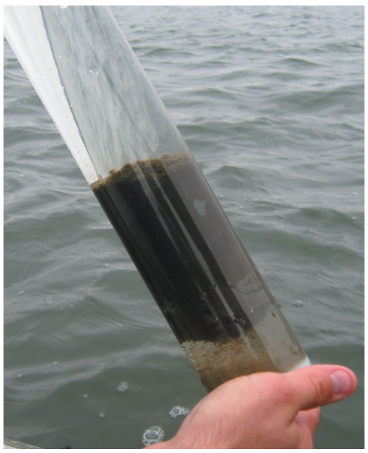
Emmons & Olivier Resources, Inc.
for the Mississippi Headwaters Board

Including: Clearwater, Beltrami, Cass, Hubbard, Itasca, Aitkin, Crow Wing, and Morrison Counties

400-Mile Mississippi Headwaters Water Quality Analysis: 2003-2013



03.28.2014

water ecology community

Cover Images

Left Image: Water Quality Sampling

Right Image: EOR staff at the Mississippi Headwaters, Itasca State Park - MN

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Abbreviations

AUID	Assessment Unit Identification
DNR	Department of Natural Resources
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
FWMC	Flow-weighted mean concentration
HUC	Hydrologic Unit Code
NPDES	National Pollutant Discharge Elimination System
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
MPCA	Minnesota Pollution Control Agency
USGS	United States Geological Survey
WWTP	Wastewater Treatment Plant

1. EXECUTIVE SUMMARY

The Mississippi Headwaters encompasses the first 400-miles of the Mississippi River, beginning in Lake Itasca in Clearwater County and extending to the Morrison/Benton County line. Along this 400-mile route, the Mississippi River flows through 6 major (HUC 8) watersheds, 9 lakes and 8 cities. The project area consists of 48 stream segments (or individual MPCA assessment units).

In 2012, the Mississippi Headwaters Board working in cooperation with member counties undertook a project to identify and prioritize areas of concern that exhibit water quality degradation or are areas critical for long term water quality protection. This project utilized all available water quality, flow, and biological data collected by MPCA, DNR, USGS, counties, and cities in the Mississippi Headwaters from 2003-2012. Implementation plans and strategies will be developed and prioritized based on the results from this project that can be incorporated into the Mississippi Headwaters Board Comprehensive Management Plan and individual County Comprehensive Local Water Plans.

An inventory of all available water quality data was conducted, and 10-year average concentrations of eight pollutants were calculated for each stream segment. The mean concentrations of pollutants were also compared to the Minnesota water quality standards for the region. Only 7 of the 18 AUIDs assessed did not meet water quality standards for one or more pollutants based on 10-year average concentrations. Total phosphorus exceedances occurred on 5 reaches, and TSS exceedances occurred on 3 reaches. River mile water quality figures were constructed to illustrate spatial trends in water quality along the entire mainstem of the Mississippi River within the Mississippi Headwaters Board jurisdiction. In general, water quality was best in the middle reaches of the Mississippi River mainstem.

Phosphorus flow-weighted mean concentrations (FWMCs) and loads were estimated using the program FLUX based on USGS flow data and MPCA phosphorus data collected between 2003 and 2012 at five stations along the Mississippi River mainstem and one major tributary (Crow Wing River). TP FWMCs are lowest between Lake Itasca and Grand Rapids, then double from Grand Rapids to Aitkin and remain mostly stable between Aitkin and Royalton. The Crow Wing River TP FWMCs were greater than the Mississippi River mainstem. The corresponding TP loads in the Mississippi River mainstem increased from upstream to downstream stations due to increasing contributing watershed area and point sources. Compared to pollutant loads in the Mississippi River through the rest of the state, the Mississippi River near Royalton contributes just 12% of the TP load measured at Lock and Dam #3, and less than 10% of the TSS and nitrogen.

To evaluate the effects of flow-through lakes and reservoirs on Mississippi River water quality, a comparison was conducted between the average annual growing season water quality in the lake or reservoir and the next downstream Mississippi River monitoring site. Only two lakes had both in-lake data and corresponding downstream data: Stump Lake in Beltrami County and Cass Lake in Cass County. Phosphorus concentrations in the Mississippi River were higher downstream of Stump Lake but lower downstream of Cass Lake, indicating that Stump Lake is contributing phosphorus to the Mississippi River mainstem while Cass Lake is removing phosphorus.

Long-term daily USGS flow records were available at six stations along the Mississippi River Headwaters mainstem. Year-round daily median flows were quantified at all stations except near Bemidji and at Ball Club for the most recent 10 years. Annual variability in median flow was more pronounced at the more downstream stations. This variability was dampened upstream of Grand Rapids where there are numerous flow-through lakes and reservoirs, large expanses of wetlands, and several dams.

Biological data from the MPCA and DNR were collected and evaluated. As part of their biological monitoring, the MPCA sampled fish and invertebrate communities at three stations along the mainstem of the Mississippi River within the MHB jurisdiction in the most recent 10 years. In 2007, the Minnesota Department of Natural resources conducted a comprehensive survey of fish and invertebrate communities in the Mississippi River between Lake Itasca and the Coon Rapids dam. In general good quality fish and invertebrate communities were found throughout the headwaters with the highest quality communities found at the more upstream sites.

The results of the data compilation and analyses are detailed in the report with the trend analysis organized by county. Maps were produced illustrating the AUIDs that had data available and AUIDs that showed exceedances organized by county. Lastly, reach summary sheets were created for each AUID that had sufficient data available summarizing the finding of the analysis. The reach summary sheets are grouped by county to facilitate ease of use by the individual counties.

2. INTRODUCTION

A. Project Purpose

The Mississippi Headwaters Board is working in cooperation with member counties to develop implementation plans and strategies that will be incorporated into individual County Comprehensive Local Water Plans. The goal of this report is to gather and present information that will help identify areas of concern along the river where water quality is degrading, and areas that are critical to long-term water quality protection.

B. Report Organization

This report is organized into four major components:

1. **Section 2: Data Assessment:** Overall assessment of data collected for the entire Mississippi River Headwaters, including summaries of:

    a. **Data inventory** from 2003-2012, identifying data gaps and future monitoring recommendations
    b. **Water quality data** and major trends, identifying river segments that exceed state water quality standards
    c. **Fish and invertebrate data** collected by the MPCA, and 2007 DNR fisheries survey of the Mississippi River headwaters.
    d. **Flow data** monitored by the USGS at six stations along the Mississippi River headwaters and one major tributary (Crow Wing River)
    e. **Pollutant sources and loads**, specifically NPDES permitted sources of phosphorus, flow weighted mean concentrations and loads of total phosphorus, and the relative contribution of TP, TSS, nitrate-nitrite, and TN of the Mississippi River Headwaters to the Mississippi River at Lock and Dam #3
    f. **In-lake and downstream water quality** of Stump and Cass Lakes, with monitoring recommendations to expand this analysis to other flow-through lakes and reservoirs
    g. **Recommendations for future studies** based on data gaps identified in this study and other general water quality concerns for the Mississippi River Headwaters.

2. **Sections 3 – 9**: Water quality trends and fish and invertebrate community descriptions for each river reach with recent (2003-2012) water quality data, organized by county.

3. **Section 10**: Appendices of average annual water quality figures for each river reach with recent (2003-2012) water quality data, organized by county.

4. **Attachment**: Graphical summary sheets for each river reach with recent (2003-2012) water quality data.

C. Study Area

The Mississippi Headwaters encompasses the first 400-miles of the Mississippi River, beginning in Lake Itasca in Clearwater County and extending to the Morrison/Benton County line (Figure 1). Along this 400-mile route, the Mississippi River flows through 6 major watersheds, 9 lakes and 8 cities (Table 1, Table 2, Table 3).

Table 1. Major watersheds of the Mississippi River Headwaters

Name	Major Watershed 8-digit Hydrologic Unit Code
Mississippi River (Headwaters)	07010101
Leech Lake River	07010102
Mississippi River (Grand Rapids)	07010103
Mississippi River (Brainerd)	07010104
Pine River	07010105
Mississippi River (Sartell)	07010201

Table 2. Lakes, cities, and counties of the Mississippi River Headwaters

Name	DNR ID	Area (acres)	Depth (feet)
Irving	04-0140-00	613	19
Bemidji	04-0130-00	6,580	76
Stump	04-0130-01	323	24
Wolf	04-0079-00	1,073	57
Andrusia	04-0038-00	1,590	60
Cass	04-0030-00	15,958	120
Winibigoshish	11-0147-00	56,471	70
Little Winibigoshish	31-0850-00	945	28
Blackwater	31-0561-00	674	72

Table 3. Cities of the Mississippi River Headwaters

Name	2010 Population (US Census)
Bemidji	13,431
Cohasset	2,698
Grand Rapids	10,869
Palisade	167
Brainerd	13,590
Baxter	7,610
Fort Ripley	69
Little Falls	8,343

Figure 1. Map of the Mississippi River Headwaters

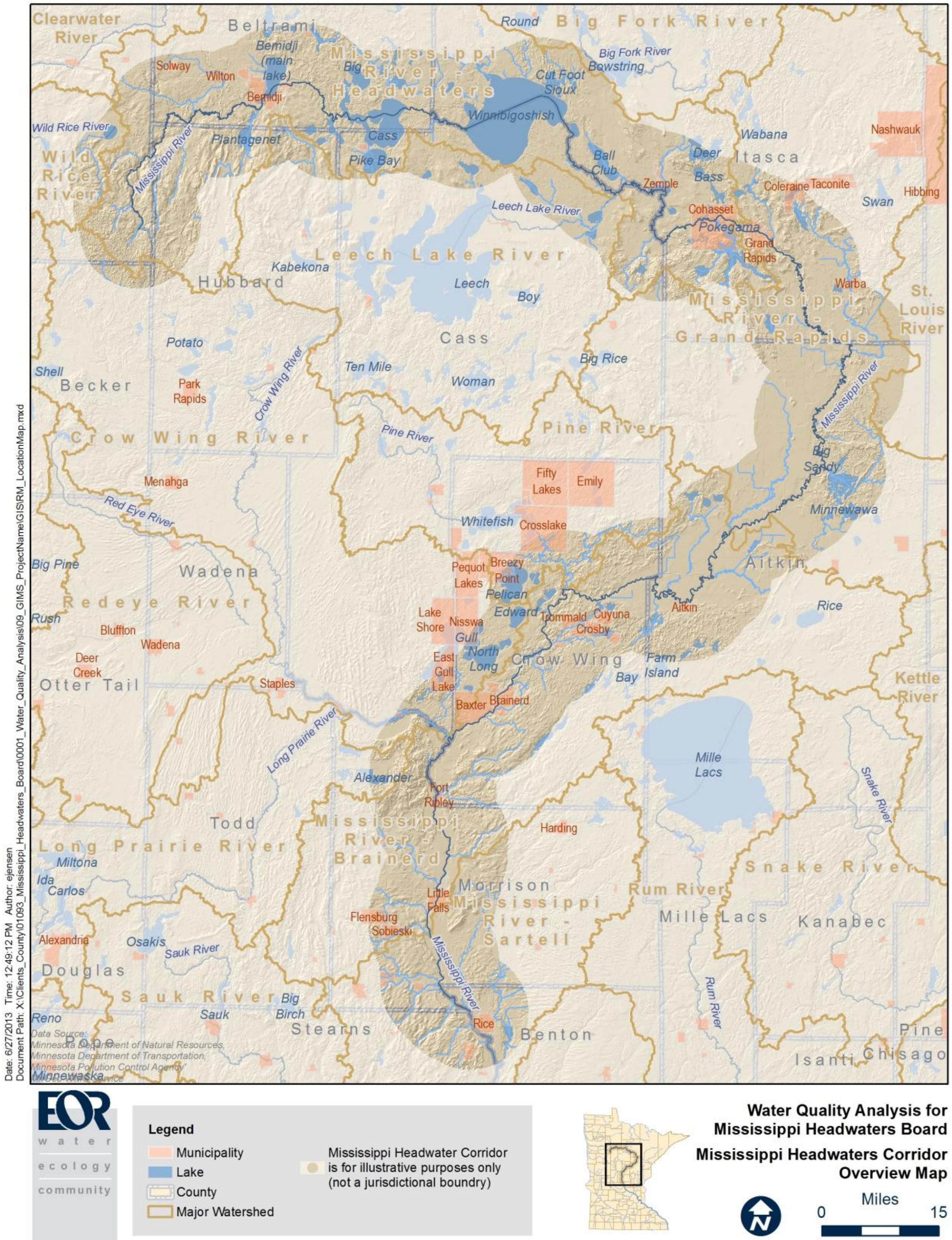


Table 4. Mississippi River Headwaters stream reach segment information
Lake reaches are highlighted in blue

AUID/DNR ID	REACH DESCRIPTION	CITIES	COUNTIES	LENGTH (MILES)	USE CLASS
07010101-923	Headwaters to Unnamed Creek		Clearwater, Hubbard	29.57	2B, 3C
07010101-924	Unnamed Creek to Schoolcraft River		Beltrami	28.60	2B, 3C
07010101-722	Schoolcraft River to Lake Irving		Beltrami	0.81	2B, 3C
04-0140-00	Lake Irving	Bemidji	Beltrami	2.11	2B, 3C
07010101-720	Lake Irving to Lake Bemidji	Bemidji	Beltrami	0.17	2B, 3C
04-0130-00	Lake Bemidji	Bemidji	Beltrami	11.69	2B, 3C
07010101-512	Lake Bemidji to Stump Lake	Bemidji	Beltrami	3.78	2B, 3C
04-0130-01	Stump Lake		Beltrami	2.36	2B, 3C
07010101-513	Stump Lake to Wolf Lake		Beltrami	6.27	2B, 3C
04-0079-00	Wolf Lake		Beltrami, Hubbard	3.30	2B, 3C
07010101-514	Wolf Lake to Andrusia Lake		Beltrami	1.98	2B, 3C
04-0038-00	Lake Andrusia		Beltrami	5.30	2B, 3C
07010101-515	Andrusia Lake to Cass Lake		Beltrami	0.63	2B, 3C
04-0030-00	Cass Lake		Beltrami, Cass	15.32	2B, 3C
07010101-507	Cass Lake to Lake Winnibigoshish		Beltrami	10.95	2B, 3C
11-0147-00	Lake Winnibigoshish		Cass, Itasca	61.07	2B, 3C
07010101-723	Lake Winnibigoshish to Little Winnibigoshish Lake		Cass, Itasca	1.67	2B, 3C
31-0850-00	Little Winnibigoshish Lake		Itasca	0.60	2B, 3C
07010101-725	Little Winnibigoshish Lake to Leech Lake River		Cass, Itasca	14.40	2B, 3C
07010101-506	Leech Lake River to Ball Club River		Cass	2.61	2B, 3C
07010101-693	Artificial Path Connects loop of 506 & 503		Cass, Itasca	0.38	2B, 3C
07010101-503	Ball Club River to Deer River		Cass, Itasca	11.11	2B, 3C
07010101-502	Deer River to Vermillion River		Cass	10.73	2B, 3C
07010101-501	Vermillion River to Blackwater Lake		Itasca	8.11	2B, 3C

AUID/DNR ID	REACH DESCRIPTION	CITIES	COUNTIES	LENGTH (MILES)	USE CLASS
31-0561-00	Blackwater Lake	Cohasset	Itasca	7.20	2B, 3C
07010101-648	Blackwater Lake to Bass Brook	Cohasset	Itasca	1.27	2B, 3C
07010103-511	Bass Brook to Cohasset Dam	Cohasset	Itasca	2.08	2B, 3C
07010103-510	Cohasset Dam to Grand Rapids Dam (31-0533-00)	Cohasset, Grand Rapids	Itasca	3.26	2B, 3C
07010103-503	Grand Rapids Dam to Prairie River	Grand Rapids	Itasca	2.82	2B, 3C
07010103-502	Prairie River to Split Hand Creek		Itasca	23.47	2B, 3C
07010103-507	Split Hand Creek to Swan River		Itasca, Aitkin	13.72	2B, 3C
07010103-505	Swan River to Sandy River		Aitkin	32.33	2B, 3C
07010103-501	Sandy River to Willow River	Palisade	Aitkin	27.80	2B, 3C
07010104-512	Willow River to Rice River		Aitkin	12.17	2B, 3C
07010104-503	Rice River to Little Willow River		Aitkin	16.41	2B, 3C
07010104-517	Little Willow River to Pine River		Aitkin, Crow Wing	25.81	2B, 3C
07010104-501	Pine River to Brainerd Dam	Brainerd	Crow Wing	20.32	2B, 3C
07010104-516	Brainerd Dam to Crow Wing River	Brainerd, Baxter	Crow Wing	13.49	2B, 3C
07010104-515	Crow Wing River to Nokasippi River	Fort Ripley	Crow Wing, Morrison	8.41	2B, 3C
07010104-576	Nokasippi River to Crow Wing/Morrison County border	Fort Ripley	Morrison, Crow Wing	1.67	2B, 3C
07010104-577	Crow Wing/Morrison County border to Fletcher Creek		Morrison	8.21	1C, 2Bd, 3C
07010104-513	Fletcher Creek to Little Elk River		Morrison	4.27	1C, 2Bd, 3C
07010104-520	Little Elk River to Little Falls Dam	Little Falls	Morrison	2.54	1C, 2Bd, 3C
07010104-519	Little Falls Dam to Swan River	Little Falls	Morrison	4.35	1C, 2Bd, 3C
07010201-501	Swan River to Two River		Morrison	7.58	1C, 2Bd, 3C
07010201-509	Two River to Spunk Creek		Morrison, Benton	3.71	1C, 2Bd, 3C
07010201-508	Spunk Creek to Platte River		Morrison, Benton	1.86	1C, 2Bd, 3C
07010201-606	Platte River to Morrison/Stearns County border		Morrison, Benton	0.52	1C, 2Bd, 3C

[1]All waters, whether designated with a specific beneficial use classification or not, are also classified as 3C, 4A, 4B, 5, and 6 waters. For waters with multiple classifications, the more restrictive standards apply.

The following figures are provided to illustrate the location and relative size of each of the stream reaches and lakes in the Headwaters area and whether they are included in the analysis.

Figure 2. Mississippi Headwaters River Mile Map – Clearwater & Beltrami Counties

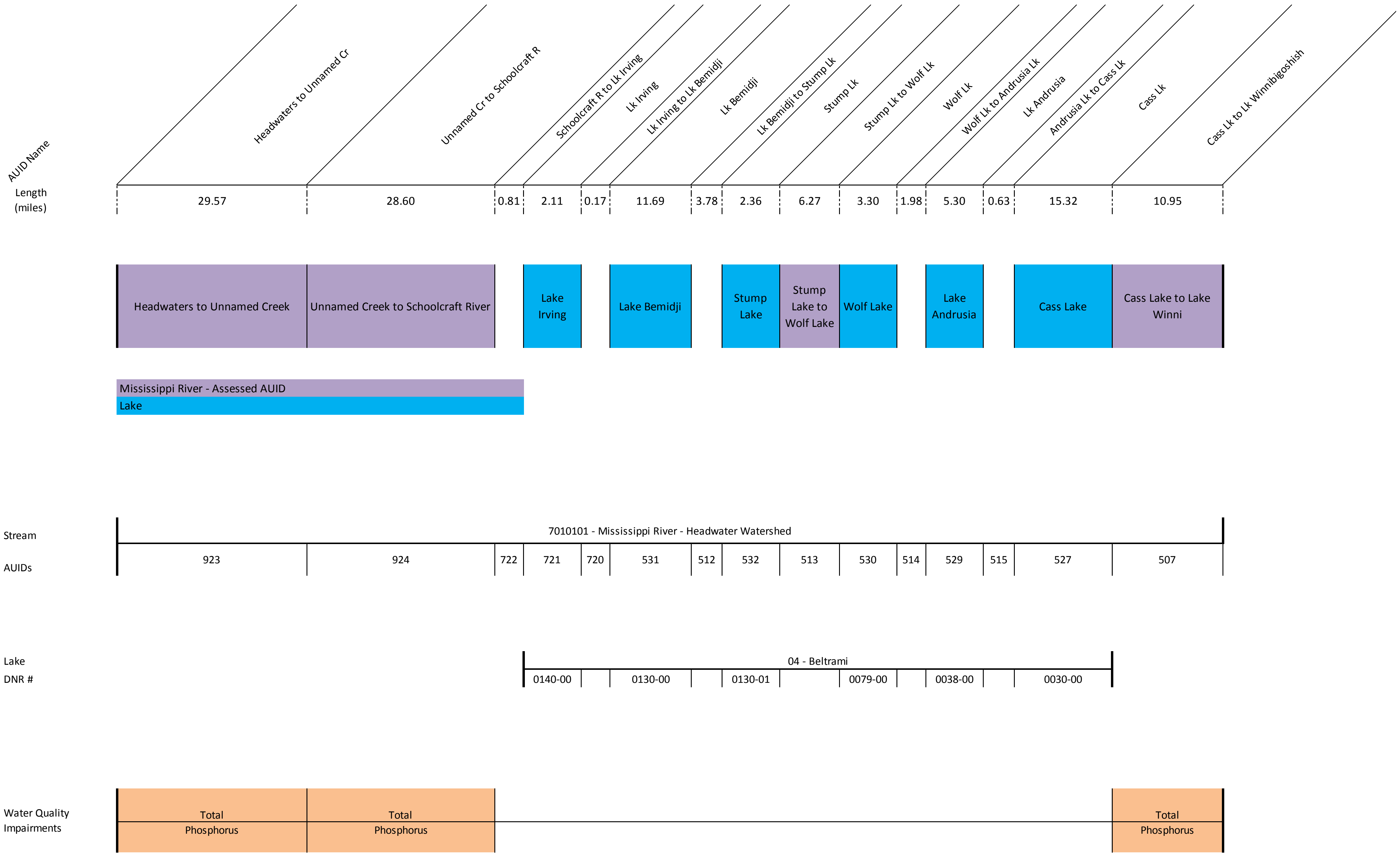


Figure 3. Mississippi Headwaters River Mile Map – Cass & Itasca Counties

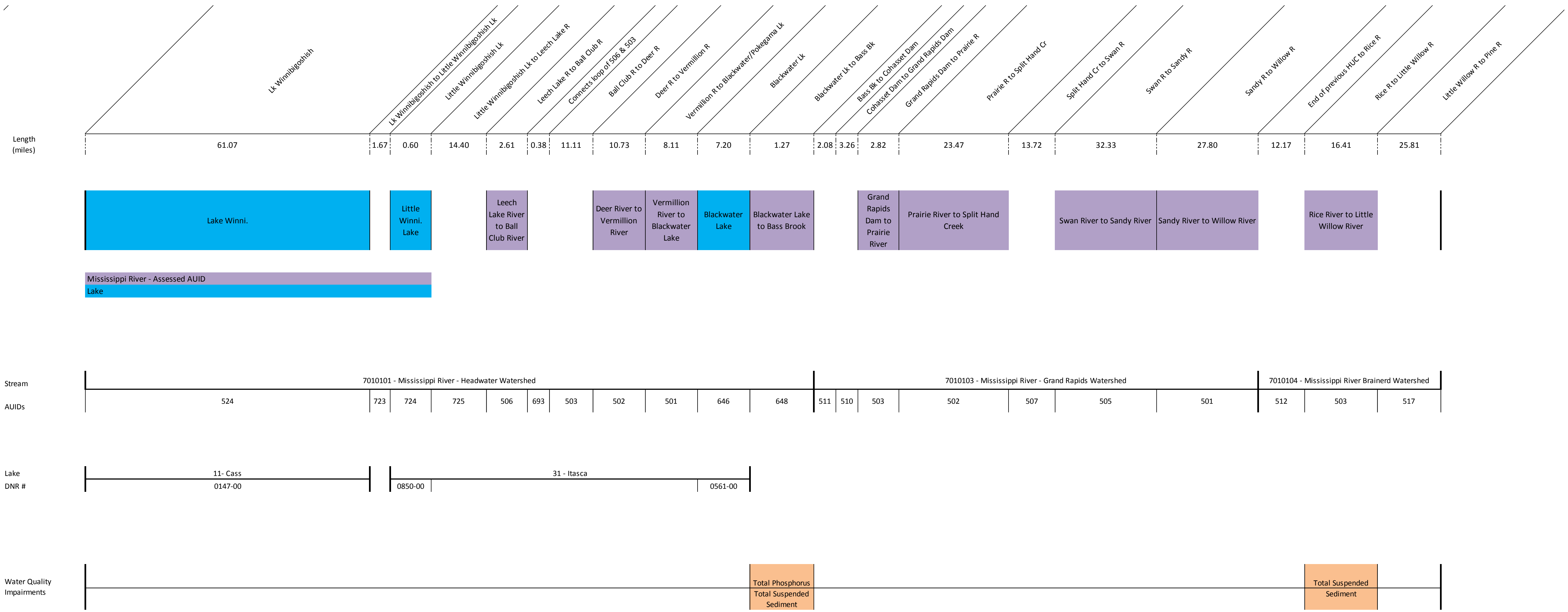
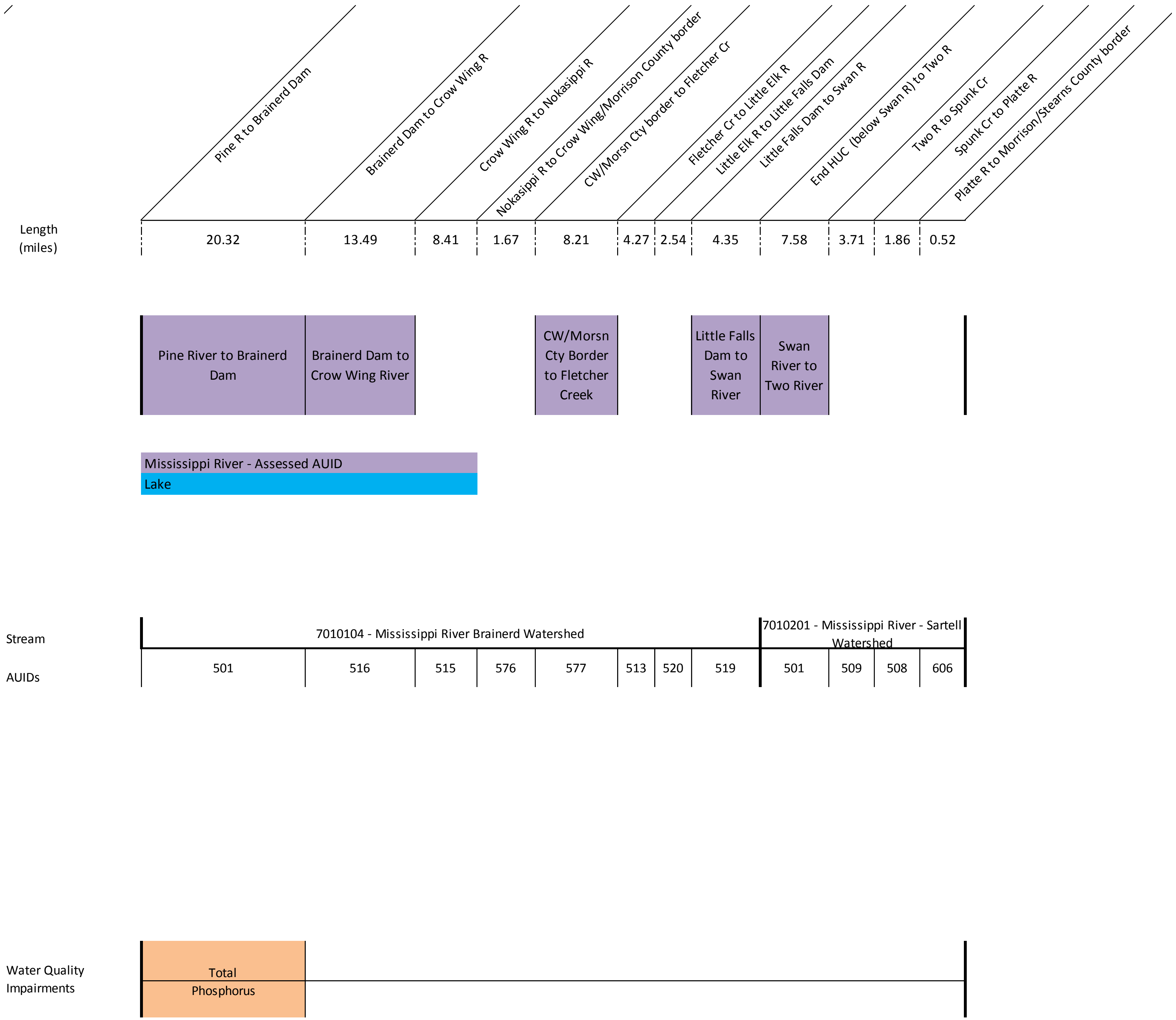


Figure 4. Mississippi Headwaters River Mile Map – Aitkin, Crow Wing & Morrison Counties



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3. DATA ASSESSMENT

A. Data Inventory

Water quality, flow and biological data from 2003-2012 were gathered from MPCA, DNR, and USGS. These data were collected at monitoring stations on a subset of all the stream segments and lakes within the Mississippi Headwaters, summarized in Table 6 and Figure 5. An inventory of all available monitoring data collected for this study is summarized in Table 7.

Data Gaps

The project area consists of 48 stream segments (listed by MPCA assessment unit identification numbers, or AUIDs) of which 30 stream segments lack data from the most recent 10 years (2003-2012). Stream segments with data available from the most recent 10 years are shown in Figure 5.

Monitoring Recommendations

In order to move toward a more comprehensive data set for future analysis of the Mississippi Headwaters, additional monitoring efforts are needed for the stream segments identified in Table 3. The stream segments in bold were found to have at least one parameter exceeding the water quality standards and should be evaluated further to determine the source of the impairment. The other stream segments are lacking in data and/or either directly upstream or downstream of a flow-through lake or a stream segment that is not meeting water quality standards. It is recommended that during the growing season (June through September) bi-weekly sampling take place for a minimum of 2 consecutive years. Sampling should be conducted at one to three stations per AUID depending on the length of the AUID. At a minimum, the following parameters should be sampled: dissolved oxygen, total phosphorus, total suspended solids, and nitrate. Sampling on all stream segments and flow-through lakes should be conducted during the same growing seasons to facilitate comparisons between stream reaches.

Table 5. Mississippi River Headwaters stream segments

AUID/DNR ID	Location (by upstream identifier)	County
07010101-923	**Headwaters**	**Clearwater**
07010101-924	**Unnamed Creek**	**Beltrami**
07010101-722	Schoolcraft River	Beltrami
07010101-720	Lake Irving	Beltrami
07010101-512	Lake Bemidji	Beltrami
07010101-514	Wolf Lake	Beltrami
07010101-515	Andrusia Lake	Beltrami
07010101-507	**Cass Lake**	**Beltrami**
07010101-723	Lake Winnibigoshish	Cass
07010101-725	Little Winnibigoshish	Cass

AUID/DNR ID	Location (by upstream identifier)	County
07010101-648	Blackwater Lake	Itasca
07010103-501	**Sandy River**	**Aitkin**
07010104-512	Willow River	Aitkin
07010104-503	**Rice River**	**Aitkin**
07010104-517	Little Willow River	Aitkin

Table 6. Mississippi River Headwaters monitoring stations by stream segment
Segments with two or more water quality, biological, or flow station types are highlighted in bold font.

AUID/DNR ID	Location (by upstream identifier)	Length (miles)	MPCA Water Quality Station ID	MPCA Biological Station ID	USGS Flow Station ID
07010101-923	**Headwaters**	**29.57**	**S000-105 S001-893 S001-895 S001-900 S001-902**	**10EM113**	
07010101-924	Unnamed Creek	28.60	S001-896 S001-897 S001-903		
07010101-722	Schoolcraft River	0.81			
04-0140-00	Lake Irving	2.11			
07010101-720	Lake Irving	0.17			
04-0130-00	Lake Bemidji	11.69			
07010101-512	Lake Bemidji	3.78			
04-0130-01	Stump Lake	2.36			
07010101-513	**Stump Lake**	**6.27**	**S000-155**		**05200510**
04-0079-00	Wolf Lake	3.30			
07010101-514	Wolf Lake	1.98			
04-0038-00	Andrusia Lake	5.30			
07010101-515	Andrusia Lake	0.63			
04-0030-00	Cass Lake	15.32			
07010101-507	Cass Lake	10.95	S002-283		
11-0147-00	Lake Winnibigoshish	61.07			
07010101-723	Lake Winnibigoshish	1.67			
31-0850-00	Little Winnibigoshish	0.60			
07010101-725	Little Winnibigoshish	14.40			
07010101-506	**Leech Lake River**	**2.61**	**S003-654**		**05207600**
07010101-693	Artificial Path	0.38			
07010101-503	Ball Club River	11.11			
07010101-502	Deer River	10.73	S003-655		

AUID/DNR ID	Location (by upstream identifier)	Length (miles)	MPCA Water Quality Station ID	MPCA Biological Station ID	USGS Flow Station ID
07010101-501	**Vermillion River**	**8.11**	**S000-154 S007-163**	**10EM082**	
31-0561-00	Blackwater Lake	7.20			
07010101-648	Blackwater Lake	1.27	S000-400 S006-923		
07010103-511	Bass Brook	2.08			
07010103-510	Cohasset Dam	3.26			
07010103-503	**Grand Rapids Dam**	**2.82**	**S002-635 S003-656**		**05211000**
07010103-502	Prairie River	23.47	S000-220		
07010103-507	Split Hand Creek	13.72			
07010103-505	Swan River	32.33	S000-153 S004-514		
07010103-501	Sandy River	27.80	S003-663 S004-515		
07010104-512	Willow River	12.17			
07010104-503	**Rice River**	**16.41**	**S002-010**	**10EM136**	**05227500**
07010104-517	Little Willow River	25.81			
07010104-501	Pine River	20.32	S000-169 S000-572 S004-623 S004-624 S007-205 S007-232		
07010104-516	**Brainerd Dam**	**13.49**	**S002-957**		**05242300**
07010104-515	Crow Wing River	8.41			
07010104-576	Nokasippi River	1.67			
07010104-577	Crow Wing/Morrison	8.21	S000-151		
07010104-513	Fletcher Creek	4.27			
07010104-520	Little Elk River	2.54			
07010104-519	Little Falls Dam	4.35	S002-643		
07010201-501	**Swan River**	**7.58**	**S000-150**		**05267000**
07010201-509	Two River	3.71			
07010201-508	Spunk Creek	1.86			
07010201-606	Platte River	0.52			

Figure 5. Mississippi River Headwaters monitoring stations with 2003-2012 available data

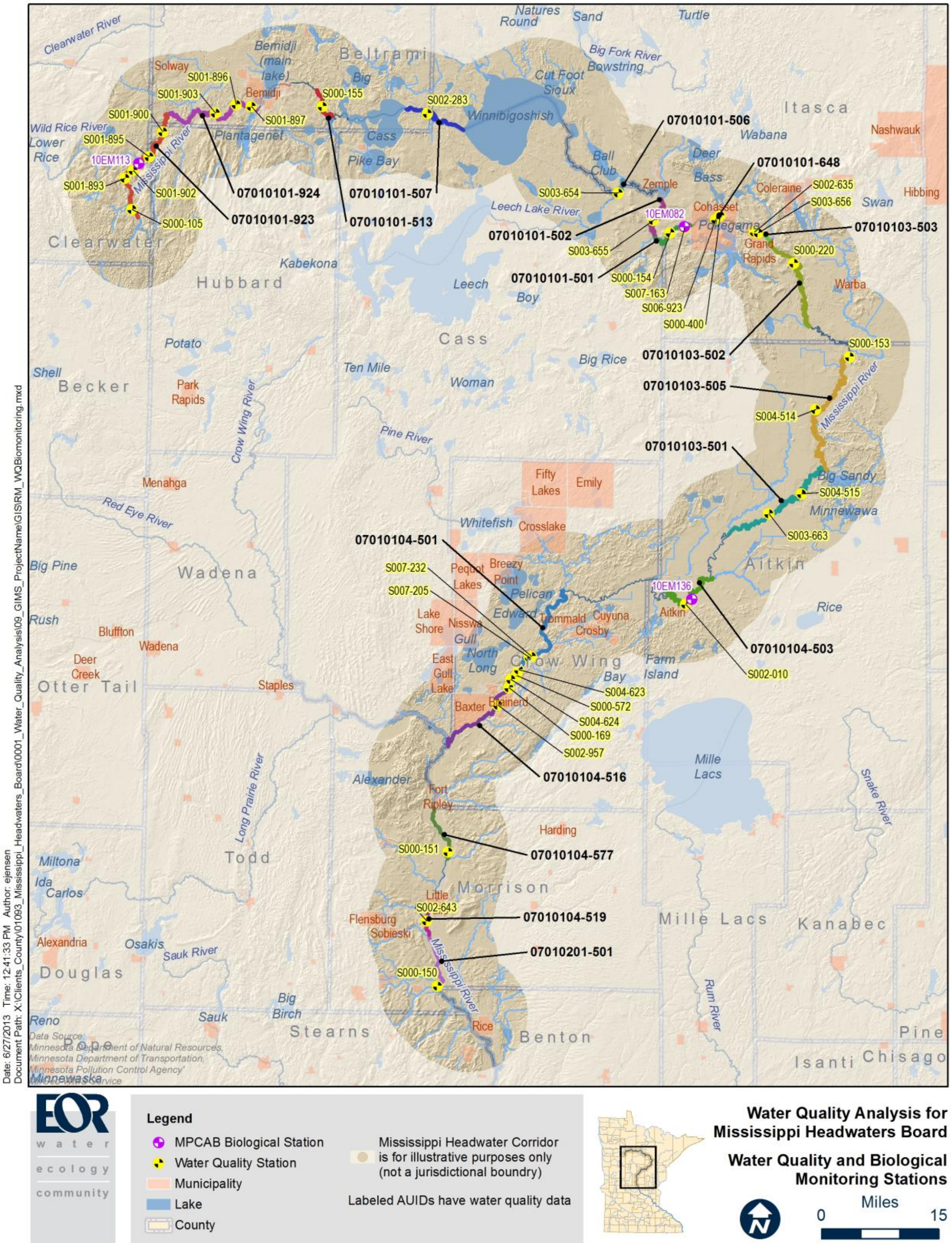


Figure 6. Mississippi River Headwater reaches with water quality data that exceed state standards

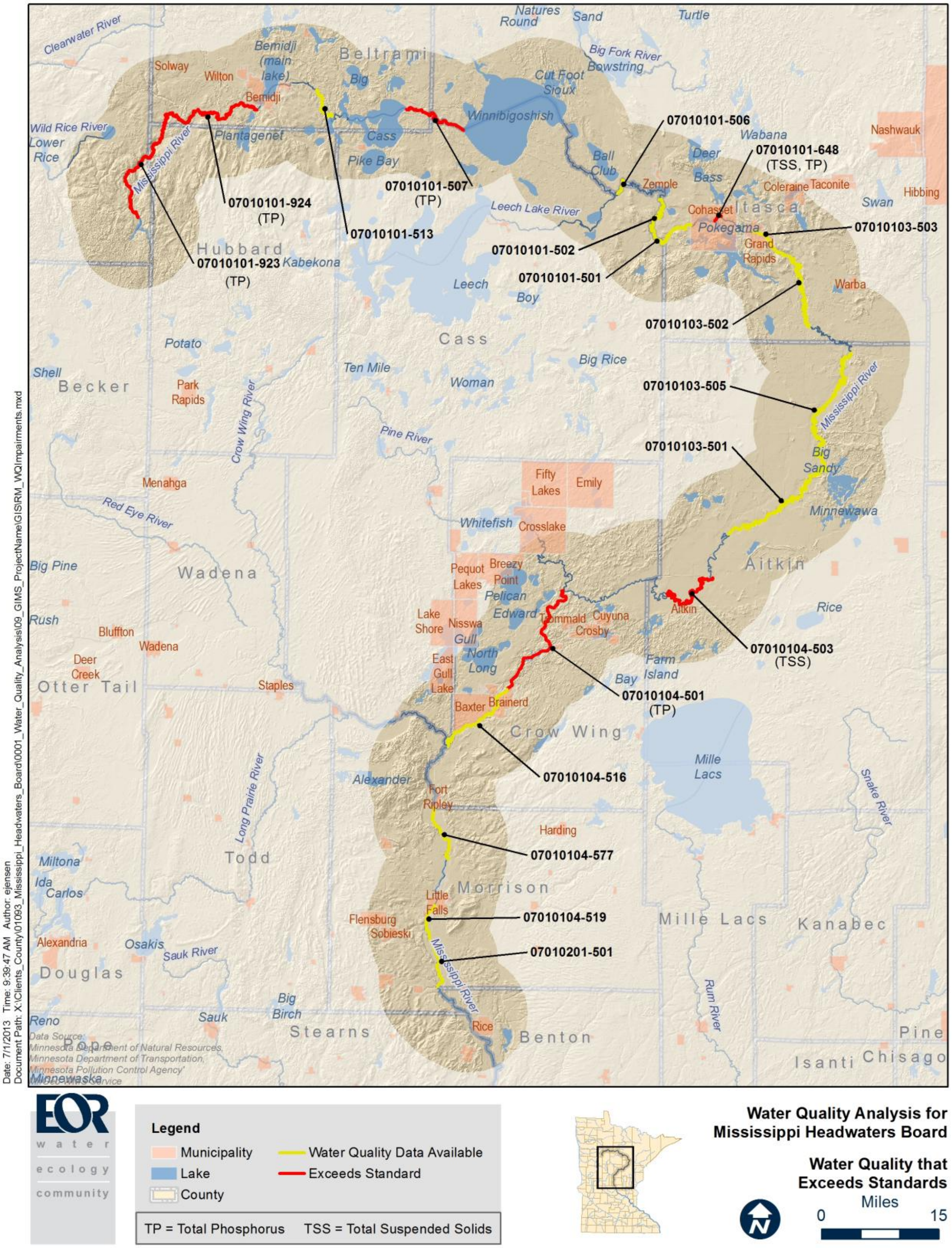


Table 7. Mississippi River Headwaters data inventory by stream segment from 2003-2012
● = >3 years of data, ○ = 1-2 years of data, and blank indicates no data are available. Most recent year of survey data shown.

