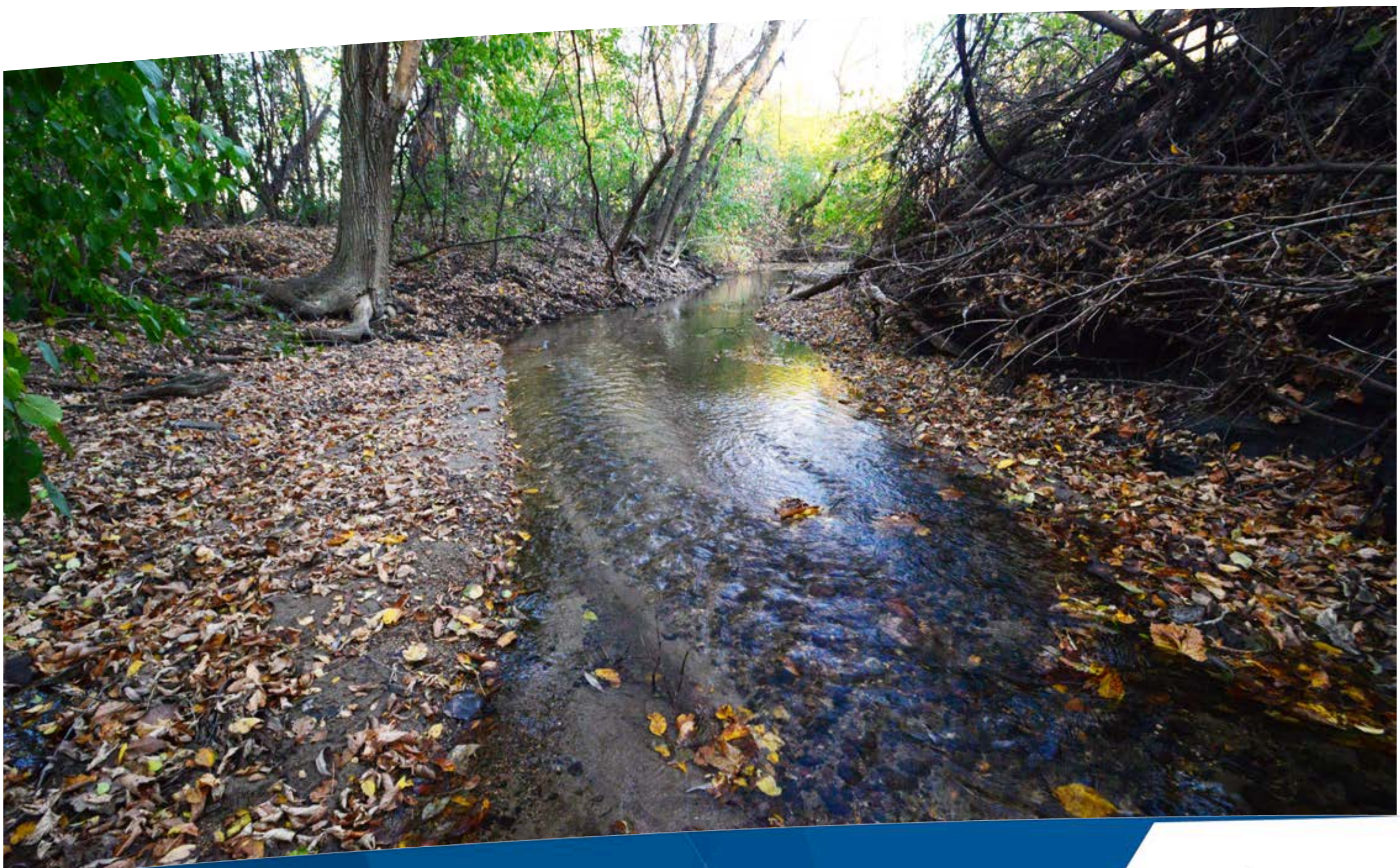
Comprehensive Water Quality Assessment of Select Metropolitan Area Streams

BLUFF CREEK



METROPOLITAN COUNCIL

December 2014

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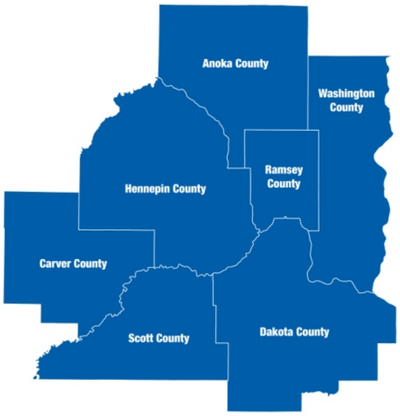

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide 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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About the Study

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. The study provides 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 sections 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 partners conducted the stream monitoring work, while MCES staff performed the data analyses, compiled the results and prepared the report.

About This Section

This section of the report, *Bluff Creek*, is one in a series produced as part of the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams.* Located in Carver and Hennepin counties, Bluff Creek is one of the nine Minnesota River tributaries examined. This section discusses a wide range of factors that have affected the condition and water quality of Bluff Creek.

Cover Photo

The photo on the cover of this section depicts Bluff Creek downstream of the MCES monitoring site. It was taken by Metropolitan Council staff.

Recommended Citations

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Content

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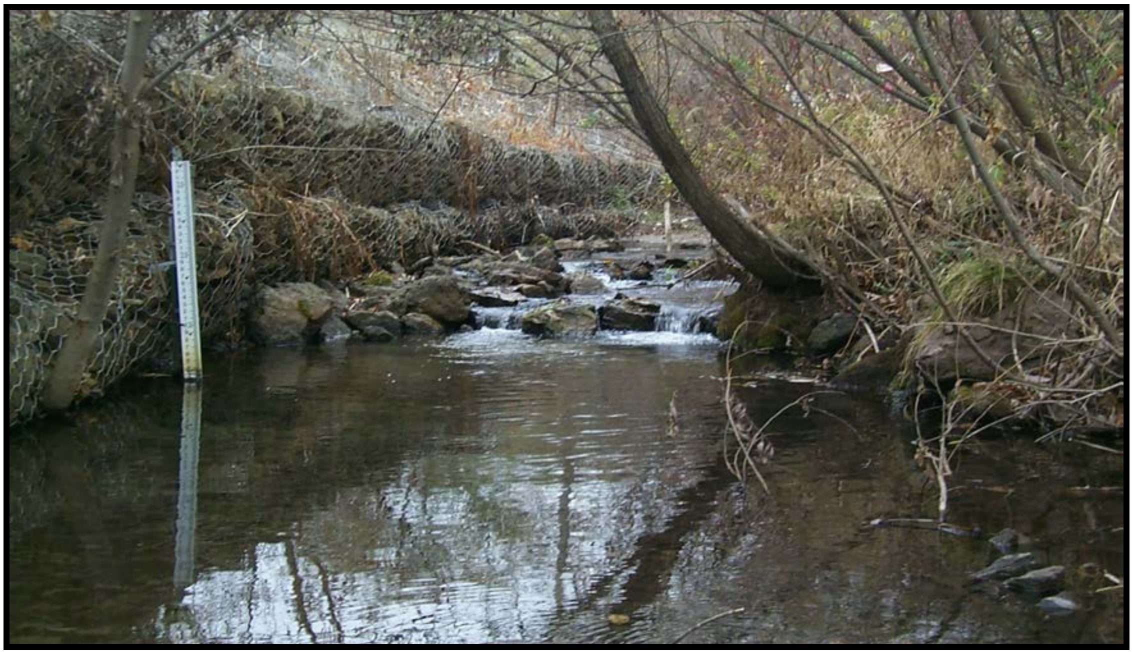
Introduction

Bluff Creek is located in the south western metropolitan area and is a tributary to the Minnesota River. It drains approximately 9.2 square miles of mixed agricultural land, open space, bluff land, and urban areas primarily within the cities of Chanhassen and Chaska in Carver County, and a small portion of Eden Prairie in Hennepin County.

Figure BL-1: Bluff Creek near Monitoring Station



This report:

- documents those characteristics of Buff Creek and its watershed most likely to influence stream flow and water quality.
- presents the results from assessments of flow, water quality, and biological data.
- presents statistical assessments of trends in stream chemistry concentrations.
- draws conclusions about possible effects of landscape features, climatological changes, and human activities on flow and water quality.
- compares Bluff Creek flow and water quality with other streams within the metropolitan area monitored by Metropolitan Council Environmental Services (MCES).
- makes general recommendations for future monitoring and assessment activities, watershed management, and other potential actions to remediate any water quality or flow concerns.

MCES plans to update this report approximately every five to 10 years, in addition to issuing annual data summary reports.

Partnerships

MCES has conducted water quality and flow monitoring on Bluff Creek since 1991. MCES staff maintain the rating curve and operate the monitoring station.

Monitoring Station Description

The MCES Bluff Creek monitoring station is located at Bluff Creek mile 3.5 near the intersection of Flying Cloud Drive and MN 101 in the city of Chanhassen. The monitoring station includes continuous flow monitoring, event-based composite sample collection, and on-site conductivity and temperature probes. The Bluff Creek station also includes an in-stream turbidity sensor (Forest Technology Systems DTS-12). There is a rain gauge at this station; however it is not used due to infrequent site visits for calibration. Precipitation data are available from the Minnesota Climatology Working Group, Chanhassen Station Number 211448 and Chaska Station Number 211465. Daily precipitation totals from these stations were used to create the hydrograph in the ***Hydrology*** section of this report.

For the analysis of precipitation-weighted loads, MCES used the Minnesota Climatological Working Group's monthly 10-kilometer gridded precipitation data to represent the variability of rainfall within the watershed (Minnesota Climatology Working Group, 2013). These data are generated from Minnesota's HIDEN (High Spatial Density Precipitation Network) dataset. The gridded data was aerially-weighted based on the watershed boundaries.

The stage-discharge relationship on Bluff Creek is relatively stable. Manual flow measurements are taken periodically each year to check validity of rating curve.

High water conditions in Bluff Creek during the spring of 2001 rendered the monitoring equipment useless and dramatically changed the rating curve. The Bluff monitoring station was also out of commission from August through December of 1998. Therefore data for 2001 and 1998 are not presented in this report.

Stream and Watershed Description

The main branch of Bluff Creek flows southeasterly through the city of Chanhassen until it discharges to Rice Lake in the Minnesota River floodplain and ultimately, the Minnesota River itself.

The Bluff Creek watershed encompasses a total of 5,892 acres, with 3,611 acres (61.3%) of the watershed upstream of the monitoring station. The watershed has 1,516 acres/25.7% (1,251 acres/34.7% within the monitored area) developed urban land and 1,014 acres/17.2% (755 acres/20.9% within the monitored area) agricultural land. The monitored portion of the watershed encompasses portions of the Cities of Chanhassen and Chaska, while the unmonitored portion includes portions of Chanhassen and Eden Prairie (Metropolitan Council Districts 3 and 4). The most heavily urbanized portions of the watershed are in the north, especially along the State Highway 5 corridor. Of the agricultural land, 11.6% (15.5% within the monitored area) is planted in corn, 20.5% (9.0% within the monitored area) in soybeans, 43.5% (52.9% within the monitored area) is pasture/hay and 6.5% (4.6% within the monitored area) is herbaceous wetlands. 4.8% (3.8% within the monitored area) of the agricultural land in the watershed is potentially drain tiled (D. Mulla, University of Minnesota, personal communication, 2012). Other primary land covers in the watershed are forest, grasses/herbaceous, and wetlands. There are no major lakes in the upper portion of the watershed. Table BL-1 and Figure BL-2 show the watershed area by land cover.

Table BL-1: Bluff Creek Land Cover Classes[1]

Land Cover Class	Monitored		Unmonitored		Total	
	Acres	Percent	Acres	Percent	Acres	Percent
5-10% Impervious	47	1.3%	29	1.3%	76	1.3%
11-25% Impervious	287	7.9%	69	3.0%	356	6.0%
26-50% Impervious	494	13.7%	97	4.3%	592	10.0%
51-75% Impervious	166	4.6%	17	0.8%	184	3.1%
76-100% Impervious	257	7.1%	52	2.3%	309	5.3%
Agricultural Land	755	20.9%	259	11.4%	1,014	17.2%
Forest (all types)	570	15.8%	396	17.3%	966	16.4%
Open Water	0	0.0%	38	1.6%	38	0.6%
Barren Land	0	0.0%	0	0.0%	0	0.0%
Shrub Land	14	0.4%	3	0.1%	17	0.3%
Grasses/Herbaceous	577	16.0%	175	7.7%	752	12.8%
Wetlands (all types)	444	12.3%	1,146	50.2%	1,589	27.0%
Total	**3,611**	**100.0%**	**2,281**	**100.0%**	**5,892**	**100.0%**

[1] Land cover spatial data file provided by MnDNR. The data is a composite of the2008 MLCCS (Minnesota Land Cover Classification System), which covered primarily the 7-county metro area; and the 2001 NLCD (National Land Cover Data), which covered the outstate areas not included in the 2008 MLCCS.

The watershed topography (Figure BL-3) is fairly gradual at the upstream end, becoming steeper at the downstream end where the creek approaches the Minnesota River through a steep ravine. The maximum watershed elevation is 1082.3 MSL and the minimum elevation is 718.5 MSL within the monitored area. Within the monitored area 2% of the slopes are considered steep, and an additional 5.9% are considered very steep (MnDNR, 2011).

Approximately ¼ of a mile downstream of the MCES monitoring station, Bluff Creek enters Rice Lake in the floodplain of the Minnesota River. Rice Lake has an area of 517 acres with an average depth of 1 foot and a maximum depth of 3 feet (HDR Inc., 2011). The creek flows through the lake before entering the Minnesota River. Some attenuation and/or modification of the creek's load likely occurs in Rice Lake. As a flood plain lake, Rice lake is totally inundated when the river floods.

There are few point sources within the Bluff Creek Watershed (Figure BL-4). The watershed contains one facility with an NPDES discharge permit for industrial wastewater. The watershed also contains two sites holding industrial stormwater permits. All permit holders are within the monitored part of the watershed. There are no domestic wastewater facilities in the watershed. There are two feedlots in the watershed. Both are under 50 animal units.

The city of Chanhassen began a project to stabilize an eroding ravine in the lower part of the watershed (Ravine 2 Mandan Circle) in late 2013. It is estimated that the project will reduce sediment delivery to the creek by as much as 89 tons per year, and also reduce phosphorus loading by about 18 pounds annually. Additional projects of this type are anticipated to be undertaken in the future.

Figure BL-2

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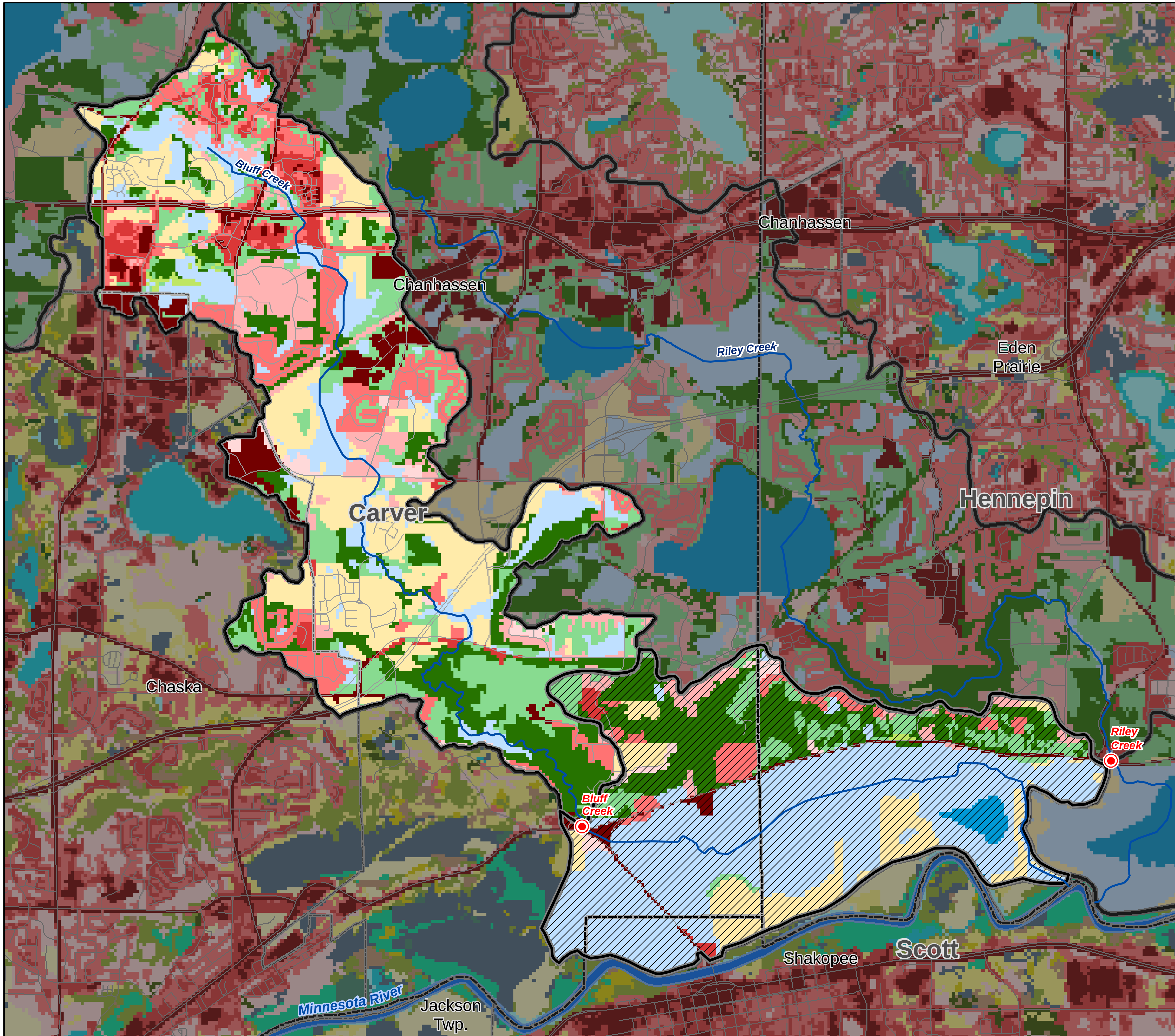
MLCCS-NLCD Hybrid Land Cover

