

## **Chapter 3: Comparisons Between Streams and Major River Basins**

Chapter 3 represents a significant addition to the MCES 2002 Stream Monitoring Report. A comparison of 2001 and 2002 water yield and select water chemistry data for all 28 monitoring stations affords an opportunity to begin assessing the non-point source impacts of various land use practices within the stream watersheds, as well as the influence of year-to-year climatological variability. Relative non-point source pollutant contributions of these streams to the three major Metropolitan Area rivers (Mississippi, Minnesota, and St. Croix) can also be examined. In addition, with several years of stream monitoring data available, compliance with water quality criteria and standards can be determined for select water quality variables (metals, chloride, and bacteria).

### **Non-Point Source Pollutant Impacts by Stream and Major River Basin**

#### **Water Yield**

Water yield is the amount of water flowing through a stream during a given time period divided by the watershed area, expressed as inches of water. Water yield is calculated on an annual basis for all 28 streams within the MCES monitoring network. The 2002 water yield for each stream can be found on the individual hydrographs presented in Chapter 2. Figure 5 presents a comparison of 2001 and 2002 annual water yields by stream and major river basin. The following is a summary of observations pertaining to Figure 5:

- With the exception of the Cannon River and the Middle Minnesota River Basin streams, water yields are generally higher in 2002 than in 2001. The higher water yields from TCMA streams in 2002 are likely a reflection of more precipitation. Conversely, the lower water yields from Middle Minnesota River Basin streams in 2002 are a reflection of drier conditions and less precipitation.
- In 2002, much of the water yield occurred later in the year, in conjunction with heavy summer and fall rain events. The spring of 2002 was characterized by very little snowmelt and runoff. In contrast, the majority of the 2001 water yield occurred early in the year (April- June), and especially in conjunction with above-normal flow conditions and spring flooding.
- A general correlation can be made between a change in water yield and the changes in pollutant loads (total suspended solids (TSS), total phosphorus (TP), dissolved phosphorus (DP), and nitrate nitrogen (NO<sub>3</sub>)) from a particular stream. If water yield increased from 2001 to 2002, then pollutant loads also tended to increase, but not necessarily in a directly proportional manner. If 2001 and 2002 water yields were similar, then pollutant loads were about the same. If water yield decreased from 2001 to 2002, then pollutant loads typically decreased. However, water yield is only one variable within a watershed that can affect pollutant loading. Other important factors include soil type, slope, and land use.
- When examining the relationship between water yield and TSS, TP, DP, and NO<sub>3</sub> loads, TSS load seems to have the highest correlation with water yield, while NO<sub>3</sub> load has the lowest.

**Figure 5. A Comparison of 2001-2002 Water Yields, by Stream and Major River Basin**

■ 2001 Water Yield      □ 2002 Water Yield

Mississippi River Basin

Minnesota River Basin

St. Croix River Basin

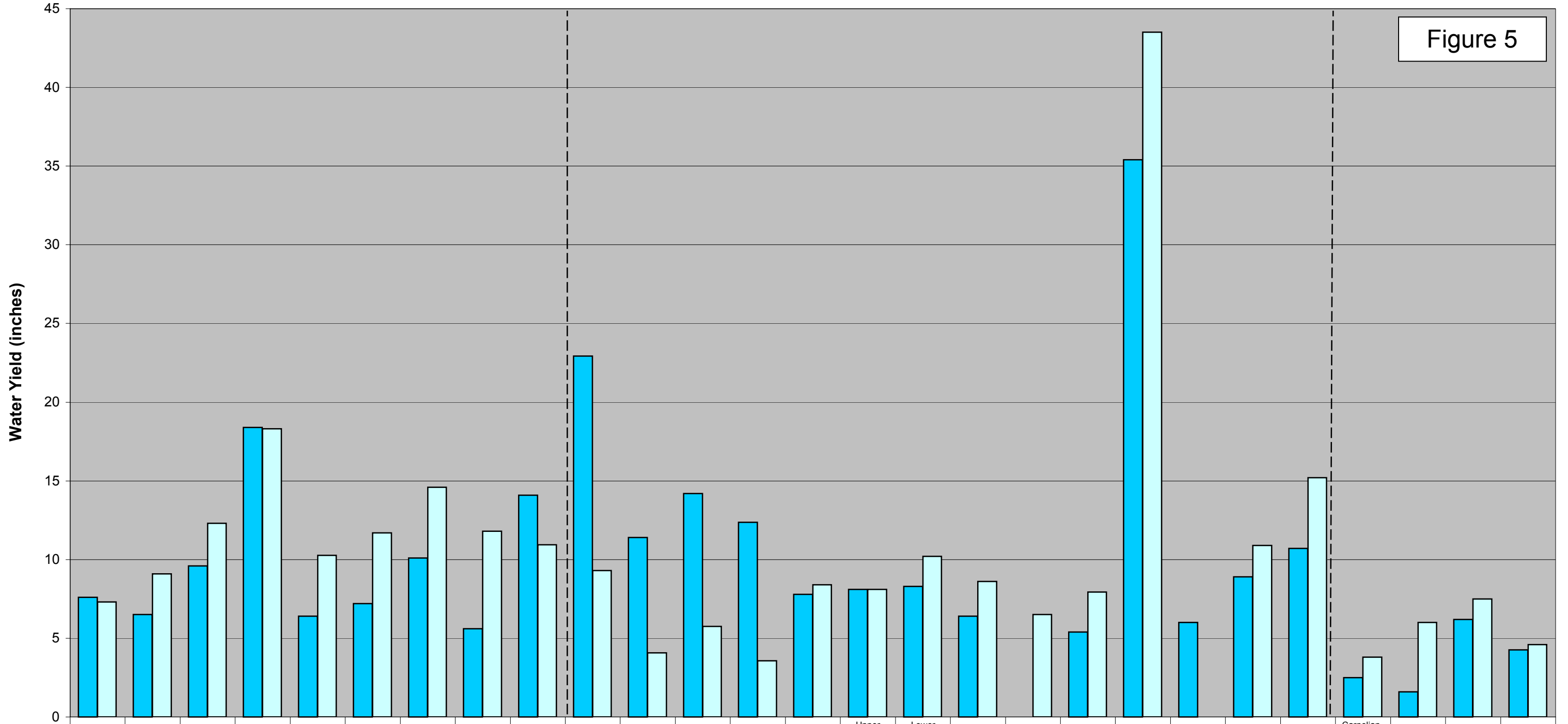


Figure 5

	South Fork Crow R.	Crow River	Rum River	Bassett Creek	Minnehaha Creek	Battle Creek	Fish Creek	Vermillion River	Cannon River	Beauford Ditch	Little Cobb River	Le Sueur River	Blue Earth River	Sand Creek	Upper Bevens Creek	Lower Bevens Creek	Carver Creek	Bluff Creek	Riley Creek	Eagle Creek	Credit River	Willow Creek	Nine Mile Creek	Carnelian-Marine Outlet	Silver Creek	Browns Creek	Valley Creek
■ 2001 Water Yield	7.6	6.5	9.6	18.4	6.4	7.2	10.1	5.6	14.1	22.9	11.4	14.2	12.4	7.8	8.1	8.3	6.4		5.4	35.4	6.0	8.9	10.7	2.5	1.6	6.2	4.3
□ 2002 Water Yield	7.3	9.1	12.3	18.3	10.3	11.7	14.6	11.8	10.9	9.3	4.1	5.8	3.6	8.4	8.1	10.2	8.6	6.5	7.9	43.5		10.9	15.2	3.8	6.0	7.5	4.6

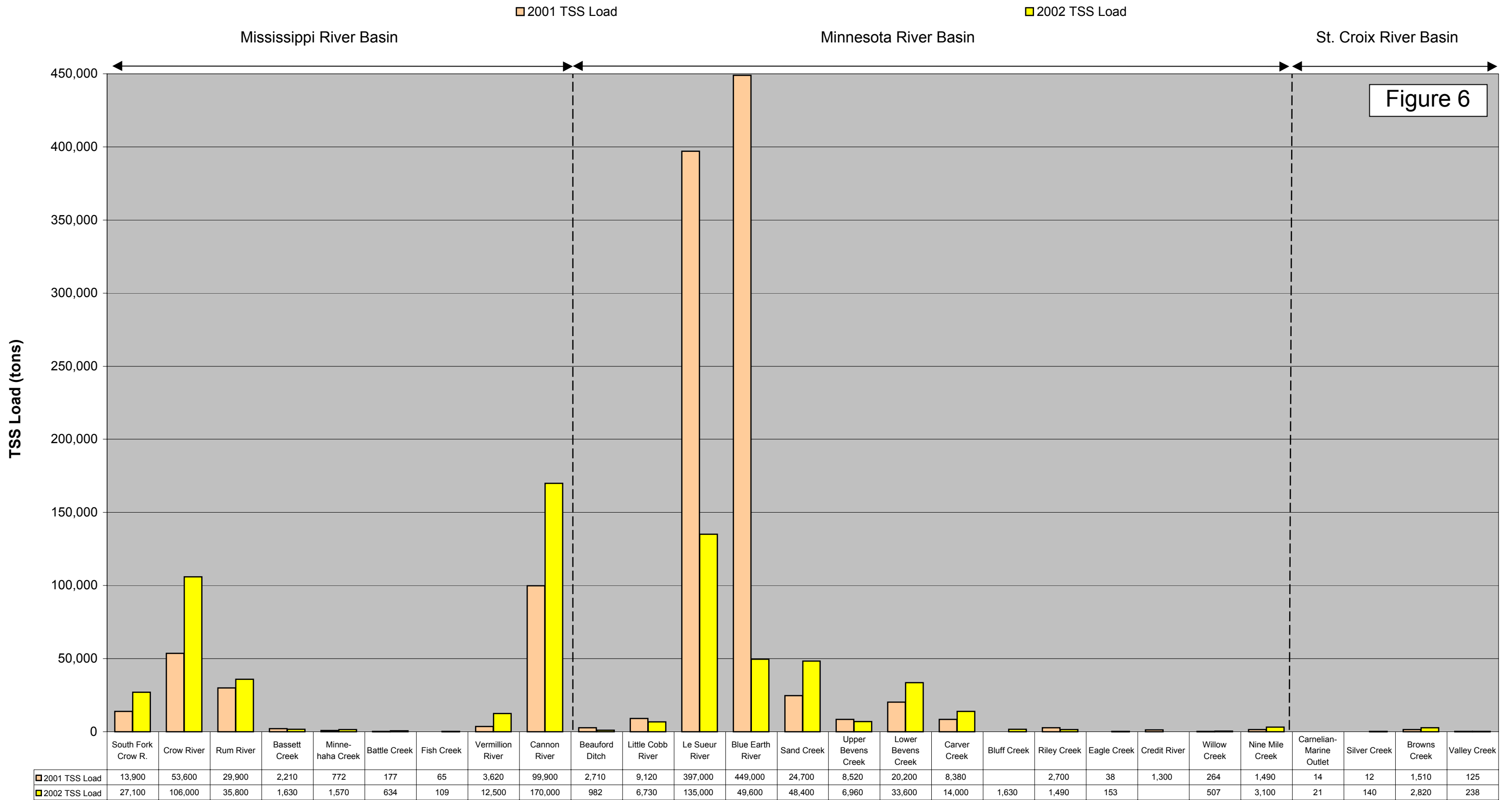
## Total Suspended Solids

Total suspended solids (TSS) is a measure of the amount of solid material (inorganic and organic) suspended in water. TSS concentrations are typically analyzed in all grab and composite samples collected at a stream monitoring station. Using the FLUX model, annual TSS loads are calculated for all 28 streams within the MCES monitoring network. Figure 6 presents a comparison of 2001 and 2002 TSS loads by stream and major river basin. Annual TSS yields, TSS normalized yields, and TSS flow-weighted mean concentrations are determined after annual TSS loads have been calculated. Comparisons of 2001 and 2002 TSS yields, normalized yields, and flow-weighted mean concentrations, by stream and major river basin, are presented in Figures 7, 8, and 9, respectively.