AUID/ DNR ID	Location (by upstream identifier or lake)	Length (miles)	Number of Stations	Stream Data Parameters										Lake Data Parameters					
				Ammonia	Chloride	DO	E. coli	pHo	Sulfate	TP	TSS	Flow	MPCA Bio Survey	TP	Chl-*a*	Secchi depth	Lake Level	DNR Fish Survey	DNR Plant Survey
07010101-923	Headwaters	29.57	5	●	●	●	●	●	●	●	●		✓						
07010101-924	Unnamed Creek	28.60	3	○		○		○		○	○								
07010101-722	Schoolcraft River	0.81																	
04-0140-00	Lake Irving	2.11												●	●	●		‘01	‘11
07010101-720	Lake Irving	0.17																	
04-0130-00	Lake Bemidji	11.69												○	○	●	●	‘06	‘11
07010101-512	Lake Bemidji	3.78																	
04-0130-01	Stump Lake	2.36												●	●	●	●	‘11	
07010101-513	Stump Lake	6.27	1	●	●	●	●	●	●	●	●	●							
04-0079-00	Wolf Lake	3.30												●	●	●	●	‘09	‘11
07010101-514	Wolf Lake	1.98																	
04-0038-00	Andrusia Lake	5.30												●	●	●	●	‘09	‘11
07010101-515	Andrusia Lake	0.63																	
04-0030-00	Cass Lake	15.32												○	○	●	●	‘11	‘11
07010101-507	Cass Lake	10.95	1	○	○	○		○		○	○								
11-0147-00	Lake Winnibigoshish	61.07												○	○	●	●	‘12	‘01
07010101-723	Lake Winnibigoshish	1.67																	
31-0850-00	Little Winnibigoshish	0.60												○	○	○	●	‘07	‘01
07010101-725	Little Winnibigoshish	14.40																	

AUID/ DNR ID	Location (by upstream identifier or lake)	Length (miles)	Number of Stations	Stream Data Parameters										Lake Data Parameters					
				Ammonia	Chloride	DO	E. coli	pHo	Sulfate	TP	TSS	Flow	MPCA Bio Survey	TP	Chl-*a*	Secchi depth	Lake Level	DNR Fish Survey	DNR Plant Survey
07010101-506	Leech Lake River	2.61	1			●		●			○	●							
07010101-693	Artificial Path	0.38																	
07010101-503	Ball Club River	11.11																	
07010101-502	Deer River	10.73	1			●		●			○								
07010101-501	Vermillion River	8.11	2	●	●	●	●	●	●	●	●		✓						
31-0561-00	Blackwater Lake	7.20														○		‘03	
07010101-648	Blackwater Lake	1.27	2	○	○	○	○	○	○	○	○								
07010103-511	Bass Brook	2.08																	
07010103-510	Cohasset Dam	3.26																	
07010103-503	Grand Rapids Dam	2.82	2	○	○	●	○	●	○	●	●	●							
07010103-502	Prairie River	23.47	1	●	●	●	●	●	●	●	●								
07010103-507	Split Hand Creek	13.72																	
07010103-505	Swan River	32.33	2			○		○			○								
07010103-501	Sandy River	27.80	2			●		●			●								
07010104-512	Willow River	12.17																	
07010104-503	Rice River	16.41	1	●	●	●	●	●	●	●	●	●	✓						
07010104-517	Little Willow River	25.81																	
07010104-501	Pine River	20.32	6	○	○	●		●	○	●									
07010104-516	Brainerd Dam	13.49	1	●		○		●		●	●	●							
07010104-515	Crow Wing River	8.41																	
07010104-576	Nokasippi River	1.67																	

AUID/ DNR ID	Location (by upstream identifier or lake)	Length (miles)	Number of Stations	Stream Data Parameters										Lake Data Parameters					
				Ammonia	Chloride	DO	E. coli	pHo	Sulfate	TP	TSS	Flow	MPCA Bio Survey	TP	Chl-*a*	Secchi depth	Lake Level	DNR Fish Survey	DNR Plant Survey
07010104-577	Crow Wing/Morrison	8.21	1	●	●	●	●	●	●	●	●								
07010104-513	Fletcher Creek	4.27																	
07010104-520	Little Elk River	2.54																	
07010104-519	Little Falls Dam	4.35	1			○	○	○											
07010201-501	Swan River	7.58	1	●	●	●	●	●	●	●	●	●							
07010201-509	Two River	3.71																	
07010201-508	Spunk Creek	1.86																	
07010201-606	Platte River	0.52																	

B. Water Quality

Several analyses were performed for each stream segment AUID of the Mississippi River Headwaters based on availability of data from the study period from 2003 through 2012. Only data collected from stations located directly on the mainstem of the Mississippi River were analyzed. Mean concentrations of pollutants in the following sections were calculated using data available from all years. Data for total phosphorus, total suspended solids, and E. coli were only analyzed for the growing season according to the notes in Table 8. Data for the remaining pollutants were analyzed for the entire period of record from which data was collected.

All surface waters in Minnesota, including lakes, rivers, streams, and wetlands, are protected for aquatic life and recreation where these uses are attainable (Minnesota Rule 7050). The beneficial use classes listed in Table 4 are associated with a specific numeric water quality standard for pollutants that sets the limit for a safe concentration of this pollutant in water (see Table 8).

Summary

Only 7 of the 18 AUIDs assessed had water quality standard exceedances when samples were averaged over the most recent 10 years. Total phosphorus and total suspended solids were the only two of the eight parameters assessed that did not meet water quality standards. Total phosphorus exceedances occurred on 5 reaches, and TSS exceedances occurred on 3 reaches.

Available water quality data varies widely among reaches and across counties. Two of three AUIDs in Beltrami County exceeded the draft phosphorus standard, and two of three AUIDs in Aitkin County had TSS exceedances. Water quality data in Cass County is limited to only dissolved oxygen and pH between 2003 and 2008, and no water quality data from the most recent 5 years was available. In general, all other counties had at least one AUID with adequate sample sizes for the most recent 10 year period. According to the data, Morrison County and Itasca County had the best water quality, as all AUIDs met the water quality standards, with the exception of 07010101-648 in Itasca County, which had very low sample sizes. Morrison County, however, seems to be at higher risk for water quality exceedances, as four WWTPs occur along the mainstem of the Mississippi River. Similarly, the Grand Rapids WWTP in Itasca County has the highest phosphorus loading of all WWTs (Table 11).

River mile water quality figures were constructed to illustrate water quality trends along the entire mainstem of the Mississippi River within the Mississippi Headwaters Board jurisdiction (Figure 7 through Figure 14). All data from the most recent 10 years for each parameter were averaged for each individual MPCA water quality monitoring station to provide a spatial trend in water quality data. The river route within the jurisdiction of the MHB is approximately 400 miles long, and is represented on the x-axis; 0 is the headwaters at Lake Itasca. In general, water quality was best in the middle reaches of the mainstem of the Mississippi River between AUIDs 07010101-506 and 07010103-505, as all water quality standards were met.

Table 8. Water quality standards for Class 2B waters (Minnesota Rules 7050.0220)

Pollutant	Standard	Units	Notes
Ammonia	0.04	mg/L	As un-ionized N, calculated from temperature and pH.
Chloride	230	mg/L	
Dissolved Oxygen	5	mg/L	Daily minimum. Compliance required for 50% of $7Q_{10}$ flows.
E. coli	126	organisms/ 100 mL	Geometric mean* of not less than 5 samples per calendar month. April 1 – October 31.
pH	> 6.5, < 9.0	unitless	
Phosphorus	0.05	mg/L	June 1 – September 30.
Sulfate	10: (wild rice present) 250: (wild rice not present)	mg/L	Standard applies only to Class 1B or 4A waters.
Total Suspended Solids	15	mg/L	May not be exceeded more than 10% of the time. April 1 – September 30.

*To measure *E. coli*, the geometric mean is used in place of arithmetic mean in order to measure the central tendency of the data, dampening the effect that very high values have on arithmetic means. The geometric mean differs from the arithmetic mean in that it uses multiplication rather than addition in its calculation. Since bacteria data sets often contain a few very high values, the geometric mean more appropriately characterizes the central tendency of the data.

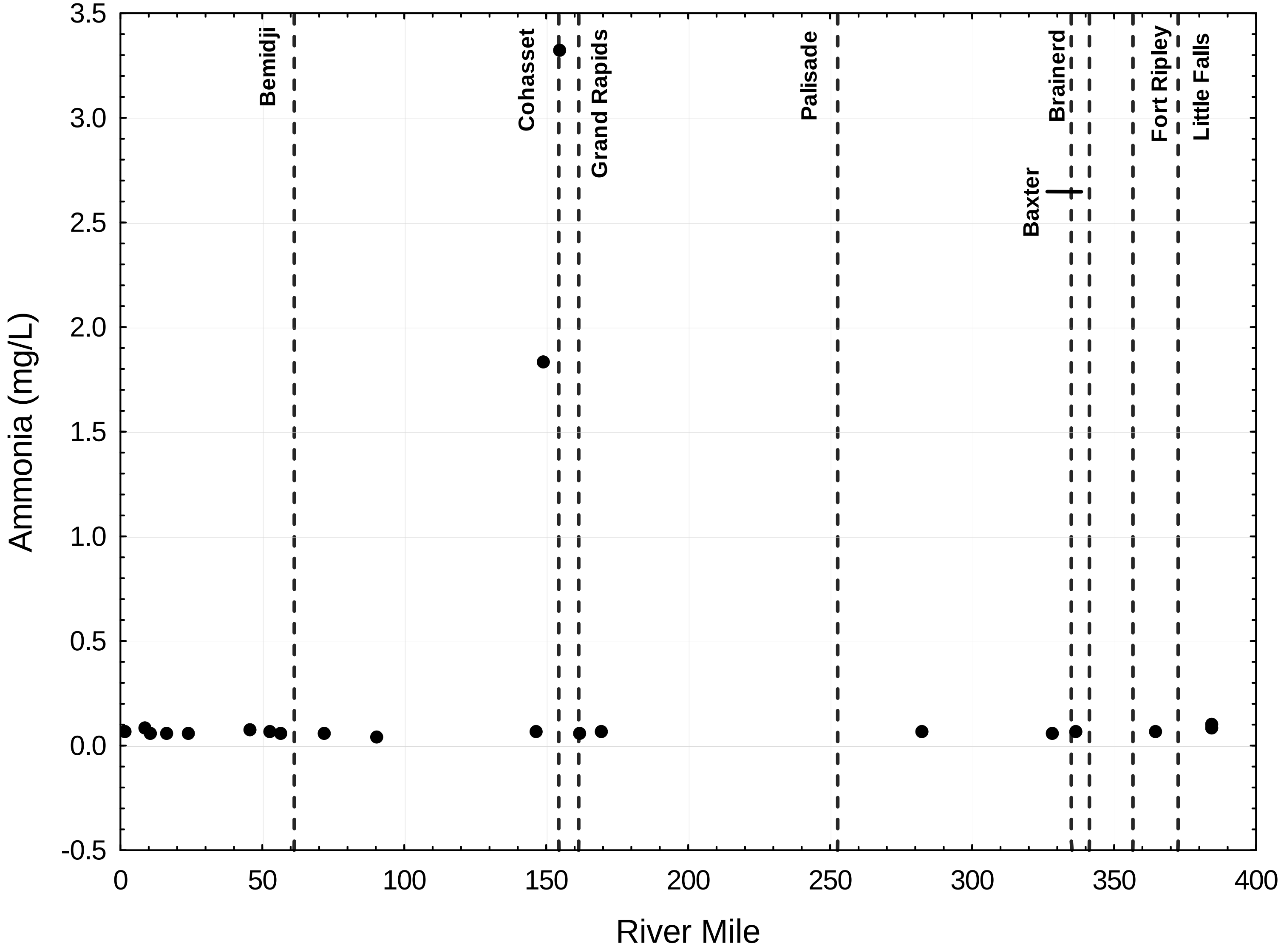


Figure 7. Mississippi River Headwaters mean ammonia concentration trends by river mile

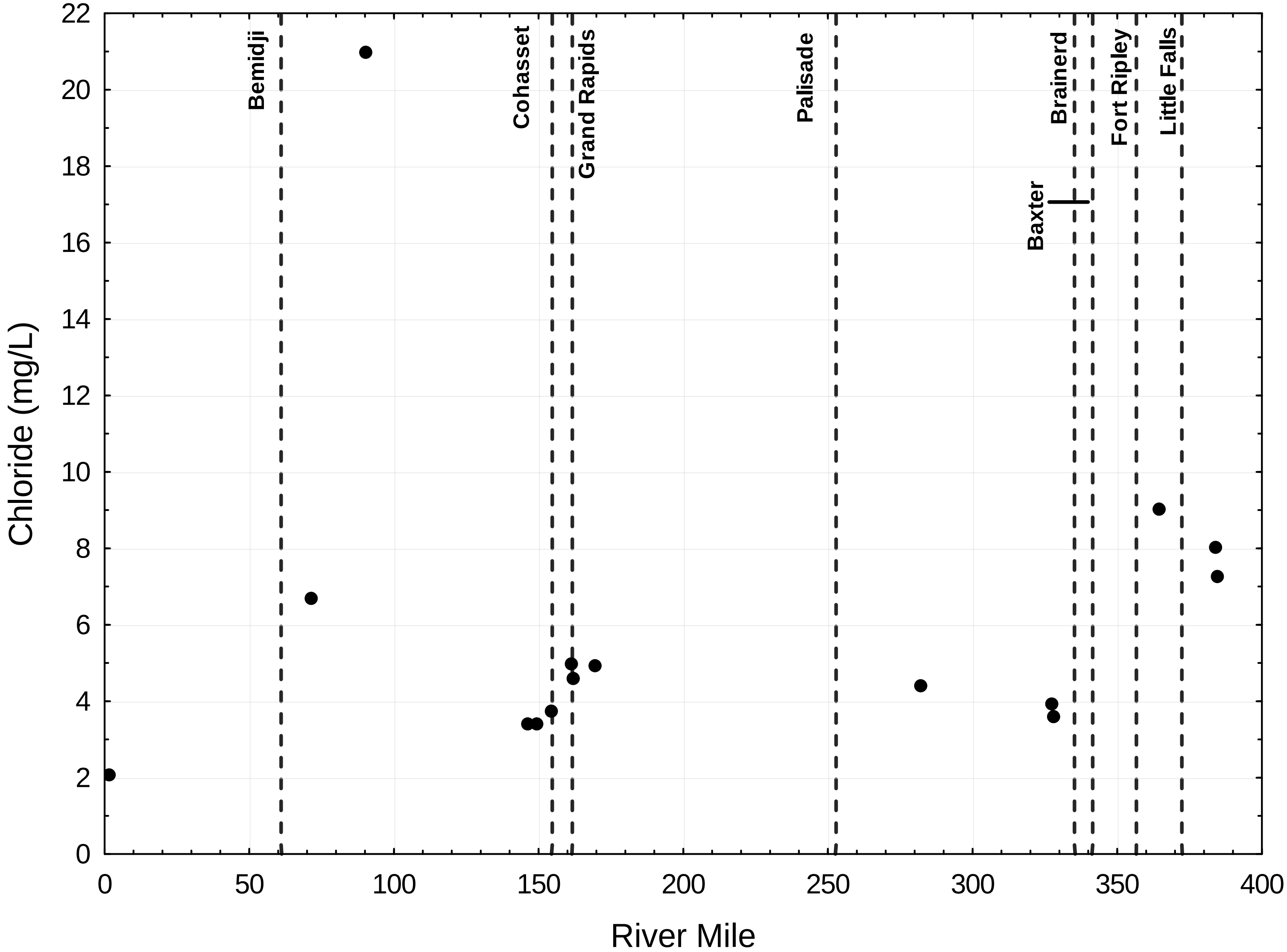


Figure 8. Mississippi River Headwaters mean chloride concentration trends by river mile

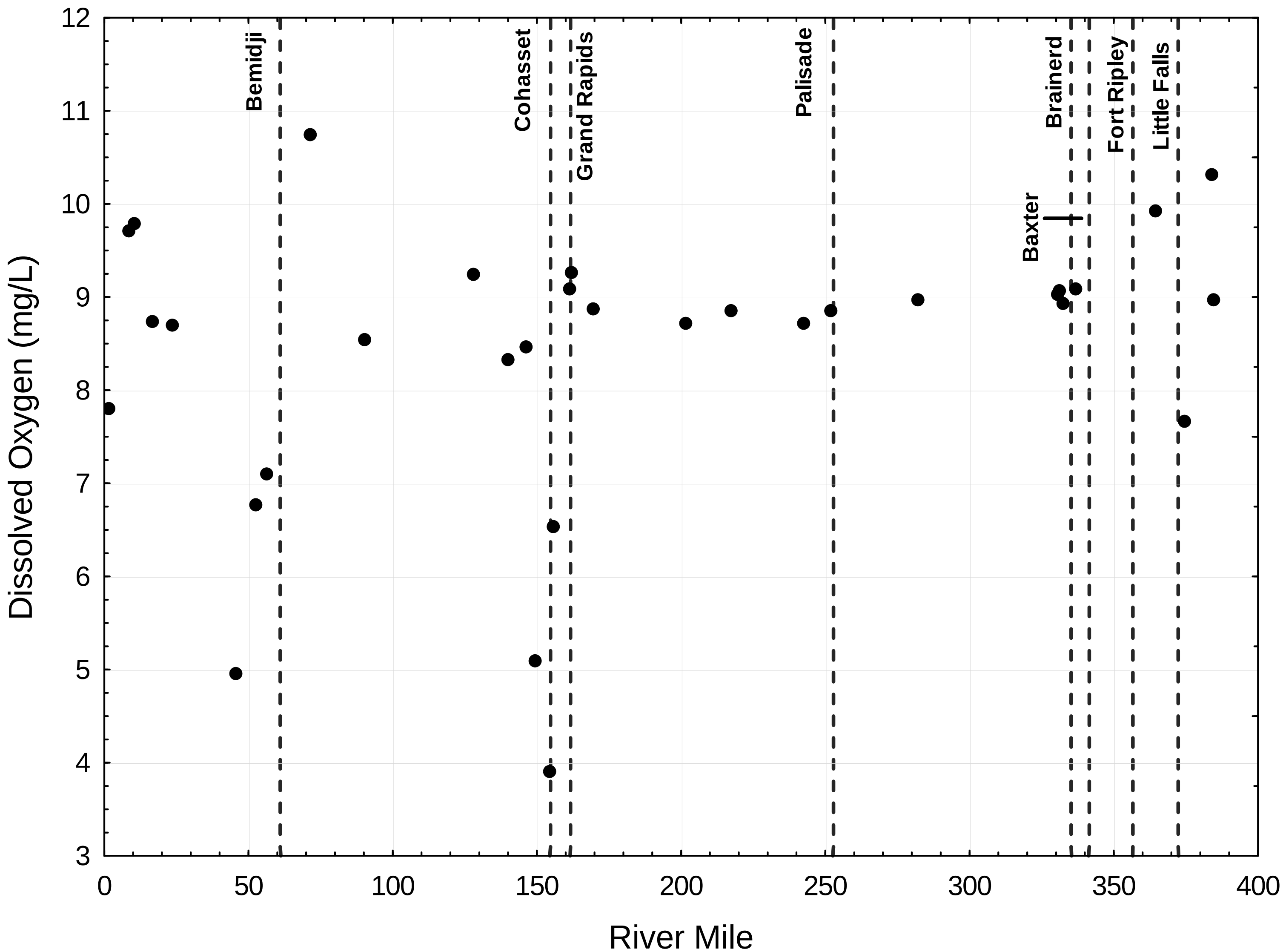


Figure 9. Mississippi River Headwaters mean dissolved oxygen concentration trends by river mile

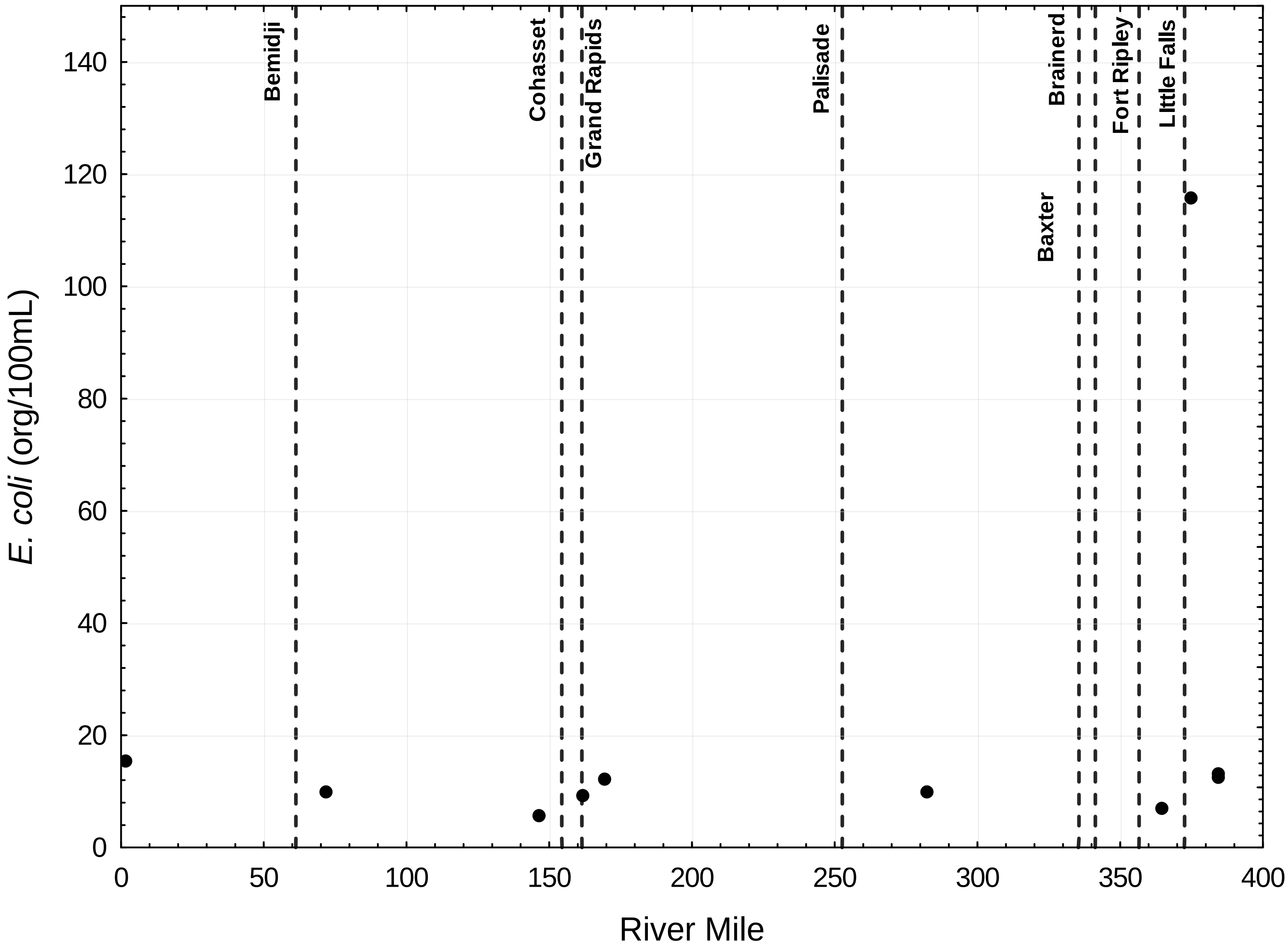


Figure 10. Mississippi River Headwaters mean *E. coli* trends by river mile

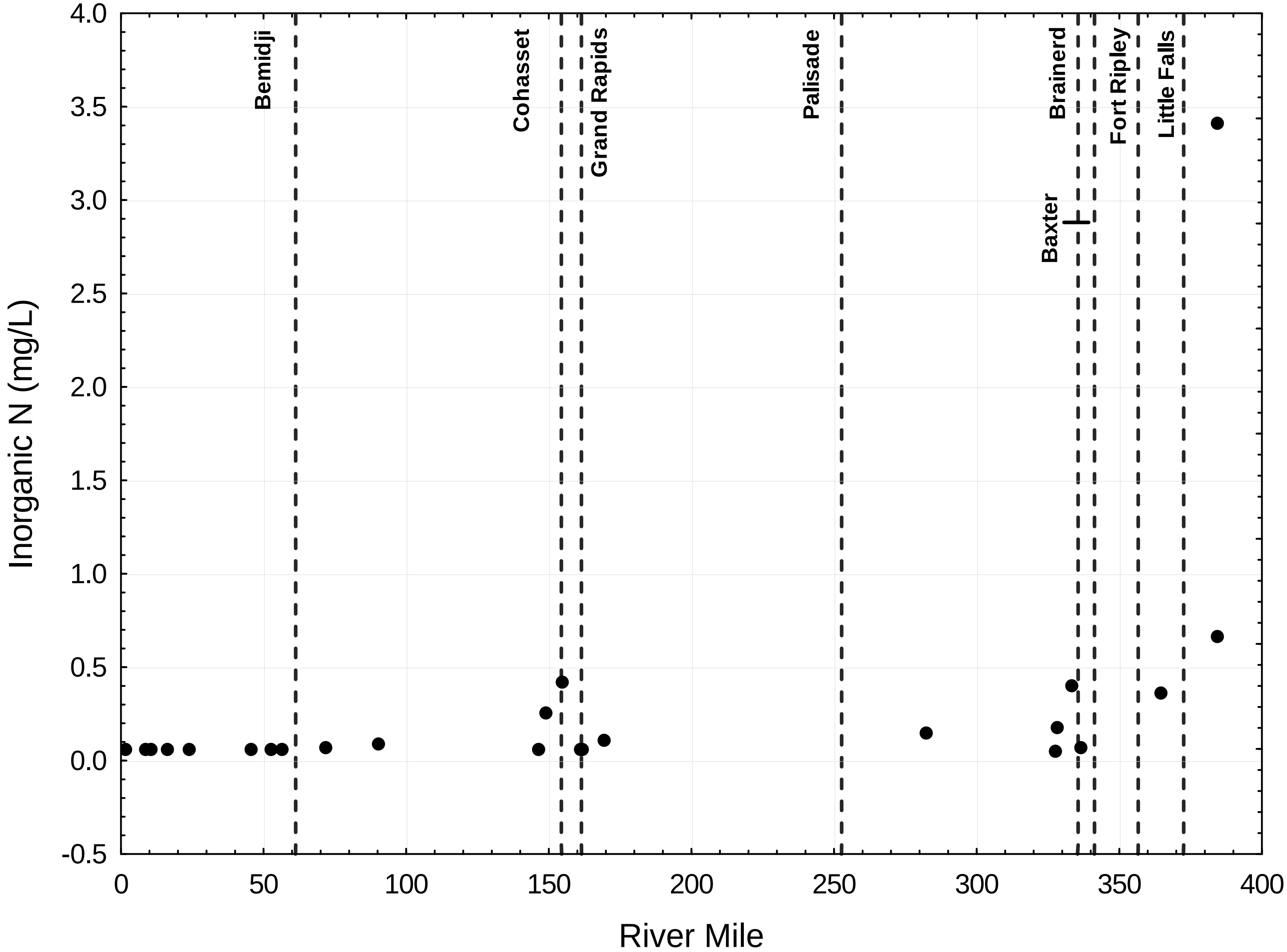


Figure 11. Mississippi River Headwaters mean inorganic nitrogen concentration trends by river mile

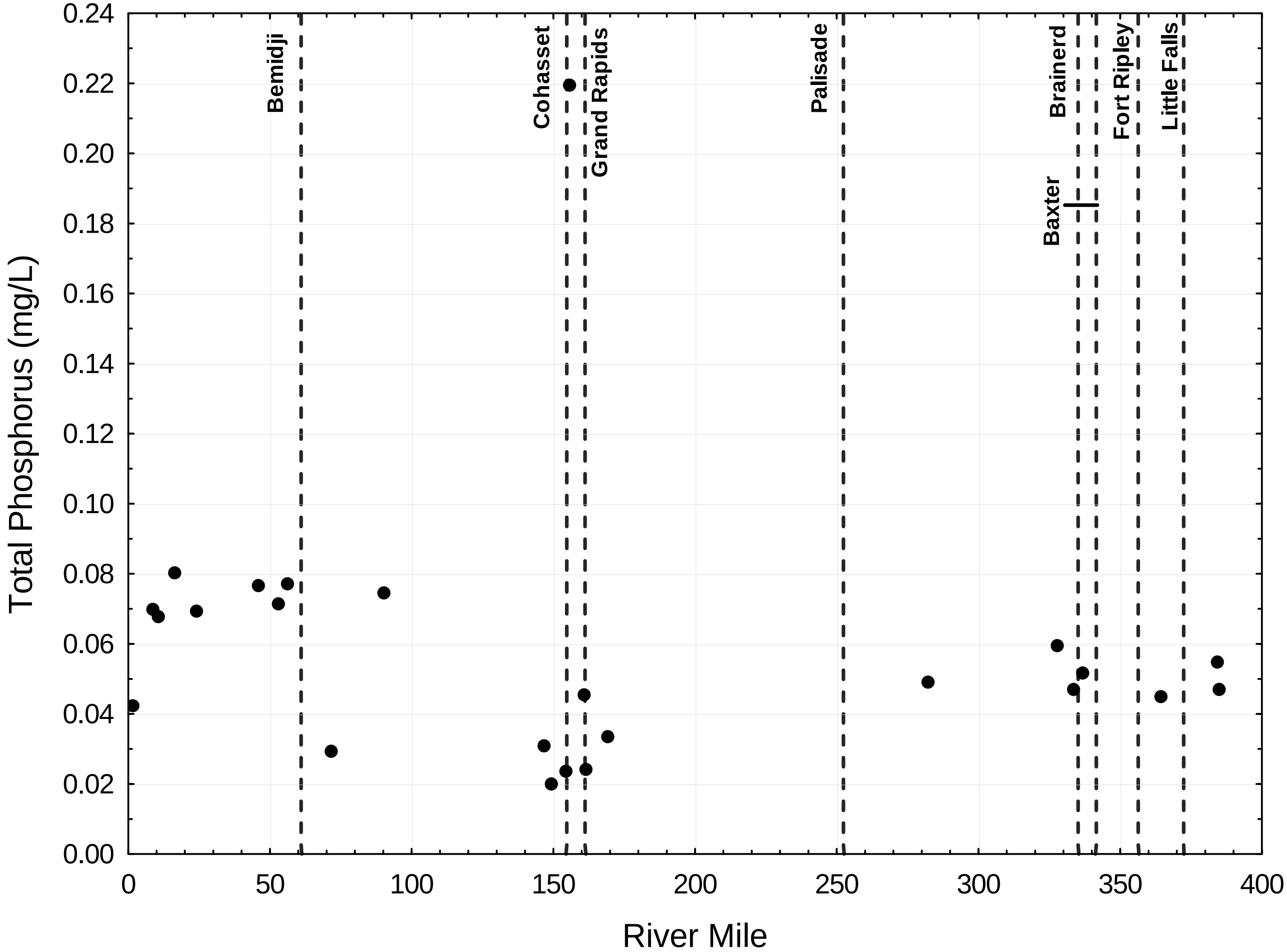


Figure 12. Mississippi River Headwaters mean total phosphorus concentration trends by river mile

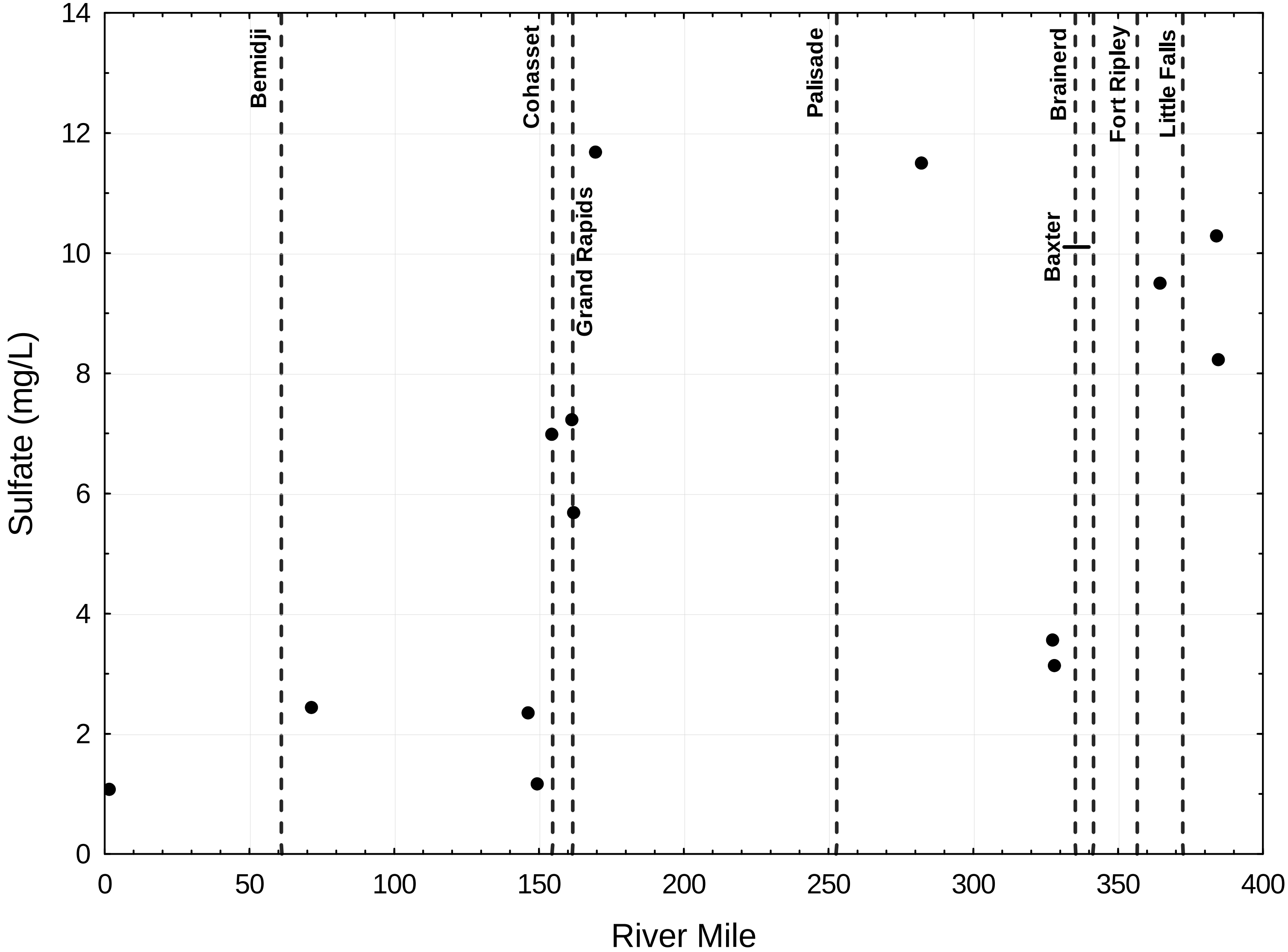


Figure 13. Mississippi River Headwaters mean sulfate concentration trends by river mile

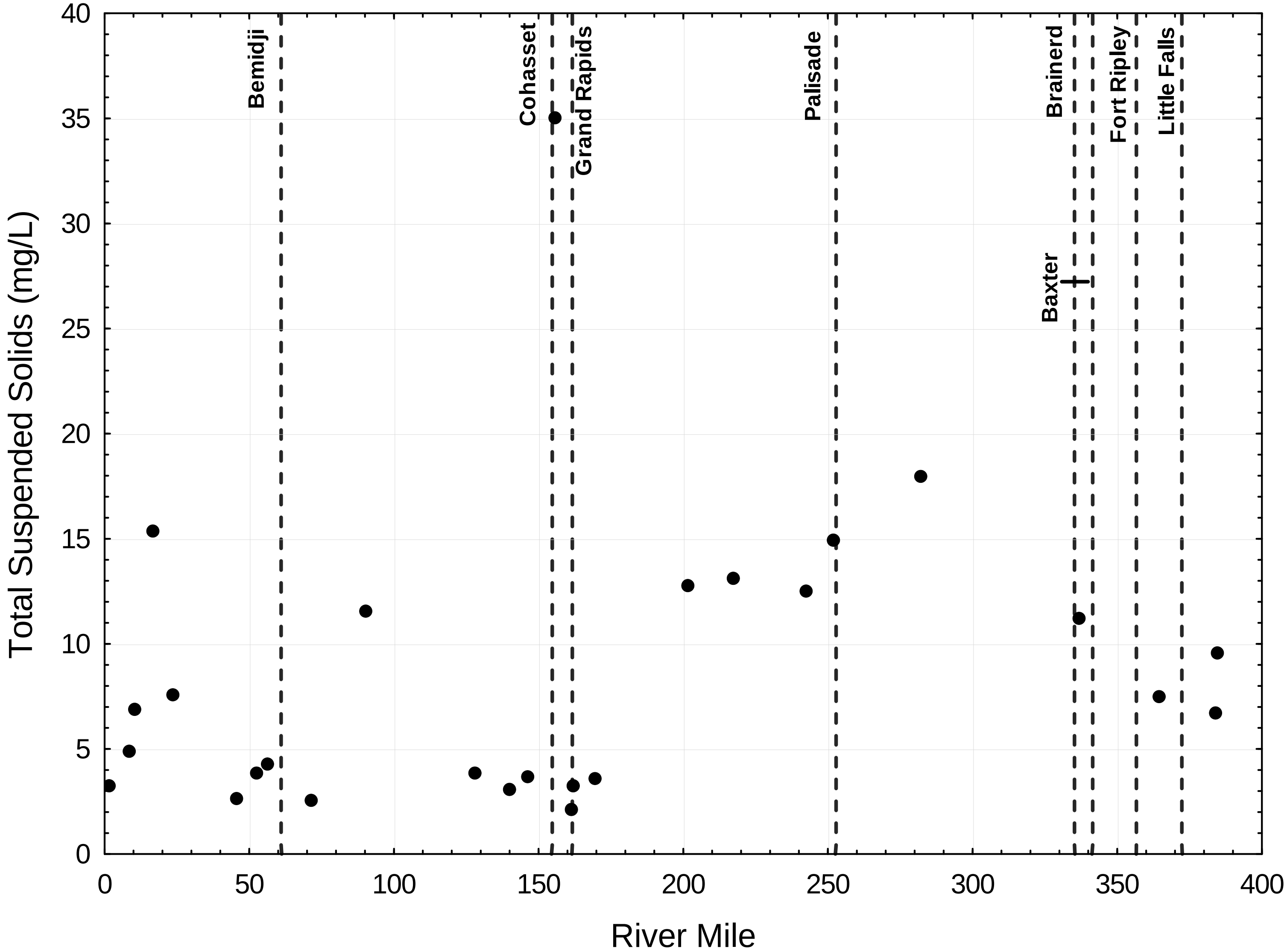


Figure 14. Mississippi River Headwaters mean total suspended solids concentration trends by river mile

C. Biology

The MPCA sampled fish and invertebrate communities at three stations along the mainstem of the Mississippi River within the MHB jurisdiction in the most recent 10 years. The stations occurred on AUID 07010101-923 in Clearwater County, AUID 07010101-501 in Itasca County, and AUID 07010104-503 in Aitkin County. Fish communities were only sampled in Itasca and Aitkin County, but were considered healthy, within an average IBI of 71. Invertebrate communities were sampled on all three reaches, and the IBI scores varied between 73 in Clearwater County and 31 in Aitkin County, indicating the invertebrate communities are healthier upstream.

In June of 2007, a statewide, coordinated, comprehensive survey of the Mississippi River headwaters (between Lake Itasca and the Coon Rapids dam) was initiated. Seven MN DNR Area Fisheries offices sampled a total of 49 reaches along the Mississippi River. A summary of the results from each county are below.

Clearwater and Beltrami Counties

In June and July 2007, the MN DNR Bemidji Area Fisheries office sampled 97 miles of the Mississippi River from the headwaters at Lake Itasca to Lake Winnibigoshish for water depth, water quality, fish community, and geomorphology. The sample area was divided into 10 reaches that occurred in Clearwater, Hubbard, and Beltrami Counties. Fish were sampled at 19 stations. A total of 11,587 individuals were caught, representing 44 species. Yellow perch was the most common species encountered, and bluegill, northern pike, rock bass, and white sucker were caught in all 10 reaches. The fish IBI Scores were inversely related to the distance downstream from Lake Itasca, with the highest scores at the headwaters, and the lowest scores near Lake Winnibigoshish. There was no indication of invasive species encountered in the report. Overall, the results of the study suggested the fish community in the Mississippi River in Clearwater and Beltrami County is healthy and has not experienced significant habitat degradation.

Itasca and Cass Counties

Eleven reaches along 85 miles of the Mississippi River on the border of Itasca and Cass Counties between Winnibigoshish Dam and the Aitkin County border were sampled for fish communities. A total of 3,736 individuals were caught, representing 32 species. Yellow perch were the most abundant species representing 38% of all fish sampled. Largemouth bass and black bullhead were also abundant, representing another 20% of all fish sampled (Table 5). Northern pike and rock bass were found in all reaches and largemouth bass, bluegill, and white sucker were found in 10 of 11 reaches. Fish IBI scores varied between 39 to 71, and ratings varied from poor to good,

Aitkin County

In June of 2007, 104 miles of the Mississippi River that flows through Aitkin County were surveyed for fish communities. Fish communities were sampled in 7 of 8 reaches. A total of 23 species were sampled, and the most common species were shorthead and silver redhorse.

Bluegill, northern pike, rock bass and shorthead redhorse were found in all seven similar reaches. Fish IBI scores were relatively low, with the highest being only 60, which occurred near the center of Aitkin County.

Crow Wing County

A fish survey was conducted along the Mississippi River in Crow Wing County by the MN DNR Fisheries Brainerd Office in 2007. Sampling was conducted using boat and backpack electrofishers and trotlines. Thirty-four species of fish were recorded, with seven species of fish found at all sampling points. The invasive common carp was found near the Brainerd Dam area. According to the MN DNR, the Brainerd Dam has an effect on the fish community; above the dam the Fish IBI score was 55, while below the dam Fish IBI score was 72.

