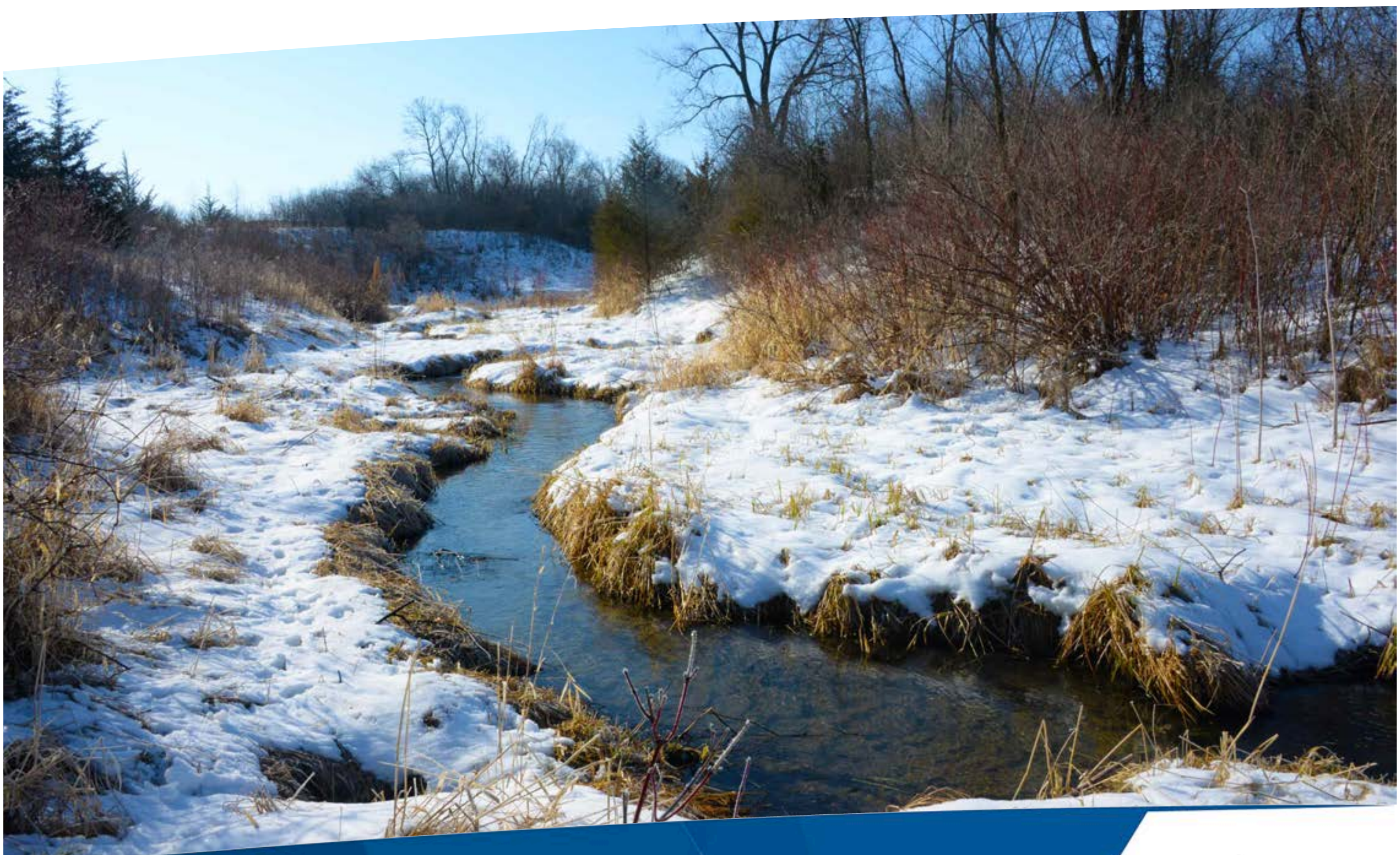
Comprehensive Water Quality Assessment of Select Metropolitan Area Streams

EAGLE CREEK



METROPOLITAN COUNCIL

December 2014

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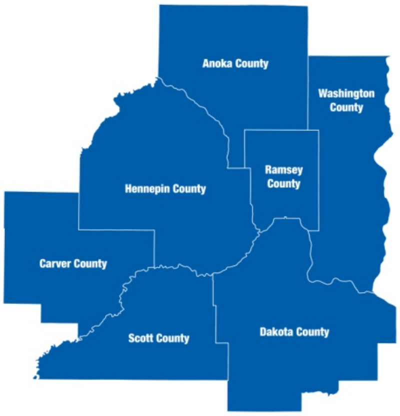

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide 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, *Eagle Creek*, is one in a series produced as part of the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams.* Located in Scott County, Eagle 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 Eagle Creek.

Cover Photo

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

Recommended Citations

Please use the following to cite this section of the report:

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Content

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Introduction

Eagle Creek is located in the south central metropolitan area and is a tributary to the Minnesota River. It drains approximately 2.6 square miles of mixed suburban land, forest, open space, bluff land, and wetlands in Scott County (Metropolitan Council District 4).

Figure EA-1: Staff Gauge at Eagle Creek Monitoring Site

This report:

- documents those characteristics of Eagle 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 Eagle 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 and Funding

MCES has supported water quality monitoring of Eagle Creek since 1999 as part of its Watershed Outlet Monitoring Program (WOMP). Partial funding for this site is provided by the Minnesota Legislature through a grant from the Minnesota Pollution Control Agency (MPCA) using Clean Water Land and Legacy Amendment funds. MCES partners with the Lower Minnesota River Watershed District (LMRWD) and the Scott County Soil and Water Conservation District (SWCD) to conduct monitoring at this station. The Scott SWCD operates the monitoring station. MCES maintains the rating curve by building upon the rating curve developed by the Minnesota Department of Natural Resources (MnDNR) in 2000.

Monitoring Station Description

The monitoring station is located on Eagle Creek in Savage, Minnesota, 0.8 miles upstream from the creek's confluence with the Minnesota River.

The monitoring station includes continuous flow monitoring, event-based composite sample collection, and on-site conductivity and temperature probes. The Eagle Creek station also has a Side-Looking Doppler Current Meter (SonTek/YSI Argonaut-SL) at this site to quantify stream velocity. A rain gauge is present at this location for measurement of precipitation, 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.

Daily precipitation totals from this station 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 ensure the variability of rainfall within the watersheds was represented (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.

Stream and Watershed Description

Eagle Creek maintains a small naturally-reproducing population of brown trout and is a MnDNR designated trout stream. The stream headwater is Boiling Springs, an artesian spring located approximately one mile upstream from the monitoring station. The bedrock source of the spring is the Prairie Du Chien aquifer. Since the flow in Eagle Creek is largely attributable to continuous discharge from this limestone formation, the term "water yield" (flow volume per watershed area) does not apply well for this small subwatershed. Very little of the flow in Eagle Creek is attributable to surface runoff generated within the watershed area.

During the winter months, the temperature of the groundwater discharge is significantly warmer than atmospheric temperatures. Therefore, unlike most small streams in the Minnesota River Basin, Eagle Creek does not freeze or form ice during the winter.

The Eagle Creek watershed encompasses a total of 1,674 acres, with 1,083 acres (64.7%) of the watershed upstream of the monitoring station (Figure EA-2). The watershed land cover is a mix of urbanized, forest, grasses/herbaceous, and wetlands. There are 99 acres/5.9% (99 acres/9.1% within the monitored area) of agricultural land in the watershed, the majority of which is at the most upstream point. The watershed has 810 acres/48.4% (450 acres/41.5% within the monitored area) of developed urban land, including portions of the cities of Prior Lake, Shakopee, and Savage. The watershed also has 297 acres/17.7% (267 acres/24.6% within the monitored area) of forested land, 245 acres/14.6% (142 acres/13.1%) of grasses/herbaceous cover, and 218 acres/13.0% (121 acres/11.2% within the monitored area) of wetlands (see Table EA-1:).

Table EA-1: Eagle Creek Land Cover Classes[1]

Land Cover Class	Monitored		Unmonitored		Total	
	Acres	Percent	Acres	Percent	Acres	Percent
5-10% Impervious	13	1.2%	7	1.3%	20	1.2%
11-25% Impervious	128	11.8%	76	12.9%	205	12.2%
26-50% Impervious	206	19.0%	49	8.2%	255	15.2%
51-75% Impervious	20	1.9%	3	0.6%	24	1.4%
76-100% Impervious	82	7.6%	224	38.0%	306	18.3%
Agricultural Land	99	9.1%	1	0.2%	99	5.9%
Forest (all types)	267	24.6%	30	5.1%	297	17.7%
Open Water	0	0.0%	0	0.0%	0	0.0%
Barren Land	0	0.0%	0	0.0%	0	0.0%
Shrubland	5	0.4%	0	0.0%	5	0.3%
Grasses/Herbaceous	142	13.1%	103	17.4%	245	14.6%
Wetlands (all types)	121	11.2%	97	16.4%	218	13.0%
Total	**1,083**	**100.0%**	**590**	**100.0%**	**1,674**	**100.0%**

[1] Land cover spatial data file provided by MnDNR. The data is a composite of the 2008 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 is very steep at the upstream end over the Minnesota River Bluff, and then flat below the bluffs (Figure EA-3). The maximum watershed elevation is 1051.4 MSL and the minimum elevation is 706.8 MSL within the monitored area. Within the monitored area, 6.9% of the slopes are considered steep, and an additional 8.4% are considered very steep (MnDNR, 2011).

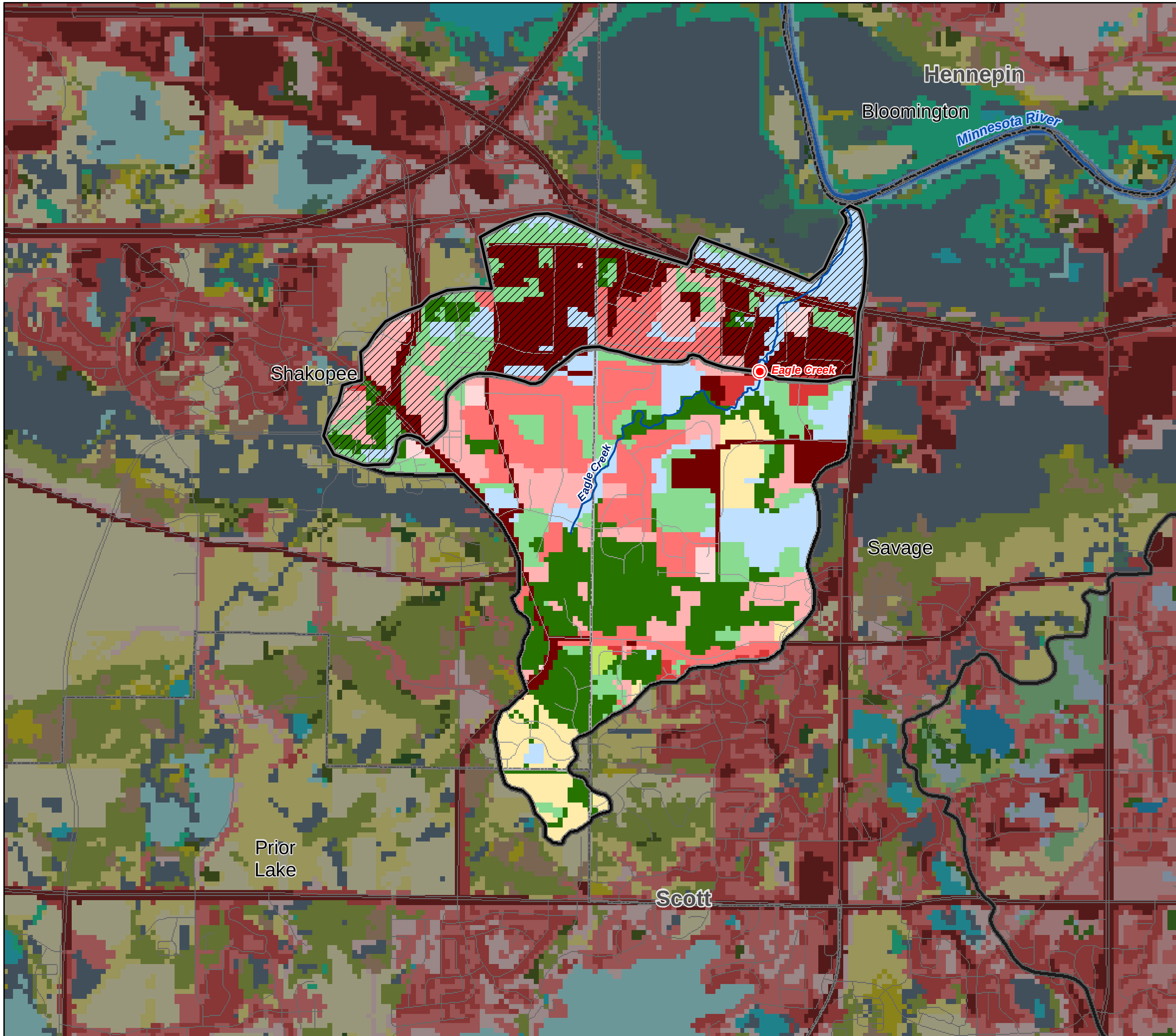
There are few point sources within the Eagle Creek Watershed. Much of the land directly adjacent to the creek is part of the MnDNR's Eagle Creek Aquatic Management Area, which protects the stream and riparian area from the influences of the encroachment of urban and commercial development (MnDNR, 2015). The watershed contains two sites holding industrial stormwater permits, both in the unmonitored part of the watershed (Figure EA-4). There are no cooling water, potable water, dewatering facilities, or industrial or domestic wastewater facilities in the watershed. There are no feedlots in the watershed.

In 2013, the LMRWD participated in a project to restore part of the stream channel through a former pasture. In this area, the channel is wide and shallow, resulting in warmer water temperatures during hot, sunny weather. Approximately 2,700 feet of the stream was excavated to narrow the degraded channel, reduce warming, and improve trout habitat.

The cities of Burnsville and Savage augment their drinking water supply with shallow ground water and surface water pumped from de-watering operations at the Kraemer Quarry in Burnsville. This water was formerly discharged to the Minnesota River. Use of this water replaces some of the groundwater that would be needed for drinking water supply in the cities and may help maintain flow in the springs and seeps that feed Eagle Creek.