Bluff Creek



MCES Stream Monitoring Sites
USGS Flow Stations
Mainstems (Monitored and Unmonitored)
Major Mainstem Tributaries
Monitored Watershed Boundaries
Unmonitored Portion of Watersheds
NCompass Street Centerlines, 2012
County Boundary
City and Township Boundaries

MLCCS-NLCD Hybrid Land Cover

- 5-10% Impervious
- 11-25% Impervious
- 26-50% Impervious
- 51-75% Impervious
- 76-100% Impervious
- Agricultural Land
- Barren Land (rock, mud)
- Forest (all types)
- Grasses/Herbaceous
- Open Water
- Shrubland
- Unknown, or No Data
- Wetlands (open water, forest, shrub and emergent)

Data Source: MnDNR

MLSSC/NLCD Hybrid Land Cover
Bluff Creek

Land Cover Class	Monitored Acres	Percent	Unmonitored Acres	Percent	Total Acres	Percent
5-10% Impervious	47	1.3%	29	1.3%	76	1.3%
11-25% Impervious	287	7.9%	69	3.0%	356	6.0%
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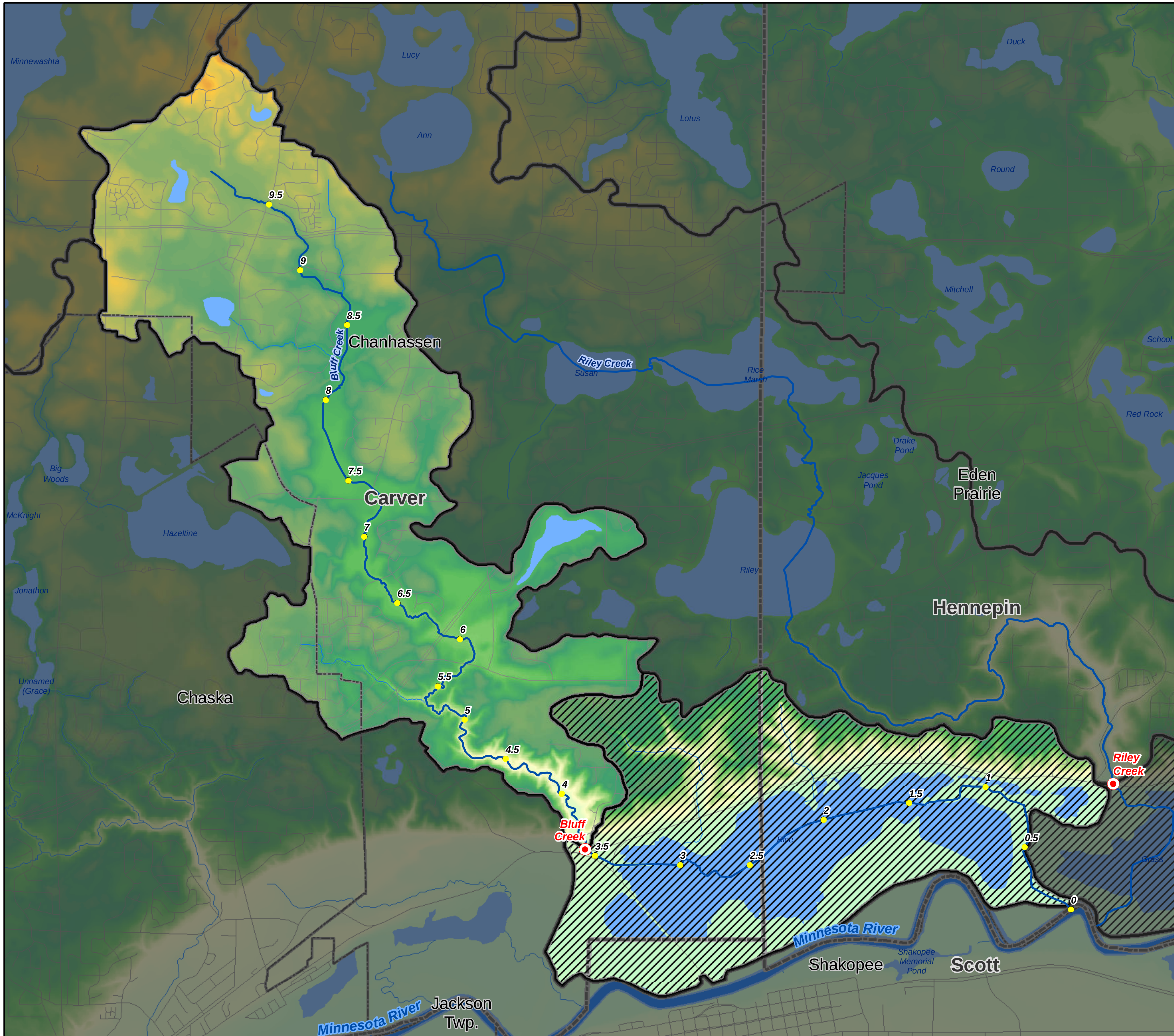
0 0.5 1 1.5
Miles

Figure BL-3

Watershed Topography

Bluff Creek



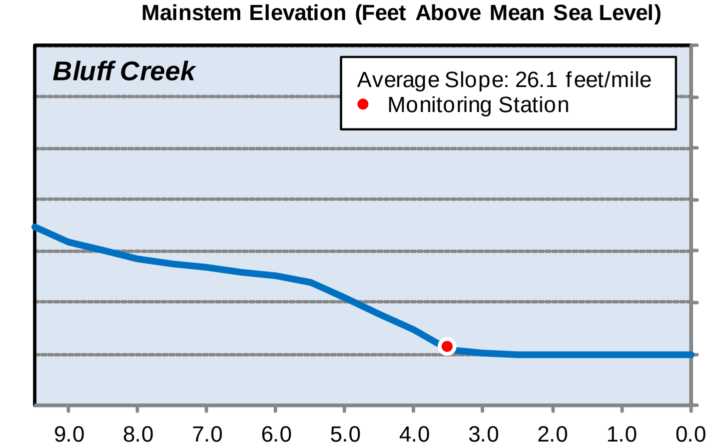
- MCES Stream Monitoring Sites
- USGS Flow Stations
- Stream Mile Markers
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Watershed Areas
- County Boundary
- City and Township Boundaries
- NCompass Street Centerlines, 2012
- Public Waters Inventory
- Other Rivers and Streams

Elevation
Feet Above Mean Sea Level

High : 1594
1400
1200
1000
800
Low : 643

Source: USGS National Elevation Dataset, 1/3 arc-second, 10-meter resolution

Mainstem Elevation (Feet Above Mean Sea Level)

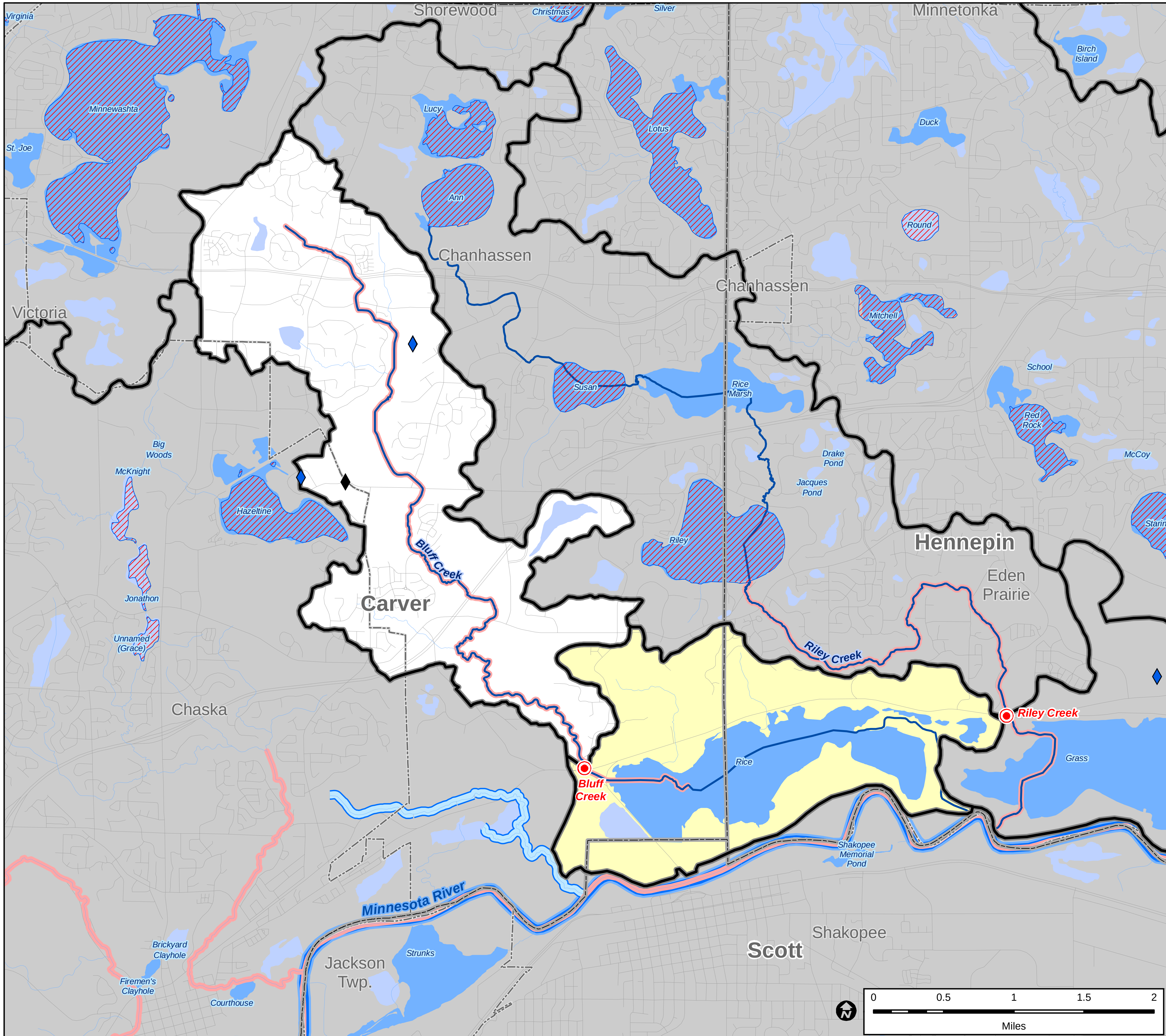


0 0.5 1 1.5
Miles

Figure BL-4

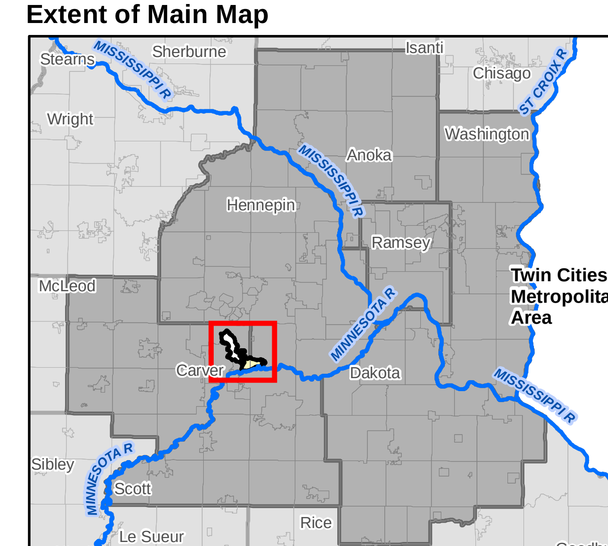
Public and Impaired Waters and Potential Pollution Sources

Bluff Creek



Data Sources: * MN DNR, ** MPCA, *** MN DOT

Extent of Main Map



Water Quality Impairments

Bluff Creek is currently designated as impaired for turbidity and fish biota on the Minnesota Pollution Control Agency's (MPCA) 2014 impaired waters list (Figure BL-4, Table BL-2). A Total Maximum Daily Load (TMDL) study and implementation plan has been completed for these impairments.

Table BL-2: Impaired Reaches of Bluff Creek as Identified on the MPCA 2014 Impaired Waters List

Reach Name	Reach Description	ID	Water Quality Impairment[1]	Approved Plan[2]	Needs Plan
Bluff Creek	Headwaters to Rice Lk	07020012-710	AQL	F-IBI, T	---

[1] AQL = Aquatic Life; [2] T = turbidity; F-IBI = Fisheries Bioassessments

Hydrology

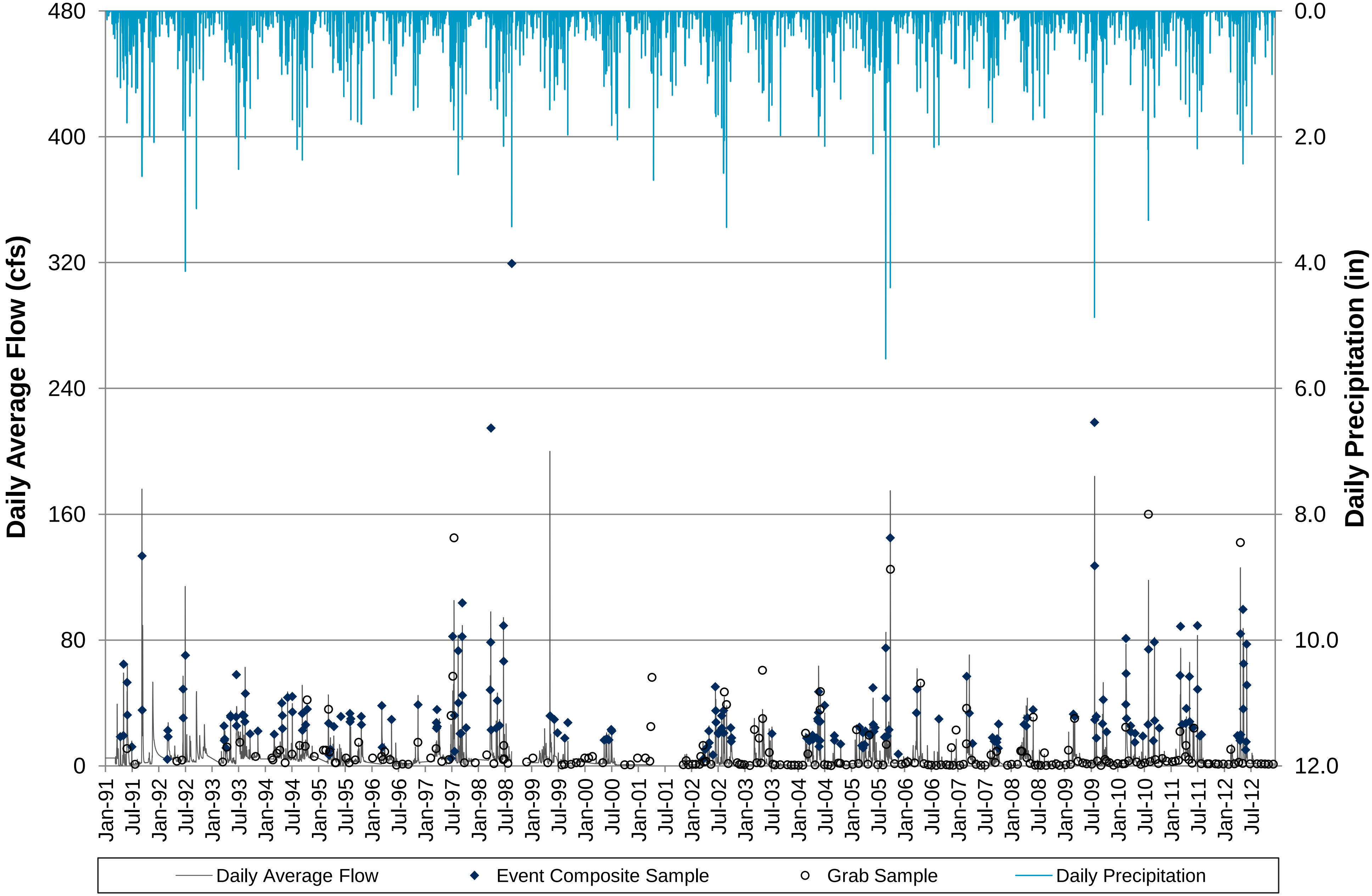
MCES has monitored flow on Bluff Creek at Chanhassen, Minnesota since 1991. Flow measurements are collected at 15-minute increments and converted to daily averages. The hydrograph of Bluff Creek, which displays daily average flow, daily precipitation, and the flow associated with grab and composite samples, indicates the variation in both intra-annual and inter-annual flow rates (Figure BL-5), and the responsiveness of flow to precipitation events.