Morrison County

The Little Falls Area Fisheries Office conducted sampling on the 66.8 miles of river from the Confluence of the Crow Wing River to the St. Cloud Dam. Seven reaches were sampled, but only five of these reaches occur within the jurisdiction of the Mississippi Headwaters Board. Along the 66.8 miles, 4,032 individuals were caught, with a total of 42 species. Invasive common carp were caught in the four most downstream reaches. Hornyhead chub (N=811) was the most abundant species comprising, followed by bluegill (N=526), rock bass (N=356), smallmouth bass (N=276) and logperch (N=266). IBI scores ranged from fair to good (51 to 79).

D. Stream Flow

Long-term daily USGS flow records were available at six stations on the Mississippi River Headwaters mainstem (Table 9 and Figure 5). The USGS also monitors flow at the outlet of one of the major tributaries (Crow Wing River), which enters the Mississippi River below the City of Brainerd (Table 10). Year-round daily mean discharge was quantified at all of these sites except at the station near Bemidji and at Ball Club. Figure 15 summarizes the median annual flows for all stations from 2003 through 2012. Average, 5th percentile (representing baseflow conditions), median/50th percentile (representing typical conditions), and 95th percentile (representing flood conditions) flows were calculated for each station and are shown in Table 9 and Figure 16 through Figure 22.

Based on median flows at all stations over the most recent ten years, dry years occurred in 2003, 2007, and 2012, and wet years occurred in 2005, 2010, and 2011. Annual variability in median flow was more pronounced at flow stations further downstream (Figure 15). This variability was dampened upstream of Grand Rapids where there are numerous flow-through lakes and reservoirs, large expanses of wetlands, and several dams.

Table 9. Mississippi River Headwaters 10-year average of annual flows (2003-2012)

				10-year average of annual flows (cfs)			
County	AUID	USGS ID	Location	Average	Q5	Q50	Q95
Beltrami	07010101-513	05200510	Near Bemidji	286	97	228	635
Cass	07010101-506	05207600	At Ball Club	922	313	817	1,890
Itasca	07010103-503	05211000	At Grand Rapids	1,105	344	1,024	2,172
Aitkin	07010104-503	05227500	At Aitkin	2,388	637	1,805	6,436
Crow Wing	07010104-516	05242300	At Brainerd	2,940	858	2,194	7,882
Morrison	07010201-501	05267000	Near Royalton	5,003	1,635	3,565	13,112

Q5 = 5th percentile (representing baseflow conditions)
Q50 = 50th percentile (representing typical conditions) or median
Q95 = 95th percentile (representing flood conditions)

Table 10. Mississippi River Headwaters tributary 10-year average of annual flows (2003-2012)

				10-year average of annual flows (cfs)			
County	AUID	USGS ID	Tributary	Average	Q5	Q50	Q95
Cass/ Morrison	07010101-513	05247500	Crow Wing River	1,628	600	1,127	4,062

Q5 = 5th percentile (representing baseflow conditions)
Q50 = 50th percentile (representing typical conditions) or median
Q95 = 95th percentile (representing flood conditions)

Figure 15. Mississippi River Headwaters and Crow Wing River median annual flows (2003-2012)

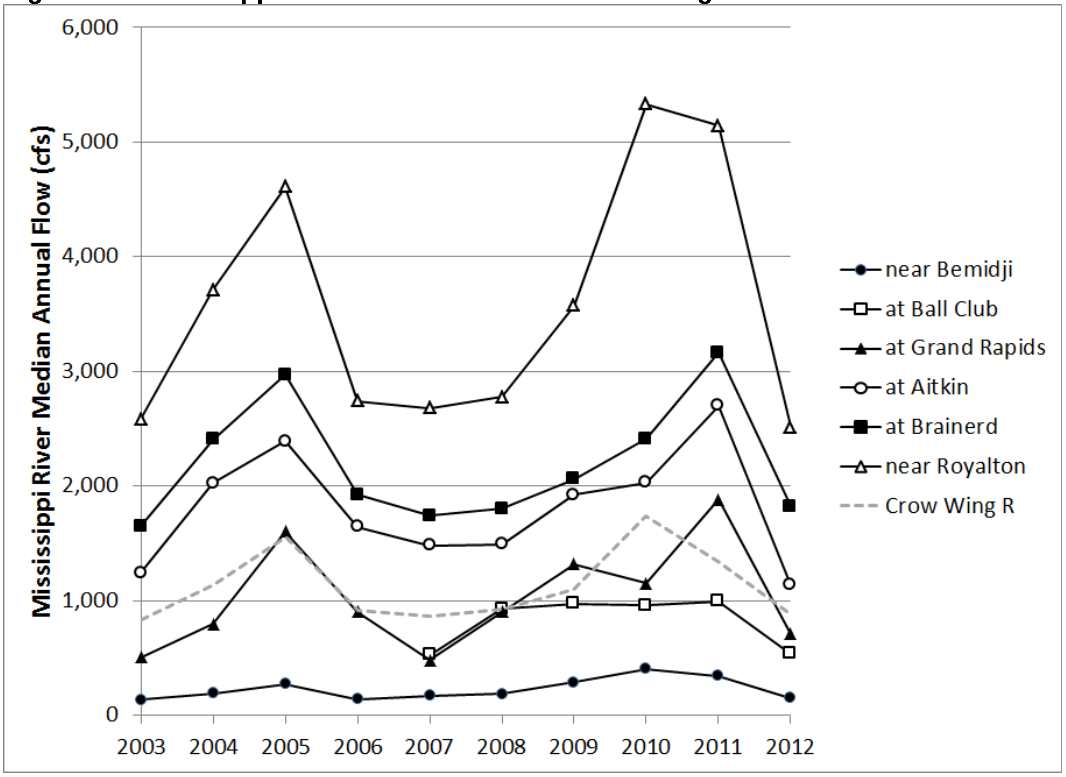


Figure 16. Median, 5th and 95th percentiles of Mississippi River flow at Bemidji (2003-12)

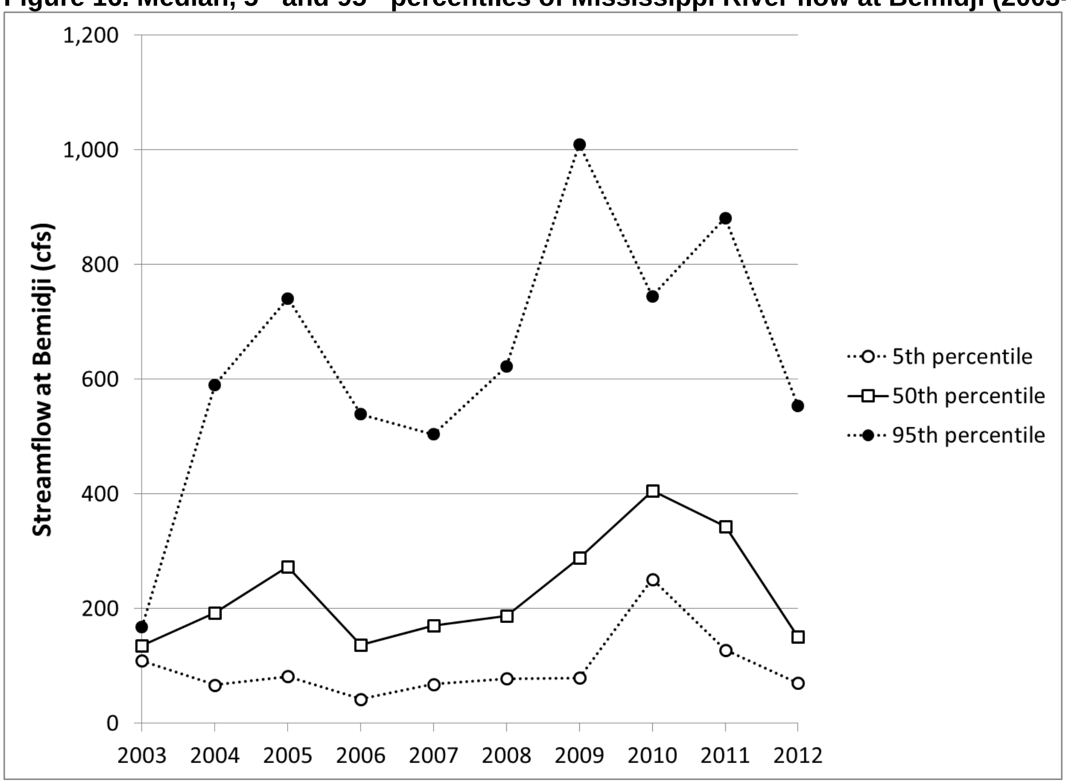


Figure 17. Median, 5th and 95th percentiles of Mississippi River flow at Ball Club (2003-12)

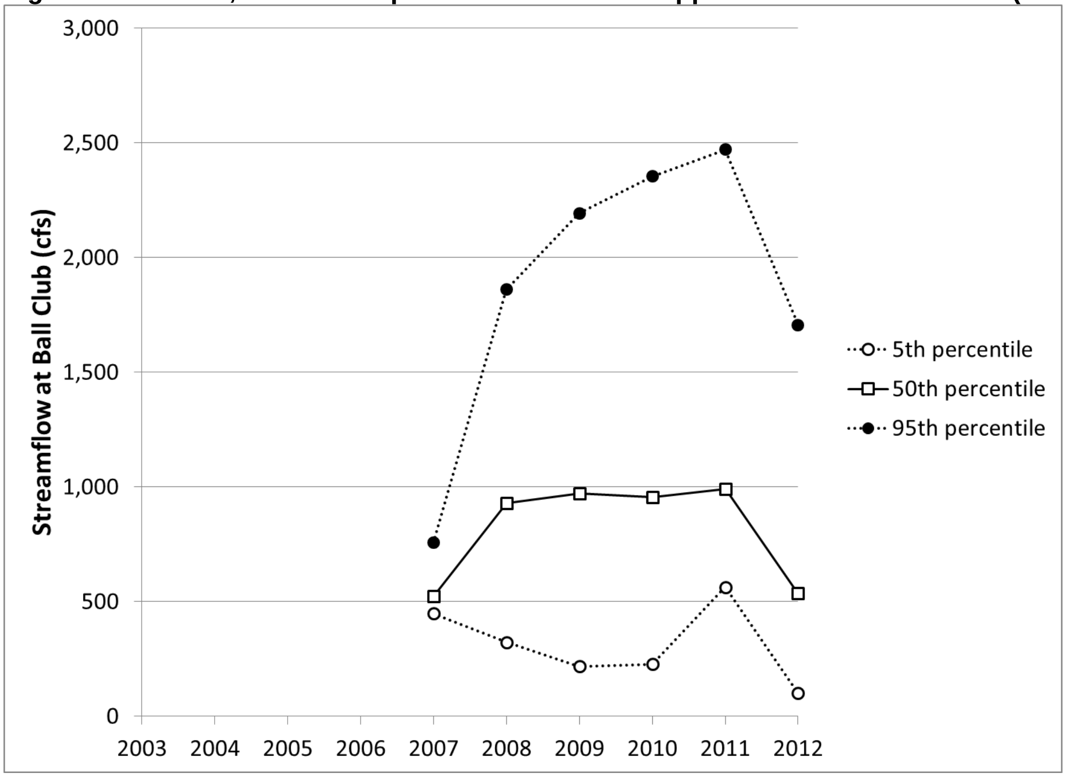


Figure 18. Median, 5th and 95th percentiles of Mississippi River flow at Grand Rapids (2003-12)

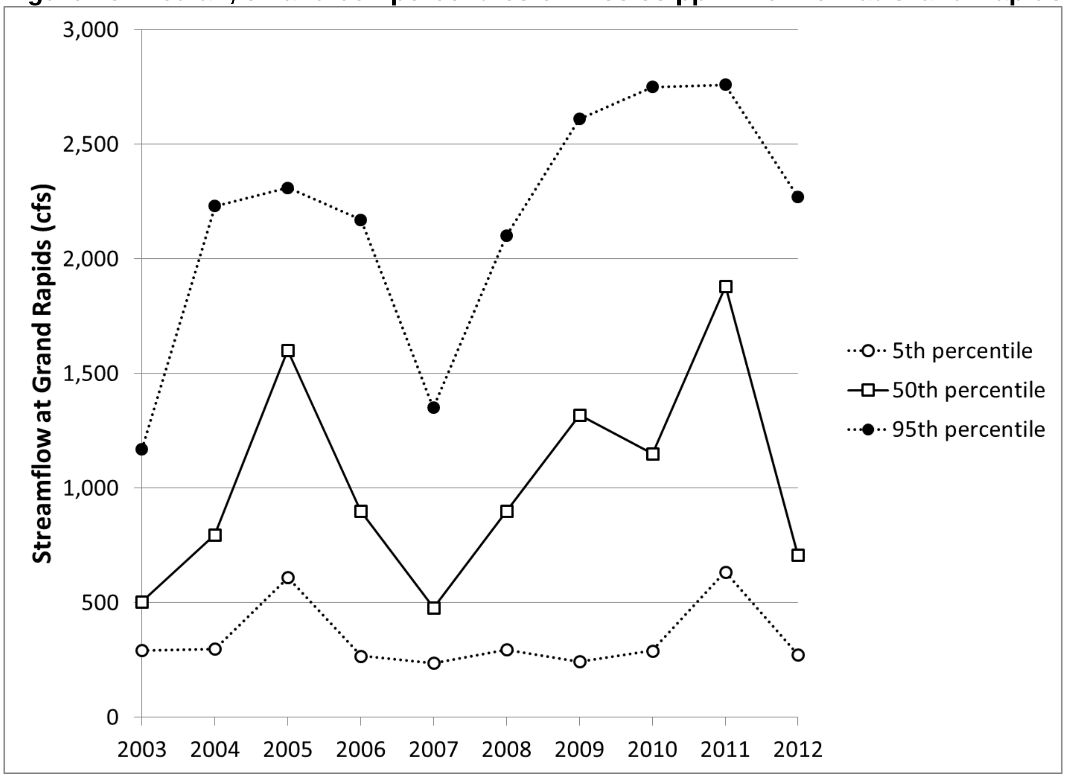


Figure 19. Median, 5th and 95th percentiles of Mississippi River flow at Aitkin (2003-12)

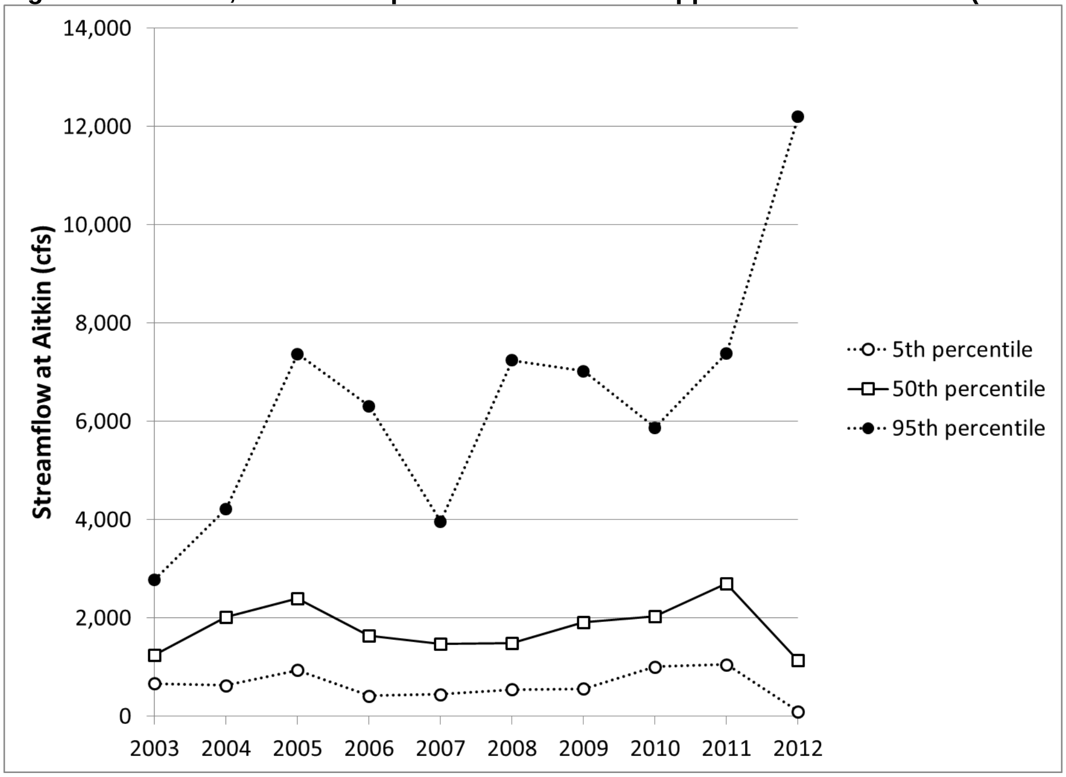


Figure 20. Median, 5th and 95th percentiles of Mississippi River flow at Brainerd (2003-12)

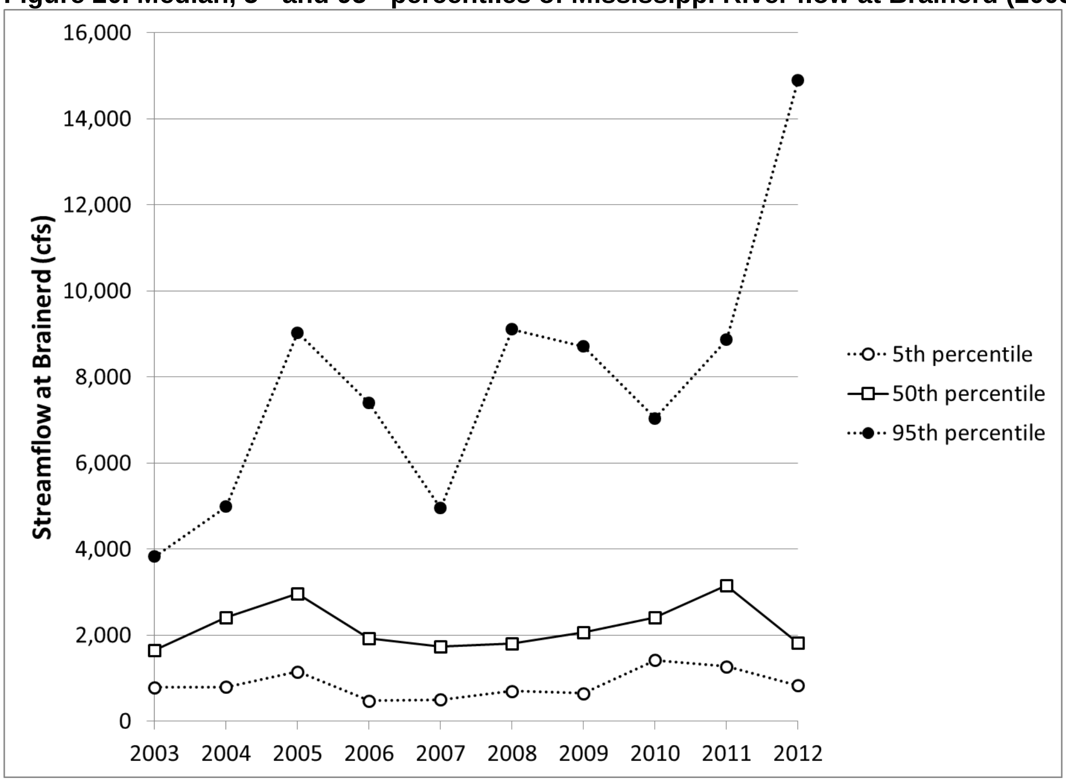


Figure 21. Median, 5th and 95th percentiles of Mississippi River flow at Royalton (2003-12)

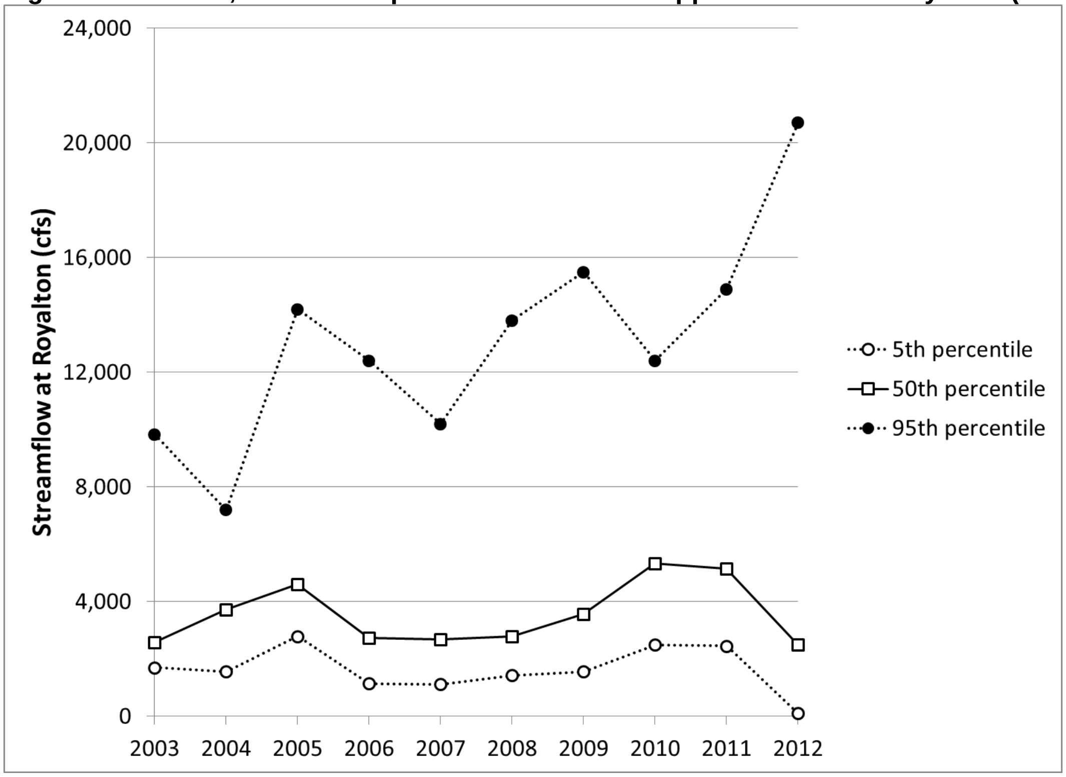
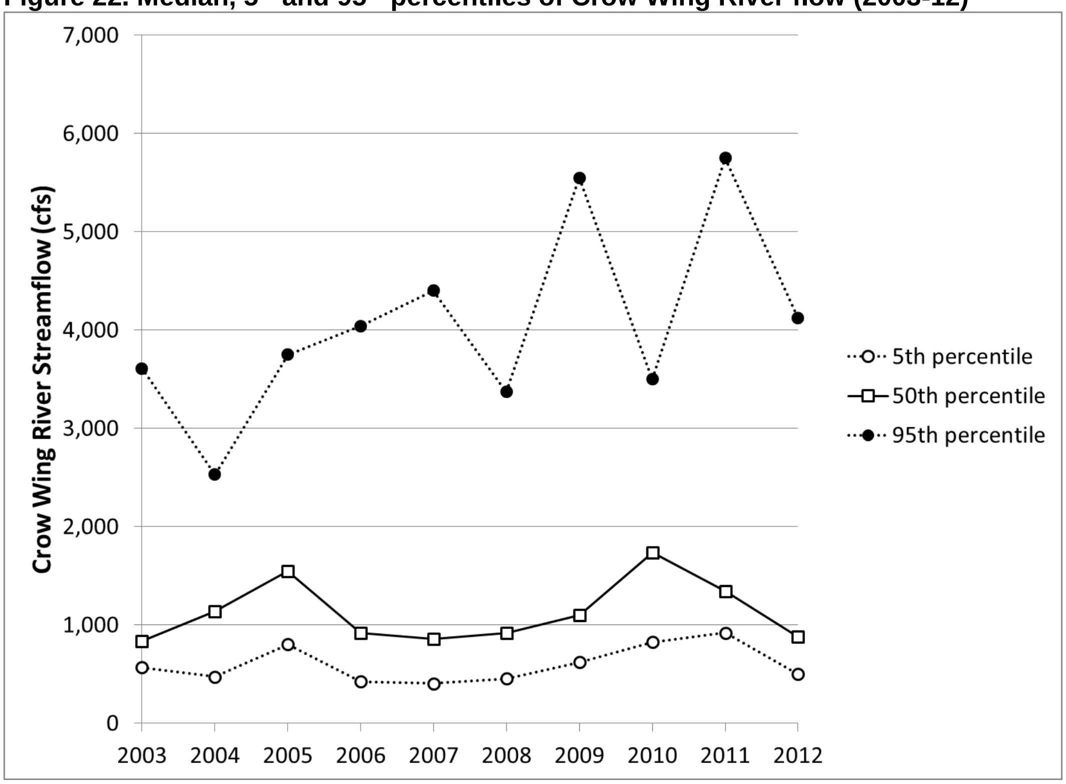


Figure 22. Median, 5th and 95th percentiles of Crow Wing River flow (2003-12)



E. Pollutant Sources and Loading

The following section summarizes the total phosphorus loading from known National Pollutant Discharge Elimination System (NPDES) point sources discharging directly to the Mississippi River mainstem and flow-through lakes, and total phosphorus flow-weighted mean concentrations and loads at several stations along the Mississippi River headwaters. NPDES point sources discharging to tributaries of the Mississippi River were excluded from this analysis, but could be major and potentially important sources of total phosphorus. Non-point sources of phosphorus from watershed runoff and sources of other pollutants (e.g., total suspended solids, nitrate, ammonia, and *E. coli*) were considered beyond the scope of this study and were also excluded.

NPDES Permitted Sources of Phosphorus

Based on a review of MPCA records, there are 15 NPDES permitted facilities that discharge total phosphorus (TP) directly into the Mississippi River Headwaters (Table 11). The majority of these sources are municipal wastewater treatment plants (WWTP).

Table 11. NPDES permitted facility average annual TP loads to the Mississippi River (2005-2012)

County	AUID	Permit ID	Facility
Beltrami	07010101-721	MNG250027	Northwoods Ice of Bemidji Inc.
		MN0022462	Bemidji WWTP
Itasca	07010101-646	MN0001007	Minnesota Power - Boswell Energy Center
	07010103-510	MN0022080	Grand Rapids WWTP
Aitkin	07010103-501	MN0050997	Palisade WWTP
	07010104-503	MN0057533	Sampson Farms
	07010104-517	MN0020095	Aitkin WWTP
Crow Wing	07010104-501	MN0001422	Wausau Paper Mills LLC
	07010104-516	MN0049328	Brainerd WWTP
Morrison	07010104-520	MN0024562	Randall WWTP
		MN0063070	Camp Ripley - Area 22 Washrack
		MN0025721	Camp Ripley WWTP
	07010104-519	MNG580016	Flensburg WWTP
		MN0020761	Little Falls WWTP
		MNG255005	Anderson Custom Processing Inc.

Phosphorus Loading

Total phosphorus flow-weighted mean concentrations (FWMCs) and average annual loads were estimated in the program $FLUX_{32}$ using USGS flow data and corresponding MPCA water quality data from 2003-2012 collected at five stations on the Mississippi River and one tributary (Crow Wing River; Table 12). These were compared to TP FWMC and loads calculated by the MPCA using data collected from 2007-2009 as part of a state-wide Watershed Pollutant Load Monitoring Network. TP FWMCs are low through Grand Rapids, then double by Aitkin and remain stable until Royalton. The Mississippi River Headwaters mainstem TP FWMCs are lower than the TP FWMC of the Crow Wing River tributary. The Mississippi River Headwaters TP FWMCs are relatively low compared to southern and western Minnesota major watersheds (Figure 24). The corresponding TP loads increased from upstream to downstream stations on the Mississippi River due to increasing contributing watershed area and point sources. Even so, the Mississippi River near Royalton contributes just 12% of the TP load measured at Lock and Dam #3, and less than 10% of the TSS and nitrogen (Table 13. Total Phosphorus Loads as a Percentage of the Load Measured at Lock and Dam #3Table 13, Figure 25 – Figure 28).

Table 12. Phosphorus load estimates along the Mississippi River using FLUX32
2003-2012 estimates from this study; 2007-2009 estimates from MPCA Load Monitoring Network

USGS ID	Location	Flow-weighted mean TP concentration (mg/L)		Average TP Load (lb/yr)	
		2003-2012	2007-2009	2003-2012	2007-2009
05200510	Mississippi River near Bemidji	0.029	N/A	17,020	N/A
05211000	Mississippi River at Grand Rapids	0.025	0.032	54,903	58,874
05227500	Mississippi River at Aitkin	0.053	0.048	248,807	204,751
05247500	Crow Wing River near Pillager	0.069	0.069	221,886	210,436
05242300	Mississippi River at Brainerd	0.054	N/A	314,528	N/A
05267000	Mississippi River near Royalton	0.059	0.059	587,122	538,570

Table 13. Total Phosphorus Loads as a Percentage of the Load Measured at Lock and Dam #3

Location	Total Phosphorus Loads as a Percentage of the Load Measured at Lock and Dam #3			
	TP	TSS	Nitrate-nitrite	TN
Mississippi River at Grand Rapids	1%	1%	0%	1%
Mississippi River at Aitkin	5%	6%	1%	4%
Mississippi River near Royalton	12%	5%	3%	8%

For more information on the **MPCA Watershed Pollutant Load Monitoring Network**, visit:
http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html

Figure 23. NPDES permitted facilities discharging TP directly to the Mississippi River

Figure 24. Watershed Pollutant Load Monitoring Network Total Phosphorus Flow Weighted Mean Concentration by Monitoring Site Watershed (2007-2009)

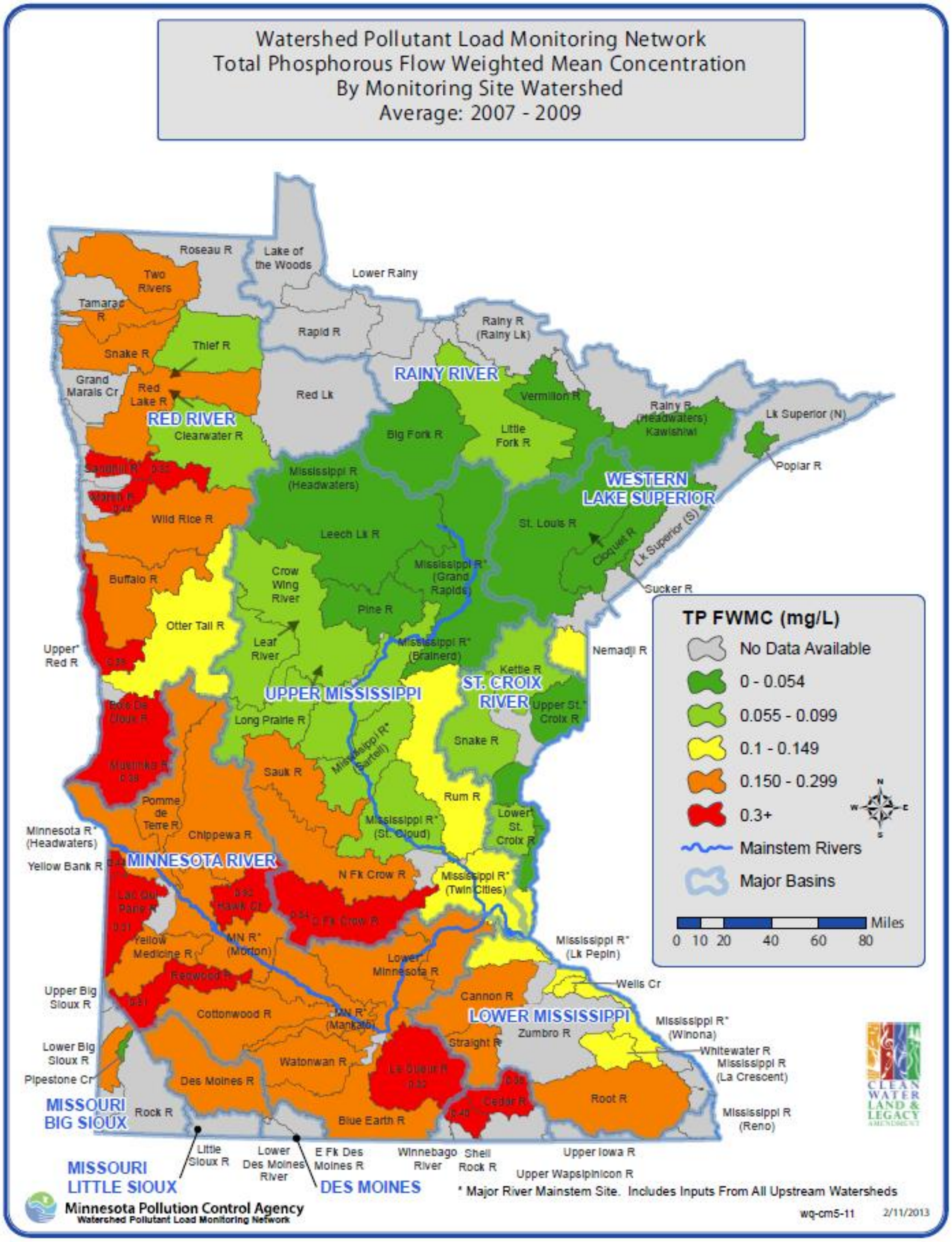


Figure 25. MPCA Total Phosphorus Loads as a Percentage of the Load Measured at Lock and Dam #3 (2007-2009)

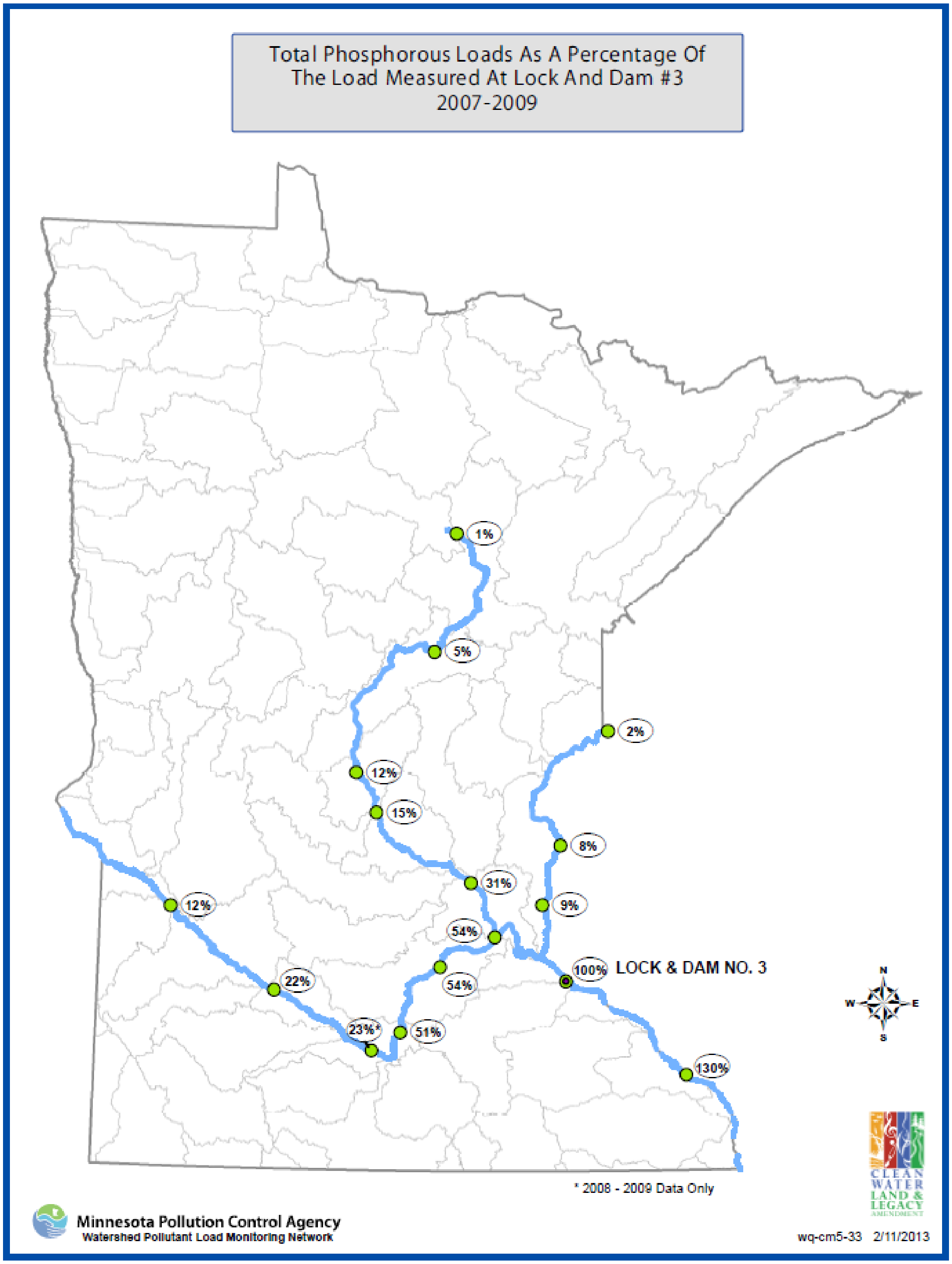


Figure 26. MPCA Total Suspended Solid Loads as a Percentage of the Load Measured at Lock and Dam #3 (2007-2009)

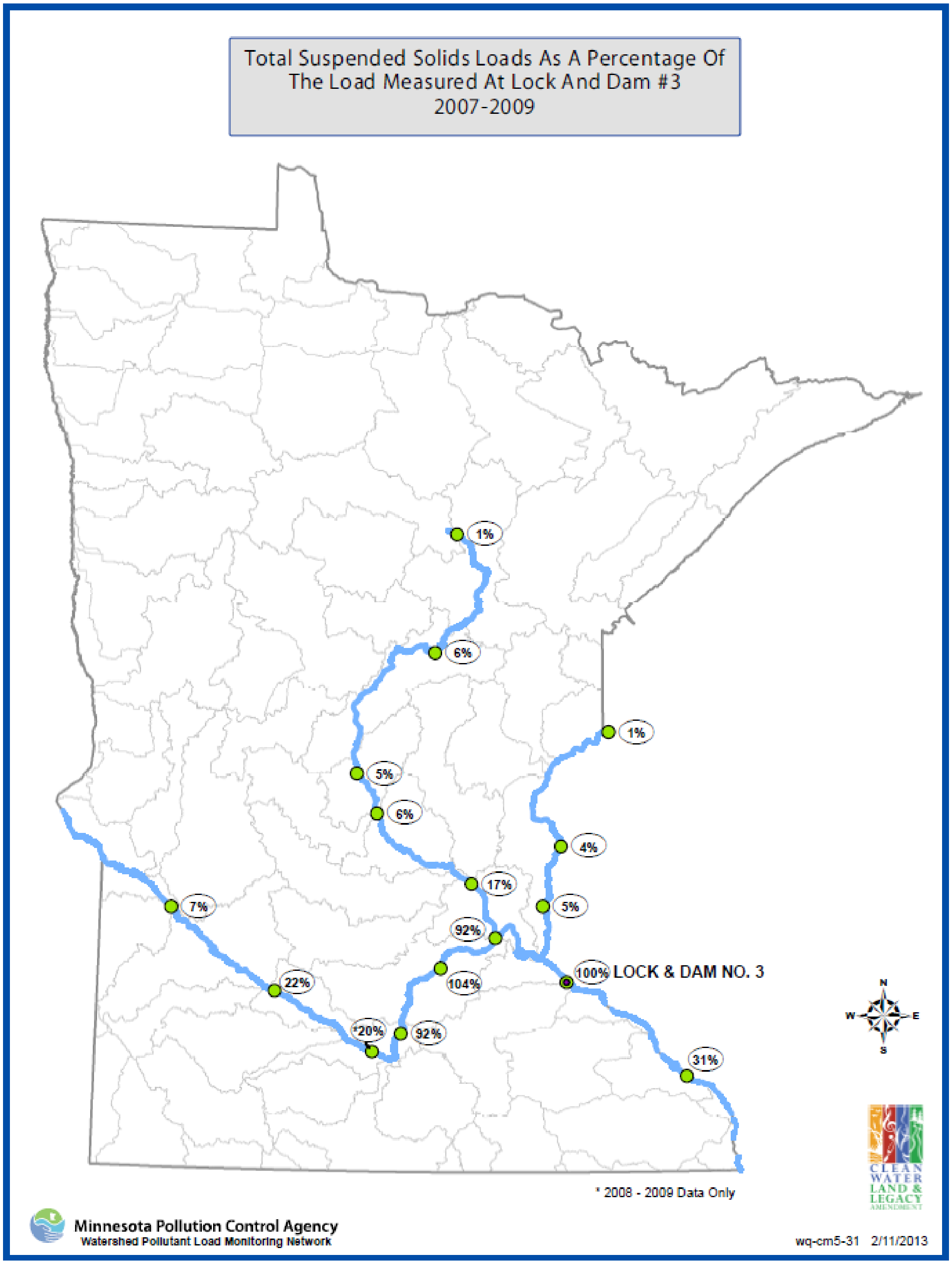


Figure 27. MPCA Nitrate-Nitrite Loads as a Percentage of the Load Measured at Lock and Dam #3 (2007-2009)