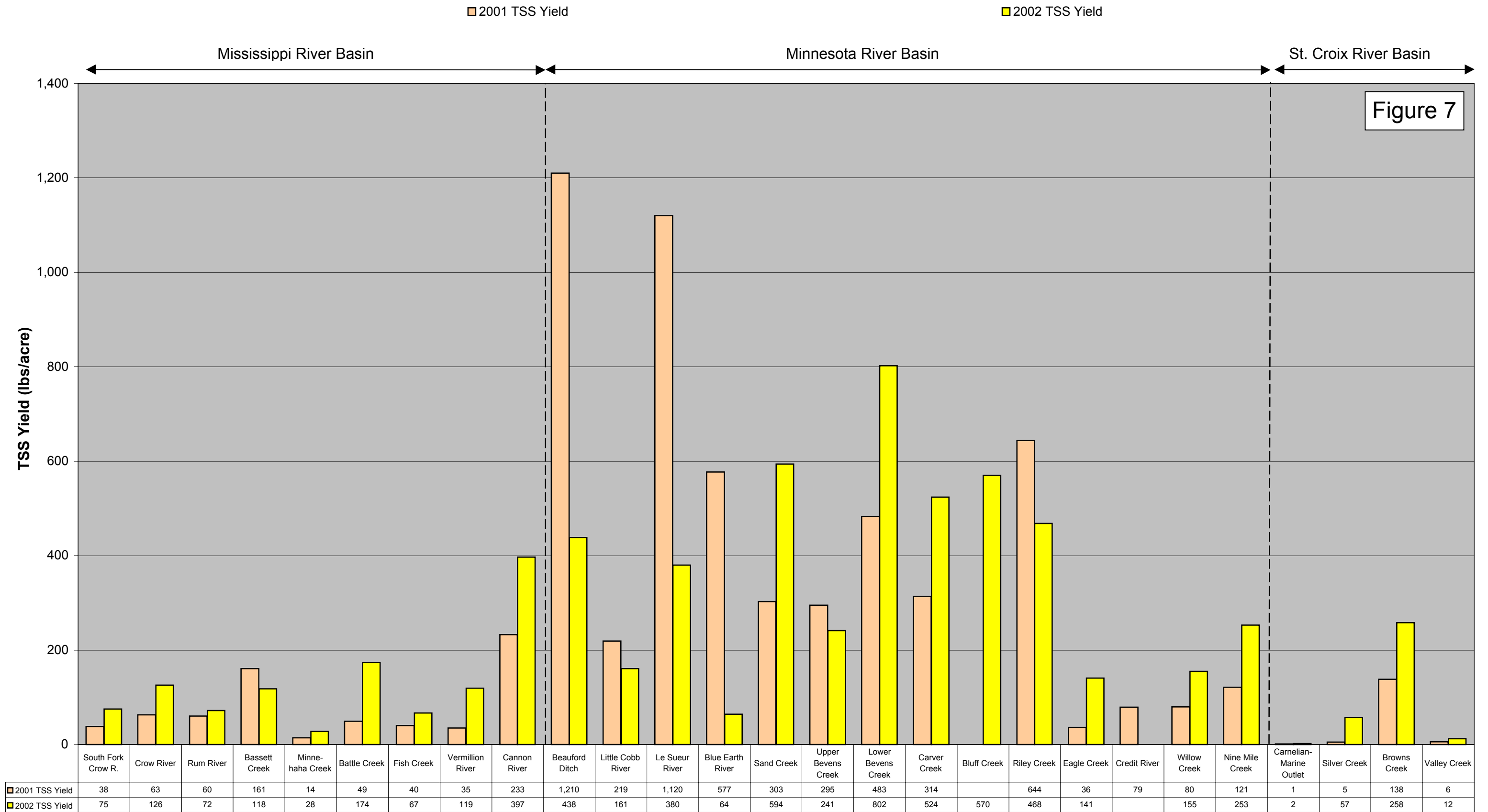
The following is a summary of observations pertaining to Figures 6-9:

- Table 2 presents a summary of streams with the highest and lowest TSS contributions in 2001 and 2002, by major river basin (Mississippi, Minnesota, and St. Croix).
- TSS loads from streams with predominantly urban watersheds are much smaller than TSS loads from streams with predominantly agricultural watersheds.
- The Le Sueur and Blue Earth Rivers in the Middle Minnesota River Basin contributed the highest TSS loads in 2001. These loads were three to four and one-half times greater than that from the next highest TSS contributor, the Cannon River.
- TSS loads and yields from streams in the Middle Minnesota River Basin were substantially less in 2002 than 2001, likely due to below-normal precipitation in 2002 (Figure 4). However, TSS loads and yields from streams in the Lower Minnesota River Basin (except Riley Creek) were greater in 2002 than in 2001, likely due to above-normal precipitation within the TCMA in 2002 (Figure 4).
- Below the confluence of the Minnesota River with the Mississippi River, the Cannon River becomes another significant TSS contributor to the Mississippi River. In 2002, the Cannon River delivered the highest TSS load of all streams monitored by MCES.
- In the St. Croix River Basin, Browns Creek contributed the highest TSS loads in 2001 and 2002. However, these loads were 20 to 300 times less than the highest TSS contributors in the Minnesota River (Blue Earth River) and Mississippi River (Cannon River) Basins.
- During the 2001-2002 period, streams monitored by MCES contributed a combined total of nearly 1.2 million tons of TSS to the Mississippi, Minnesota, and St. Croix Rivers. Mississippi, Minnesota, and St. Croix River tributaries contributed 519,000 (44%), 661,000 (56%), and 5,000 (<1%) tons of TSS, respectively.
- TSS yields from streams with small urban watersheds can equal the yields from streams with larger agricultural watersheds. For example, 2001 and 2002 TSS yields from Riley Creek were greater than yields from the Cannon, Crow, and Vermillion Rivers. The 2001 and 2002 Nine Mile Creek TSS yields were also greater than those from the Rum River.
- Riley Creek, draining a relatively small urban watershed tributary to the Lower Minnesota River, demonstrated a two-year pattern of high TSS yields and concentrations. This may be due in part to several large-scale construction projects that occurred within the watershed.
- With the exception of Riley Creek, streams with agricultural watersheds generally exhibit the highest TSS flow-weighted mean concentrations.

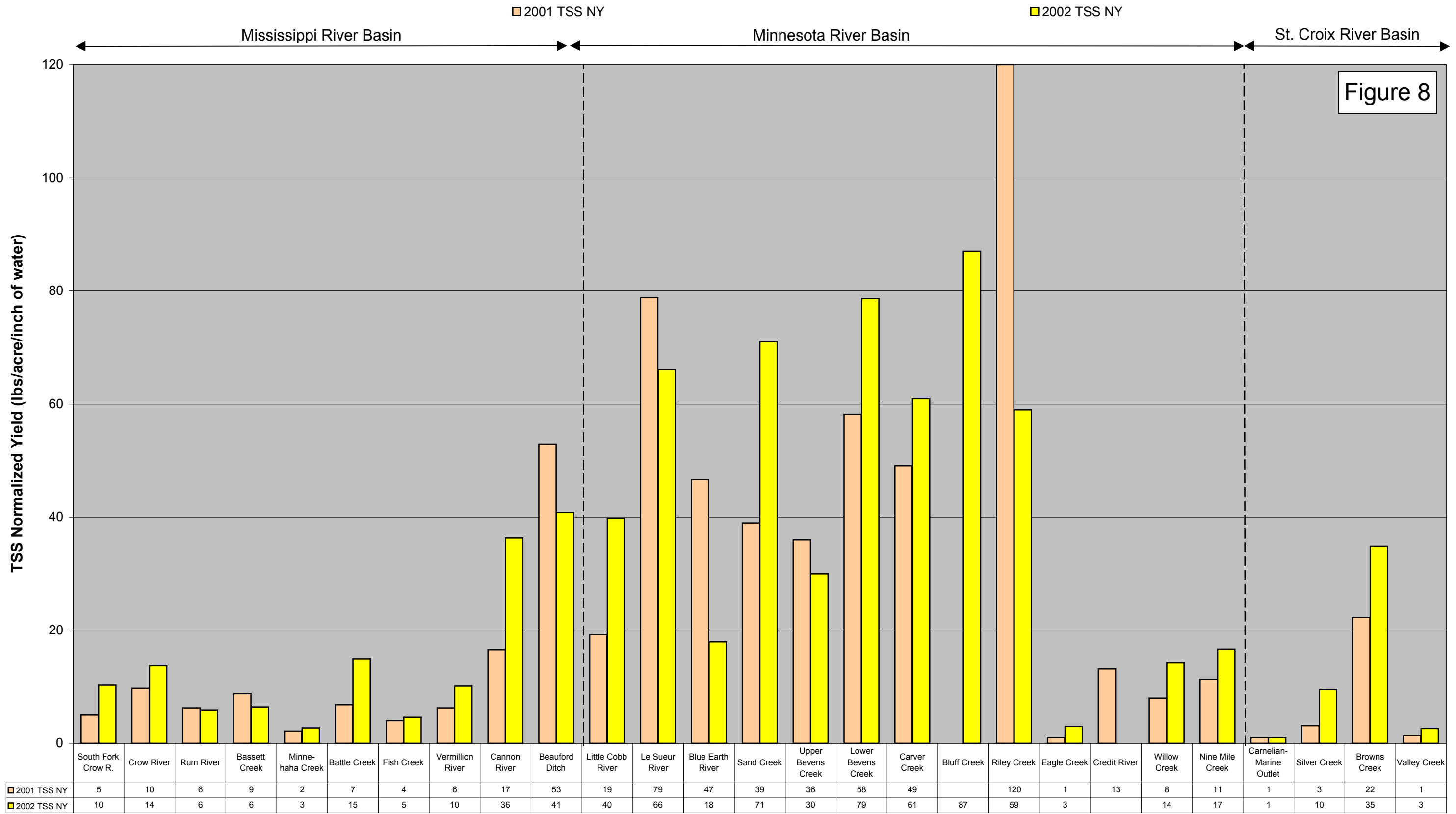
**Figure 6. A Comparison of 2001-2002 Total Suspended Solids (TSS) Loads, by Stream and Major River Basin**



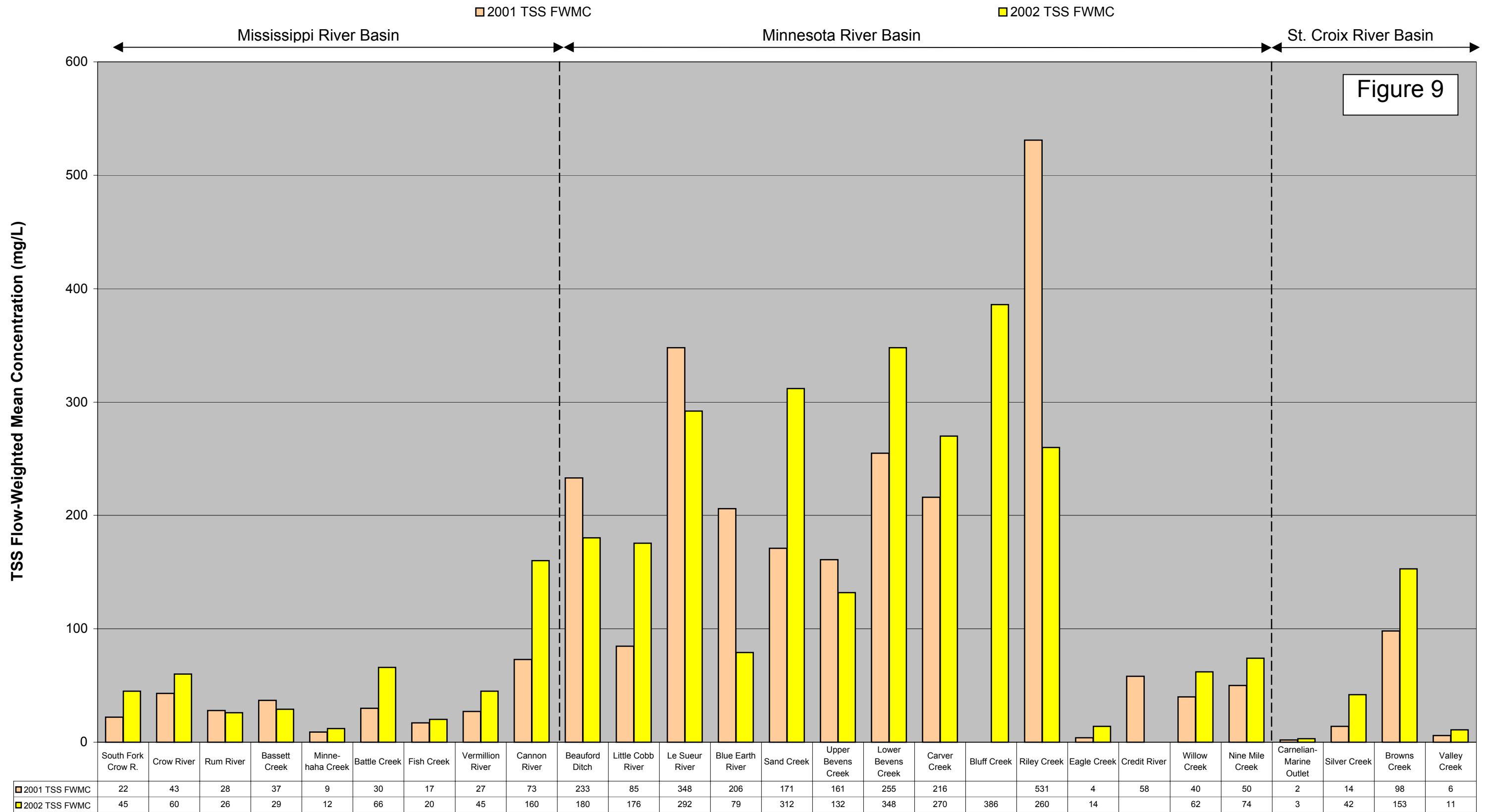
**Figure 7. A Comparison of 2001-2002 Total Suspended Solids (TSS) Yields, by Stream and Major River Basin**



**Figure 8. A Comparison of 2001-2002 Total Suspended Solids (TSS) Normalized Yields (NY), by Stream and Major River Basin**



**Figure 9. A Comparison of 2001-2002 Total Suspended Solids (TSS) Flow-Weighted Mean Concentrations (FWMC) by Stream and Major River Basin**




**Table 2. Streams with the Highest and Lowest Total Suspended Solids (TSS) Contributions: 2001 - 2002**


STREAMS WITH THE HIGHEST TOTAL SUSPENDED SOLIDS (TSS) CONTRIBUTIONS: 2001-2002


STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	TOTAL SUSPENDED SOLIDS (TSS)							
		Highest Load (tons)		Highest Yield ( lbs / acre )		Highest Normalized Yield ( lbs/acre/ inch of water )		Highest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Cannon River	agricultural	99,900	170,000	233	397	17	36	73	160
Blue Earth River	agricultural	449,000							
Le Sueur River	agricultural		135,000					348	
Beauford Ditch	agricultural			1,210					
Lower Bevens Creek	agricultural				802				
Bluff Creek	agricultural						87		386
Riley Creek	urban					120			
Browns Creek	agricultural	1,510	2,820	138	258	22	35	98	153

STREAMS WITH THE LOWEST TOTAL SUSPENDED SOLIDS (TSS) CONTRIBUTIONS: 2001-2002

STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	TOTAL SUSPENDED SOLIDS (TSS)							
		Lowest Load (tons)		Lowest Yield ( lbs / acre )		Lowest Normalized Yield ( lbs/acre/ inch of water )		Lowest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Fish Creek	urban	65	109						
Minnehaha Creek	urban			14	28	2	3	9	12
Eagle Creek	urban	38	153	36		1	3	4	14
Blue Earth	agricultural				64				
Silver Creek	agricultural	12							
Carnelian-Marine Outlet	agricultural		21	1	2	1	1	2	3

