Comprehensive Water Quality Assessment of Select Metropolitan Area Streams

BASSETT CREEK

METROPOLITAN COUNCIL

December 2014

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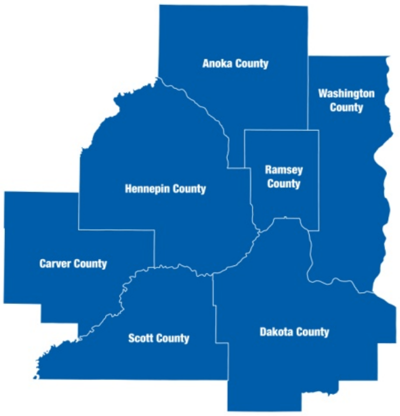

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide 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, *Bassett Creek*, is one in a series produced as part of the *Comprehensive Water Quality Assessment of Select Metropolitan Area Streams.* Located entirely in Hennepin County, Bassett Creek is one of the eight Mississippi River tributaries examined. This section discusses a wide range of factors that have affected the condition and water quality of Bassett Creek. Special funding for this project was provided through the Clean Water Fund.

CLEAN WATER LAND & LEGACY AMENDMENT

Cover Photo

The cover photo depicts Bassett Creek in Golden Valley after restoration.

Recommended Citations

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Introduction

Bassett Creek is located in the north central metropolitan area and is a tributary to the Mississippi River, discharging above the Mississippi's confluence with the Minnesota River. It drains approximately 39 square miles of mostly urbanized land in Hennepin County. The creek's headwaters are at Medicine Lake and it discharges to the Mississippi River through a storm tunnel under downtown Minneapolis.

Figure BS-1: Bassett Creek Meandering through Bassett Creek Park

Photo Credit: Daniel Johnson

This report:

- documents the characteristics of Bassett Creek and its watershed most likely to influence flow and water quality
- lists examples of recent improvement projects completed by local governmental units (LGUs)
- presents the results from assessments of flow and water quality data
- presents statistical assessments of trends in TSS (total suspended solids), TP (total phosphorus), and NO_3 (nitrate)
- draws conclusions about possible effects of landscape features, climatological changes, and human activities on flow and water quality
- compares Bassett Creek flow and water quality with other streams within the metropolitan area monitored by Metropolitan Council Environmental Services (MCES)

- makes watershed-specific recommendations for future monitoring and assessment activities, partnerships, and other potential actions to remediate any water quality or flow concerns

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

Partnerships and Funding

MCES has supported water quality monitoring of Bassett Creek since March 2000 through 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 partnered with the Minneapolis Park and Recreation Board to operate the monitoring station through the end of 2012. Since 2013, MCES has partnered with the Bassett Creek Watershed Management Commission (BCWMC) to operate the monitoring station.

Monitoring Station Description

The monitoring station is located on Bassett Creek in Minneapolis, Minnesota, 1.9 miles upstream from the creek confluence with the Mississippi River. The monitoring station includes continuous stage monitoring, baseflow grab sample collection, event-based composite sample collection, and *in situ* conductivity and temperature probes. The site originally had a Campbell Scientific SR50 Ultrasonic Distance Sensor to measure flow, but this sensor occasionally experienced electrical interference from nearby high-voltage power lines. Replacement, shielding, and grounding of the ultrasonic sensor proved to be only a partial solution. Therefore, a gas-purge bubbler system was also installed as a backup option for stage measurement. Stage is calibrated on site visits with a tape lowered from the Noble Avenue bridge deck. A continuous discharge record is obtained by relating stage to flow with a rating curve unique to the site. Stage-discharge measurements are made with an acoustic doppler velocimeter several times a year, and the rating curve is adjusted when rating points fall significantly off the existing rating curve, or a change in the station cross-section is observed.

A tipping bucket rain gauge is present at this location for measurement of precipitation. However, because there were some gaps in the precipitation record, daily precipitation totals from Minnesota Climatology Working Group stations 214884-Lower St. Anthony Falls and 215838-New Hope 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 watersheds (Minnesota Climatology Working Group, 2013). These data are generated from Minnesota's HIDEN (High Spatial Density Precipitation Network) dataset. The gridded data was areally-weighted based on the watershed boundaries.

The Bassett Creek station has been in operation continuously since March 2000, with the first full year of sample collection beginning in 2001. This report uses flow data from March 2000-2012, and water quality data from 2001-2012.

Stream and Watershed Description

The Main Stem of Bassett Creek originates as the outlet from Medicine Lake in Plymouth, and flows easterly through Plymouth, Golden Valley, a corner of Crystal, and Minneapolis before discharging into the Mississippi River. In the vicinity of the monitoring station, the creek is quite straight, with no meanders and rip-rap along each bank (Figure BS-2). About a quarter mile downstream from the station, at Glenwood and Colfax avenues in Minneapolis, the creek enters a tunnel and flows underneath the major business sector of Minneapolis until it discharges to the Mississippi River.

Figure BS-2: Bassett Creek near Monitoring Station

Photo Credit: Metropolitan Council

The main stem of Bassett Creek has a total channel length of approximately 13.5 miles from the Medicine Lake outfall to the Mississippi River, and consists of several tributaries: Plymouth Creek originates upstream of Medicine Lake and drains the west section of the watershed into Medicine Lake; the North Branch of Bassett Creek drains the north part of the watershed before joining the main stem at Bassett Creek Park Pond; and the Sweeney Lake Branch drains the south part of the watershed before joining the main stem just north of Sweeney Lake (BCWMC, 2004).

Bassett Creek was originally diverted into the storm tunnel under Minneapolis more than a century ago. As the Bassett Creek watershed developed, the tunnel size became inadequate, resulting in flooding in the watershed (BCWMC, 2004). Over the period 1979-1996, the U.S. Army Corps of Engineers engaged in a series of flood control projects within the watershed that included replacing the tunnel and creating storage upstream throughout the watershed to reduce peak flows during large events. These improvements − as well as other flood control projects completed by BCWMC, watershed cities, and the Minnesota Department of Transportation (MnDOT) − have substantially reduced flooding along the creek.

There are a number of lakes in the watershed. About 75% of the watershed first drains to a lake or wetland prior to discharging to Bassett Creek. The largest and most significant is Medicine Lake, with a 902 acre surface area, which receives drainage from almost half of the watershed (11,613 acres) (BCWMC, 2004). Other significant lakes are Turtle (surface area 28 acres, watershed area 397 acres), Parkers (surface area 97 acres, watershed area 950 acres), Crane (surface area 30 acres, watershed area 353 acres), Westwood (surface area 38 acres, watershed area 399 acres), Northwood (surface area 15 acres, watershed area 1,340 acres), Bassett Creek Park Pond (surface area 9.7 acres, watershed area 1,281 acres downstream of Northwood Lake), Grimes, North Rice and South Rice Ponds (total surface area 13 acres, watershed area 527 acres), Wirth (surface area 38 acres, watershed area 348 acres), Sweeney (surface area 67 acres, watershed area 2,369 acres) and Twin (surface area 21 acres, watershed area 72 acres).

The Bassett Creek watershed encompasses a total of 25,155 acres, with 24,911 acres (99.2%) of the watershed upstream of the monitoring station (Figure BS-3; Table BS-1). The watershed encompasses portions of the cities of Plymouth, Minnetonka, St. Louis Park, New Hope, Crystal, Robbinsdale, and Minneapolis, the majority of Golden Valley, and all of Medicine Lake. The entirety of the Bassett Creek watershed is within Metropolitan Council Districts 1,2,3,6, and 7. The Bassett Creek watershed upstream of the monitoring station is contained within the Bassett Creek Watershed Management Commission (BCWMC), a joint powers organization between the nine communities in the Bassett Creek Watershed.

Table BS-1: Bassett Creek Land Cover Classes[1]

Land Cover Class	Monitored		Unmonitored		Total	
	Acres	Percent	Acres	Percent	Acres	Percent
5-10% Impervious	199	0.8%	0	0.0%	199	0.8%
11-25% Impervious	174	0.7%	0	0.0%	174	0.7%
26-50% Impervious	5,107	20.5%	9	3.5%	5,115	20.3%
51-75% Impervious	5,032	20.2%	21	8.5%	5,053	20.1%
76-100% Impervious	5,381	21.6%	167	68.6%	5,548	22.1%
Agricultural Land	0	0.0%	0	0.0%	0	0.0%
Forest (all types)	1,843	7.4%	21	8.8%	1,865	7.4%
Open Water	1,345	5.4%	0	0.0%	1,345	5.3%
Barren Land	0	0.0%	0	0.0%	0	0.0%
Shrubland	0	0.0%	0	0.0%	0	0.0%
Grasses/Herbaceous	3,512	14.1%	25	10.1%	3,537	14.1%
Wetlands (all types)	2,317	9.3%	1	0.5%	2,318	9.2%
Total	**24,911**	**100.0%**	**244**	**100.0%**	**25,155**	**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 seven-county metro area; and the 2001 NLCD (National Land Cover Data), which covered the outstate areas not included in the 2008 MLCCS.

Figure BS-3

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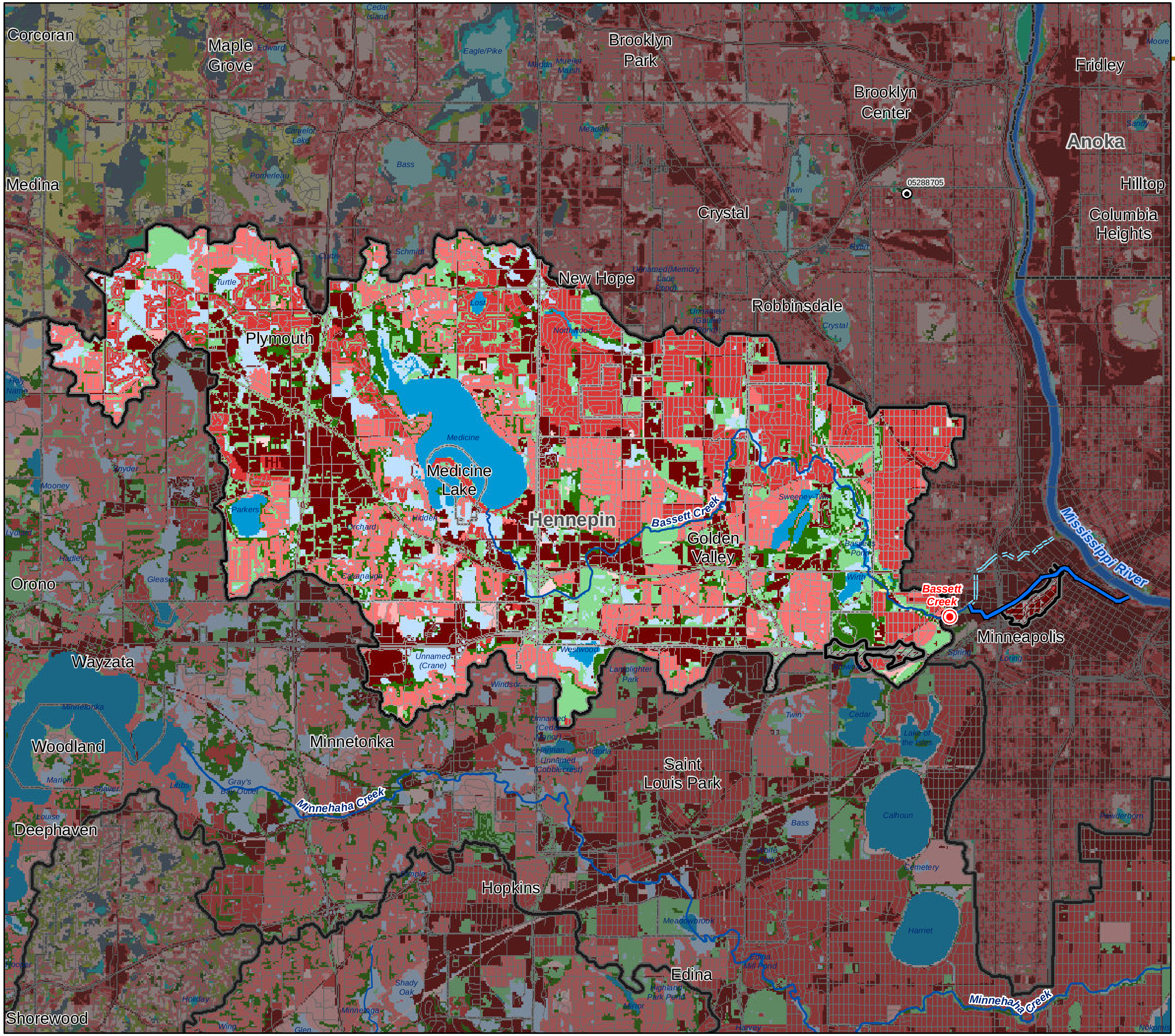
MLCCS-NLCD Hybrid Land Cover

Bassett Creek



- MCES Stream Monitoring Sites
- USGS Flow Stations
- Mainstems (Monitored and Unmonitored)
- New Bassett Creek Outflow Tunnel
- Old Bassett Creek Outflow Tunnel
- 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
Bassett Creek

Land Cover Class	Monitored Acres	Monitored Percent	Unmonitored Acres	Unmonitored Percent	Total Acres	Total Percent
5-10% Impervious	199	0.8%	0	0.0%	199	0.8%
11-25% Impervious	174	0.7%	0	0.0%	174	0.7%
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Forest (all types)	1,843	7.4%	21	8.8%	1,865	7.4%
Open Water	1,345	5.4%	0	0.0%	1,345	5.3%
Barren Land	0	0.0%	0	0.0%	0	0.0%
Shrubland	0	0.0%	0	0.0%	0	0.0%
Grasses/Herbaceous	3,512	14.1%	25	10.1%	3,537	14.1%
Wetlands (all types)	2,317	9.3%	1	0.5%	2,318	9.2%
Total	**24,911**	**100.0%**	**244**	**100.0%**	**25,155**	**100.0%**

0 0.5 1 1.5 2 2.5 3
Miles

The watershed is completely urbanized, with 16,090 acres/64.0% developed land (15,893 acres/63.8% within monitored area) and no agricultural land (based on 2008 Minnesota Land Cover Classification System (MLCCS) data). Other primary land covers in the watershed are forest, grasses/herbaceous, open water and wetlands. The most heavily urbanized portions of the watershed are in the west near the intersection of Hwy. 55 and I-694 and along the I-394 corridor on the south side of the watershed.

According to the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) STATSGO soils data, the majority (99.5%) of native soils in the monitored part of the Bassett Creek watershed are B soils, which have moderately low runoff potential (USDA, 2009). Small pockets of A soil which have low runoff potential exist in the northern portion of the watershed. Because the Bassett Creek watershed is heavily urbanized, many of the native soils have been disturbed, and the STATSGO soil survey may not be representative of actual conditions. For installation of infiltration practices, soil borings should be taken from the exact location of the proposed site location to assess level of soil filling or disturbance.