The MCES sampling program specifies collection of baseflow grab samples between events and event-based composites. The hydrograph indicates samples were collected during most events and that baseflow was also adequately sampled.

Flow duration analysis of daily average flows indicates the upper 10th percentile flows for period 1990-2012 ranged between approximately 10-200 cfs, while the lowest 10th percentile flows ranged from 0.1-0.6 cfs (See Figure BL-12 in the ***Flow and Load Duration Curves*** section of this report).

Additional annual flow/volume metrics are shown on Figures BL-6 to BL-9, along with the annual pollutant load parameters. The first graph on each sheet illustrates an annual flow metric consisting of 1) average annual flow (a measure of annual flow volume); 2) areal-weighted flow; and 3) the fraction of annual precipitation ending up as flow.

Figure BL-5: Bluff Creek Daily Average Flow, Sample Flow, and Precipitation, 1991-2012*



*Flows for parts of 1998 and 2001 could not be determined; precipitation record was acquired from NWS COOP stations: 211465-Chaska and 211448-Chanhassen WSFO

Vulnerability of Stream to Groundwater Withdrawals

Regional analysis (Metropolitan Council, 2010) of hydrogeologic conditions in the seven-county metropolitan area suggests that some surface water features are in direct connection with the underlying regional groundwater flow system and may be impacted by groundwater pumping. While regional in nature, this analysis serves as a screening tool to increase awareness about the risk that groundwater pumping may have for surface water protection and to direct local resources toward monitoring and managing the surface waters most likely to be impacted by groundwater pumping. Additional information, including assumptions and analytical methodologies, can be found in the 2010 report.

To assess the vulnerability of Bluff Creek to groundwater withdrawals, MCES staff examined spatial datasets of vulnerable stream segments and basins created as part of the 2010 regional groundwater analysis. Eight stream segments comprising the lower portion of the stream beginning near Highway 212 and extending to the stream's confluence with Rice Lake were identified as potentially vulnerable. At the regional level the analysis was done at, no lakes or wetlands within the watershed were identified as vulnerable to groundwater withdrawals.

MCES is continuing to evaluate the effects of groundwater withdrawal on surface waters, including updating analyses with the best available data and linking results to predictive groundwater modeling and the comprehensive planning process.

Pollutant Loads

The U.S. Army Corps of Engineers program Flux32 (Walker, 1999) was used to convert daily average flow, coupled with grab and event-composite sample concentrations, into annual and monthly loads and flow-weighted mean concentrations. Loads were estimated for total suspended solids (TSS), total phosphorus (TP), total dissolved phosphorus (TDP), nitrate (NO_{3}), ammonia (NH_{3}), and chloride (Cl), for each year of monitored data in Bluff Creek (1991-2012). The Bluff monitoring station was out of commission from August of 1998 through December 1998, and through most of 2001; therefore results are not presented for those years.

Figures BL-6 to BL-9 illustrate annual loads expressed as mass, as flow-weighted mean (FWM) concentration, as mass –per-unit area (lb/ac), and as mass-per-unit area-per inch of precipitation (lb/ac/in), as well as two hydrological metrics (annual average flow rate and fraction of annual precipitation as flow). A later section in this report (***Comparison with Other Metro Area Streams***) offers graphical comparison of the Bluff Creek loads and FWM concentrations with the other MCES-monitored metropolitan area tributaries.

The flow metrics indicate year-to-year variation in annual flow rate that is likely driven by variation in annual precipitation amount as well as by variation in frequency of intense storm events. The fraction of annual precipitation delivered as flow also varies between years; year-to-year variation is likely influenced by drought periods, by low soil moisture caused by dry periods, by increased capacity in upland storage areas during drought periods, and other factors.

The annual mass loads for all parameters exhibit significant year-to-year variation, indicating the influence of precipitation and flow on the transport of pollutants within the watershed and the stream. There has been an apparent decrease in NO_3 and TP loads from the early 1990s to 2012. This decrease may be due to reductions in agricultural land use in the watershed or changes in agricultural practices over this time period.

The annual FWM concentrations for all parameters also fluctuate year-to-year and are likely influenced by changes in annual precipitation and flow, as well as the timing and intensity of precipitation events.

Figures BL-8 and BL-9 present the areal and precipitation-weighted loads, respectively. These graphics are presented to assist local partners and watershed managers, and will not be discussed here.

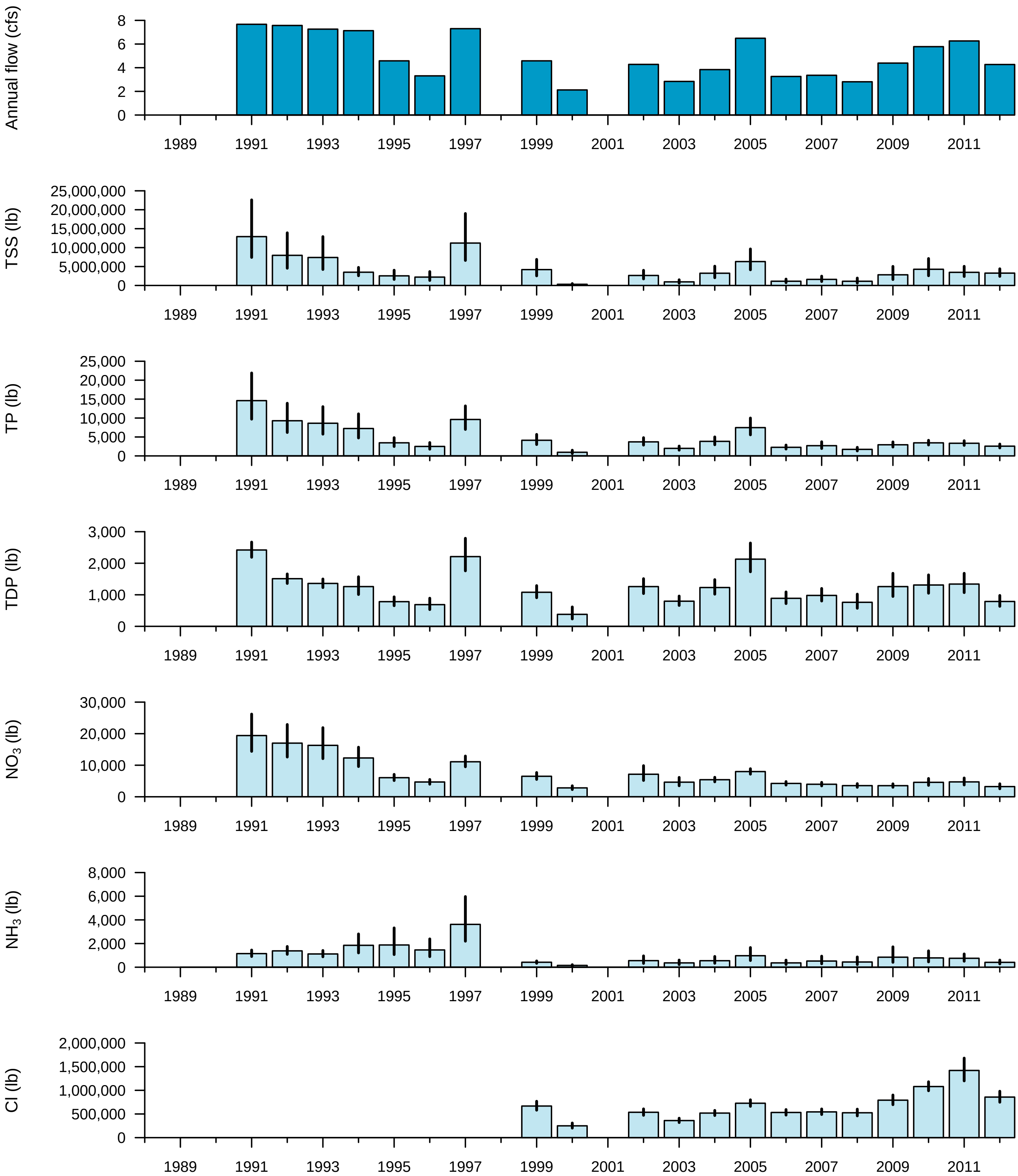
The Flux32 loads and FWM concentrations were also compiled by month to allow analysis of time based patterns in the loads in Bluff Creek (Figure BL-10 and BL-11). The results for each month are expressed in two ways: the monthly results for the most recent year of data (2012 for Bluff Creek) and the monthly average for the 10-year period 2003-2012 (with a bar indicating the maximum and minimum value for that month).

Over the 2003-2012 period the highest average flows, and in turn mass loads, generally occurred in March of each year, likely due to effects of snow melt and spring rains. Flows then generally decreased each subsequent month until September or October, when a secondary flow/load pulse often occurred. In 2012, the highest loads occurred in May, as did the highest monthly flow. There were no secondary load pulses in the late summer or fall of 2012, due to low precipitation (and in turn flows) during this period.

It is apparent that the highest mass loads of all constituents in Bluff Creek usually occur in spring each year (generally in March), likely due to effects of snow melt and spring rains. Secondary load pulses occurred in September and October due to fall precipitation. Average monthly loads showed a large range, especially for the spring flow peak, and the secondary flow peak in late summer or fall.

The FWM concentrations generally showed less month-to-month variability than the loads. Average TSS and TP concentrations were highest in spring and fall, corresponding to high flow periods. Cl concentrations showed little variation throughout the year, but the highest loads are generally in March, April, and May, likely reflecting the impact of snowmelt and spring rains on road de-icers applied during winter months. However, it is uncertain why monthly Cl concentrations are consistently high, especially during the June, July, and August.

Figure BL−6: Bluff Creek*
Annual Mass Load

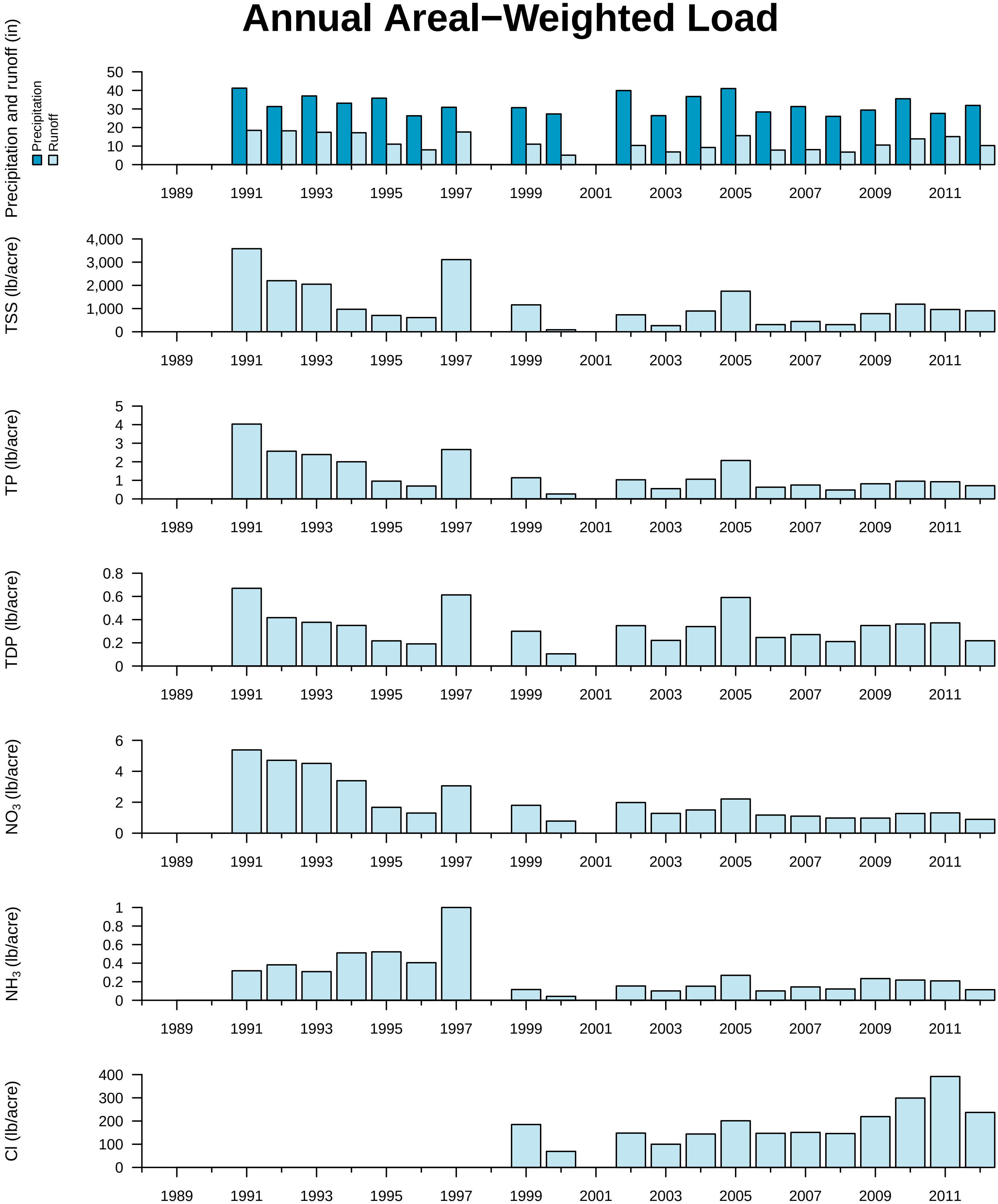


*TSS, TP, TDP, NO3, and NH3 sampling began in 1991, Cl began in 1999. The station was down in 1998 and 2001 so no loads could be calculated.
Bars represent 95% confidence intervals as calculated in Flux32.

Figure BL−7: Bluff Creek*
Annual Flow−Weighted Mean Concentration

*TSS, TP, TDP, NO3, and NH3 sampling began in 1991, Cl began in 1999. The station was down in 1998 and 2001 so no loads could be calculated.

Figure BL−8: Bluff Creek*
Annual Areal−Weighted Load



*TSS, TP, TDP, NO3, and NH3 sampling began in 1991, Cl began in 1999. The station was down in 1998 and 2001 so no loads could be calculated.

Figure BL−9: Bluff Creek*
Annual Precipitation−Weighted Areal Load

*TSS, TP, TDP, NO3, and NH3 sampling began in 1991, Cl began in 1999. The station was down in 1998 and 2001 so no loads could be calculated.