 = Tributary to the Mississippi River

 = Tributary to the Minnesota River

 = Tributary to the St. Croix River

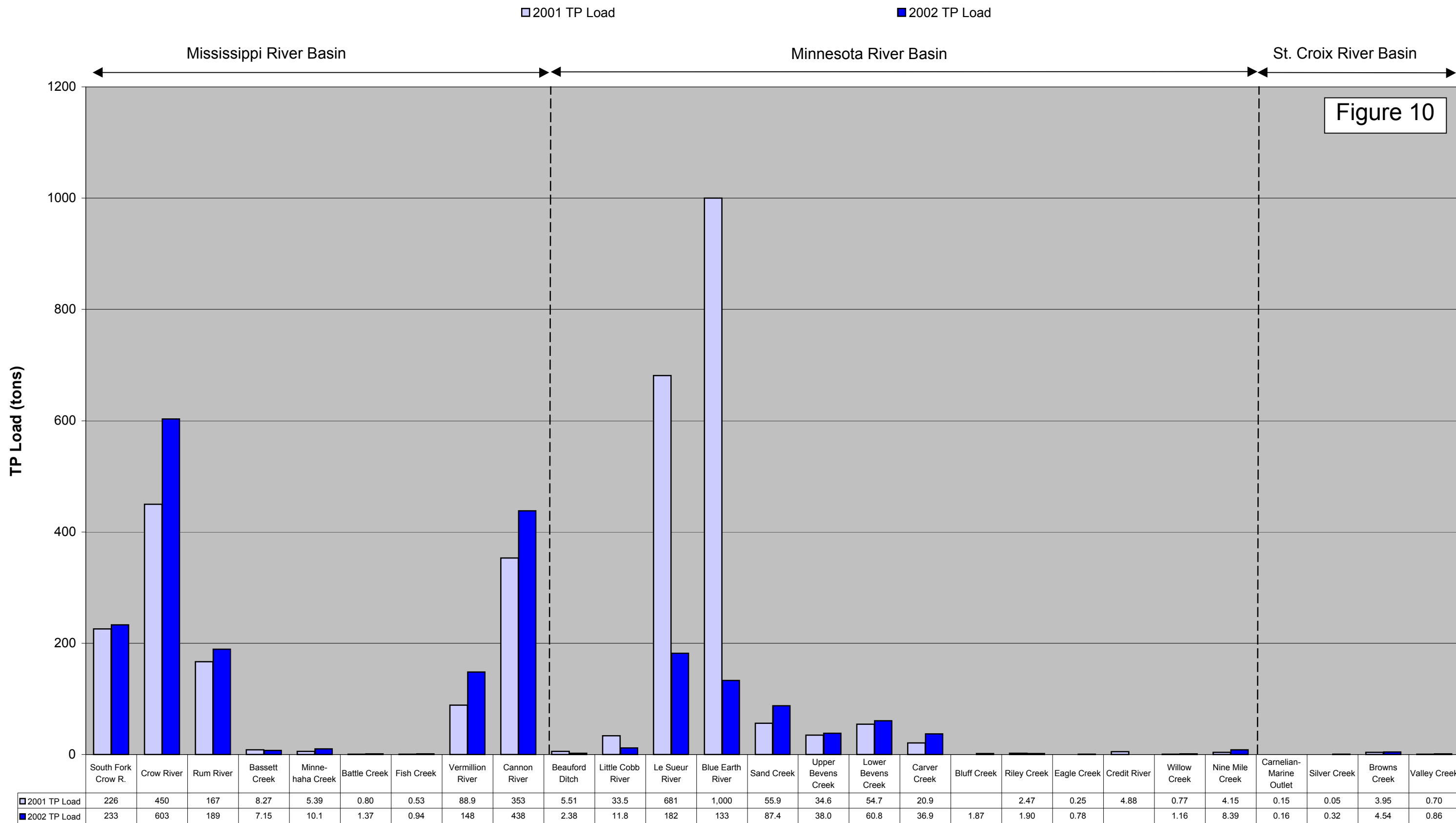
## Total Phosphorus

Total phosphorus (TP) is a measure of all forms of phosphorus in water, including dissolved, particulate, inorganic, and organic phosphorus. Phosphorus is an essential nutrient for primary productivity in streams, but excessive amounts cause eutrophic conditions. TP concentrations are typically analyzed in all grab and composite samples collected at a stream monitoring station. Using the FLUX model, annual TP loads are calculated for all 28 streams within the MCES monitoring network. Figure 10 presents a comparison of 2001 and 2002 TP loads by stream and major river basin. Annual TP yields, TP normalized yields, and TP flow-weighted mean concentrations are determined after annual TP loads have been calculated. Comparisons of 2001 and 2002 TP yields, normalized yields, and flow-weighted mean concentrations, by stream and major river basin, are presented in Figures 11, 12, and 13, respectively.

The following is a summary of observations pertaining to Figures 10-13:

- Table 3 presents a summary of streams with the highest and lowest TP contributions in 2001 and 2002, by major river basin (Mississippi, Minnesota, and St. Croix).
- Streams draining agricultural watersheds, particularly those in the Minnesota and Mississippi River Basins, generally exhibit the highest TP loads, yields, normalized yields, and flow-weighted mean concentrations.
- Streams draining urban watersheds with no wastewater treatment plant discharges generally exhibit the lowest TP loads, yields, normalized yields, and flow-weighted mean concentrations.
- Higher TP loads, yields, normalized yields, and flow-weighted mean concentrations are evident in streams which receive wastewater treatment plant discharges. High TP levels in the Crow River likely reflect the presence of 38 municipal wastewater treatment plants located throughout the watershed, as well as the influence of agricultural activity. Similarly, high TP levels in the Vermillion River reflect both wastewater treatment plant discharges (including the MCES Empire Plant) and substantial agricultural activity.
- In general, TP loads appear to be strongly correlated with water yield. In streams where water yields decreased from 2001 to 2002, there was a corresponding decrease in TP loads. In streams where water yields increased from 2001 to 2002, there was a corresponding increase in TP loads. The only exception to this is the Cannon River, where the TP load decreased in 2002, in spite of an increased water yield.
- In general, changes in TP loads appear to be directly correlated with changes in TSS loads. In streams where TSS loads increased from 2001 to 2002, TP loads also increased. If 2001-2002 TSS loads were similar, TP loads were also similar. If TSS loads decreased from 2001 to 2002, TP loads also decreased. This same TSS-TP relationship for loads appears to be applicable for yields, normalized yields, and flow-weighted mean concentrations as well.
- During the 2001-2002 period, streams monitored by MCES contributed a combined total of about 4,000 tons of TP to the Mississippi, Minnesota, and St. Croix Rivers. Mississippi, Minnesota, and St. Croix River tributaries contributed 2,500 (62%), 1,500 (37%), and 10 (<1%) tons of TP, respectively.
- While tributaries in the St. Croix River Basin contributed very small amounts of TP, Browns Creek consistently exhibited the highest TP loads, yields, normalized yields, and flow-weighted mean concentrations.

**Figure 10. A Comparison of 2001-2002 Total Phosphorus (TP) Loads, by Stream and Major River Basin**



**Figure 11. A Comparison of 2001-2002 Total Phosphorus (TP) Yields, by Stream and Major River Basin**

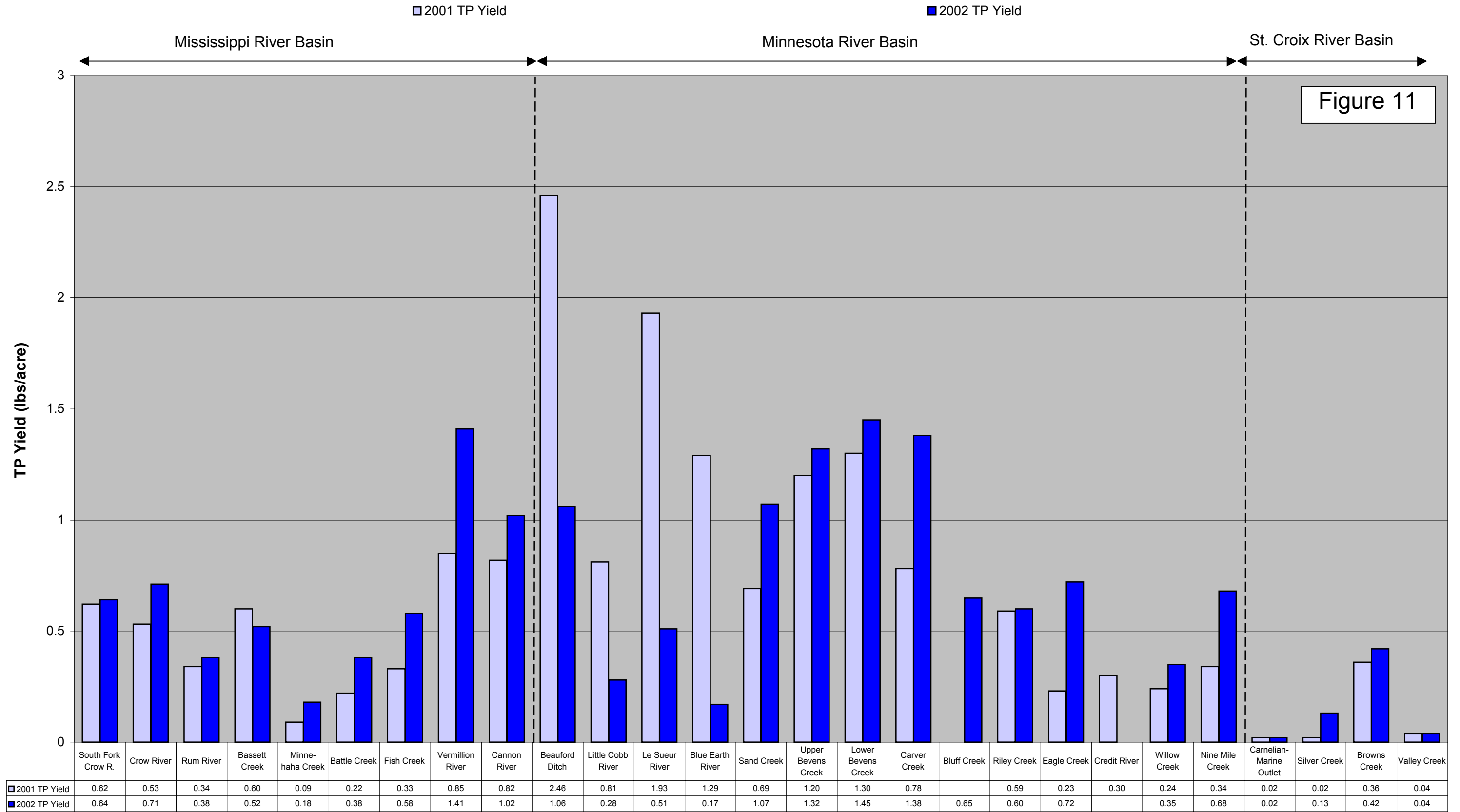
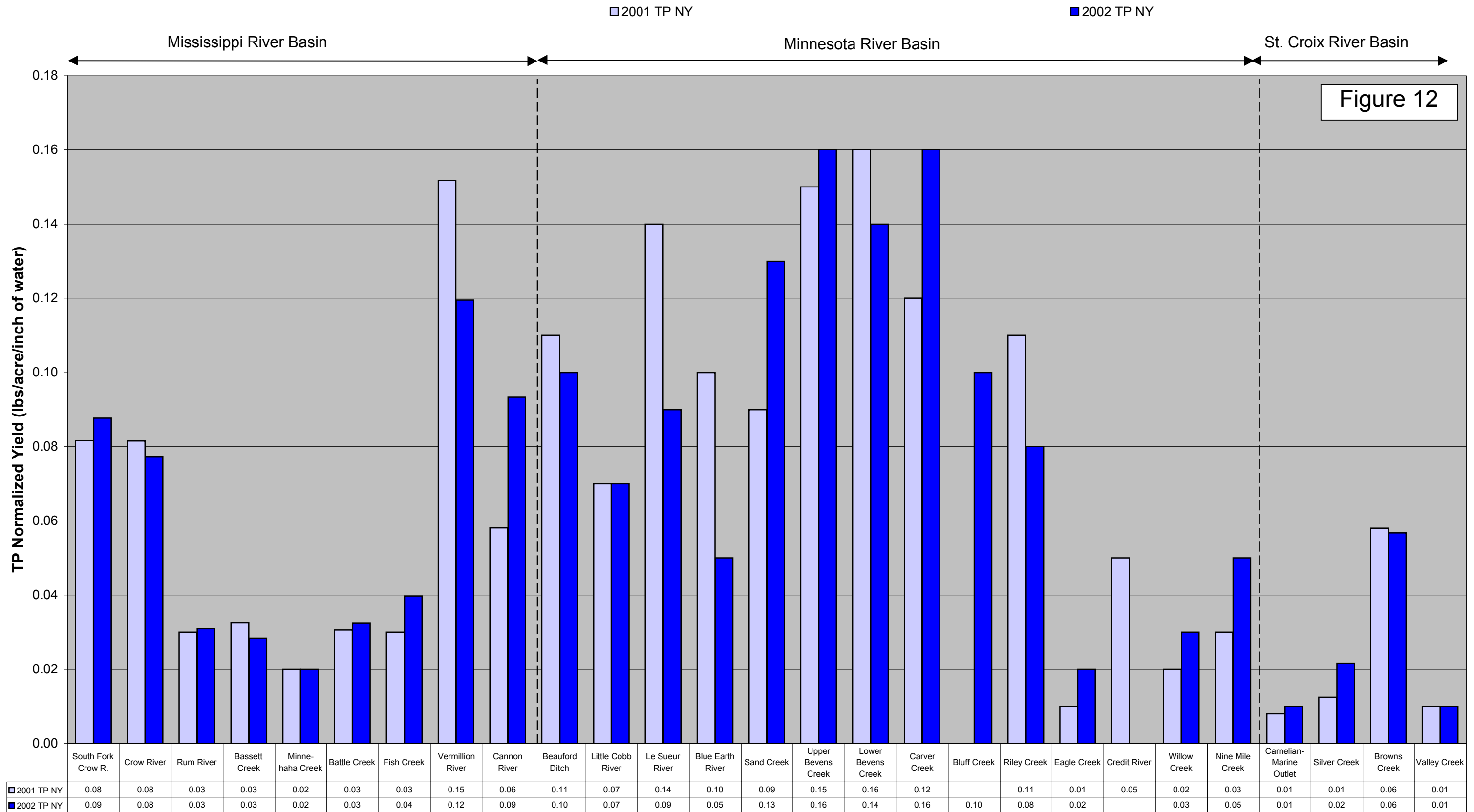
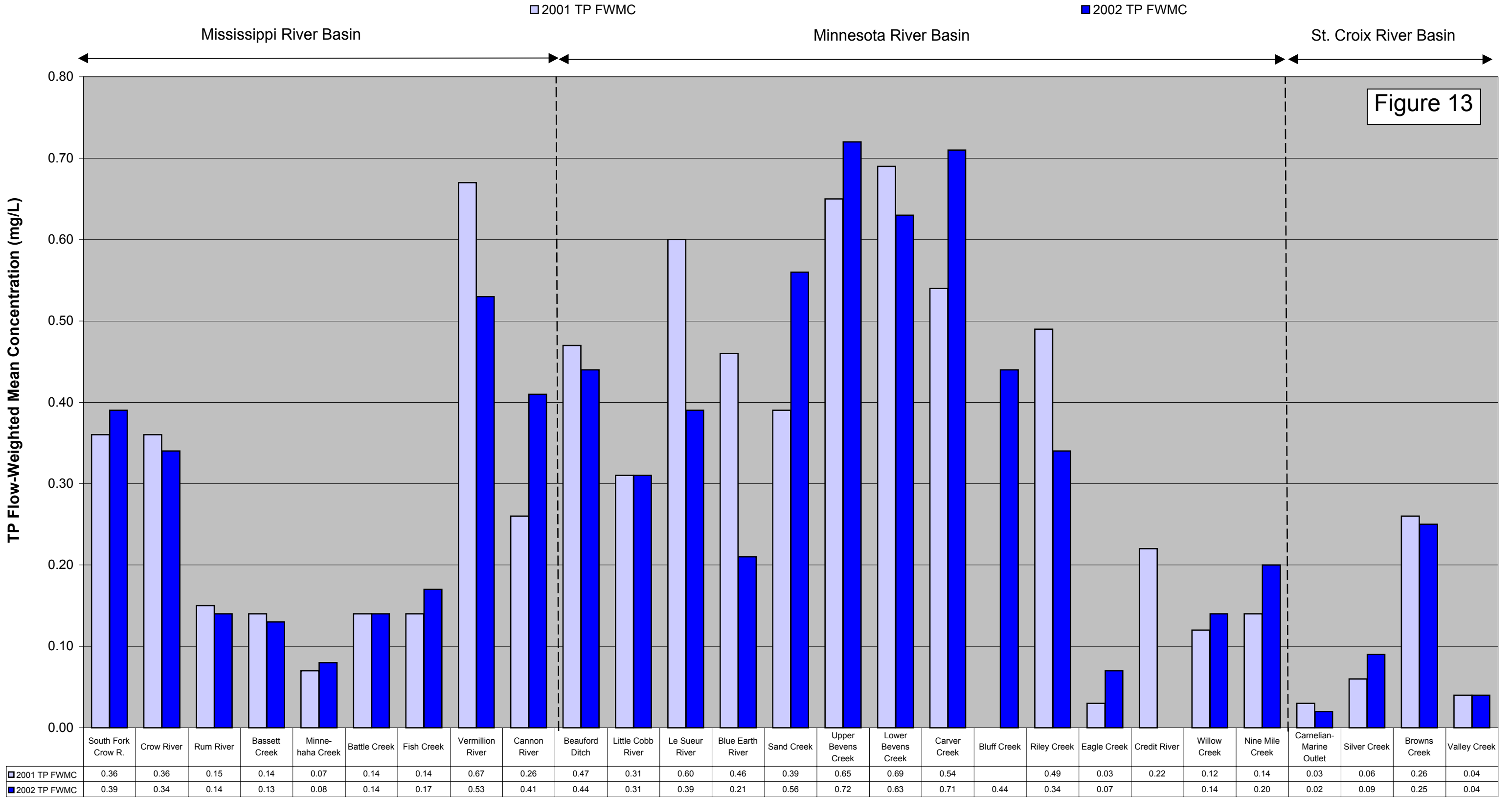


