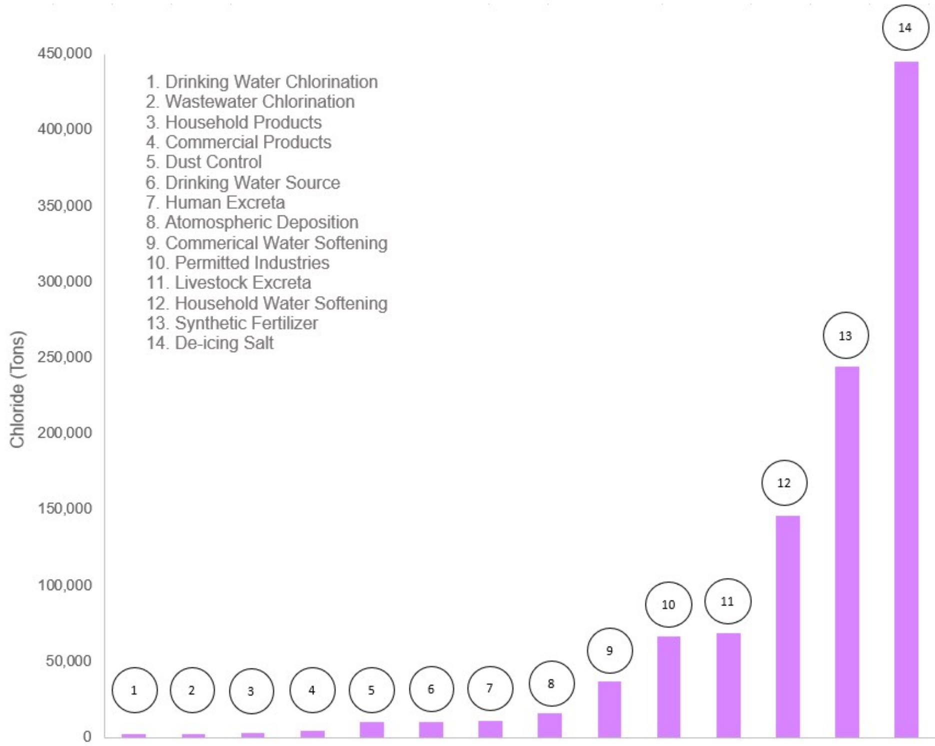

Figure 1: Major chloride sources and their annual chloride contributions to the environment in Minnesota.

Chloride is a permanent water pollutant, there is no easy way to remove it with existing technology. It is toxic to fish, aquatic bugs, and amphibians. Chronic toxicity is indicated by samples above 230 mg/L, acute toxicity by samples above 860 mg/L.[5]

Chloride pollution in Minnesota has multiple sources.[6] The four largest are livestock excreta, household water softening, synthetic fertilizer, and de-icing salt (Figure 1).

Livestock Excreta: Research found elevated chloride in seepage from earthen-lined manure storage and high chloride levels in groundwater downgradient of manure storage[7], but there is little research investigating effects of livestock feedlots or manure application practices on chloride levels in water.

Household water softening: More than 70% of the drinking water used in the Twin Cities comes from groundwater[8] and many groundwater users soften their water with chloride salts. The chloride waste from the water softening process enters surface and groundwater through wastewater treatment plants or residential subsurface sewage treatment systems.[9]

Synthetic fertilizer: Chloride is associated with macronutrients like potassium. The most common potassium source in Minnesota is potash fertilizer, potassium chloride.[10] Plants consume the potassium and release the chloride into surface and groundwater.

De-icing salt: Approximately 402,000 tons of de-icing salt is annually applied in the Twin Cities.[11] De-icing salt is carried by melting ice and snow into surface and groundwater.

Climate change is creating a warmer, wetter climate in Minnesota and the effects are most significant during the coldest months. An altered winter freeze-thaw cycle will have unpredictable effects on chloride use and pollution dynamics.