Figure BL−10: Bluff Creek Mass Load by Month

Most Recent Year (2012) of Data Compared to 2003−2012 Average

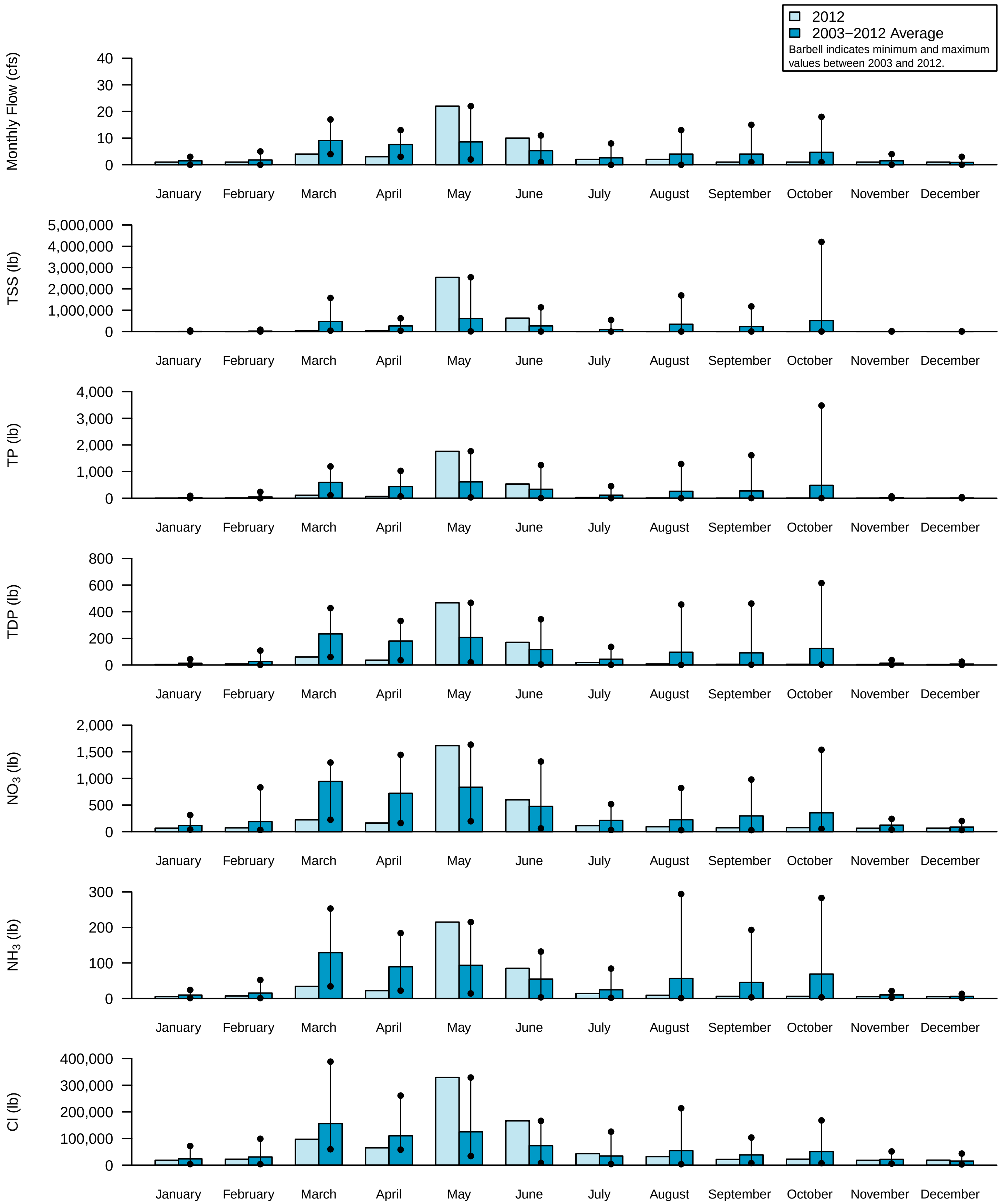
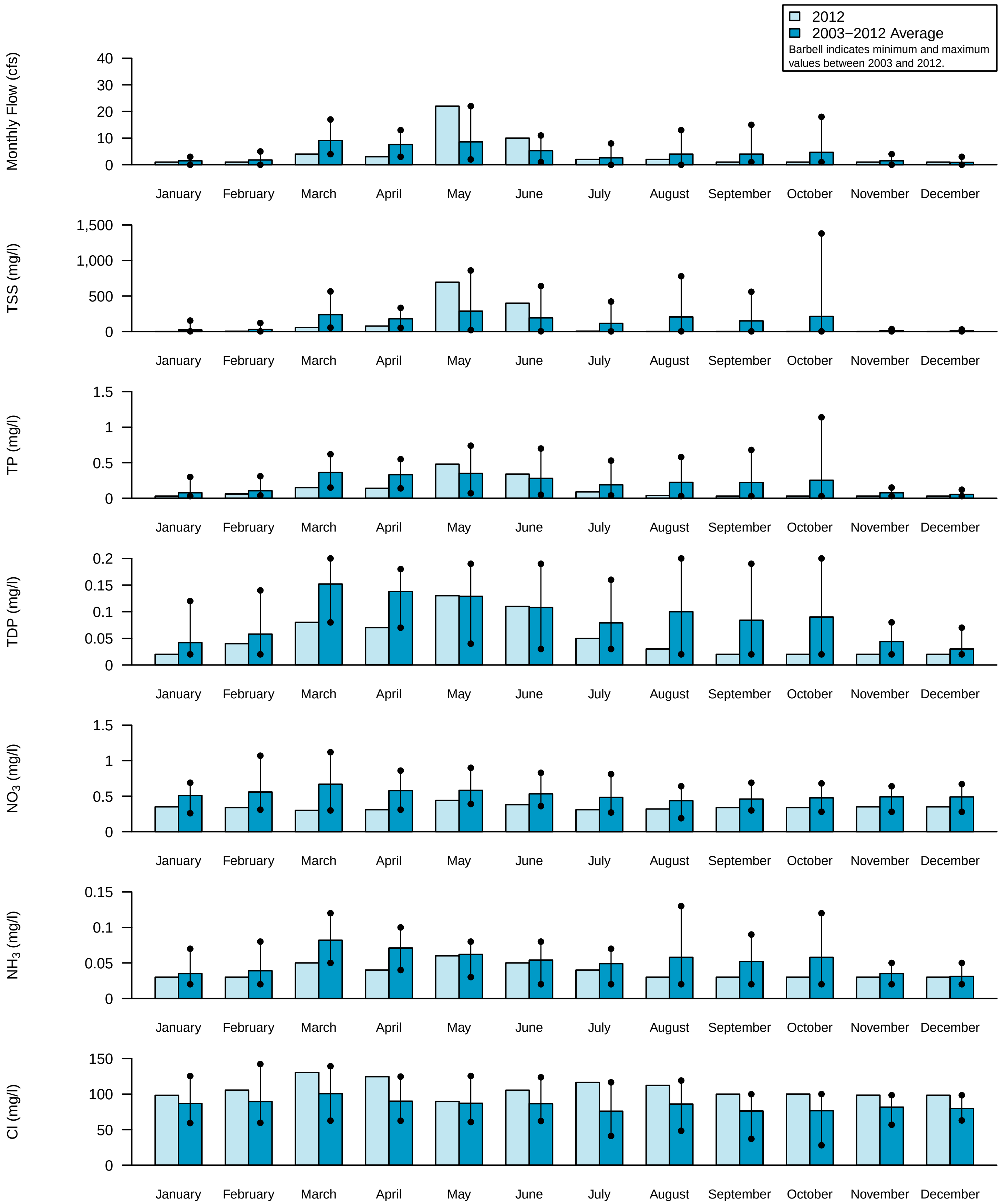


Figure BL−11: Bluff Creek
Flow−Weighted Mean Concentation by Month

Most Recent Year (2012) of Data Compared to 2003−2012 Average



Flow and Load Duration Curves

Load duration curves are frequently used to assess water quality concentrations occurring at different flow regimes within a stream or river (high flow, moist conditions, mid-range, dry conditions, and low flow). The curves can also be used to provide a visual display of the frequency, magnitude, and flow regime of water quality standard exceedances if standard concentrations are added to the plots (USEPA, 2007).

MCES developed flow and load duration curves for each stream locations using recommendations of the U.S. Environmental Protection Agency, including:

- Develop flow duration curves using average daily flow values for entire period of record plotted against percent of time that flow is exceeded during the period of record.
- Divide the flow data into five zones: high flows (0-10% exceedance frequency); moist conditions (10-40%); mid-range flows (40-60%); dry conditions (60-90%); and low flows (90-100%). Midpoints of each zone represent the 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles, respectively.
- Multiply concentration and flow for each sampling event for period of record, to result in approximate daily mass loads included on the curve as points.
- Multiply water quality standard concentration and monitored flow to form a line indicating allowable load. Sample load points falling below the line meet the standard; those falling above the line exceed the standard.

The final load duration curves provide a visual tool to assess if standard exceedances are occurring, and if so, at which flow regimes.

MCES selected four parameters to assess using load duration curves: TSS, TP, $NO_{3,}$ and Cl. Each of the parameters was plotted using Bluff Creek monitoring station daily average flows and sample data, along with the most appropriate MPCA draft numerical standard as listed in Table BL-3. No draft standard has been set for NO_3, so MCES used the drinking water standard of 10 mg/l.

Most of the draft standards proposed by MPCA have accompanying criteria that are difficult to show on the load duration curves: for example, for a water body to violate the draft TP river criteria, the water body must exceed the causative variable (TP concentration), as well as one or more response variables: sestonic (suspended) chlorophyll, biochemical oxygen demand (BOD_5), dissolved oxygen (DO) flux, and/or pH (MPCA, 2013a). Thus for this report, the load duration curves are used as a general guide to identify flow regimes at which water quality violations may occur. The MPCA is responsible for identifying and listing those waters not meeting water quality standards; the results of this report in no way supersede MPCA's authority or process.

The 1991–2012 flow duration curve and load duration curves for TSS, TP, NO_3, and Cl for the Bluff Creek monitoring station (mile 3.5, near MN 101) are shown in Figure BL-12.

The TSS load duration curve shows that most of the violations of the proposed 30 mg/l TSS standard occurred at higher flows (the "high flow" and "moist conditions" flow regimes). There were a few exceedances at other flow regimes, but it appears that essentially all of the monitored concentrations at high flows exceeded the proposed standard. This response is consistent with other streams in the Minnesota River watershed, where high flows lead to streambank, bluff, and ravine erosion.

Similarly, there were violations of the proposed TP standard at all flow regimes, but the majority of the concentrations that exceeded the standard occurred during high flow and moist conditions.

The standard shown on the NO_3 load duration curve is the current drinking water standard of 10 mg/l. The final standard for NO_3 in streams and rivers will likely to be lower than this. From the curve, it is appears that one violation would have occurred at the high flow regime. .All other NO_3 concentrations at all flow regimes met the drinking water standard of 10 mg/l.

Cl concentrations in Bluff Creek were below the draft Cl standard at all flow regimes. Concentrations were highest at the highest flows, which may indicate contributions of Cl from spring snowmelt and rain storms carrying dissolved road salt.

Table BL-3: Bluff Creek Beneficial Use and River Nutrient Region Classifications and Pollutant Draft Standards

Monitoring Station	Use Classification[1] for Domestic Consumption (Class 1) and Aquatic Life and Recreation (Class 2)	River Nutrient Region (RNR)[2] of Monitoring Station	Chloride Draft Stnd[3] (mg/l)	TSS Draft Stnd[4] (mg/l)	TP Draft Criteria[5] (ug/l)	NO_3 DW Stnd[6] (mg/l)
Bluff Creek Inlet to Rice Lake (BL3.5)	2B	Central	230	30	100	10

[1] MN Rules 7050.0470 and 7050.0430

[2] Watershed includes more than one River Nutrient Region (RNR). Listed RNR is for watershed at monitoring station or as designated by MPCA, 2010.

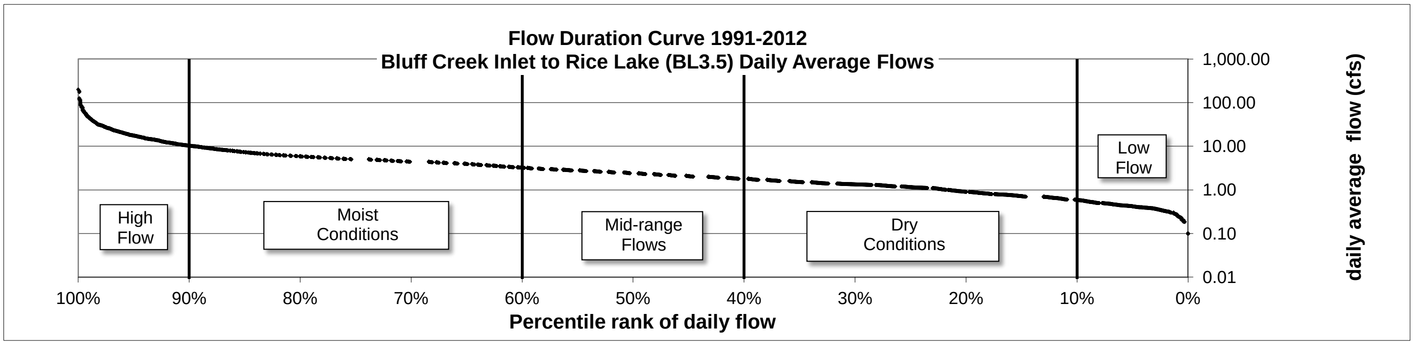
[3] Mark Tomasek, MPCA, personal communication, March 2013. MCES used 230 mg/l as the draft chloride standard pending results of EPA toxicity tests.

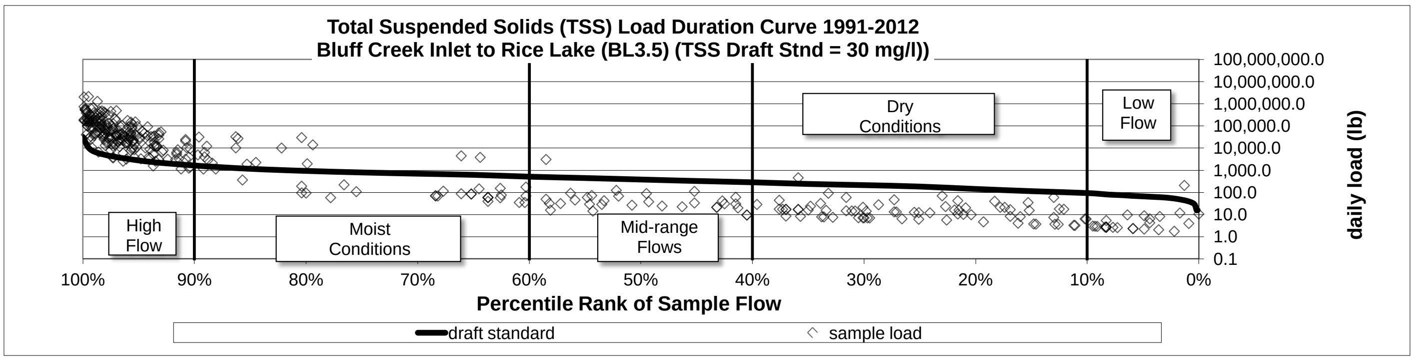
[4] MPCA, 2011. Draft standard states TSS standard concentration for Class 2A and 2B water must not be exceeded more than 10% of the time over a multiyear data window, with an assessment period of April through September.

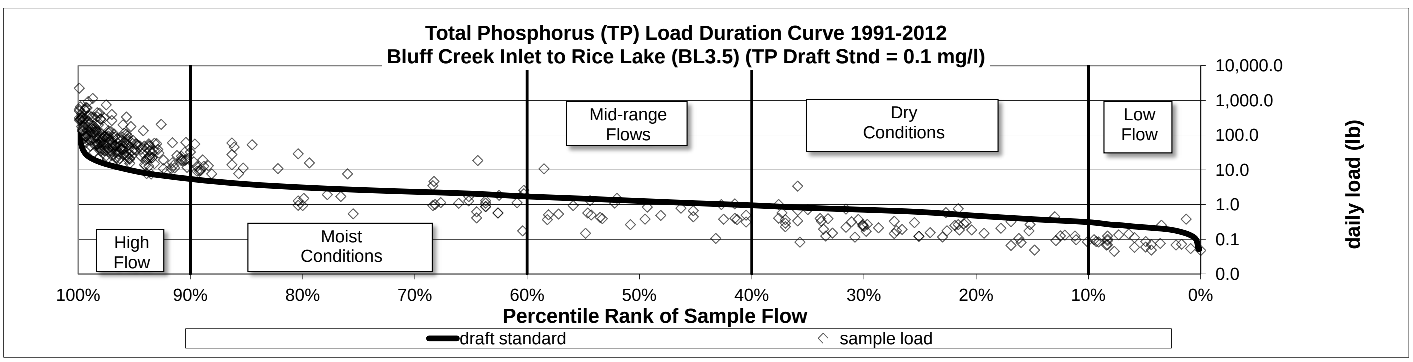
[5] MPCA, 2013a.

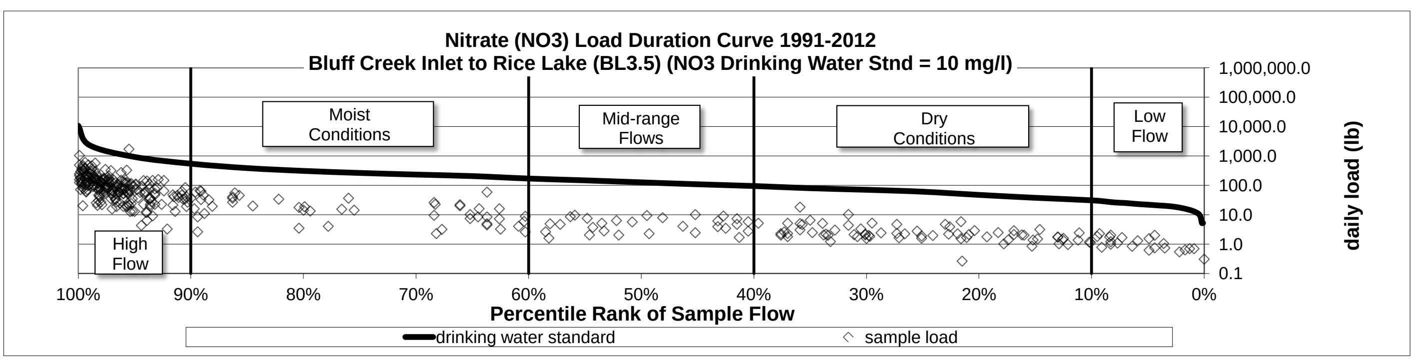
[6] MCES used the NO_3 drinking water standard of 10 mg/l pending results of EPA toxicity tests and establishment of a draft NO_3 standard for rivers and streams.

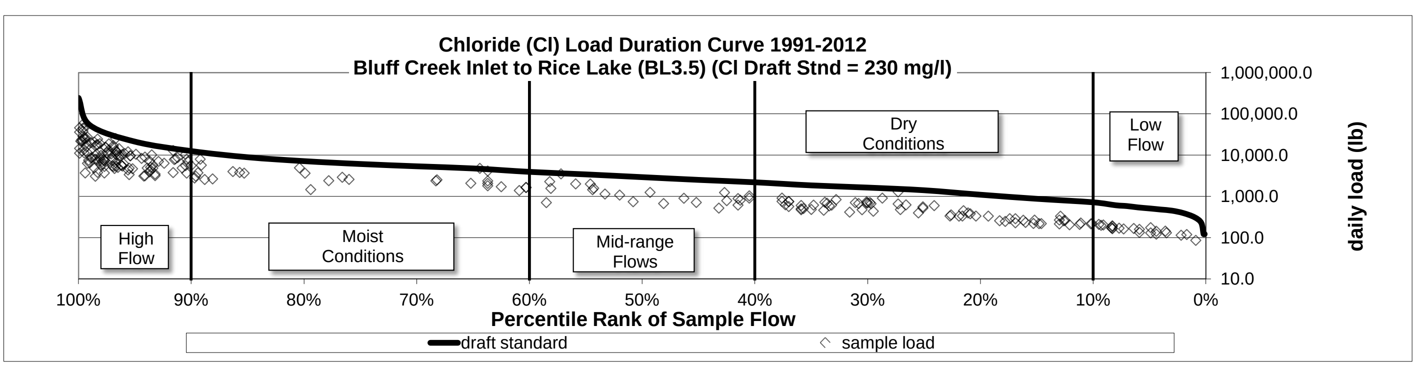
Figure BL-12: Bluff Creek Flow and Load Duration Curves, 1991-2012











Aquatic Life Assessment Based on Macroinvertebrates

Macroinvertebrates, including aquatic insects, worms, snails, crustaceans, and bivalves, are important indicators of water quality. Different types of macroinvertebrates have differing sensitivities to changes in pollution levels, habitat, flows, energy, and biotic interactions. As these environmental attributes change over time, they shape the composition of the macroinvertebrate community. Metrics have been developed that relate these community shifts with human-caused stresses.