Figure 12. A Comparison of 2001-2002 Total Phosphorus (TP) Normalized Yields (NY), by Stream and Major River Basin



**Figure 13. A Comparison of 2001-2002 Total Phosphorus (TP) Flow-Weighted Mean Concentrations (FWMC) by Stream and Major River Basin**




**Table 3. Streams with the Highest and Lowest Total Phosphorus (TP) Contributions: 2001-2002**


STREAMS WITH THE HIGHEST TOTAL PHOSPHORUS (TP) CONTRIBUTIONS: 2001-2002


STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	TOTAL PHOSPHORUS (TP)							
		Highest Load (tons)		Highest Yield ( lbs / acre )		Highest Normalized Yield ( lbs/acre/ inch of water )		Highest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Crow River, South Fork	agricultural								0.69
Crow River	agricultural	450	603						
Vermillion River	agricultural			0.85	1.41	0.15	0.12	0.67	0.63
Blue Earth River	agricultural	1,000							
Le Sueur River	agricultural		182						
Beauford Ditch	agricultural			2.46					
Upper Bevens Creek	agricultural								0.72
Lower Bevens Creek	agricultural				1.45			0.69	
Riley Creek	urban					0.16			
Carver Creek	agricultural						0.16		
Browns Creek	agricultural	3.95	4.54	0.36	0.42	0.06	0.06	0.26	0.25

STREAMS WITH THE LOWEST TOTAL PHOSPHORUS (TP) CONTRIBUTIONS: 2001-2002

STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	TOTAL PHOSPHORUS (TP)							
		Lowest Load (tons)		Lowest Yield ( lbs / acre )		Lowest Normalized Yield ( lbs/acre/ inch of water )		Lowest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Minnehaha Creek	urban			0.09	0.18	0.02	0.02	0.07	0.08
Fish Creek	urban	0.53	0.94						
Eagle Creek	urban	0.25	0.78	0.23		0.01	0.02	0.03	0.07
Blue Earth River	agricultural				0.17				
Carnelian-Marine Outlet	agricultural		0.16	0.02	0.02		0.01	0.03	0.02
Silver Creek	agricultural	0.05							
Valley Creek	agricultural					0.01			

 = Tributary to the Mississippi River

 = Tributary to the Minnesota River

 = Tributary to the St. Croix River

## Dissolved Phosphorus

Dissolved phosphorus (DP) is a measure of soluble forms of phosphorus (both inorganic and organic) in water. DP is the most readily available form of phosphorus for primary productivity in streams. DP concentrations are typically analyzed in all grab and composite samples collected at a stream monitoring station. Using the FLUX model, annual DP loads are calculated for all 28 streams within the MCES monitoring network. Figure 14 presents a comparison of 2001 and 2002 DP loads by stream and major river basin. Annual DP yields, DP normalized yields, and DP flow-weighted mean concentrations are determined after annual DP loads have been calculated. Comparisons of 2001 and 2002 DP yields, normalized yields, and flow-weighted mean concentrations, by stream and major river basin, are presented in Figures 15, 16, and 17, respectively.

The following is a summary of observations pertaining to Figures 14-17:

- Table 4 presents a summary of streams with the highest and lowest DP contributions in 2001 and 2002, by major river basin (Mississippi, Minnesota, and St. Croix).
- In all three major river basins, the streams with the highest TP loads also had highest DP loads (Tables 3 and 4).
- Streams draining agricultural watersheds, particularly those in the Minnesota and Mississippi River Basins, generally exhibit the highest DP loads, yields, normalized yields, and flow-weighted mean concentrations.
- Streams draining urban watersheds with no wastewater treatment plant discharges generally exhibit the lowest DP loads, yields, normalized yields, and flow-weighted mean concentrations.
- High DP levels in the Crow and Vermillion Rivers, like the high TP levels, reflect the contributions of both wastewater treatment plant discharges to these rivers and substantial agricultural activity in their watersheds.
- DP loads in streams within the Middle Minnesota River Basin were substantially higher in 2001 than in 2002. Although precipitation amounts and water yields were greater in 2001, the higher 2001 DP loads might also be attributed in part to extensive spring flooding. The prolonged contact of floodwaters with agricultural lands can promote the release of dissolved phosphorus from soil and crop residue into the overlying water. In 2002, spring flooding did not occur, providing no opportunity for DP to be released via this mechanism.
- In general, changes in DP loads appear to be directly correlated with changes in TP loads. In streams where TP loads increased from 2001 to 2002, DP loads also increased. If 2001-2002 TP loads were similar, DP loads were also similar. If TP loads decreased from 2001 to 2002, DP loads also decreased. The Cannon River is an exception to this relationship.
- During the 2001-2002 period, streams monitored by MCES contributed a combined total of about 2,000 tons of DP to the Mississippi, Minnesota, and St. Croix Rivers. Mississippi, Minnesota, and St. Croix River tributaries contributed 1,400 (70%), 600 (30%), and 3 (<1%) tons of DP, respectively.
- In the St. Croix River Basin, Browns Creek is the greatest contributor of DP.
- Minnehaha Creek in the Mississippi River Basin is one of the largest TCMA urban watersheds, yet in comparison to other urban watersheds, exhibits lower DP yields and flow-weighted mean concentrations, perhaps due to the upstream influence of Lake Minnetonka.

Figure 14. A Comparison of 2001-2002 Dissolved Phosphorus (DP) Loads, by Stream and Major River Basin

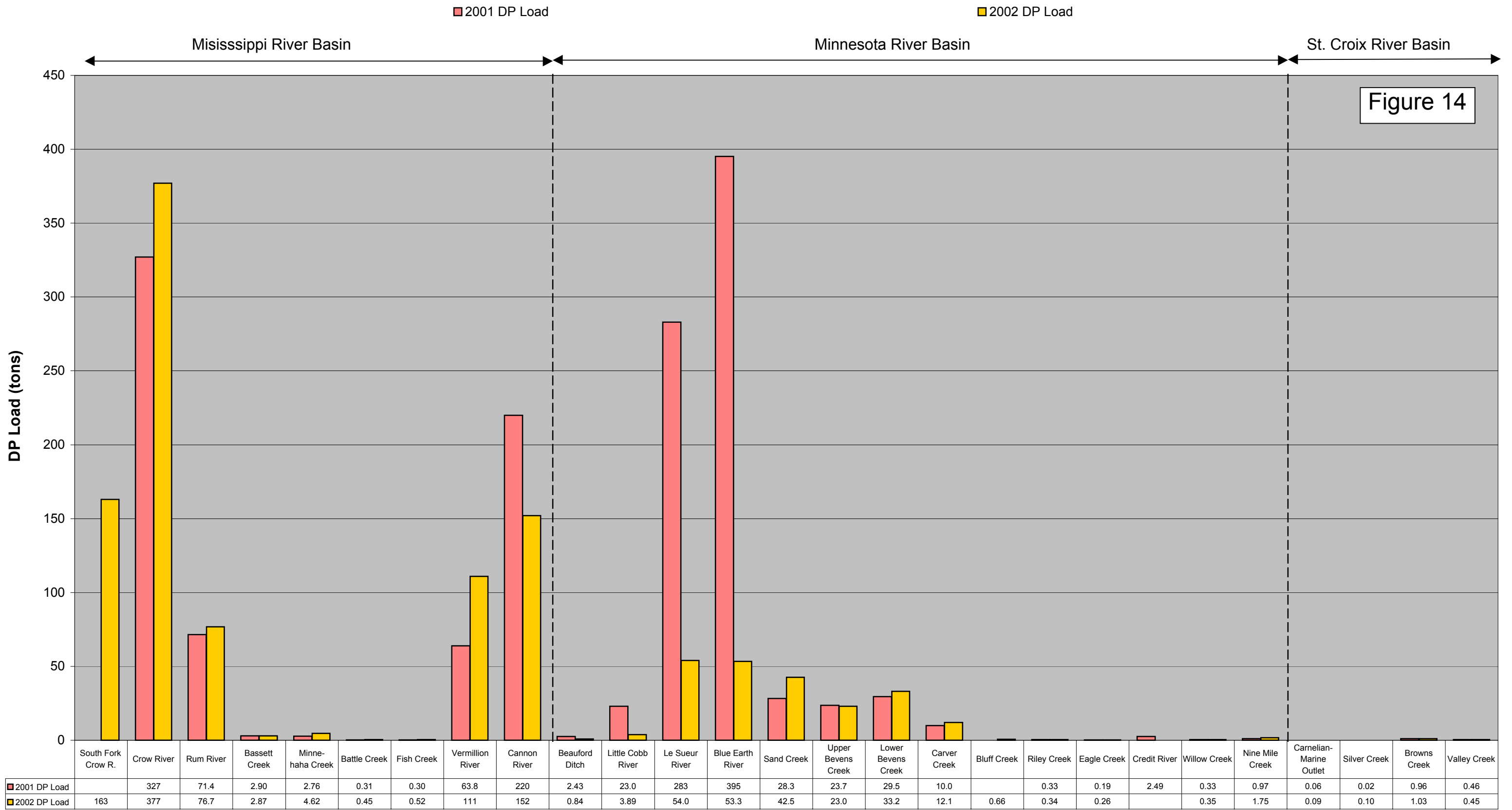


Figure 15. A Comparison of 2001-2002 Dissolved Phosphorus (DP) Yields, by Stream and Major River Basin