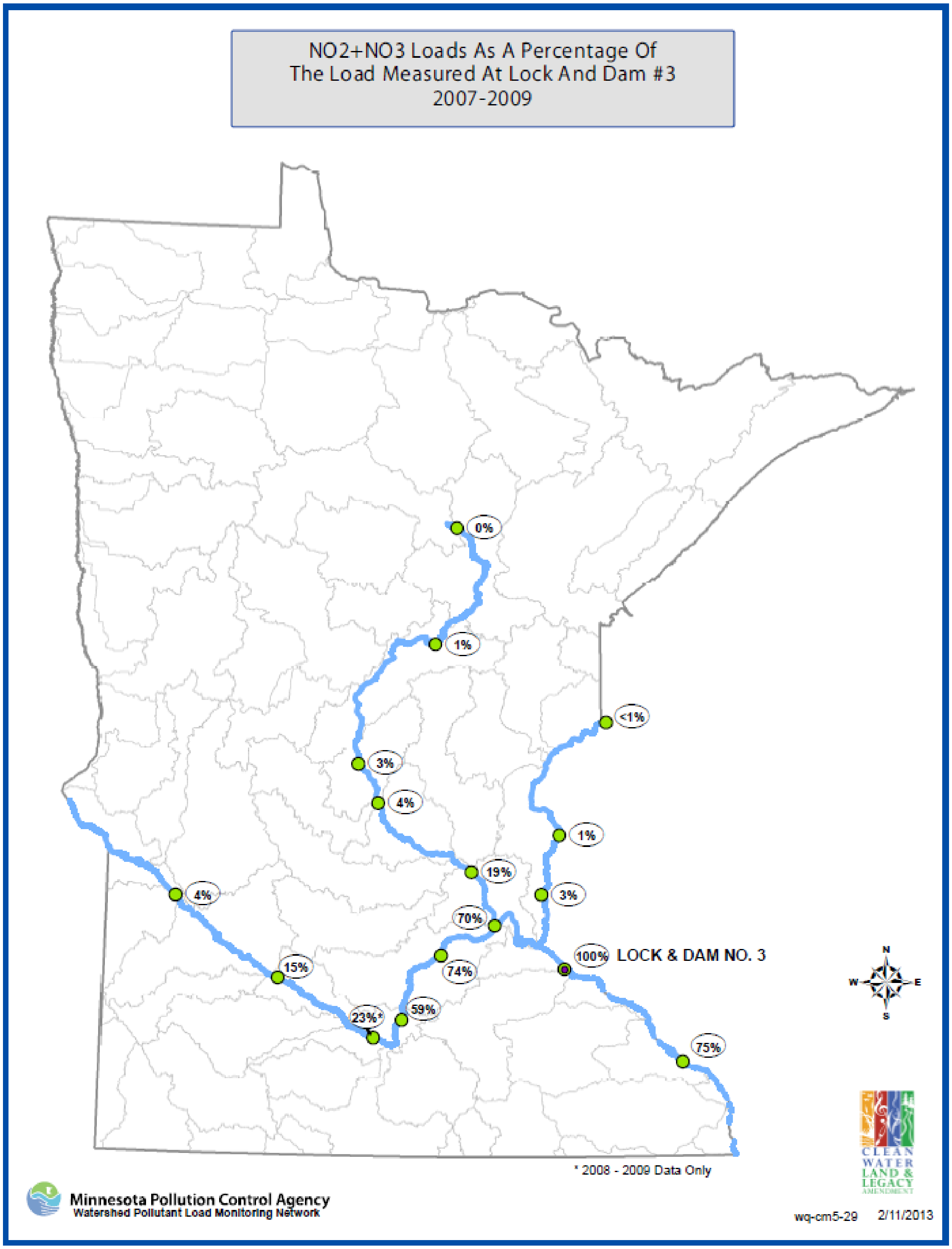
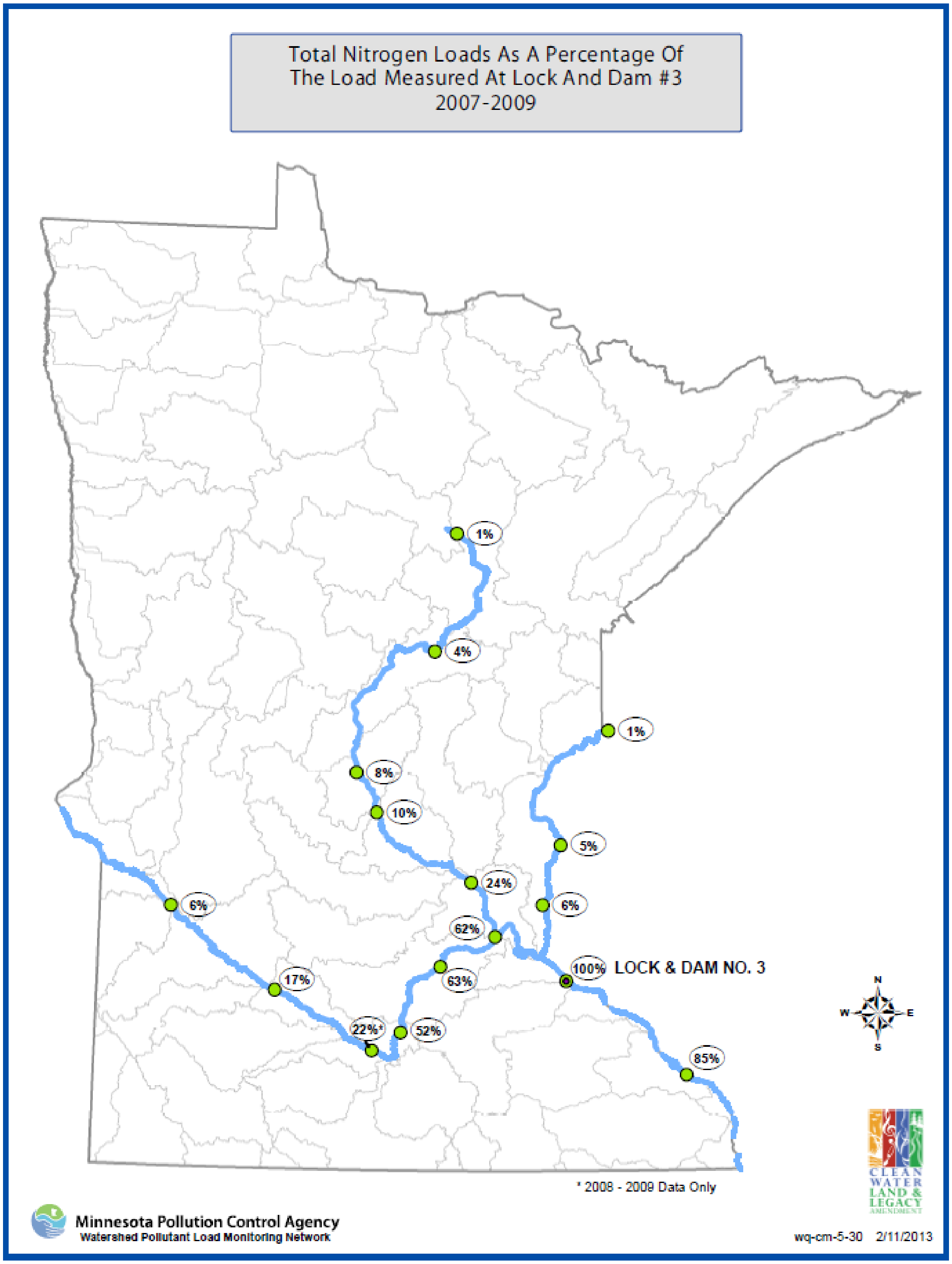


Figure 28. MPCA Total Nitrogen Loads as a Percentage of the Load Measured at Lock and Dam #3 (2007-2009)



F. Flow-Through Lakes and Reservoirs

To evaluate the effects the flow-through lakes and reservoirs have on Mississippi River water quality, a comparison was conducted between the average annual growing season water quality in the lake or reservoir and the next downstream Mississippi River monitoring site. Only two lakes had both in-lake data and corresponding downstream data: Stump Lake and Cass Lake, summarized below.

Stump Lake

Stump Lake is a 323-acre impoundment on the Mississippi River controlled by a dam operated by Ottertail Power. In-lake and stream data were available in 2005. The in-lake annual growing season mean TP concentration was slightly greater than the TP concentration at the downstream sampling site (S000-155) in the stream segment 07010101-513. This indicates that Stump Lake may have potentially acted as a source of TP to the Mississippi River in 2005.

Table 14. Comparison of phosphorus (mg/L) in Stump Lake and the downstream stream segment

AUID/Lake	YEAR	Phosphorus (mg/L)					
		N	Mean	Std. Dev.	25th Quartile	Median	75th Quartile
Stump Lake	2005	4	0.037	0.005	0.034	0.038	0.040
07010101-513	2005	4	0.032	0.009	0.025	0.031	0.040

Cass Lake

Cass Lake is a 15,958-acre reservoir on the Mississippi River controlled by the Knutson Dam operated by U.S. Forest Service. In-lake and stream data were available in 2004. The in-lake annual growing season mean TP concentration was less than the TP concentration at the downstream sampling site S002-283 in the stream segment 07010101-507. This indicates that Cass Lake may have potentially acted as a sink of TP from the Mississippi River in 2004.

Table 15. Comparison of phosphorus (mg/L) in Cass Lake and the downstream stream segment

AUID/Lake	YEAR	Phosphorus (mg/L)					
		N	Mean	Std. Dev.	25th Quartile	Median	75th Quartile
Cass Lake	2004	4	0.015	0.002	0.014	0.016	0.016
07010101-507	2004	8	0.042	0.016	0.029	0.038	0.057

Additional monitoring is needed to more thoroughly understand what impact flow-through lakes and reservoirs are having on Mississippi River water quality. We recommend that phosphorus and turbidity (Secchi depth in lakes, TSS in rivers) data be collected in the AUID immediately upstream of each of the lakes, in-lake, and at several monitoring sites along the AUID immediately downstream of the lake. In lakes located in wetland areas (e.g., Cass), dissolved oxygen fluxes should also be monitored.

G. Future Study Recommendations

Consolidated HSPF Model

Over the next several years the MPCA will be constructing HSPF watershed loading and water quality models for the entire Mississippi River Headwaters watershed. These models will be used to predict flows and pollutant loadings in support of watershed-wide total maximum daily load (TMDL) studies and watershed restoration and protection planning. Listed below are the HUC-8 watersheds in the Headwaters area along with the year the MPCA plans to begin their intensive watershed monitoring. The HSPF model will be built in the 1-3 year period following the intensive monitoring so it is assumed that the entire Headwaters area will have HSPF modeling completed by around 2018.

1. Mississippi River (Headwaters) – 2013
2. Leech Lake River – 2012
3. Pine River – 2012
4. Mississippi River (Grand Rapids) – 2014
5. Crow Wing River – 2010
6. Mississippi River (Brainerd) – 2015
7. Mississippi River (Sartell) – 2016

As currently proposed, each of the HSPF models will be separate tools built at the HUC 8 level. The Headwaters Board could take advantage of this modeling effort by consolidating the various models and adding in the unique resources of the river system. The consolidated HSPF model could then be used to predict the impact that various land use scenarios throughout the region may have on each of the lakes and river reaches in the system.

Mississippi River Channel Erosion

The watershed for the Headwaters of the Mississippi River has gone through a number of man influenced hydraulic changes since the pre-settlement times. In the northern stretch of the Mississippi Headwaters the land cover is primarily forested with small amounts of agricultural and urban uses. These forests were originally old growth stands but are now comprised of young stands that regenerated after the initial logging of the area and are now managed for timber production. This is significant because the hydrology of young and middle aged forests behave differently than old growth forests. In portions of the watershed the pre-settlement streams feeding to the Mississippi were also modified to convey logs harvested to the mills, create water sources for hydro-powered mills, and in some areas to provide drainage to post-logging agriculture. After the initial logging and during the settlement of the area, dams were constructed for power generation and the creation of reservoirs.

As a result of the hydraulic changes to the watershed of the Headwaters of the Mississippi River, the channel is experiencing greater stress. A higher volume of water is entering the Mississippi from feeder streams and dam operations of the impounded waters are in some areas causing the Mississippi to flow at near bank-full conditions for extended periods of time. The result of the stress of extended bank flow on the Mississippi River channel is larger amounts of erosion and channel meandering adding nutrients and sediment to the load carried by the river.

Utilizing the channel assessment work already done by the DNR Fisheries, an in-depth analysis of reservoir dam operation plans and agricultural operation plans (wild rice farming) a hydrologic model for the 400 miles of the Headwaters could be constructed. Coupled with the effects of the changing climate and changes in landuse, the developed hydrologic model would be used to test scenarios of water release to reduce conditions that cause stream channel instability in the Mississippi River. The results of this analysis could then be used to update dam and field operation management plans for the protection of the Mississippi River.

For identification of potential areas of erosion adding to the nutrient and sediment load in the Mississippi River a terrain and stream channel analysis of the sub-watersheds for the contributing to the Mississippi River could be conducted. The sub-watershed analysis would use the available LIDAR data, soils data, landuse data and data sets from the USGS to identify areas highly susceptible to erosion. These areas could then be targeted for restoration activities if high amounts of erosion are taking place or restoration efforts to prevent future erosion problems.

4. CLEARWATER COUNTY

The headwaters of the Mississippi River are located in Clearwater County at Lake Itasca. Only one AUID (07010101-923) occurs within this county; water quality and biological data are summarized below. Figures for all water quality data are located in Appendix A.

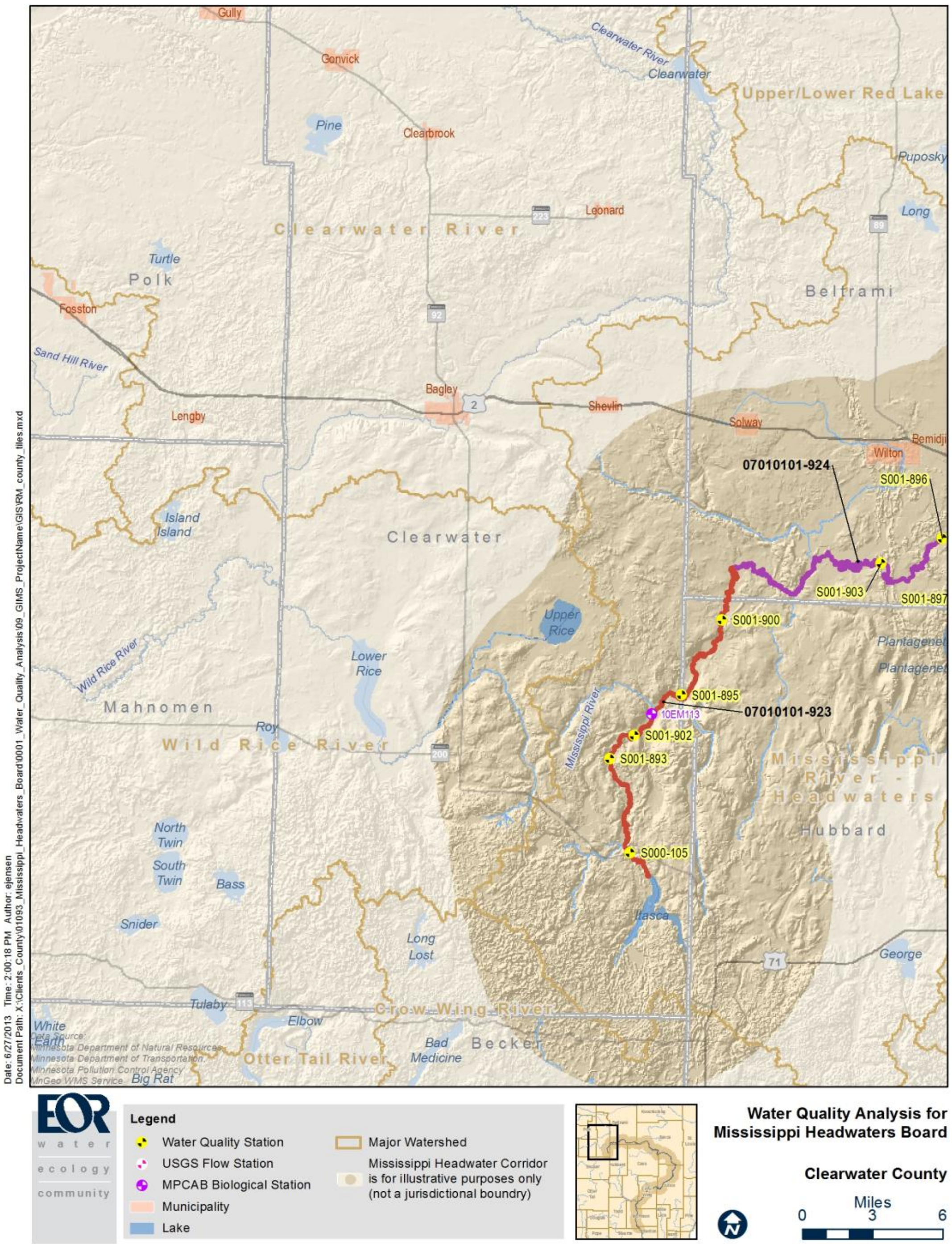


Figure 29. Mississippi River mainstem reaches located in Clearwater County

A. 07010101-923 (Headwaters to Unnamed Creek)

Data Inventory and Trends

Water quality data was collected from 5 stations on 07010101-923 between 2003 and 2010 (Table 16). Data was collected for all parameters for several years, but none in the most recent two years. Phosphorus slightly exceeded the draft water quality standard when averaged across all years (Table 17), but met the standard in 2010 (Figure 30).

Table 16. Data inventory for 07010101-923 (Headwaters to Unnamed Creek)

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003	61		61		61	62	61	1	61
2004	2		2	1	2	2	2		2
2005	9		8	6	9	12	9	1	8
2006	2		7	8	2	9	2	1	2
2007	8	7	7	6	8	11	8	7	8
2009	2	2	2		2	2	2	2	2
2010	8	7	8		8	8	8	8	8

Table 17. Summary of water quality data for 07010101-923 (Headwaters to Unnamed Creek)
Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)[1]	0.04 mg/L	92	0.06	0.00	0.05	0.05	0.05	0.05	0.26
Chloride	230 mg/L	16	2.03	0.21	1.40	1.51	1.70	2.22	4.70
DO	>5 mg/L	95	8.52	0.29	0.86	7.30	8.85	10.25	14.38
E. coli (geometric mean)	Geometric mean 126 org/ 100mL (Apr-Oct)	21	15.11	36.65	1.00	8.00	20.00	24.00	130.00
Inorganic N	10 mg/L	92	0.05	0.00	0.05	0.05	0.05	0.05	0.11
pH	>6.5, <9.0	106	7.90	0.03	6.73	7.69	7.98	8.12	8.64
Phosphorus	0.05 mg/L (June-Sept)	57	0.06	0.00	0.03	0.05	0.06	0.07	0.15
Sulfate	250 mg/L	20	1.07	0.06	1.00	1.00	1.00	1.00	2.05
TSS	15 mg/L (Apr-Sept)	68	7.07	1.55	1.00	2.00	3.60	7.60	98.00

[1] Standard of 0.04 mg/L is for unionized ammonia. The mean concentration is total ammonia.

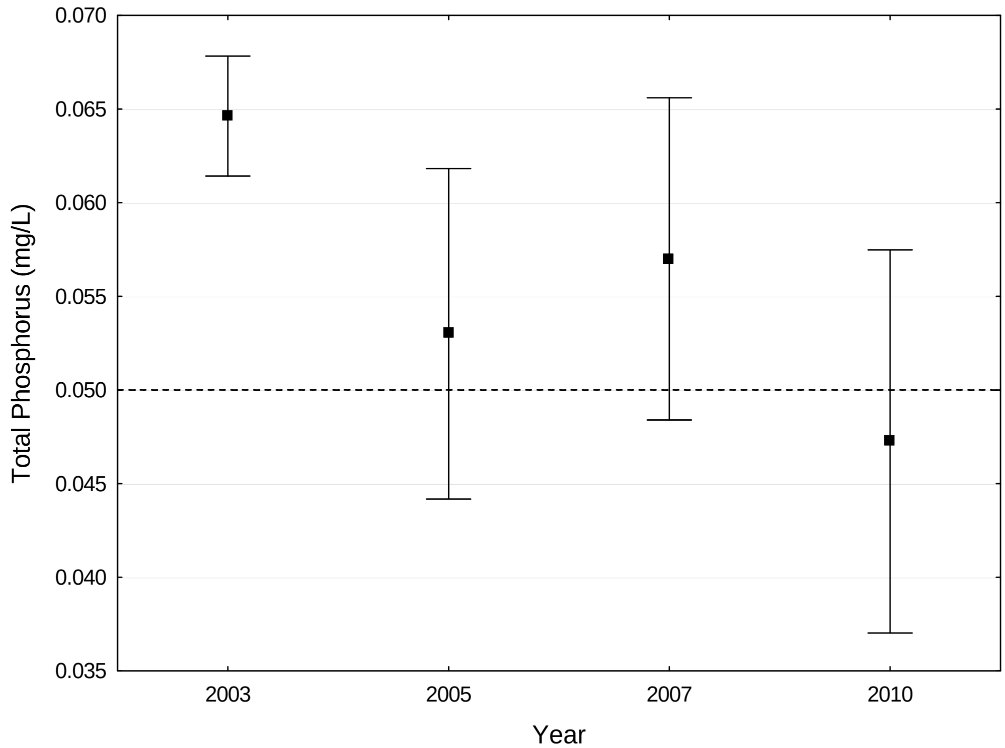


Figure 30. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010101-923 (Headwaters to Unnamed Creek). The dotted line indicates the proposed water quality standard (0.05 mg/L).

Biological Data

Three biological monitoring stations occur on reach 07010101-923, but only one station has data from the most recent ten years. Station 10EM113 was sampled for invertebrates in 2011 (Table 18). Twenty-five families were documented, and the IBI score was 73.

Table 18. Attributes of invertebrates sampled at 07010101-923 (Headwaters to Unnamed Creek)

Attribute	Count/ percent
EPT Taxa	12
Ephemeroptera Taxa	4
Hilsenhoffs Biotic Index (HBI)	4.2
Intolerant Families	5
Percent Pollution Tolerant	1
Percent Chironomidae	8.4
Percent Diptera	20
Percent Dominant Taxa	55.2
Percent Dominant Two Taxa	66.5
Percent Filterers	16.5
Percent Gatherer	74.2
Percent Hydropsychidae	2.3
Percent Scraper	4.8
Plecoptera Families	3
Trichoptera Families	5
Total Families	25

5. BELTRAMI COUNTY

Ten AUIDs occur in Beltrami County, but only three AUIDs have water quality data within the most recent 10 years. None of the three AUIDs have biological monitoring data within the most recent 10 years. Figures for all water quality data are located in Appendix B.

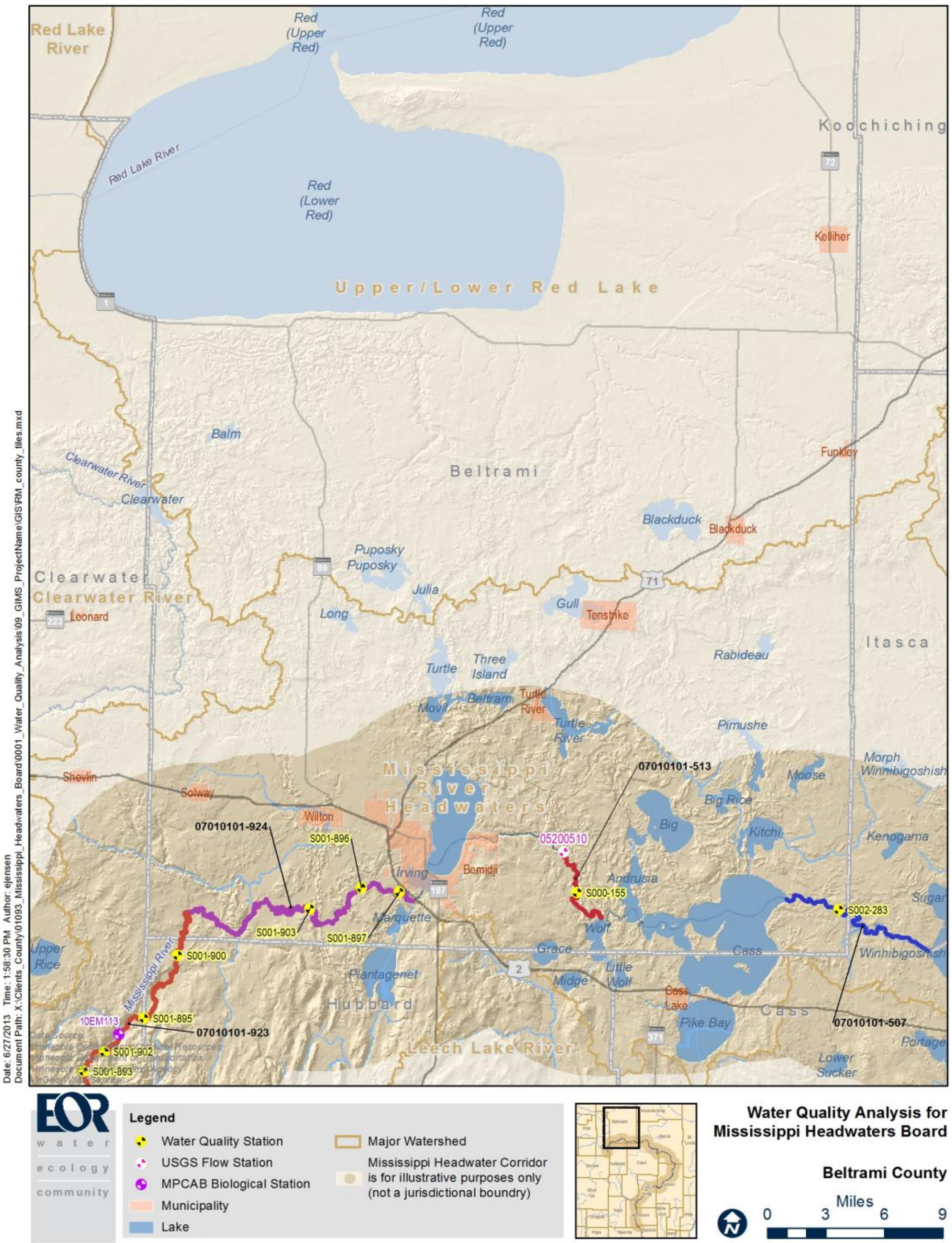


Figure 31. Mississippi River mainstem reaches in Beltrami County.

A. 07010101-924 (Unnamed Creek to Schoolcraft River)

Data Inventory and Trends

Water quality data was collected from three stations in 2003 on 07010101-924. No data was collected for chloride, *E. coli*, or sulfate (Table 19). Phosphorus slightly exceeded the water quality standard in 2003. All other water quality parameters met the water quality standards.

Table 19. Data inventory for 07010101-924 (Unnamed Creek to Schoolcraft River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003	36		36		36	36	36		36

Table 20. Summary of water quality data for 07010101-924 (Unnamed Creek to Schoolcraft River). Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	36	0.06	0.00	0.05	0.05	0.05	0.07	0.19
Chloride	230 mg/L								
DO	>5 mg/L	36	6.27	0.43	0.90	4.32	6.45	8.25	10.33
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L	36	0.05	0.00	0.05	0.05	0.05	0.05	0.08
pH	>6.5, <9.0	36	7.67	0.06	6.80	7.45	7.70	7.94	8.36
Phosphorus	0.05 mg/L (June-Sept)	27	0.08	0.01	0.05	0.07	0.08	0.09	0.16
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	30	3.71	0.47	1.00	1.60	3.00	4.40	9.60

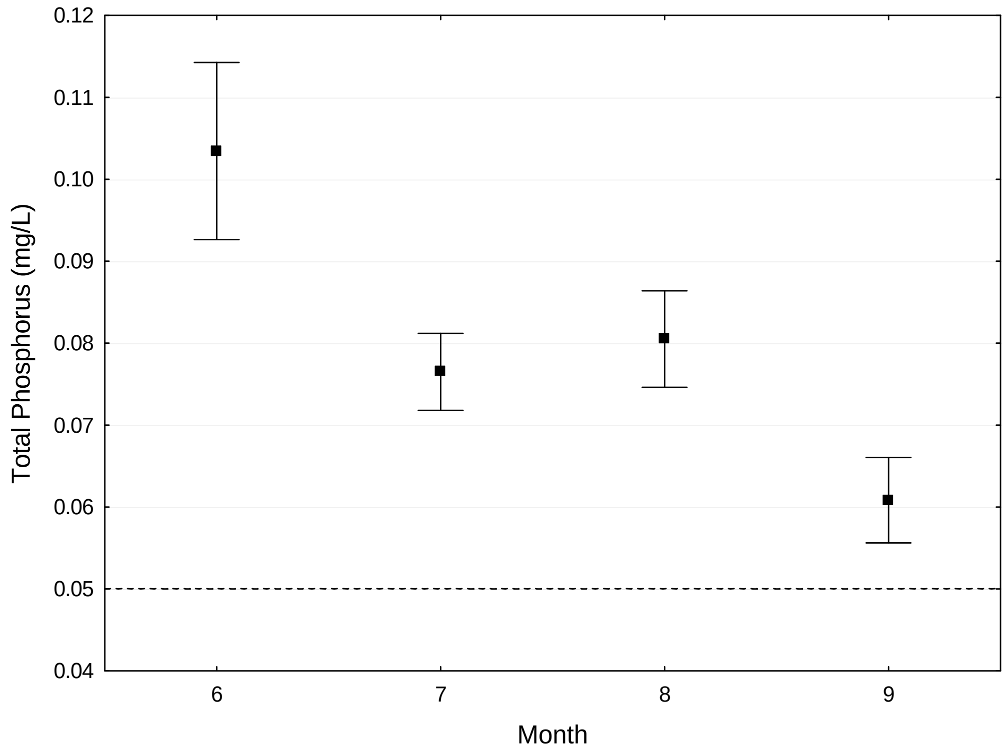


Figure 32. Growing season (June-Sept) mean ±SE total phosphorus concentration per month in 2003 on 07010101-924 (Unnamed Creek to Schoolcraft River). The dotted line indicates the proposed water quality standard (0.05 mg/L).

B. 07010101-513 (Stump Lake to Wolf Lake)

Data Inventory and Trends

Water quality data was collected from one station on 07010101-513 between 2004 and 2010, but no data was collected in 2008 (Table 21). No *E. coli* data has been collected in the most recent 5 years. All water quality parameters met the standards for all when averaged over the past 10 years (Table 22).

Table 21. Data inventory for 07010101-513 (Stump Lake to Wolf Lake).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2004	2		2	1	2	2	2		2
2005	8		8	6	8	12	8		8
2006	2		8	8	2	9	2	1	2
2007	8	7	7	6	8	11	8	7	8
2008									
2009	2	2	2		2	2	2	2	2
2010	8	7	8		8	8	8	8	8

Table 22. Summary of water quality data for 07010101-513 (Stump Lake to Wolf Lake).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	30	0.05	0.00	0.05	0.05	0.05	0.05	0.05
Chloride	230 mg/L	16	6.66	0.18	5.30	6.20	6.60	6.90	8.57
DO	>5 mg/L	35	10.74	0.40	6.79	9.05	10.16	12.86	15.07
E. coli	126 org/ 100mL (Apr-Oct)	21	9.79	1.00	32.55	4.00	12.00	28.00	140.00
Inorganic N	10 mg/L	30	0.07	0.01	0.05	0.05	0.05	0.05	0.30
pH	>6.5, <9.0	44	8.42	0.04	7.75	8.30	8.40	8.58	8.88
Phosphorus	0.05 mg/L (June-Sept)	12	0.03	0.00	0.02	0.02	0.03	0.03	0.05
Sulfate	250 mg/L	18	2.41	0.12	1.65	1.78	2.60	2.76	3.25
TSS	15 mg/L (Apr-Sept)	18	2.63	0.59	1.00	1.20	1.60	3.20	11.00

C. 07010101-507 (Cass Lake to Lake Winnibigoshish)

Data Inventory and Trends

Water quality data was collected from one station on 07010101-507 in 2004 and 2005. Data was not collected for *E. coli* or sulfate (Table 23). When averaged over the two years data was collected, phosphorus exceeded the draft standard (Table 24). Phosphorus met the standard in 2004, but exceeded the draft water quality standard in 2005 (Table 24).

Table 23. Data inventory for 07010101-507 (Cass Lake to Lake Winnibigoshish).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2004	16	16	16		16	16	16		16
2005	18	18	18		18	17	18		18

Table 24. Summary of water quality data for 07010101-507 (Cass Lake to Lake Winnibigoshish).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	34	0.04	0.01	0.01	0.01	0.02	0.04	0.25
Chloride	230 mg/L	34	20.95	0.77	11.10	17.49	20.99	24.49	27.10
DO	>5 mg/L	34	8.53	0.44	3.76	6.67	8.25	10.87	12.78
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L	34	0.08	0.02	0.02	0.02	0.02	0.08	0.46
pH	>6.5, <9.0	33	7.92	0.04	7.46	7.76	7.99	8.09	8.34
Phosphorus	0.05 mg/L (June-Sept)	18	0.07	0.01	0.02	0.04	0.06	0.09	0.15
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	28	11.63	2.17	0.50	3.00	7.54	18.50	40.00

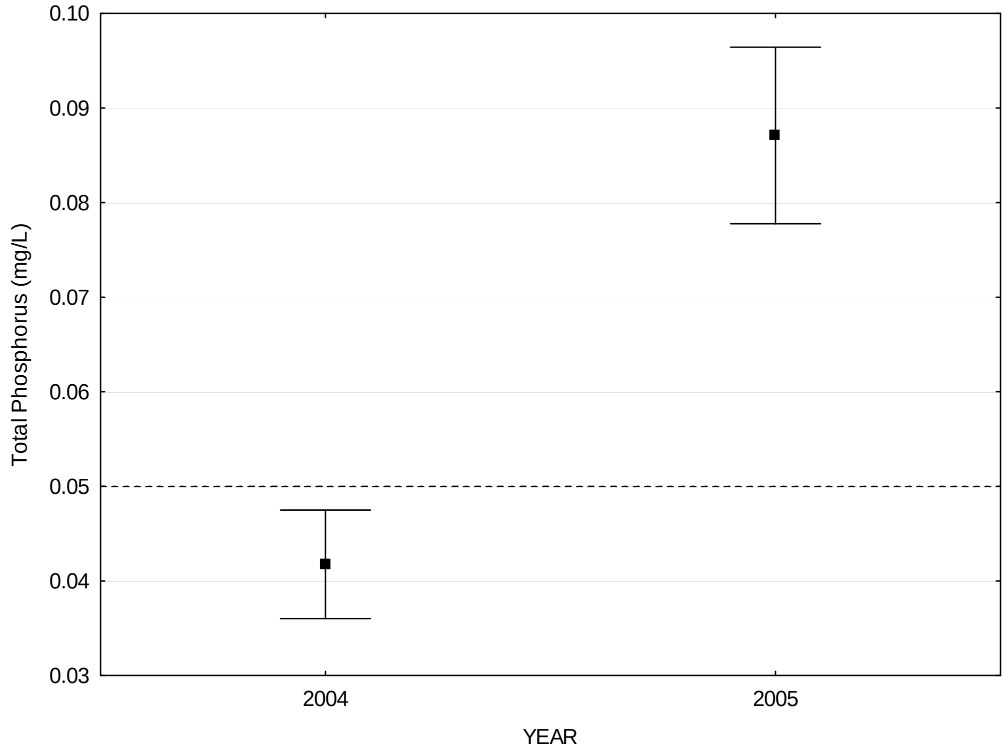


Figure 33. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010101-507 (Cass Lake to Lake Winnibigoshish). The dotted line indicates the proposed water quality standard (0.05 mg/L).

6. CASS COUNTY

The Mississippi River forms the boundary between Cass and Itasca Counties. Six AUIDs occur within Cass County, but water quality data from the most recent 10 years is available for two AUIDs. No MPCA biological monitoring data has been collected on any of the reaches within the most recent ten years. Figures for all water quality data are located in Appendix C.

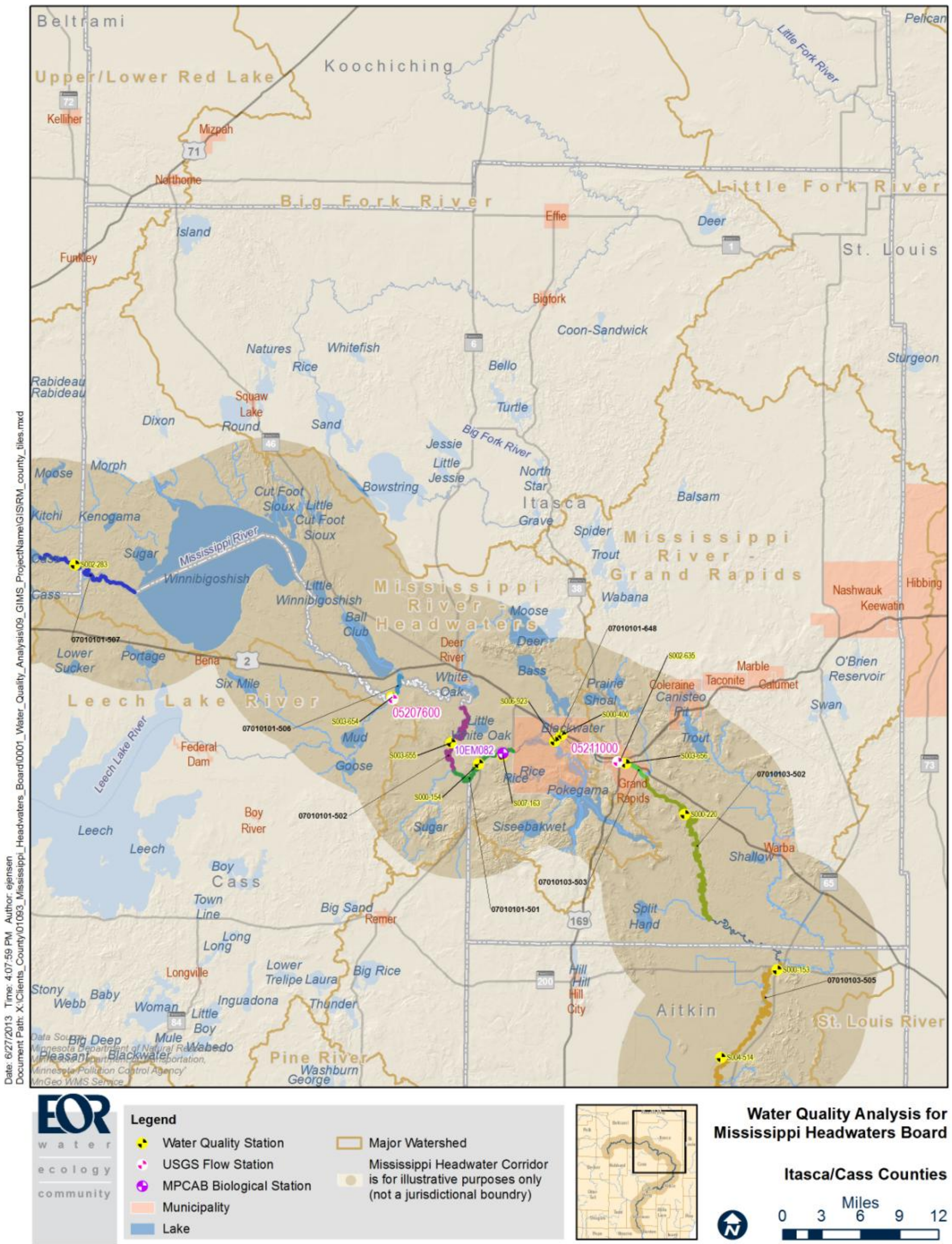


Figure 34. Mississippi River mainstem reaches in Cass County

A. 07010101-506 (Leech Lake River to Ball Club River)

Data Inventory and Trends

Water quality data was collected from one station between 2003 and 2008 on 07010101-506 (Table 25). Dissolved oxygen and pH data were collected between 2003 and 2008, and met the water quality standards when averaged across all years data was collected. Total suspended solids (TSS) data was only collected in 2008 and met the water quality standard (Table 26).

Table 25. Data inventory for 0701010-506 (Leech lake to Ball Club River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003			19			19			
2004			30			30			
2005			6			6			
2006			6			6			
2007			25			25			
2008			9			9			9

Table 26. Summary of water quality data for 07010101-506 (Leech lake to Ball Club River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	40 ug/L								
Chloride	230 mg/L								
DO	>5 mg/L	95	9.23	0.25	2.94	7.46	8.87	10.70	18.35
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L								
pH	>6.5, <9.0	95	8.07	0.03	7.00	7.87	8.08	8.30	8.80
Phosphorus	0.05 mg/L (June-Sept)								
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	6	1.57	0.36	1.00	1.00	1.10	2.00	3.20

B. 07010101-502 (deer River to Vermillion River)

Data Inventory and Trends

Water quality data was collected from one station between 2003 and 2008 on 07010101-502 (Table 27). Dissolved oxygen and pH data were collected between 2003 and 2008, and met the water quality standards when averaged across all years data was collected. Total suspended solids (TSS) data was only collected in 2008 and met the water quality standard (Table 28).

Table 27. Data inventory for 07010101-502 (Deer River to Vermillion River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003			18			18			
2004			30			30			
2005			5			5			
2006			6			6			
2007			24			24			
2008			10			10			10

Table 28. Summary of water quality data for 07010101-502 (Deer River to Vermillion River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	40 ug/L								
Chloride	230 mg/L								
DO	>5 mg/L	93	8.31	0.24	2.87	6.47	8.04	9.99	13.35
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L								
pH	>6.5, <9.0	93	7.87	0.03	7.01	7.71	7.83	8.02	8.58
Phosphorus	0.05 mg/L (June-Sept)								
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	7	2.66	0.85	1.00	1.00	1.20	5.60	6.00

7. ITASCA COUNTY

Eight AUIDs along the Mississippi River occur in Itasca County. Four of these AUIDs have water quality data, and only one AUID (07010101-501) has biological monitoring data that was collected in the most recent 10 years. Figures for all water quality data are located in Appendix D.