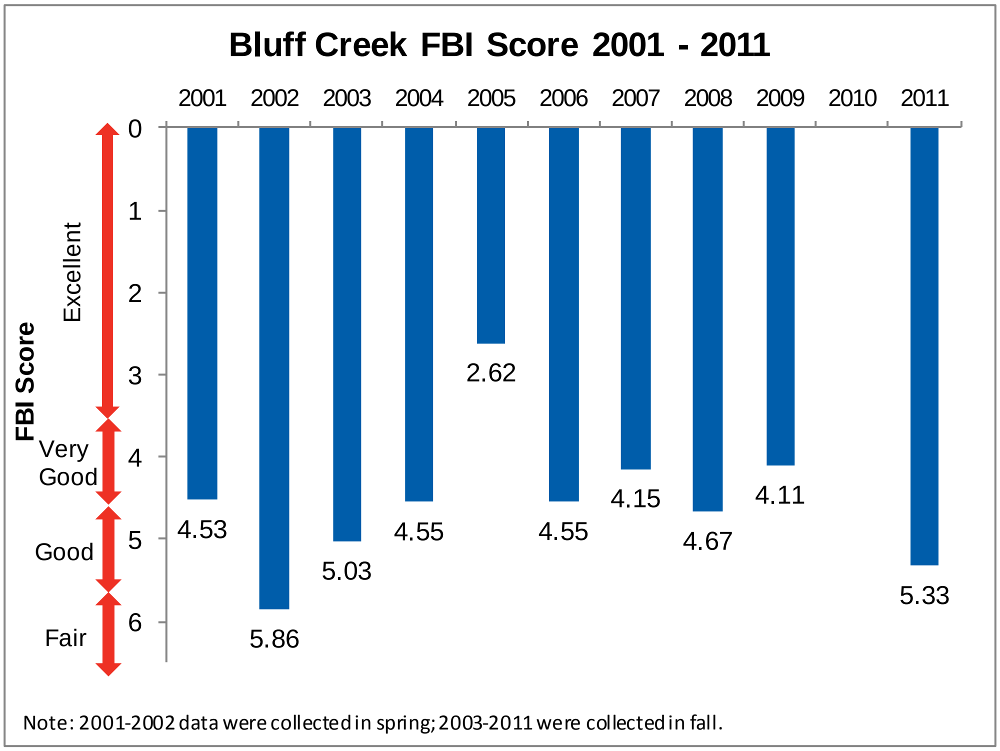
Each metric is independently important and clarifies one aspect of the ecosystem health: species richness, community diversity, water quality, and other factors. The results may have conflicting conclusions when comparing the single metric results. However, integrating the individual metrics into a multi-metric analysis provides a holistic assessment of the stream system.

MCES has been sampling for macroinvertebrates in Bluff Creek since 2001. The entire dataset was analyzed with three metrics: Family Biotic Index (FBI), Percent Intolerant Taxa, and Percent POET Taxa. A subset of data, 2004-2009 and 2011, was analyzed using the multi-metric, Minnesota-specific, MPCA 2014 Macroinvertebrate Index of Biological Integrity (M-IBI).

Family Biotic Index (FBI)

FBI is a commonly used water quality assessment. Each family is assigned a tolerance value that describes its ability to tolerate organic pollution. The values range from 0 to 10; zero is intolerant to pollution, ten is quite tolerant of pollution. The tolerance values are used to calculate a weighted average tolerance value for the sample, allowing for year to year comparisons. The Bluff Creek FBI scores showed excellent (2005) to fair (2002) water quality, indicating the presence of some organic pollution during most years (Figure BL-13).

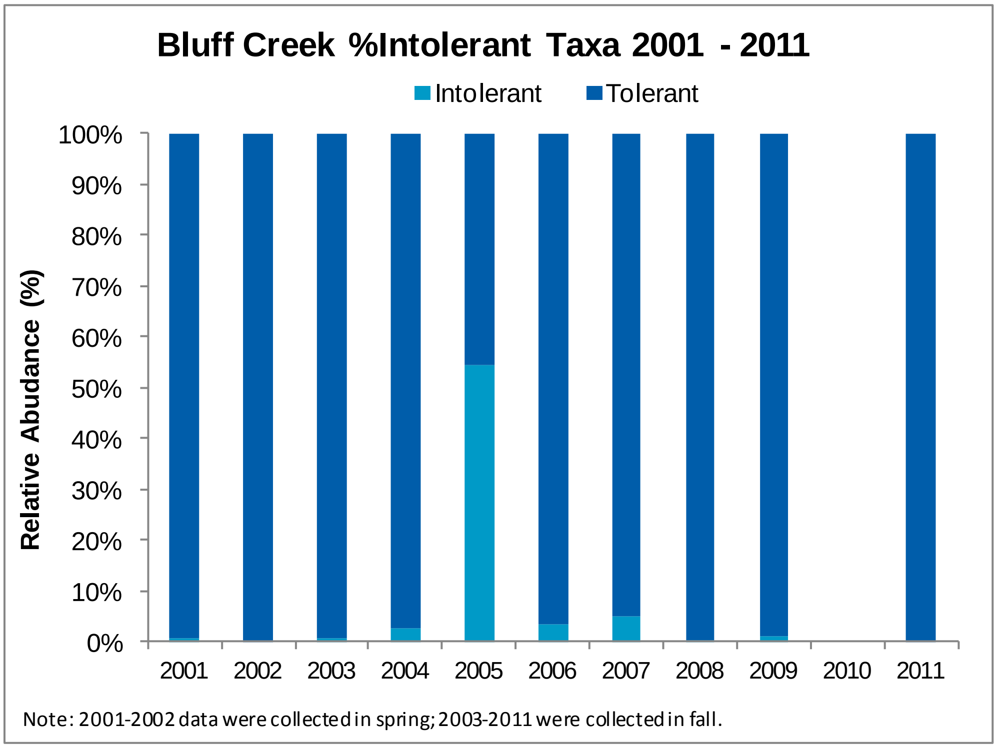
Figure BL-13: Bluff Creek Annual Family Biotic Index (FBI) Scores, 2001-2011



Percent Intolerant Taxa

The Percent Intolerant Taxa is another assessment to evaluate the degree of pollution at the monitoring reach. This metric identifies the percent of taxa with a tolerance value of two or less (Figure BL-14). The presence of moderate numbers of intolerant taxa is an indicator of good aquatic health (Chirhart, 2003). In Bluff Creek, intolerant taxa were greater than 10% of the sample in 2005 when they comprised 54% of the sample. The percentage of intolerant taxa in the other years analyzed did not exceed 5%. The consistently low values of intolerant taxa strongly suggest a presence of organic pollution that influences the macroinvertebrate population.

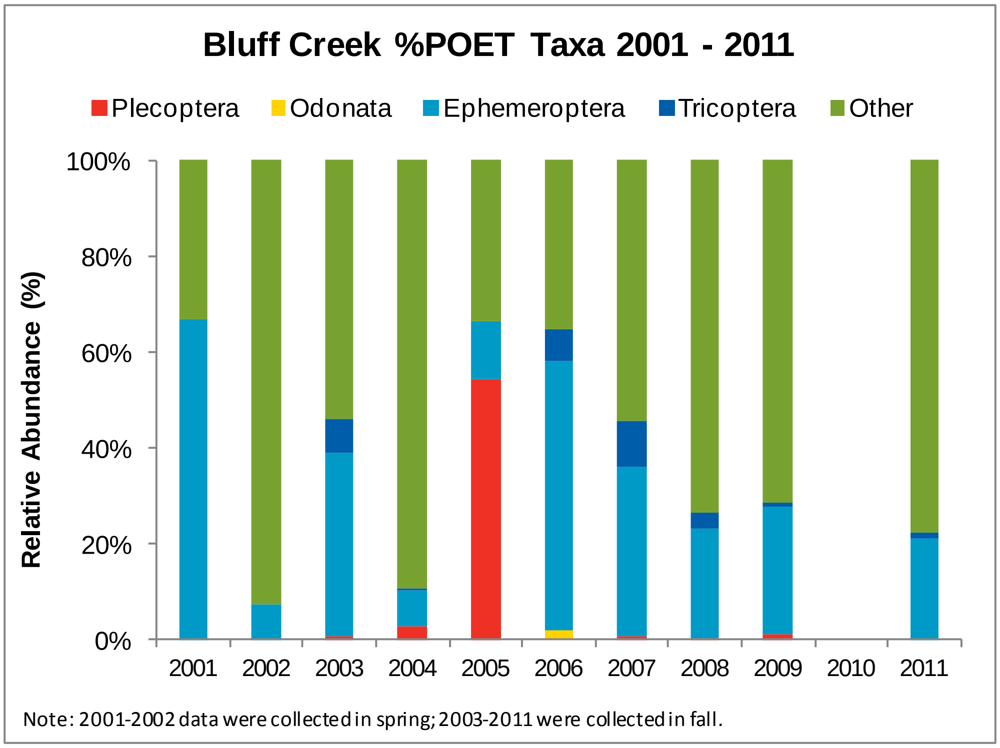
Figure BL-14: Bluff Creek Percent Abundance of Pollution Intolerant Taxa, 2001-2011



Percent POET Taxa

The taxonomic richness metric, Percent POET Taxa (Figure BL-15), is the percent of individuals in the sample that belong to the orders **P**lecoptera (stoneflies), **O**donata (dragonflies and damselflies), **E**phemeroptera (mayflies), and **T**richoptera (caddisflies). Individuals in these orders vary in sensitivity to organic pollution and sedimentation. High Percent POET values indicate high community diversity due to good water quality. The Percent POET taxa were highest in 2001 and 2005 at 67%, and lowest in 2002 at 7%.

Figure BL-15: Bluff Creek Percent Abundance of POET Taxa, 2001-2011



Macroinvertebrate Index of Biotic Integrity (M-IBI)

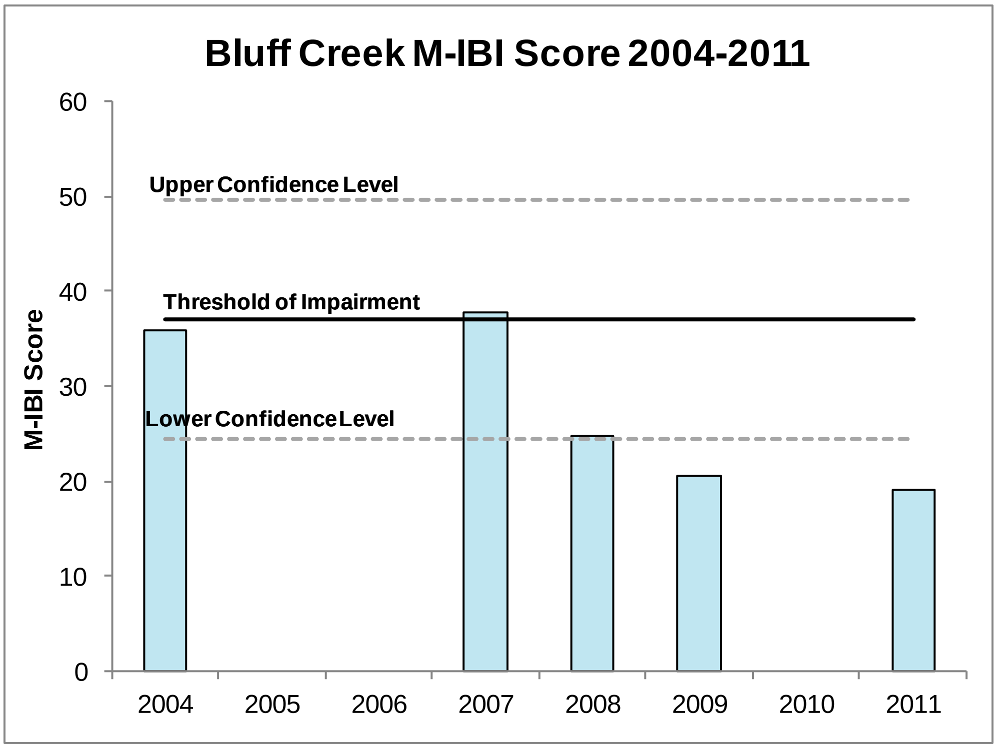
The M-IBI score integrates community richness and composition, pollution tolerance, life histories, trophic interactions, and physical and other parameters that all are components of the biological integrity of the stream. These composite scores are usually shown in context with a threshold value and confidence levels to aid in the assessment of the water quality. If the value for a given year is above the threshold of impairment and the upper confidence level, it can confidently be said the site is not impaired. Conversely, if the value is below the threshold of impairment and below the lower confidence level, it can be said the site is likely to be impaired. Note: 2005 and 2006 monitoring data did not meet the total sample size criteria to be used in for M-IBI analysis.

In 2009 and 2011 the M-IBI scores were below the lower confidence interval, suggesting the water quality may not have been able to sustain the needs of the aquatic community (Figure BL-16). The 2004, 2007, and 2008 scores were between the upper and lower confidence intervals. Consequently, it is difficult to confidently assess the water quality by biological assessment alone. It is necessary to incorporate other monitoring information, such as hydrology, water chemistry, and land use change into the final assessment (MPCA 2014b). The overall trend throughout the study period shows a decline in M-IBI scores. This strongly suggests that stressors are negatively affecting the macroinvertebrates community. This stream may be unable to sustain the aquatic community.

In 2001 and 2002, Bluff Creek macro invertebrate samples were collected in June; for the remaining years (2003-2011), samples were collected in the fall (September or October). For 2001-2011 period, most of the macro invertebrate samples were collected at flows less than one cubic foot per second (cfs). A significant storm event (4.5 inches of rain) occurred within the week macro invertebrate samples were collected in 2005, with the maximum average daily flow reaching 175 cfs. Average daily flow was 6 cfs the day the 2005 samples were taken. This event may explain the excellent FBI score in 2005, as well as the greater percentage of intolerant taxa and Plecoptera that year.

MCES is planning additional future analysis to fully investigate our biological monitoring data.

Figure BL-16: Bluff Creek Annual Macroinvertebrate Index of Biological Integrity (M-IBI) Scores, 2004-2011



Trend Analysis

Trend analysis was completed for the historical record of TSS, TP, and NO_3 using the U.S. Geological Survey (USGS) program QWTREND (Vecchia, 2003). QWTREND removes the variability of annual flow and seasonality from the statistical analysis; thus any trend identified should be independent of flow and seasonal variation.

Due to the relatively short flow record for the monitored streams, MCES did not attempt to assess increases or decreases in flow. However other researchers have performed regional assessments of variations in flow rate; their results can be used to form general assumptions about changes in flows in the metropolitan area streams. Novotny and Stefan (2007) assessed flows from 36 USGS monitoring stations across Minnesota over a period of 10 to 90 years, finding that peak flow due to snowmelt was the only streamflow statistic that has not changed at a significant rate. Peak flows due to rainfall events in summer were found to be increasing, along with the number of days exhibiting higher flows.

Both summer and winter baseflows were found to be increasing, as well. Novotny and Stefan hypothesized that increases in annual precipitation, larger number of intense precipitation events, and more days with precipitation are driving the increased flows. Alterations in land use and land management have also likely contributed to increasing flow rates. For example, Schottler et al. (2013) found that agricultural watersheds with large land use changes have exhibited increases in seasonal and annual water yields, with most of the increase in flow rate due to changes in artificial drainage and loss of natural storage. MCES staff plan to repeat the following trend analyses in five years. At that time, we anticipate sufficient data will have been collected for us to assess changes in flow rate, as well as to update the pollutant trends discussed below.

MCES staff assessed trends for the period of 1991-2012 on Bluff Creek for TSS, TP, and NO_3. The results are presented below. The station was down in 1998 and 2001, and no flow data was available during these years.

Total Suspended Solids

One downward trend was identified for TSS flow-adjusted concentrations in Bluff Creek from 1991 to 2012 (Figure BL-17, top panel). The assessment was performed using QWTREND without precedent five-year flow setting. The trend identified was statistically significant ($p=8.98x10^{-9}$). The TSS flow-adjusted concentration decreased gradually from 24.1 mg/l to 5.8 mg/l (-76% change) over the entire assessed period at a rate of -0.83 mg/l/yr.

The five-year trend in TSS flow-adjusted concentration in Bluff Creek (2008-2012) was calculated to compare with other MCES-monitored streams (visually shown in the report section ***Comparison with Other Metro Area Streams***). TSS flow-adjusted concentrations decreased from 7.1 mg/l to 5.8 mg/l (-19% change) over this period at a rate of -0.27 mg/l/yr. Based on the QWTREND results, the water quality in Bluff Creek in terms of TSS improved during 2008-2012.