Figure EA-2

MLCCS-NLCD Hybrid Land Cover
Eagle 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
Eagle Creek

Land Cover Class	Monitored Acres	Percent	Unmonitored Acres	Percent	Total Acres	Percent
5-10% Impervious	13	1.2%	7	1.3%	20	1.2%
11-25% Impervious	128	11.8%	76	12.9%	205	12.2%
26-50% Impervious	206	19.0%	49	8.2%	255	15.2%
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Barren Land	0	0.0%	0	0.0%	0	0.0%
Shrubland	5	0.4%	0	0.0%	5	0.3%
Grasses/Herbaceous	142	13.1%	103	17.4%	245	14.6%
Wetlands (all types)	121	11.2%	97	16.4%	218	13.0%
Total	**1,083**	**100.0%**	**590**	**100.0%**	**1,674**	**100.0%**

0 0.25 0.5 0.75 1
Miles

Figure EA-3

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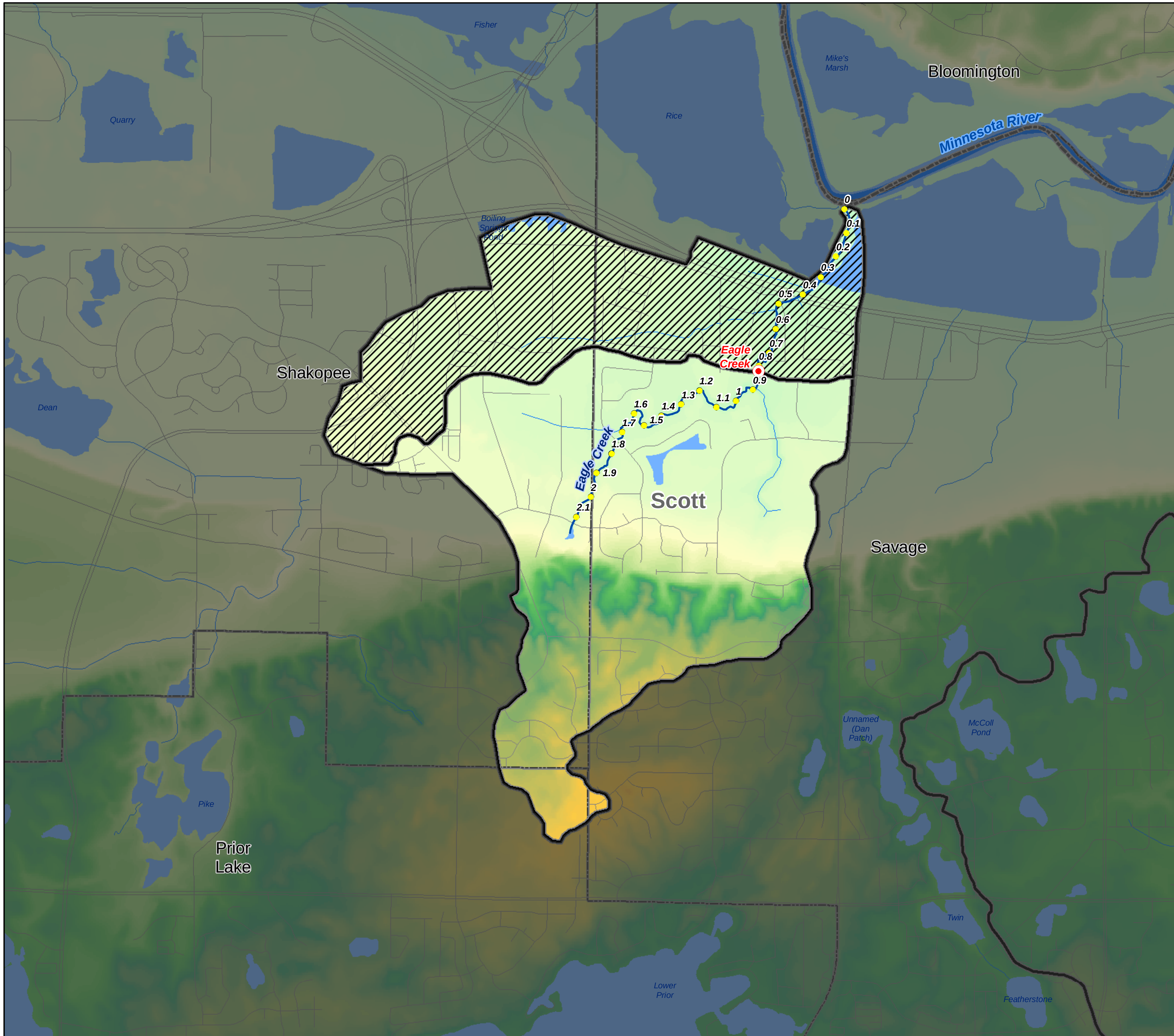
Watershed Topography

Eagle Creek



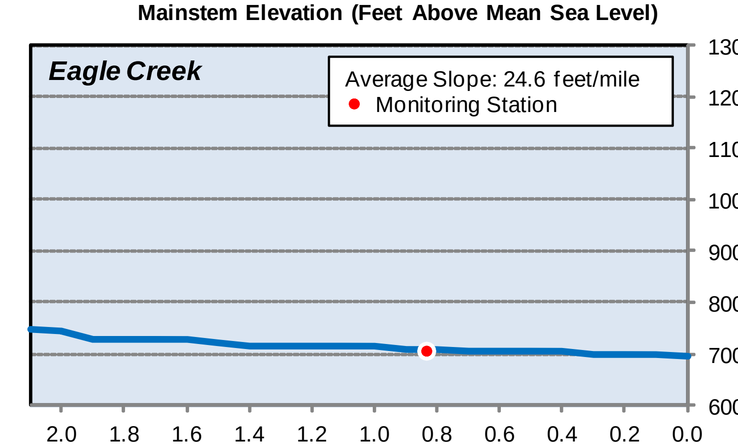
- MCES Stream Monitoring Sites
- USGS Flow Stations
- Stream Mile Markers
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Watershed Areas
- Public Waters Inventory
- Other Rivers and Streams
- City and Township Boundaries
- County Boundary
- NCompass Street Centerlines, 2010

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)



River Mile

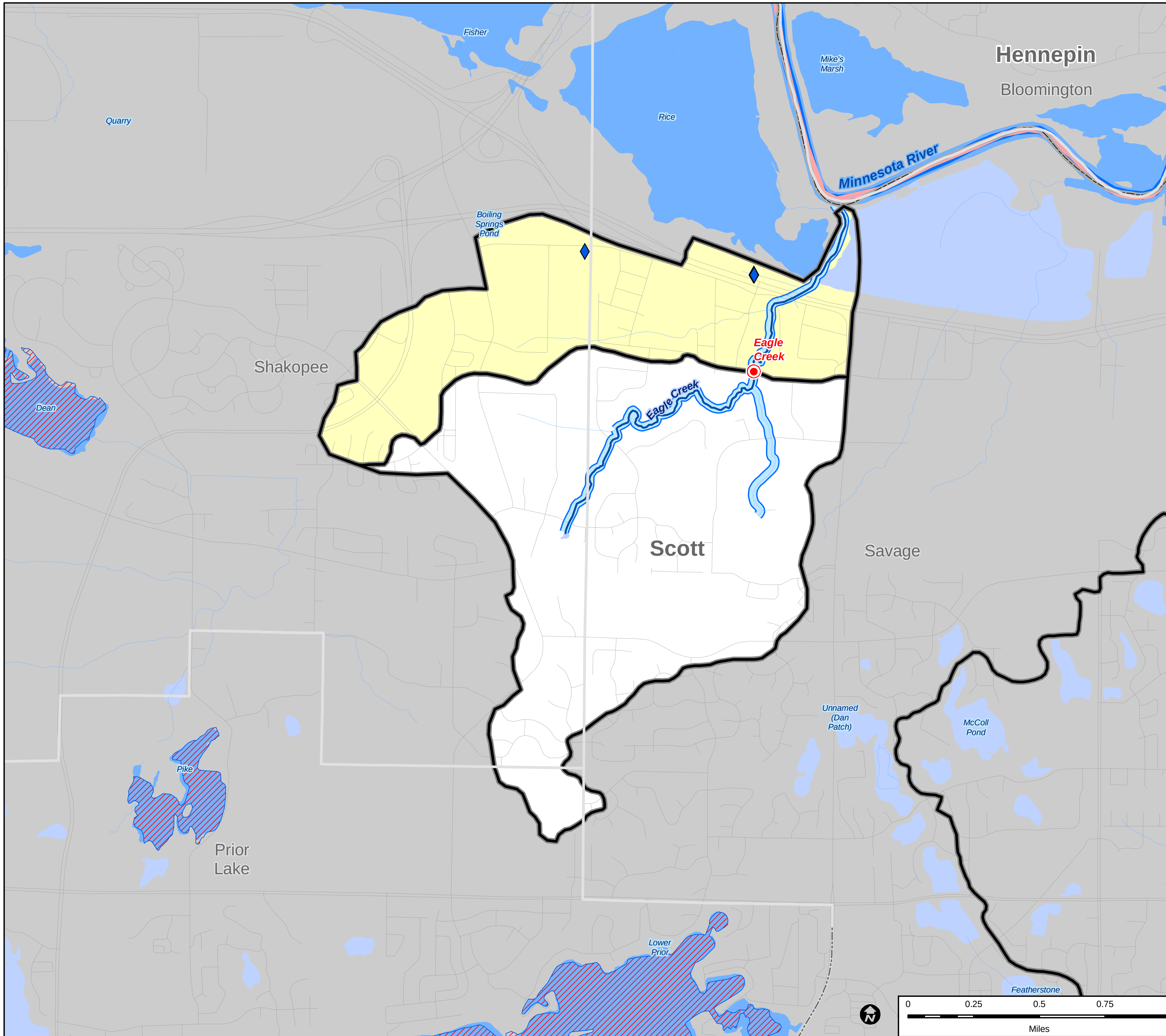
0 0.2 0.4 0.6 0.8 1

Miles

Figure EA-4

Public and Impaired Waters and Potential Pollution Sources

Eagle Creek



- MCES Stream Monitoring Sites
- USGS Flow Stations
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Portion of Watersheds

Industrial Discharges **

- Industrial Stormwater
- Industrial & Individual Wastewater
- Cooling, Potable Treatment & Dewatering

Domestic Wastewater Discharges **

- Class A
- Class B
- Class C
- Class D
- Class Unknown

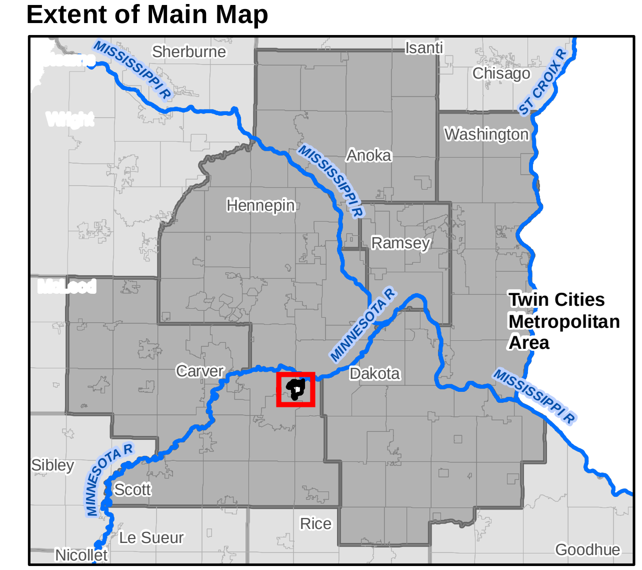
Feedlots with 100 or more animal units **

- 100 - 249
- 250 - 499
- 500 - 999
- 1000 or more

- Impaired Lakes (2014 Draft MPCA 303(d) List) **
- Impaired Streams (2014 Draft MPCA 303(d) List) **
- Other Rivers and Streams *
- Lakes and Other Open Water (PWI) *
- Wetlands (PWI) *
- Designated Trout Streams *
- NCompass Street Centerlines, 2013
- County Boundary
- City and Township Boundaries

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

Extent of Main Map



Water Quality Impairments

No stream segments of Eagle Creek are currently listed as impaired. There are no impaired lakes or water bodies in the Eagle Creek watershed.

Hydrology

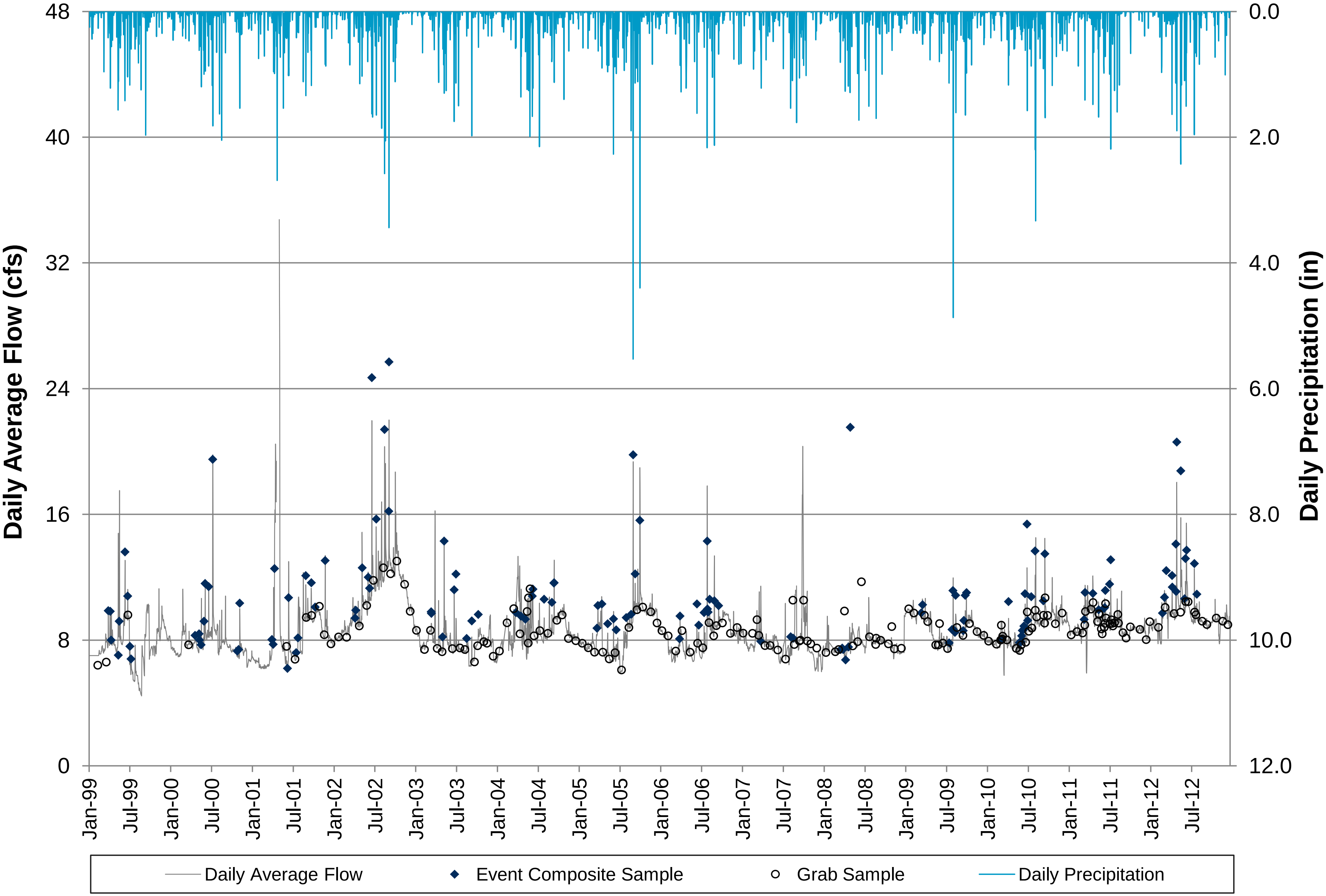
MCES has monitored flow on Eagle Creek near west 126th Street since 1999. Flow measurements are collected at 15-minute intervals and converted to daily averages. The hydrograph of Eagle Creek, which displays daily average flow, daily precipitation, and the flow associated with grab and composite samples, indicates the variations in flow rates from season to season and year to year (Figure EA-5), and the effect of precipitation events on flow.