STREAM AND WATERSHED DESCRIPTION

The Credit River watershed is located in the southwest metropolitan area and is a tributary to the Minnesota River. The Credit River watershed encompasses a total of 47.2 square miles (30,236 acres). The land cover in the watershed is a diverse mix of agricultural, forest, grasses/herbaceous, and urban. The monitored watershed has 9,940 acres (33.1%) of developed urban land, 4,234 acres (14.1%) of agricultural land, 4,453 acres (14.8%) of forested land, 6,100 acres (20.3%) of grass/herbaceous land cover, and 4,371 acres (14.6%) of wetlands.[12]

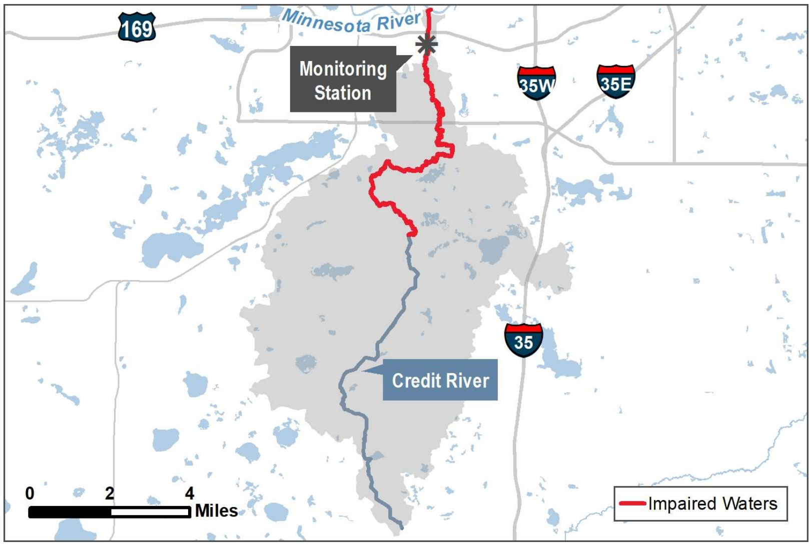

Figure 2: Map of Credit River Watershed

Approximately 9% of the Credit River watershed is roadways, based on an analysis completed by the Minnesota Pollution Control Agency.[13] The MPCA found that watersheds with 18% roadway density or higher are more likely to have chloride concentrations above water quality standards.[14]

The lower segment of Credit River was listed as impaired for chloride in 2018 by the Minnesota Pollution Control Agency. The impaired segment is from near the intersection of Murphy Boulevard and 165th Street E to the confluence with the Minnesota River (Figure 2).

Credit River chloride pollution sources may include livestock excreta, household water softening, synthetic fertilizer, and de-icing salt.

Livestock Excreta: The Credit River watershed has 2 registered feedlots.

Household Water Softening: While some household wastewater from the watershed is treated at MCES WWTPs that discharge directly to the Minnesota River, there are several community septic treatment systems in the watershed as well as some residential developments served by subsurface sewage treatment systems. The chloride waste from the water softening process has the potential to enter surface and groundwater in the Credit River watershed through the community septic treatment systems and residential subsurface sewage treatment systems.[15]

Synthetic Fertilizer: Chloride may come from agricultural and urban application of potash fertilizer.[16] This source of chloride is not well understood in the watershed.

De-icing Salt: De-icing salt is primarily applied between December and March and would likely runoff during melt events from February through April.

FINDINGS

Annual Chloride Dynamics 1999-2019

Chloride Concentration

MCES collected 555 chloride samples between 1999 and 2019. The ambient concentrations are plotted with the annual median concentration (Figure 3). Despite the relatively low median concentrations, isolated high ambient concentrations resulted in the impaired status of the creek. Ambient concentration describes the conditions experienced by aquatic organisms in the stream. These values are affected by precipitation, flow and watershed factors, including those caused by human activity.

Median concentration increased steadily from 1999 through 2013, then declined before increasing in 2018 and then declining again in 2019.

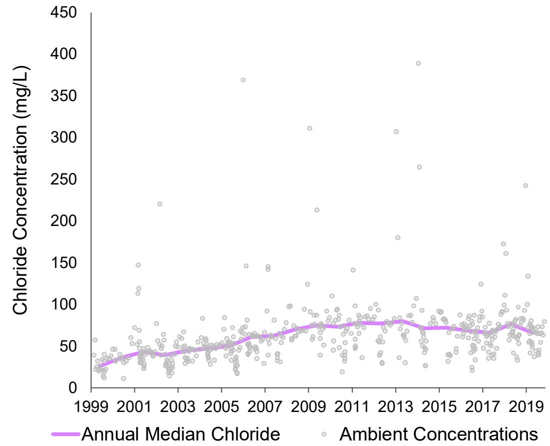

Figure 3: Annual median and ambient chloride concentrations in Credit River

Ambient concentration: The mass of chloride divided by the total volume of water in a stream at a specific time. This value represents the instantaneous amount of chloride in the stream water.