Total Phosphorus

Two downward trends were identified for TP flow-adjusted concentrations in Bluff Creek from 1991 to 2012 (Figure BL-17, middle panel). The assessment was performed using QWTREND without precedent 5-year flow. The trends identified were statistically significant ($p=2.78x10^{-11}$).

- Trend 1: 1991 to 2006, TP flow-adjusted concentration decreased slightly from 0.12 mg/l to 0.12 mg/l (-2% change) at a rate of -0.0001 mg/l/yr.
- Trend 2: 2006 to 2012, TP flow-adjusted concentration decreased from 0.12 mg/l to 0.05 mg/l (-60% change) at a rate of -0.012 mg/l/yr.

The five-year trend in TP flow-adjusted concentration in Bluff Creek (2008-2012) was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. TP flow-adjusted concentration decreased from 0.11 mg/l to 0.05 mg/l (-57%) at a rate of -0.012 mg/l/yr. Based on these QWTREND results, the water quality in Bluff Creek in terms of TP improved during 2008-2012.

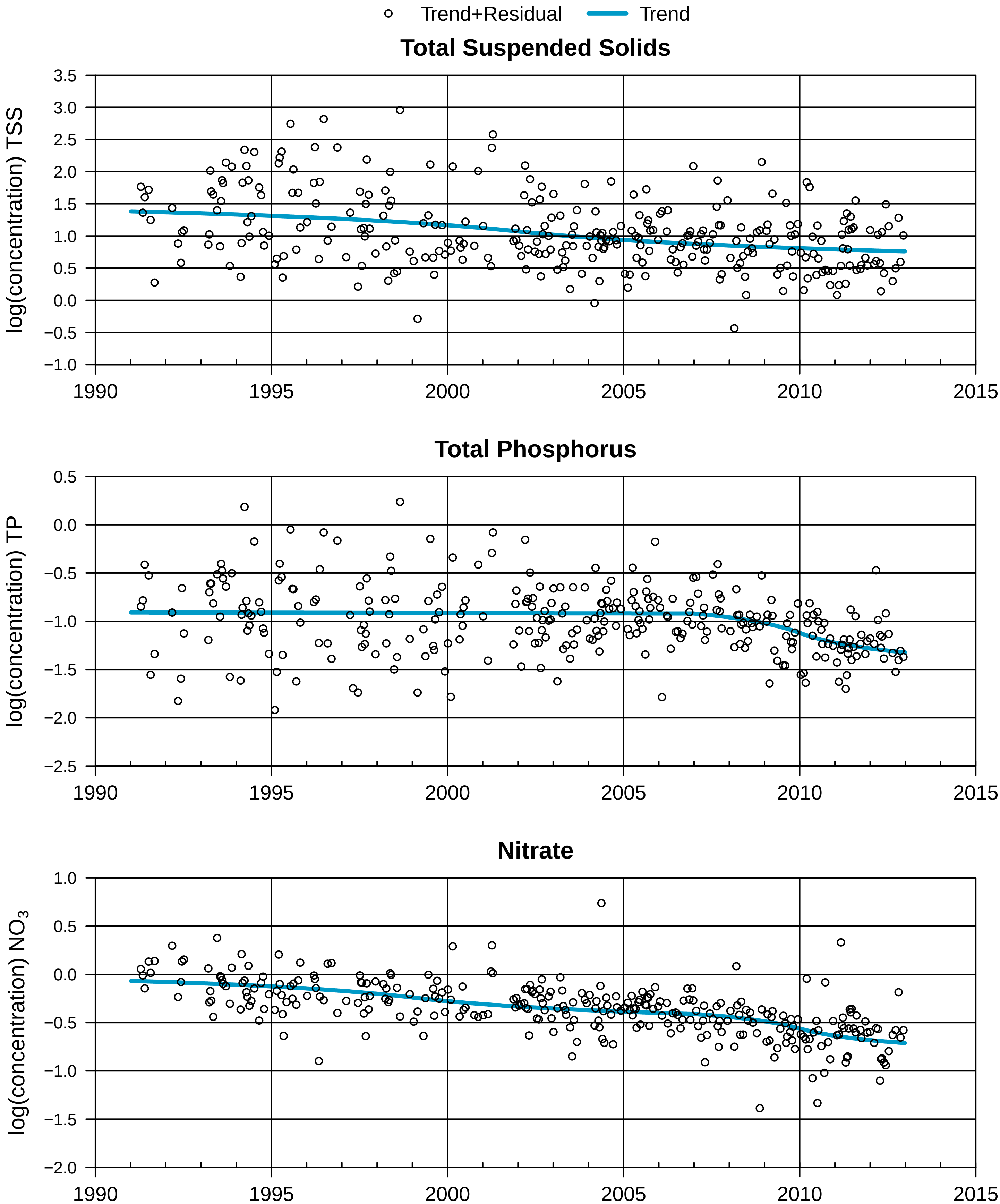
Nitrate

Two downward trends were identified for NO_3 flow-adjusted concentration in Bluff Creek from 1991 to 2012 (Figure BL-17, bottom panel). The assessment was performed using QWTREND without precedent 5-year flow. The trends identified were statistically significant ($p=1.46x10^{-9}$).

- Trend 1: 1991 to 2006, NO3 flow-adjusted concentration decreased from 0.86 mg/l to 0.39 mg/l (-55%) at a rate of -0.029 mg/l/yr.
- Trend 2: 2006 to 2012, NO3 flow-adjusted concentration decreased from 0.39 mg/l to 0.19 mg/l (-50%) at a rate of -0.032 mg/l/yr.

The five-year trend (2008-2012) in NO3 flow-adjusted concentration in Bluff Creek was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. NO_3 flow-adjusted concentration decreased from 0.36 mg/l to 0.19 mg/l (-46%) at a rate of -0.034 mg/l/yr. Based on these QWTREND results, the water quality in Bluff Creek in terms of NO_3 improved during 2008-2012.

Figure BL−17: Bluff Creek Trends for TSS, TP and NO_3



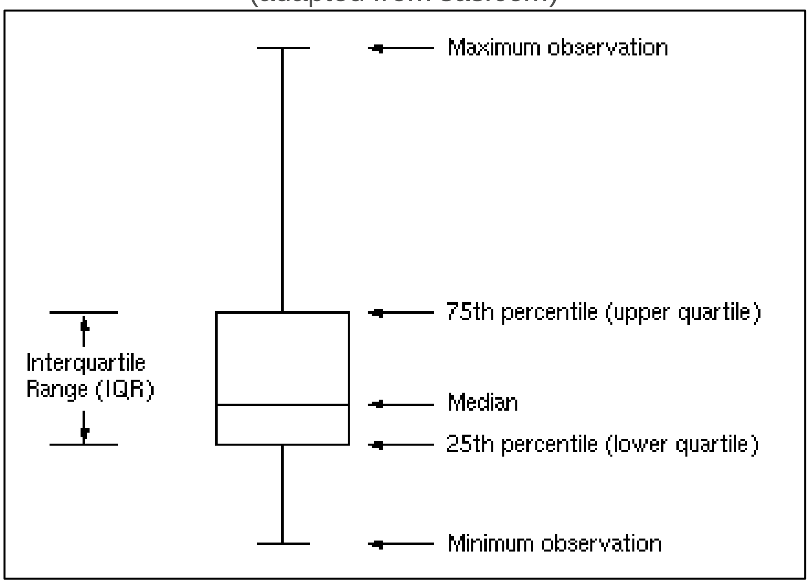
Comparison with Other Metro Area Streams

Chemistry

Box-and-whisker plots are used to summarize the comparison of the historical flow, TSS, TP, and NO_3, and Cl data for Bluff Creek with those of the other metropolitan area streams monitored by MCES and with the major receiving water (in this case the Minnesota River). The comparisons are show in Figure BL-19 to Figure BL-22.

Figure BL-18 shows the formatted legend of the box-and-whisker plots used in this report. Note that 50% of data points fall within the box (also known as the interquartile range), with the centroid delineated by the median line. The outer extents of the whiskers designate the maximum and minimum values.

Figure BL-18: General Schematic of a Box-and-Whisker Plot
(adapted from *sas.com*)



Comparisons for each chemical parameter for period 2003-2012 are shown using box-and-whisker plots of four metrics: annual flow-weighted mean (FWM) concentration, annual runoff ratio (volume/precipitation, which are identical on each of the four parameter pages), total annual load, and annual areal yield), grouped on one page, with streams grouped by major receiving river and listed in order of upstream-to-downstream. In addition, the plot of FWM concentration includes the 2003-2012 FWM concentration for the three receiving rivers (Mississippi, St. Croix, and Minnesota), shown as a dashed line.

Total Suspended Solids. The median annual FWM TSS concentration in Bluff Creek was among the highest of the monitored Minnesota River tributaries, similar to Sand Creek and Riley Creek, and was higher than that for tributaries closer to the confluence of the Minnesota River and the Mississippi River i.e. Eagle, Credit, Willow, and Nine Mile (Table BL-4; Figure BL-19). The FWM concentration in Bluff Creek is also higher than that in the Minnesota River as measured at Jordan Minnesota (304 mg/l vs. 142 mg/l, respectively), indicating that Bluff Creek was serving to increase the TSS concentration in the Minnesota River. Although the FWM TSS concentration was among the highest of the monitored Minnesota River tributaries, the median annual load ranked in the middle of these creeks, much lower than the more agricultural watersheds to the west, but higher than the more urbanized watersheds to the east. The median TSS load was relatively low (despite the high TSS concentration) due to the small area of the watershed; 9.21 square miles versus 133 square miles for Bevens Creek and 274 square miles for Sand Creek. Bluff Creek had the highest median annual areal yield of TSS of all the monitored Minnesota River tributaries, again largely explained by the small area of the watershed, especially the area above the monitoring station (5.64 square miles).

The high TSS concentration and areal yield are thought to be due to erosion from gullies and ravines along the bluff in the lower part of the watershed south of Highway 212, and are worthy of further investigation. As part of the Bluff Creek turbidity TMDL study, MPCA funded additional stream monitoring at Pioneer Trail in 2008. Based on the data collected, it was estimated that more than 90% of the median daily sediment load at the MCES monitoring station originated in the lower portion of the watershed between Pioneer Trail and the MCES monitoring station at MN 101(Barr Engineering Company, 2013).

It is apparent from Figure BL-19 that those tributaries entering the Minnesota River nearest Jordan had significantly higher FWM TSS concentrations and annual yields (expressed in lb/acre) than the other tributaries to the Minnesota or any of the Mississippi or St. Croix River tributaries monitored by MCES. This likely reflects the relatively unstable landform within the Minnesota River watershed, where tributaries channels and associated gullies and ravines are still down-cutting towards geographic equilibrium (Jennings, 2010).

The median annual runoff ratio for Bluff Creek was higher than any other monitored Minnesota River tributary, with the exception of groundwater-dominated Eagle Creek. The reasons for this are unclear, but may be due to efficient drainage from tile and storm sewers and the general absence of lakes and other impoundments on the stream channel.

Total Phosphorus. As with TSS, the median annual FWM TP concentration in Bluff Creek was higher than the Minnesota River and thus served to increase the TP concentration in the river (Figure BL-20). The Bluff Creek FWM (0.348 mg/l) was lower than that of Bevens or Sand Creek, and higher than those of Riley Creek, Credit River, Carver Creek, Nine Mile Creek, Willow Creek, and Eagle Creek. The Bluff Creek TP concentration ranked in the middle of these tributaries despite its high TSS concentrations; this may be because much of the TSS originates from erosion of the ravines in the forested bluff areas (thus the eroded soil is likely low in TP content) and that the stream does not receive effluent from any wastewater treatment plants. Bluff Creek (along with Bevens and Sand Creek) also had higher median FWM TP concentrations than all of the other MCES monitored streams in the metro area.

Bluff Creek's median annual TP load was fourth lowest of the monitored Minnesota River tributaries, higher only than that of Riley, Willow, and Eagle Creeks. However, the median annual TP yield of Bluff Creek was third highest of the Minnesota River tributaries, again as with TSS, probably due to the relatively small area of the watershed.

Nitrate. Median annual FWM NO_3 concentration in Bluff Creek was much lower than in the Minnesota River, (0.61 mg/l vs. 6.8 mg/l) and thus served to dilute the river concentration (Figure BL-21). Bluff Creek's FWM concentration was higher than that of the more urbanized Minnesota River tributaries (Nine Mile, Willow, and Eagle), similar to that of nearby Riley Creek, and much lower than those of the more agricultural Minnesota River tributaries (Bevens, Sand, and Carver Creeks). Median annual NO_3 load from Bluff Creek was low, (4,405 pounds per year) higher only than Willow and Eagle Creek among the monitored Minnesota River tributaries. The Bluff Creek median annual NO_3 yield ranked near the middle of the monitored Minnesota River tributaries despite the small median annual load, again likely due to the small monitored area of Bluff Creek.

Chloride. The median annual Cl FWM concentration in Bluff Creek (Figure BL-22) was higher than in the Minnesota River, and higher than the concentrations observed in the other Minnesota River watersheds monitored by MCES, with the exceptions of Nine Mile and Willow Creeks. Total Cl load was the third lowest of the Minnesota River tributaries, while median annual yield was the second highest. A likely explanation for the high Cl concentration was application of salt to road surfaces as a de-icer; the low annual load and high areal yield relative to the other Minnesota River watersheds was likely due to the relatively small size of the Bluff Creek watershed above the monitoring station.

Macroinvertebrates

The historic biomonitoring data, summarized as M-IBI scores, are also shown as box-and-whisker plots. However, the streams were organized by stream type because the MPCA impairment thresholds are type-specific (MPCA, 2014b) and this attribute does not correlate with major river basins.

The M-IBI scores for Bluff Creek intersected the MPCA impairment threshold (Figure BL-23). This shows that over the period of study the monitored stream reach scored a range of values both above and below the threshold of impairment. The median was below the threshold, which suggests that this stream reach habitat and water quality typically were not optimal for sustaining the needs of aquatic life. These results are unlike those of the other warm water, developing Minnesota River watershed -Credit River - which scored higher than the threshold. This suggests that there may be an additional stressor to the Bluff Creek macroinvertebrate community beyond land use. High TSS concentrations are certainly a possible candidate, as are high Cl concentrations, but MCES monitoring data alone is insufficient to determine causality and further investigation is warranted.

Figure BL−19: Total Suspended Solids for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

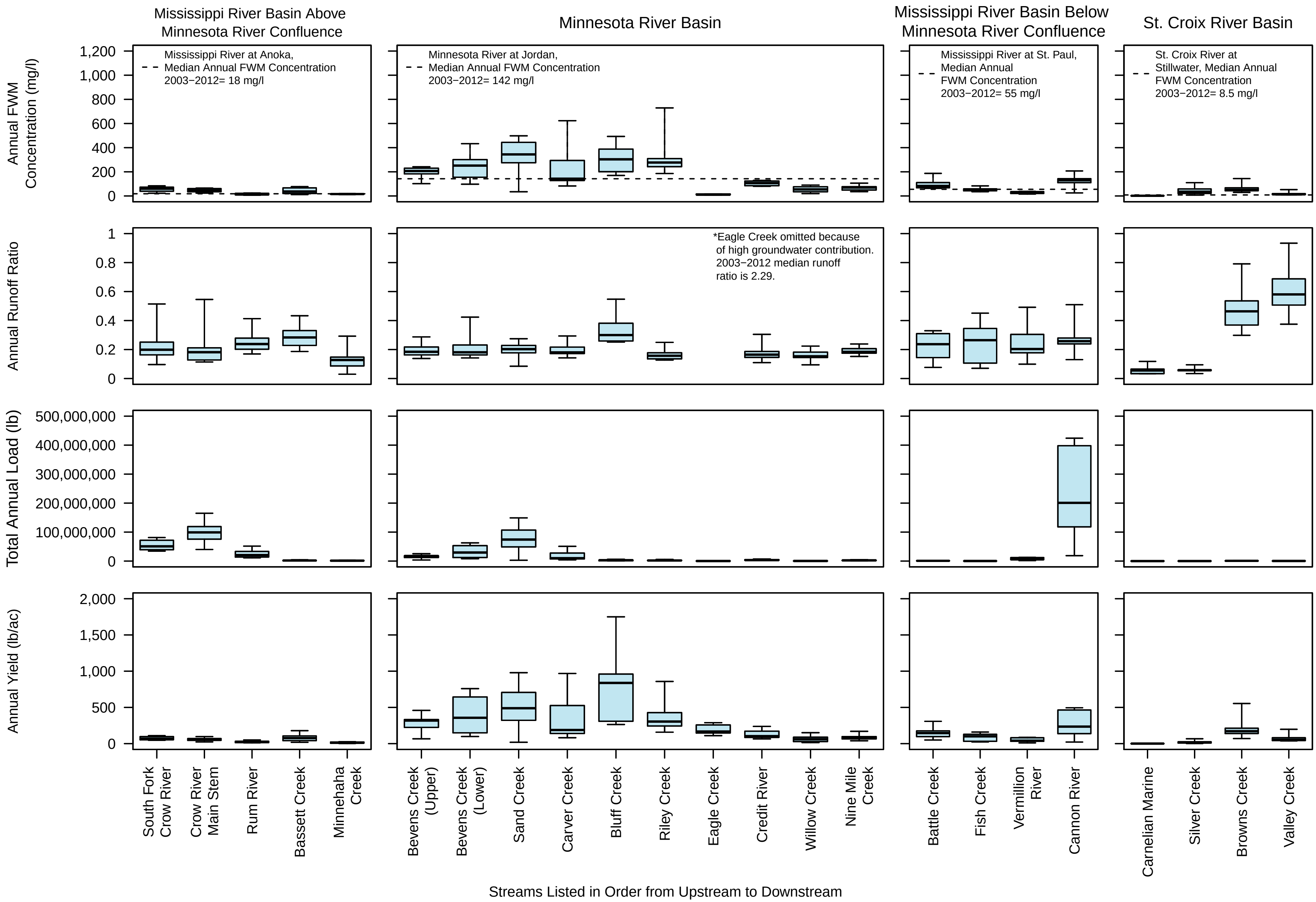


Figure BL−20: Total Phosphorus for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