The MCES sampling program collects grab samples of base flows between events and composites of precipitation based events. The hydrograph indicates samples were collected during most events and that baseflow was also adequately sampled.

Analysis of the duration of daily average flows indicate that the upper 10th percentile flows for the period 1999-2012 ranged between approximately 10-35 cubic feet per second (cfs), while the lowest 10th percentile flows ranged from 4-7 cfs (see Figure EA-12 in the ***Flow And Load Duration Curves*** section of this report).

Additional annual flow/volume metrics are shown on Figure EA-6 to EA-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) or; 2) the fraction of annual precipitation converted to flow. Figure EA-6 indicates the highest average annual flow (and thus the highest volume of flow) during 1999-2012 occurred during 2002 (approximately 10.8 cfs average annual flow); the lowest in 1999 (approximately 7.7 cfs average annual flow).

Figure EA-5: Eagle Creek Daily Average Flow, Sample Flow, and Precipitation, 1999-2012*



*Precipitation record was acquired from NWS COOP station 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 Eagle Creek to groundwater withdrawals, MCES staff examined spatial datasets of vulnerable stream segments and basins created as part of the 2010 regional groundwater analysis. Within the Eagle Creek watershed, nearly the entire stream was identified as potentially vulnerable to groundwater withdrawals. A number of small basins and unnamed wetlands within the watershed were also 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 involving local communities.

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 Eagle Creek (1999-2012).

Figures EA-6 to EA-9 illustrate annual loads expressed as mass, as flow-weighted mean (FWM) concentration, as mass per unit of area (lb/ac), and as mass per unit of 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 Eagle Creek loads and FWM concentrations with the other MCES-monitored metropolitan area tributaries.

Eagle Creek is a small watershed with a significant groundwater component. The flow metrics indicate some year-to-year variation in annual flow rate 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 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. Ground water contributions to Eagle Creek likely buffer the stream's response to precipitation events.

The annual mass loads for most 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. The NH_3 and Cl mass loads are an exception, and the mass loads do not mirror the average annual flows.

The annual FWM concentrations for all parameters also fluctuate year-to-year and are likely influenced by annual precipitation and flow.

Figures EA-8 and EA-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. However, one thing of note is that flow (called "runoff" in the top plot in Figure EA-8) always exceeded precipitation due to the groundwater component in the watershed.

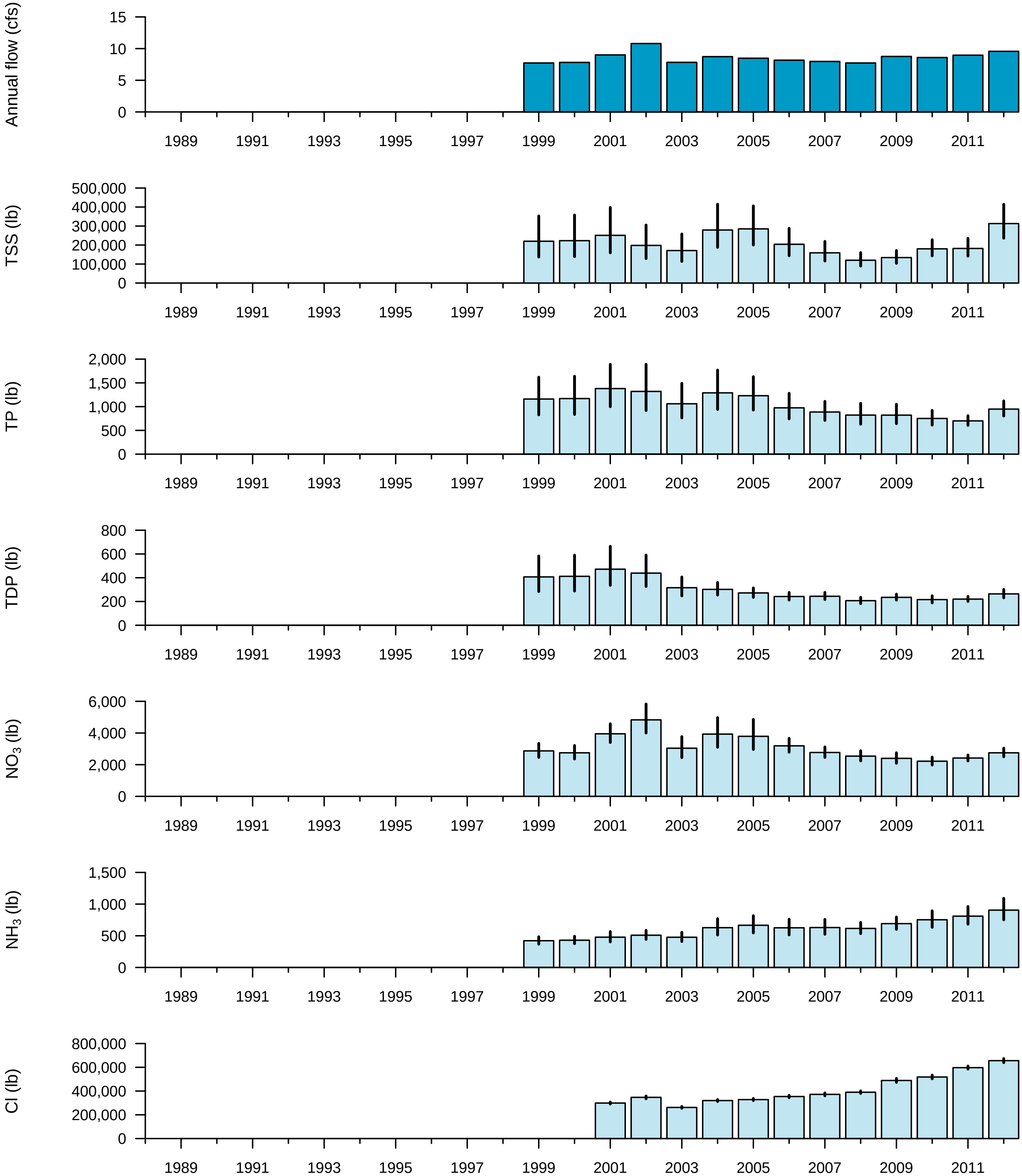
The Flux32 loads and FWM concentrations were also compiled by month to allow analysis of time based patterns in the loads in Eagle Creek (Figure EA-10 and EA-11). The results for each month are expressed in two ways: the monthly results for the most recent year of data (2012 for Eagle Creek) and the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

As stated above, Eagle Creek is a small watershed with a significant groundwater component. The most striking thing about the monthly monitoring data is the consistency of the flows, concentrations, and loads on a monthly basis within each monitored year.

It is apparent that the highest TSS and TP mass loads in Eagle Creek generally occur in connection with the highest flows. The highest flows do not necessarily occur in the same month every year. The differences in flow are probably the result of precipitation and storm runoff additions to the relatively constant groundwater flow.

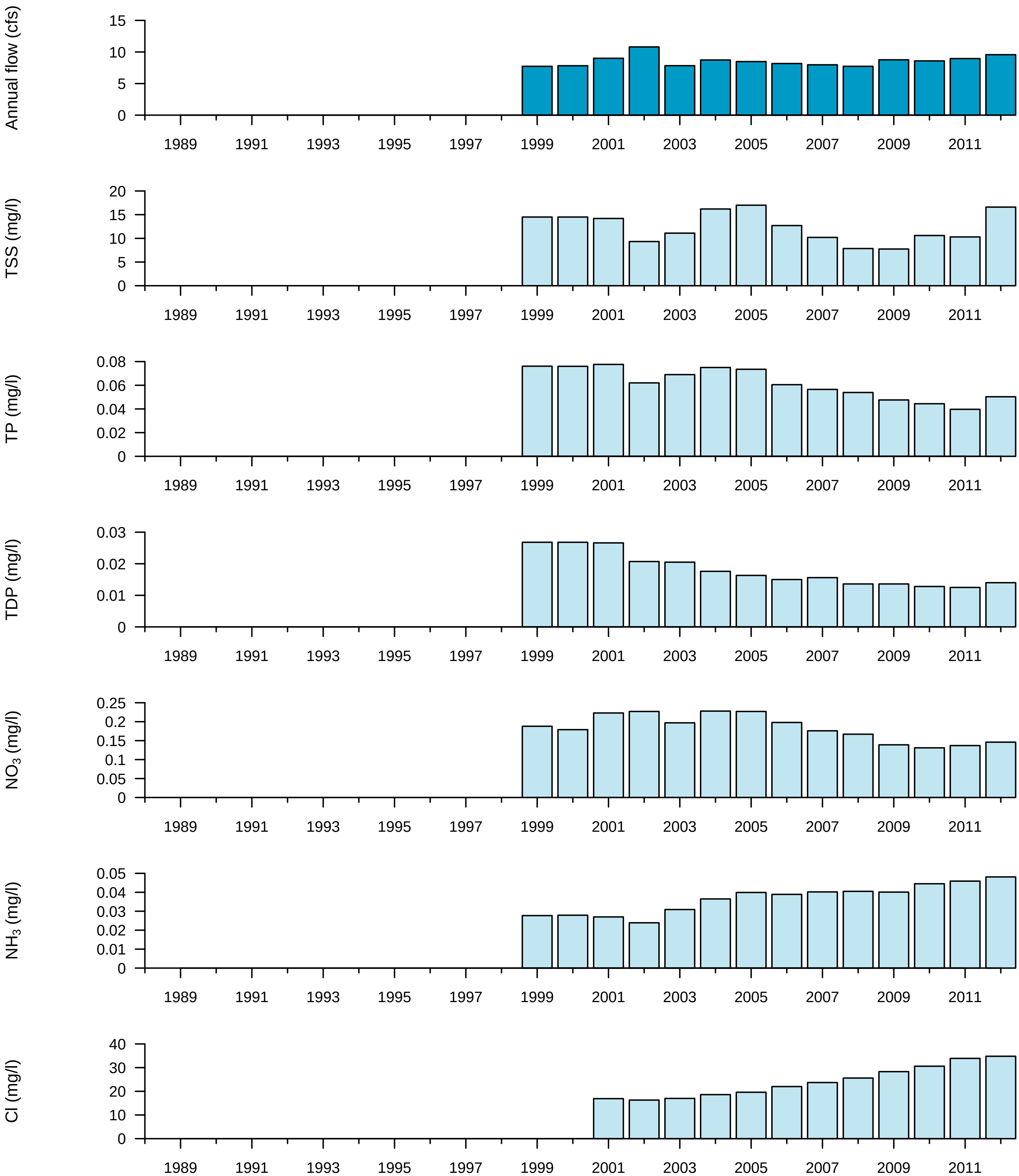
The FWM concentrations generally show month-to-month variability similar to the loads. Differences in FWM concentrations are also probably due to storm event runoff. Chloride concentrations show little variation throughout the year. Although the primary source is generally thought to be road de-icers applied during winter months, the uniformity of the chloride FWM concentrations and loads throughout the year deserves further investigation.

Figure EA−6: Eagle Creek*
Annual Mass Load



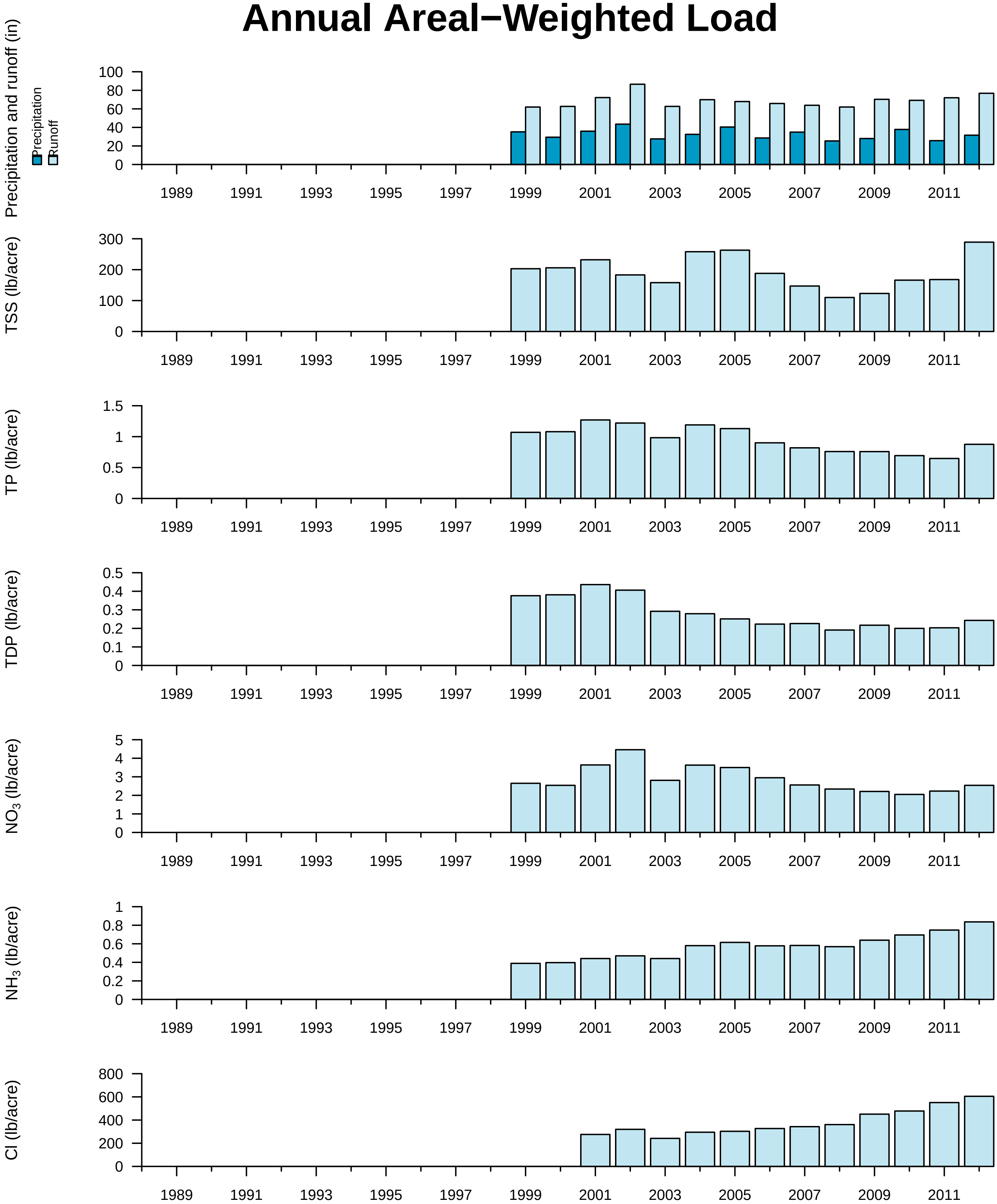
*TSS, TP, TDP, NO3, and NH3 sampling began in 1999, Cl began in 2001. Because of high groundwater contributions the runoff from the watershed exceeds precipitation.
Bars represent 95% confidence intervals as calculated in Flux32.