Annual Median Concentration: This is the 'typical' concentration observed in the stream during the year. It is the center of our observed data and is not affected by extreme high or low concentrations.

Precipitation and Streamflow

Ambient concentrations are often closely tied to rainfall and resulting flow conditions in the stream. Figure 4 shows annual total precipitation and the 1981-2010 National Weather Service Climate Normal precipitation at Minneapolis-St. Paul airport[17] with the Credit River annual mean flows. Flow is usually higher in years with greater rainfall. Flow in Credit River varied dynamically during the assessment period. The highest annual mean flow occurred in 2019 reflecting higher precipitation that year.

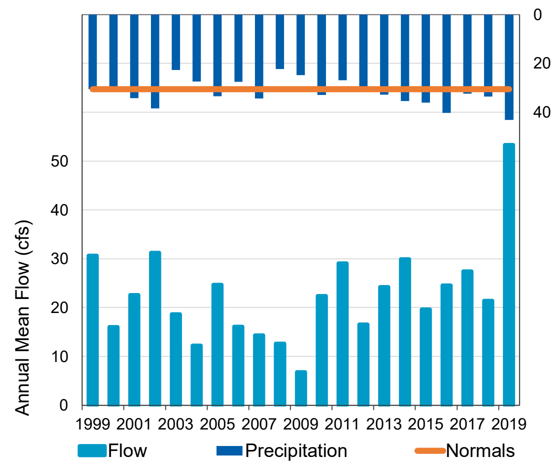

Figure 4: Flow and Precipitation for the Credit River

Annual Mean Flow: The average of all daily flows for the year.

Streamflow and Chloride Concentration

Figure 5 shows annual median chloride concentration and annual median flow values, representing typical conditions for each year. The figure shows little relationship between flow and concentration. This means that factors other than flow impact chloride conditions in the stream.

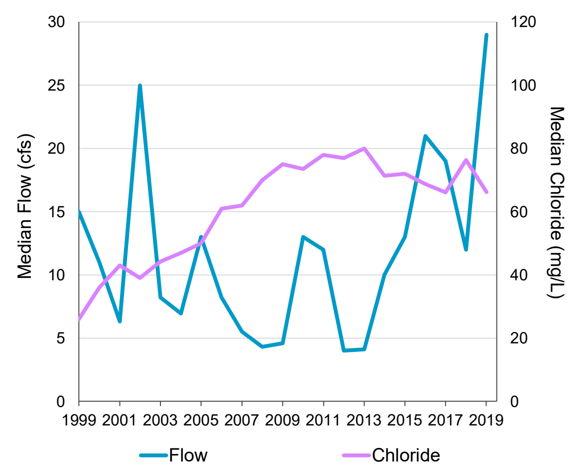

Figure 5: Annual Median Flow and Chloride Concentration in Credit River

In order to see how non-flow factors such as watershed practices may have affected chloride concentrations, we used the R-QWTREND model.

Chloride Trends

R-QWTREND is a statistical model specifically designed to investigate pollutant trends, which tests potential trends (increase or decrease in concentration) against a no-trend model (no increase or decrease in concentrations). This model removes the variability of annual flow and seasonality from the statistical analysis. If the model does not show a statistically significant trend for a given time period, there is not sufficient evidence to claim that concentrations are increasing or decreasing. If increasing or decreasing concentrations cannot be described, then concentrations are assumed to be stable.

R-QWTREND analysis shows that changes in chloride concentration in Credit River can be best represented by a statistically significant two-trend model, p =0. This model has only one significant period, from 1999-2012, which shows a gradual increase in flow-adjusted concentration. From 2012-2019 there is not strong enough evidence that a trend exists. This period is reported as statistically non-significant (NS) and the modeled trend concentrations, changes in percentages, and rates are not provided (Table 1 and Figure 6).