The watershed is primarily hummocky till, with Bassett Creek traveling through glacial outwash plains and post-glacial marshes (Meyer, 2007). Within the monitored area, the maximum elevation is 1046.2 MSL (above mean sea level) and the minimum elevation is 806.9 MSL (Figure BS-4). The watershed is highest in the west and lowest in the east. Slopes in the watershed are generally gradual: 4% of slopes within the monitored area are considered steep, and an additional 1% are considered very steep. Steep slopes are those between 12-18%, and very steep slopes are those 18% or greater (MnDNR, 2011). The only steep areas are along a north-south ridge on the west side of Medicine Lake, and some hilly areas in the east part of the watershed stretching south to north between Wirth and Twin Lakes.

There are few pollutant point sources within the Bassett Creek watershed (Figure BS-5). The watershed contains four cooling, potable water, and dewatering facilities and three individual wastewater facilities holding NPDES discharge permits. The watershed also contains 11 facilities holding industrial stormwater permits. All permit holders are within the monitored part of the watershed. There are no domestic wastewater facilities in the watershed, nor any feedlots.

In the time between the start of the WOMP program on Bassett Creek in 2000 and 2012, a number of water quality improvements have been made within the watershed. Water quality ponds were constructed to treat stormwater runoff in the Medicine Lake, Northwood Lake, Westwood Lake and Wirth Lake watersheds (BCWMC, 2009). Channel restoration has been completed in a portion of the Sweeney Lake Branch of Bassett Creek, in Plymouth Creek from Medicine Lake to 26th Avenue, and in the Bassett Creek Main Stem Channel from the Crystal border to Regent Avenue (Figures BS-6 and BS-7) (BCWMC, 2009 and BCWMC, 2012).

An aquatic herbicide was applied to Medicine Lake to treat curlyleaf pondweed (*Potamogeton crispus*) during 2004-2006 and 2008-2011 (McComas, 2011). During 2007 there was a significant curlyleaf pondweed growth in those areas where no herbicide was applied. Curlyleaf pondweed begins to naturally die-off in late June-early July, producing a spike in nutrients that can be taken up by algae (Three Rivers Park District, 2008). Therefore, lakes with large patches of curlyleaf pondweed may see a spike in phosphorus in late June-early July, followed by algae blooms in late-July and August. When herbicide was applied again in 2008, curlyleaf pondweed was once more controlled (McComas, 2011).

Figure BS-4

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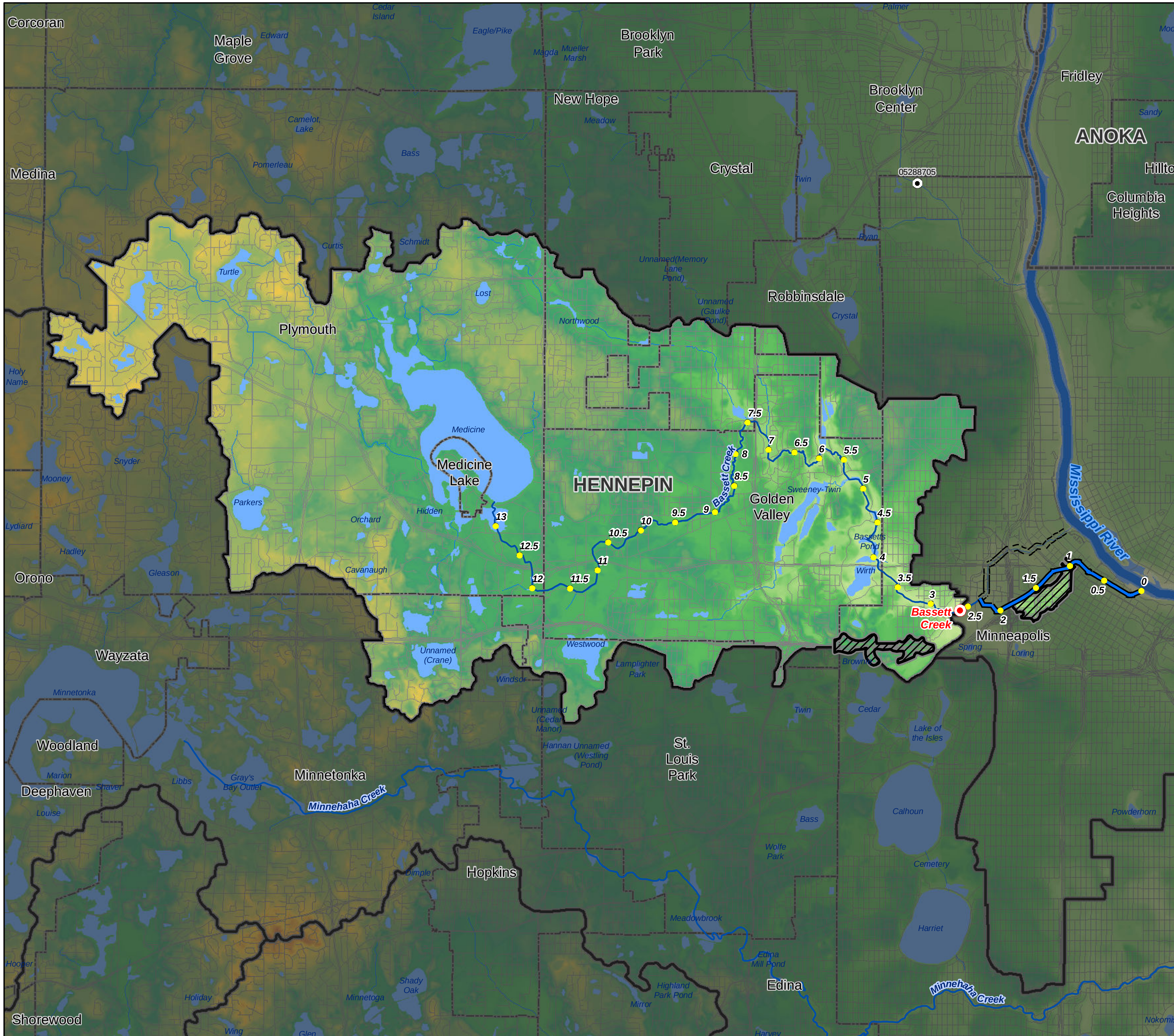
Watershed Topography
Bassett Creek



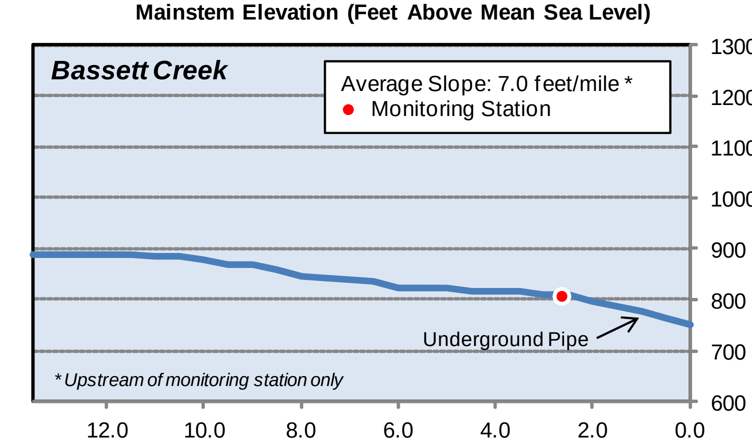
- MCES Stream Monitoring Sites
- USGS Flow Stations
- Stream Mile Markers
- New Bassett Creek Outflow Tunnel
- Old Bassett Creek Outflow Tunnel
- Mainstems (Monitored and Unmonitored)
- Monitored Watershed Boundaries
- Unmonitored Watershed Areas
- Public Waters Inventory
- Other Rivers and Streams
-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

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 1 2 3
Miles

Figure BS-5

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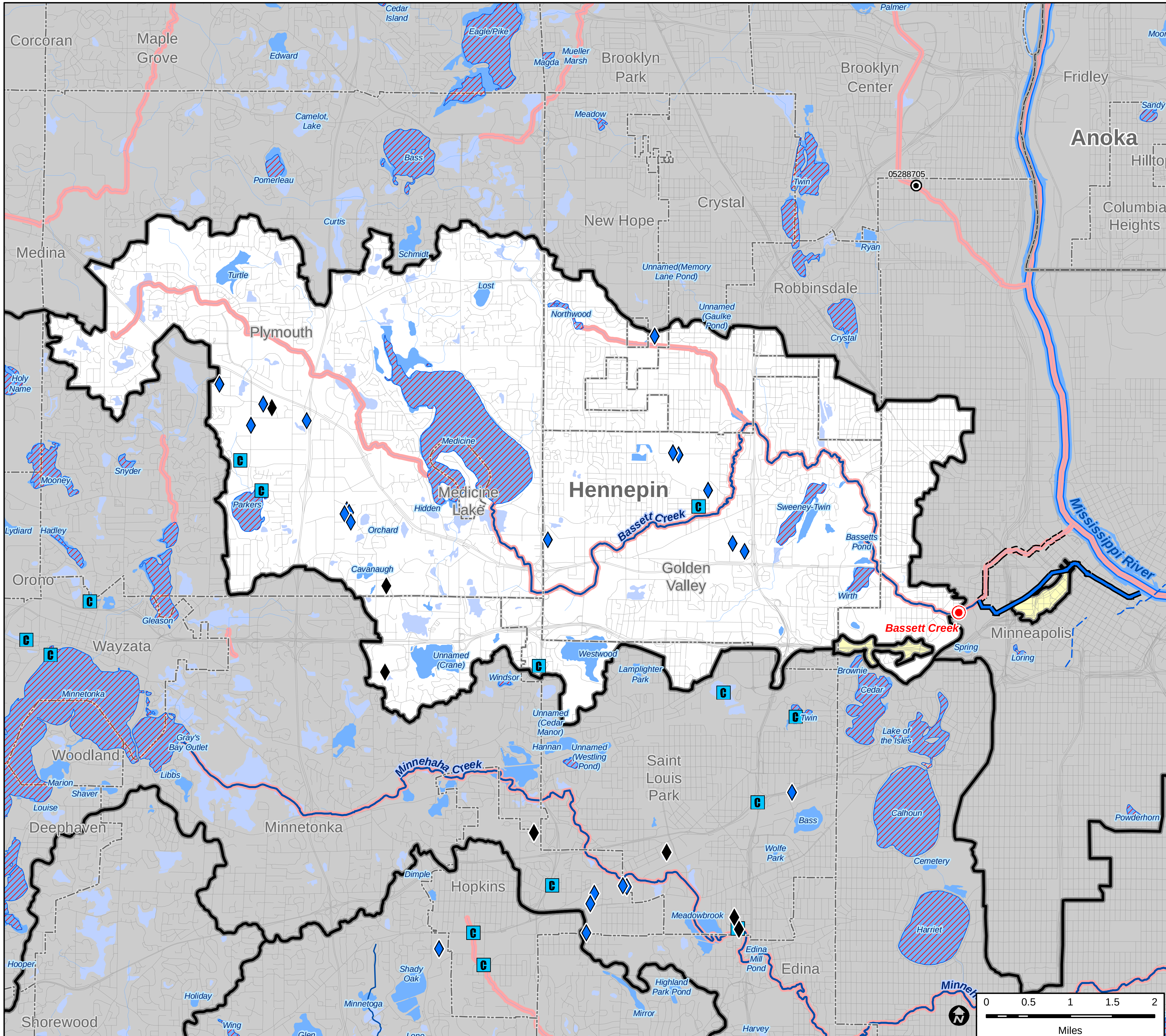
Public and Impaired Waters and Potential Pollution Sources

Bassett Creek



- MCES Stream Monitoring Sites
- USGS Flow Stations
- New Bassett Creek Outflow Tunnel
- Old Bassett Creek Outflow Tunnel
- 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

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

Extent of Main Map

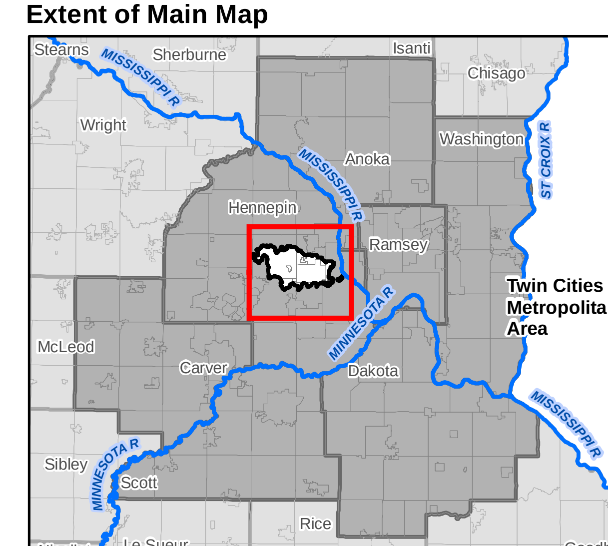


Figure BS-6: Bassett Creek Stream Restoration Just After Completion

Photo Credit: BCWMC

Figure BS-7: Bassett Creek Stream Restoration after Vegetation was Reestablished

Photo Credit: BCWMC

Water Quality Impairments

The Bassett Creek watershed contains three stream reaches and five lakes that are included on the MPCA 2014 Impaired Waters List (MPCA, 2014; Figure BS-5; Tables BS-2 and BS-3). Bassett Creek is impaired from Medicine Lake to the Mississippi River for aquatic life due to stressors affecting the fish community and excess chloride, and for aquatic recreation due to high fecal coliform counts. Two unnamed creeks are also impaired. An unnamed creek that discharges to Medicine Lake is impaired for aquatic life due to excess chloride and aquatic recreation due to high *E. coli* (*Escherichia coli*) counts. An unnamed creek that discharge to Bassett Creek is impaired for aquatic recreation due to high *E. coli* counts.

Medicine, Northwood, and Sweeney Lakes are impaired for aquatic recreation due to excess nutrients. TMDL (Total Maximum Daily Load) plans have been completed for Medicine and Sweeney; no plan has been completed for Northwood Lake. An aquatic recreation impairment for Wirth Lake based on excess nutrients was removed in 2014 because new data meets the standard. The delisting occurred after a new outlet structure was installed in Wirth Lake to prevent backflow from Bassett Creek which was primary source of phosphorus to the lake. Medicine, Parkers, and Wirth are also impaired for aquatic consumption based on mercury levels. Medicine and Wirth are covered under the statewide mercury TMDL plan, while Parkers Lake still needs a TMDL plan. Parkers and Sweeney Lakes are also impaired for aquatic life based on excess chloride levels.