Figure EA−7: Eagle Creek*
Annual Flow−Weighted Mean Concentration



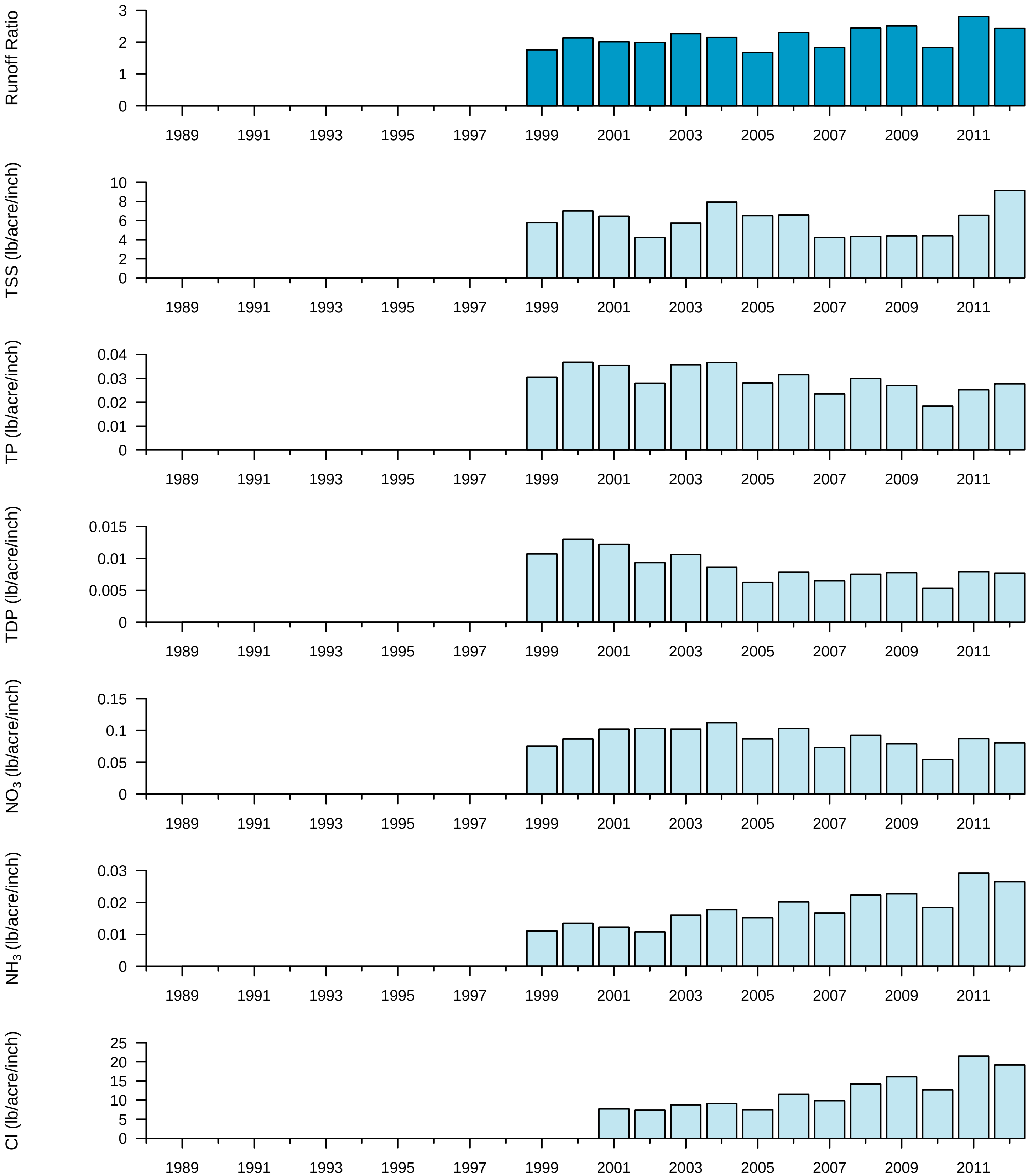
*TSS, TP, TDP, NO3, and NH3 sampling began in 1999, Cl began in 2001. Because of high groundwater contributions the runoff from the watershed exceeds precipitation.

Figure EA−8: Eagle Creek*
Annual Areal−Weighted Load



*TSS, TP, TDP, NO3, and NH3 sampling began in 1999, Cl began in 2001. Because of high groundwater contributions the runoff from the watershed exceeds precipitation.

Figure EA−9: Eagle Creek*
Annual Precipitation−Weighted Areal Load



*TSS, TP, TDP, NO3, and NH3 sampling began in 1999, Cl began in 2001. Because of high groundwater contributions the runoff from the watershed exceeds precipitation.

Figure EA−10: Eagle Creek Mass Load by Month

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

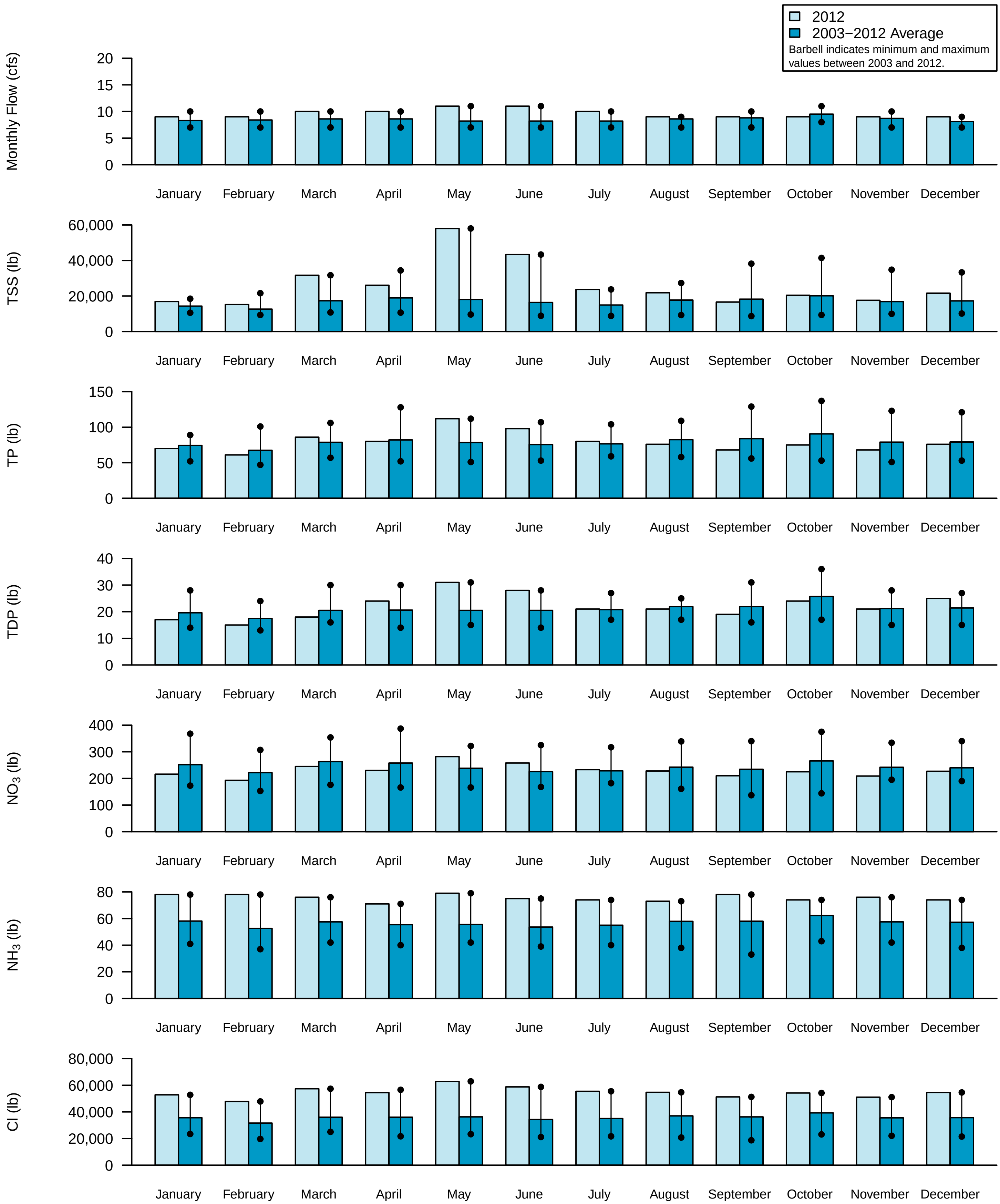
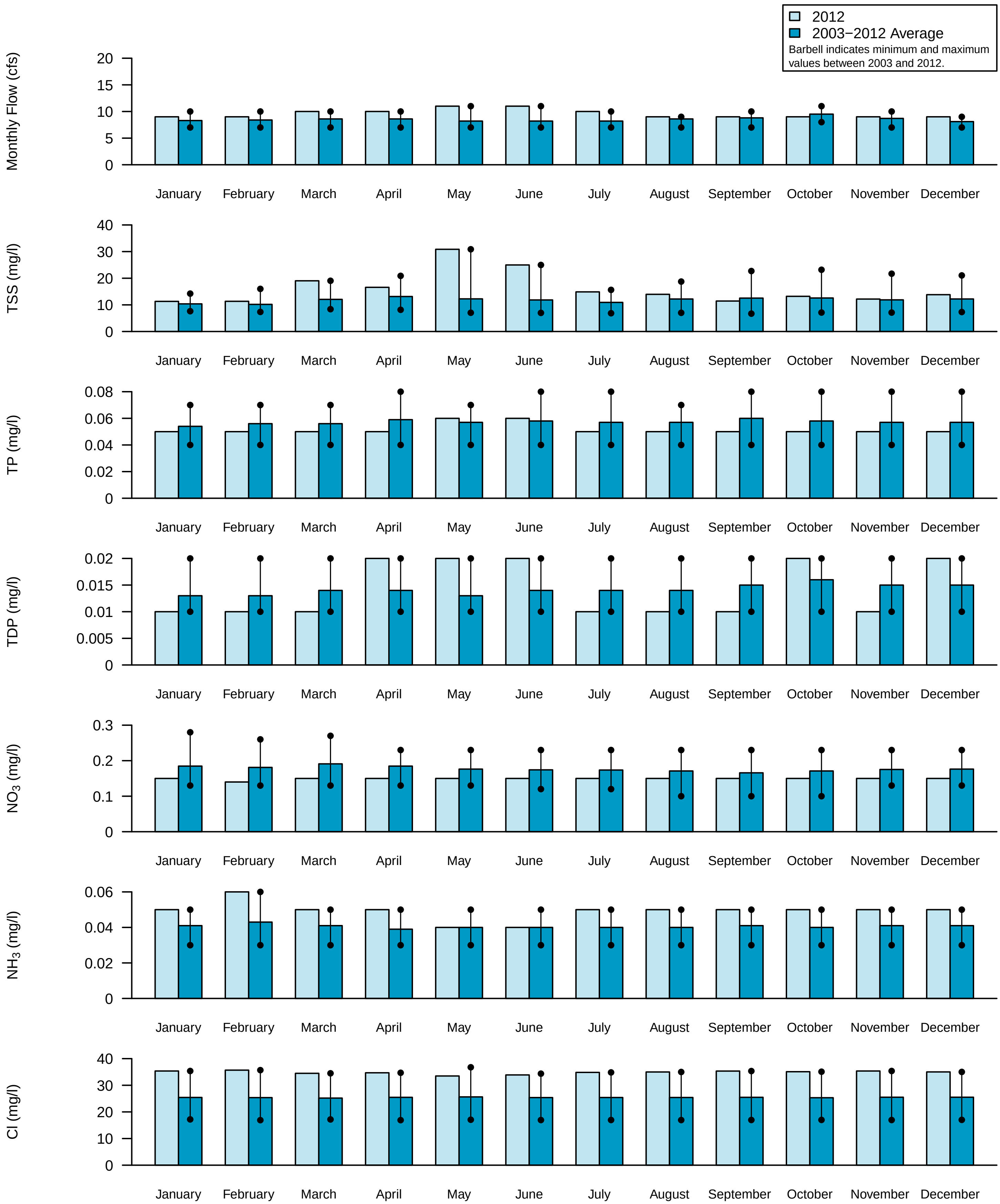


Figure EA−11: Eagle Creek
Flow−Weighted Mean Concentation by Month

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 (USEPA), 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 Eagle Creek monitoring station daily average flows and sample data, along with the most appropriate MPCA draft numerical standard as listed in Table EA-2. 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 1999–2012 flow duration curve and load duration curves for TSS, TP, NO_3, and Cl for the Eagle Creek monitoring station (mile 0.8) are shown in Figure EA-12.

Because Eagle Creek is a designated trout stream, the proposed Eagle Creek TSS standard is 10 mg/l (rather than 30 mg/l). The TSS load duration curve shows that some exceedances of the proposed 10 mg/l TSS standard have occurred at all flow regimes. Thus it appears that Eagle Creek could likely be considered impaired for TSS under the draft standard.