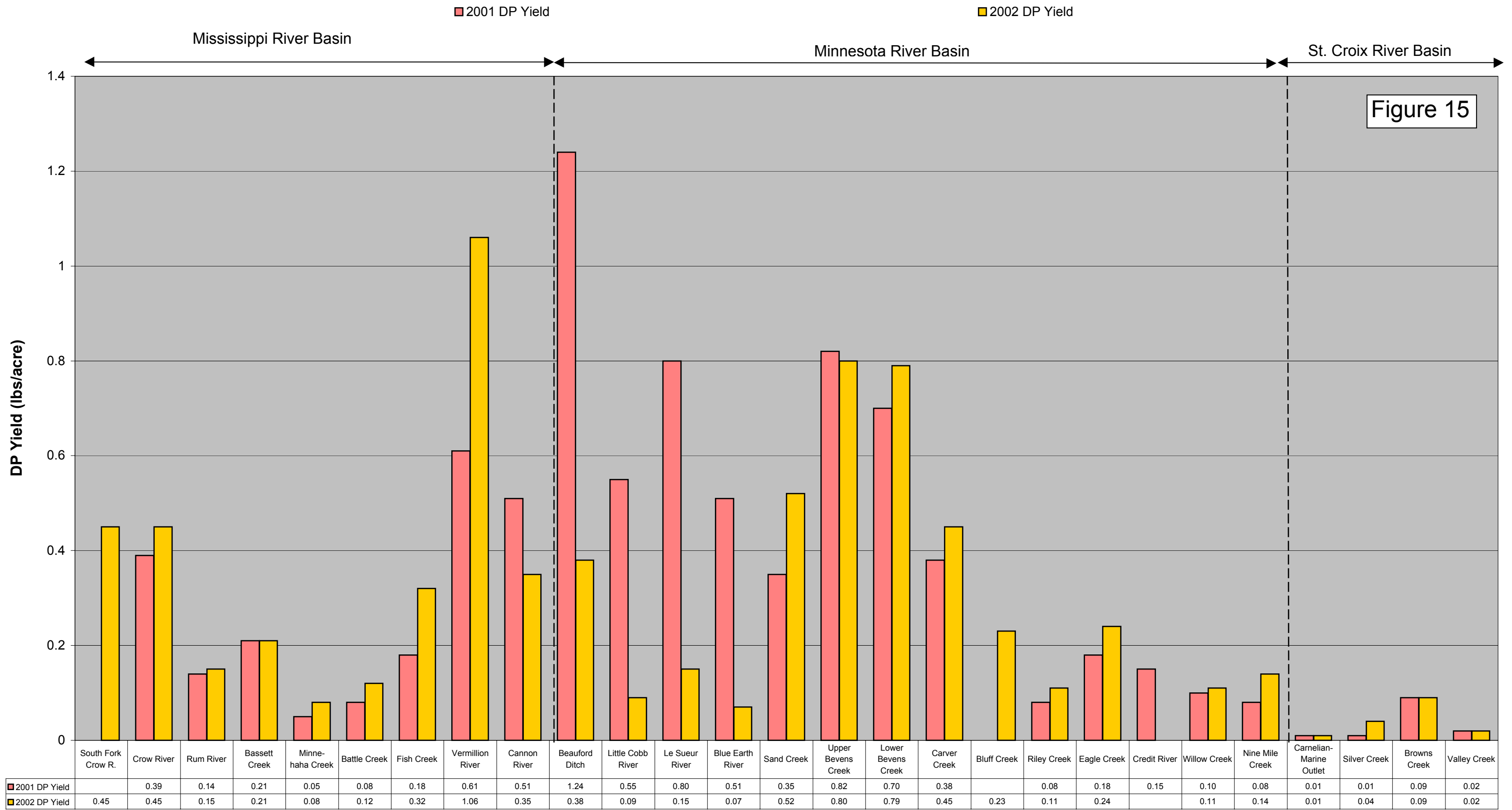
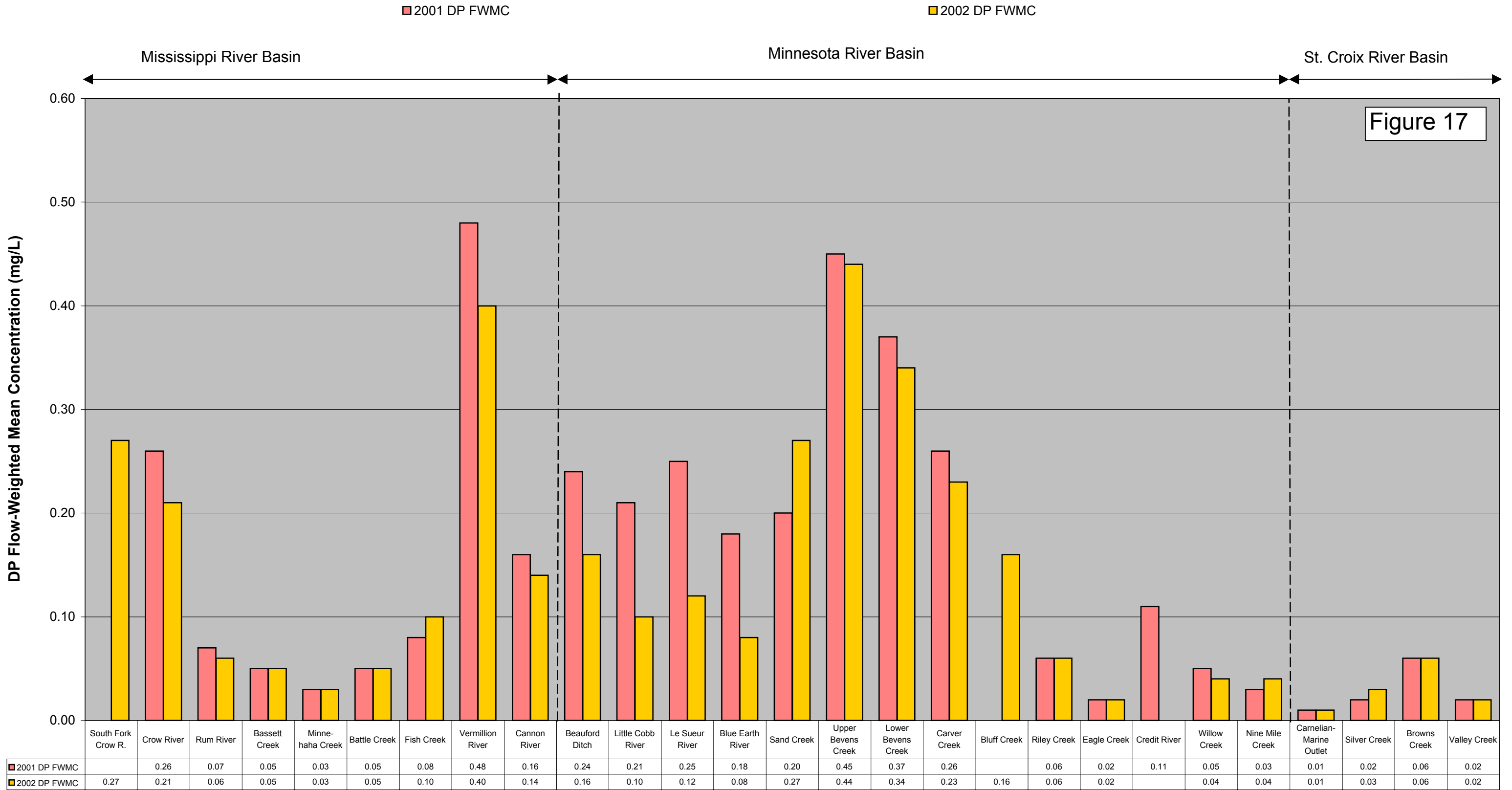




Figure 17. A Comparison of Dissolved Phosphorus (DP) Flow-Weighted Mean Concentrations (FWMC), by Stream and Major River Basin




**Table 4. Streams with the Highest and Lowest Dissolved Phosphorus (DP) Contributions: 2001 - 2002**


STREAMS WITH THE HIGHEST DISSOLVED PHOSPHORUS (DP) CONTRIBUTIONS: 2001-2002

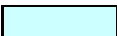
STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	DISSOLVED PHOSPHORUS (DP)							
		Highest Load (tons)		Highest Yield ( lbs / acre )		Highest Normalized Yield ( lbs/acre/ inch of water )		Highest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Crow River, South Fork	agricultural								0.27
Crow River	agricultural	327	377					0.26	
Vermillion River	agricultural			0.61	1.06	0.11	0.09		
Blue Earth River	agricultural	395							
Le Sueur River	agricultural		54.0						
Beauford Ditch	agricultural			1.24					
Upper Bevins Creek	agricultural				0.80	0.10	0.10	0.45	0.44
Browns Creek	agricultural	0.96	1.03	0.09	0.09	0.01	0.01	0.06	0.06

STREAMS WITH THE LOWEST DISSOLVED PHOSPHORUS (DP) CONTRIBUTIONS: 2001-2002

STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	DISSOLVED PHOSPHORUS (DP)							
		Lowest Load (tons)		Lowest Yield ( lbs / acre )		Lowest Normalized Yield ( lbs/acre/ inch of water )		Lowest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Fish Creek	urban	0.30							
Minnehaha Creek	urban			0.05	0.08	0.01	0.01	0.03	0.03
Bassett Creek	urban		2.87						
Eagle Creek	urban	0.19	0.26			0.01	0.01	0.02	0.02
Blue Earth River	agricultural				0.07				
Nine Mile Creek	urban			0.08					
Silver Creek	agricultural	0.02		0.01					
Carnelian-Marine Outlet	agricultural		0.09		0.01	0.01	0.01	0.01	0.01

 = Tributary to the Mississippi River

 = Tributary to the Minnesota River

 = Tributary to the St. Croix River

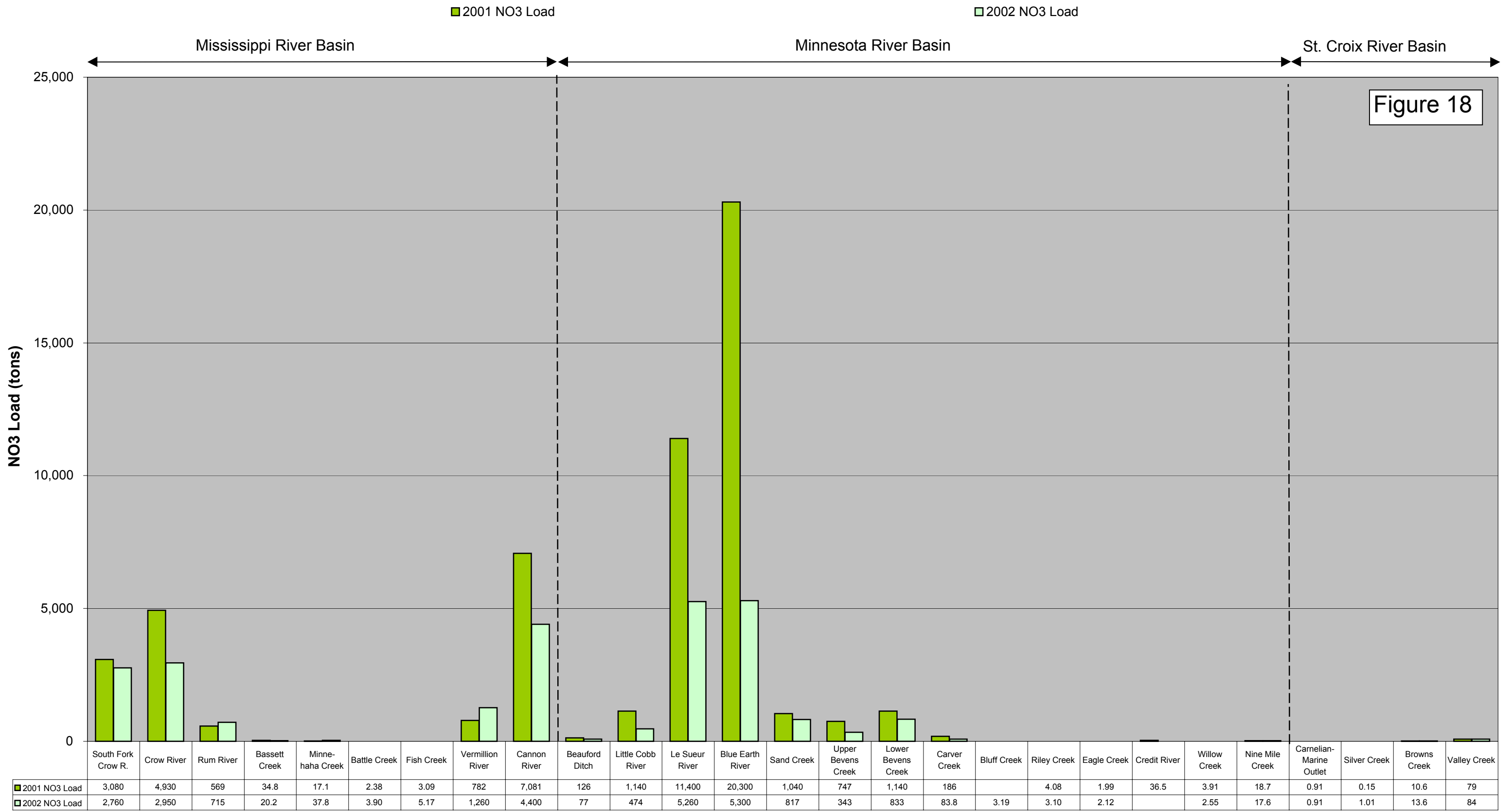
## Nitrate Nitrogen

Nitrate nitrogen (NO<sub>3</sub>) is generally one of the major forms of soluble inorganic nitrogen in water, as well as an essential nutrient for primary productivity in streams. NO<sub>3</sub> concentrations are typically analyzed in all grab and composite samples collected at a stream monitoring station. Using the FLUX model, annual NO<sub>3</sub> loads are calculated for all 28 streams within the MCES monitoring network. Figure 18 presents a comparison of 2001 and 2002 NO<sub>3</sub> loads by stream and major river basin. Annual NO<sub>3</sub> yields, NO<sub>3</sub> normalized yields, and NO<sub>3</sub> flow-weighted mean concentrations are determined after annual NO<sub>3</sub> loads have been calculated. Comparisons of 2001 and 2002 NO<sub>3</sub> yields, normalized yields, and flow-weighted mean concentrations, by stream and major river basin, are presented in Figures 19, 20, and 21, respectively.