Table BS-2: Impaired Reaches of Bassett Creek as Identified on the MPCA 2014 Impaired Waters List (MPCA, 2014)

Reach Name	Reach Description	Reach ID	Affected Use(s)[1]	Approved Plan	Needs Plan[2]
Bassett Creek	Medicine Lk to Mississippi R	07010206-538	AQL, AQR	–	Cl, FC, F-IBI
Unnamed Creek	Headwaters to Medicine Lk	07010206-526	AQL, AQR	–	Cl, E.coli
Unnamed Creek	Unnamed lk to Bassett Cr	07010206-552	AQR	–	E.coli

[1] AQR = Aquatic Recreation; AQL = Aquatic Life;

[2] FC = Fecal Coliform; Cl = Chloride; F-IBI = Fisheries Bioassessments;

Table BS-3: Impaired Lakes in the Bassett Creek Watershed as Identified on the MPCA 2014 Impaired Waters List (MPCA, 2014)

Lake Name	Lake ID	Affected Use(s)[1]	Approved Plan[2]	Needs Plan[2]
Medicine	27-0104-00	AQC, AQL, AQR	HgF, Nutrients	
Northwood	27-0627-00	AQR	--	Nutrients
Parkers	27-0107-00	AQC, AQL	--	Cl, HgF
Sweeney	27-0035-01	AQL, AQR	Nutrients	Cl
Wirth	27-0037-00	AQC, AQL, AQR	HgF, Nutrients (delisted in 2014)	

[1] AQC = Aquatic Consumption; AQL = Aquatic Life; AQR = Aquatic Recreation

[2] HgF = Mercury in Fish Tissue; Cl = Chloride

Hydrology

MCES has monitored flow on Bassett Creek at Irving Avenue since March of 2000. Flow measurements are collected at 15-minute intervals and converted to daily averages. The hydrograph of Bassett 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 from year to year (Figure BS-8), and the effect of precipitation events on flow.

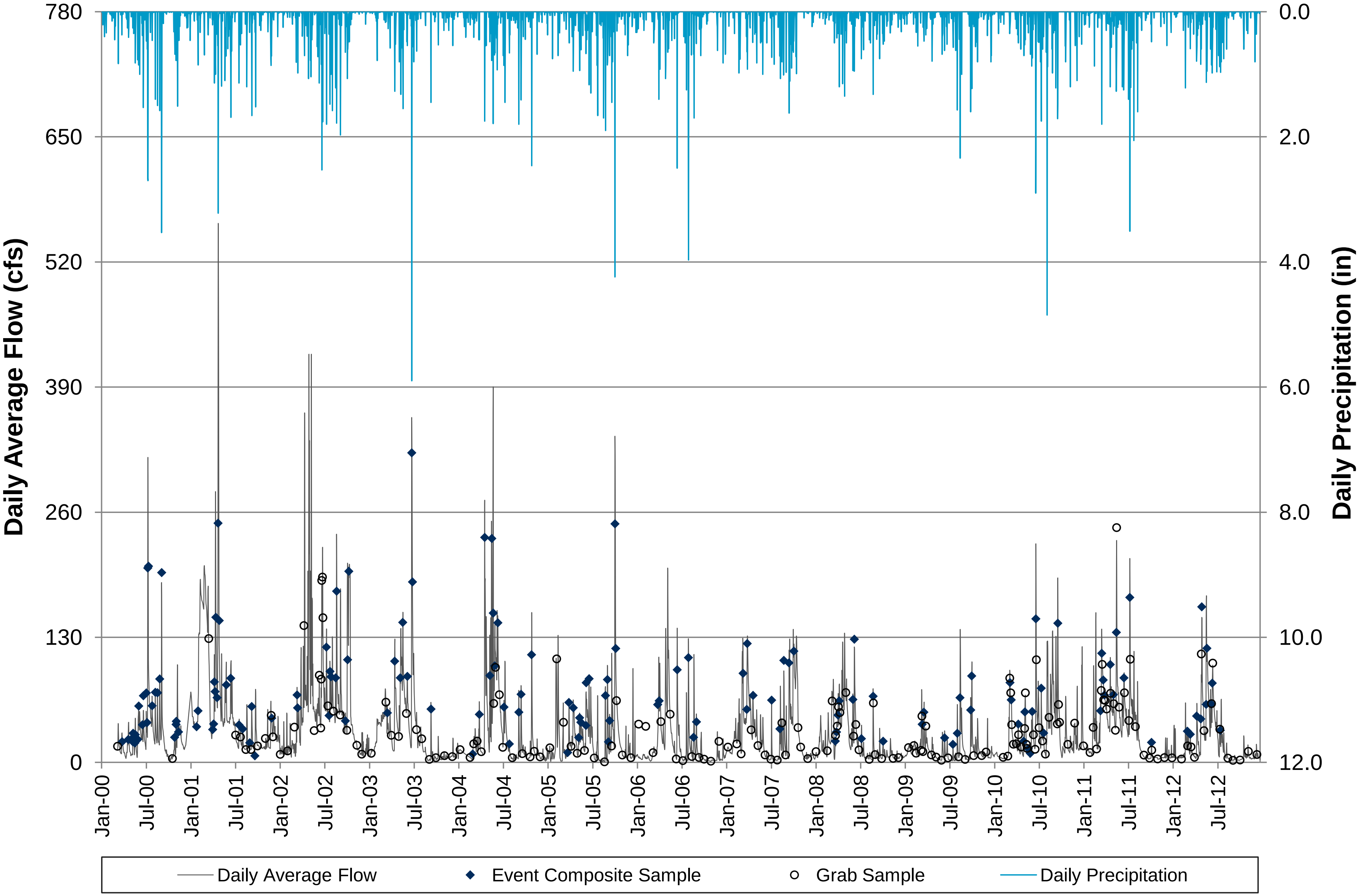
The MCES sampling program specifies collection of baseflow grab samples between events and event-based composites. The hydrograph indicates samples were collected during most events and that baseflow was also adequately sampled.

Both BCWMC and MnDNR monitor water levels on Medicine Lake. The Medicine Lake outlet is a composite overflow weir structure (BCWMC, 2004). Using the BCWMC water levels and rating curve for the Medicine Lake outlet structure (City of Plymouth, 1996), Medicine Lake discharge was estimated. The median annual percentage of Bassett Creek flow discharged from Medicine lake is 24%. There was little or no discharge from Medicine Lake during winter ice-on periods.

Analysis of the duration of daily average flows indicates that the upper 10th percentile flows for the period 2000-2012 ranged between approximately 70-550 cubic feet per second (cfs), while the lowest 10th percentile flows ranged from 0.5-4.0 cfs. (See Figure BS-15 in the ***Flow and Load Duration Curves*** section of this report).

Additional annual flow/volume metrics are shown on Figures BS-9 to BS-12, 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 BS-9 indicates the highest average annual flow (and thus the highest volume of flow) during 2001-2012 occurred during 2011(approximately 58 cfs average annual flow); the lowest in 2009 (approximately 14 cfs average annual flow).

Figure BS-8: Bassett Creek Daily Average Flow, Sample Flow, and Precipitation, 2000-2012*



*Precipitation record was acquired from NWS COOP stations: 214884-Lower St. Anthony Falls and 215838-New Hope

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 Bassett Creek to groundwater withdrawals, MCES staff examined spatial datasets of vulnerable stream segments and basins created as part of the 2010 regional groundwater analysis. The entire length of Bassett Creek is considered vulnerable, with the estimated creek surface elevation below or within 10 feet of the water table. Medicine Lake is also considered vulnerable, with the estimated water table above the lake bottom elevation. Medicine Lake also has a large littoral (shallow shoreland) area, which makes it especially susceptible to impacts from changes in lake level. A number of other waterbodies, primarily in the central and eastern parts of the watershed, are also considered vulnerable, including Sweeney, Twin, Wirth, Northwood, Parkers, and Westwood lakes; Bassett Creek Park Pond; and a number of unnamed ponds and wetlands.

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 full year of monitored data in Bassett Creek (2001-2012). Flow monitoring and sampling began in March 2000, but loads are calculated beginning in 2001, the first complete year of data collection.

Figures BS-9 through BS-12 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 three hydrological metrics (annual average flow rate, depth of flow (annual flow per unit area) coupled with precipitation depth, and runoff ratio). A later section in this report, ***Comparison with Other Metro Area Streams***, offers graphical comparison of the Bassett 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 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 (runoff ratio) was highest in 2001 and 2002, decreased somewhat in 2003, and then dropped into relative stability from 2004 on. Year-to-year variation was likely influenced by drought periods, by low soil moisture caused by dry periods, and by increased capacity in upland storage areas during drought periods. Because the creek originates at Medicine Lake, drought effects can be prolonged. A drop in Medicine Lake water level can take several years to be restored, causing low creek flows to persist even through wet years.

The annual mass loads for all parameters exhibited significant year-to-year variation (Figure BS-9), indicating the influence of precipitation and flow on the transport of pollutants within the watershed and the stream.

The annual FWM concentrations for all parameters also fluctuated from year-to-year and were likely influenced by annual precipitation and flow (Figure BS-10). TSS and TP concentrations peaked in 2007 and decreased in subsequent years. TDP, NO_3, and NH_3 remained relatively stable over the monitoring period. Cl concentrations increased slightly over time. The increase in Cl concentrations was likely due to application of road salt during winter, as well as export of salt that has built up in watershed lakes.

Figures BS-11 and BS-12 present the areal- and precipitation-weighted loads, respectively. These graphics are presented to assist local partners and watershed managers, and will generally not be discussed here.

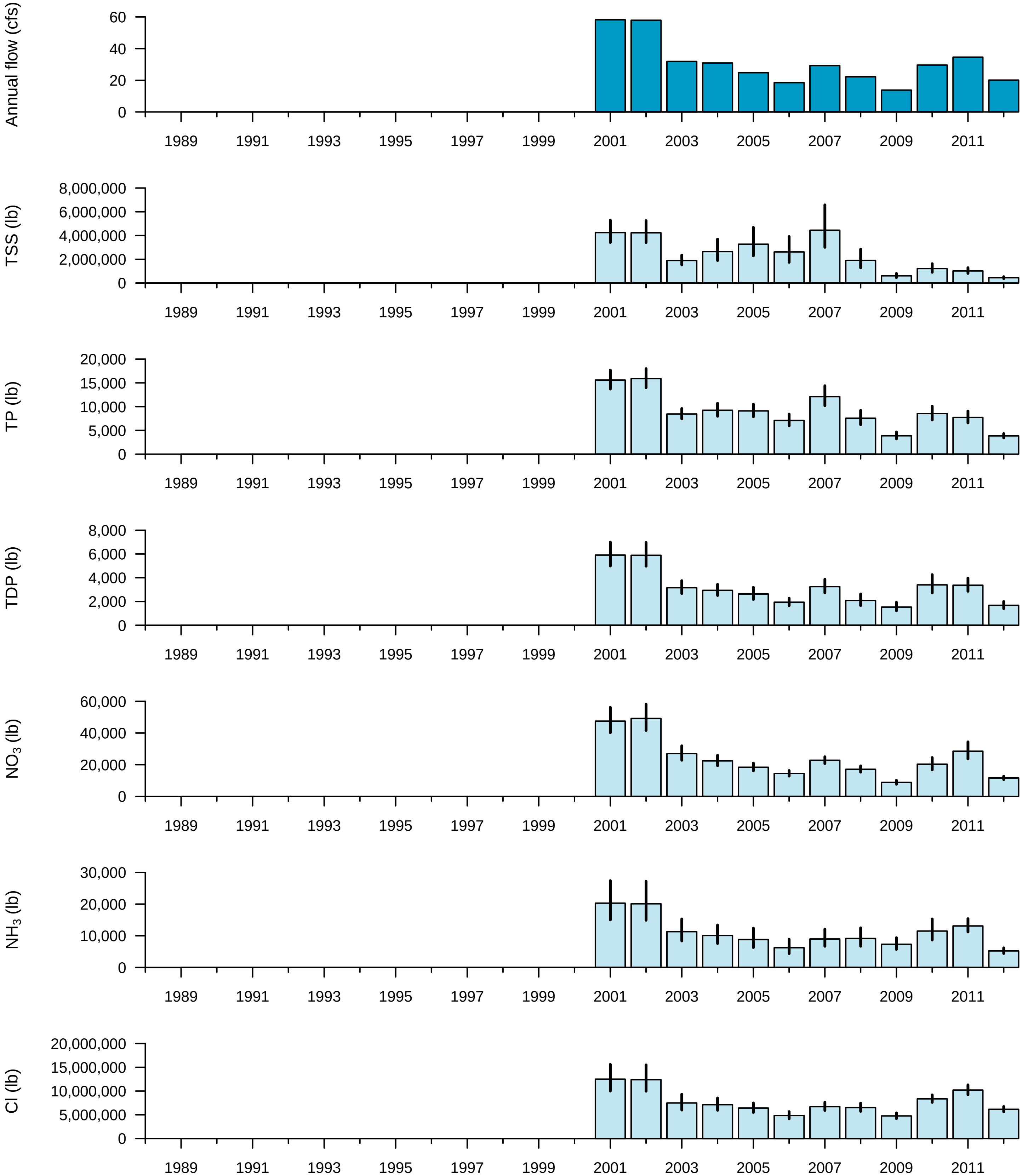
The Flux32 loads and FWM concentrations were also compiled by month to allow analysis of time-based patterns in the loads in Bassett Creek (Figures BS-13 and BS-14). The results for each month are expressed in two ways: the monthly results for the most recent year of data (2012 for Bassett Creek) and the monthly average for 2003-2012 (with a bar indicating the maximum and minimum value for that month).

For most constituents in Bassett Creek, the mass load was low in the months of January and February and then increased in March and April, likely due to effects of snow melt and spring rains. Mass load usually peaked in May before decreasing slightly through the summer months and then peaking again in September and October. This secondary load pulse is likely due to fall precipitation occurring after tree leaf fall and vegetation die-off. Loads fell off in November and December as lakes froze and snowpack began to build. The only pollutant load that did not really follow this pattern is NH_3, which peaked in March, ahead of the other pollutants.

The FWM concentration showed less month-to-month variability than the loads. TSS and TP concentrations were highest in spring and fall, corresponding to high flow periods. TDP and NO_3 concentrations were quite stable through the year. Cl concentrations were highest in November-February, likely reflecting the impact of road de-icers during winter months. There was not as great a difference in Cl concentrations between months as might be expected, however, which may indicate buildup of Cl in lakes during the winter months and then release from lakes throughout the year.