For TP, there are a few violations of the draft nutrient standard at all flow regimes, and TP loading does not appear to be flow related. Again, depending on the response variables, it appears that Eagle Creek might be considered impaired for TP under the proposed standard.

In Eagle Creek, all NO_3 concentrations at all flow regimes were below the drinking water standard of 10 mg/l. The final river nutrient standard for nitrate will likely be less than that. From the load duration curve, it appears that nitrate concentrations are largely independent of flow, probably reflecting the groundwater component.

As with nitrate, chloride concentrations in Eagle Creek are below the draft criteria at all flow regimes, and seem nearly independent of flow. Although this stream is dominated by ground water flow, chloride concentrations seem to increase slightly as flow increases, which may reflect inputs of salt applied for road deicing in the small watershed upstream of the monitoring station.

Table EA-2 : Eagle Creek Beneficial Use and River Nutrient Region (RNR) 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)[3] of Monitoring Station	Chloride Draft Stnd[4] (mg/l)	TSS Draft Stnd[5] (mg/l)	TP Draft Criteria[6] (ug/l)	Nitrate DW Stnd[7] (mg/l)
Eagle Creek above 126th St. (EA0.8)	1B, 2A[2]	Central	230	10	100	10

[1] Minn. Rules 7050.0470 and 7050.0430

[2] Trout stream identified in Minn. Rule 7050.0470

[3] MPCA, 2010.

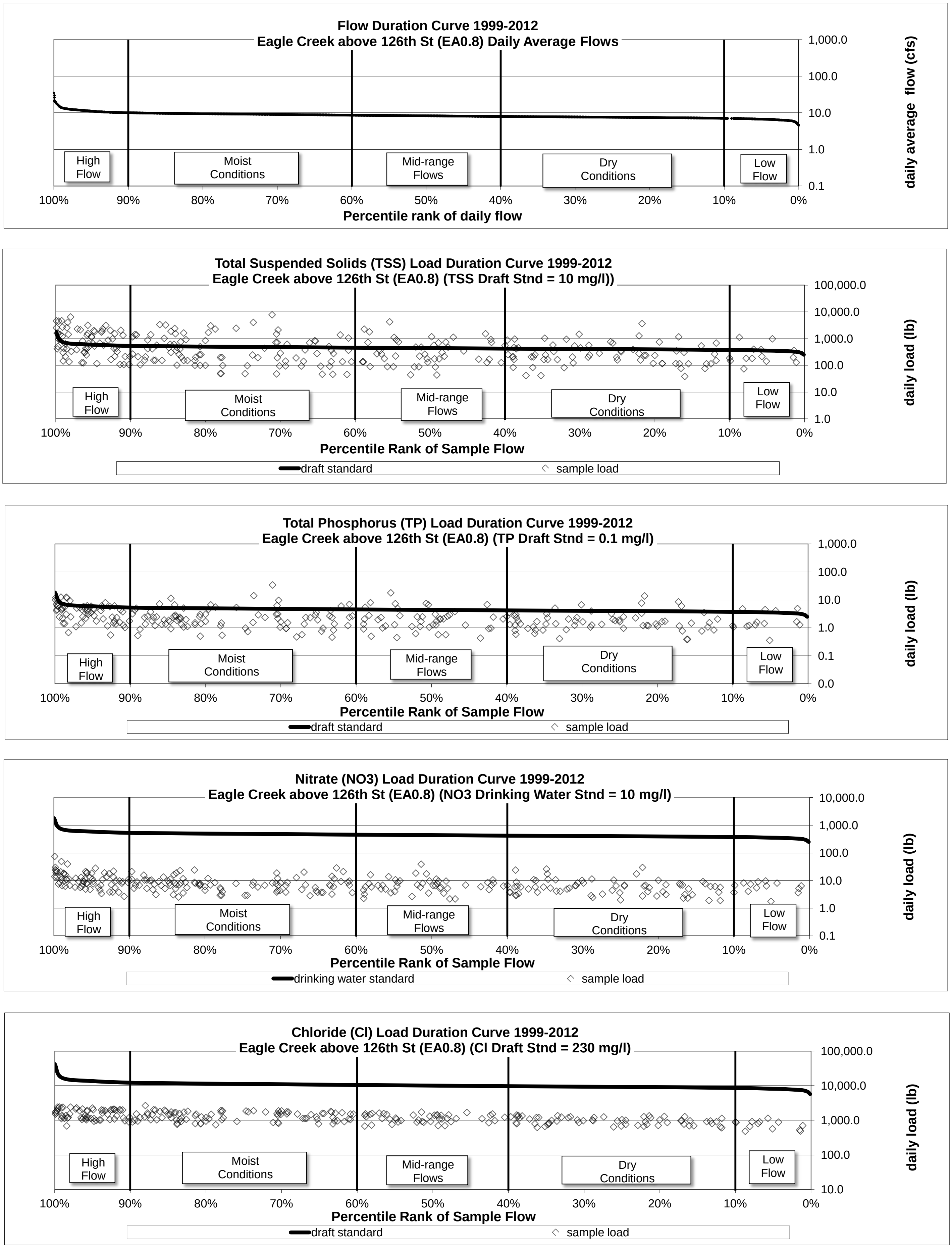
[4] Mark Tomasek, MPCA, personal communication, March 2013. MCES used 230 mg/l as the draft chloride standard pending results of EPA toxicity tests.

[5] 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.

[6] MPCA, 2013a.

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

Figure EA-12: Eagle Creek Flow and Load Duration Curves, 1999-2012



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.

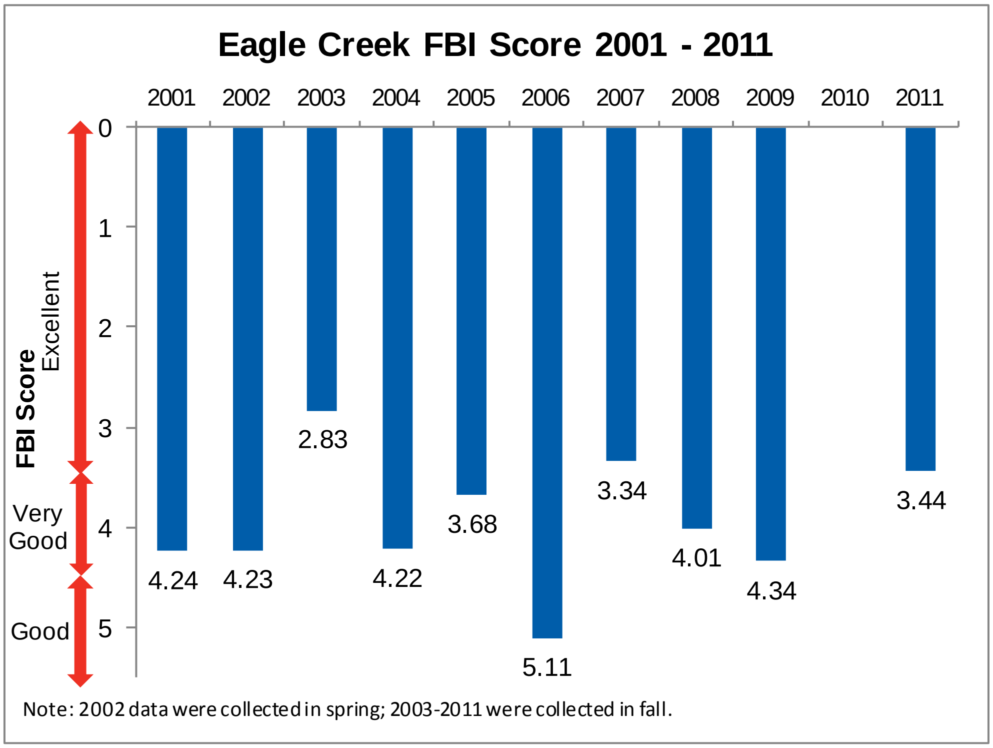
Each metric is independently important and clarifies one aspect of the ecosystem health: species richness, community diversity, water quality, and other factors. The results may have conflicting conclusions when comparing the single metric results. However, integrating the individual metrics into a multi-metric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

MCES has been sampling for macroinvertebrates in Eagle 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 comparisons from year to year. The Eagle Creek FBI scores show excellent (2003, 2007, 2011) to good (2006) water quality, indicating the possible presence of organic pollution (Figure EA-13).

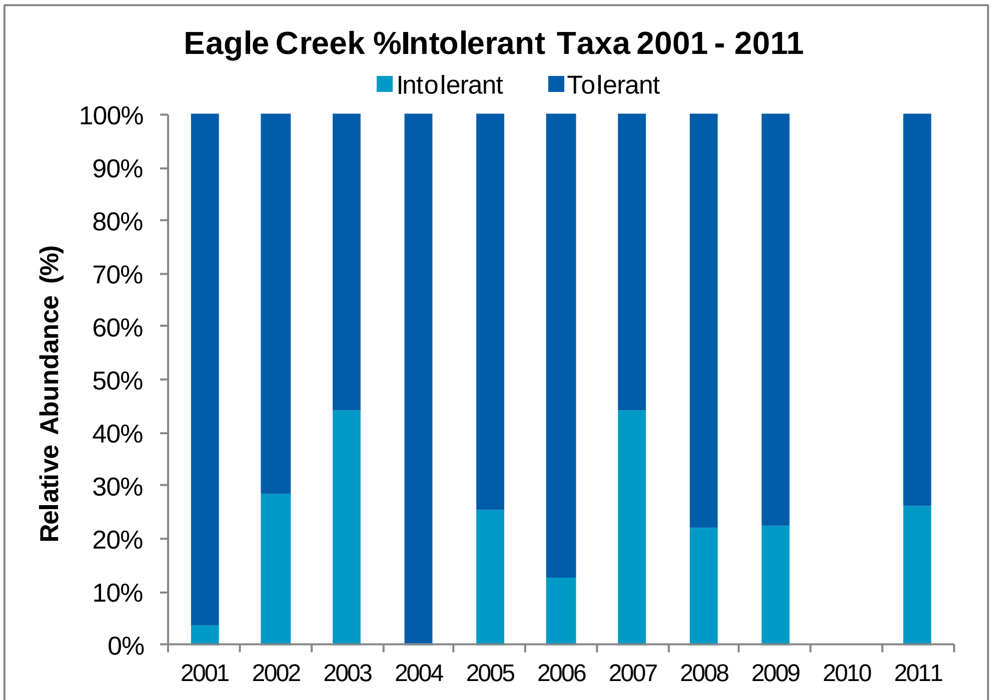
Figure EA-13: Eagle Creek Annual Family Biotic Index (FBI) Scores, 2001-2011



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 EA-14). The presence of moderate numbers of intolerant taxa is an indicator of good aquatic health (Chirhart, 2003). Intolerant taxa were greater than 10% of the taxa in 2002, 2003, and 2005 through 2011. The highest Percent Intolerant Taxa, 44%, occurred in 2003 and 2007. Intolerant taxa were present in every sample except 2004. The 2004 sample was collected in a prolonged period of high flow (average daily flow > 8cfs), which may have reduced the numbers of intolerant taxa.

Figure EA-14: Eagle Creek Percent Abundance of Pollution Intolerant Taxa, 2001-2011

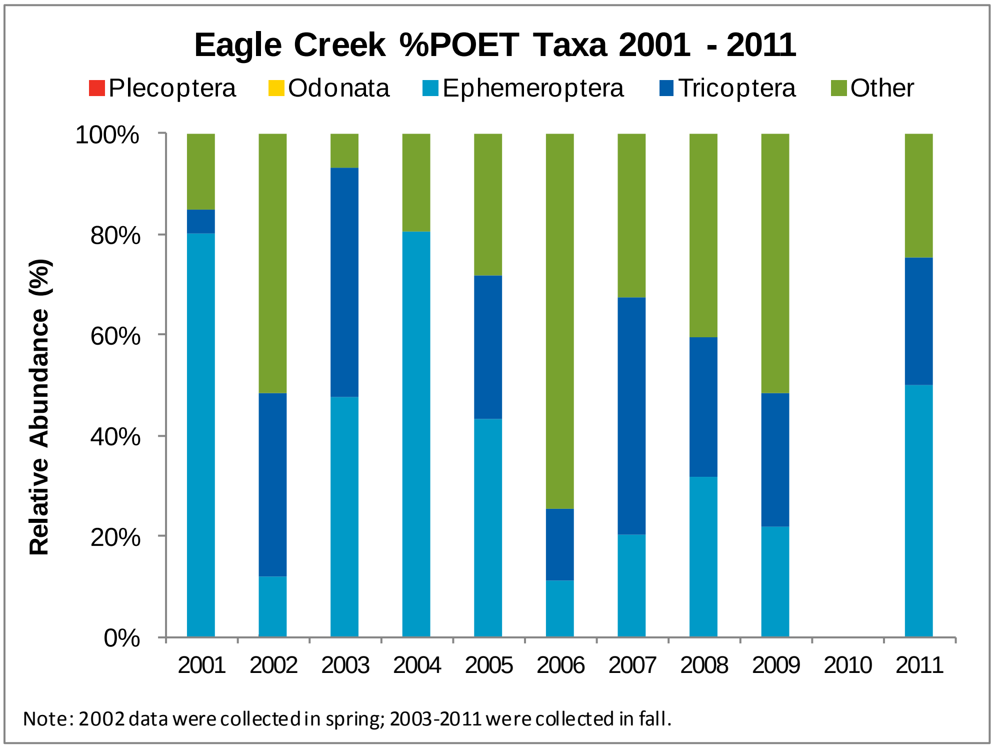


Note: 2002 data were collected in spring; 2003-2011 were collected in fall.

Percent POET Taxa

The taxonomic richness metric, Percent POET Taxa (Figure EA-15), is the percent of individuals in the sample which 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 comprise almost 50% or more of the sample every year except 2006 where they account for only 26% of the taxa. The 2006 sample was collected on 9/13/06, ten days after a major flow event (13.6 cfs), which may have affected the macroinvertebrate populations in the stream.