The following is a summary of observations pertaining to Figures 18-21:

- Table 5 presents a summary of streams with the highest and lowest NO<sub>3</sub> contributions in 2001 and 2002, by major river basin (Mississippi, Minnesota, and St. Croix).
- Streams draining agricultural watersheds in the Minnesota River Basin are substantial NO<sub>3</sub> contributors, exhibiting some of the highest nitrate loads, yields, normalized yields, and flow-weighted mean concentrations observed in 2001 and 2002. These watersheds are characterized by extensive row crop agriculture with sub-surface drainage systems that effectively convey NO<sub>3</sub> to surface waters.
- During the 2001-2002 period, streams monitored by MCES contributed a combined total of about 52,800 tons of NO<sub>3</sub> to the Mississippi, Minnesota, and St. Croix Rivers. Mississippi, Minnesota, and St. Croix River tributaries contributed 22,800 (43%), 29,800 (57%), and 200 (<1%) tons of NO<sub>3</sub>, respectively.
- Of all the streams monitored by MCES, the four largest NO<sub>3</sub> load contributors are the Cannon and Crow Rivers in the Mississippi River Basin and the Blue Earth and Le Sueur Rivers in the Minnesota River Basin. During the 2001-2002 period, the Crow and Cannon Rivers contributed 85% of the combined measured NO<sub>3</sub> load to the Mississippi River, while the Blue Earth River (including the Le Sueur River's contribution) accounted for 86% of the combined measured NO<sub>3</sub> load to the Minnesota River. All four rivers drain large agricultural watersheds.
- In the St. Croix River Basin, Valley Creek is the highest NO<sub>3</sub> contributor. The baseflow in Valley Creek is groundwater discharge from bedrock aquifers. With agricultural land use in the aquifer recharge zone, ground water can be a persistent reservoir of high ambient levels of NO<sub>3</sub>.
- The combined NO<sub>3</sub> load to the Mississippi, Minnesota, and St. Croix Rivers decreased by 54% from 2001 (36,200 tons) to 2002 (16,600 tons). The majority of this NO<sub>3</sub> load reduction is due to a dramatically reduced load in the Blue Earth River. The primary factors affecting the 2002 NO<sub>3</sub> load reduction in the Blue Earth River include decreased precipitation, water yield, and water volume. Timing of precipitation and runoff may also have played a role. In 2001, major runoff events occurred in the spring and early summer, during the period of fertilizer application but prior to crop canopy closure. In 2002, major runoff events occurred in the late summer, when fertilizer application was complete, crop canopy closure was extensive, and the evaporation/transpiration potential was greater.

Figure 18. A Comparison of 2001-2002 Nitrate Nitrogen (NO3) Loads, by Stream and Major River Basin



**Figure 19. A Comparison of 2001-2002 Nitrate Nitrogen (NO3) Yields, by Stream and Major River Basin**

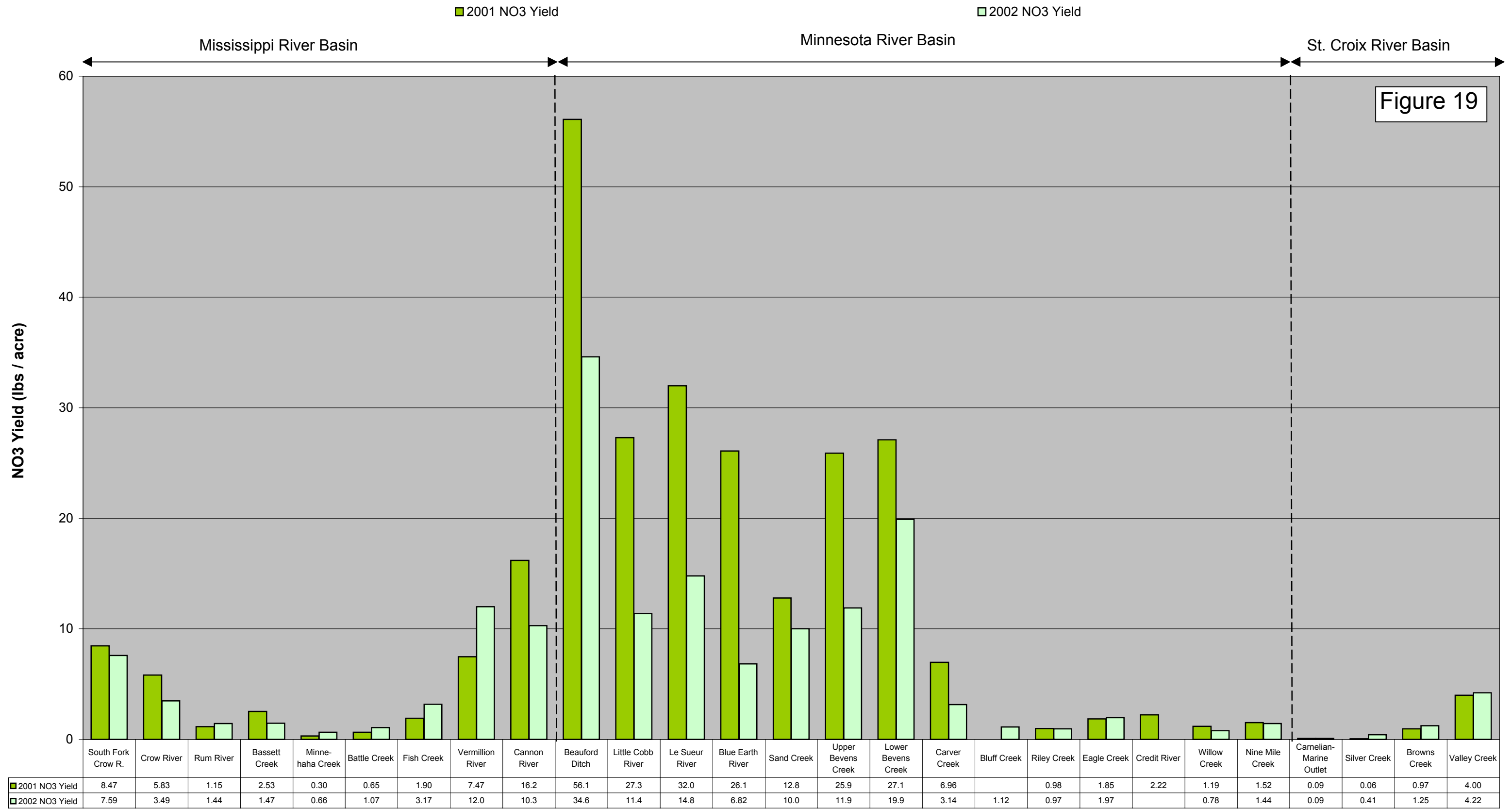
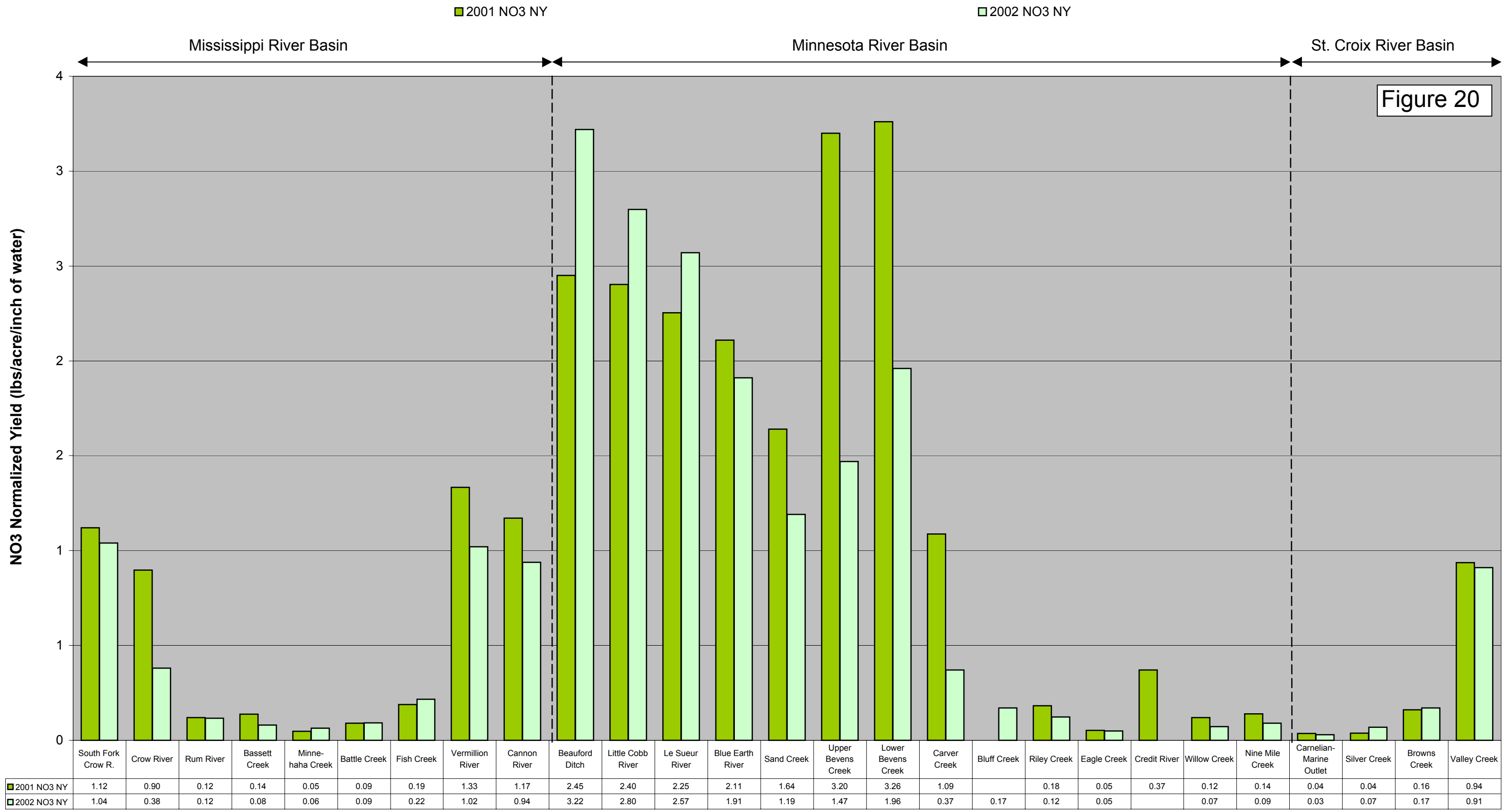
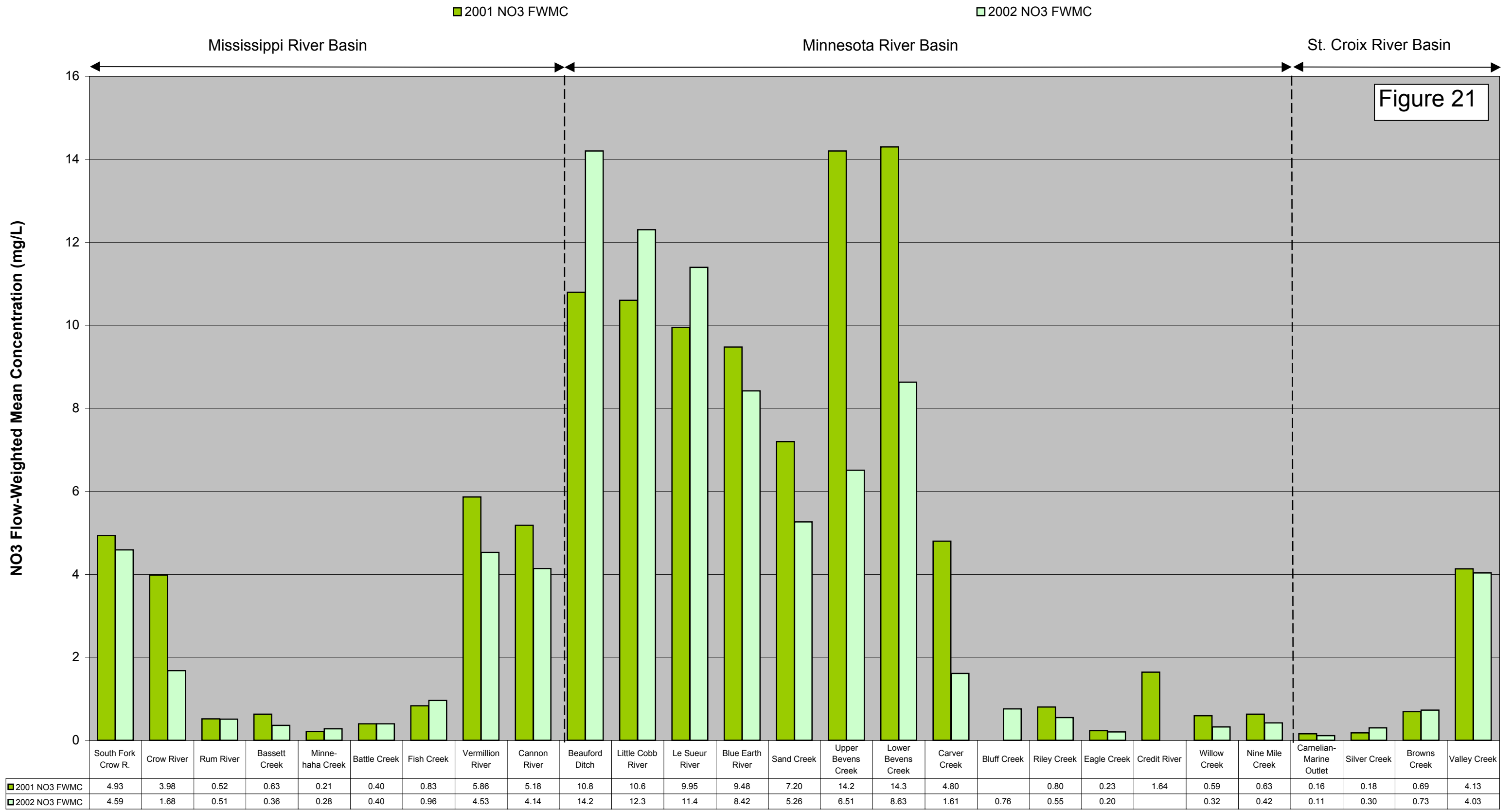