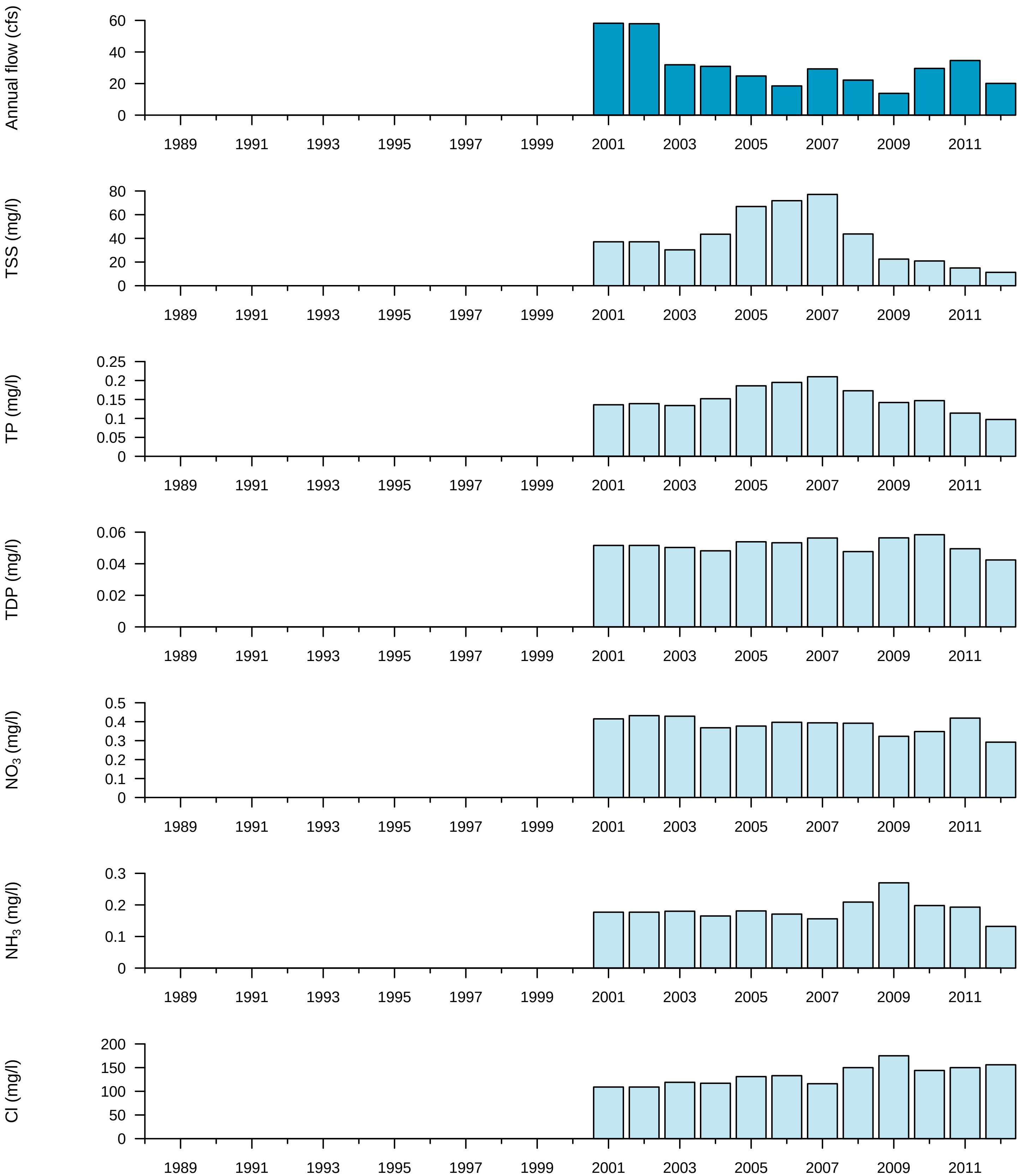
As with load, NH_3 concentration patterns were significantly different from those of the other pollutants. NH_3 concentrations were highest in January-March, and then dropped off steeply in April. The high NH_3 concentrations may have been caused by lower rates of nitrification due to low temperatures, and limited algal assimilation because of low temperature and light limitation caused by snow cover (Lee *et al.*, 2012). There may also have been increased nitrogen mineralization of decaying organisms in the reducing environment of stream bottom sediments when the creek was frozen or partially frozen.

Figure BS−9: Bassett Creek*
Annual Mass Load



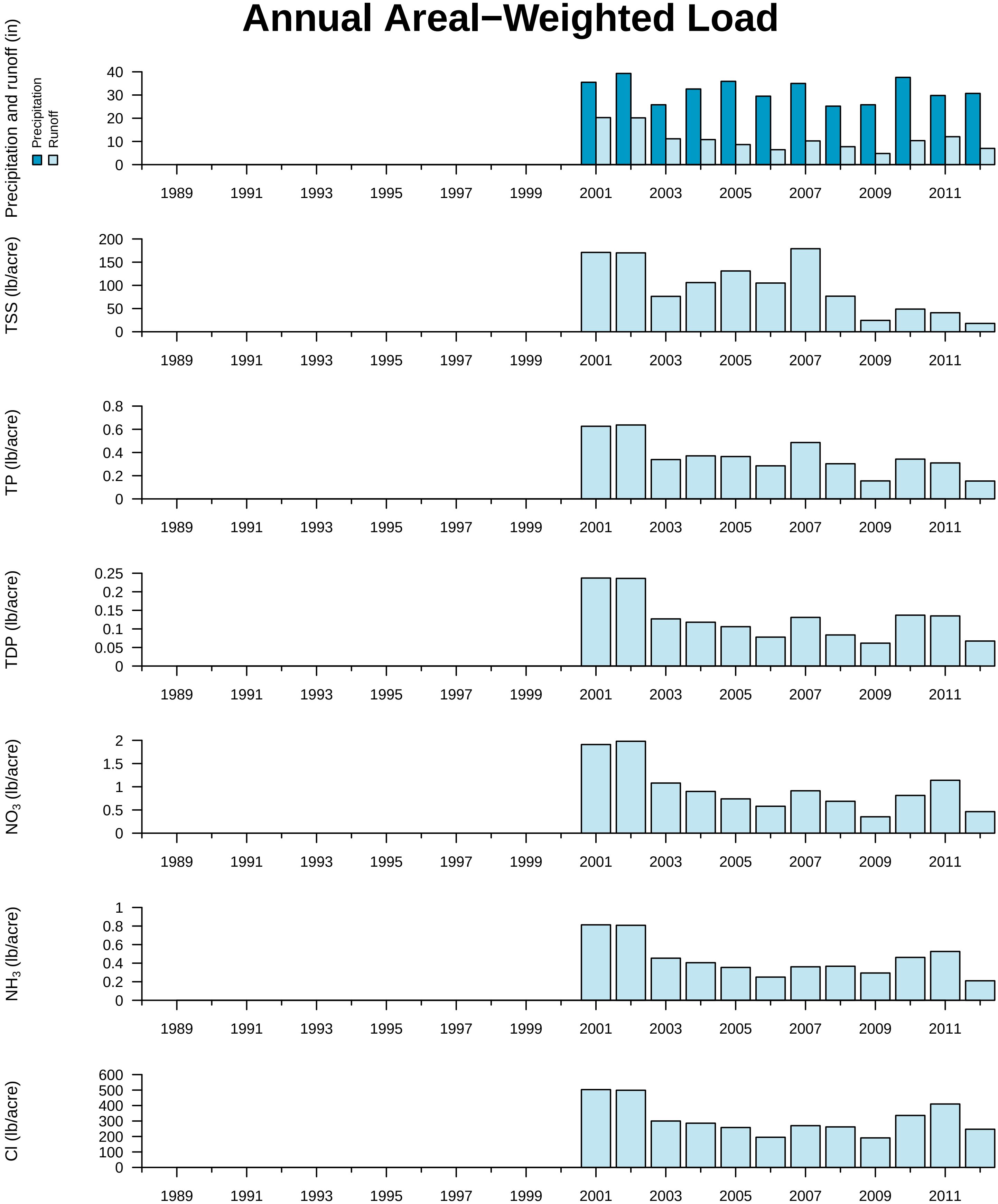
*First full year of sampling began in 2001.
Bars represent 95% confidence intervals as calculated in Flux32.

Figure BS−10: Bassett Creek*
Annual Flow−Weighted Mean Concentration



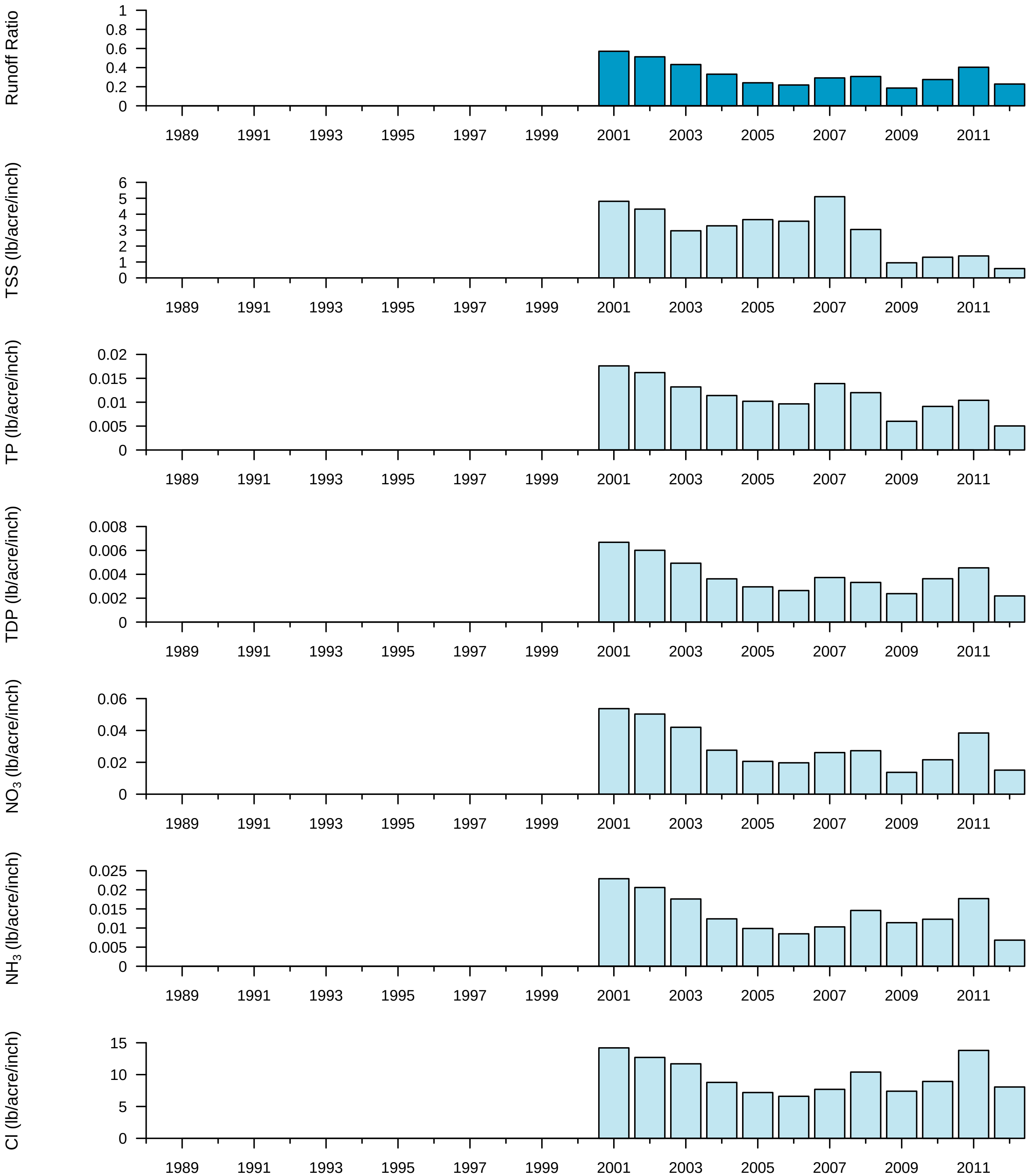
*First full year of sampling began in 2001.

Figure BS−11: Bassett Creek* Annual Areal−Weighted Load



*First full year of sampling began in 2001.

Figure BS−12: Bassett Creek*
Annual Precipitation−Weighted Areal Load



*First full year of sampling began in 2001.

Figure BS−13: Bassett Creek Mass Load by Month

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

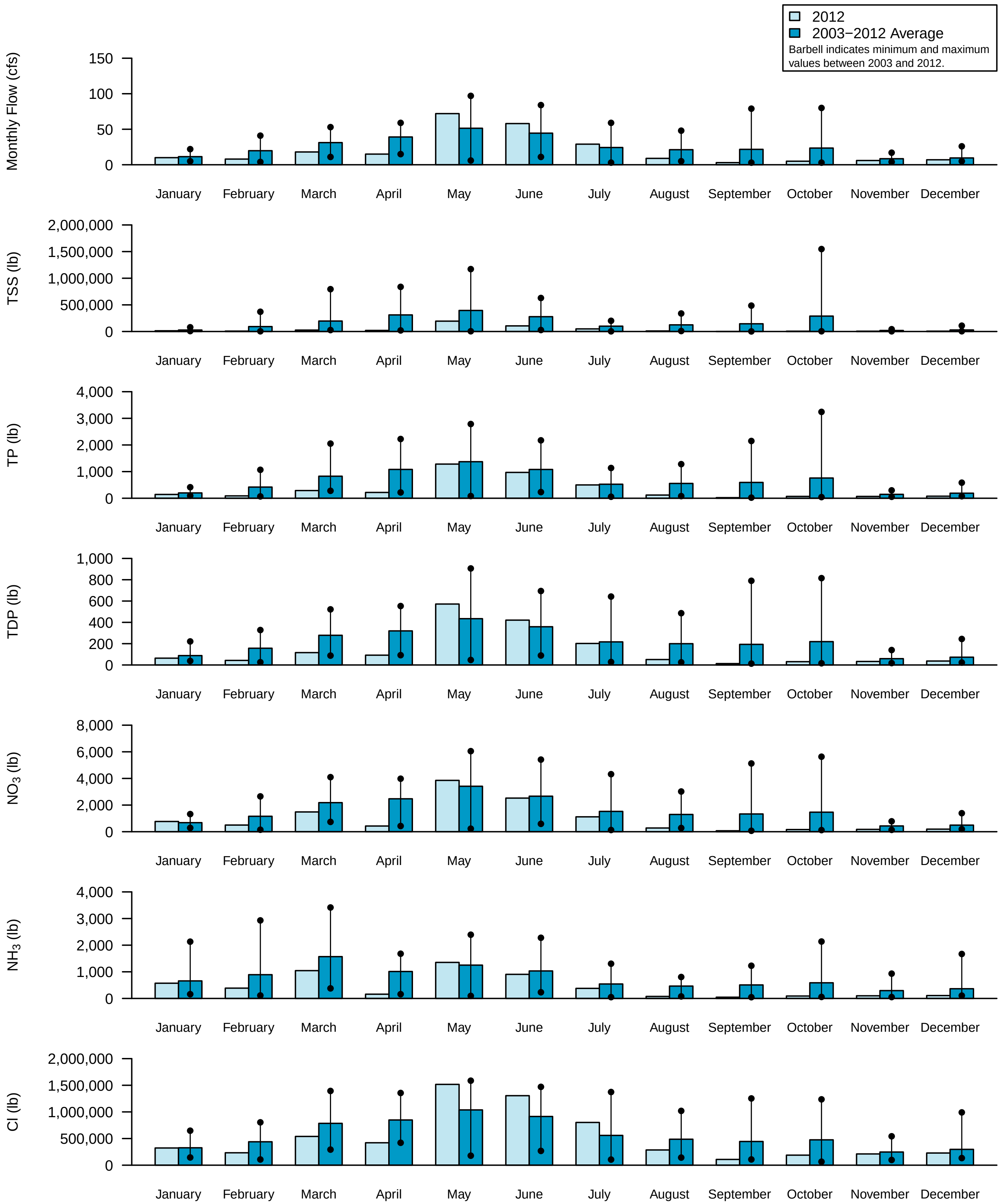
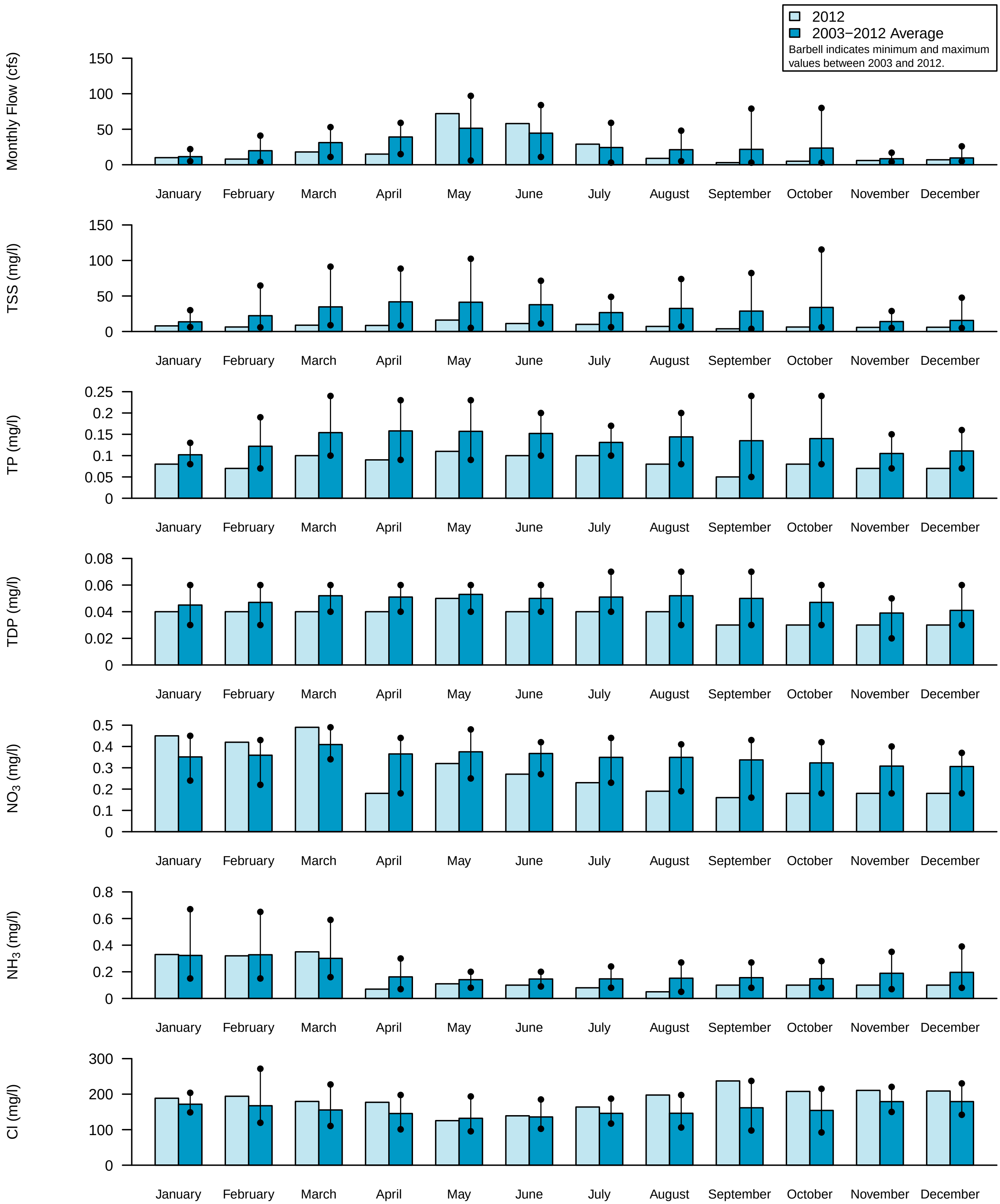