Table 1: Statistical Trend for Chloride Concentration in Credit River

Trend Period	Concentration range (mg/L)	Change in Conc (%)	Change Rate (mg/L/yr)	p	Trend
1999 - 2012	38.6 - 76.4	98%	2.9	0.0000	⬆
2013 - 2019	---	---	---	0.3700	

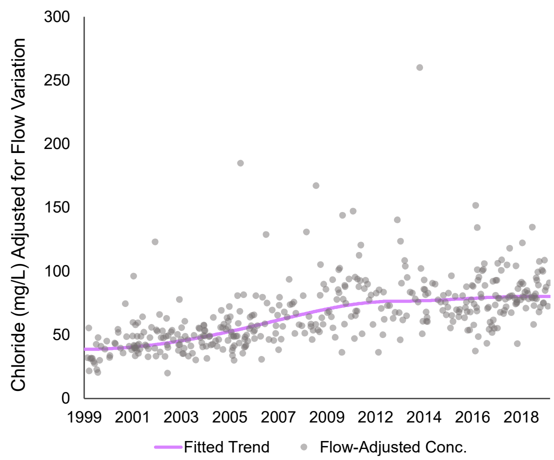

Figure 6: Flow-Adjusted Trends for Chloride Concentration in Credit River

The increasing trend from 1999-2012 was likely due to behaviors in the watershed, including potentially an increase in use of de-icing salt. At this time, it appears that the increasing trend from 1999 to 2012 may have been slowed or halted in 2013 by actions occurring in the watershed, including implementation of chloride best management practices, which interrupted the increasing chloride trend.

Additional data from 2020 and into the future has the potential to impact the significance and the direction of the recent trend period.

Pollutant trend: An analysis that shows the direction of change (improving vs. declining water quality) in a pollutant over time. This study examined changes in flow-adjusted chloride concentration from 1999 – 2019, allowing us to look at human-caused influences in chloride concentrations.

Flow-adjusted concentration: An adjustment to ambient concentration that removes variability of annual flow and seasonality mathematically, for use in statistical analysis.

Chloride Loads

Figure 7 illustrates annual loads and annual mean flow. The annual loads for chloride exhibited significant year-to-year variation indicating the influence of precipitation and flow on the transport of pollutants within the watershed and the stream.

The increase in chloride loads in years of higher flow could be due to the increased flushing of salt that had built up in the watershed during drier years, when pollutants are less likely to be mobilized.

Annual loads were higher from 2010 – 2019 compared to earlier years of the study period with similar flows (Figure 7), reflecting the higher chloride concentrations in the later years as shown by the trend analysis (Table 1 and Figure 6).

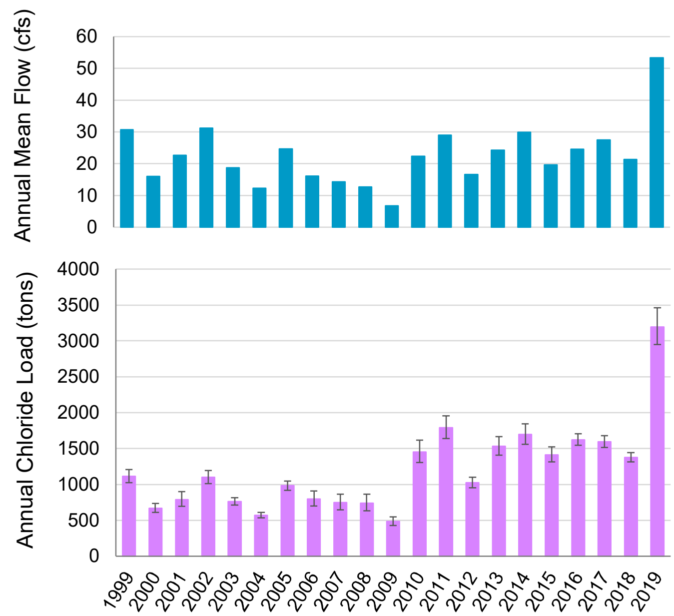

Figure 7: Annual Chloride Loads in Credit River (Error bars = 95% Confidence Interval)

Pollutant load: The total mass of a pollutant exported from a stream over a period of time. MCES uses Flux32 software to estimate pollutant loads.

Seasonal Chloride Dynamics 1999 – 2019

Chloride Concentration and Streamflow

Figure 8 shows monthly median chloride concentration and monthly median flow values, representing typical conditions in each month. Seasonal changes can influence monthly median flow and monthly median chloride concentration. In Credit River, higher chloride concentrations occur in winter and higher flows occur in spring and early summer. Chloride concentrations are typically highest in winter months when flows are low; concentrations decrease as flows increase in spring and early summer, then reach a low in late summer before increasing again in the fall.