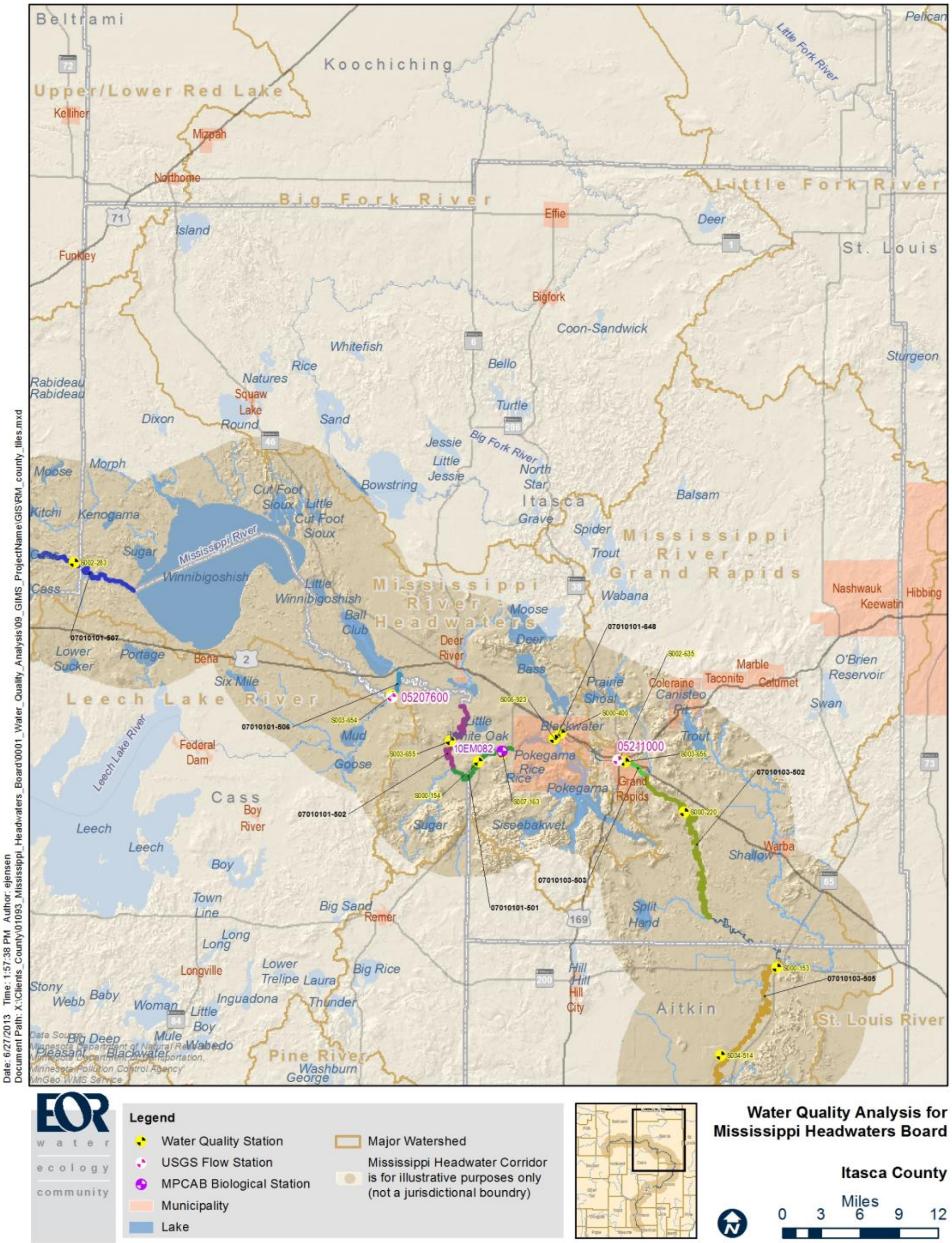


Figure 35. Mississippi River mainstem reaches in Itasca County.

A. 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake)

Data Inventory and Trends

Water quality data was collected from two stations between 2003 and 2012 on 07010101-501 (Table 29). All water quality parameters met the water quality standards when averaged across all years data was collected (Table 30).

Table 29. Data inventory for 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003			19			19			
2004	2		32	1	2	32	2		2
2005	8		8	6	8	12	8		8
2006	2		7	8	2	9	2	1	2
2007	8	7	7	6	8	11	8	7	8
2008			10			10			10
2009	16	18	21	2	22	22	22	18	22
2010	8	6	8		8	8	8	7	8
2011	1	1	1		1	2	1	1	
2012	1	1			1	2	1	1	

Table 30. Summary of water quality data for 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	46	0.14	0.08	0.05	0.05	0.05	0.05	3.60
Chloride	230 mg/L	33	3.40	0.09	2.66	3.07	3.31	3.70	4.70
DO	>5 mg/L	113	8.42	0.25	3.15	6.28	8.23	10.10	14.83
E. coli	126 org/ 100mL (Apr-Oct)	23	5.66	1.00	9.71	3.00	5.00	11.00	42.00
Inorganic N	10 mg/L	52	0.06	0.01	0.05	0.05	0.05	0.05	0.46
pH	>6.5, <9.0	127	7.85	0.03	6.61	7.65	7.87	8.06	8.76
Phosphorus	0.05 mg/L (June-Sept)	21	0.03	0.00	0.01	0.03	0.03	0.03	0.04
Sulfate	250 mg/L	35	2.27	0.12	1.09	1.88	2.22	2.64	4.79
TSS	15 mg/L (Apr-Sept)	40	3.48	0.29	1.00	2.00	3.20	4.60	8.40

Biological Data

Biological data was collected from one MPCA biological monitoring station (10EM082) in 2010. A total of 151 individuals, representing 19 fish species were documented (Table 31, Table 32). Black chin shiner and blacknose shiner were the most abundant species, and no invasive species were observed. The fish community was given and IBI score of 74. Additionally, 14 families of invertebrates were documented (Table 33, Table 34), and the invertebrate community was given an IBI score of 38.

Table 31. Attributes of fish sampled on 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake).

Attribute	Count
DELT (abnormalities)	0
Darter species	0
Exotic species	0
Fish per 100 m	0
Game fish species	7
Gravel spawning species	5
Piscivore species	6
Pollution intolerant species	5
Special concern species	0
Total species	19

Table 32. Fish species observed on 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake) in 2010.

Species	Count	Min Length (mm)	Max Length (mm)
Black Crappie	1	88	88
Blackchin Shiner	392	34	65
Blacknose Shiner	253	33	61
Bluegill	9	38	213
Bluntnose Minnow	2	44	76
Bowfin	4	615	730
Burbot	3	155	173
Common Shiner	1	64	64
Golden Shiner	76	39	99
Greater Redhorse	3	610	365
Largemouth Bass	6	64	374
Mimic Shiner	81	51	66
Northern Pike	1	215	215
Pumpkinseed	1	190	190
Rock Bass	5	74	260
Shorthead Redhorse	8	428	518
Spottail Shiner	17	42	100
White Sucker	5	442	510
Yellow Perch	151	45	281

Table 33. Attributes of invertebrates on 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake).

Attribute	Count/ percent
EPT Taxa	5
Ephemeroptera Taxa	3
Hilsenhoffs Biotic Index (HBI)	2.1
Intolerant Families	0
Percent Pollution Tolerant	16
Percent Chironomidae	1
Percent Diptera	1
Percent Dominant Taxa	69.2
Percent Dominant Two Taxa	83.3
Percent Filterers	0
Percent Gatherer	73.4
Percent Hydropsychidae	0
Percent Scraper	22.8
Plecoptera Families	0
Trichoptera Families	2
Total Families	14

Table 34. List of invertebrates on 07010101-501 (Vermillion River to Blackwater/ Pokegama Lake).

Invertebrates
Amphipods
Chiggers
Flatworms
Gastropods
Green-Eyed Skimmers
Long-Horn Caddisflies
Mayflies
Micro-Caddisflies
Midges
Narrow-Winged Damselflies
Nematoda
Oligochaeta
Riffle Beetles

B. 07010101-648 (Blackwater Lake to Bass Lake)

Data Inventory and Trends

Water quality data was collected from two stations in 2009, 2011, and 2012 on 07010101-648. Sample sizes, however, were very low and only one sample was collected per year for each pollutant, except pH (Table 35). The few measurements of phosphorus and TSS exceeded water quality standards (Table 36). Due to the low sample sizes, there are no figures for this AUID in Appendix D.

Table 35. Data inventory for 07010101-648 (Blackwater Lake to Bass Lake).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2009			1	1		1	1		1
2011	1	1	1		1	2	1	1	
2012	1	1			1	2	1	1	

Table 36. Summary of water quality data for 07010101-648 (Blackwater Lake to Bass Lake). Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	2	3.32	3.28	0.04	0.04	3.32	6.60	6.60
Chloride	230 mg/L	2	3.71	0.14	3.57	3.57	3.71	3.85	3.85
DO	>5 mg/L	2	5.21	1.32	3.89	3.89	5.21	6.53	6.53
E. coli	126 org/ 100mL (Apr-Oct)	1	260.00		260.00	260.00	260.00	260.00	260.00
Inorganic N	10 mg/L	2	0.42	0.37	0.05	0.05	0.42	0.79	0.79
pH	>6.5, <9.0	5	7.44	0.24	6.60	7.35	7.59	7.63	8.04
Phosphorus	0.05 mg/L (June-Sept)	3	0.09	0.07	0.02	0.02	0.03	0.22	0.22
Sulfate	250 mg/L	2	6.98	3.33	3.65	3.65	6.98	10.30	10.30
TSS	15 mg/L (Apr-Sept)	1	35.00		35.00	35.00	35.00	35.00	35.00

C. 07010103-503 (Grand Rapids Dam to Prairie River)

Data Inventory and Trends

Water quality data was collected from two stations between 2003 and 2012 on 07010103-503. Data for ammonia, chloride, E. coli, and sulfate was limited to one year (Table 37). All water quality parameters met the water quality standards when averaged across all years data was collected (Table 30).

Table 37. Data inventory for 07010103-503 (Grand Rapids dam to Prairie River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003			38			38			
2004			60			60			
2005			10			10			
2006			12			12			
2007			50			50			
2008			10			10			10
2009	9	10	11	1	12	12	12	10	12
2010			20		26	26	26		26
2011			20		21	21	21		21
2012			20		30	29	30		30

Table 38. Summary of water quality data for 07010103-503 (Grand Rapids dam to Prairie River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	9	0.05	0.00	0.05	0.05	0.05	0.05	0.06
Chloride	230 mg/L	10	4.62	1.08	3.06	3.18	3.47	3.75	14.20
DO	>5 mg/L	261	9.19	0.13	5.47	7.63	8.85	10.73	17.03
E. coli	126 org/ 100mL (Apr-Oct)	1	9.00		9.00	9.00	9.00	9.00	9.00
Inorganic N	10 mg/L	89	0.05	0.00	0.05	0.05	0.05	0.05	0.14
pH	>6.5, <9.0	268	7.95	0.01	7.30	7.80	7.96	8.10	8.36
Phosphorus	0.05 mg/L (June-Sept)	31	0.03	0.00	0.01	0.02	0.03	0.03	0.04
Sulfate	250 mg/L	10	5.83	0.74	3.37	4.31	4.90	7.22	10.60
TSS	15 mg/L (Apr-Sept)	72	2.82	0.19	1.00	2.00	2.80	3.20	10.00

D. 07010103-502 (Prairie River Split Hand Creek)

Data Inventory and Trends

Water quality data was collected from one station between 2003 and 2011 on 07010103-502. All water quality parameters had adequate sample sizes (Table 39) and met the water quality standards when averaged across all years data was collected (Table 40).

Table 39. Data inventory for 07010103-502 (Prairie River Split Hand Creek).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2003			19			19			
2004	2		33	1	2	34	2		2
2005	8		12	6	8	17	8		8
2006	2		13	8	2	15	2	1	2
2007	26	21	46	18	23	52	22	21	23
2008	3	14	22	8	17	25	17	15	24
2009	8	15	23	2	25	25	24	14	24
2010	11	9	12		12	12	12	10	12
2011			3			3		3	

Table 40. Summary of water quality data for 07010103-502 (Prairie River Split Hand Creek).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	60	0.06	0.01	0.05	0.05	0.05	0.05	0.43
Chloride	230 mg/L	59	4.92	0.17	3.03	4.30	4.70	5.52	11.00
DO	>5 mg/L	183	8.86	0.18	4.30	6.73	8.46	10.51	16.19
E. coli	126 org/ 100mL (Apr-Oct)	40	11.17	47.02	1.00	4.00	11.00	21.50	210.00
Inorganic N	10 mg/L	89	0.10	0.04	0.05	0.05	0.05	0.05	3.70
pH	>6.5, <9.0	202	7.84	0.02	6.87	7.73	7.85	7.99	8.82
Phosphorus	0.05 mg/L (June-Sept)	32	0.03	0.00	0.03	0.03	0.04	0.04	0.04
Sulfate	250 mg/L	64	11.67	0.96	3.17	6.43	9.15	14.10	34.70
TSS	15 mg/L (Apr-Sept)	62	3.75	0.27	1.00	2.40	3.30	4.80	12.00

8. AITKIN COUNTY

Five AUIDs occur on the Mississippi River in Aitkin County, but only three have water quality data from the most recent 10 years. One of the AUIDs (07010103-501) has MPCA biological monitoring data within the most recent 10 years. Figures for all water quality data are located in Appendix E.

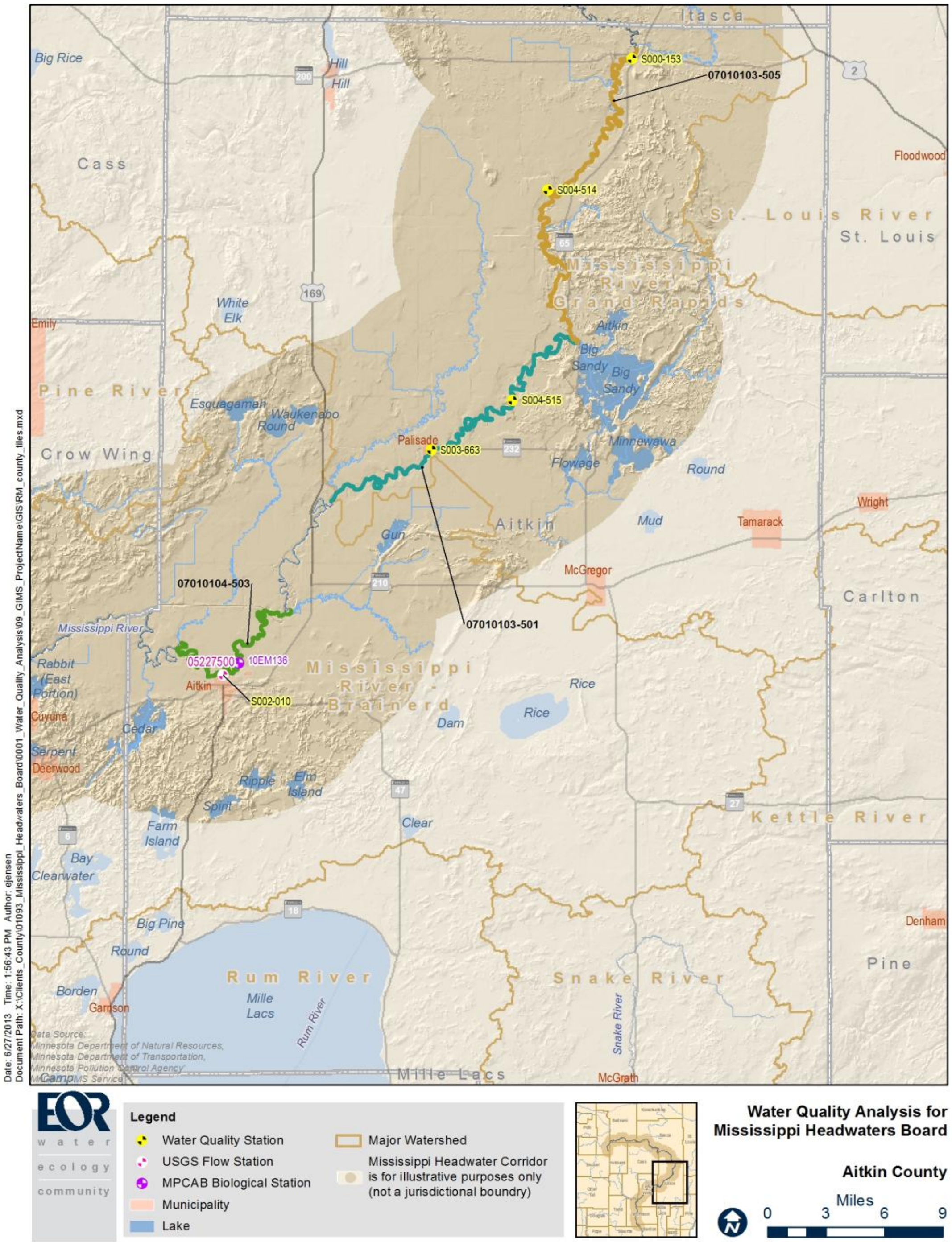


Figure 36. Mainstem Mississippi River reaches in Aitkin County.

A. 07010103-505 (Swan River to Sandy River)

Data Inventory and Trends

Water quality data was collected from two stations between 2007 and 2009 on 07010103-505 (Table 41). Data was only collected for dissolved oxygen, pH, and total suspended solids, and all parameters met the water quality standards (Table 42).

Table 41. Data inventory for 07010103-505 (Swan River to Sandy River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2007			50			53			45
2008			48			44			47
2009			15			15			15

Table 42. Summary of water quality data for 07010103-505 (Swan River to Sandy River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	40 ug/L								
Chloride	230 mg/L								
DO	>5 mg/L	113	8.77	0.16	6.29	7.48	8.35	9.62	14.01
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L								
pH	>6.5, <9.0	112	7.88	0.02	7.32	7.71	7.88	8.06	8.27
Phosphorus	0.05 mg/L (June-Sept)								
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	80	14.03	0.75	3.20	8.00	14.00	18.00	29.00

B. 07010103-501 (Sandy River to Willow River)

Data Inventory and Trends

Water quality data was collected from two stations between 2003 and 2009 on 07010103-501 (Table 43). Data was only collected for dissolved oxygen, pH, and total suspended solids, and dissolved oxygen and pH met the water quality standards (Table 44). When averaged across all years, TSS slightly exceeded the water quality standard and was the highest in 2009 (Table 44).

Table 43. Data inventory for 07010103-501 (Sandy River to Willow River).

Year	Ammonia	Chloride	DO	*E. coli*	Inorganic N	pH	TP	Sulfate	TSS
2003			19			19			
2004			30			30			
2005			15			15			
2006			14			14			
2007			50			52			46
2008			48			48			48
2009			10			10			10

Table 44. Summary of water quality data for 07010103-501 (Sandy River to Willow River). Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L								
Chloride	230 mg/L								
DO	>5 mg/L	186	8.80	0.12	5.92	7.62	8.38	9.74	13.94
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L								
pH	>6.5, <9.0	188	7.96	0.04	7.07	7.77	7.98	8.11	14.20
Phosphorus	0.05 mg/L (June-Sept)								
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	78	15.04	0.97	4.00	7.20	12.50	22.00	37.00

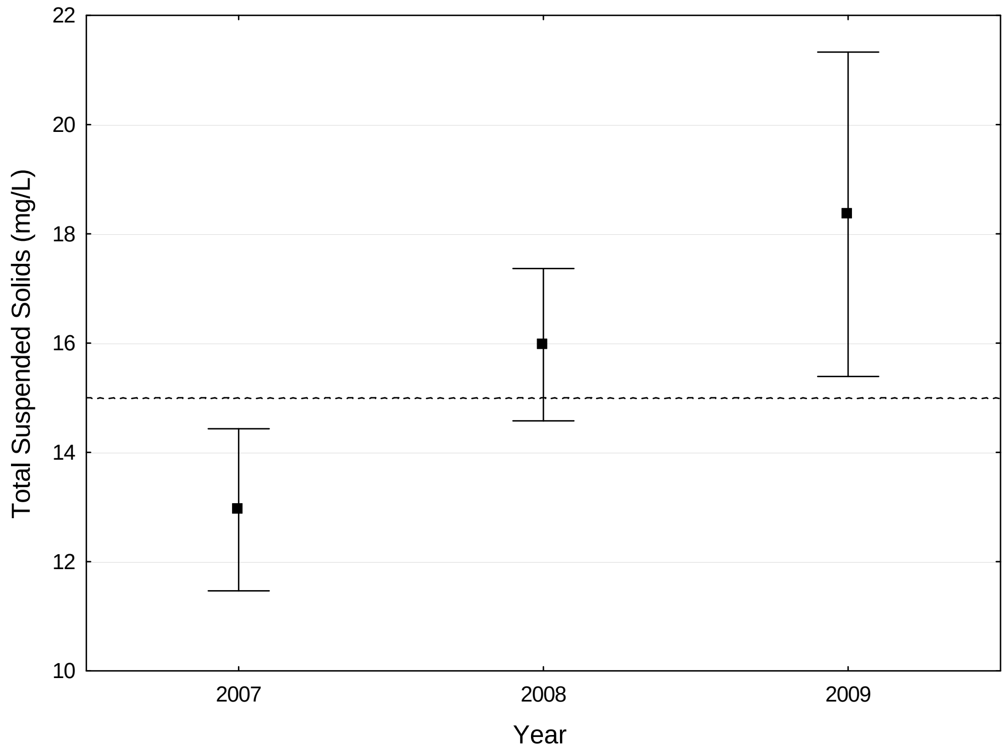


Figure 37. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year. The dotted line indicates the water quality standard (15 mg/L).

C. 07010104-503 (Rice River to Little Willow River)

Data Inventory and Trends

Water quality data was collected from one station between 2004 and 2012 on 07010104-503 (Table 45). All water quality parameters met the water quality standards, except TSS. When averaged across all years, TSS exceeded the water quality standard and was the highest in 2004 (Table 46).

Table 45. Data inventory for 07010104-503 (Rice River to Little Willow River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2004	15		43		15	61	15		15
2005	18		12		18	19	18		18
2006	15		28		15	32	15		15
2007	16	15	41	13	16	42	15	15	39
2008	4	16	37	8	18	42	19	16	39
2009	6	11	22	2	24	22	25	11	22
2010	3	3	34		30	30	30	3	30
2011			22		20	23	20	3	20
2012			28		29	28	29		29

Table 46. Summary of water quality data for 07010104-503 (Rice River to Little Willow River). Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04mg/L	77	0.06	0.00	0.05	0.05	0.05	0.05	0.30
Chloride	230 mg/L	45	4.40	0.16	1.00	3.68	4.40	5.08	6.50
DO	>5 mg/L	276	8.96	0.13	2.54	7.48	8.61	10.17	15.50
E. coli	126 org/ 100mL (Apr-Oct)	21	9.98	15.18	1.00	5.00	13.00	18.00	59.00
Inorganic N	10 mg/L	185	0.15	0.03	0.05	0.05	0.05	0.10	3.90
pH	>6.5, <9.0	318	7.90	0.01	6.92	7.75	7.93	8.07	8.96
Phosphorus	0.05 mg/L (June-Sept)	75	0.05	0.00	0.02	0.04	0.05	0.06	0.10
Sulfate	250 mg/L	48	11.48	1.02	2.87	6.18	9.64	14.40	34.00
TSS	15 mg/L (Apr-Sept)	169	19.95	0.99	4.00	11.00	18.00	26.00	120.00

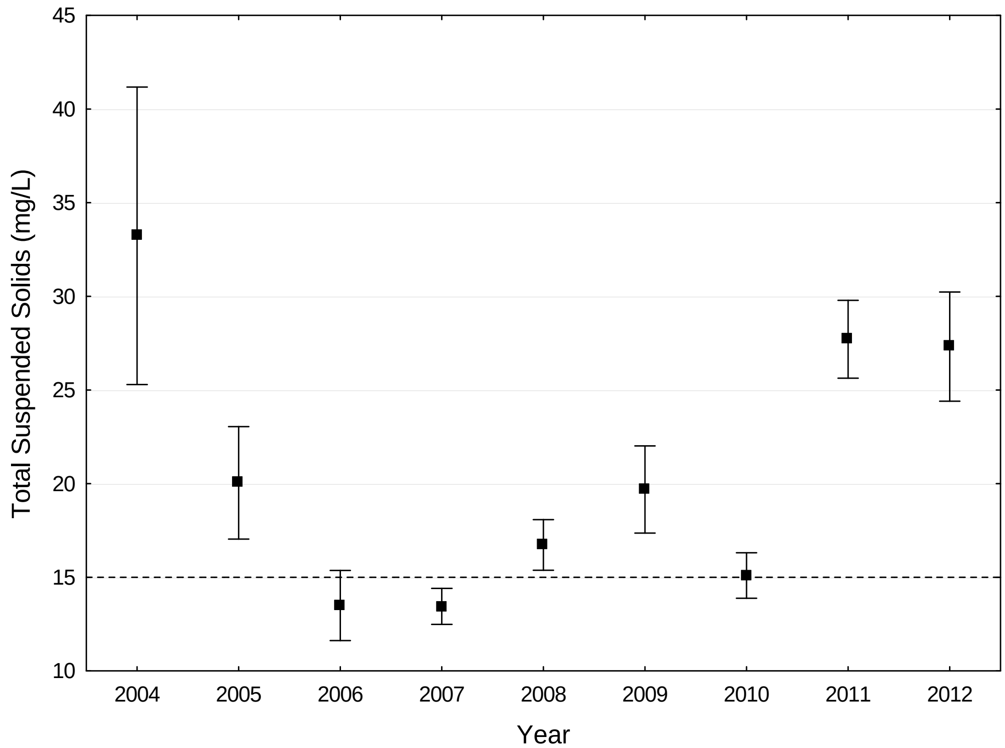


Figure 38. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010104-503 (Rice River to Little Willow River). The dotted line indicates the water quality standard (15 mg/L).

Biological Data

Fish and invertebrate community data was collected at one MPCA biological monitoring station (10EM136) in 2010. A total of 95 individual fish were caught, representing 11 species (Table 48). Spotfin shiner was the most abundant species, and no invasive species were documented. The fish community was given an IBI score of 68. Fifteen invertebrate families were documented (Table 50), and were given an IBI score of IBI 31.

Table 47. Attributes of fish sampled on 07010104-503 (Rice River to Little Willow River).

Attribute	Count
DELT (abnormalities)	0
Darter species	0
Exotic species	0
Fish per 100 m	18.6
Game fish species	2
Gravel spawning species	5
Piscivore species	1
Pollution intolerant species	2
Special concern species	0
Total species	11

Table 48. Fish species observed on 07010104-503 (Rice River to Little Willow River).

Species	Count	Min Length (mm)	Max Length (mm)
Bigmouth Buffalo	1	765	765
Common Shiner	1	40	40
Golden Shiner	2	57	72
Greater Redhorse	1	489	489
Shorthead Redhorse	9	272	378
Silver Redhorse	20	415	547
Smallmouth Bass	1	62	62
Spotfin Shiner	38	53	86
Spottail Shiner	1	48	48
White Sucker	1	475	475
Yellow Perch	18	62	205

Table 49. Attributes of invertebrates sampled on 07010104-503 (Rice River to Little Willow River).

Attribute	Count/ percent
EPT Taxa	3
Ephemeroptera Taxa	2
Hilsenhoffs Biotic Index (HBI)	3.4
Intolerant Families	0
Percent Pollution Tolerant	29.5
Percent Chironomidae	2.9
Percent Diptera	3.2
Percent Dominant Taxa	53.5
Percent Dominant Two Taxa	81.4
Percent Filterers	0.3
Percent Gatherer	68.9
Percent Hydropsychidae	0
Percent Scraper	28.5
Plecoptera Families	0
Trichoptera Families	1
Total Families	15

Table 50. List of invertebrates on 07010104-503 (Rice River to Little Willow River).

Invertebrates
Amphipods
Balloon Flies
Broad-Winged Damselflies
Chiggers
Crawling Water Beetles
Electric Light Bugs
Fingernail Clam
Gastropods
Grass Moths
Long-Horn Caddisflies
Mayflies
Midges
Narrow-Winged Damselflies
Oligochaeta
Riffle Beetles
Water Scorpions

9. CROW WING COUNTY

Three reaches on the mainstem of the Mississippi River are located in Crow Wing County (Figure 39). Water quality data from the most recent 10-year period (2003-2012) were available for two of these reaches: 07010104-501 and 07010104-516. None of the reaches have MPCA biological monitoring data from the most recent 10 years. The MN DNR Fisheries Brainerd Office conducted a fish survey of the Mississippi River mainstem in 2007. Figures for all water quality data are located in Appendix F.

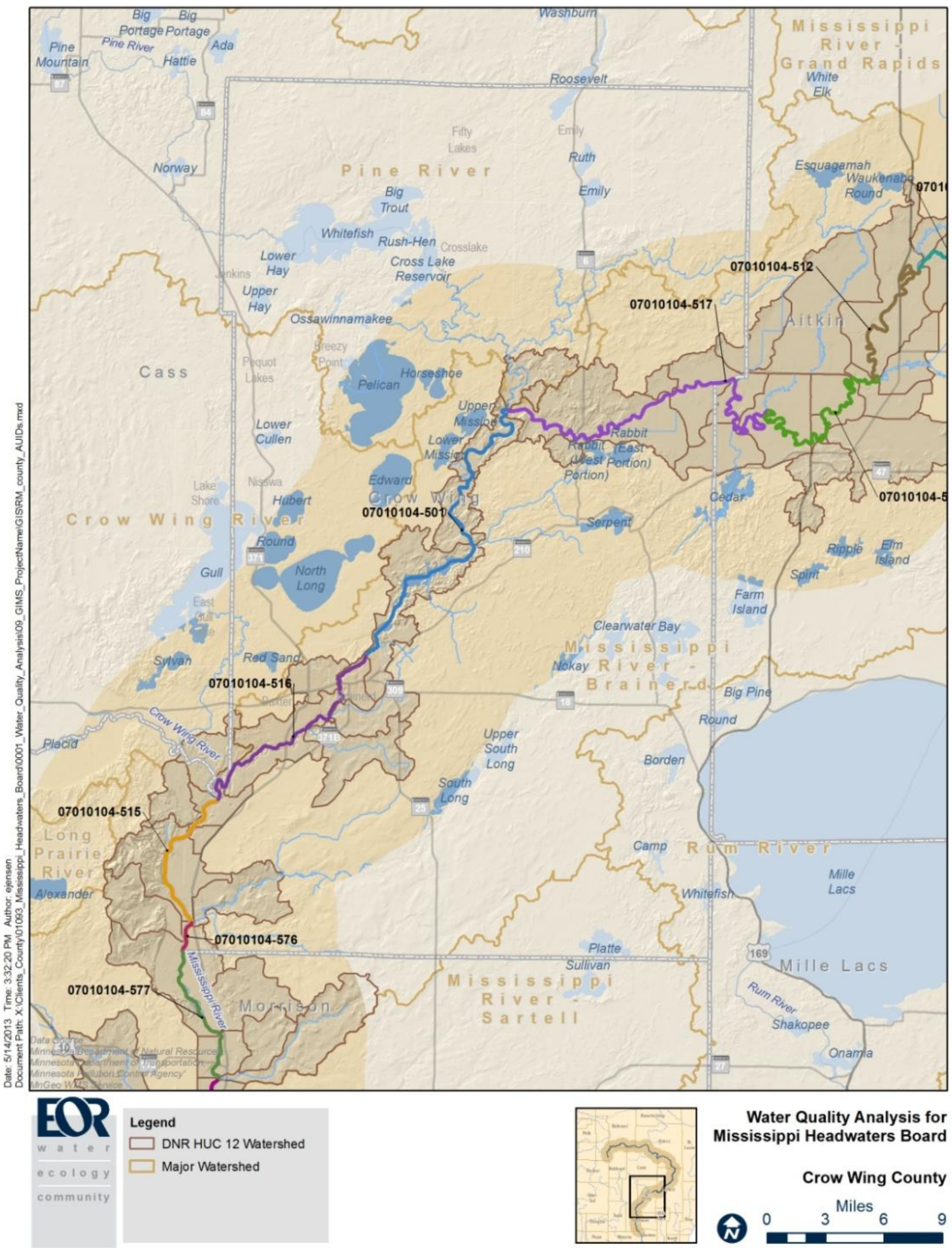


Figure 39. Mississippi River mainstem stream reaches located in Crow Wing County.

A. 07010104-501 (Pine River to Brainerd Dam)

Data Inventory and Trends

Water quality data were collected at six stations along 07010104-501 (Table 51). Limited data were available for ammonia, chloride, and sulfate, and no data were available for *E. coli* or TSS. Water quality data were available for dissolved oxygen, inorganic N and total phosphorus from three of the most recent 10 years (2003-2012; Table 52.). Total phosphorus exceeded the standard each year data was collected and had the highest concentration in 2012 (Figure 40).

Table 51. Data inventory for 07010104-501 (Pine River to Brainerd Dam).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2005			12			12			
2006			9			9			
2007			30			30			
2010					4		4		
2011					4		4		
2012	1	2			6	2	5	2	

Table 52. Water quality data summary for reach 07010104-501 (Pine River to Brainerd Dam). Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	1	0.05		0.05	0.05	0.05	0.05	0.05
Chloride	230 mg/L	2	3.75	0.16	3.59	3.59	3.75	3.90	3.90
DO	>5 mg/L	51	9.00	0.31	4.80	7.11	8.81	9.72	14.00
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L	14	0.36	0.03	0.05	0.40	0.40	0.40	0.40
pH	>6.5, <9.0	53	7.83	0.03	6.88	7.70	7.87	7.99	8.17
Phosphorus	0.05 mg/L (June-Sept)	7	0.06	0.01	0.03	0.04	0.05	0.07	0.08
Sulfate	250 mg/L	2	3.34	0.21	3.13	3.13	3.34	3.54	3.54
TSS	15 mg/L (Apr-Sept)								

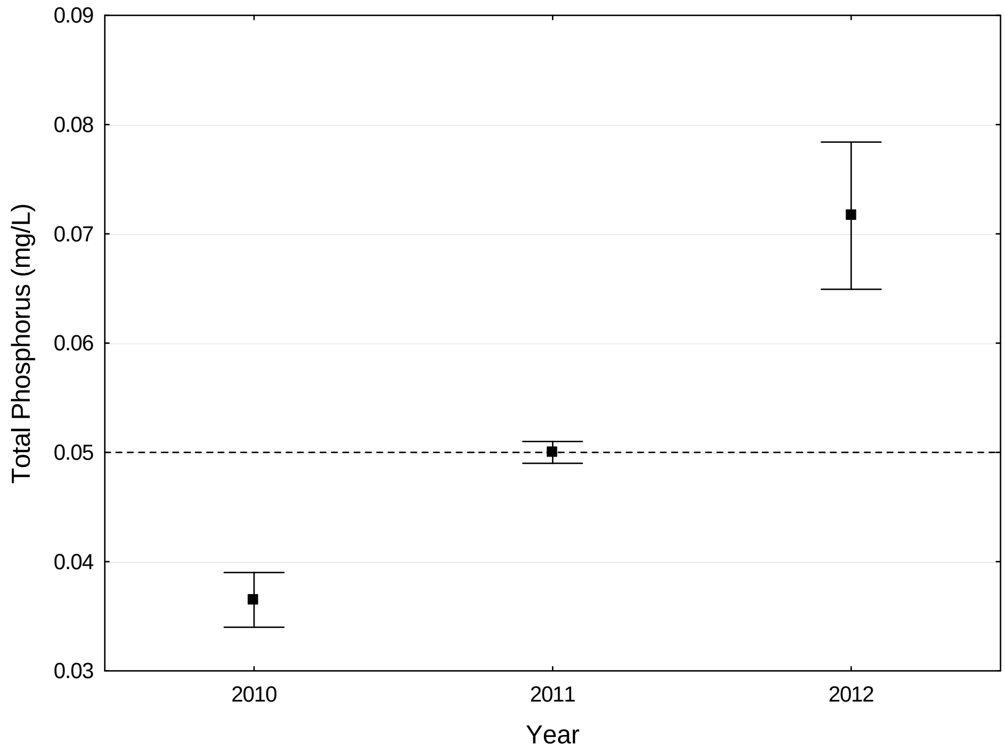


Figure 40. Growing season mean (±SE) of total phosphorus for 07010104-501 (Pine River to Brainerd Dam). Dotted line indicates proposed water quality standard (MPCA 2013).

B. 07010104-516 (Brainerd Dam to Crow Wing River)

Data Inventory and Trends

Water quality data were collected from one station on reach 07010104-516 for four years (2004-2007) within the most recent ten years (2003-2012) (Table 53). All water quality parameters met the water quality standard in all years data was collected (Table 54).

Table 53. Data invenoty for 07010104-516 (Brainerd Dam to Crow Wing River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2004	15		15		15	30	15		15
2005	17				17	7	17		17
2006	14		13		14	17	14		14
2007	1				1		1		1

Table 54. Water quality data summary for 07010104-516 (Brainerd Dam to Crow Wing River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	47	0.06	0.00	0.05	0.05	0.05	0.05	0.11
Chloride	230 mg/L								
DO	>5 mg/L	28	9.07	0.47	3.53	7.42	8.26	11.19	13.56
E. coli	126 org/ 100mL (Apr-Oct)								
Inorganic N	10 mg/L	47	0.07	0.01	0.05	0.05	0.05	0.06	0.24
pH	>6.5, <9.0	54	7.91	0.03	7.20	7.80	7.96	8.05	8.31
Phosphorus	0.05 mg/L (June-Sept)	21	0.05	0.00	0.03	0.04	0.05	0.06	0.08
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)	40	11.89	1.21	1.60	6.60	8.70	17.00	34.00

10. MORRISON COUNTY

Nine AUIDs occur on the mainstem of the Mississippi River in Morrison County (Figure 41). Only three of these reaches have water quality data within the most recent 10 years, and none have MPCA biological monitoring data. Figures for all water quality data are located in Appendix G.

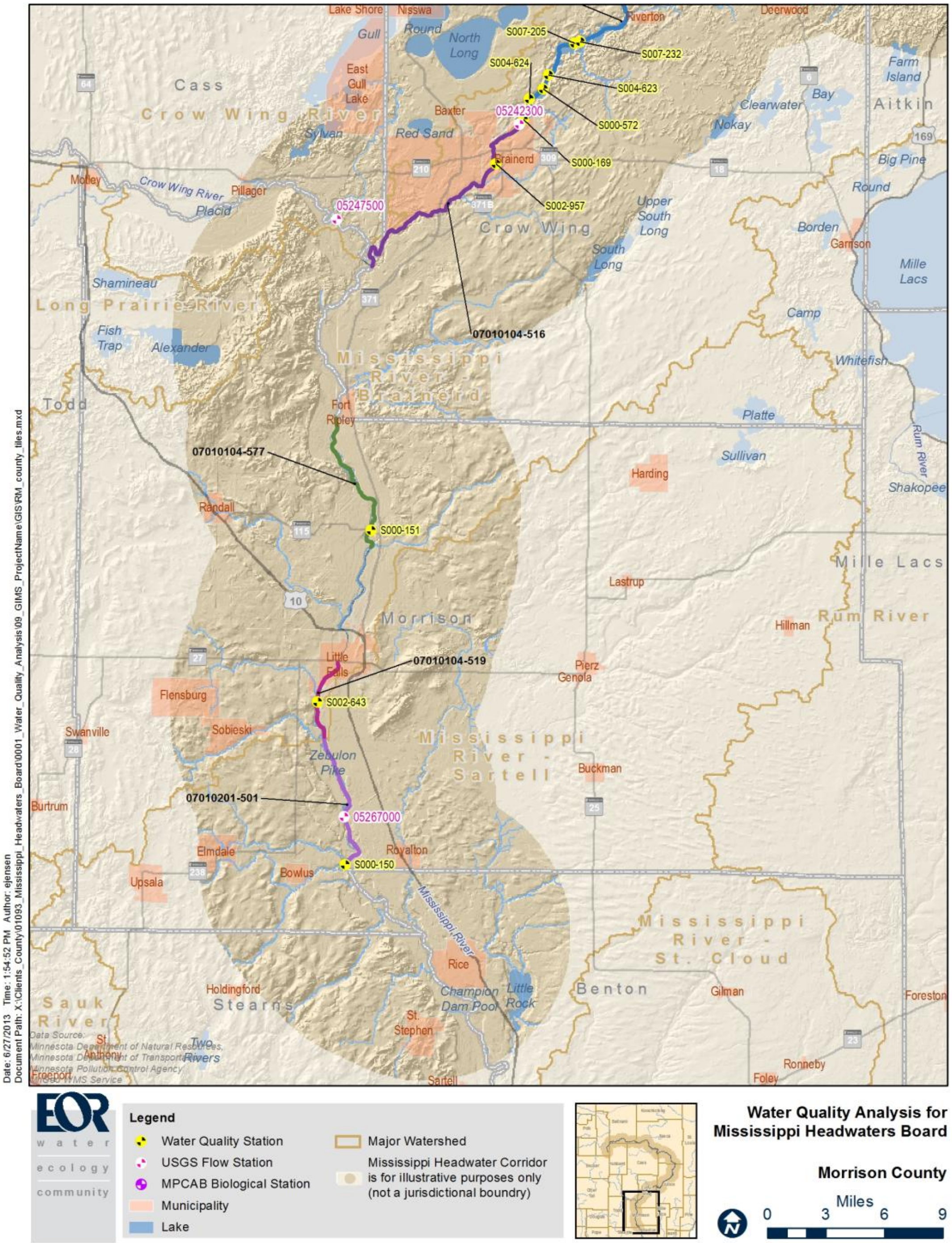


Figure 41. Mississippi River mainstem reaches in Morrison County.

A. 07010104-577 (Crow Wing/Morrison County border to Fletcher Creek)

Data Inventory and Trends

Water quality data was collected from one station between 2004 and 2010 on 07010104-577 (Table 55). All water quality parameters met the water quality standards (Table 56).

Table 55. Data inventory for 07010104-577 (Crow Wing/Morrison County Border to Fletcher Creek).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2004	2		2	1	2	2	2		2
2005	8		8	6	8	12	8		8
2006	2		6	8	2	9	2	1	2
2007	8	7	7	6	8	11	8	7	8
2009	2	2	2		2	2	2	2	2
2010	8	8	8		8	8	8	8	8

Table 56. Water quality summary for 07010104-577 (Crow Wing/Morrison County Border to Fletcher Creek).
Pink lines indicate a water quality standard exceedance.

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	30	0.06	0.00	0.05	0.05	0.05	0.05	0.17
Chloride	230 mg/L	17	9.00	0.62	6.07	7.21	8.50	10.00	14.80
DO	>5 mg/L	33	9.91	0.35	6.62	8.42	9.67	11.05	15.51
E. coli	126 org/ 100mL (Apr-Oct)	21	6.76	9.53	1.00	4.00	8.00	11.00	40.00
Inorganic N	10 mg/L	30	0.36	0.06	0.05	0.14	0.23	0.39	1.20
pH	>6.5, <9.0	44	8.40	0.05	7.69	8.13	8.40	8.71	9.04
Phosphorus	0.05 mg/L (June-Sept)	12	0.05	0.00	0.02	0.03	0.05	0.06	0.07
Sulfate	250 mg/L	18	9.50	0.90	3.87	6.65	8.60	12.50	16.90
TSS	15 mg/L (Apr-Sept)	18	7.99	1.84	1.00	2.80	4.90	12.00	32.00

B. 07010104-519 (Little Falls Dam to Swan River)

Data Inventory and Trends

Water quality data was collected from one station in 2011 and 2012 on 07010104-519 (Table 57). All water quality parameters met the water quality standards (Table 58).