Figure BS−14: Bassett Creek
Flow−Weighted Mean Concentation by Month

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 location using recommendations of the U.S. Environmental Protection Agency (USEPA), including:

- Develop flow duration curves using average daily flow values for the 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 Bassett Creek monitoring station daily average flows and sample data, along with the most appropriate MPCA draft numerical standard as listed in Table BS-4. 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 standard, 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 2000–2012 flow duration curve and load duration curves for TSS, TP, NO_3, and Cl for the Bassett Creek monitoring station are shown in Figure BS-15. TSS concentrations have mostly remained below the draft standard at low flow and dry conditions; many samples exceed the draft standard during moist conditions and high flow. TP concentrations consistently exceeded the draft nutrient criteria concentration at all flows. The largest number of elevated concentrations was again in the mid-range to high flows. The exceedances in TSS and TP were probably caused by channel and streambank erosion generated by intense runoff events in the highly urbanized watershed.

All NO_3 concentrations at all flow regimes met the drinking water standard of 10 mg/l. The final river nutrient standard for NO_3 will likely be much less than that and NO_3 concentrations in the Bassett Creek watershed will need to be reevaluated at that time.

Cl concentrations in Bassett Creek exceeded the standard in a few samples at both high and low flows, indicating that Cl concentrations in the stream were more likely to be seasonally driven by winter and spring runoff containing dissolved road salt, rather than flow driven.

Table BS-4: Bassett 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)[2] of Monitoring Station	Chloride Draft Stnd[3] (mg/l)	TSS Draft Stnd[4] (mg/l)	TP Draft Stnd[5] (ug/l)	Nitrate DW Stnd[6] (mg/l)
Bassett Creek at Irving Ave. (BS1.9)	2B	Central	230	30	100	10

[1] Minn. Rules 7050.0470 and 7050.0430.

[2] MPCA, 2010.

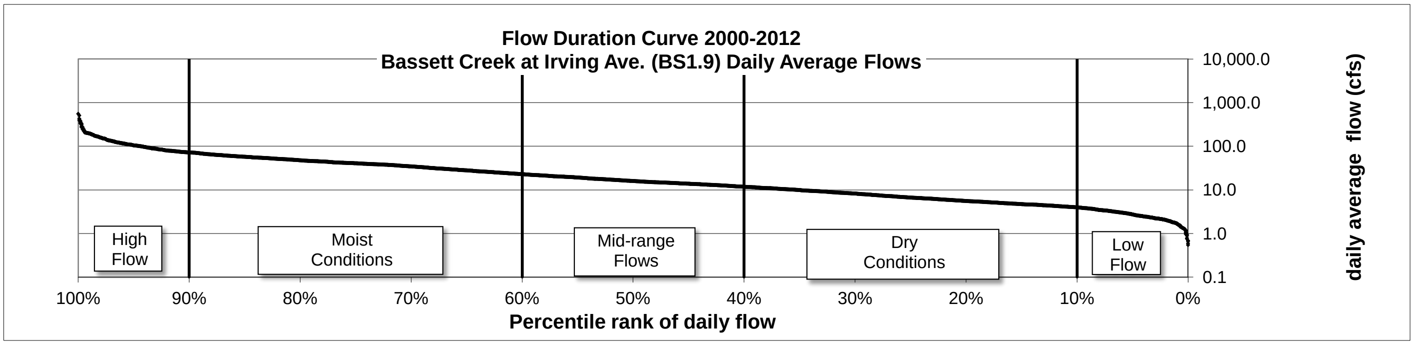
[3] Mark Tomasek, MPCA, personal communication, March 2013. MCES used 230 mg/l as the draft chloride standard pending results of EPA toxicity tests.

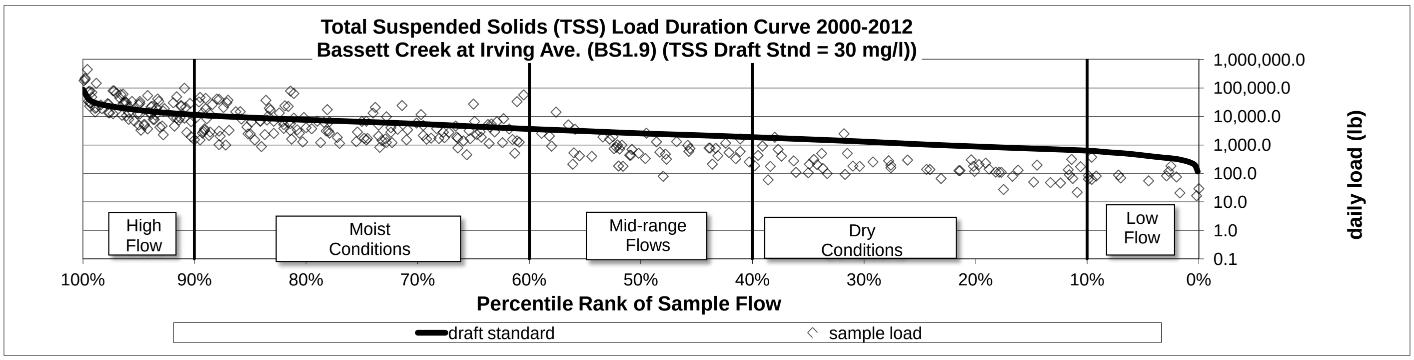
[4] MPCA, 2011. Draft standard states TSS standard concentration for Class 2A and 2B water must not be exceeded more than 10% of the time over a multiyear data window, with an assessment period of April through September.

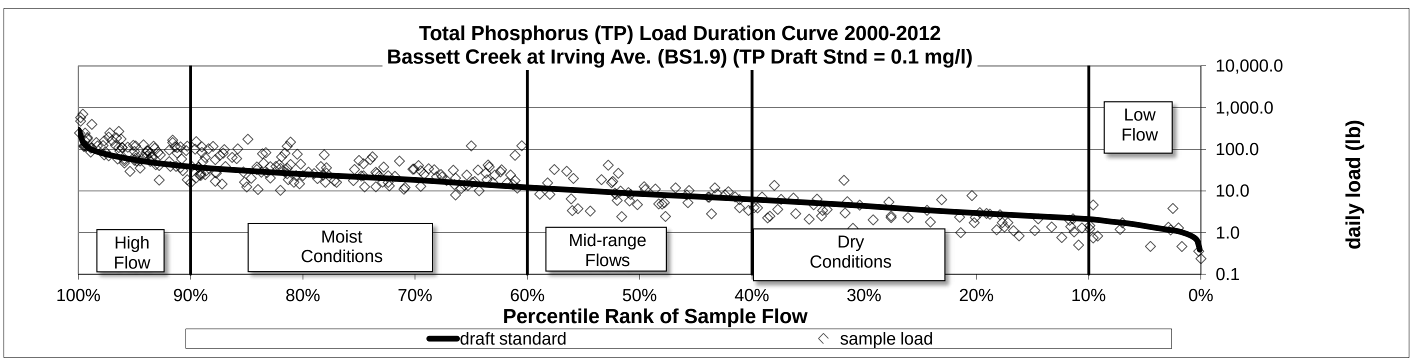
[5] MPCA, 2013a. To violate criteria, concentration of causative variable (TP) must be exceeded, as well as one or more response variables: sestonic chlorophyll, BOD_5, DO flux, and/or pH.

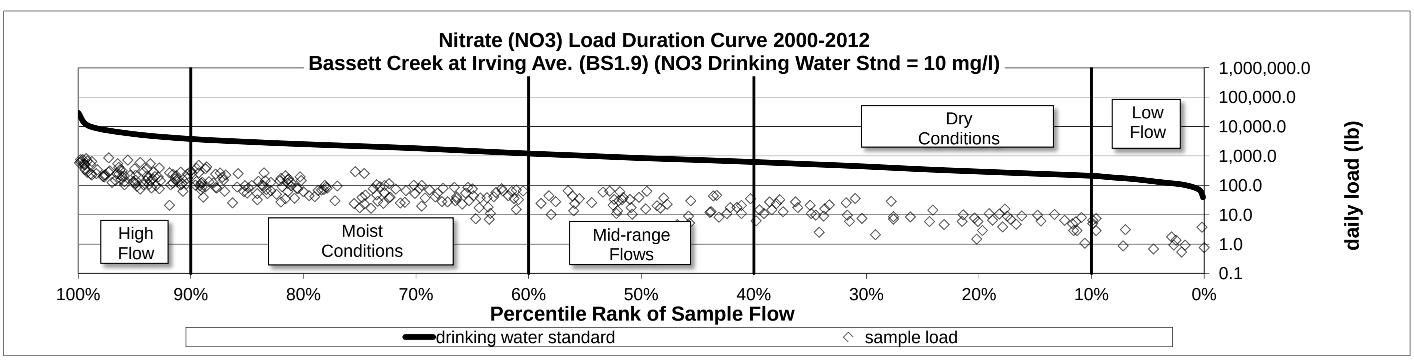
[6] MCES used the nitrate drinking water standard of 10 mg/l pending results of EPA toxicity tests and establishment of a draft nitrate standard for rivers and streams.

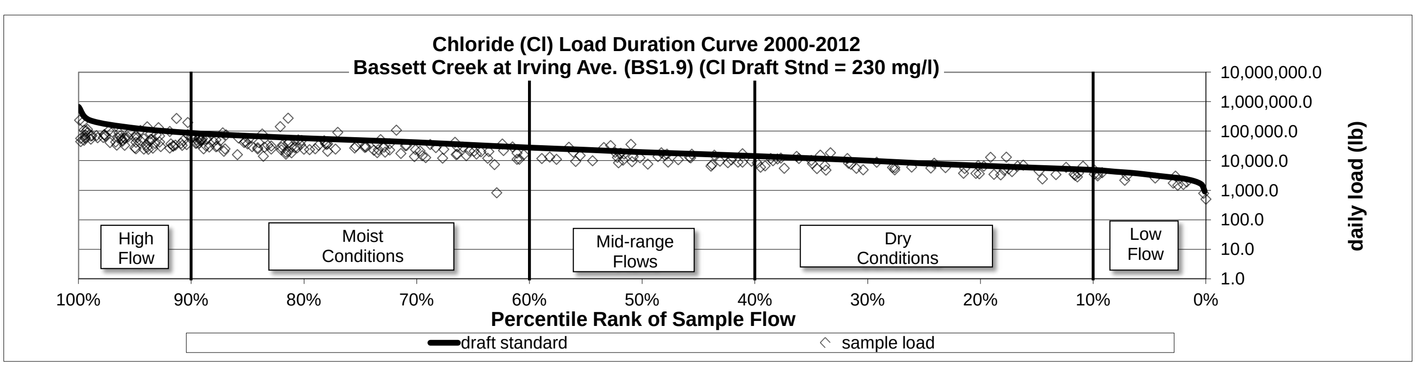
Figure BS-15: Bassett Creek Flow and Load Duration Curves, 2000-2012











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.

Bassett Creek has not been sampled for macroinvertebrates by MCES. BCWMC and its consultant have collected macroinvertebrate samples from various points on the creek. Future adjustments to the MCES sampling program should consider cooperating with BCWMC on macroinvertebrate sample collection and analysis.

Trend Analysis

Trend analysis was completed for the historical record of TP, NO_3, and TSS using the U.S. Geological Survey (USGS) program QWTREND (Vecchia, 2003). QWTREND removes the variability of annual flow and seasonality from the statistical analysis, so 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 alterations 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 (2007) 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 likely have also 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 depressional storage. MCES staff plan to repeat the following trend analyses in five to10 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 2000-2012 on Bassett Creek for TP and NO_3, and for the period of 2000-2013 for TSS, using daily average flow, baseflow grab sample, and event composite sample data. Trends were assessed for the period of 2000-2013 for TSS to more fully investigate an apparent short upward trend when trends were investigated only through 2012. It was not within the scope of this report to calculate all trends through 2013. The results are presented below. Readers should note that while QWTREND allows identification of changes of pollutant concentration with time, it does not identify causation. MCES staff have not attempted to identify changes in watershed management, climactic changes, or any other actions which may affected concentration in the stream. A recommendation of this report is for MCES staff to work with local partners to identify causative actions which will aid in interpretation when MCES repeats the trend analysis in five years.