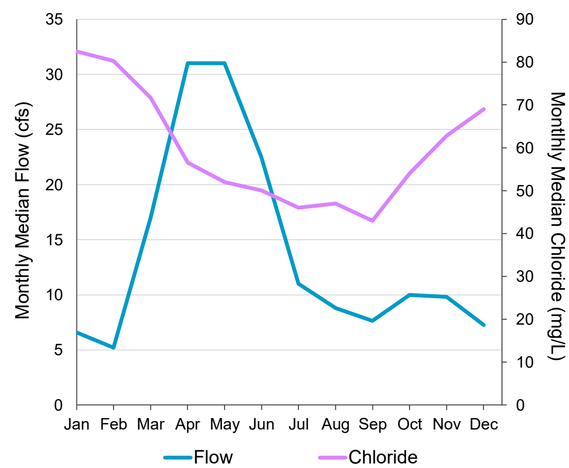

Figure 8: Monthly Median Flow and Median Ambient Chloride Concentrations in Credit River

Chloride Load

Chloride load is seasonally dynamic. The highest chloride load occurs from March through June. Loads then fall to a nearly constant level for the remainder of the year. Chloride loads calculated with Flux32 were compiled as monthly averages for 1999-2019, Figure 9 uses a line to indicate maximum and minimum values for each month. The bottom of each box represents the first quartile, the top represents the third quartile, and the line in the middle of the box represents the median monthly chloride load.

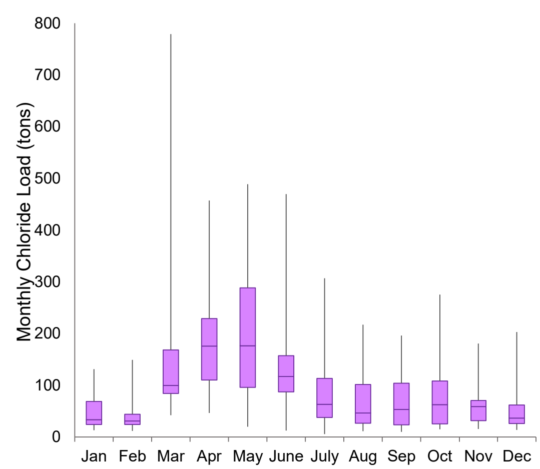

Figure 9: Monthly Chloride Loads in Credit River

From 1999-2019, higher monthly loads occur in the spring and early summer, possibly due to de-icing salt and synthetic fertilizer runoff coupled with the higher flows occurring during that period.

LIMITATIONS

The analyses described in this memo identify changes in chloride concentrations in the stream, but they do not identify the cause of those changes. MCES has suggested hypotheses about causes of changing chloride dynamics but additional information or research is needed to identify specific changes in watershed management, climactic changes, or any other factors which may have affected concentration in the stream.

During some winter months in from 1999 – 2019, hazardous conditions precluded sample collection. This data gap possibly biases our understanding of seasonal and annual chloride dynamics. Credit River monitoring equipment was relocated during 2000 from the former site at Credit River Mile 0.6 to the current location at river mile 0.9.

RECOMMENDATIONS & NEXT STEPS

Chloride pollution reduction projects and initiatives are most effective when guided by data collection and analysis. In order to support prioritizing resources to understand chloride dynamics and mitigate chloride pollution, MCES provides the following recommendations:

- Calculate or compile the watershed water and chloride budgets including but not limited to, fertilizer use, livestock waste management, household water softening, wastewater treatment plant discharge, and de-icing salt application.
- Investigate the potential for stormwater runoff to enter shallow groundwater and how that affects chloride pollution timing and concentration.
- Compile a timeline of land use changes, chloride best management practices and stormwater management installations in the watershed to better understand the flow-adjusted concentration trend.
- Continue to monitor water quality and flow upstream of the WOMP station to better identify chloride sources to Credit River.
- Continue to implement chloride mitigation and management BMPs including trainings to minimize de-icing salt use and synthetic fertilizer runoff.

We are aware that not all watershed organizations have the time, capacity, or resources to take these or other future next steps. MCES may have the ability to assist with future data collection, data analysis or other technical advice. Please contact us to discuss the potential of future partnerships if you are interested in continuing this work. Please contact us for additional technical information or information on field, laboratory and data analysis methods. Method documentation is also available as part of the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams* report, *Introduction and Methodologies* section, available on the Council website at https://metrocouncil.org/streams.

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