Figure 20. A Comparison of 2001-2002 Nitrate Nitrogen (NO3) Normalized Yields (NY), by Stream and Major River Basin



**Figure 21. A Comparison of Nitrate Nitrogen (NO<sub>3</sub>) Flow-Weighted Mean Concentrations (FWMC), by Stream and Major River Basin**




**Table 5. Streams with the Highest and Lowest Nitrate Nitrogen (NO<sub>3</sub>) Contributions: 2001 – 2002**


STREAMS WITH THE HIGHEST NITRATE NITROGEN (NO<sub>3</sub>) CONTRIBUTIONS: 2001-2002


STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	NITRATE NITROGEN (NO <sub>3</sub> )							
		Highest Load (tons)		Highest Yield ( lbs / acre )		Highest Normalized Yield ( lbs/acre/inch of water )		Highest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Crow River, South Fork	agricultural						1.04		4.59
Cannon River	agricultural	7,081	4,400	16.2	10.3				
Vermillion River	agricultural					1.33		5.86	
Blue Earth River	agricultural	20,300	5,300						
Beauford Ditch	agricultural			56.1	34.6	2.45	3.22	10.8	14.2
Valley Creek	agricultural	79	84	4.00	4.22	0.94	0.91	4.13	4.03

STREAMS WITH THE LOWEST NITRATE NITROGEN (NO<sub>3</sub>) CONTRIBUTIONS: 2001-2002

STREAM ( Grouped by Major River Basin )	PREDOMINANT LAND USE	NITRATE NITROGEN (NO <sub>3</sub> )							
		Lowest Load (tons)		Lowest Yield ( lbs / acre )		Lowest Normalized Yield ( lbs/acre/inch of water )		Lowest Concentration ( mg/L)	
		2001	2002	2001	2002	2001	2002	2001	2002
Battle Creek	urban	2.38	3.90						
Minnehaha Creek	urban			0.30	0.66	0.05	0.06	0.21	0.28
Eagle Creek	urban	1.99	2.12			0.05	0.05	0.23	0.20
Riley Creek	urban			0.98					
Willow Creek	urban				0.78				
Silver Creek	agricultural	0.15		0.06					
Carnelian-Marine Outlet	agricultural		0.91		0.09	0.04	0.02	0.16	0.11

 = Tributary to the Mississippi Riiver

 = Tributary to the Minnesota River

 = Tributary to the St. Croix River

## **Compliance with Water Quality Standards**

### **Standards for Protection of Aquatic Life and Recreation**

The Minnesota Pollution Control Agency (MPCA) has established a use classification system for all surface waters in the state. All MCES streams have been assigned the beneficial use classification of Class 2: Aquatic life and recreation. Browns Creek, Valley Creek, and Eagle Creek are further designated as Class 2A: Cold water fisheries, trout waters.

To protect the designated beneficial uses of surface waters as classified, the MPCA has established numeric water quality standards. Water quality standards for Class 2 waters, for instance, have been set at levels that afford protection of aquatic life and recreation. Standards for Class 2A waters provide greater protection of a cold water fishery.

For surface waters with available monitoring data, compliance with water quality standards is assessed by the MPCA on a biennial basis. This biennial assessment, as required by Section 305(b) of the federal Clean Water Act, is submitted to the Environmental Protection Agency (EPA) as a “305(b) report”. As a part of the “305(b) report”, Section 303(d) of the Clean Water Act requires the MPCA to publish a “303(d) list” of all state waters that are not currently meeting water quality standards and are thereby determined to be “impaired”.

The beneficial use classification system for Minnesota surface waters, water quality standards for various pollutants, and the MPCA assessment protocols for determining surface water impairment are detailed in the MPCA’s “Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report and 303(d) List”. This manual was published in January 2003 and is available on the MPCA’s website at: <http://www.pca.state.mn.us/publications/manuals/tmdl-guidancemanual.pdf>.

### **Trace Metals**

Although many trace metals are essential elements for aquatic life, excessive levels from anthropogenic sources can cause short-term (acute) or long-term (chronic) toxicity. As such, the MPCA has established toxicity-based chronic and maximum (acute) water quality standards for trace metals. These standards for total trace metals, including cadmium, chromium III, copper, lead, nickel, and zinc, vary with the total hardness of the water. The chronic and maximum standards for all toxic contaminants are detailed in the MPCA’s “Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report and 303(d) List”. A stream is considered impaired if the chronic standard for any trace metal is exceeded two or more times and/or if the maximum standard is exceeded one or more times during a three-year period.

Using the MPCA’s assessment approach in conjunction with the trace metals standards, the trace metals data for MCES streams were evaluated for the January 1, 2000 – December 31, 2002 period. All MCES streams fully supported the water quality standards for chromium III and nickel. With the exception of Beltline Interceptor, all MCES streams fully supported the water quality standards for cadmium. Beltline Interceptor in the Mississippi River Basin was identified as impaired due to three exceedances of the chronic cadmium standard during the three-year assessment period.

### *Copper*

Sixteen of the 28 streams monitored by MCES were identified as impaired due to occasional high copper levels. Ten streams were impaired due to exceedances of both the chronic and the maximum standards. Four streams were impaired due to an exceedance of the chronic standard only. Two streams were impaired due to an exceedance of the maximum standard only. Table 6 provides a list of MCES streams with a copper impairment.

**Table 6. MCES Streams with a Copper Impairment**

<b>Basin</b>	<b>Stream</b>	<b>Standard Exceeded</b>
Mississippi River	Minnehaha Creek	Chronic and Maximum
Mississippi River	Beltline Interceptor	Chronic and Maximum
Mississippi River	Battle Creek	Chronic and Maximum
Mississippi River	Vermillion River	Chronic
Middle Minnesota River	Beauford Ditch	Chronic and Maximum
Middle Minnesota River	Little Cobb River	Chronic
Middle Minnesota River	Le Sueur River	Chronic and Maximum
Lower Minnesota River	Carver Creek	Chronic and Maximum
Lower Minnesota River	Bluff Creek	Chronic and Maximum
Lower Minnesota River	Riley Creek	Chronic and Maximum
Lower Minnesota River	Sand Creek	Chronic and Maximum
Lower Minnesota River	Willow Creek	Chronic and Maximum
Lower Minnesota River	Nine Mile Creek	Chronic and Maximum
St. Croix River	Silver Creek	Chronic
St. Croix River	Browns Creek	Chronic
St. Croix River	Valley Creek	Chronic and Maximum

In the Mississippi River Basin, three urban streams and one agricultural stream were identified as copper-impaired.

In the Minnesota River Basin, one urban stream, Riley Creek, was identified as copper-impaired. Several of the agricultural and rural streams were also identified as copper-impaired.

In the St Croix River Basin, three of four streams monitored were identified as copper-impaired. The St Croix River Basin is mostly agricultural and rural.

## ***Lead***

Thirteen of the 28 streams monitored by MCES were identified as impaired due to occasional high lead levels. The Beltline Interceptor was impaired due to exceedances of both the chronic and the maximum standards, while the remaining 12 streams were impaired due to an exceedance of the chronic standard only. Table 7 provides a list of MCES streams with a copper impairment.

**Table 7. MCES Streams with a Lead Impairment**

<b>Basin</b>	<b>Stream</b>	<b>Standard Exceeded</b>
Mississippi River	Basset Creek	Chronic
Mississippi River	Minnehaha Creek	Chronic
Mississippi River	Beltline Interceptor	Chronic and Maximum
Mississippi River	Battle Creek	Chronic
Mississippi River	Fish Creek	Chronic
Middle Minnesota River	Beauford Ditch	Chronic
Middle Minnesota River	Le Sueur River	Chronic
Lower Minnesota River	Bluff Creek	Chronic
Lower Minnesota River	Riley Creek	Chronic
Lower Minnesota River	Willow Creek	Chronic
Lower Minnesota River	Nine Mile Creek	Chronic
St. Croix River	Silver Creek	Chronic
St. Croix River	Browns Creek	Chronic

In the Mississippi River Basin, five urban streams were identified as lead-impaired.

In the Minnesota River Basin, three urban and three agricultural streams were identified as lead-impaired.

In the St Croix River Basin, two of four streams monitored (Silver Creek and Browns Creek) were identified as lead-impaired. The St Croix River Basin is mostly agricultural and rural.

## ***Zinc***

Five of the 28 streams monitored by MCES were identified as impaired due to occasional high zinc levels. Four streams were impaired due to exceedances of both the chronic and the maximum standards. One stream, Le Sueur River, was impaired due to an exceedance of the chronic standard only. Table 8 provides a list of MCES streams with a zinc impairment.

**Table 8. MCES Streams with a Zinc Impairment**

<b>Basin</b>	<b>Stream</b>	<b>Standard Exceeded</b>
Mississippi River	Beltline Interceptor	Chronic and Maximum
Mississippi River	Battle Creek	Chronic and Maximum
Middle Minnesota River	Le Sueur River	Chronic
Lower Minnesota River	Riley Creek	Chronic and Maximum
Lower Minnesota River	Willow Creek	Chronic and Maximum

In the Mississippi River Basin, two urban streams (Beltline Interceptor and Battle Creek) were identified as zinc-impaired. No agricultural streams were identified as zinc-impaired.

In the Minnesota River Basin, one agricultural stream (Le Sueur River) and two urban streams (Riley and Willow Creeks) were identified as zinc-impaired.

In the St Croix River Basin, no MCES streams were identified as zinc-impaired. All four streams in the basin are characterized by agricultural/rural watersheds.

### **Chloride**

Chloride in road salt can be a particular concern in urban areas, especially during snowmelt and spring runoff periods when storm sewer systems readily convey road runoff to surface waters. Excessive levels of chloride in surface waters can cause short-term (acute) or long-term (chronic) toxicity to aquatic life. As such, the MPCA has established toxicity-based chronic and maximum (acute) water quality standards for chloride. The chronic standard for chloride is 230 mg/L and the maximum standard is 860 mg/L. A stream is considered impaired if the chronic standard for chloride is exceeded two or more times and/or if the maximum standard is exceeded one or more times during a three-year period.

Using the MPCA's assessment approach in conjunction with the chloride standards, the chloride data for MCES streams were evaluated for the January 1, 2000 – December 31, 2002 period. Five of the 28 streams monitored by MCES were identified as impaired due to occasional high chloride levels. Three streams were impaired due to exceedances of both the chronic and the maximum standards, while the remaining 2 streams were impaired due to an exceedance of the chronic standard only. Table 9 provides a list of MCES streams with a chloride impairment.

**Table 9. MCES Streams with a Chloride Impairment**

<b>Basin</b>	<b>Stream</b>	<b>Standard Exceeded</b>
Mississippi River	Bassett Creek	Chronic and Maximum
Mississippi River	Minnehaha Creek	Chronic and Maximum
Lower Minnesota River	Upper Bevens Creek	Chronic
Lower Minnesota River	Willow Creek	Chronic and Maximum
Lower Minnesota River	Nine Mile Creek	Chronic

In the Mississippi River Basin, two urban streams (Bassett and Minnehaha Creeks) were identified as chloride-impaired. No agricultural streams were identified as chloride-impaired.

In the Minnesota River Basin, one agricultural stream (Upper Bevens Creek) and two urban streams (Willow and Nine Mile Creeks) were identified as chloride-impaired.

In the St Croix River Basin, no MCES streams were identified as chloride-impaired. All four streams in the basin are characterized by agricultural/rural watersheds.

### **Bacteria**

Maintaining fishable and swimmable waters is an important goal of the federal Clean Water Act. Water-based recreational activities are typically divided into two categories: primary and secondary body contact. Primary body contact includes any form of water recreation, such as swimming, where immersion in the water and the possibility of inadvertently ingesting some water is likely. Secondary body contact includes types of recreation like fishing and canoeing, where the likelihood of ingesting water is much smaller.

The MPCA uses fecal coliform bacteria as a measure of the recreational suitability of Minnesota waters. These bacteria reside in the digestive tracts of warm-blooded animals, including humans, dogs, and cattle. While the fecal coliform bacterium is not pathogenic, its occurrence in surface water may indicate the presence of pathogens responsible for diseases such as typhoid fever, hepatitis, and dysentery.

The MPCA's water quality standard for fecal coliform bacteria is a monthly geometric mean of 200 organisms or less per 100 mL of water, based upon a minimum of five samples obtained during a calendar month. Furthermore, a maximum bacteria level of 2,000 organisms per 100 mL is not to be exceeded in more than 10% of all samples obtained during a calendar month. This standard is applicable for primary body contact in Class 2 waters during the April 1 – October 31 period of the calendar year.

The water quality standard for fecal coliform bacteria is detailed in the MPCA's "Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report and 303(d) List".

The determination of bacteria impairment in surface waters is a two-step assessment. The first step is a screening process that identifies waters with potential fecal coliform bacteria problems. Step 1 requires a minimum of 10 data points obtained during the most recent 10-year period. The individual fecal coliform bacteria values during the April 1 – October 31 period are compared to the water quality standard of 200 organisms per 100 mL. If fewer than 10% of the bacteria values exceed the standard, the water body is identified as fully supporting the beneficial use (primary body contact), and no further evaluation is conducted. If 10% or more of the bacteria values exceed the standard, the water body is identified as potentially impaired, and Step 2 of the assessment process begins.