Total Suspended Solids (TSS)

One downward trend was identified for TSS flow-adjusted concentrations in Bassett Creek during the assessment period from 2000 to 2013 (Figure BS-16; top graph). Based on the QWTREND model run without a five year flow precedent, the p value was 2.7×10^{-5}, indicating the trend identified was statistically significant. From 2000 to 2013, TSS flow-adjusted concentration decreased 72%, from 19.4 mg/l to 5.3 mg/l, at a rate of -1.0 mg/l/yr.

The five-year trend in TSS flow-adjusted concentration In Bassett Creek (2009-2013) was calculated to compare with other MCES-monitored streams, shown in report section ***Comparison with Other Metro Area Streams***. From 2009 to 2013, TSS flow-adjusted concentration decreased 30%, from 7.7 mg/l to 5.3 mg/l, at a rate of -0.46 mg/l/yr. Based on the QWTREND results, the water quality in Bassett Creek in terms of TSS improved during 2009-2013.

Total Phosphorus (TP)

Two downward trends were identified for TP flow-adjusted concentration in Bassett Creek from 2000 to 2012 (Figure BS-16, middle graph). Based on the QWTREND model run without a five year flow precedent, the p value was $p=4.0 \times 10^{-8}$, indicating the trends identified were statistically significant. From 2000 to 2002, TP flow-adjusted concentration decreased 41%, from 0.18 mg/l to 0.10 mg/l, at a rate of -0.02 mg/l/yr. From 2003 to 2012, TP flow-adjusted concentration decreased 31%, from 0.10 mg/l to 0.07 mg/l, at a rate of -0.003 mg/l/yr.

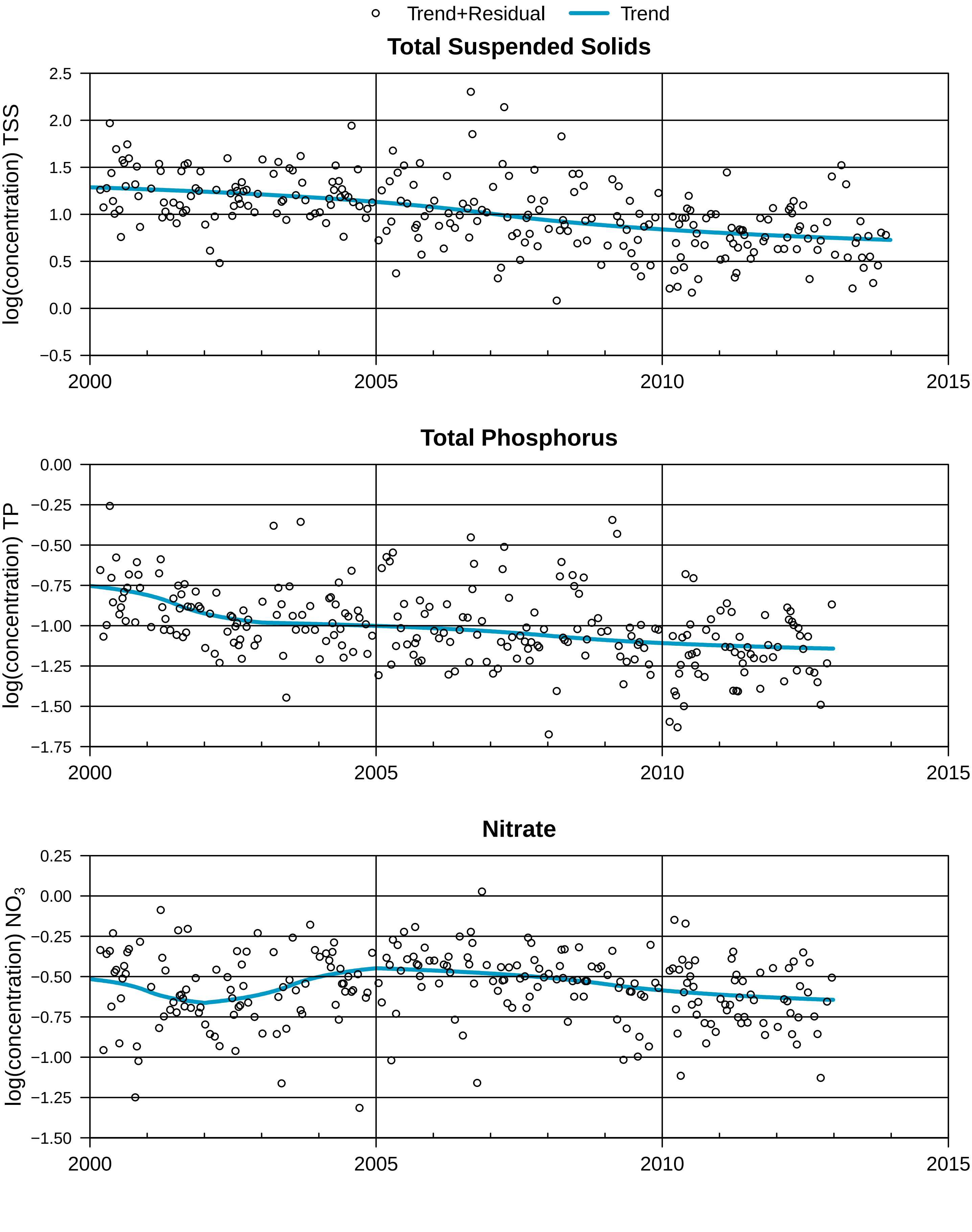
The five-year trend in TP flow-adjusted concentrations in Bassett Creek (2008-2012) was calculated to compare with other MCES-monitored streams, as shown in report section ***Comparison with Other Metro Area Streams***. TP flow-adjusted concentration decreased 17%, from 0.09 mg/l to 0.07 mg/l, at a rate of -0.003 mg/l/yr. Based on the QWTREND results, the water quality in Bassett Creek in terms of TP improved during 2008-2012.

Nitrate (NO_3)

Both upward and downward trends were identified for NO_3 flow-adjusted concentration in Bassett Creek from 2000 to 2012 (Figure BS-16; bottom graph);. Based on the QWTREND model run without a five year flow precedent, the p value was $p=8.3 \times 10^{-4}$, indicating the trends identified were statistically significant. From 2000 to 2001, NO_3 flow-adjusted concentration decreased 29%, from 0.31 mg/l to 0.22 mg/l, at a rate of -0.04 mg/l/yr. From 2002 to 2004, NO_3 flow-adjusted concentration increased 64%, from 0.22 mg/l to 0.36 mg/l, at a rate of 0.05 mg/l/yr. From 2005 to 2012, NO_3 flow-adjusted concentration decreased 36%, from 0.36 mg/l to 0.23 mg/l, at a rate of -0.02 mg/l/yr.

The five-year trend (2008-20012) for NO_3 in Bassett Creek was calculated to compare with other MCES-monitored streams, as shown in report section ***Comparison with Other Metro Area Streams***. From 2008 to 2012, NO_3 flow-adjusted concentration decreased 27%, from 0.31 mg/l to 0.23 mg/l, at a rate of -0.02 mg/l/yr. Based on the QWTREND results, the water quality in Bassett Creek in terms of NO_3 improved during 2008-2012.

Figure BS−16: Bassett Creek Trends for TSS, TP and NO_3



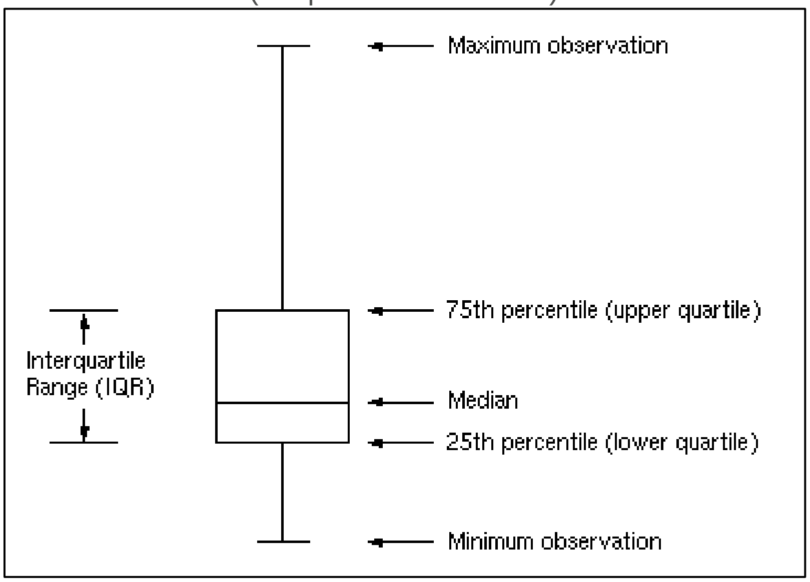
Comparison with Other Metro Area Streams

Chemistry

Box-and-whisker plots were used to summarize the comparison of the historical flow, TSS, TP, and NO_3, and Cl data for Bassett Creek with those of other metropolitan area streams monitored by MCES and with the major receiving water (in this case the Mississippi River above the confluence with the Minnesota River). The comparisons are shown in Figure BS-18 to Figure BS-23.

Figure BS-17 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 BS-17: General Schematic of a Box-and-Whisker Plot
(adapted from *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 each 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.

Flow. The median annual runoff ratio for Bassett Creek is on the higher end of metropolitan area urban streams: higher than Nine Mile, Willow, and Battle Creek, while slightly lower than Fish Creek. Because the Bassett Creek watershed is highly influenced by wetlands and lakes, one would expect a relatively lower runoff ratio. However, because Bassett Creek is estimated to be below the groundwater table (see section ***Vulnerability of Stream to Groundwater Withdrawals***), some shallow groundwater may enter Bassett Creek. That would explain the heightened runoff, although Bassett Creek has a significantly lower median runoff ratio than Eagle Creek or Valley Creek, which are highly influenced by shallow groundwater inflow.

Bassett Creek may also have a higher runoff ratio than many of the other urban streams because of the high concentration of highways in the watershed, which form large areas of directly connected impervious surface.

Total Suspended Solids. The FWM concentration in Bassett Creek is higher than that in the Mississippi River (as measured at Anoka, Minnesota; 37 mg/l vs. 18 mg/l, respectively), indicating that Bassett Creek contributes to an increased TSS concentration in the Mississippi River. The median annual FWM concentration for TSS in Bassett Creek is lower than the other highly urbanized watersheds (Fish, Battle, Nine Mile, and Willow creeks). (Figure BS-18), and all the urbanized watersheds have significantly lower TSS concentrations than the agricultural watersheds, especially those in the Minnesota River basin.

Total Phosphorus. As with TSS, the FWM TP concentration in Bassett Creek is slightly higher than that of the Mississippi River (0.15 mg/l vs. 0.12 mg/l, respectively), and thus increases the river's concentration (Figure BS-19). Like TSS, the Bassett Creek annual phosphorus yield is less than for the other highly urbanized watersheds. All of the highly urbanized streams have a significantly lower FWM TP concentration than the more agricultural watersheds monitored by MCES, especially those in the Minnesota River basin.

Nitrate. The NO_3 FWM concentration in Bassett Creek is significantly lower than in the Mississippi River (0.38 mg/l vs. 1.4 mg/l, respectively), and thus dilutes the river concentration (Figure BS-20). The areal load and annual yield of NO_3 in Bassett Creek are also low and similar to the streams with more urban watersheds, which are dwarfed by the streams with primarily agricultural watersheds, such as the Crow River, Vermillion River, and Cannon River.

Chloride. The Cl FWM concentration in Bassett Creek is significantly higher than that in the Mississippi River (139 mg/l vs. 16 mg/l, respectively), and so increases the Cl concentration in the river (Figure BS-21). Bassett Creek has the highest median concentration of Cl of any stream monitored by MCES, though very similar to Battle, Fish, Nine Mile, and Willow creeks, which are the other most urbanized watersheds.

The two most prevalent sources of Cl to streams are road surfaces (from winter Cl application as a de-icer) and WWTP effluent (from domestic water softeners). Bassett does not have any domestic WWTPs, but has a dense network of roads and highways that are de-iced in the winter. Bassett Creek watershed includes portions of I-394, I-694, Hwy. 100, Hwy. 169, and Hwy. 55, which may contribute to the high Cl concentration. The entities responsible for the major highways (Hennepin County and MnDOT) have the highest application rates of road de-icers (Shingle Creek Watershed Management Commission, 2006).

Macroinvertebrates

The historic biomonitoring data, summarized as the M-IBI metric scores, were also exhibited as box-and-whisker plots. However, no biomonitoring by MCES has occurred at Bassett Creek so no plots will not presented in this section.