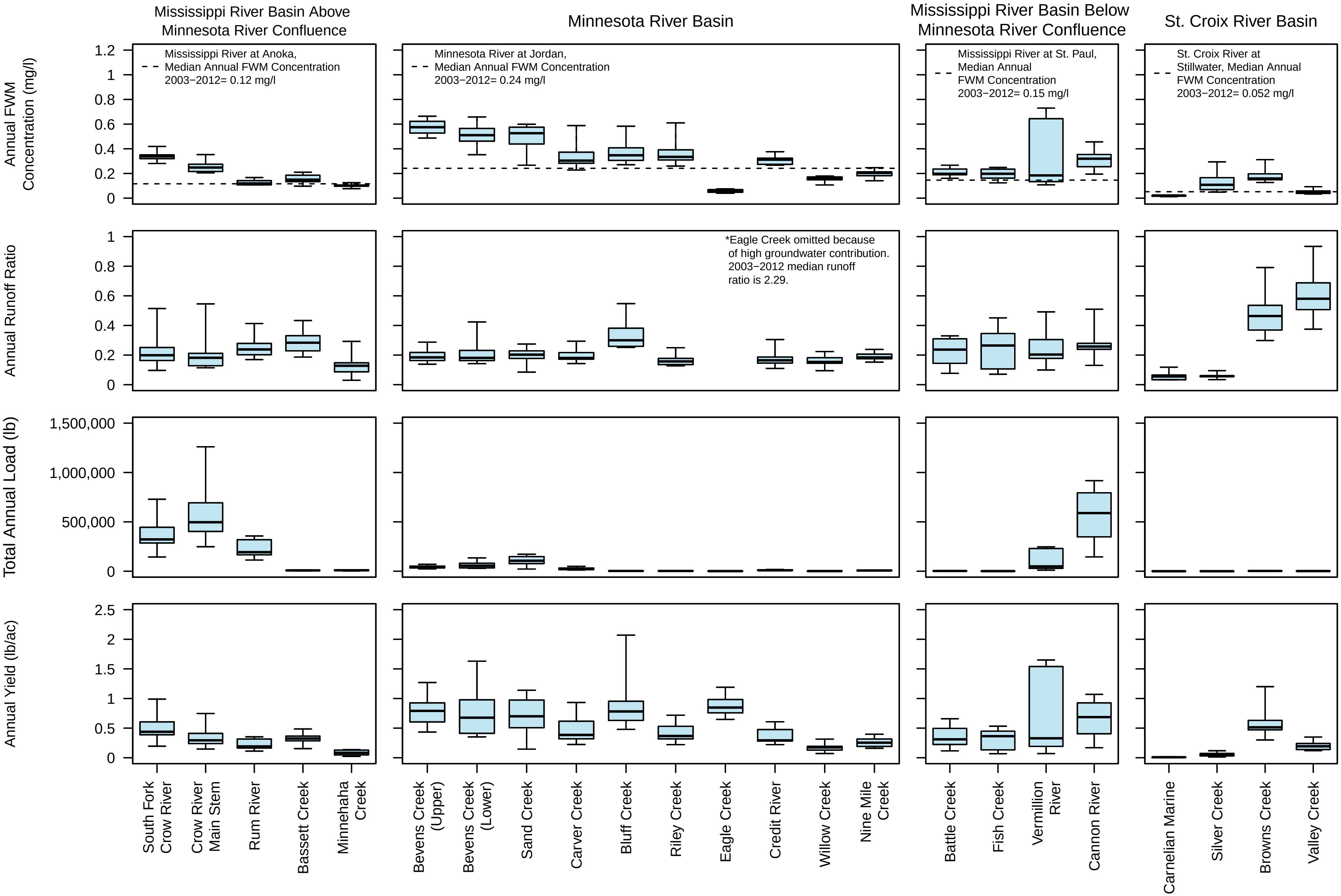


Figure BL−21: Nitrate for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

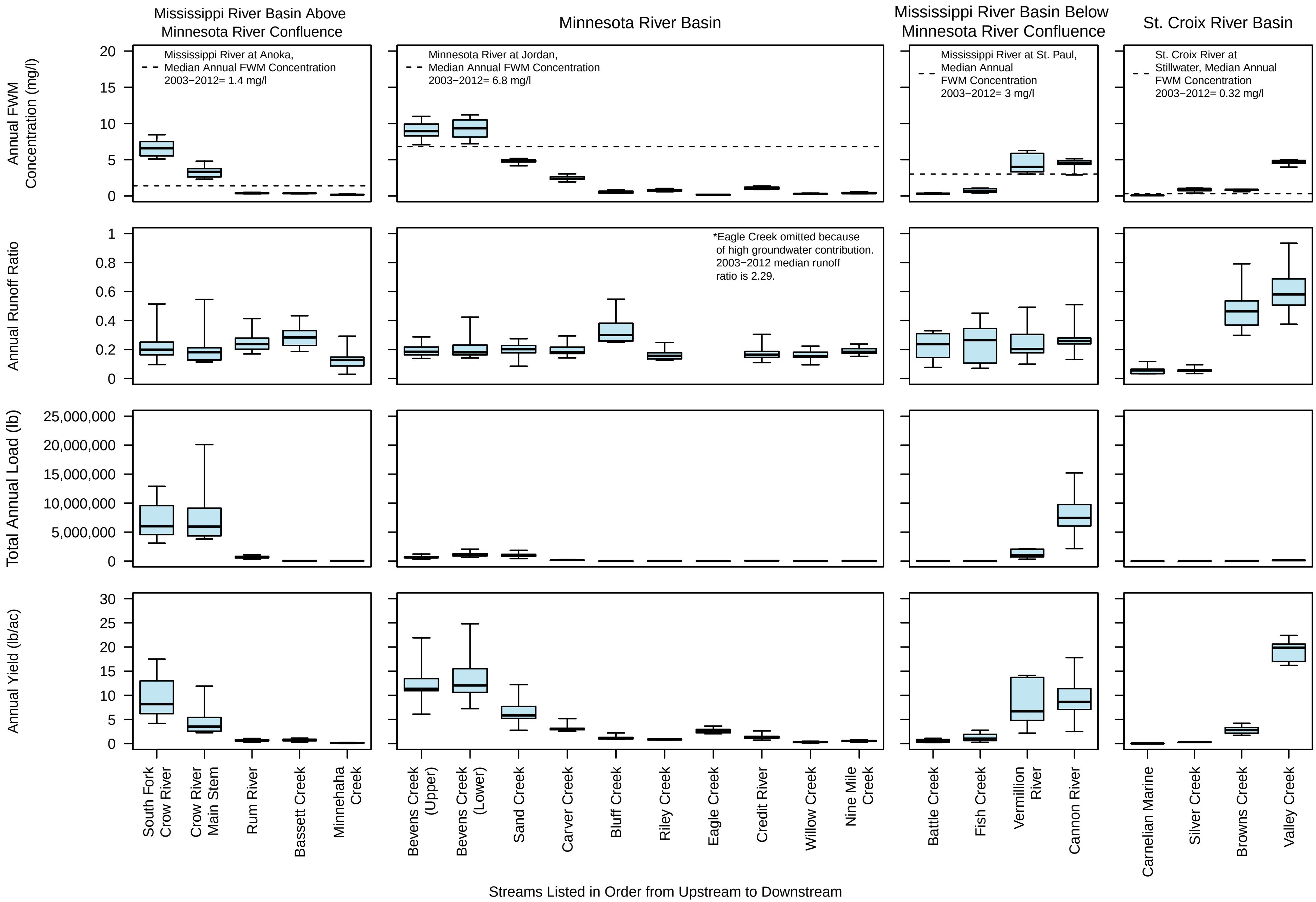


Figure BL−22: Chloride for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

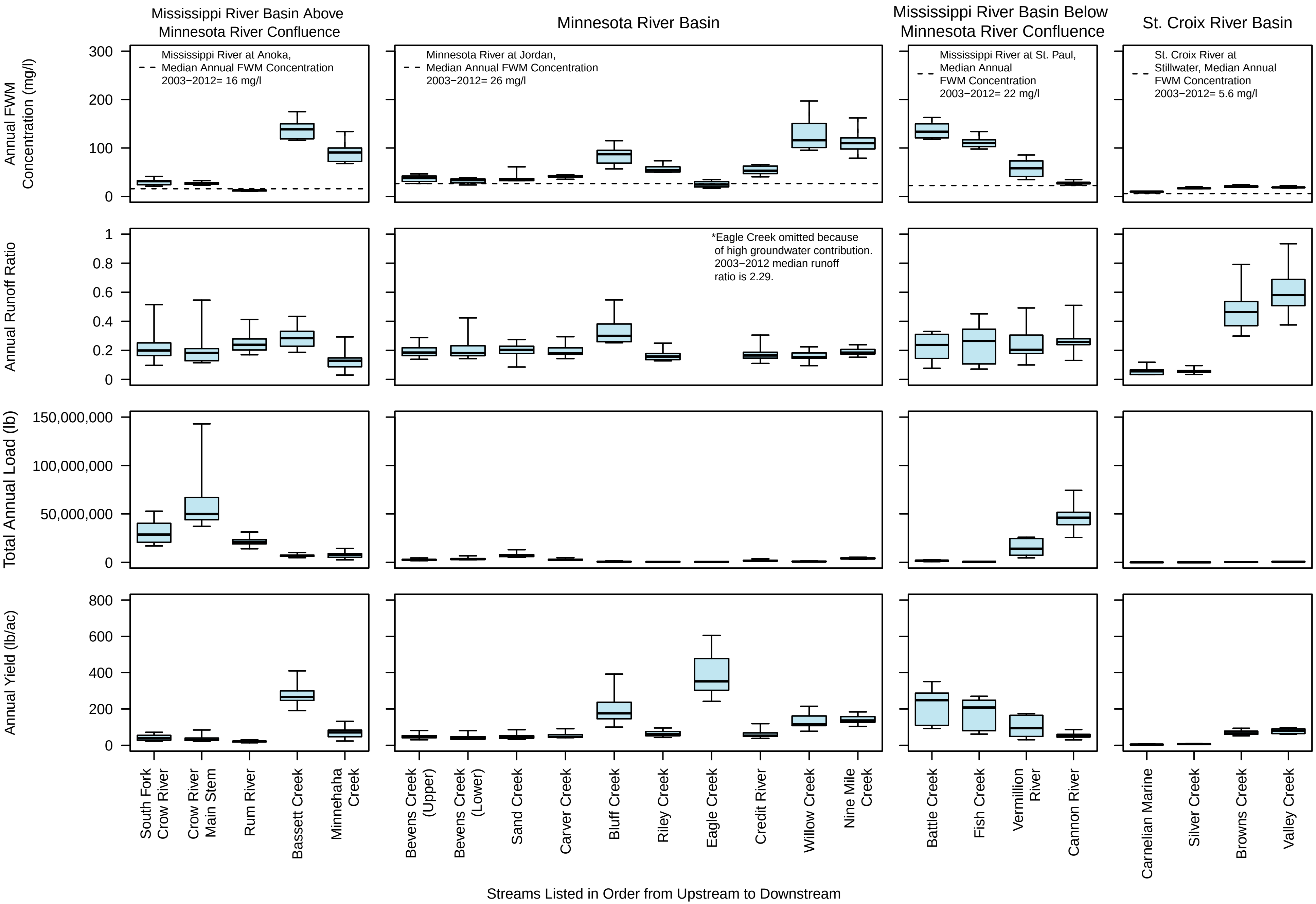


Table BL-4: Annual Median Concentrations, Loads, and Yields for MCES-Monitored Streams, 2003-2012

Station	Stream Name	Major Watershed	Median Runoff Ratio[1]	TSS Median Annual FWM Conc[2] (mg/l)	TSS Median Annual Load[3] (lb/yr)	TSS Median Annual Yield[4] (lb/ac/yr)	TP Median Annual FWM Conc[2] (mg/l)l	TP Median Annual Load[3] (lb/yr)	TP Median Annual Yield[4] (lb/ac/yr)	NO_3 Median Annual FWM Conc[2] (mg/l)	NO_3 Median Annual Load[3] (lb/yr)	NO_3 Median Annual Yield[4] (lb/ac/yr)	Cl Median Annual FWM Conc[2] (mg/l)	Cl Median Annual Load[3] (lb/yr)	Cl Median Annual Yield[4] (lb/ac/yr)
BE5.0	Bevens Creek (Upper)	Minnesota	0.18	207	17,600,000	319	0.575	43,650	0.791	8.95	628,000	11.4	38	2,600,000	47.2
BE2.0	Bevens Creek (Lower)	Minnesota	0.18	252	29,550,000	357	0.511	55,950	0.677	9.34	996,500	12.1	34	3,395,000	41.1
SA8.2	Sand Creek	Minnesota	0.20	344	74,200,000	489	0.526	106,000	0.700	4.85	886,000	5.8	36	6,980,000	46.0
CA1.7	Carver Creek	Minnesota	0.18	143	9,870,000	188	0.304	20,200	0.385	2.35	157,000	3.0	41	2,500,000	47.5
BL3.5	Bluff Creek	Minnesota	0.30	304	3,025,000	838	0.348	2,820	0.782	0.61	4,405	1.2	87	635,500	176.0
RI1.3	Riley Creek	Minnesota	0.16	277	2,025,000	305	0.335	2,440	0.367	0.79	5,840	0.9	54	407,000	61.3
EA0.8	Eagle Creek	Minnesota	2.29	11	181,000	167	0.055	918	0.848	0.17	2,760	2.6	25	381,000	352.0
CR0.9	Credit River	Minnesota	0.16	107	3,090,000	103	0.312	8,800	0.293	1.15	37,400	1.3	53	1,590,000	53.1
WI1.0	Willow Creek	Minnesota	0.15	54	391,000	61	0.161	1,130	0.175	0.28	1,980	0.3	116	750,000	116.0
NM1.8	Nine Mile Creek	Minnesota	0.18	70	2,520,000	88	0.205	7,335	0.255	0.38	15,750	0.5	110	3,930,000	136.5
CWS20.3	Crow River (South)	Mississippi	0.20	60	50,800,000	69	0.339	322,500	0.438	6.58	5,995,000	8.2	31	28,650,000	39.0
CW23.1	Crow River (Main)	Mississippi	0.18	46	98,950,000	59	0.248	496,000	0.294	3.33	5,960,000	3.5	27	49,950,000	29.6
RUM0.7	Rum River	Mississippi	0.24	12	20,700,000	21	0.119	193,000	0.191	0.38	654,000	0.6	13	21,150,000	21.0
BS1.9	Bassett Creek	Mississippi	0.28	37	1,905,000	77	0.150	8,090	0.325	0.38	19,350	0.8	139	6,620,000	266.0
MH1.7	Minnehaha Creek	Mississippi	0.13	16	1,415,000	13	0.102	9,095	0.084	0.17	16,400	0.2	91	7,700,000	71.0
BA2.2	Battle Creek	Mississippi	0.24	83	1,043,000	146	0.197	2,220	0.311	0.32	3,945	0.6	134	1,775,000	248.5
FC0.2	Fish Creek	Mississippi	0.26	55	296,500	101	0.198	1,066	0.364	0.71	3,035	1.0	111	610,000	208.0
VR2.0	Vermillion River	Mississippi	0.20	29	6,025,000	40	0.185	49,000	0.328	4.02	1,001,500	6.7	58	14,050,000	94.1
CN11.9	Cannon River	Mississippi	0.26	130	201,000,000	235	0.320	589,000	0.687	4.59	7,435,000	8.7	28	46,050,000	53.8
CM3.0	Carnelian-Marine Outlet	St. Croix	0.06	2	7,570	0.4	0.022	156	0.009	0.10	701	0.04	10	69,500	3.9
SI0.1	Silver Creek	St. Croix	0.06	35	80,700	15	0.108	235	0.042	0.83	1,765	0.3	17	37,100	6.7
BR0.3	Browns Creek	St. Croix	0.46	51	785,500	172	0.160	2,355	0.514	0.86	12,900	2.8	20	300,000	65.6
VA1.0	Valley Creek	St. Croix	0.58	14	392,500	54	0.047	1,415	0.193	4.74	145,500	19.9	19	589,500	80.4

[1] Runoff ratio = annual flow volume at monitoring station / annual area-weighted precipitation. Area-weighted precipitation for each watershed provided by Minnesota Climatological Working Group (2013)