Table 57. Data inventory for 07010104-519 (Little Falls Dam to Swan River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2011			10	6		10			
2012			9	9		9			

Table 58. Summary of water quality data for 07010104-519 (Little Falls Dam to Swan River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75TH Quartile	Max
Ammonia (unionized)	0.04 mg/L								
Chloride	230 mg/L								
DO	>5 mg/L	19	7.66	0.32	4.73	6.96	7.75	8.27	10.78
E. coli	126 org/ mL (Apr-Oct)	15	115.50	97.71	27.90	35.90	178.50	248.90	272.30
Inorganic N	10 mg/L								
pH	>6.5, <9.0	19	8.33	0.13	7.44	7.97	8.30	8.65	9.46
Phosphorus	0.05 mg/L (June-Sept)								
Sulfate	250 mg/L								
TSS	15 mg/L (Apr-Sept)								

C. 07010201-501 (Swan River to Two River)

Data Inventory and Trends

Water quality data was collected from one station between 2007 and 2012 on 07010201-501 (Table 59). All water quality parameters met the water quality standards when averaged across all years (Table 60).

Table 59. Data inventory for 07010201-501 (Swan River to Two River).

Year	Ammonia	Chloride	Dissolved oxygen	*E. coli*	Inorganic Nitrogen	pH	Total Phosphorus	Sulfate	Total Suspended Solids
2007	18	15	18	14	19	19	19	15	19
2008	5	13	16	7	16	16	16	14	16
2009	6	9	24	3	24	24	24	9	24
2010	3	3	34	15	28	37	28	3	28
2011			31	18	25	33	25	3	25
2012			26		28	26	28		28

Table 60. Water quality summary for 07010201-501 (Swan River to Two River).

Pollutant	Standard	N	Mean	SE	Min	25th Quartile	Median	75th Quartile	Max
Ammonia (unionized)	0.04 mg/L	33	0.10	0.02	0.05	0.05	0.05	0.10	0.44
Chloride	230 mg/L	40	7.99	0.32	4.60	6.45	8.00	9.31	13.00
DO	>5 mg/L	149	10.31	0.18	6.01	8.46	10.21	12.12	15.62
E. coli	126 org/ 100mL (Apr-Oct)	55	12.12	68.67	1.00	4.00	10.00	35.00	345.00
Inorganic N	10 mg/L	140	3.40	3.14	0.05	0.13	0.20	0.35	440.00
pH	>6.5, <9.0	155	8.03	0.05	2.76	7.92	8.10	8.26	8.90
Phosphorus	0.05 mg/L (June-Sept)	54	0.05	0.00	0.03	0.04	0.05	0.07	0.10
Sulfate	250 mg/L	44	10.27	0.88	3.32	6.79	8.86	10.25	31.70
TSS	15 mg/L (Apr-Sept)	97	6.68	0.48	1.00	3.20	6.40	8.00	30.00

11. APPENDICES

Figures of available water quality data for ammonia, chloride, dissolved oxygen, *E. coli*, inorganic nitrogen, pH, sulfate, total phosphorus, and total suspended solids over the most recent ten years (2003-2012) are shown below for each Mississippi River reach, organized by county.

A. Clearwater County

AUID 07010101-923 (Headwaters to Unnamed Creek) Temporal Trends

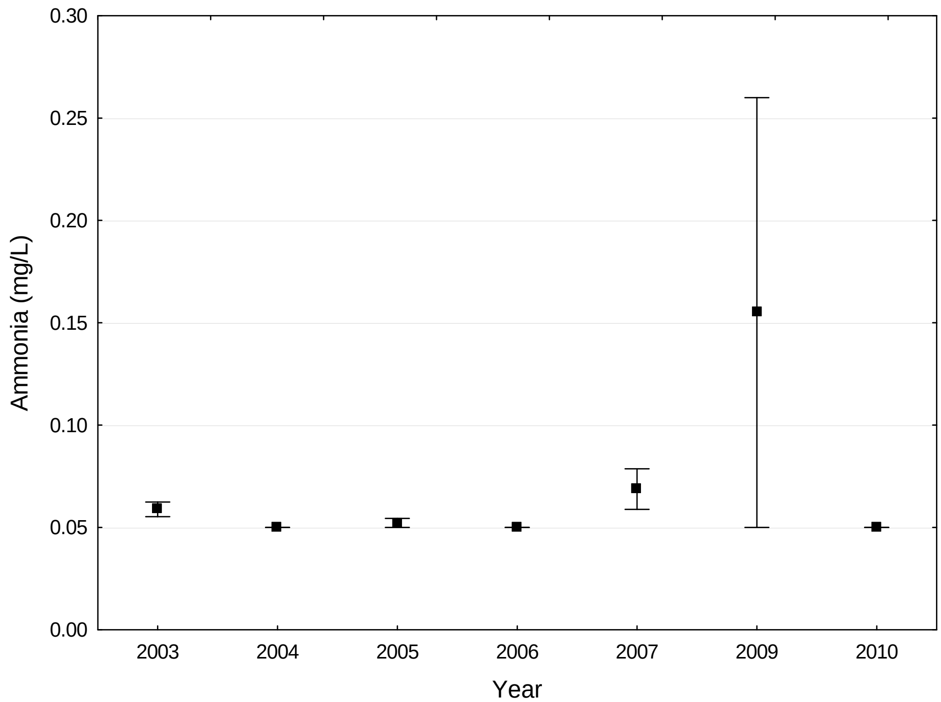


Figure 42. Mean ±SE ammonia concentration per year on 07010101-923. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

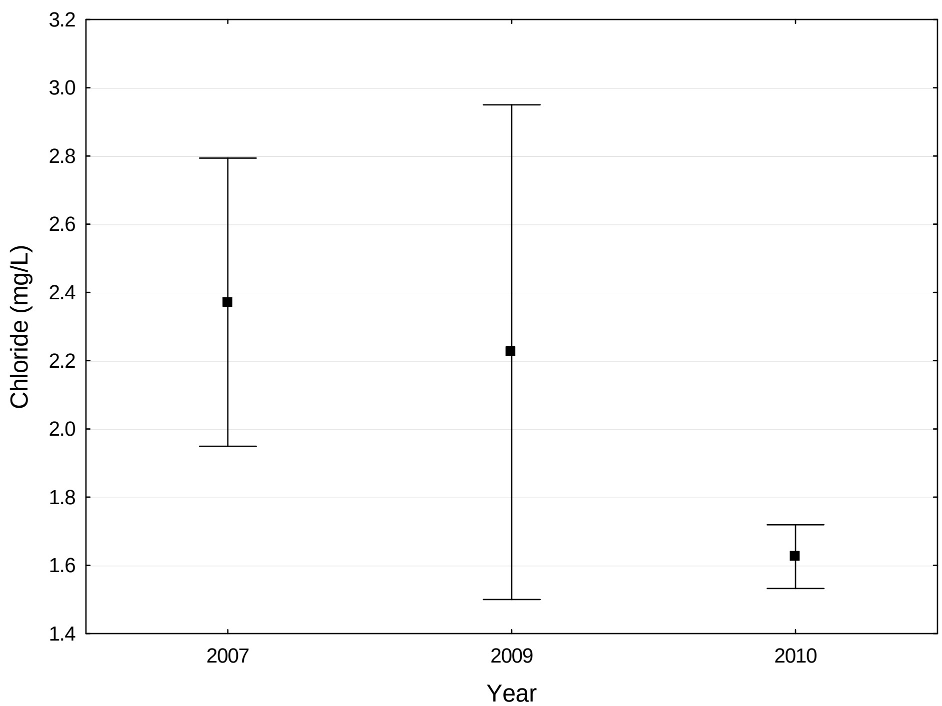


Figure 43. Mean ±SE chloride concentration per year on 07010101-923. The water quality standard for chloride is 230 mg/L.

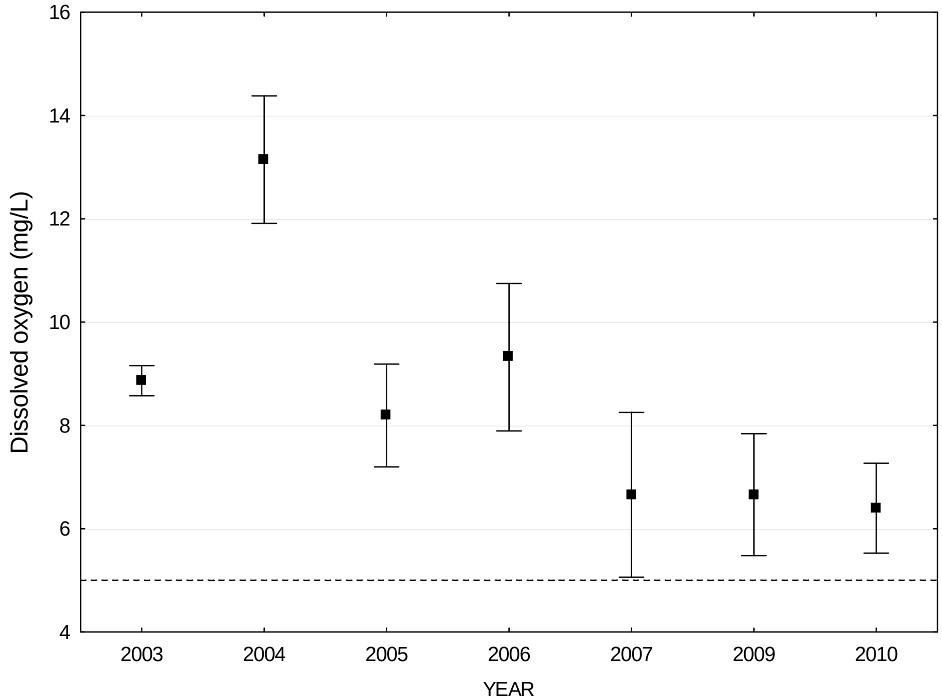


Figure 44. Mean ±SE dissolved oxygen per year on 07010101-923 (. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

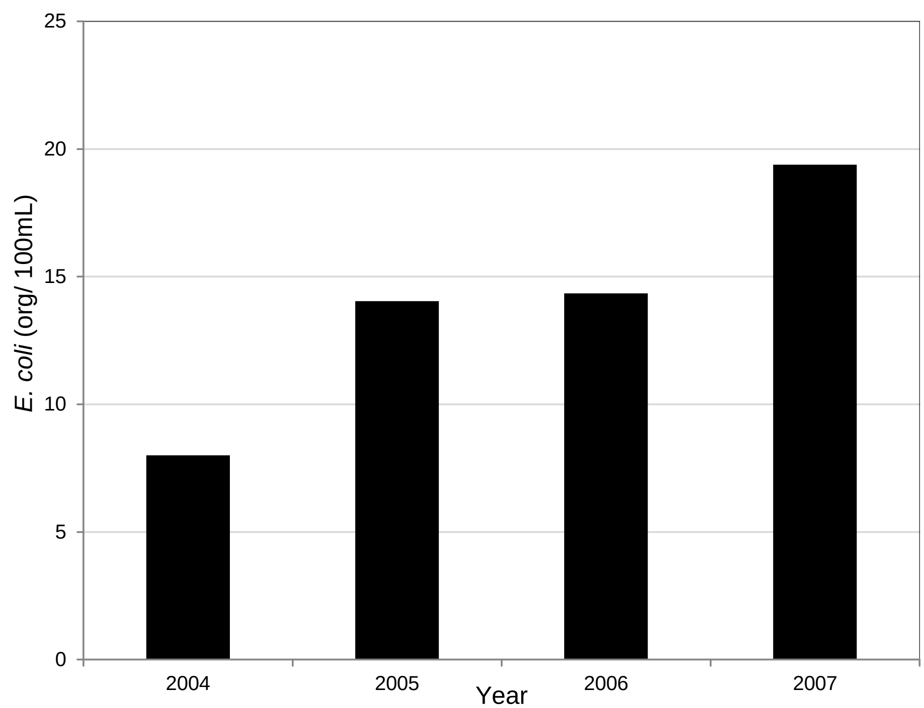


Figure 45. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010101-923 (. The water quality standard for *E. coli* is 126 organisms/ mL.

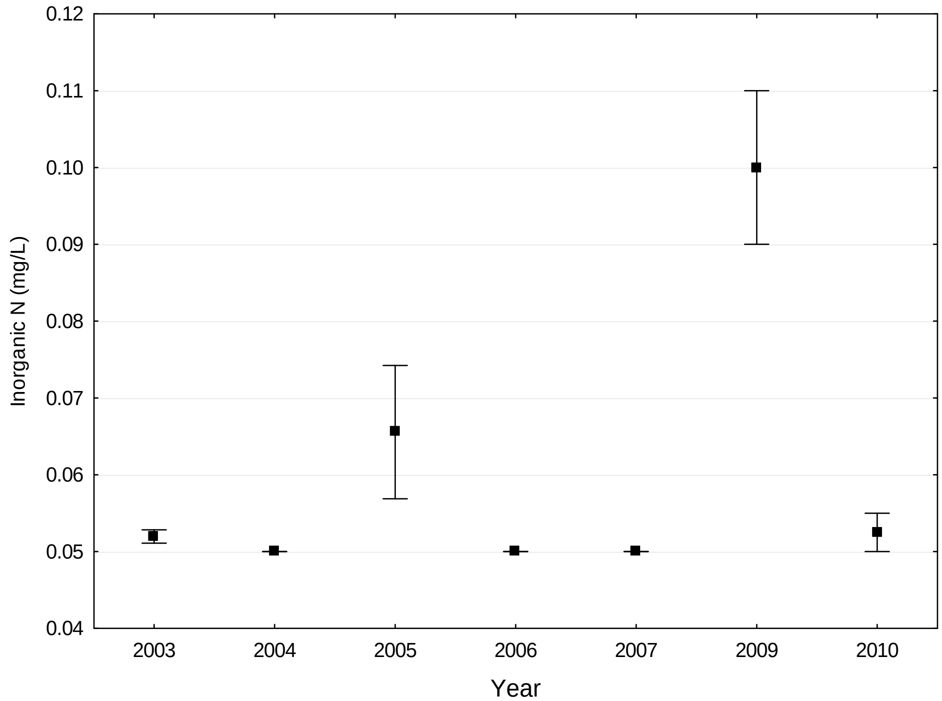


Figure 46. Mean ±SE inorganic N concentration per year on 07010101-923. The water quality standard for inorganic N is 10 mg/L.

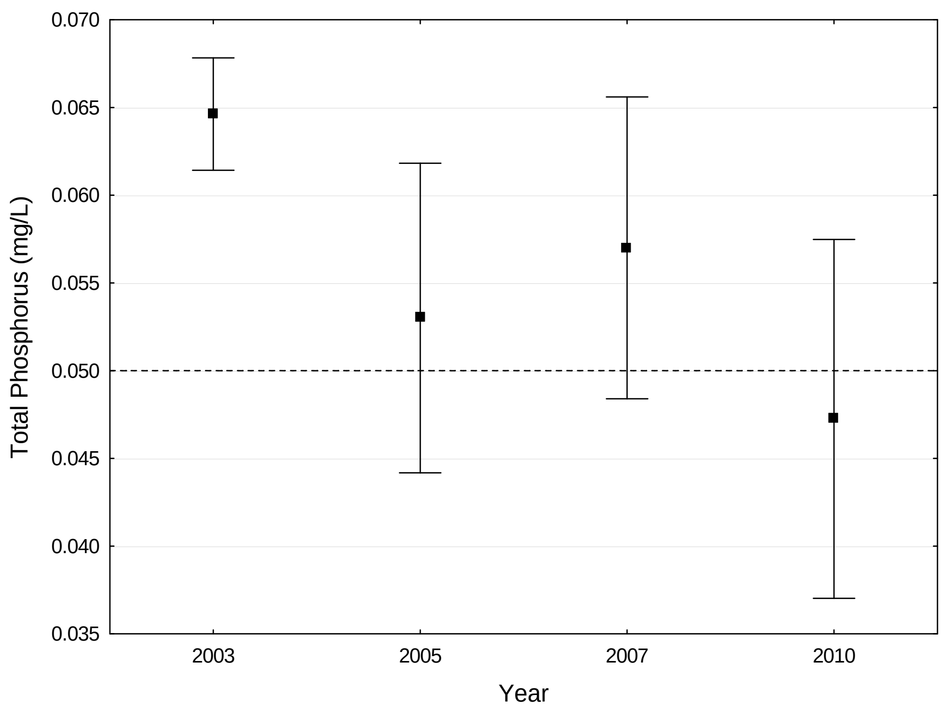


Figure 47. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010101-923. The dotted line indicates the proposed water quality standard (0.05 mg/L).

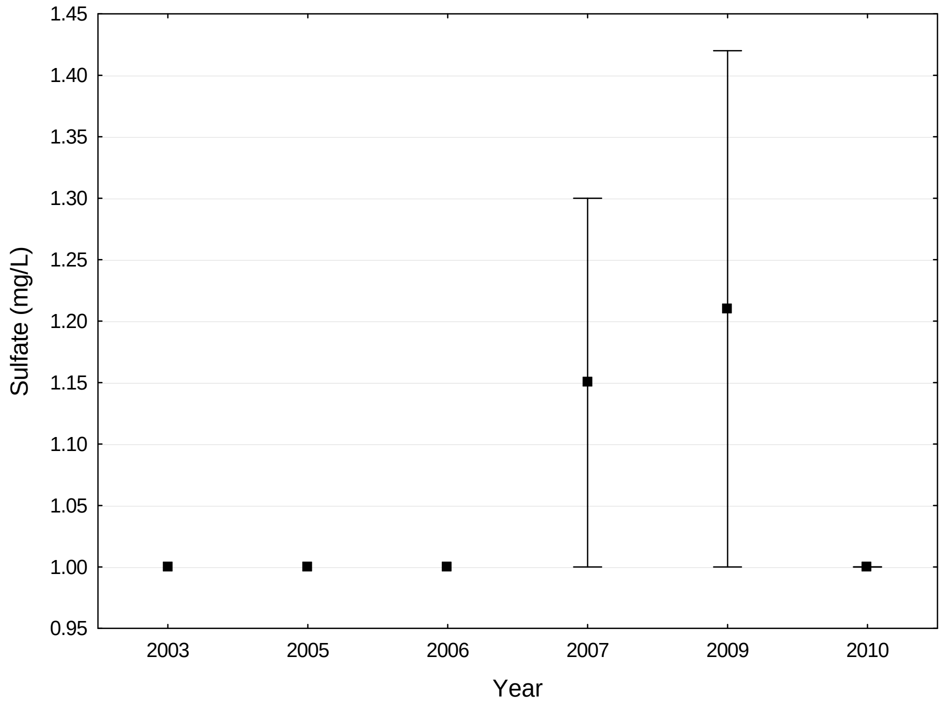


Figure 48. Mean ±SE sulfate concentration per year. The water quality standard for sulfate is 250 mg/L.

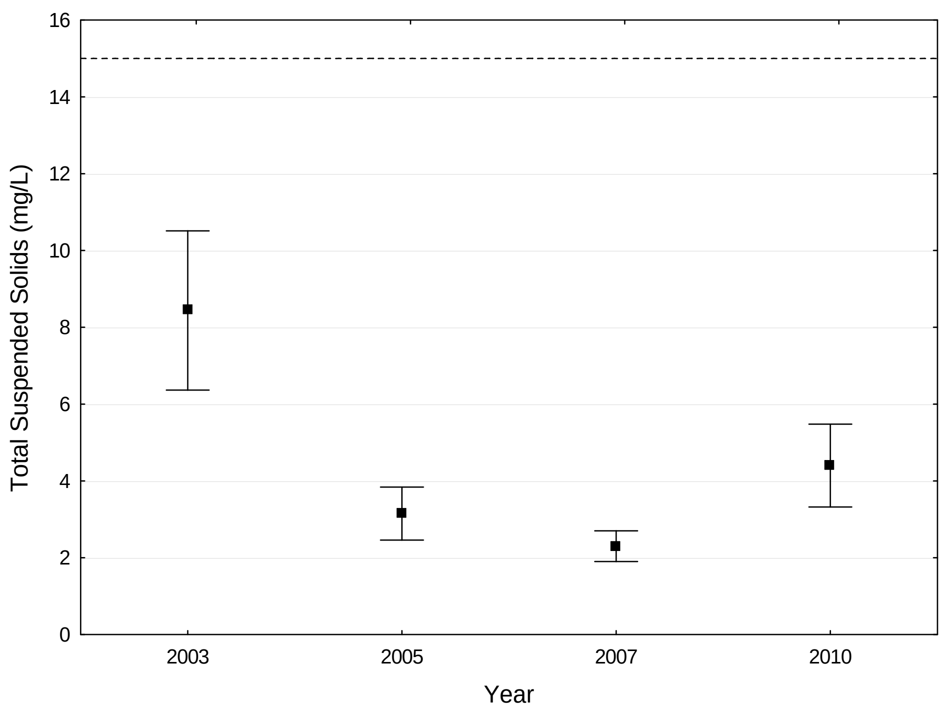


Figure 49. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year. The dotted line indicates the water quality standard (15 mg/L).

B. Beltrami County

AUID 07010101-924 (Unnamed Creek to Schoolcraft River) Temporal Trends

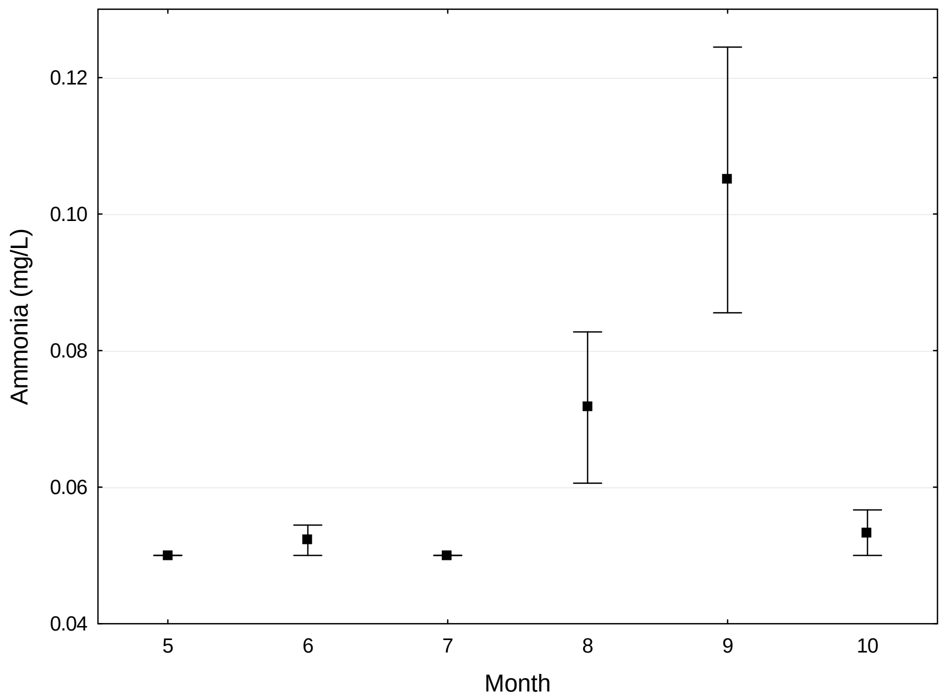


Figure 50. Mean ±SE ammonia concentration per year on 07010101-924. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

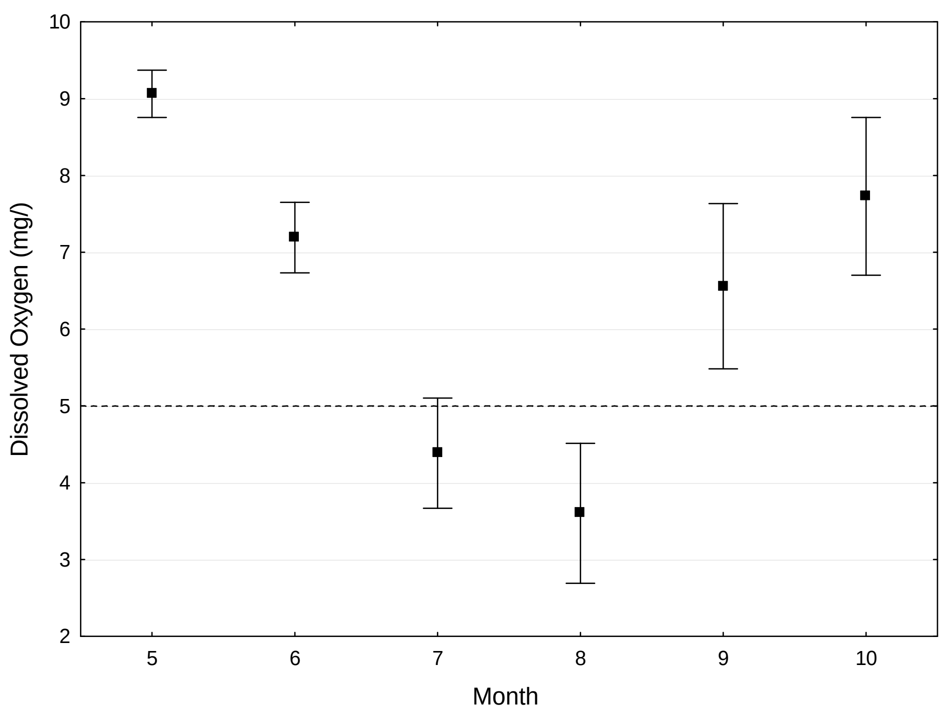


Figure 51. Mean ±SE dissolved oxygen concentration per month in 2003 on 07010101-924. The dotted line indicates the water quality standard for dissolved oxygen (>5 mg/L).

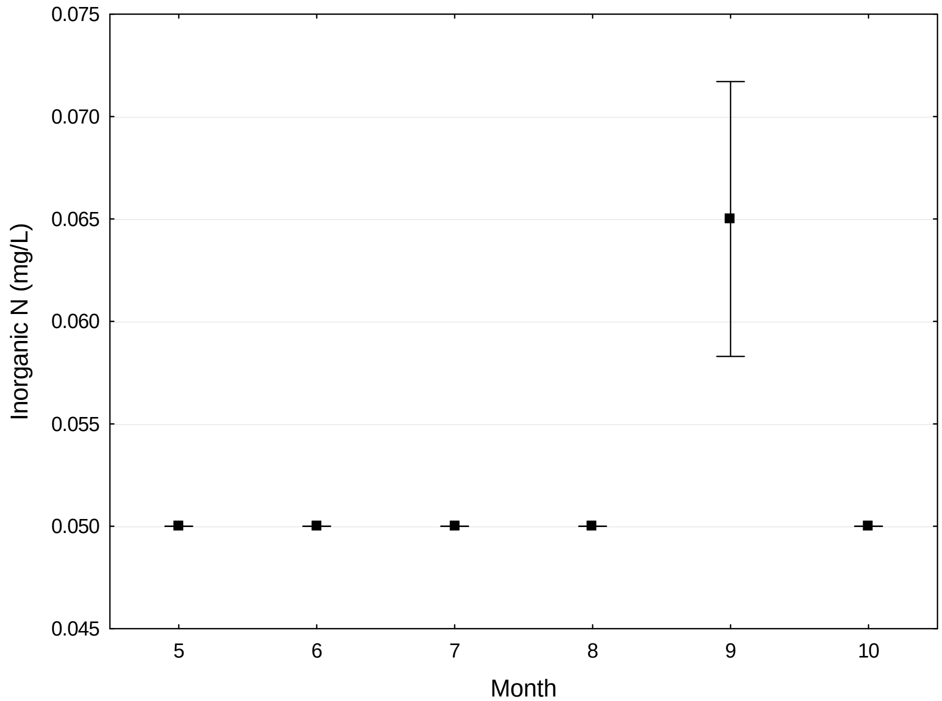


Figure 52. Mean ±SE inorganic N concentration per month in 2003 on 07010101-924. The water quality standard for inorganic N is 10 mg/L.

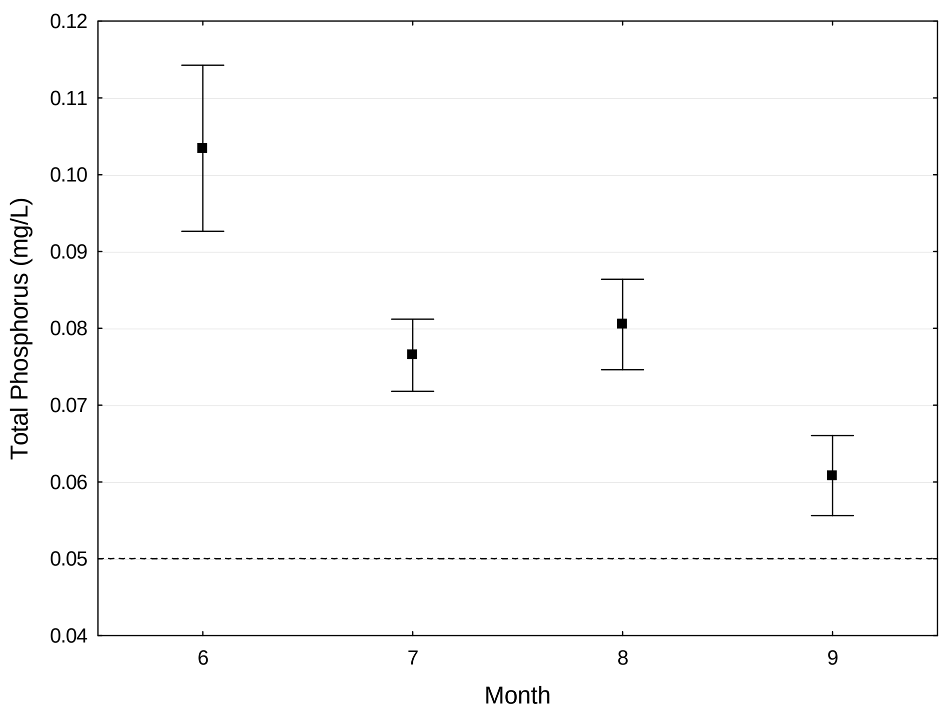


Figure 53. Growing season (June-Sept) mean ±SE total phosphorus concentration per month in 2003 on 07010101-924. The dotted line indicates the proposed water quality standard (0.05 mg/L).

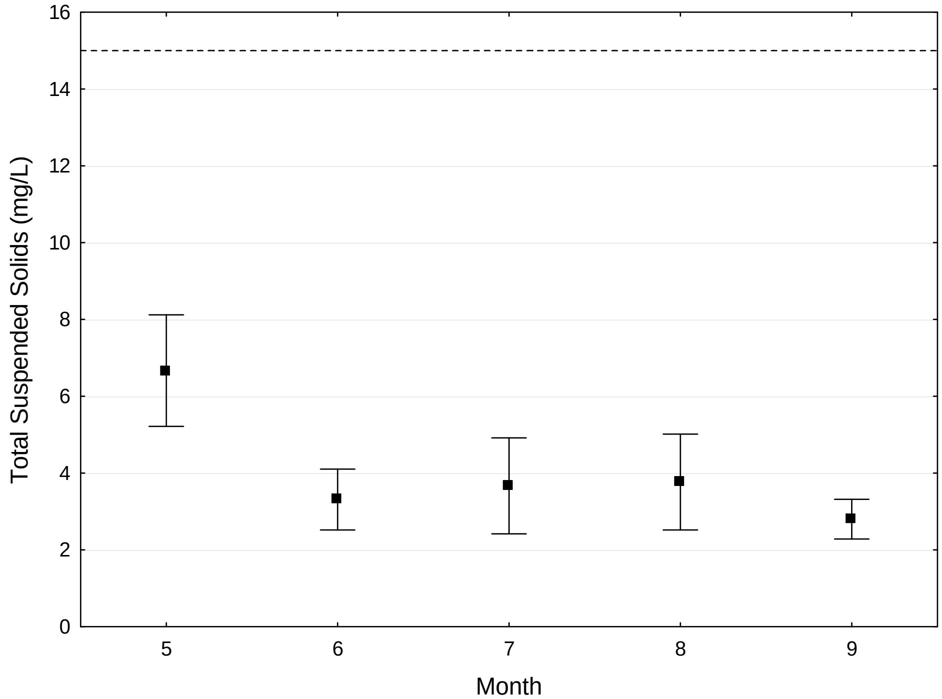


Figure 54. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per month in 2003 07010101-924. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010101-513 (Stump Lake to Wolf Lake) Temporal Trends

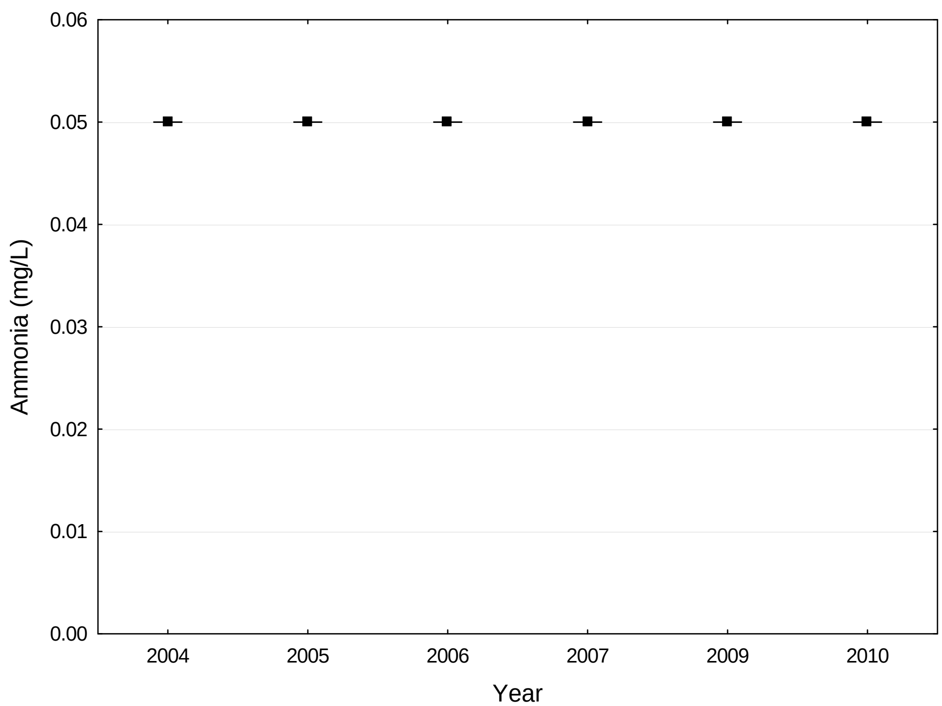


Figure 55. Mean ±SE ammonia concentration per year on 07010101-513. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

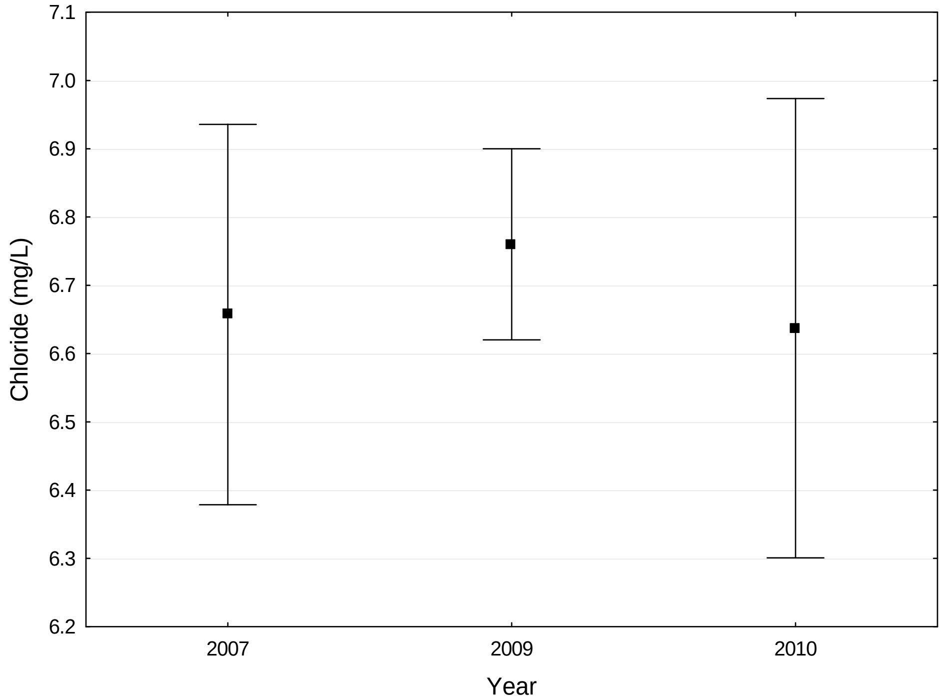


Figure 56. Mean ±SE chloride concentration per year on 07010101-513. The water quality standard for chloride is 230 mg/L.

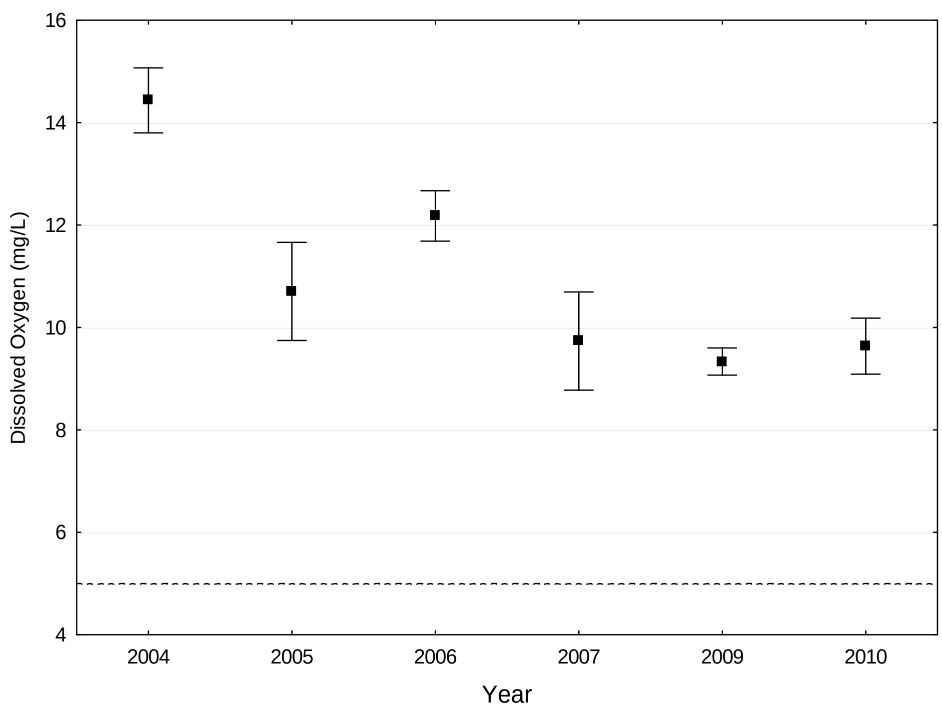


Figure 57. Mean ±SE dissolved oxygen concentration per year on 07010101-513. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

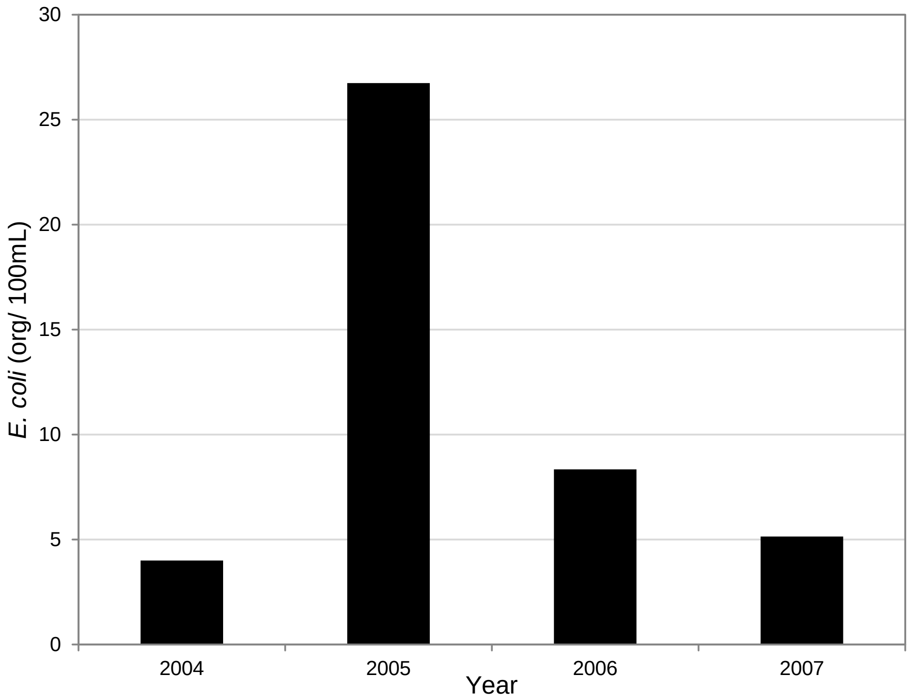


Figure 58. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010101-513. The water quality standard for *E. coli* is 126 organisms/100mL.