Figure BS−18: Total Suspended Solids for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

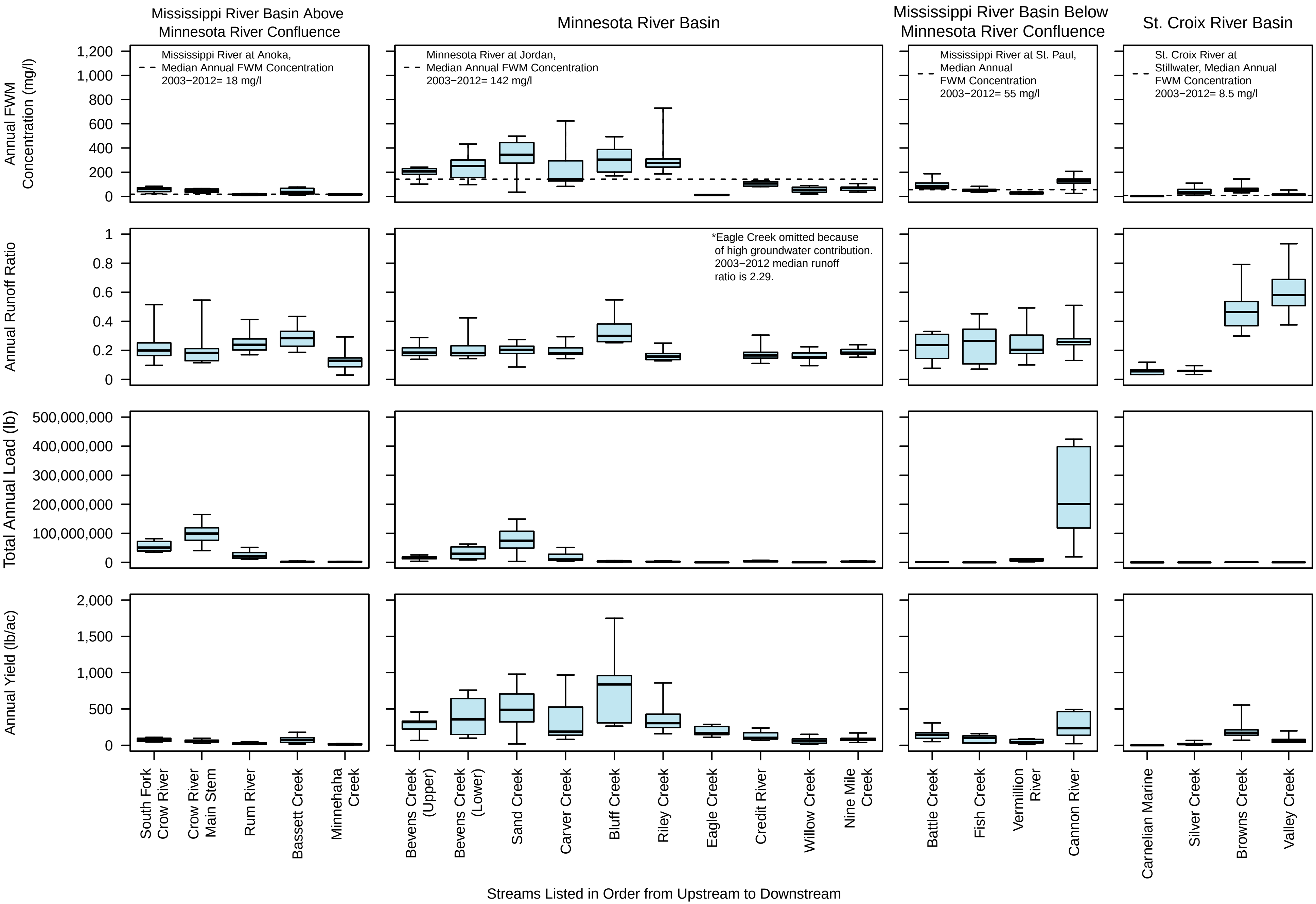


Figure BS−19: Total Phosphorus for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

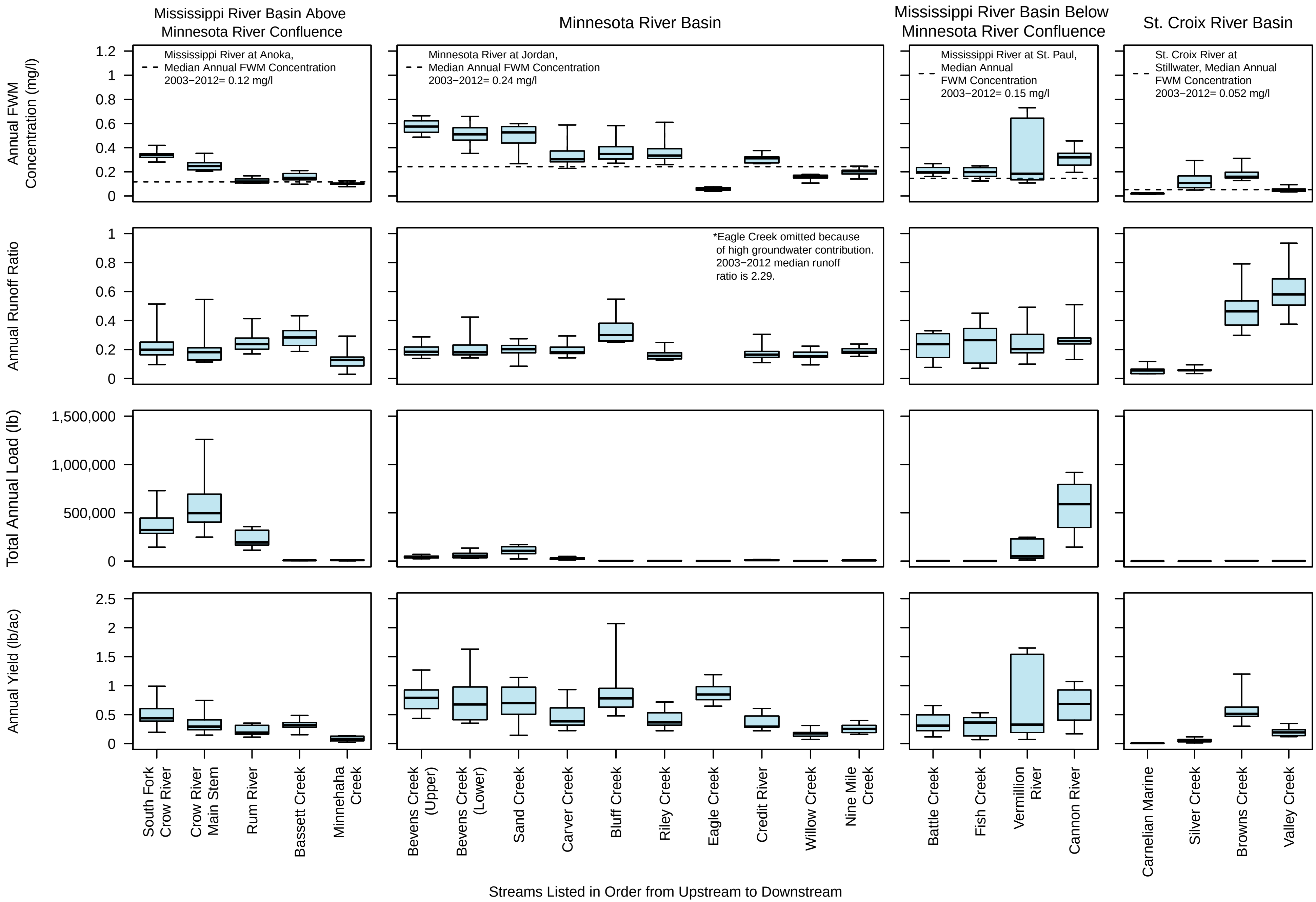


Figure BS−20: Nitrate for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

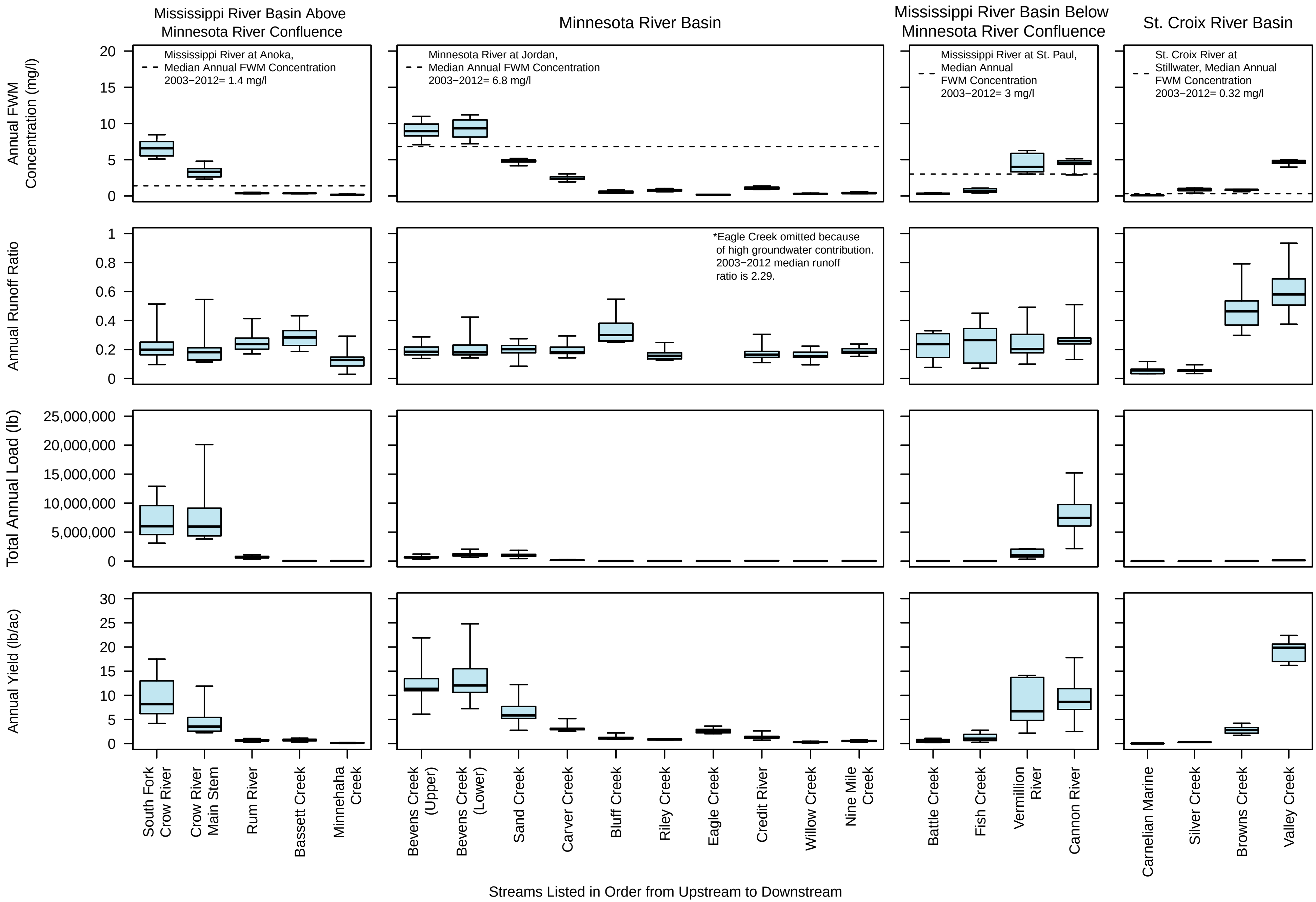


Figure BS−21: Chloride for MCES−Monitored Streams, 2003−2012

Organized by Major River Basin

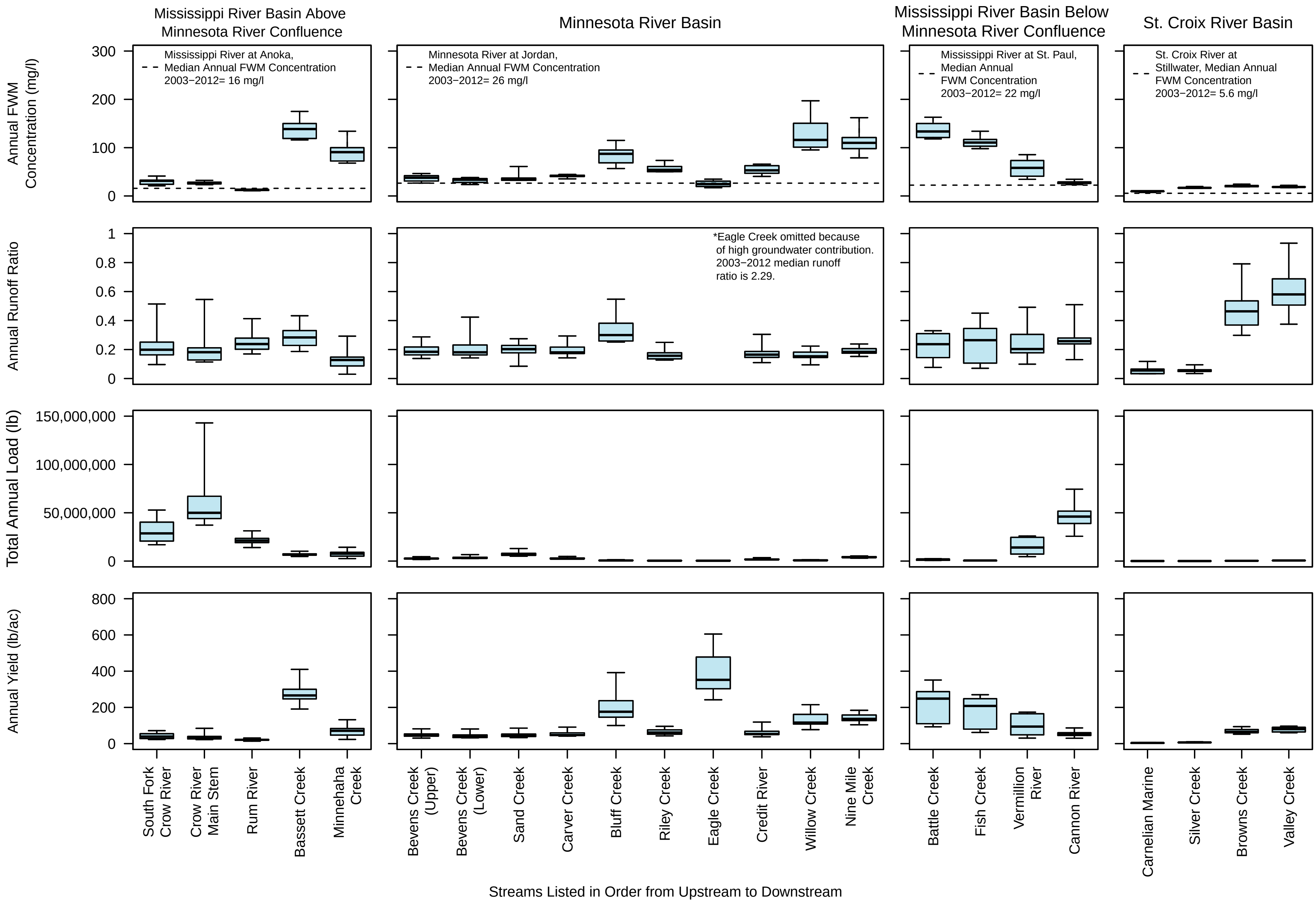


Table BS-5: Annual Median Concentrations, Loads, and Yields for MCES-Monitored Streams, 2003-2012

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

Metropolitan Area Trend 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.