Figure EA-15: Eagle Creek Percent Abundance of POET Taxa, 2001-2011

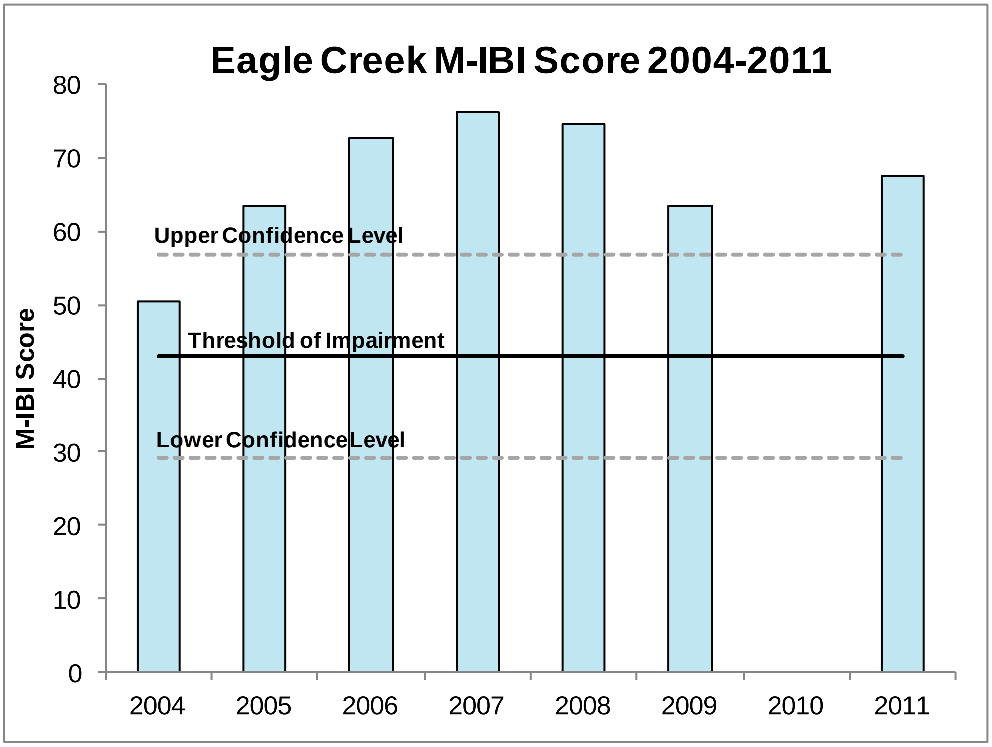


Macroinvertebrate Index of Biotic Integrity (M-IBI)

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 (MPCA, 2014b).

The most recent six years of monitoring Eagle Creek have resulted in M-IBI scores above both the impairment threshold and the upper confidence level (Figure EA-16). Since 2005, the water quality at this stream reach has likely been adequate to sustain the needs of aquatic life.

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



Taken together, these three metrics indicate that Eagle Creek has good to excellent water quality, and generally supports the needs of aquatic life. MCES is planning additional future analysis to fully investigate the biological monitoring data.

Trend Analysis

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

Due to 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 periods 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 to 10 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 1999-2012 on Eagle Creek for TSS, TP, and NO_3. The results are presented below. Readers should note that while QWTREND allows identification of changes of pollutant flow-adjusted concentration with time, it does not identify causation. MCES staff have not attempted to identify changes in watershed management, climactic changes, or any other factors which may affected concentration in the stream.

Total Suspended Solids

Five trends were identified for TSS flow-adjusted concentration in Eagle Creek from 1999 to 2012 (Figure EA-17). The assessment was performed using QWTREND without precedent 5-year flow. The trends identified were statistically significant ($p=9.2x10^{-8}$):

- Trend 1: 1999 to 2000, TSS flow-adjusted concentration decreased sharply from 21.1 mg/l to 4.0 mg/l (-81%) at a rate of -8.5 mg/l/yr.
- Trend 2: 2001 to 2003, TSS flow-adjusted concentration increased from 4.0 mg/l to 10.9 mg/l (172%) at a rate of 2.3 mg/l/yr.
- Trend 3: 2004 to 2008, TSS flow-adjusted concentration decreased from 10.9 mg/l to 5.1 mg/l (-53%) at a rate of -0.23 mg/l/yr.
- Trend 4: 2009 to 2010, TSS flow-adjusted concentration increased from 5.1 mg/l to 11.1 mg/l (116%) at a rate of 3.0 mg/l/yr.
- Trend 5: 2011 to 2012, TSS flow-adjusted concentration decreased from 11.1 mg/l to 5.3 mg/l (-52%) at a rate of -2.9 mg/l/yr.

The five-year trend in TSS concentration in Eagle Creek (2008-2012) was calculated to compare with other MCES-monitored streams, shown in the report section ***Comparison with Other Metro Area Streams***. TSS flow-adjusted concentration decreased from 5.6 mg/l to 5.3 mg/l (-5.2%) at a rate of -0.058 mg/l/yr. Based on these QWTREND results, the water quality in Eagle Creek in terms of TSS improved during 2008-2012.

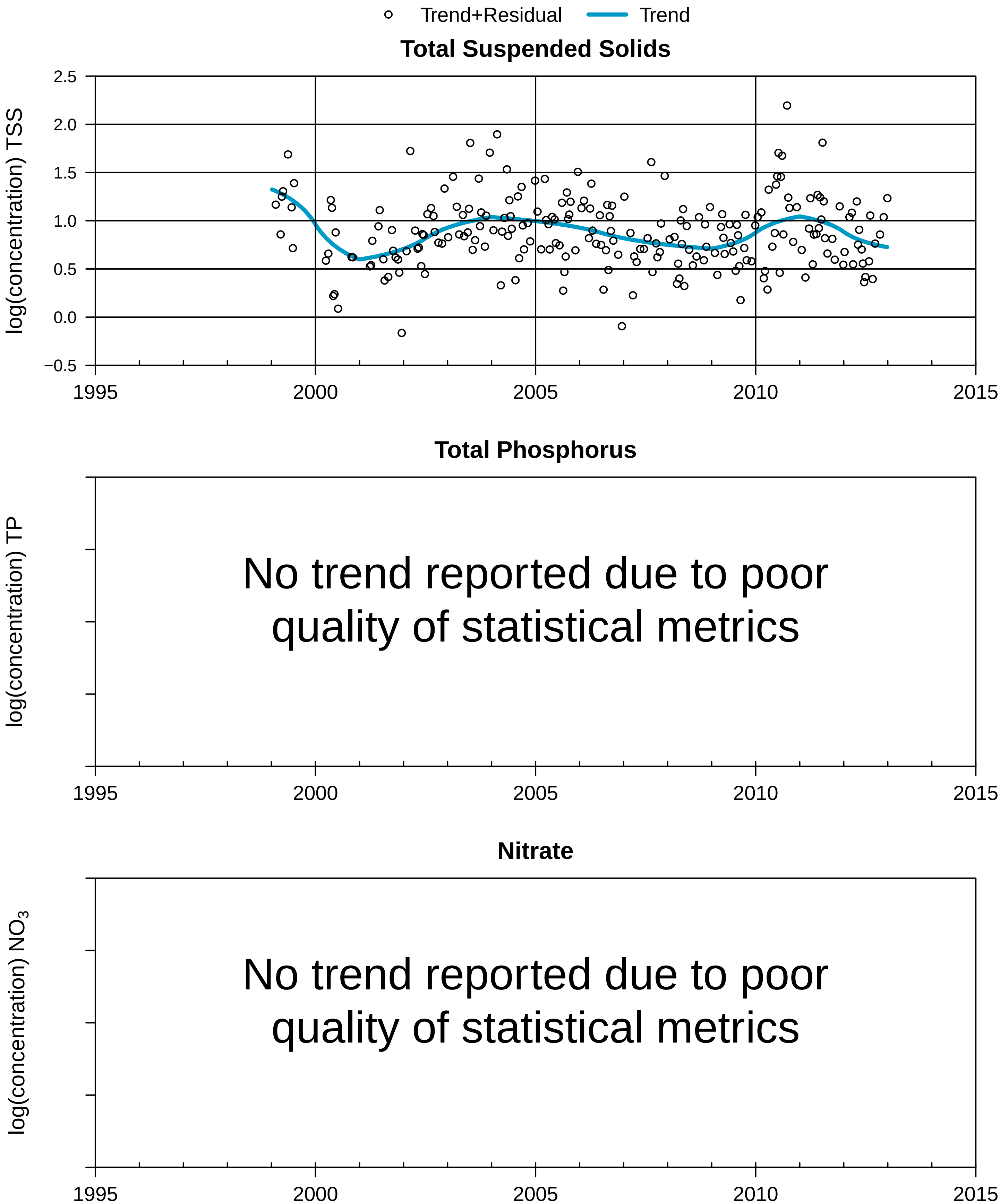
Total Phosphorus

No trend was reported for TP flow-adjusted concentration in Eagle Creek from 1999 to 2012, due to poor quality of statistical metrics.

Nitrate

No trend was reported for NO_3 concentration in Eagle Creek from 1999 to 2012 due to poor quality of statistical metrics.

Figure EA−17: Eagle Creek Trends for TSS, TP and NO_3



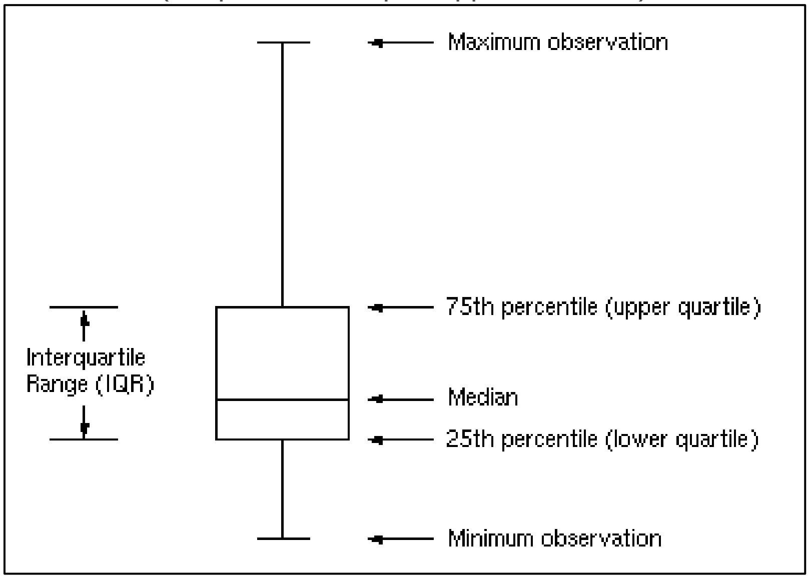
Comparison with Other Metro Area streams

Chemistry

Box-and-whisker plots are used to summarize the comparison of the historical flow, TSS, TP, NO_3, and Cl data for Eagle 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 shown in Figure EA-19 to Figure EA-22.

Figure EA-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 EA-18: General Schematic of a Box-and-Whisker Plot
(adapted from http://support.sas.com)



Comparisons for each chemical parameter for the 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 concentration for TSS in Eagle Creek (11 mg/l) is much lower than other monitored Minnesota River tributaries (Figure EA-19; Table EA-3), and is lower than any other MCES monitored stream except the Carnelian-Marine lake outlet in the St. Croix basin. The median annual FWM TSS concentration in Eagle Creek is also much lower than that of the Minnesota River (as measured at Jordan Minnesota; 142 mg/l), indicating that Eagle Creek has little impact on the TSS concentration in the Minnesota River. Eagle Creek's median annual TSS load is the lowest of the MCES monitored Minnesota River tributaries, and its median annual TSS yield is the second lowest (after Willow Creek).

Median annual runoff ratio for Eagle Creek is much higher (2.29 vs. a mean of 0.22 for all others) than other monitored metropolitan area streams; and is not plotted with the other streams in Figures EA-19 through EA-22. This higher runoff ratio is most likely due to the flow being highly influenced by shallow groundwater inflow, which generates very uniform annual and monthly flows (Figures EA-6 and EA-10).

Total Phosphorus. Similar to TSS, the median FWM TP concentration in Eagle Creek (0.06 mg/l) is much lower than other monitored Minnesota River tributaries, and is lower than any other MCES monitored streams except Valley Creek and the Carnelian-Marine outlet in the St. Croix basin (Figure EA-20). The Eagle Creek median annual TP load is also lower (918 lb/year) than the other upper Minnesota metropolitan area tributaries (i.e. Bevens, Sand, Bluff) and is lower than all of the Mississippi and St. Croix tributaries, with the exception of the Carnelian-Marine outflow and Silver Creek in the St. Croix basin (156 lb/year and 235 lb/year, respectively).

Nitrate. Median FWM NO_3 concentration in Eagle Creek (0.17 mg/l) is the lowest of the monitored Minnesota River streams, and among the lowest of all monitored metro area streams. NO_3 median FWM concentration in Eagle Creek is lower than that of the Minnesota River, and thus serves to dilute the river concentration (Figure EA-21). The median annual NO_3 load in Eagle Creek (2,760 lb/year) is the second lowest of the monitored Minnesota River tributaries, and among the lowest of all MCES monitored streams. Given the relatively low annual load, the areal yield in Eagle Creek is slightly higher than would be expected (2.6 lb/acre/year), but this is due to the small size of the watershed (1,083 acres upstream of the monitoring station).

Chloride. The median FWM Cl concentration and load in Eagle Creek are the smallest of the monitored Minnesota River streams (25 mg/l and 381,000 lb/year) (Figure EA-22). The median areal Cl yield in Eagle Creek is the highest of all MCES-monitored tributaries (352 lb/acre/year) but this is again due to the small size of the watershed. Chloride is highly soluble in water and the high concentrations and loads in Eagle Creek may be due to ground water inflows with high chloride concentrations. The two most prevalent sources of chloride to streams are road surfaces (from chloride application as a de-icer) and WWTP effluent (from domestic water softeners). However, as stated above, average monthly Cl concentrations are very consistent, and the sources of Cl in Eagle Creek should be investigated further (see Figure EA-11).

Macroinvertebrates

The historic biomonitoring data, summarized as M-IBI scores, were also summarized as box-and-whisker plots. However, the streams were divided by stream type as the MPCA impairment thresholds are type-specific and this attribute does not correlate with major river basins (Figure EA-23).

The M-IBI scores for Eagle Creek were above the MPCA impairment threshold. This includes the median, which suggests that this stream reach habitat and water quality typically were able to sustain the needs for aquatic life. These results were similar to the other cold water streams, Browns, Silver, and Valley Creeks. The cold water, spring-fed streams appear to have less negative stressors on their macroinvertebrate communities than the warm water, surface-fed streams in the metropolitan area.