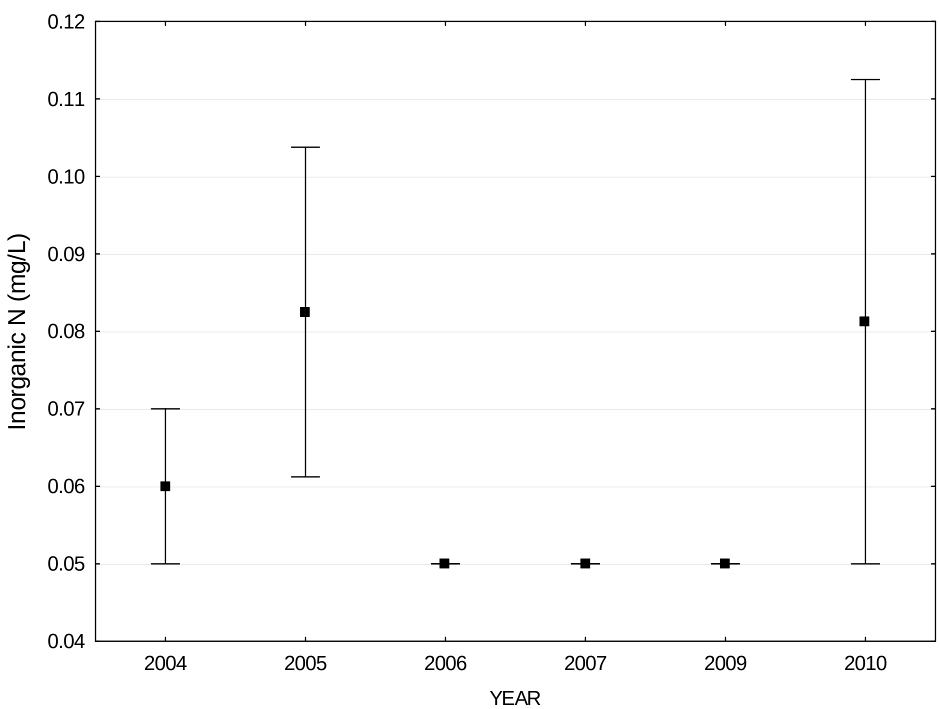


Figure 59. Mean ±SE inorganic N concentration per year on 07010101-513. The water quality standard for inorganic N is 10 mg/L.

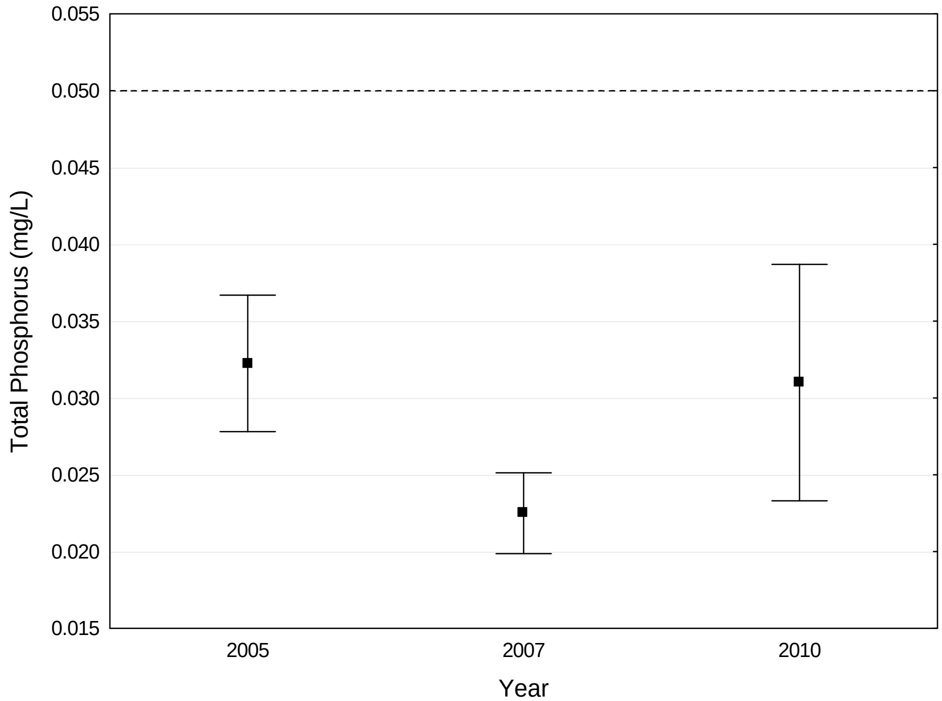


Figure 60. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010101-513. The dotted line indicates the proposed water quality standard (0.05 mg/L).

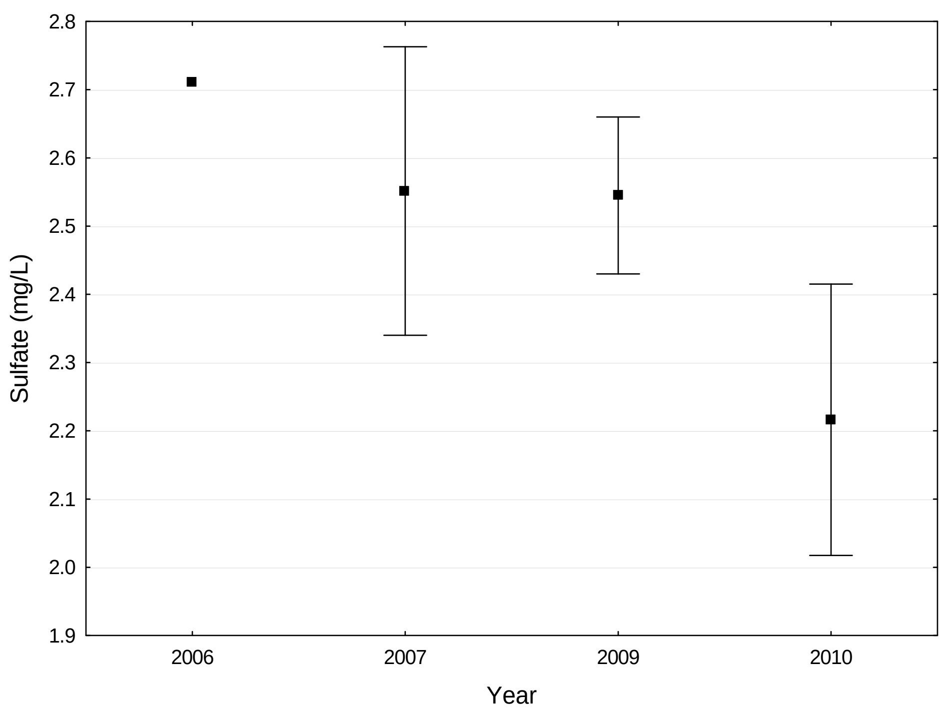


Figure 61. Mean ±SE sulfate concentration per year 07010101-513. The water quality standard for sulfate is 250 mg/L.

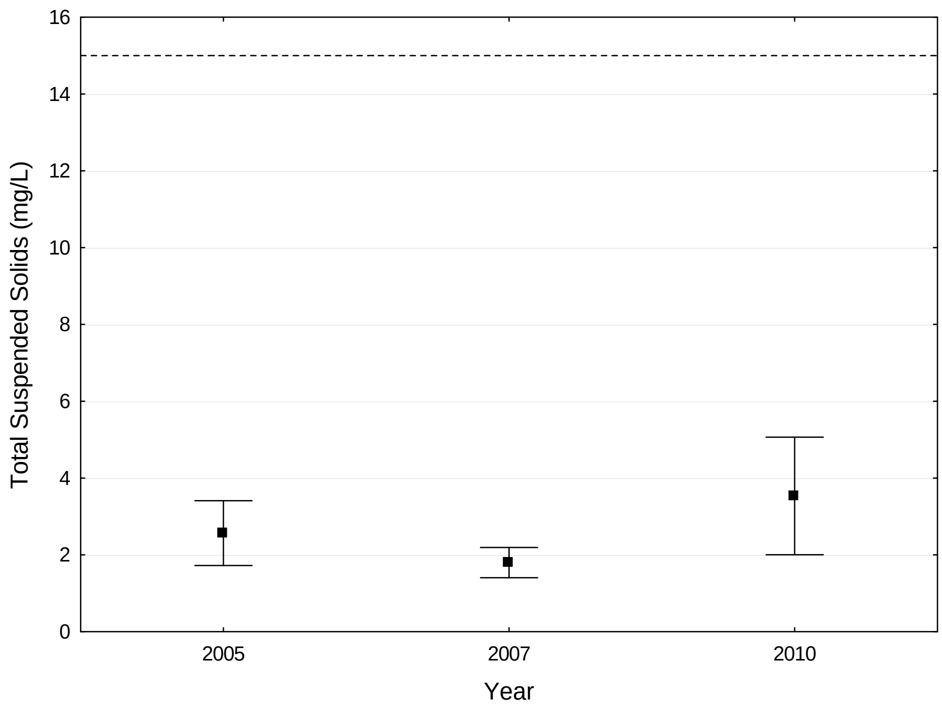


Figure 62. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010101-513. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010101-507 (Cass Lake to Lake Winnibigoshish) Temporal Trends

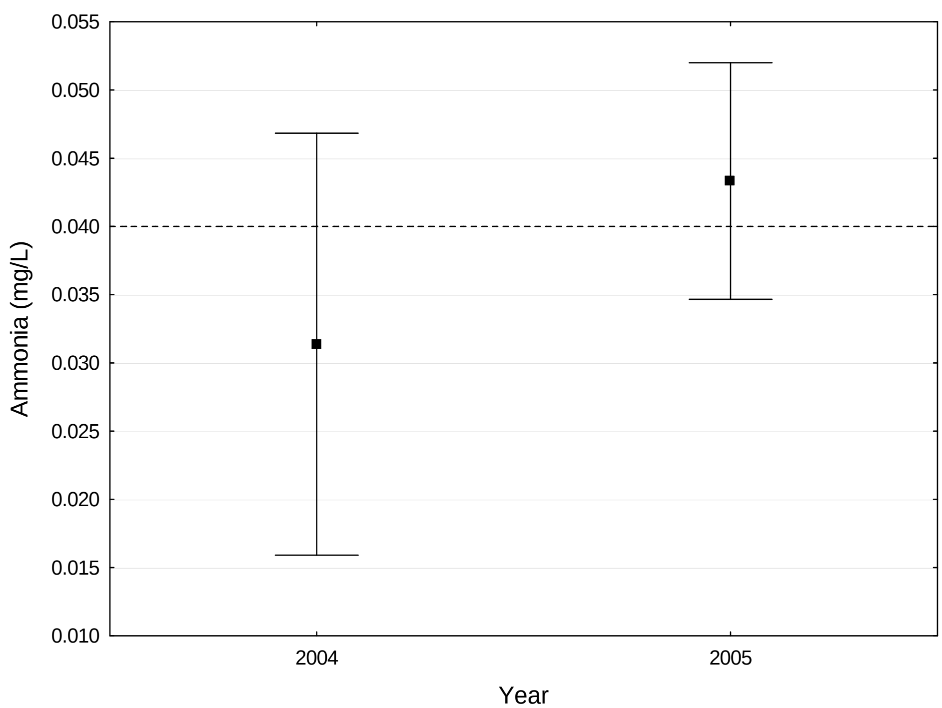


Figure 63. Mean ±SE ammonia concentration per year on 07010101-507. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

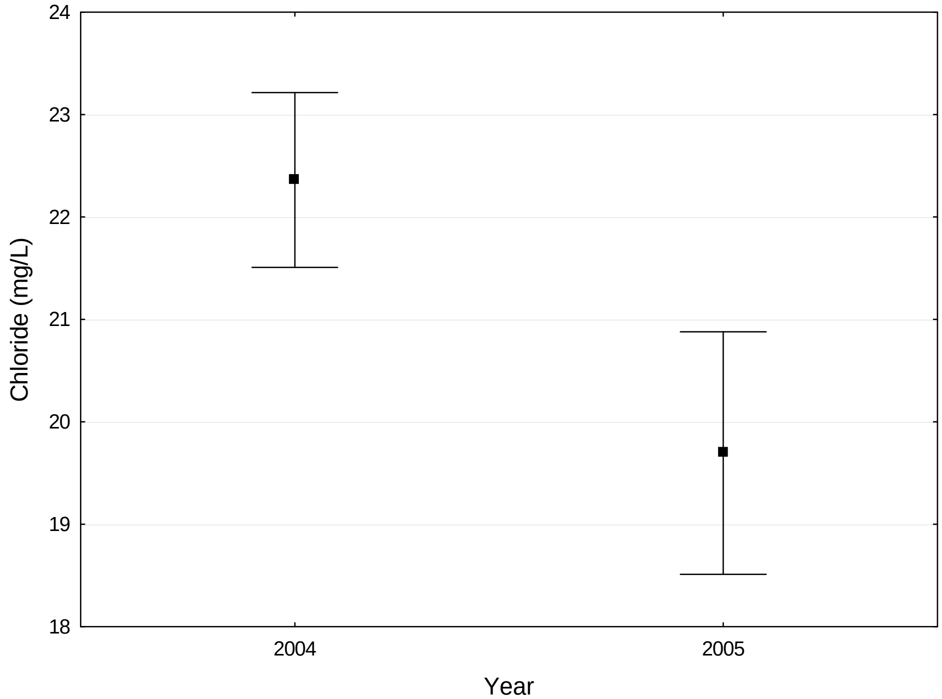


Figure 64. Mean ±SE chloride concentration per year on 07010101-507. The water quality standard for chloride is 230 mg/L.

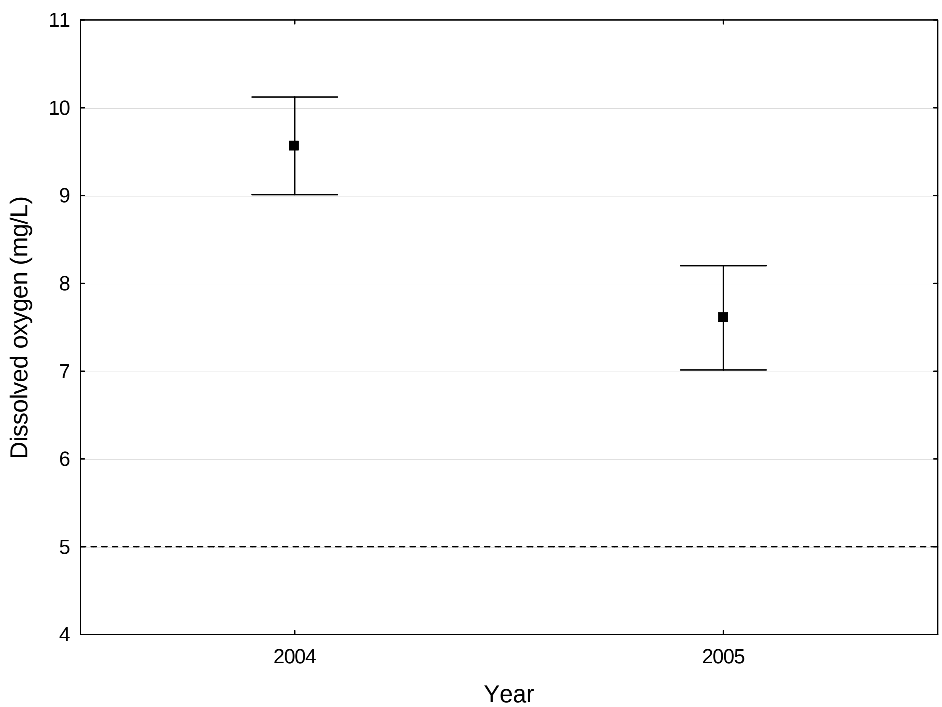


Figure 65. Mean ±SE dissolved oxygen per year on 07010101-507. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

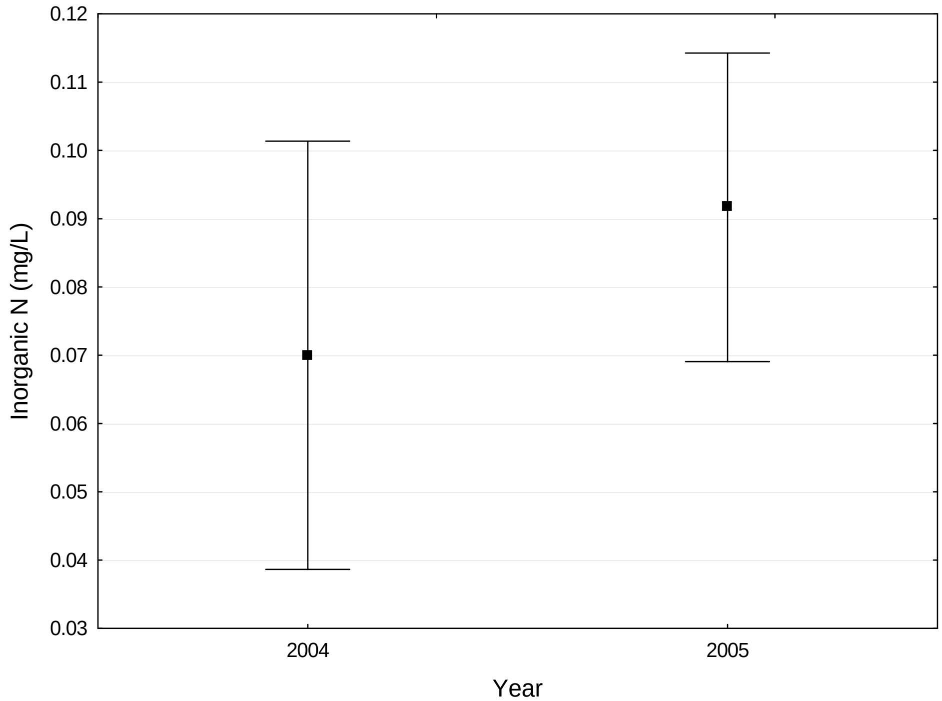


Figure 66. Mean ±SE inorganic N concentration per year 07010101-507. The water quality standard for inorganic N is 10 mg/L.

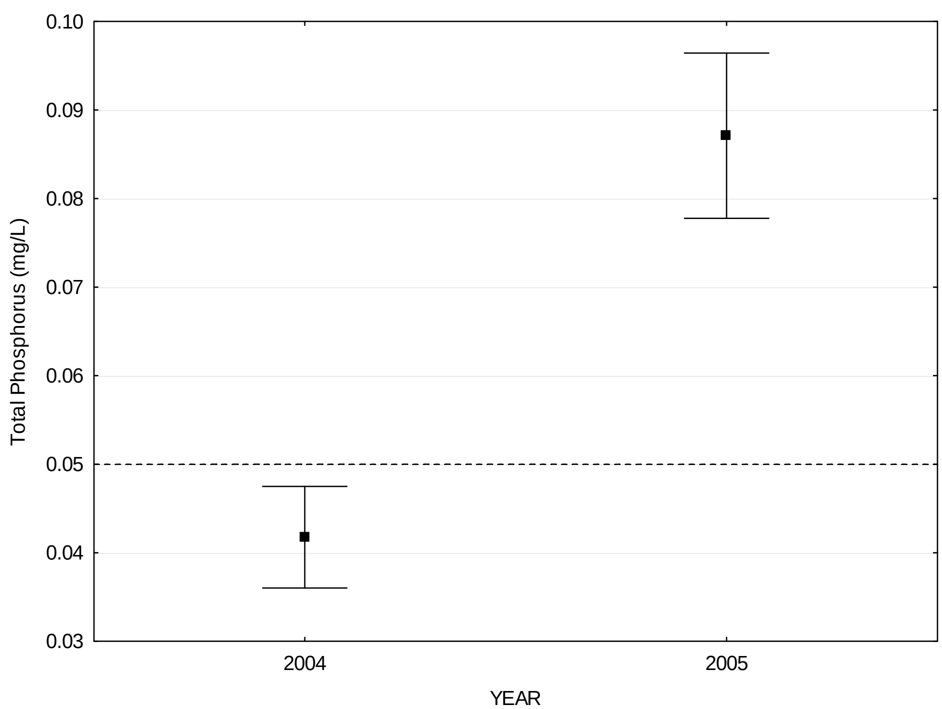


Figure 67. Growing season (June-Sept) mean ±SE total phosphorus concentration per year 07010101-507. The dotted line indicates the proposed water quality standard (0.05 mg/L).

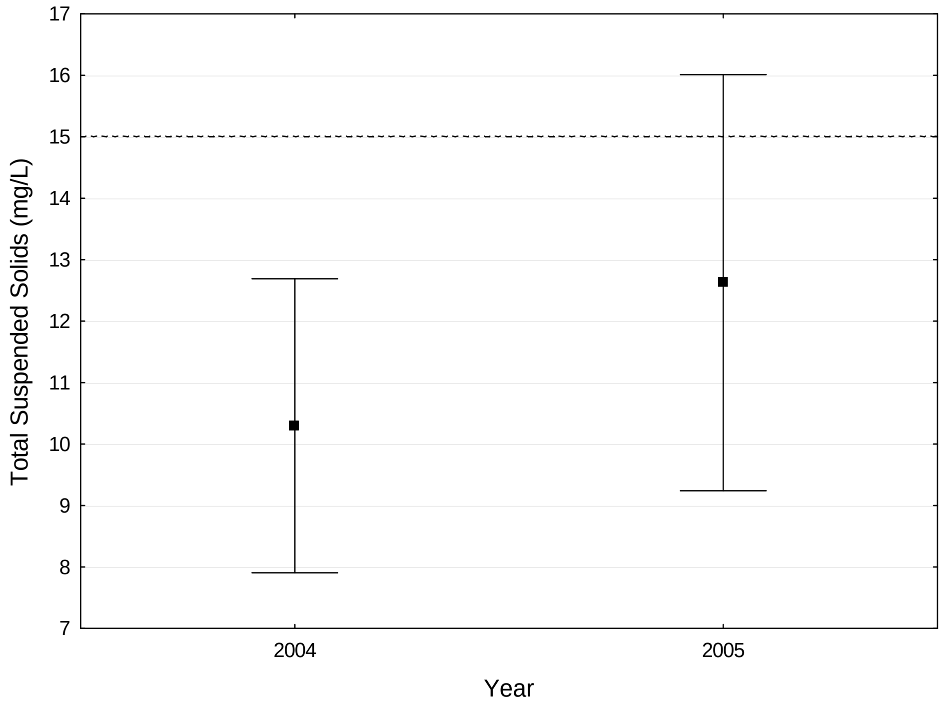


Figure 68. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year 07010101-507. The dotted line indicates the water quality standard (15 mg/L).

C. Cass County

AUID 07010101-506 (Leech Lake River to Ball Club River) Temporal Trends

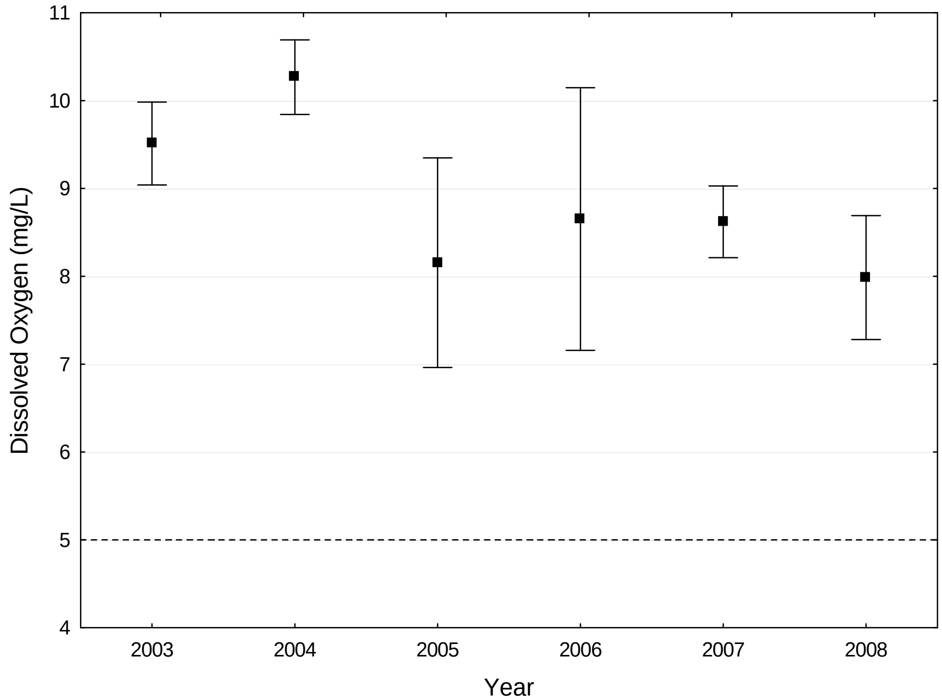


Figure 69. Mean ±SE dissolved oxygen concentration per year on 07010101-506. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

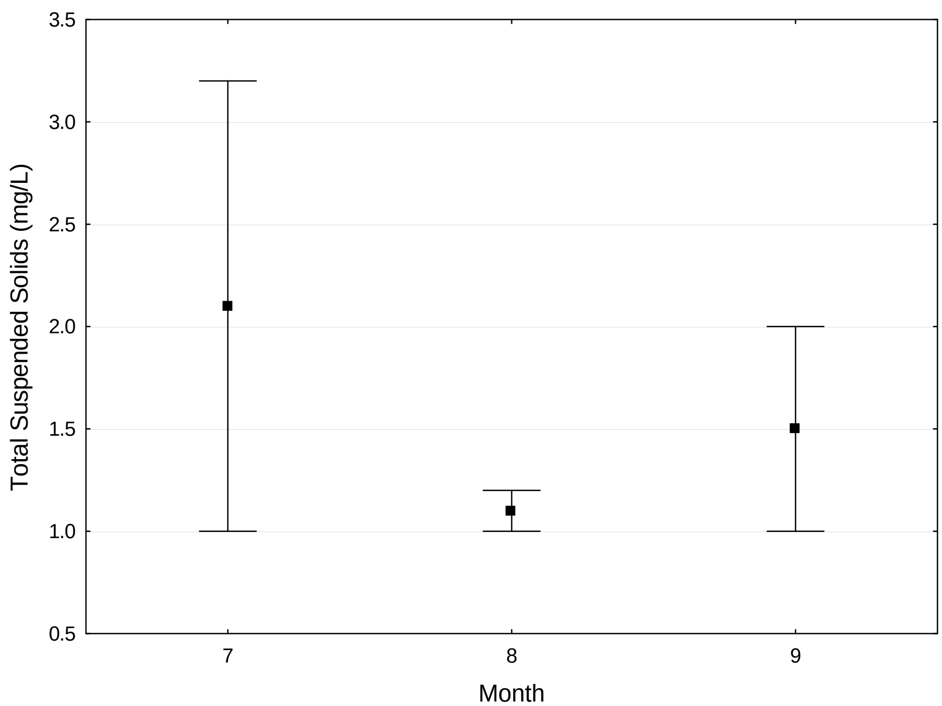


Figure 70. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per month in 2009 on 07010101-506. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010101-502 (Deer River to Vermillion River) Temporal Trends

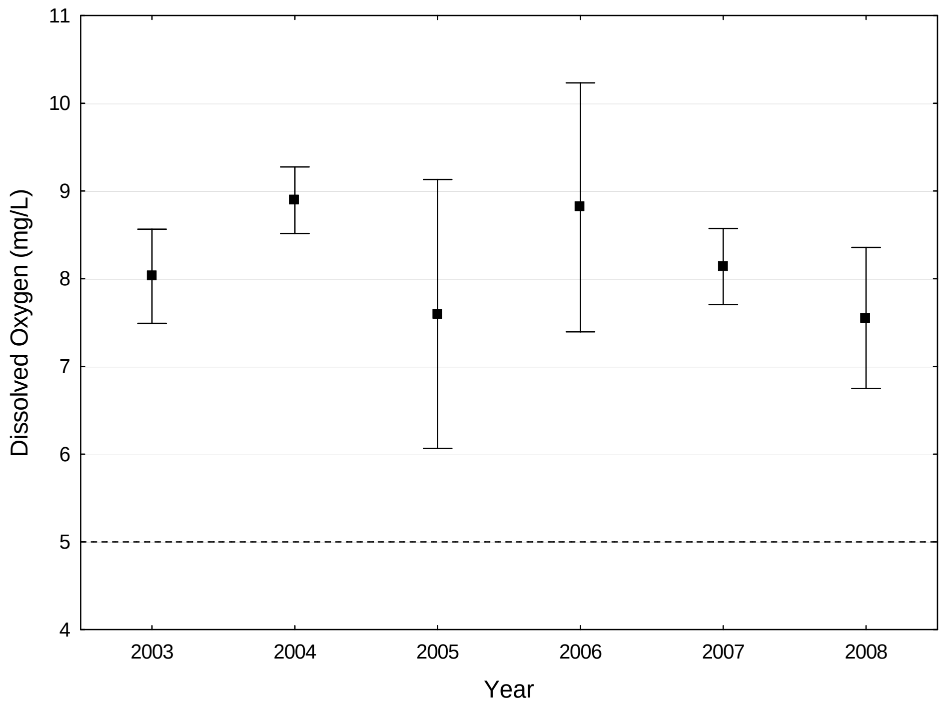


Figure 71. Mean ±SE dissolved oxygen concentration per year on 07010101-502. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

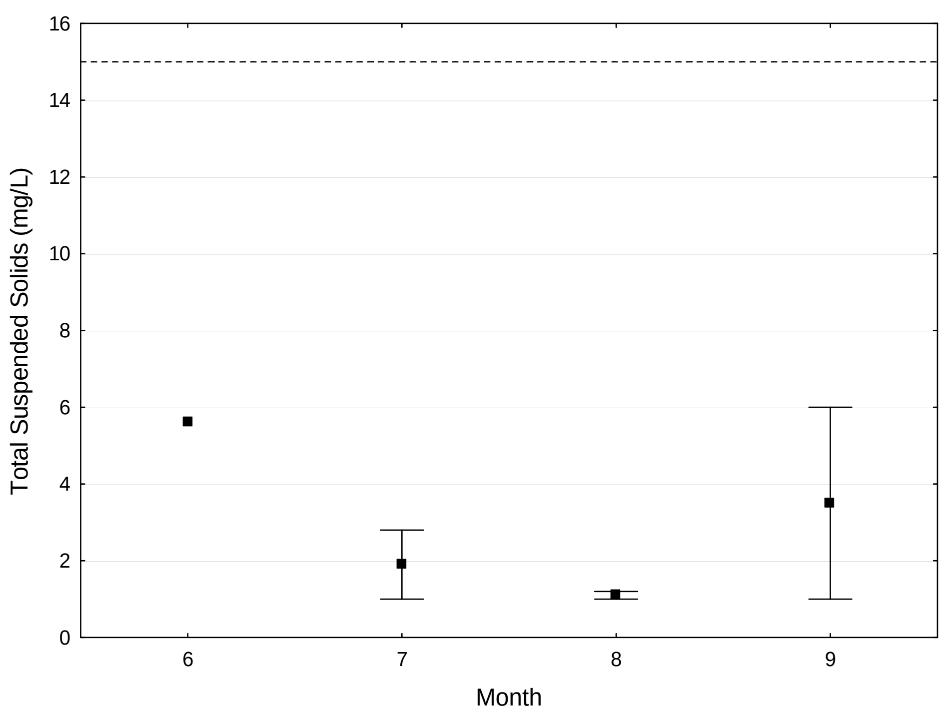


Figure 72. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per month in 2008 on 07010101-502. The dotted line indicates the water quality standard (15 mg/L).

D. Itasca County

AUID 07010101-501 (Vermillion River to Blackwater Lake) Temporal Trends

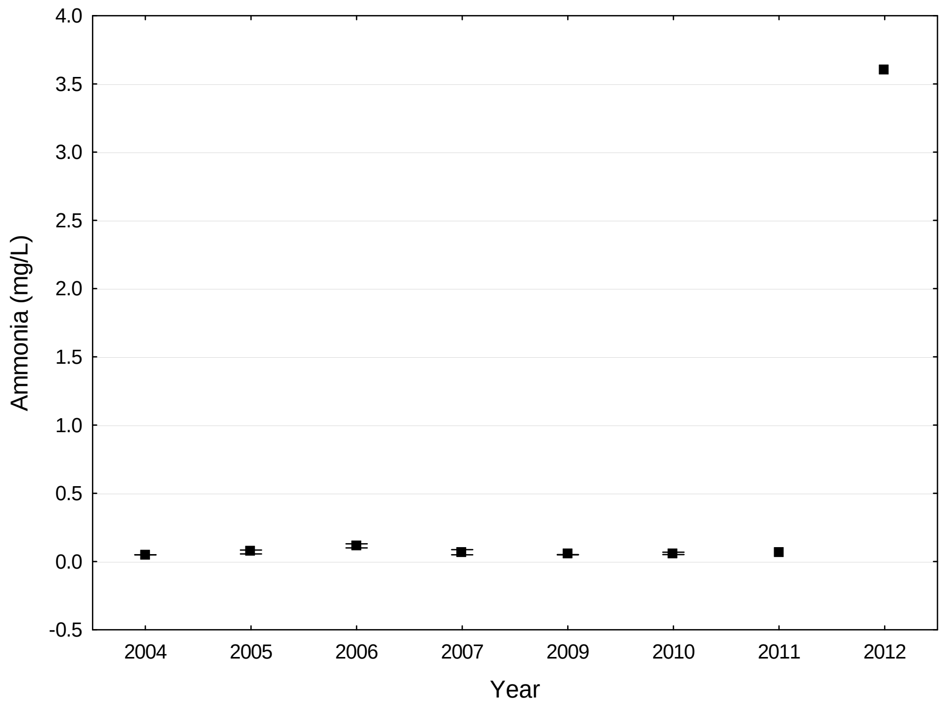


Figure 73. Mean ±SE ammonia concentration per year on 07010101-501. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

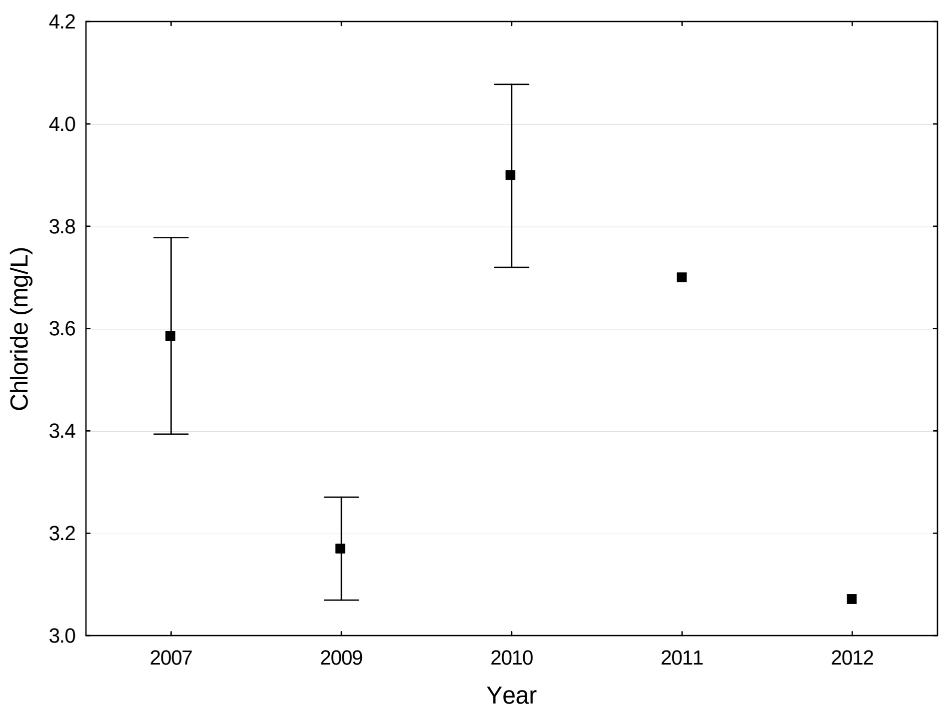


Figure 74. Mean ±SE chloride concentration per year on 07010101-501. The water quality standard for chloride is 230 mg/L.

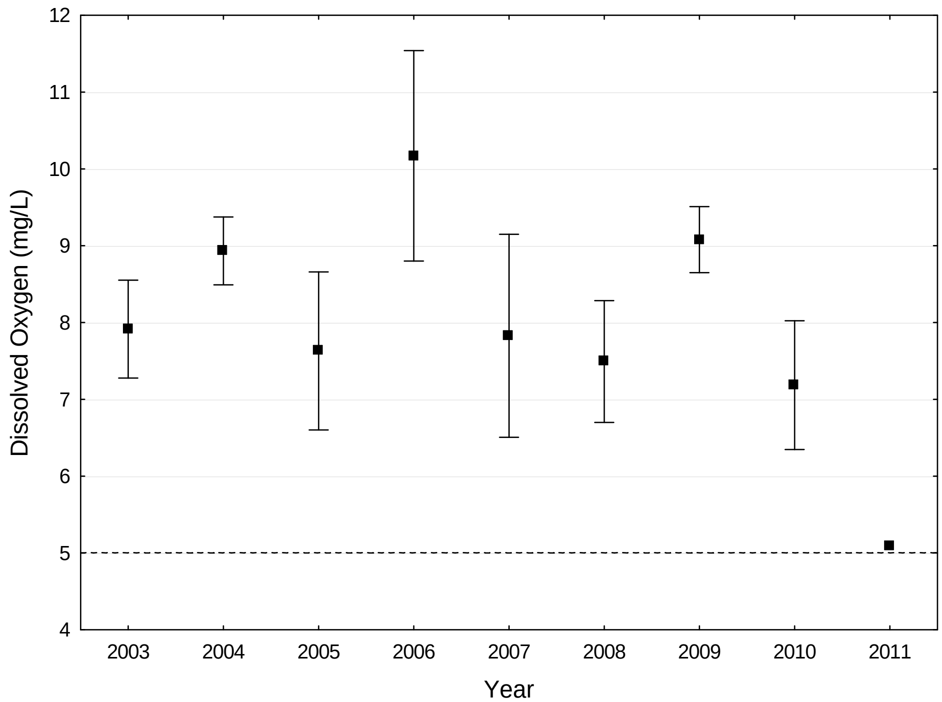


Figure 75. Mean ±SE dissolved oxygen concentration per year on 07010101-501. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

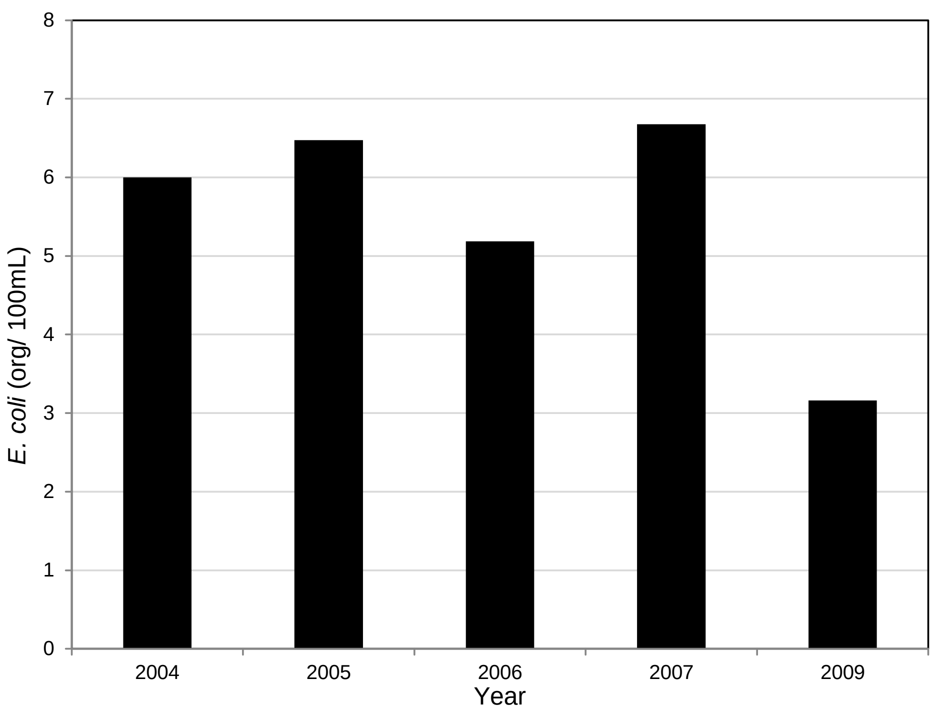


Figure 76. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010101-501. The water quality standard for *E. coli* is 126 organisms/100mL.

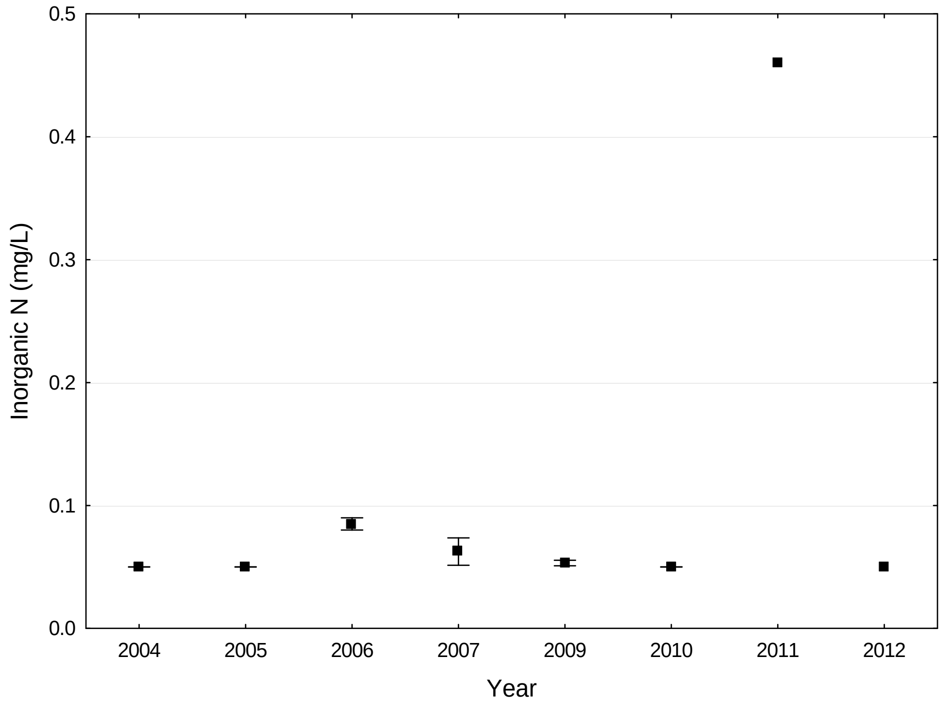


Figure 77. Mean ±SE inorganic N concentration per year on 07010101-501. The water quality standard for inorganic N is 10 mg/L.