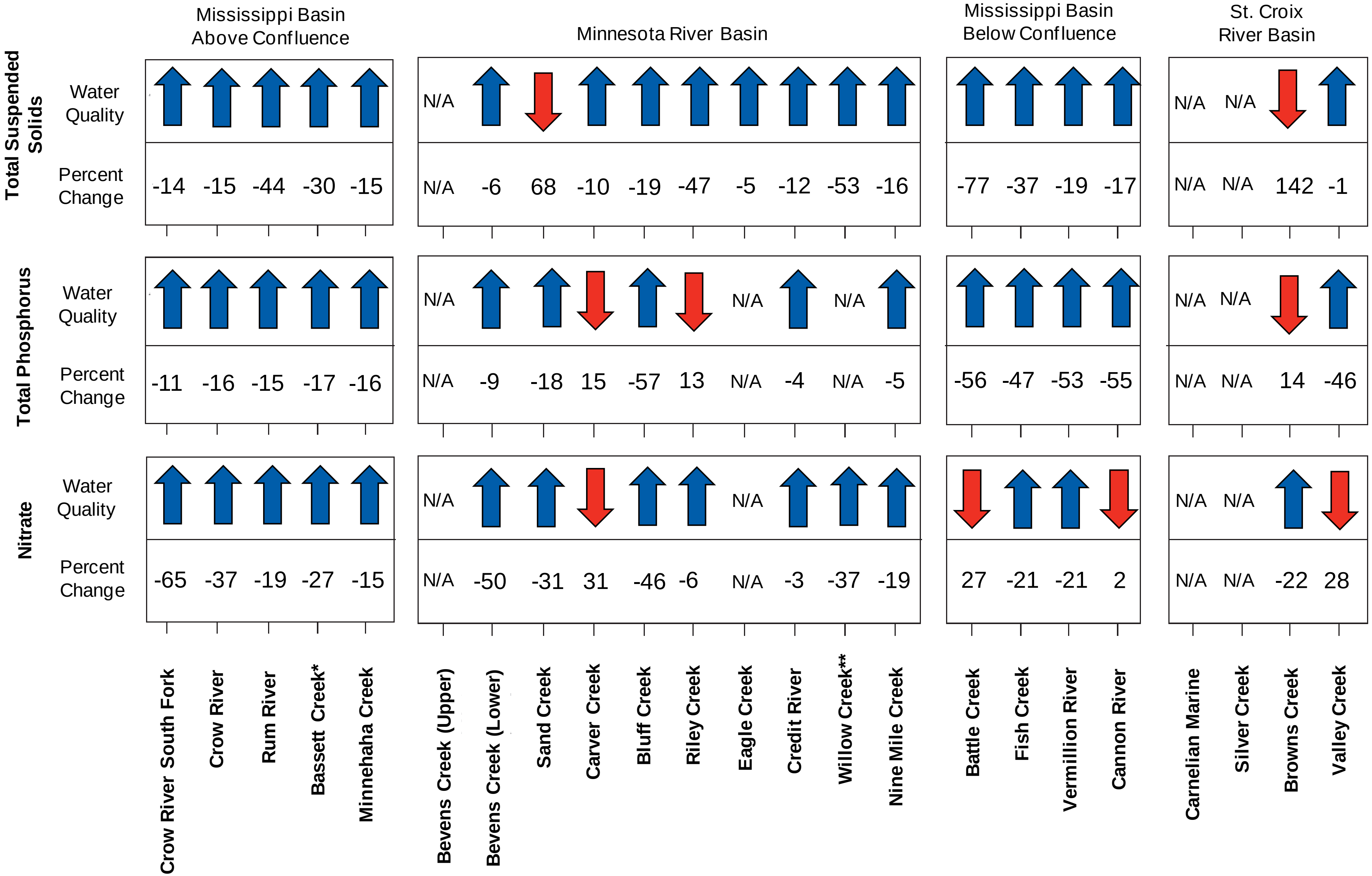
Estimated changes for TSS, TP, and NO_3 in MCES-monitored streams are presented below in two ways. First, tabulated results with directional arrows indicating improving (blue upward arrow) and declining (red downward arrow) water quality, paired with percent change in flow-adjusted concentration estimated for 2008-2012 (Figure BS-22). 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 BS-23).

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 Mississippi River and its tributaries above the confluence with the Minnesota River typically had lower pollutant concentrations than the Minnesota River and associated tributaries, but higher pollutant concentrations than the waters in the St. Croix River Basin. The trend analysis results indicate improving water quality for the Mississippi River tributaries above the confluence with the Minnesota River for TSS, TP and NO_3 from 2008-2012.

Figure BS-22: Regional Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and NO_3, 2008-2012

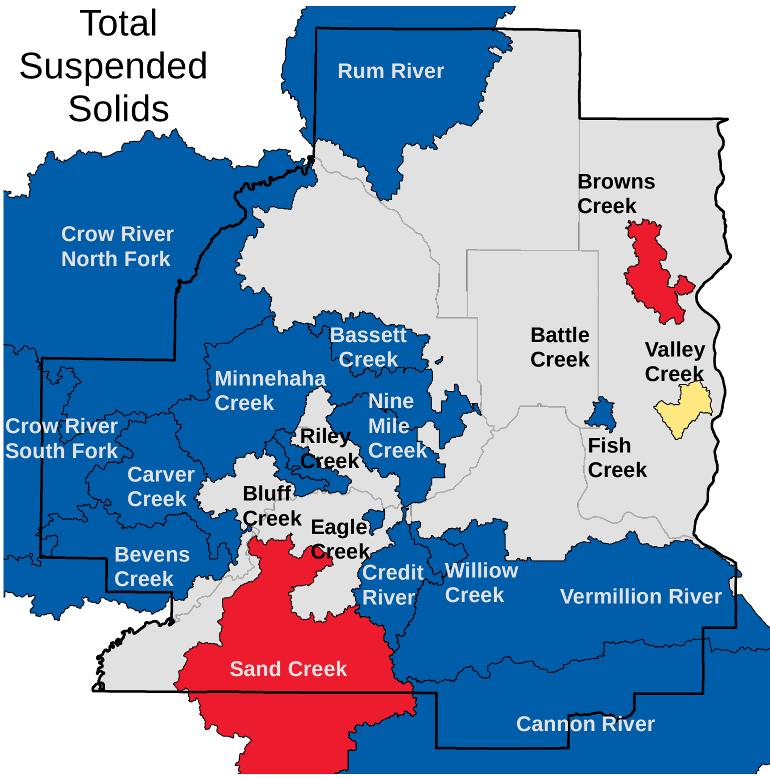
(Grouped by Major River Basin; As estimated by QWTrend)

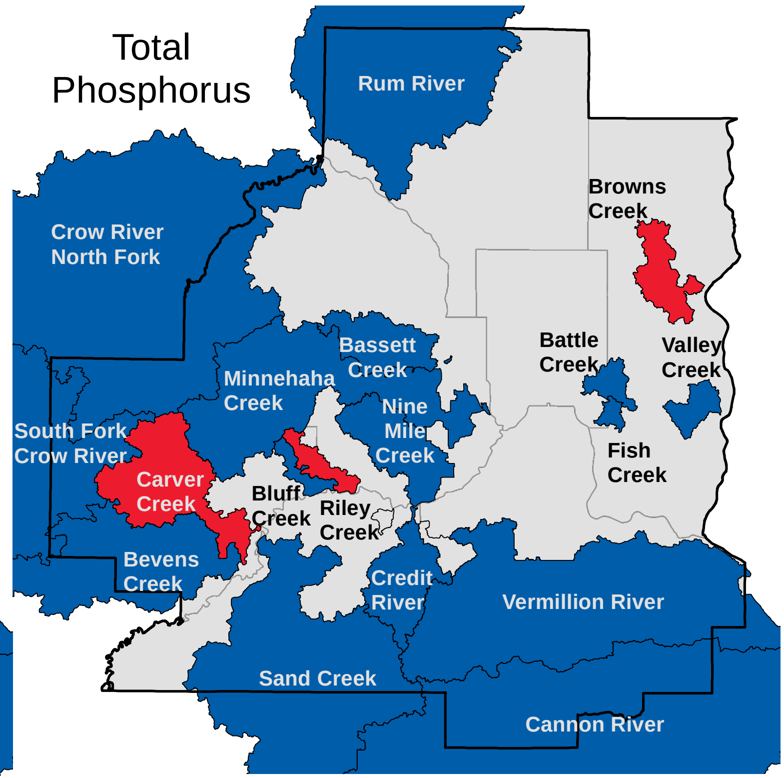


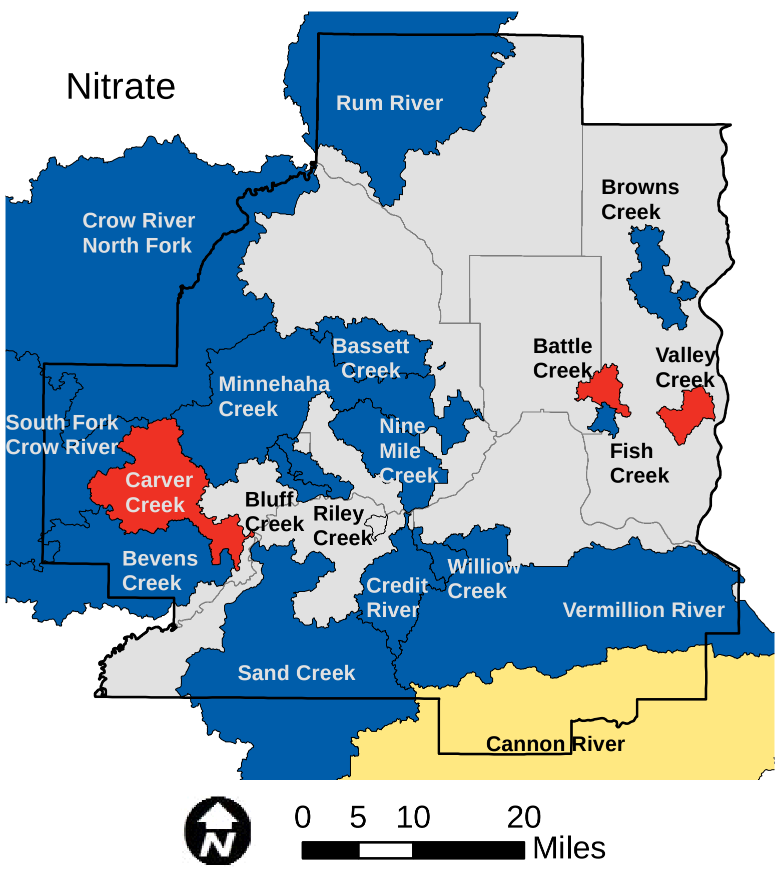
Blue arrows indicate improved water quality; Red arrows indicate declining water quality.
"N/A" indicates analysis was not performed as data were not appropriate for analysis by QWTrend.
* Bassett Creek TSS Trends were assessed over 2009-2013. **Monitoring at Willow Creek was suspended in 2009.

Figure BS-23: Regional Maps of Estimated Trends in Flow-Adjusted Stream Concentrations of TSS, TP, and NO3, 2008-2012

(As estimated by QWTrend)







Less than -3% Change (Indicates Increasing Water Quality)

-3% to 3% Change

Greater than 3% Change (Indicates Decreasing Water Quality)

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Conclusions

Bassett Creek is a tributary to the Mississippi River and drains portions of the cities of Plymouth, Minnetonka, St. Louis Park, New Hope, Crystal, Robbinsdale, and Minneapolis, the majority of Golden Valley, and all of Medicine Lake. The entire watershed is within Hennepin County. The watershed is almost completely urbanized, with the most heavily urbanized portions of the watershed in the west near the intersection of Hwy. 55 and I-694 and along the I-394 corridor on the south side of the watershed.

There are no major pollutant point sources in the watershed. Slopes in the watershed are generally gradual, with a steeper ridge just west of Medicine Lake, and also some steeper areas in the east. The stormwater drainage system is dominated by lakes, with only about 25% of the watershed draining directly to Bassett Creek, and almost half of the watershed draining to Medicine Lake prior to discharge to the creek.

The monitoring station is located 1.9 miles upstream from the Mississippi River. Immediately downstream of the monitoring station Bassett Creek enters a tunnel under downtown Minneapolis, and there is very little additional area that drains to the creek downstream of the monitoring station. The monitoring data presented in this report does not reflect the potential improvement or decline in water quality that may occur downstream of the monitoring station.

The water quality in Bassett Creek is clearly affected by urban runoff, including reasonably high TSS loads possibly due to high flows and erosion from stream banks, reasonably high TP loads, and very high Cl loads. Bassett Creek is affected by several factors: highly urbanized areas with increased runoff and high de-icing application, erosion along streambanks, and impaired lakes. TSS and TP in the stream are both slightly higher in concentration than the Mississippi River, but are comparable and slightly below other highly urbanized streams monitored by MCES.

NO_3 concentrations and loads in the Bassett Creek watershed remain very low and significantly below the Mississippi River median concentration above the confluence with the Minnesota River. The Cl loads and concentrations in Bassett Creek were higher than any other watershed monitored by MCES, reflecting the high level of development and road density (especially highways) in the watershed.

Trend analysis indicates a downward trend in TSS flow-adjusted concentration since 2000 and thus improving water quality. Trend analysis shows decreasing TP flow-adjusted concentration trends since 2000, indicating improving water quality. Trend analysis indicated both upward and downward trends in NO_3 flow-adjusted concentration since 2000, and the most recent trend is of decreasing NO_3 flow-adjusted concentration and thus improving water quality. All trends will be investigated again in 5 years. At that time, sufficient data will have been collected for Cl trends to also be investigated.

No biological monitoring has occurred at Bassett Creek by MCES.

Recommendations

This section presents recommendations for monitoring and assessment of Bassett Creek, as well as recommendations for partnerships to implement stream improvements. MCES recognizes that cities, counties, and local water management organizations, like BCWMC, 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 10 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, BCWMC, and Mississippi Water Management Organization (MWMO) should consider partnering to monitor and assess the water entering Bassett Creek downstream of the monitoring station (in the Bassett Creek tunnel). This would allow a more accurate estimate of the Bassett Creek load actually reaching the Mississippi River. In the meantime, MCES should add a footnote to the annual load database informing users that runoff volume and pollutant load entering the Bassett Creek tunnel downstream of the monitoring station are not included in the MCES load estimates.
- Currently the WOMP station is the only continuous stream monitoring station in the watershed. To gain a better understanding of the relative contributions of subwatersheds and lakes in the basin, MCES recommends additional flow monitoring stations. MCES also recommends that BCWMC use its continuous lake level data on Medicine Lake to better understand the contribution of Medicine Lake outflow to Bassett Creek during low and high flow periods.
- As resources allow, MCES should provide BCWMC and other local water managers with information about the heightened potential for surface waters to be impacted by groundwater changes in the Bassett Creek watershed. This information should be included in watershed and local surface water management plan updates.
- Due to a high groundwater table along the length of Bassett Creek, MCES recommends investigating quantitatively the groundwater component flowing to Bassett Creek, both to understand additional pollutant sources and baseflow conditions, and to understand the potential implications of groundwater fluctuation (due to withdrawal or climate change) on the creek.
- MCES and partners should host educational outreach meetings to provide citizens with information about surface water - groundwater interactions and how groundwater withdrawals may affect lake levels in the watershed. These meetings could easily be tied to the importance of water conservation in reducing water withdrawals from the region's aquifers.
- MCES and partners should add annual macroinvertebrate sampling to the Bassett Creek station. MCES and partners should also consider adding a Stream Habitat Assessment similar to the habitat surveys performed by the MPCA.

In the past, BCWMC has sponsored macroinvertebrate data collection in stream segments upstream of the monitoring. Any macroinvertebrate data collected and assessed by MCES should be interpreted using the data previously collected by BCWMC. This interpretation should occur at the genus level.

- MCES staff routinely attend BCWMC TAC (Technical Advisory Committee) meetings. This partnership should continue. MCES staff should also participate in future assessments and plan preparations of Bassett Creek (especially metropolitan area WRAPS (Watershed Restoration and Protection Strategies)) led by the MPCA.
- MCES and partners (especially BCWMC) 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.
- The BCWMC has spent the past 10 years actively using their Capital Improvement Plan to construct water quality basins and innovative stormwater practices upstream of lakes and perform streambank restoration projects along Bassett Creek and its tributaries. MCES supports the work of BCWMC in this ongoing work and should offer technical assistance, as resources allow, to help BCWMC achieve its goals.
- The Bassett Creek watershed is heavily urbanized, thus many of the native soils have been disturbed. Published soil surveys may not be representative of actual conditions at specific locations. For installation of infiltration-based stormwater practices (like bioinfiltration basins, raingardens, and pervious pavers), soil borings should be taken from the exact location of the proposed location to assess level of soil filling or disturbance. Based on the boring results, best management practices designs should be customized and appropriate soil amendments added.

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