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

Organized by Major River Basin

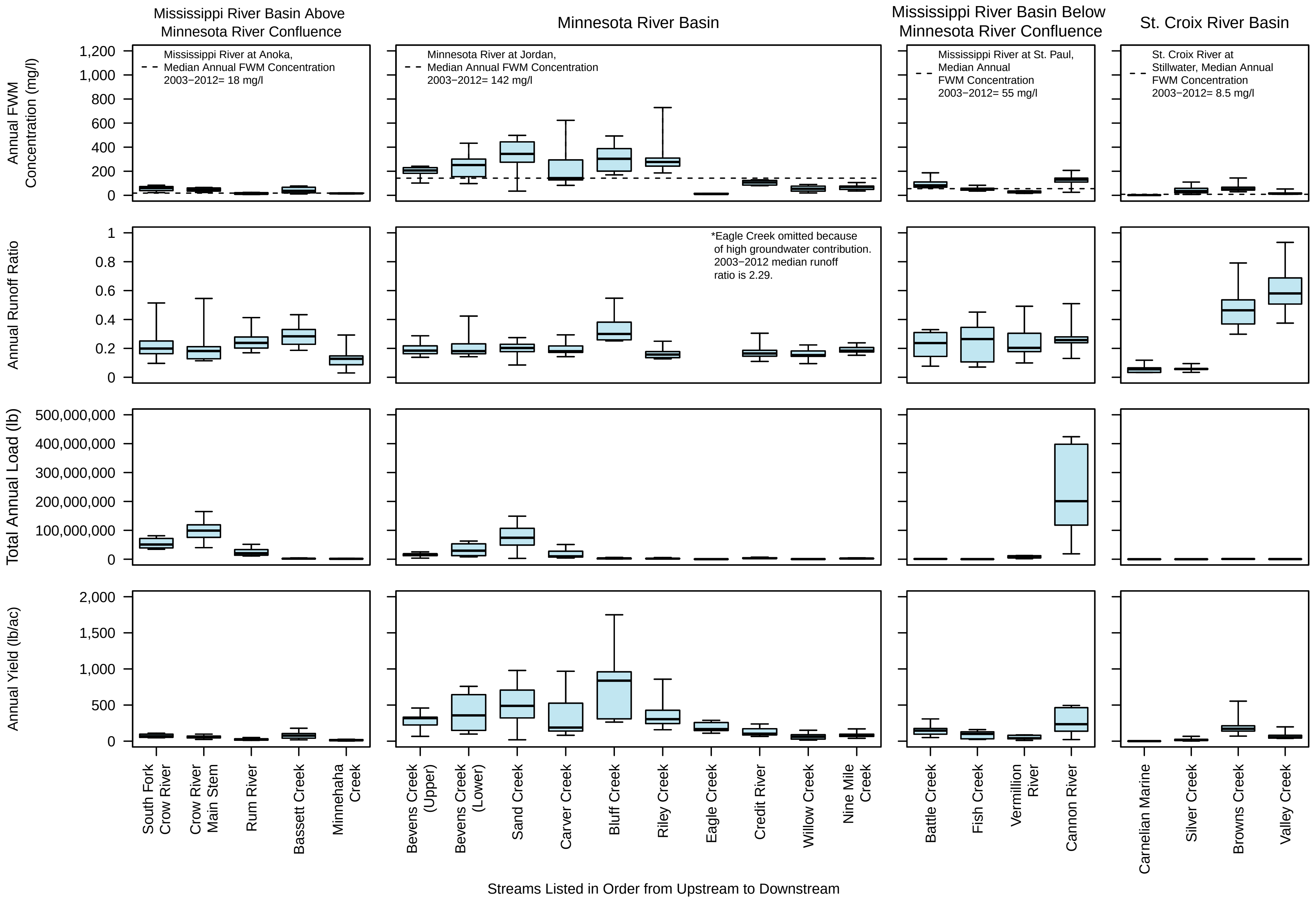


Figure EA−20: Total Phosphorus for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

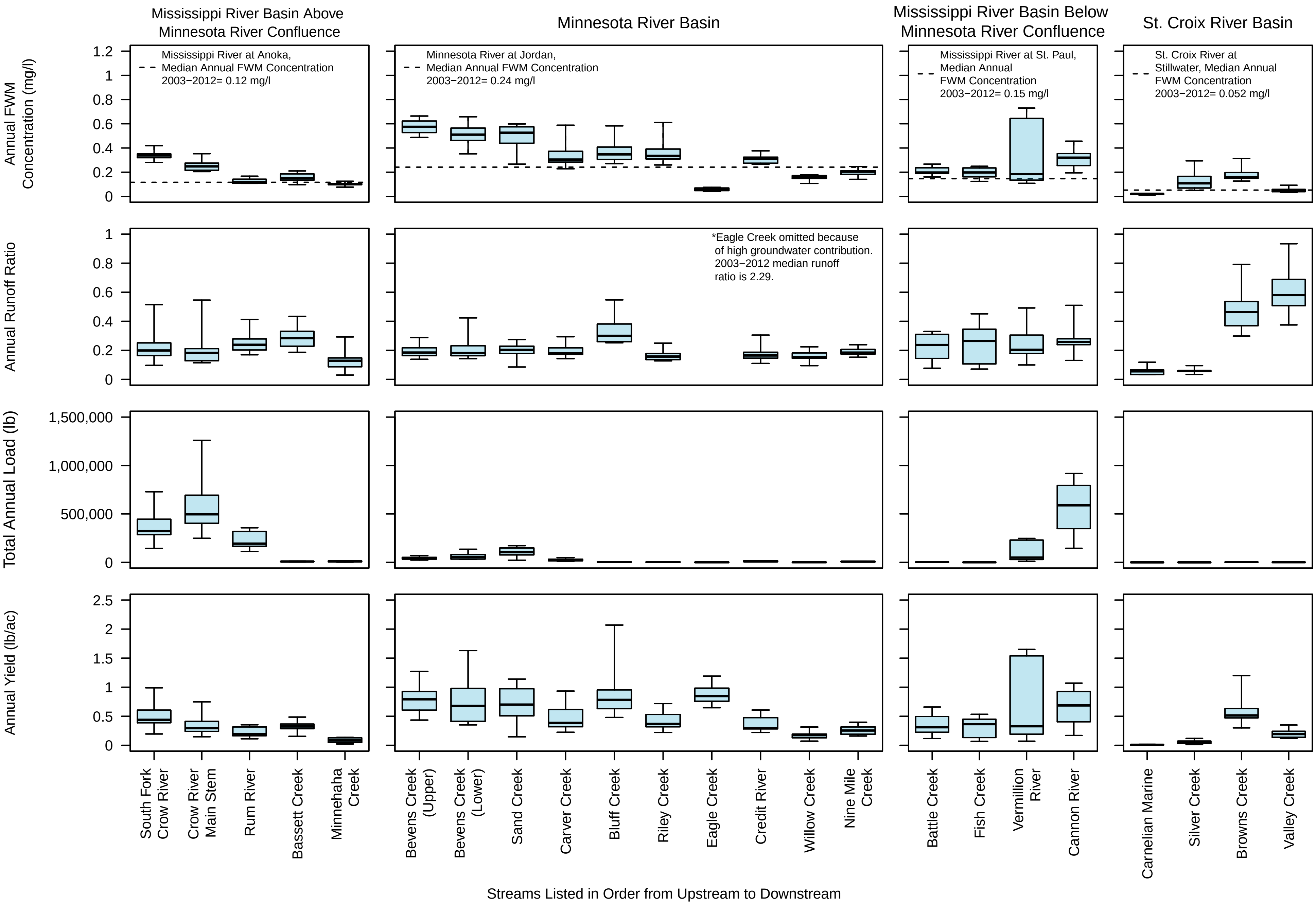


Figure EA−21: Nitrate for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

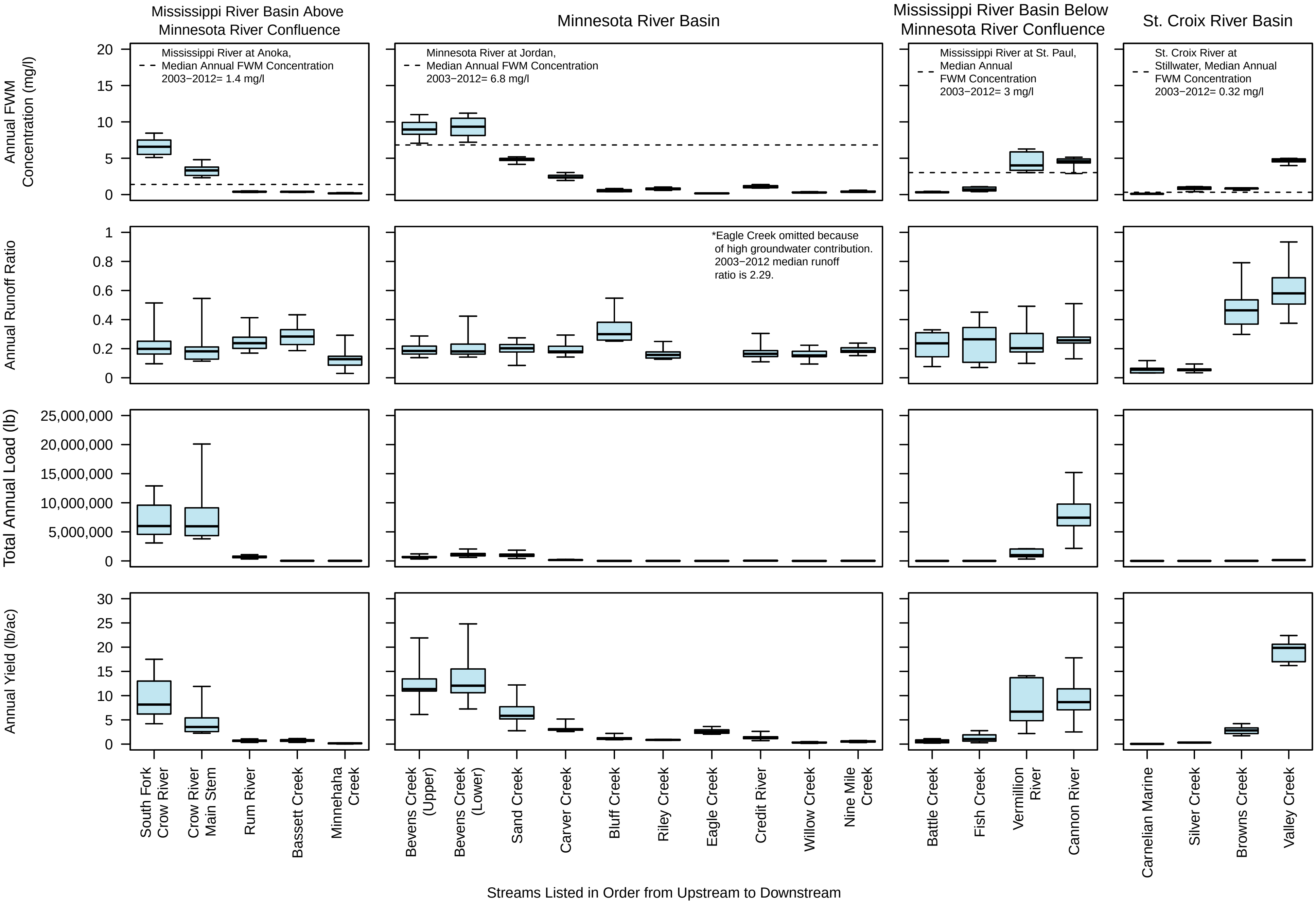


Figure EA−22: Chloride for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

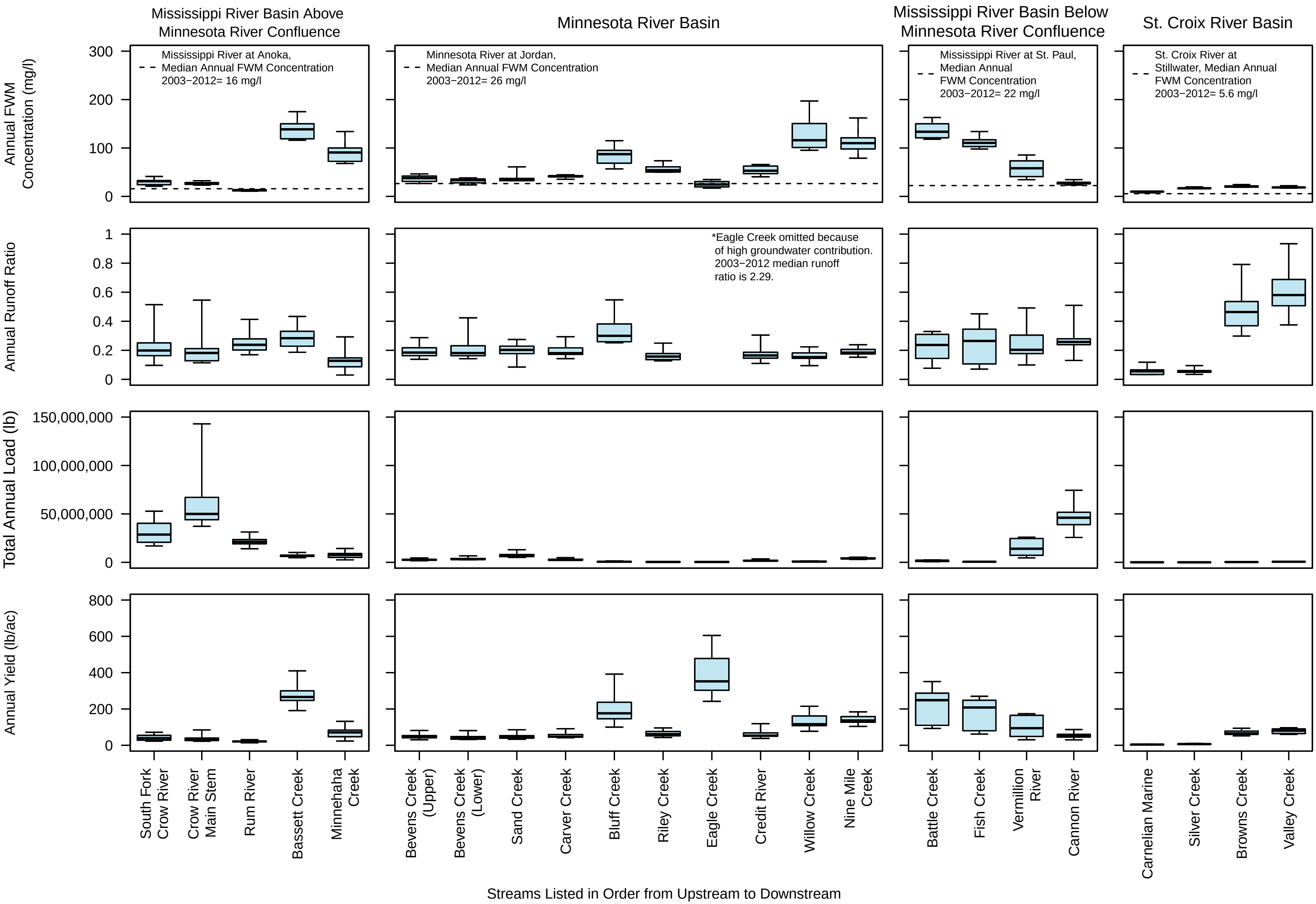


Table EA-3: Annual Median Concentrations, Loads, and Yields for MCES-Monitored Streams, 2003-2012