In Step 2, all bacteria data for the 10-year period are aggregated by calendar month, for the April 1 – October 31 period. A minimum of five values per month is needed for further assessment, and geometric means are calculated for the aggregated monthly data. If the geometric means for all months do not exceed the water quality standard of 200 organisms per 100 mL, the water body is identified as fully supporting the beneficial use. If the geometric mean(s) for one or two months exceed the water quality standard of 200 organisms per 100 mL, the water body is identified as partially supporting the beneficial use. If the geometric means for three or more months exceed the water quality standard of 200 organisms per 100 mL, the water body is identified as not supporting the beneficial use. Also, a water body is identified as partially supporting if 10-25% of individual bacteria values for the 10-year period (independent of month) exceed 2,000 organisms per 100 mL (or 400 organisms per 100 mL for a Class 2A water body). If more than 25% of individual bacteria values for the 10-year period (independent of month) exceed 2,000 organisms per 100 mL (or 400 organisms per 100 mL for a Class 2A water body), the water body is identified as not supporting.

Using the MPCA's assessment approach in conjunction with the fecal coliform bacteria standard, the bacteria data for MCES streams were evaluated for the January 1, 2000 – December 31, 2002 period. This three-year period constitutes the entire period of record for MCES streams, as bacteria sampling began in 2000.

Twenty-two of the 28 streams monitored by MCES have insufficient fecal coliform bacteria data for a Step 1 assessment, and no conclusions can be reached regarding their bacteria impairment status. The lack of bacteria data for MCES streams is largely a reflection of the monitoring approach, which tends to focus on pollutant loading information, thereby employing automatic composite sampling to fully characterize all runoff events. With the extended holding times and possible contamination issues associated with these composite samples, analysis for fecal coliform bacteria is not feasible. To obtain additional data for assessment of bacteria impairment, grab samples would have to be collected during both runoff and baseflow conditions, and samples would have to be delivered to the MCES Laboratory within the six-hour holding time. While this approach is possible, it would certainly entail additional time and effort by MCES staff and local cooperators.

Six streams had sufficient bacteria data (minimum of 10 values) for a Step 1 assessment. These streams include the Crow River, Bassett Creek, Minnehaha Creek, Vermillion River, and Cannon River in the Mississippi River Basin and Eagle Creek in the Lower Minnesota River Basin. The Step 1 assessment identified all six streams as potentially impaired.

With only a three-year period of record, none of the six streams met the minimum Step 2 criterion of five bacteria values per month during the April 1 – October 31 period. As a modification of the MPCA assessment approach for Step 2, the 2000-2003 data for each of the six streams were aggregated to create periods that combined the minimum number of consecutive months needed to obtain the minimum of five bacteria values (Table 10).

**Table 10. Time Periods for Step 2 Assessment of Fecal Coliform Bacteria Data**

Stream	Period 1	Period 2	Period 3	Period 4
Crow River	April, May	June	July, August	September, October
Bassett Creek	April	May, June	July, August	September, October
Minnehaha Creek	April, May	June, July, August	September, October	
Vermillion River	April, May, June, July	August, September, October		
Cannon River	April, May, June	July	August	September, October
Eagle Creek	April, May, June	July, August, September, October		

For example, the 2000-2003 bacteria data for Bassett Creek were aggregated into four periods as follows: Period 1 (6 bacteria values in April); Period 2 (5 bacteria values in May-June); Period 3 (6 bacteria values in July-August); and Period 4 (6 bacteria values in September-October).

Geometric means were then calculated for all periods generated for the six streams identified in Step 1 as potentially impaired. If the geometric means for all periods did not exceed the water quality standard of 200 organisms per 100 mL, the stream was identified as fully supporting the beneficial use. If the geometric mean(s) for one or two periods exceeded the water quality standard of 200 organisms per 100 mL, the stream was identified as partially supporting the beneficial use. If the geometric means for three or more periods exceeded the water quality standard of 200 organisms per 100 mL, the stream was identified as not supporting the beneficial use. Also, a stream was identified as partially supporting if 10-25% of individual bacteria values in the 2000-2003 dataset (independent of period) exceeded 2,000 organisms per 100 mL (or 400 organisms per 100 mL for a Class 2A water body). If more than 25% of individual bacteria values for the three-year dataset (independent of period) exceeded 2,000 organisms per 100 mL (or 400 organisms per 100 mL for a Class 2A water body), the stream was identified as not supporting.

Table 11 presents the results of the fecal coliform bacteria assessment for MCES streams.

**Table 11. Assessment of Fecal Coliform Bacteria Impairment in MCES Streams**

Stream	Step 1		Step 2					
	% of Values Exceeding 200 Organisms per 100 mL	Impairment Status	Period 1 Geo-Mean (#/100 mL)	Period 2 Geo-Mean (#/100 mL)	Period 3 Geo-Mean (#/100 mL)	Period 4 Geo-Mean (#/100 mL)	% of Values Exceeding 2,000 Organisms per 100 mL	Impairment Status
Crow River	14%	Potentially Impaired	30	112	250	81	5%	Partially Supporting
Bassett Creek	60%	Potentially Impaired	162	164	428	205	10%	Partially Supporting
Minnehaha Creek	29%	Potentially Impaired	34	210	213		5%	Partially Supporting
Vermillion River	65%	Potentially Impaired	131	641			18%	Partially Supporting
Cannon River	32%	Potentially Impaired	139	104	336	33	21%	Partially Supporting
Eagle Creek	23%	Potentially Impaired	31	108			0%	Fully Supporting

Using the MPCA approach as modified by MCES, five streams (Crow River, Bassett Creek, Minnehaha Creek, Vermillion River, and Cannon River in the Mississippi River Basin) were identified as partially supporting their beneficial uses. Eagle Creek in the Lower Minnesota River Basin was identified as fully supporting its beneficial use. Please note that the results in Table 10 do not constitute an “official” MPCA assessment of bacteria impairment in these six streams. Only the MPCA can assess surface water impairment for 305(b) reporting and 303(d) listing purposes.

The evaluation of fecal coliform bacteria data for MCES streams yields several significant conclusions. Bacteria data for 22 of the 28 MCES streams (80%) are insufficient for any assessment of possible impairment. More data are needed for these streams. Data for six streams were sufficient enough to indicate potential impairment when a Step 1 assessment was conducted; and five of these six streams were designated as partially supporting their designated uses when a modified Step 2 assessment was conducted. Based upon a limited number of streams with sufficient bacteria data, it seems apparent that bacteria contamination may be a significant water quality concern in MCES streams.

## **Glossary of Stream Monitoring Terms**

**Baseflow:** Stream discharge or flow composed of ground water drainage and delayed surface drainage. Baseflow is typically characterized as that portion of stream flow not related to precipitation-induced runoff.

**Best Management Practices:** Agricultural and urban land management practices that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

**BOD:** Biochemical Oxygen Demand (BOD) is a measure of the quantity of dissolved oxygen necessary per volume of water for the decomposition of organic matter by microorganisms, such as bacteria.

**Composite Sample:** A combined water sample consisting of a series of discrete water samples taken over a given period of time and mixed according to a specified weighting factor such as stream flow. A composite sample is often collected with the use of an automated sampler over the duration of a runoff event.

**Conductivity:** A measure of the ability of water to carry an electrical current, related to the amount of ions in the solution.

**EPT richness index:** A biological index of stream health, expressed as the sum of the number of taxa in three aquatic insect orders: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These three insect orders are composed primarily of species considered to be relatively intolerant of pollution and environmental alterations. Variations of the EPT index include number of EPT taxa, percentage of EPT taxa, number of EPT individuals, and percentage of EPT individuals in a macroinvertebrate sample.

**Flow:** Stream or river flow, commonly expressed as cubic feet per second or "cfs".

**Flow Weighted Mean Concentration:** Similar to normalized yield, the "flow weighted mean concentration" (FWMC) of a water quality variable is calculated by dividing the total mass or load of that variable by the total stream flow, for a given time period. The FWMC is mass normalized for flow, expressed as milligrams per liter (mg/L). Conceptually, a FWMC would be the same as routing all the stream flow that passed by a monitoring site during a given time period into a big, well-mixed pool, and collecting and analyzing one sample from the pool to obtain an average concentration for the water quality variable of interest.

**FLUX:** An interactive program developed by the U.S. Army Corps of Engineers that allows the user to estimate loads and flow weighted mean concentrations for water quality variables, using grab sample concentration data and continuous stream flow records. The term "load" refers to a mass of material passing through a stream during a given time period.

**Grab Sample:** A discrete water sample collected at a particular time and place. A grab sample is most often collected manually with appropriate sampling equipment.

**Hilsenhoff Biotic Index:** A biological index of stream health that measures macroinvertebrate tolerance of organic (nutrient) enrichment. The Hilsenhoff Biotic Index (HBI) is calculated and expressed on a 1-10 scale. An HBI value of 1 suggests the presence of a macroinvertebrate community that is most intolerant of organic enrichment, while an HBI value of 10 suggests the presence of a macroinvertebrate community that is most tolerant of organic enrichment.

**Hydrograph:** A graph of stream flow during a given time period, often seasonal or annual. MCES hydrographs depict daily average stream flows, in cubic feet per second (cfs).

**Load:** A "load" is the total amount or mass of a water quality variable passing through a stream during a given time period, often seasonally or annually. A load reflects the combined contributions of surface runoff and ground water discharge from a specific watershed, as measured at the monitoring station. MCES uses water chemistry and stream flow data to calculate annual loads (expressed in tons) using a FLUX program.

**Macroinvertebrate:** An aquatic invertebrate animal large enough to be seen with the naked eye. Macroinvertebrates include insects, freshwater "shrimp", crayfish, clams, snails, and worms. An analysis of the types and numbers of macroinvertebrates present in a stream, often expressed as a biological "index", is a very useful indicator of water quality and habitat conditions.

**Non-Point Source Pollution:** Non-point source (NPS) pollution, unlike point source pollution from industrial and wastewater treatment plants, comes from many diffuse sources in urban and rural areas. NPS pollution is primarily caused when runoff from rainfall or snowmelt picks up natural and human-made pollutants from land surfaces and carries these pollutants into ground water, streams, rivers, lakes, and wetlands.

**Normalized Yield:** For many water quality variables, the more precipitation that falls on a given watershed, the higher the stream loads and watershed yields will be. To help account for spatial and temporal differences in precipitation, a yield can be further divided by the number of inches of water (water yield) contributed to the stream by the watershed during a given time period, providing a "normalized yield" expressed as pounds per acre per inch of water.

**Phosphorus:** Aquatic plants provide food, oxygen, and habitat for aquatic organisms. However, an excess of plant growth can lead to unsightly algae blooms which cause oxygen depletion and odor upon decaying, making the water unpleasant for recreational activities and unsuitable for aquatic life. Phosphorus, a common component of wastewater treatment plant discharges and urban and agricultural runoff, can stimulate excessive plant growth when phosphorus levels in surface waters are too high.

**Point Source Pollution:** Point source pollution comes from easily identifiable sources, such as discharges from industrial and wastewater treatment plants.

**Rating Curve:** A continuous record of stream discharge or flow (hydrograph) is established by developing a mathematical relationship between water stage, which is continuously measured at the monitoring station, and discharge. This stage-discharge relationship, or "rating curve", is developed by pairing stage data with individual point-in-time discharge measurements. To properly develop a rating curve, discharge measurements should be made at a variety of water stages, from low to high. Using the rating curve, all water stages continuously measured at the monitoring station can be converted to flows, thereby establishing a flow record (hydrograph) for a given time period.

**River Mile:** The distance upstream from the mouth of a river. For example, Le Sueur River Mile 1.3 indicates a location 1.3 miles upstream from the mouth of the Le Sueur River.

**Runoff:** Rainfall, snowmelt, or irrigation water that runs off the land into streams, rivers, lakes, and wetlands. Runoff frequently picks up natural and human-made pollutants from land surfaces and carries these pollutants into surface waters.

**Runoff Event:** The response of stream flow to precipitation-induced runoff. After a precipitation event, a runoff event is characterized by an increase in flow from the baseflow condition as watershed runoff reaches the stream, followed by a subsequent decrease in flow to the baseflow condition after watershed runoff passes through the stream. One objective of the MCES stream monitoring program is to sample throughout each runoff event (via composite sampling), to characterize concentrations and loads of key nonpoint source pollutants.

**Species (Taxa) Richness:** A biological index of stream health, species (taxa) richness is the number of species or taxa present in a biological sample.

**Stage:** The level or height of the water surface, commonly measured in feet.

**Taxon (plural Taxa):** An identifiable taxonomic group of aquatic organisms. Common macroinvertebrate taxa, for instance, include class, order, family, genus, and species.

**Target Pollutant Load:** A target pollutant load is a goal set to limit the amount or load of a pollutant that is being discharged from a watershed via the stream. MCES is developing target pollutant loads for TCMA watersheds, to reduce water quality impacts due to nonpoint source pollution, to help achieve federal and state water quality standards, and to help reduce unnecessary investments in advanced wastewater treatment. Target pollutant loads will be developed through an iterative process that comprehensively assesses stream monitoring data, identifies water quality problems, uses a water quality model to help evaluate the feasibility of target pollutant load goals, and provides support for development of watershed plans that identify management strategies for improvement or protection of stream water quality. MCES intends this to be a collaborative process involving local stakeholders, including watershed management organizations and districts and other local units of government.

**TCMA:** Twin Cities Metropolitan Area.

**Turbidity:** A reduction in water clarity or a cloudiness caused by soil particles or organic matter in the water. These particles may harm aquatic life by decreasing light availability for plant growth, increasing water temperature, clogging the gills of aquatic organisms, and covering habitat. Low turbidity values (at or below 25 NTU) generally indicate good water quality.

**Watershed:** The land area that contributes surface water drainage to a stream. The watershed of a larger stream or river may encompass a number of smaller tributary subwatersheds.

**Water Yield:** The amount of water flowing through a stream during a given time period divided by the watershed area, expressed as inches of water.

**Yield:** One way to assess and compare the pollutant loads from watersheds of different sizes is to determine the "yield", or pollutant load per unit area of the watershed. Yield normalizes pollutant load on the basis of watershed area, allowing for more relative comparisons to be made between watersheds. Yield is calculated by dividing the total pollutant load for a given time period by the watershed area, and is commonly expressed as pounds per acre. Pollutant loads and yields are primarily a function of soil type, land use, landscape characteristics, and the amount, timing, and intensity of precipitation.