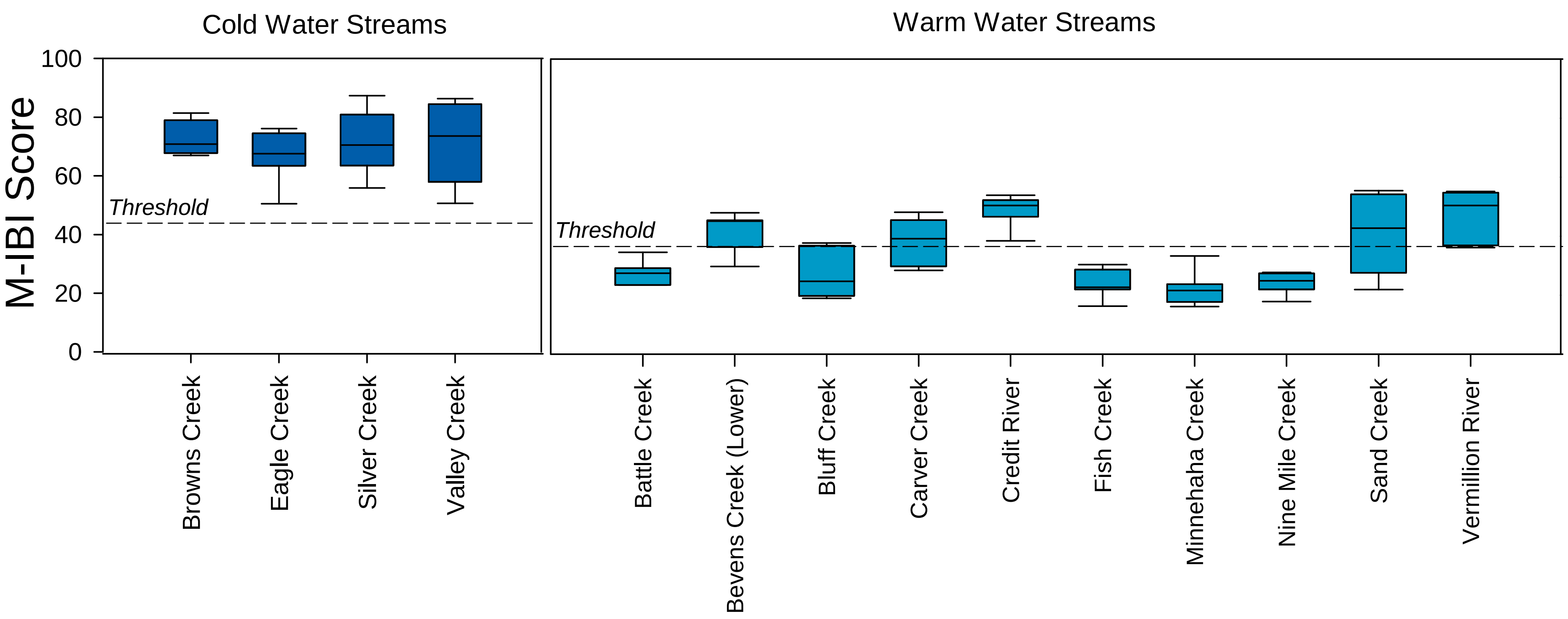
[2] FWM conc = annual flow-weighted mean concentration estimated using Flux32 (Walker, 1999).

[3] Load = annual pollutant load mass estimated using Flux32 (Walker, 1999).

[4] Yield = watershed pollutant yield calculated from annual pollutant load mass estimated using Flux32 (Walker, 1999) divided by area of watershed upstream of MCES monitoring station

Figure BL-23: M-IBI Results for MCES-Monitored Streams, 2004-2011

Organized by Stream Type



Higher M-IBI scores are indicative of a better water quality.
Each stream type has system-specific impairment thresholds set by the MPCA (2014b).
If a portion of the box plot is below the threshold, the stream may not have supported the needs of aquatic life during the study period.

Metropolitan Area Trends Analysis

Statistical trend analysis for each MCES stream monitoring station was performed using QWTREND (Vecchia, 2003). Trend estimates were calculated for 2008-2012 (the last five years of available data) to allow uniform comparison of changes in water quality between streams. A similar approach was used in the 2013 MPCA nitrogen study (MPCA, 2013b) to compare QWTREND assessments in statewide streams and rivers.

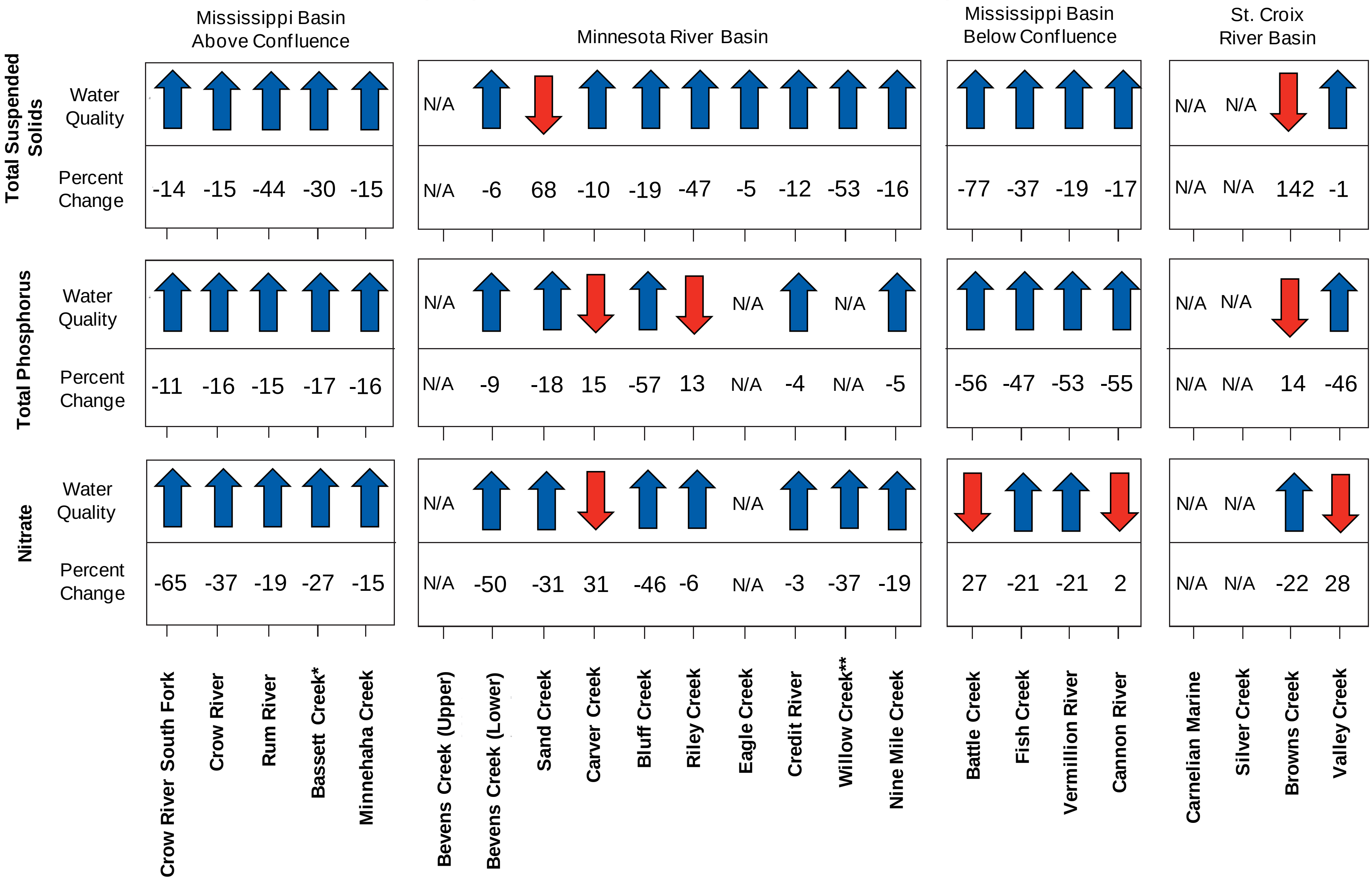
Estimated changes for TSS, TP, and NO_3 in MCES-monitored streams are presented below in two ways. First, tabulated results with directional arrows indicate improving (blue upward arrow) and declining (red downward arrow) water quality, paired with percent change in flow-adjusted concentration estimated for 2008-2012 (Figure BL-24). Second, changes are shown by three seven-county metropolitan area maps (one each for TSS, TP, and NO_3 trends), with stream watersheds colored to represent improving and declining water quality (Figure BL-25). In both figures, no trend was reported for those QWTREND analyses with poor quality of statistical metrics (eg. $p>0.05$).

In general, of the 20 monitoring stations assessed, most exhibited improving water quality (and thus decreasing flow-adjusted concentration) for TSS, TP, and NO_3. There does not appear to be a spatial pattern for those few stations with declining water quality. There is no station with declining water quality for all three parameters, although both TP and NO_3 flow-adjusted concentrations increased in Carver Creek (a Minnesota River tributary) and TSS and TP increased in Browns Creek (a St. Croix River tributary).

The Minnesota River and its tributaries typically have had higher TSS concentrations than the Mississippi or St. Croix Rivers and associated tributaries. The trend analysis results indicate decreasing TSS flow-adjusted concentrations in all Minnesota River tributaries with the exception of Sand Creek. In addition to decreasing TSS concentrations, Bluff Creek also had decreasing TP and NO_3 concentrations over the last five years, indicating improving water quality for these parameters.

Figure BL-24: Regional Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and NO_3, 2008-2012

(Grouped by Major River Basin; As estimated by QWTrend)



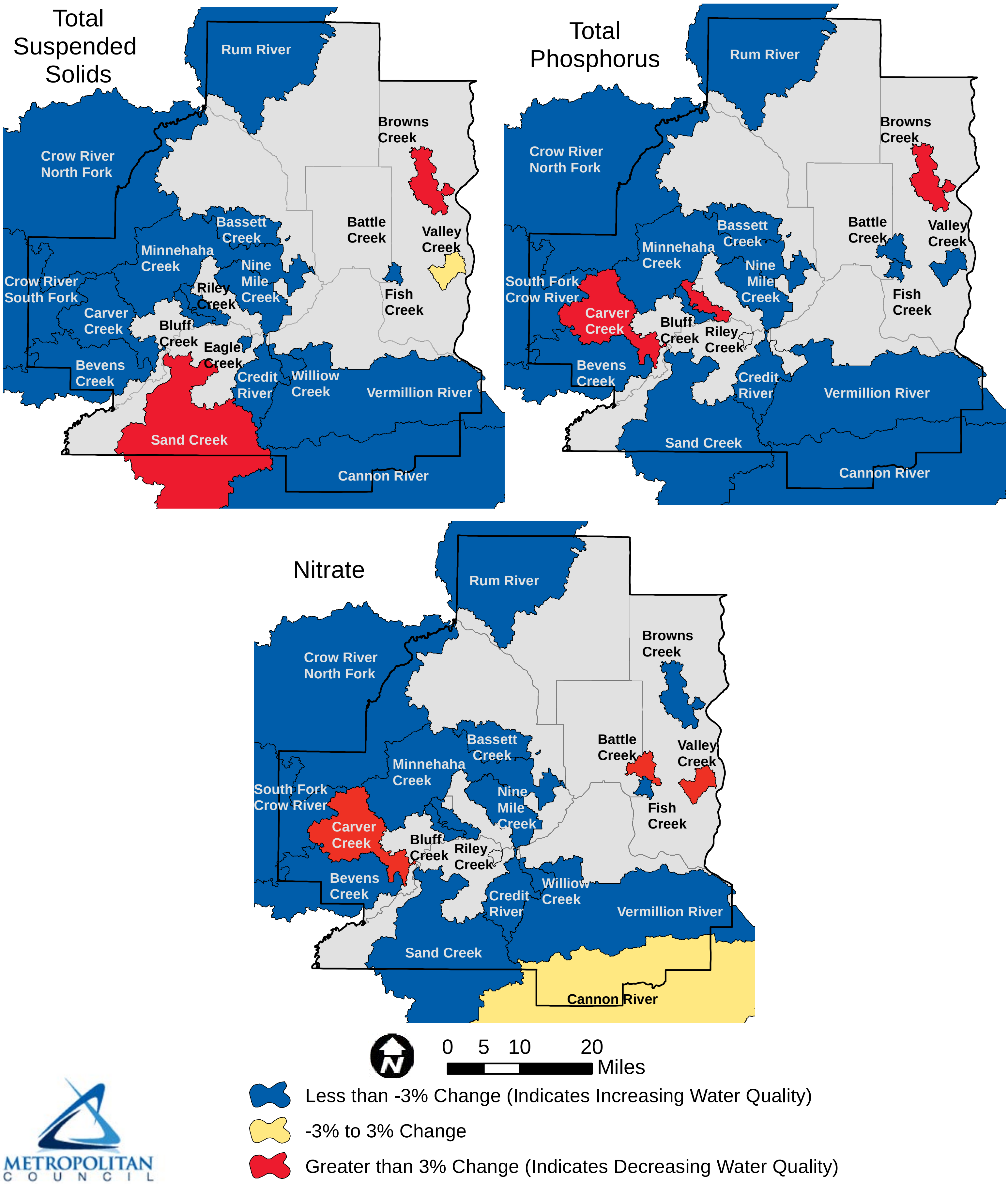
Blue arrows indicate improved water quality; Red arrows indicate declining water quality.

"N/A" indicates analysis was not performed as data were not appropriate for analysis by QWTrend.

* Bassett Creek TSS Trends were assessed over 2009-2013. **Monitoring at Willow Creek was suspended in 2009.

Figure BL-25: Regional Maps of Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and NO3, 2008-2012

(As estimated by QWTrend)



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Conclusions

Bluff Creek is a tributary to the Minnesota River in the southwestern metropolitan area. The creek drains portions of Carver and Hennepin counties, and receives runoff from the cities of Chanhassen and Chaska, as well as a small portion Eden Prairie. The watershed is a mixture of agricultural, forest, open space, suburban and urban land cover. There are no major WWTPs or other point sources in the Bluff Creek watershed. The upper watershed is relatively flat, while the topography steepens south of Highway 212 from the top of the Minnesota River bluff to the river floodplain. The MCES monitoring station is located on Bluff Creek near MN 101 in Chanhassen, Minnesota, about 3.5 miles upstream from the creek confluence with the Minnesota River. Bluff Creek flows through a shallow lake in the Minnesota River floodplain (Rice Lake), before discharging to the river itself.

Bluff Creek is impaired for turbidity and fish biota. A TMDL study and implementation plan have been completed for these impairments (Barr Engineering Company, 2013). Total suspended solids concentrations are high, but due to the small size of the watershed loads are relatively small compared to the other MCES-monitored Minnesota River tributaries. Additional monitoring in 2008 sponsored by the MPCA for the Bluff Creek TMDL study has estimated that 90% of the TSS loading monitored at the MCES station is from the area between Pioneer Trail and Highway 101.

Concentrations and loads for other monitored constituents generally rank near the middle of the MCES-monitored Minnesota River tributaries.

Macroinvertebrate M-IBI scores for Bluff Creek indicate that habitat and water quality in the stream reach near the MCES monitoring station are not optimal for sustaining the needs of warm water aquatic life.

Trend analysis with QWTREND indicates that flow-adjusted concentrations of TSS, TP, and NO_3 in Bluff Creek decreased during 2008-2012, resulting in improved water quality.

Recommendations

This section presents recommendations for monitoring and assessment of Bluff Creek, as well as recommendations for partnerships to implement stream improvements. MCES recognizes that cities, counties, and local water management organizations, like RPBCWD, are ideally suited to target and implement volume reduction, pollutant removal, and stream restoration projects within the watershed. It is beyond the scope of this document to suggest locations for implementation projects. Instead, MCES encourages the local water management organization to use the results of this report to leverage funding and partnerships to target, prioritize, and implement improvement projects. MCES will repeat its analysis of water quality trends in 5 years, to assess potential changes in water quality.

The following recommendations have been drafted from the results of this report and are intended to assist MCES and its partners in directing future assessment work:

- Highway 101 is scheduled to be rebuilt in the near future, and the MCES monitoring station will not be operational during this construction. MCES should re-open the monitoring station as soon as possible following road construction to track effects of ravine remediation implemented for the turbidity TMDL.

- Macroinvertebrate monitoring for Bluff Creek should be continued and further investigation of the lack of intolerant species should be pursued. MCES should continue to analyze and evaluate the biomonitoring program. Potential additions should include a Stream Habitat Assessment similar to the habitat surveys performed by the MPCA or the addition of fish population and algal community data.
- The water quality of Rice Lake, and any attenuation effect it has should be investigated to determine the actual Bluff Creek loads entering the Minnesota River; in addition, its biologic and wildlife value should also be evaluated.
- The trend analysis should be repeated in 5 years, expanding the list of assessed parameters to include NH3, bacteria, and chlorophyll. Sufficient data should exist at that time to also assess trends in Cl and flow.
- MCES and partners (especially RPBCWD) should create a timeline of past projects and management activities that may have improved or altered stream flow and/or water quality. This information would allow more accurate assessment and interpretation of trends.
- After the TMDL implementation plan is implemented, local government units should be alert to new erosion and ravine formation, so problems are not just relocated to new areas.
- As resources allow, MCES should provide RPBCWD and other local water managers with information about the heightened potential for surface waters to be impacted by groundwater changes in the Bluff Creek watershed. This information should be included in watershed and local surface water management plan updates.
- MCES should continue to evaluate the effects of groundwater withdrawal on surface waters, including updating analyses with the best available data and linking results to predictive groundwater modeling and the comprehensive planning process.

Citations

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