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)

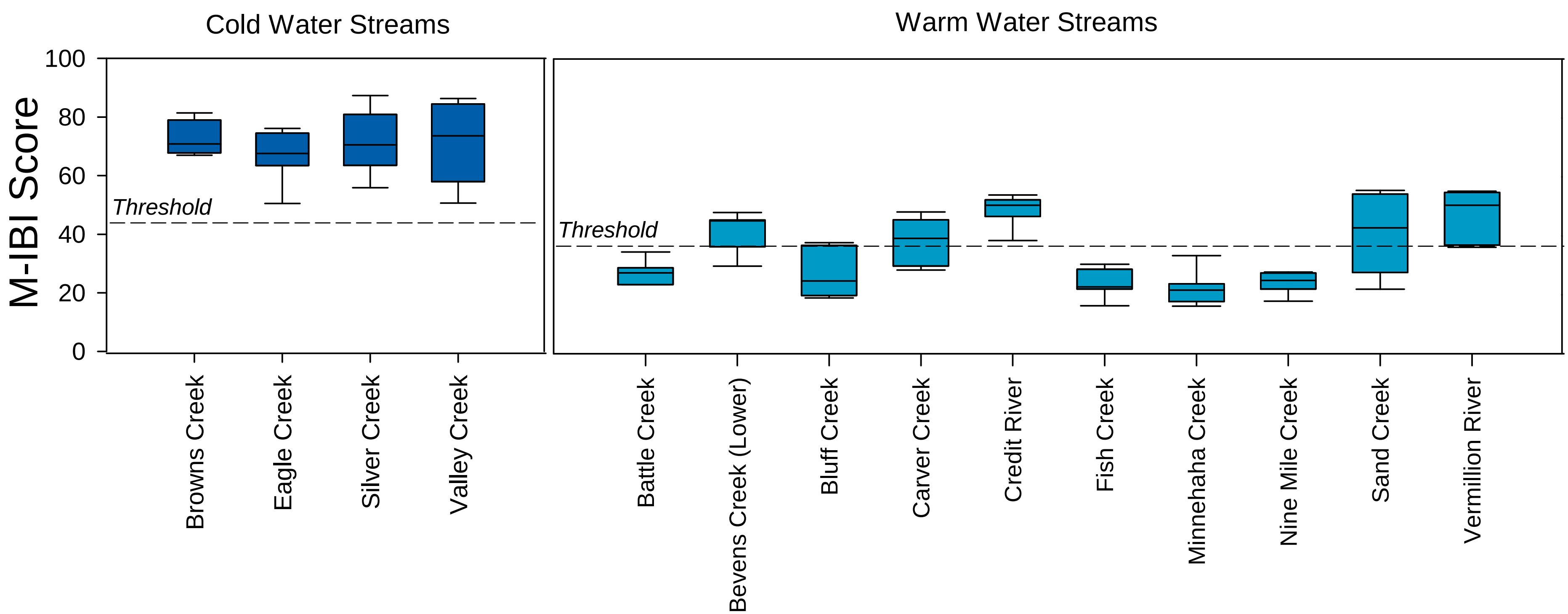
[2] FWM conc = annual flow-weighted mean concentration estimated using Flux32 (Walker, 1999).

[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 EA-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 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.

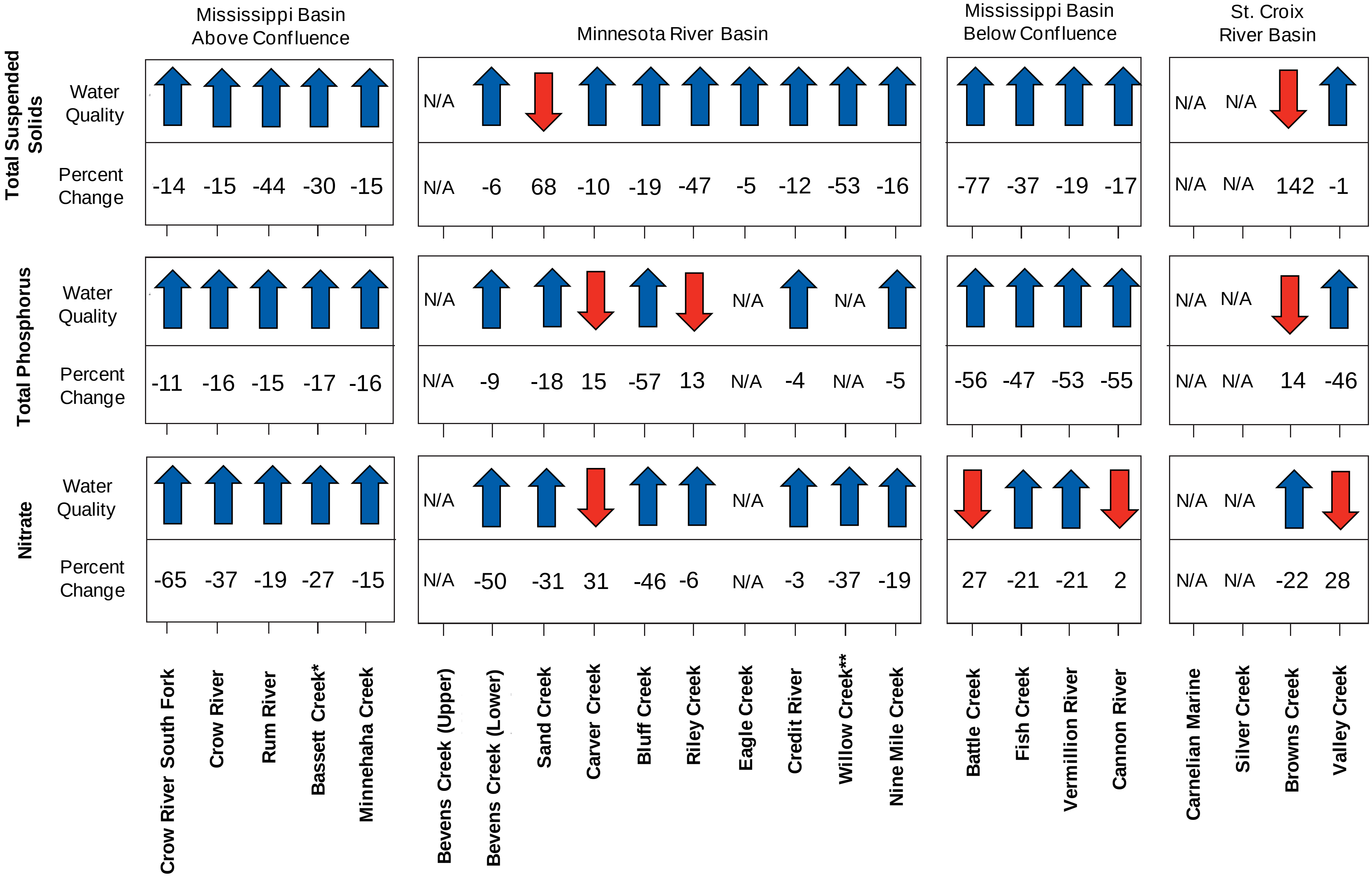
Estimated changes for TSS, TP, and NO_3 in MCES-monitored streams are presented below in two ways. First, tabulated results with directional arrows indicating improving (blue upward arrow) and declining (red downward arrow) water quality paired with percent change in flow-adjusted concentration estimated for 2008-2012 (Figure EA-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 EA-25). In both figures no trend was reported for those QWTREND analyses with poor quality of statistical metrics ($p>0.05$).

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 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 concentrations in all Minnesota River tributaries with the exception of Sand Creek. For Eagle Creek, annual median TSS flow-adjusted concentrations decreased by 5 percent over the 2008-2012 period. Over the same time period, no trends in median annual TP or NO_3 concentrations were reported, due to poor statistical metrics of the QWTREND model.

Figure EA-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)



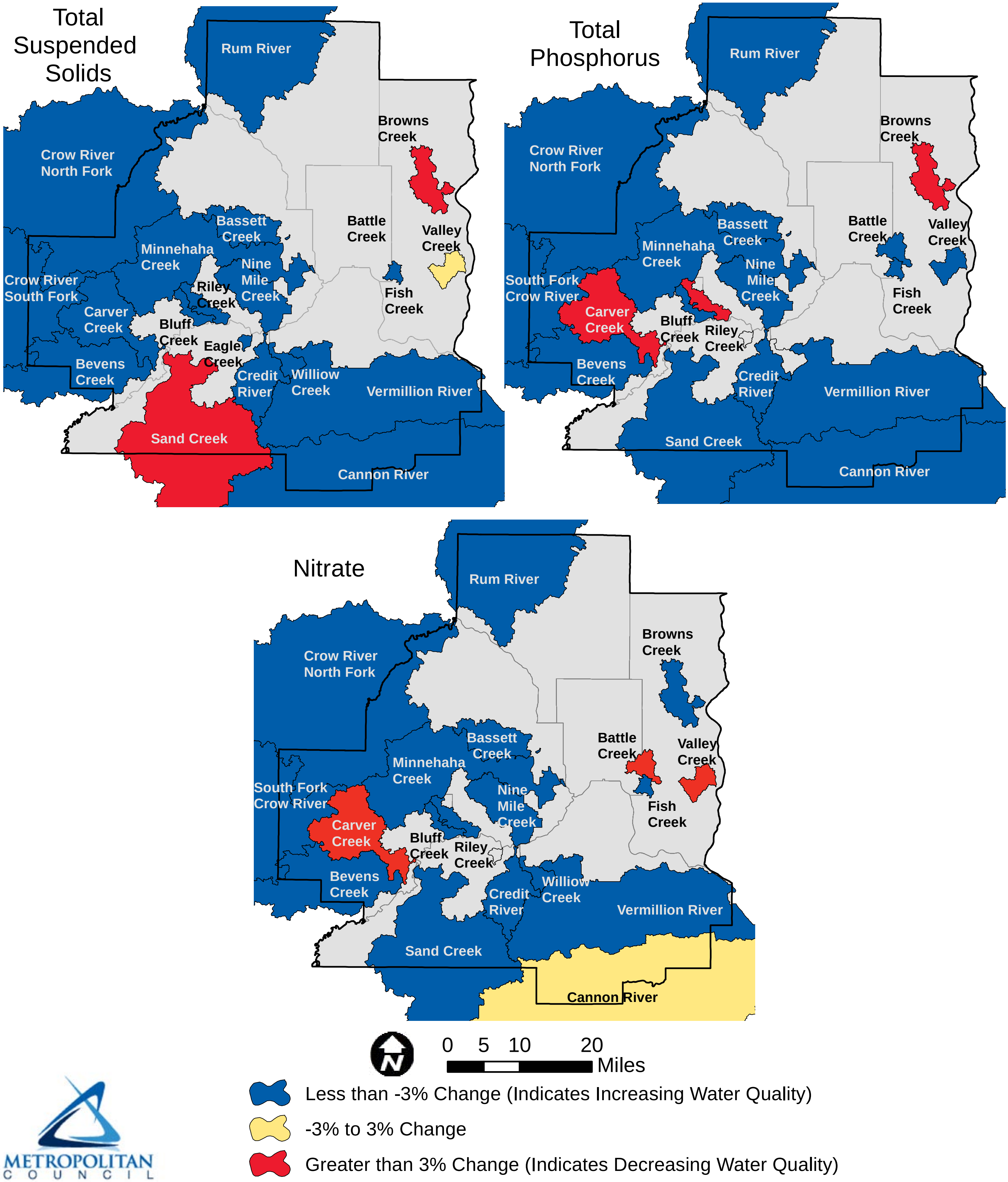
Blue arrows indicate improved water quality; Red arrows indicate declining water quality.

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

(As estimated by QWTrend)



METROPOLITAN COUNCIL

Conclusions

Eagle Creek is a tributary to the Minnesota River located in the south central metropolitan area. It drains approximately 2.6 square miles of mixed suburban land, forest, open space, bluff land, and wetlands in Scott County. The creek flows through the Minnesota Valley National Wildlife Refuge before entering the Minnesota River.

The stream's headwater is Boiling Springs, an artesian spring located approximately one mile upstream from the monitoring station. Eagle Creek is a Minnesota Department of Natural Resources (MnDNR) designated trout stream. The MCES monitoring station is located in Savage, Minnesota, 0.8 miles upstream from the creek confluence with the Minnesota River.

MCES has monitored the water quality of Eagle Creek since 1999, with partial funding provided through a grant from the MPCA using Clean Water Land and Legacy Amendment funds. MCES partners with the LMRWD and the Scott SWCD, which operates the monitoring station.

Water quality in Eagle Creek is among the best of the MCES monitored metropolitan area tributaries to the Minnesota River, and also among the best of MCES monitored streams. Over the latest five year period for which data are available (2008-2012), trends in TSS flow-adjusted concentrations have decreased, resulting in improved water quality for that pollutant. No trends for TP and NO_3 flow-adjusted concentrations were identified due to the low level of statistical quality metrics. Macroinvertebrate samples evaluated with the Macroinvertebrate Index of Biological Integrity (M-IBI; MPCA 2014b) metric indicated that water quality at the monitoring station has been adequate to sustain the needs of aquatic life.

In general, Eagle Creek is a small, cold, spring fed, stream with good water quality and a small watershed, with small surface runoff inputs. Currently, the stream is not impaired, and there are no impaired waters in the Eagle Creek watershed.

Recommendations

This section presents recommendations for monitoring and assessment of Eagle Creek, as well as recommendations for partnerships to implement stream improvements. MCES recognizes that cities, counties, and local water management organizations, like LMRWD and Scott SWCD, 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 organizations 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:

- MCES should continue monitoring of Eagle Creek and should partner with LMRWD and Scott SWCD to investigate possible sources of pollutants in the creek.
- MCES should partner with the U.S. Fish and Wildlife Service to investigate the effects of Eagle Creek on the Minnesota Valley National Wildlife Refuge.

- MCES and partners (especially LMRWD and Scott SWCD) 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.
- As resources allow, MCES should provide LMRWD, Scott SWCD, the MnDNR, and other local water managers with information about the heightened potential for surface waters to be impacted by groundwater changes in the Eagle 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 Eagle Creek, including updating analyses with the best available data and linking results to predictive groundwater modeling and the comprehensive planning process.
- MCES should continue macroinvertebrate monitoring in Eagle Creek. 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.
- MCES should partner with LMRWD, Scott SWCD, and the MnDNR to investigate the sources of chloride delivered to Eagle Creek.

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