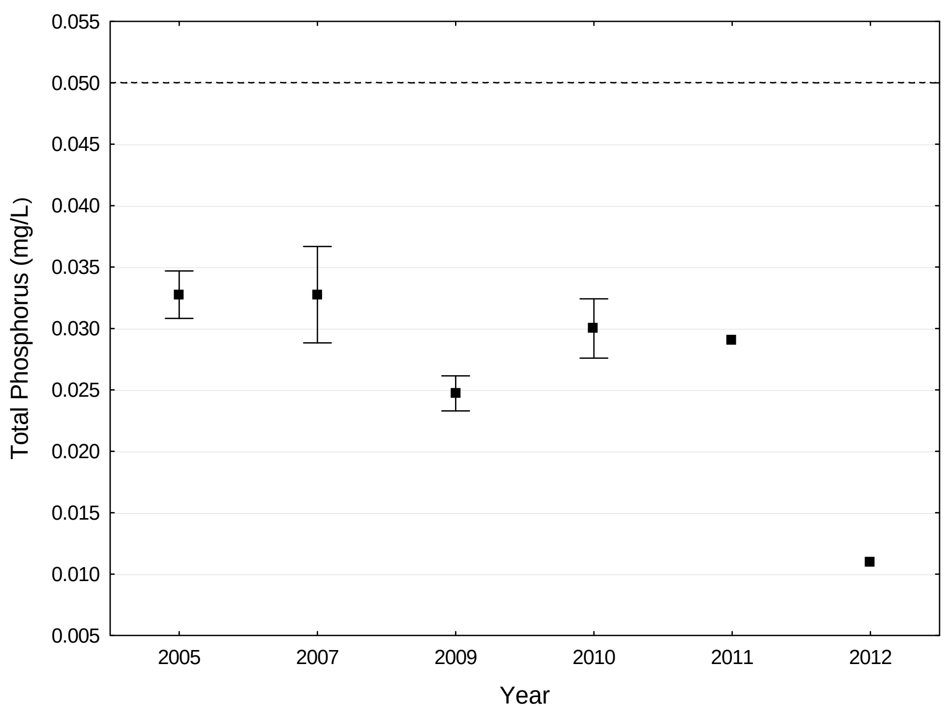


Figure 78. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010101-501. The dotted line indicates the proposed water quality standard (0.05 mg/L).

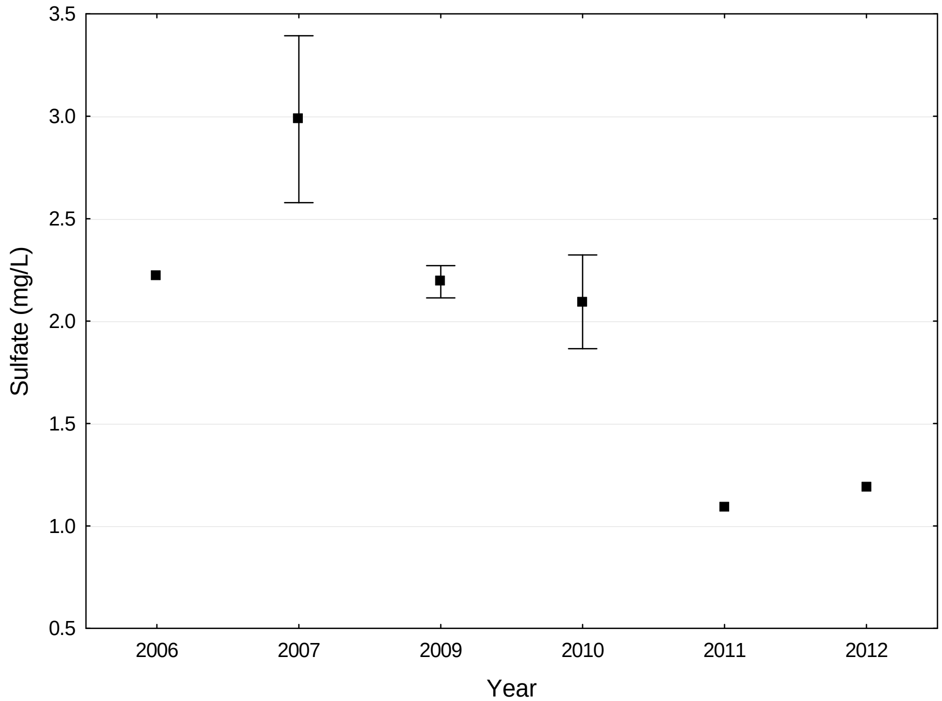


Figure 79. Mean ±SE sulfate concentration per year on 07010101-501. The water quality standard for sulfate is 250 mg/L.

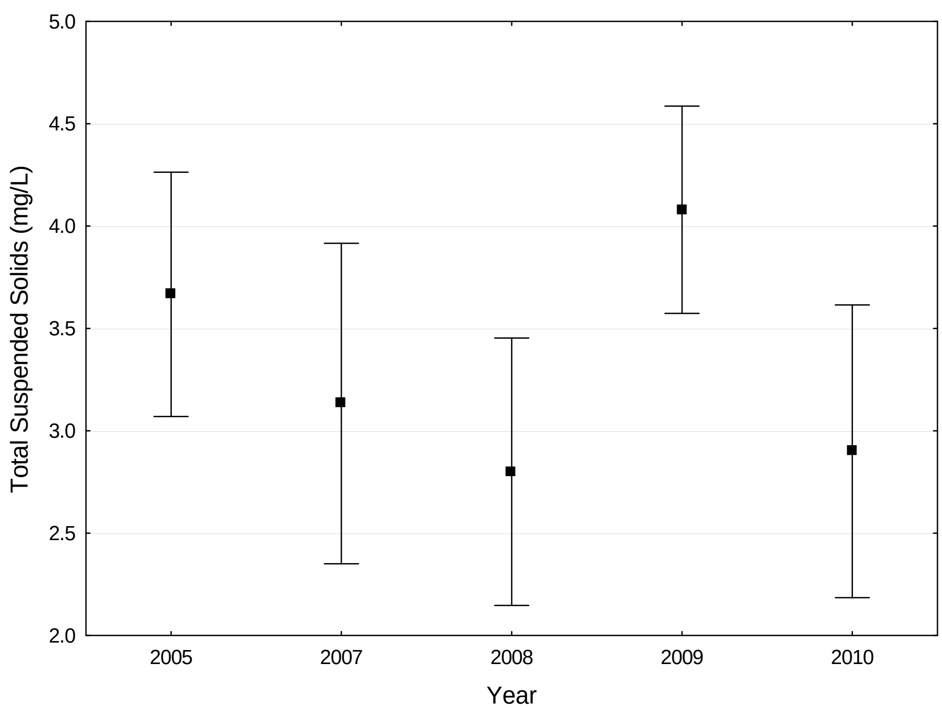


Figure 80. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010101-501. The water quality standard for total suspended solids is 15 mg/L.

AUID 07010103-503 (Grand Rapids Dam to Prairie River) Temporal Trends

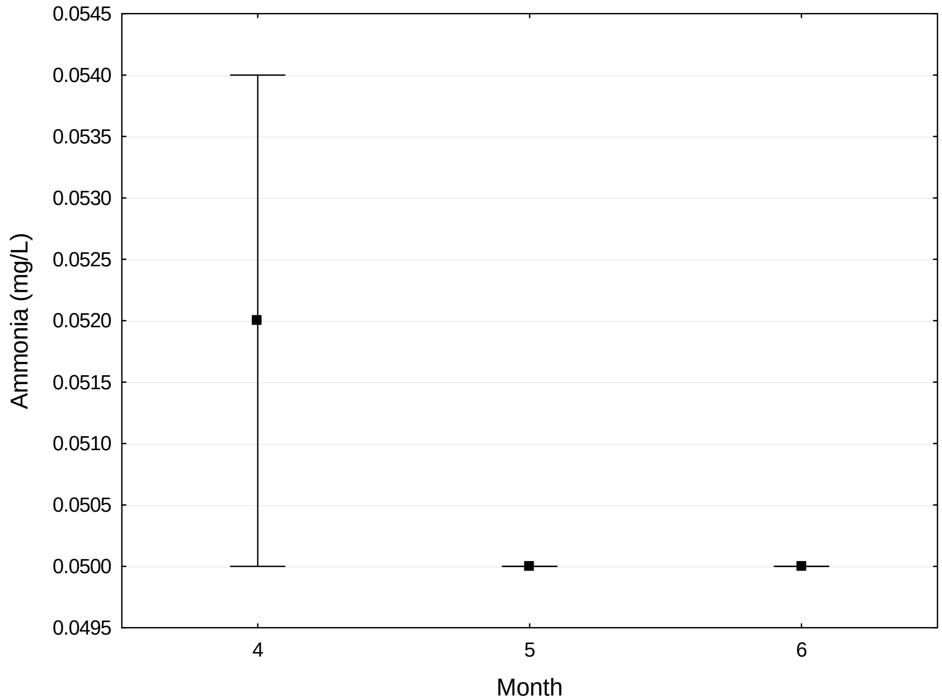


Figure 81. Mean ±SE ammonia concentration per month in 2009 on 07010103-503. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

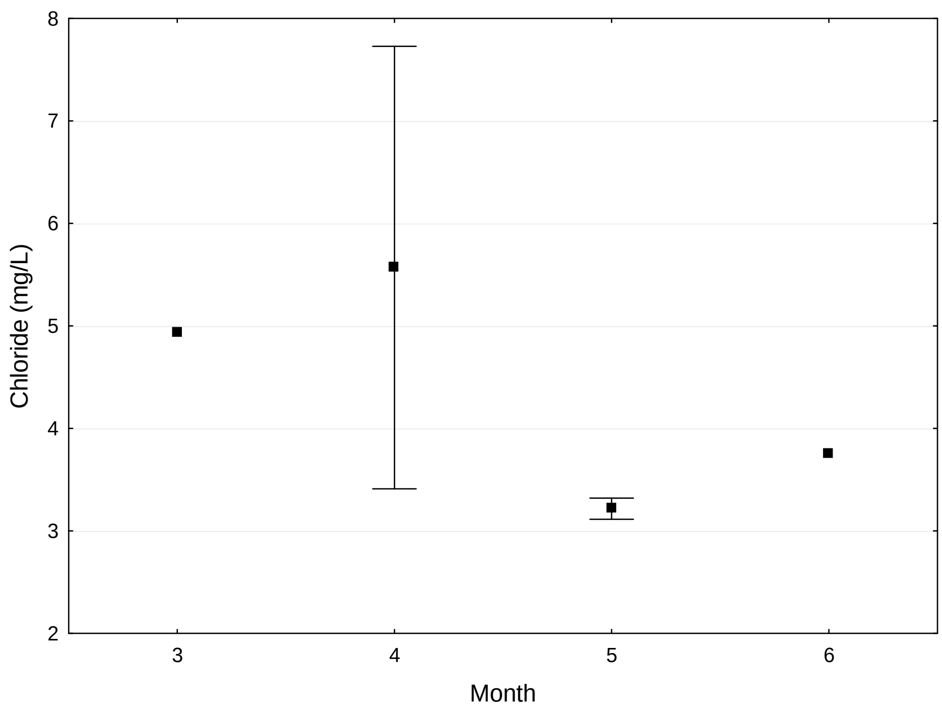


Figure 82. Mean ±SE chloride concentration per month in 2009 on 07010103-503. The water quality standard for chloride is 230 mg/L.

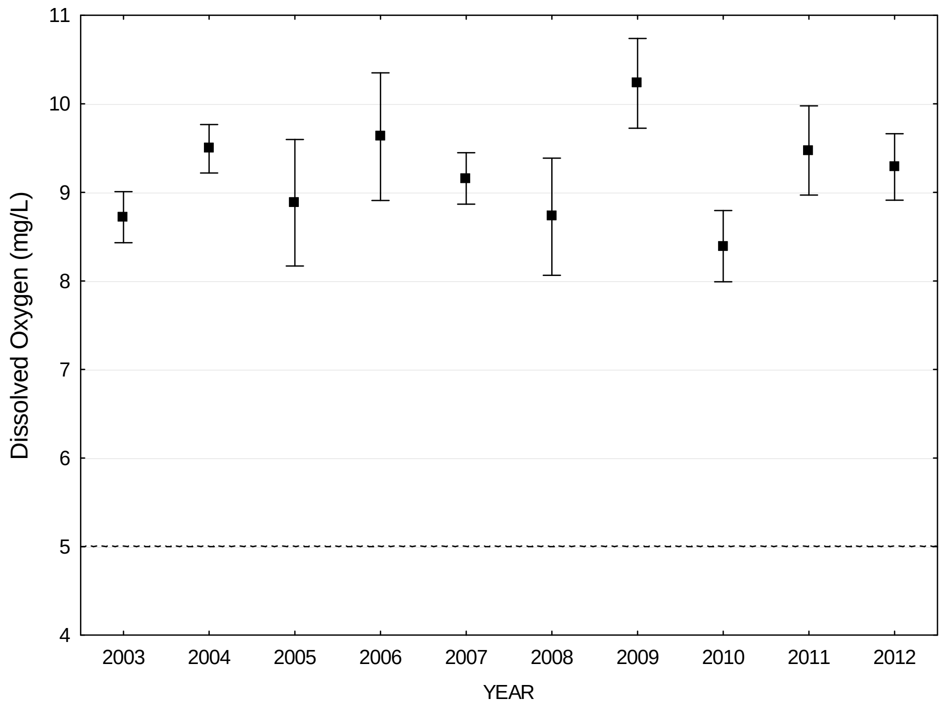


Figure 83. Mean ±SE dissolved oxygen concentration per year on 07010103-503. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

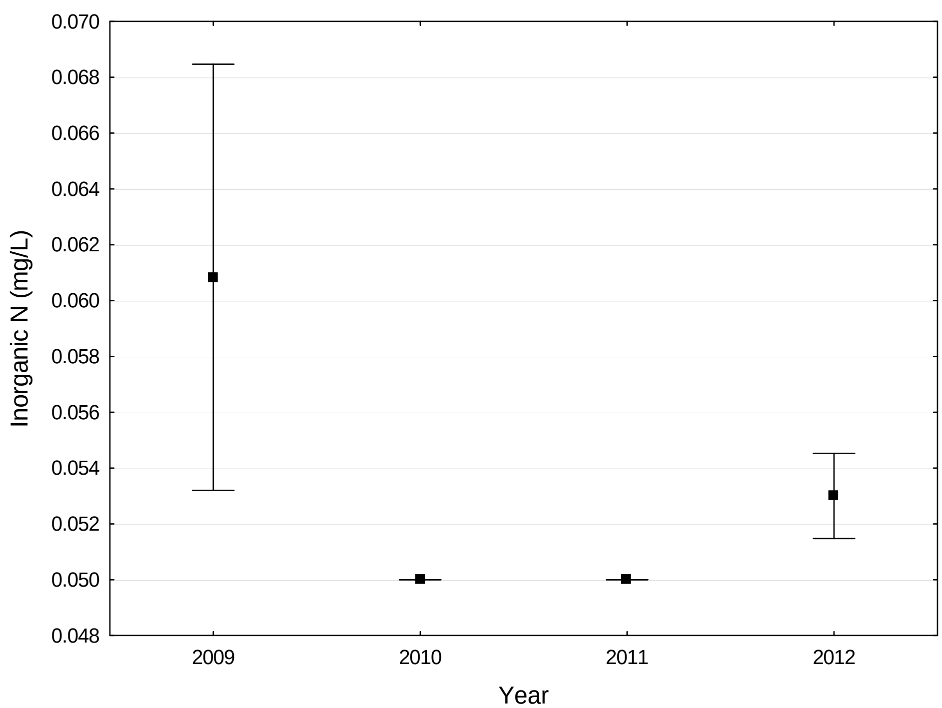


Figure 84. Mean ±SE inorganic N concentration per year on 07010103-503. The water quality standard for inorganic N is 10 mg/L.

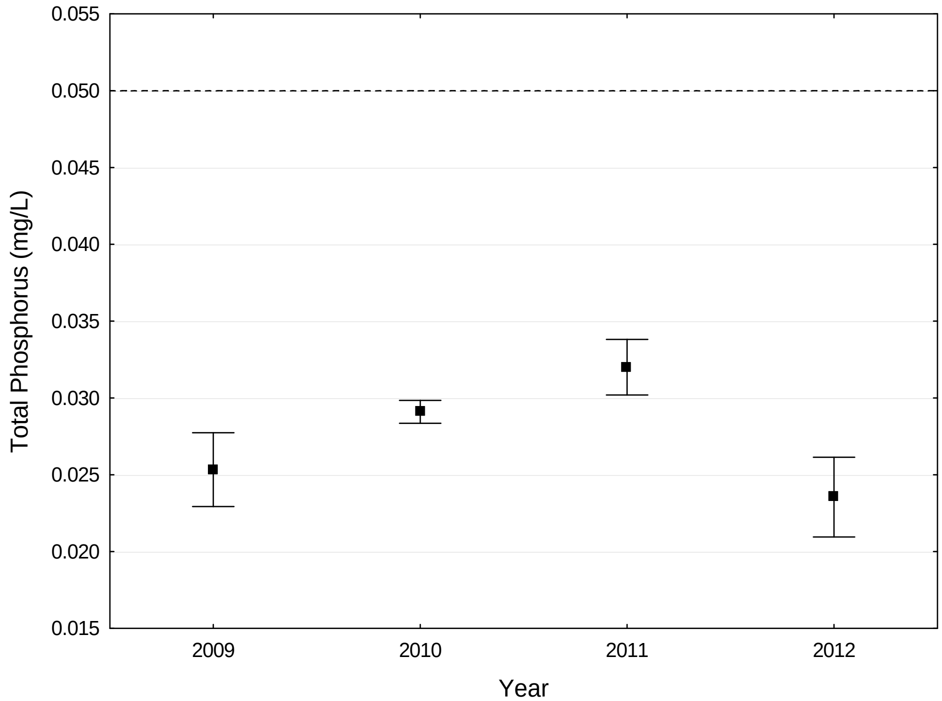


Figure 85. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010103-503. The dotted line indicates the proposed water quality standard (0.05 mg/L).

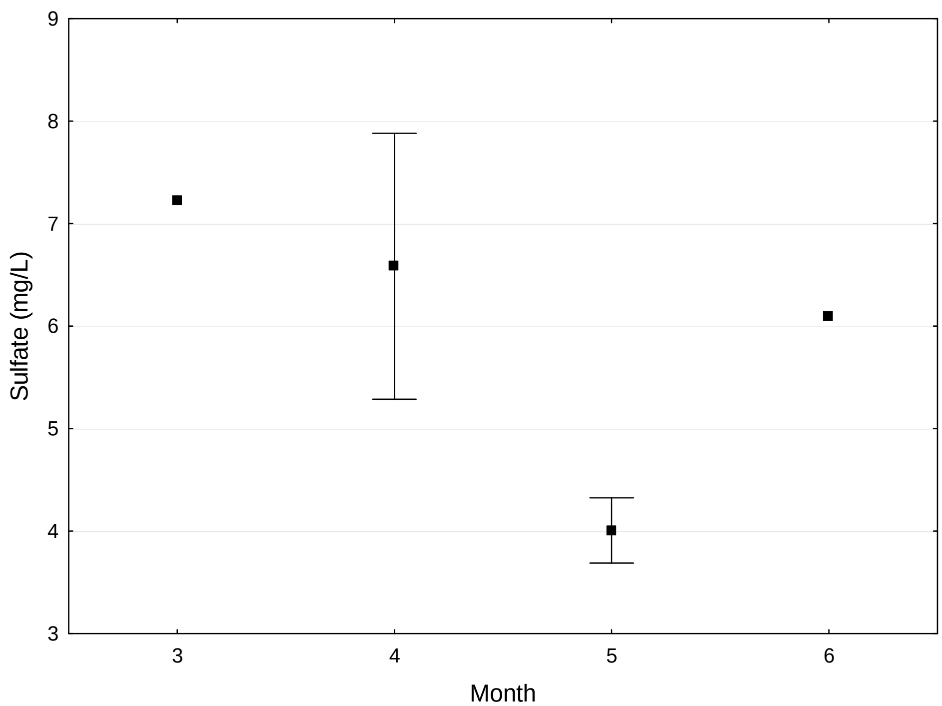


Figure 86. Mean ±SE sulfate concentration per month in 2009 on 07010103-503. The water quality standard for sulfate is 250 mg/L.

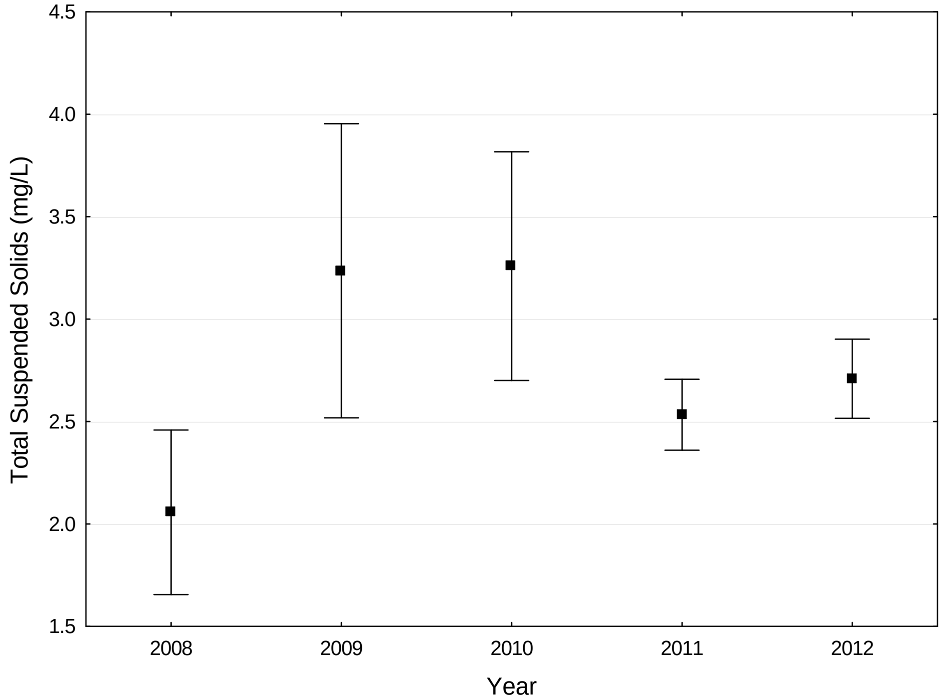


Figure 87. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010103-503. The water quality standard for total suspended solids is 15 mg/L.

AUID 07010103-502 (Prairie River to Split Hand Creek) Temporal Trends

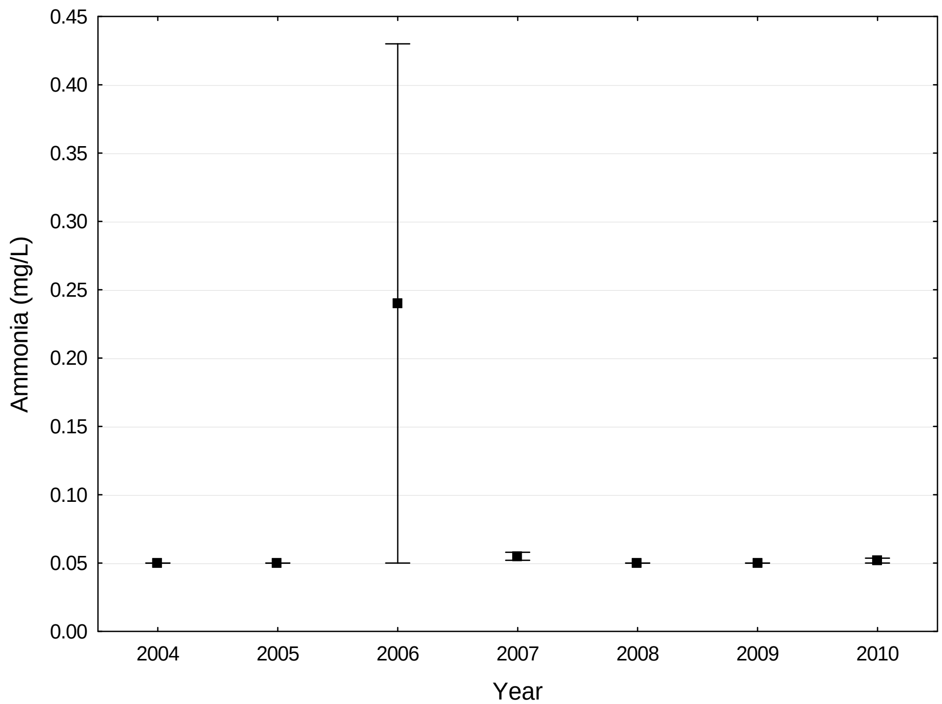


Figure 88. Mean ±SE ammonia concentration per year on 07010103-502. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

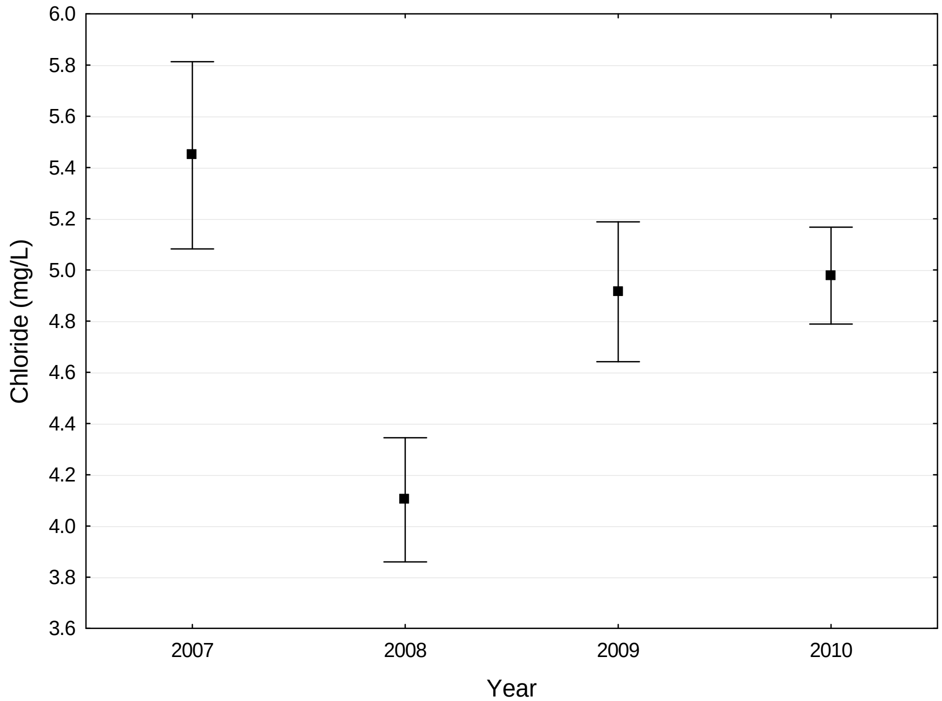


Figure 89. Mean ±SE chloride concentration per year on 07010103-502. The water quality standard for chloride is 230 mg/L.

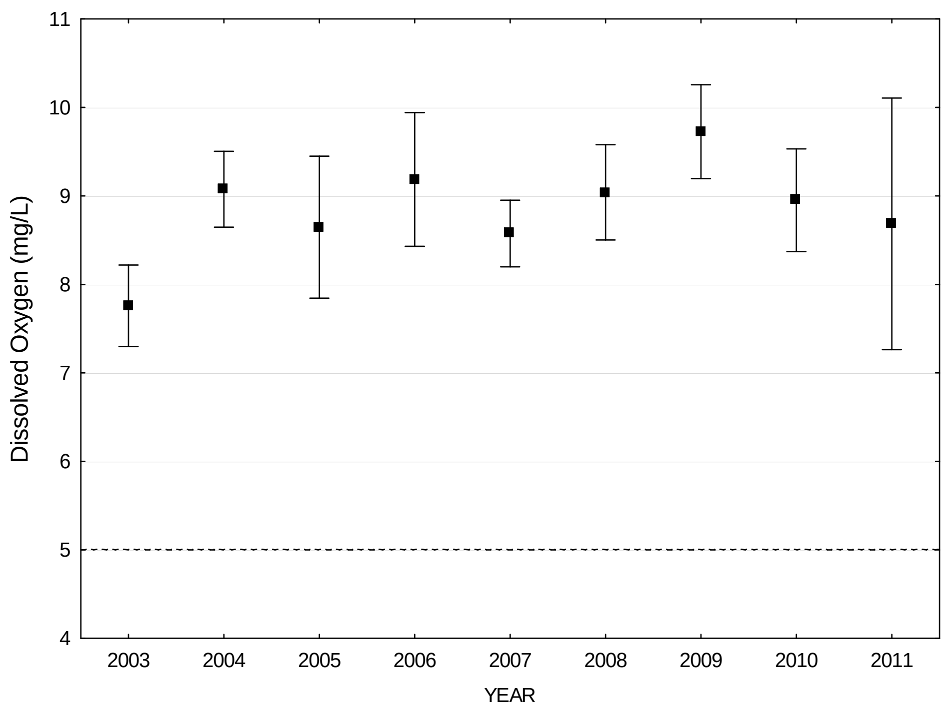


Figure 90. Mean ±SE dissolved oxygen concentration per year on 07010103-502. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

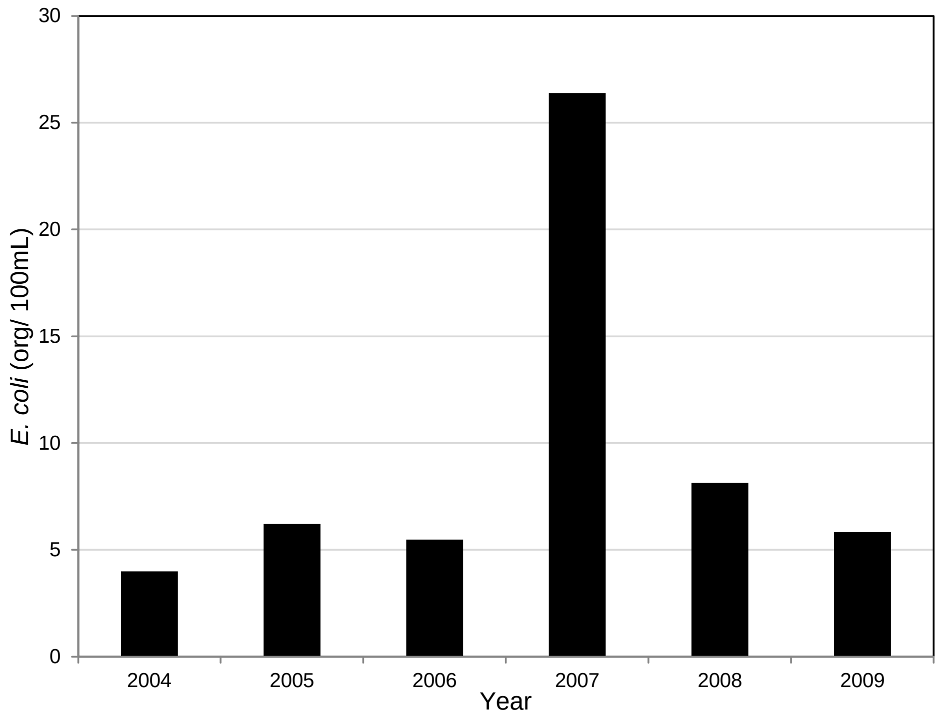


Figure 91. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010103-502. The water quality standard for *E. coli* is 126 organisms/100mL.

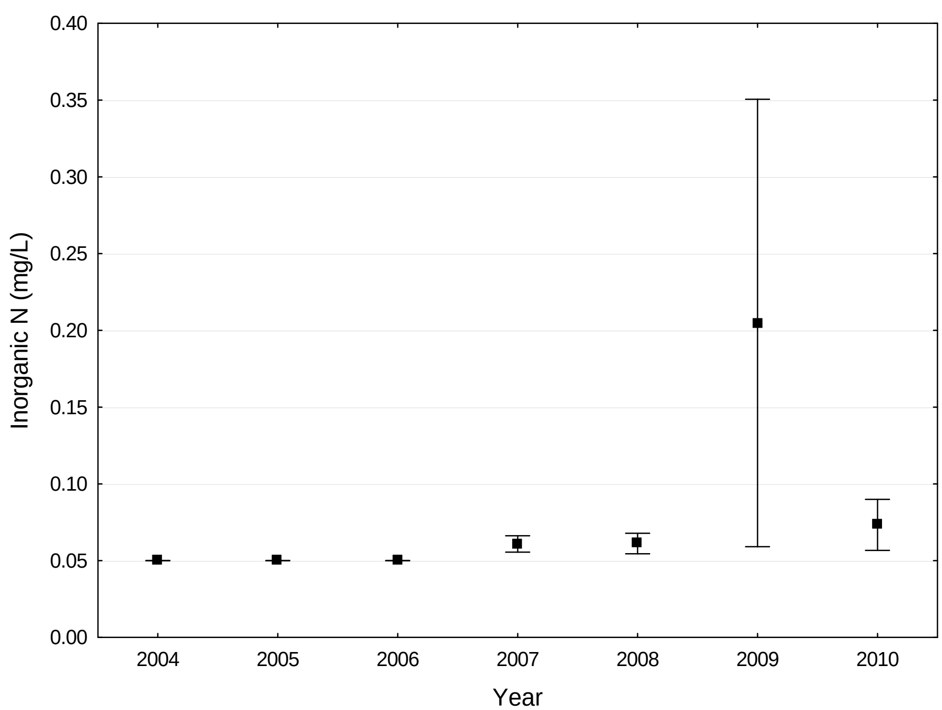


Figure 92. Mean ±SE inorganic N concentration per year on 07010103-502. The water quality standard for inorganic N is 10 mg/L.

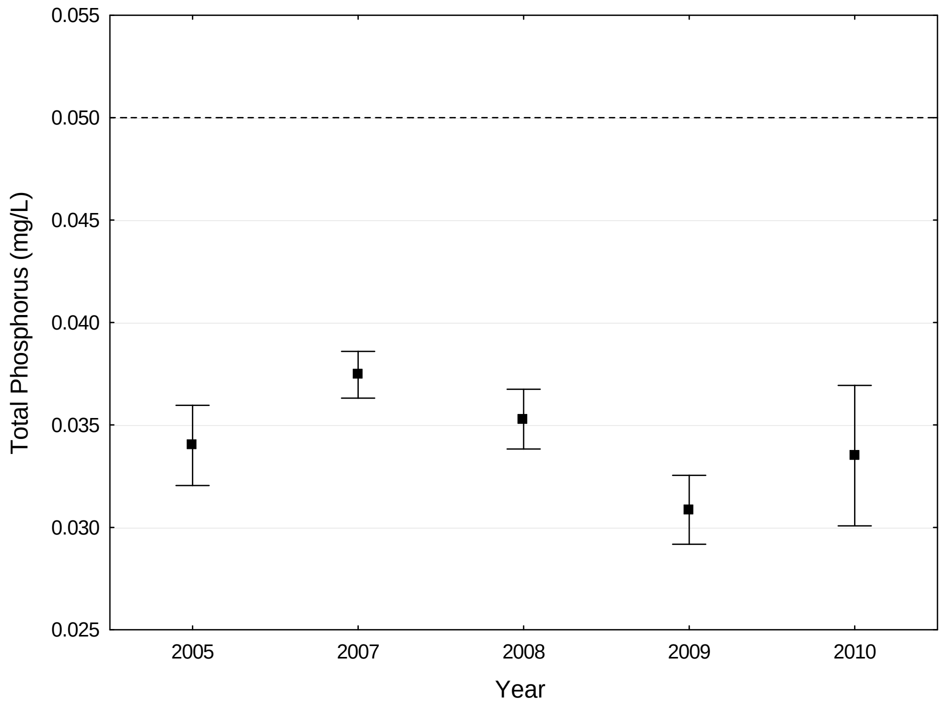


Figure 93. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010103-502. The dotted line indicates the proposed water quality standard (0.05 mg/L).

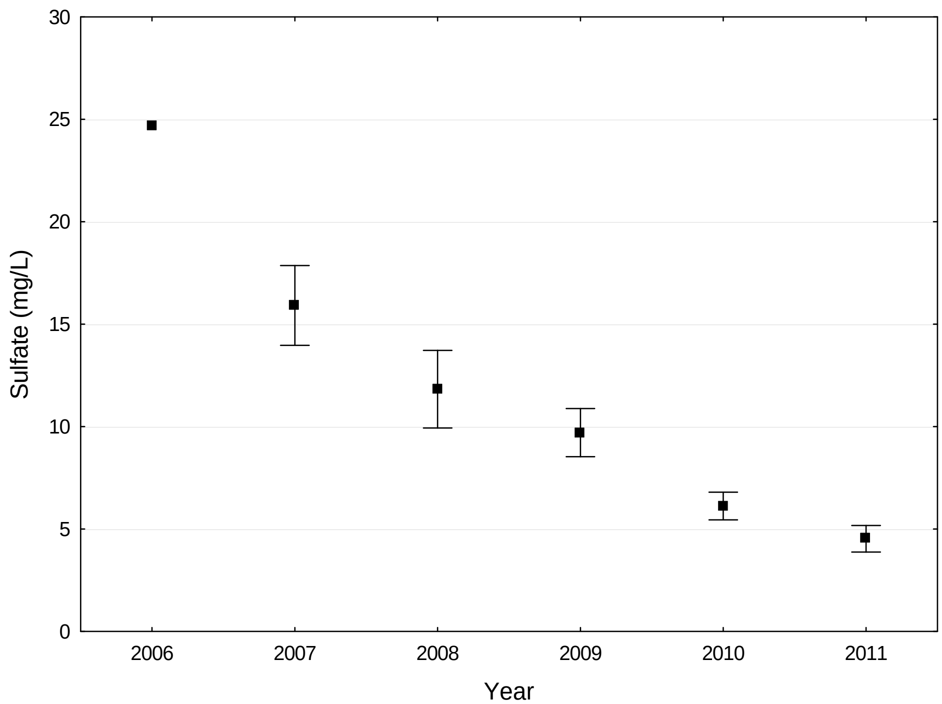


Figure 94. Mean ±SE sulfate concentration per year on 07010103-502. The water quality standard for sulfate is 250 mg/L.

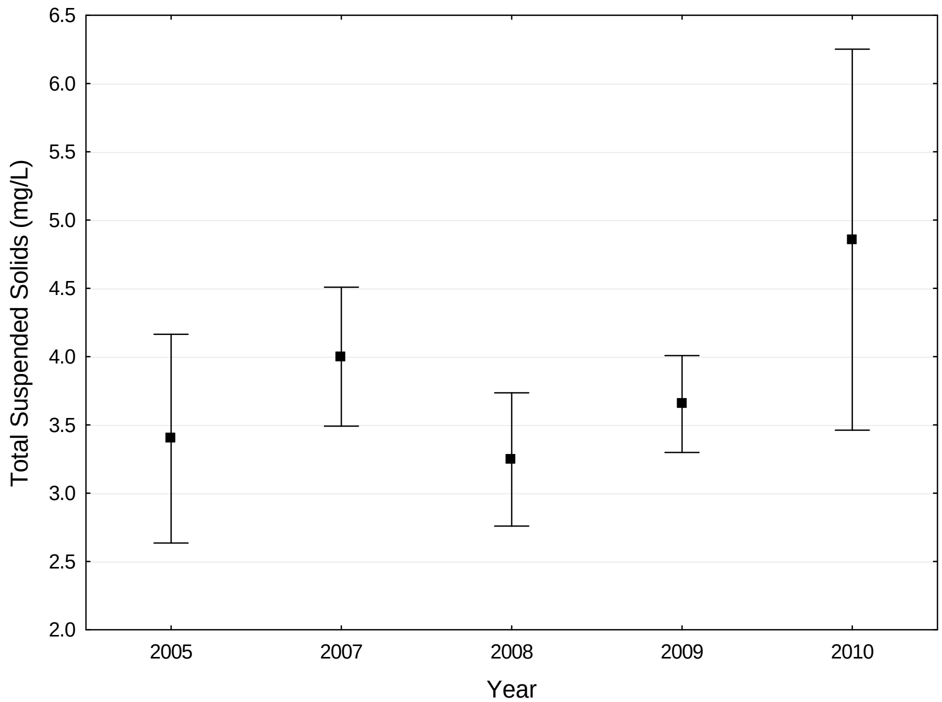


Figure 95. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010103-502. The water quality standard for total suspended solids is 15 mg/L.

E. Aitkin County

AUID 07010103-505 (Swan River to Sandy River) Temporal Trends

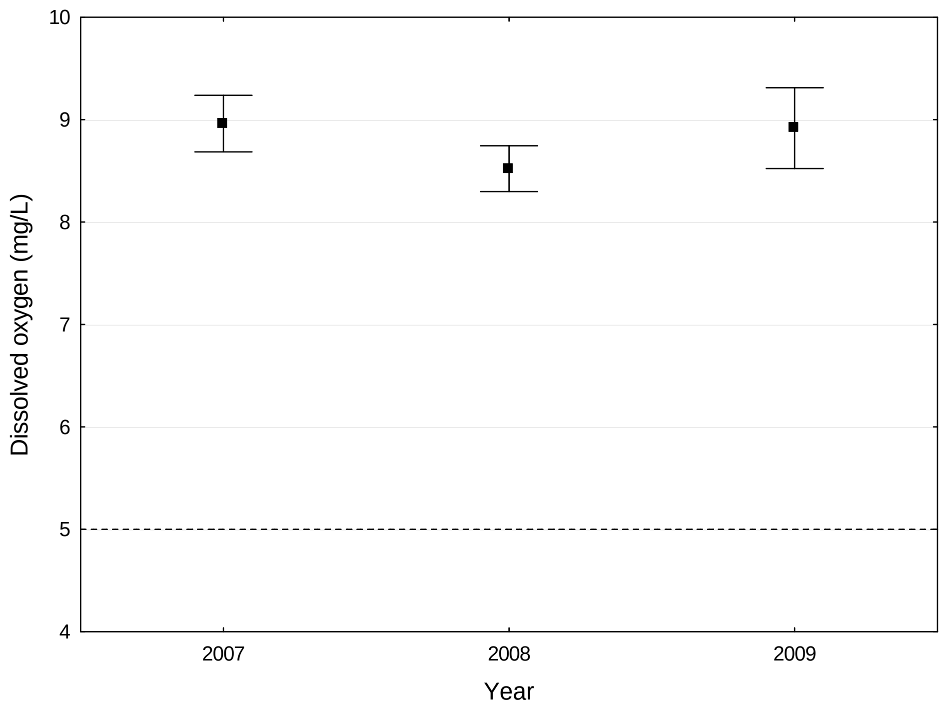


Figure 96. Mean ±SE dissolved oxygen concentration per year on 07010103-505. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

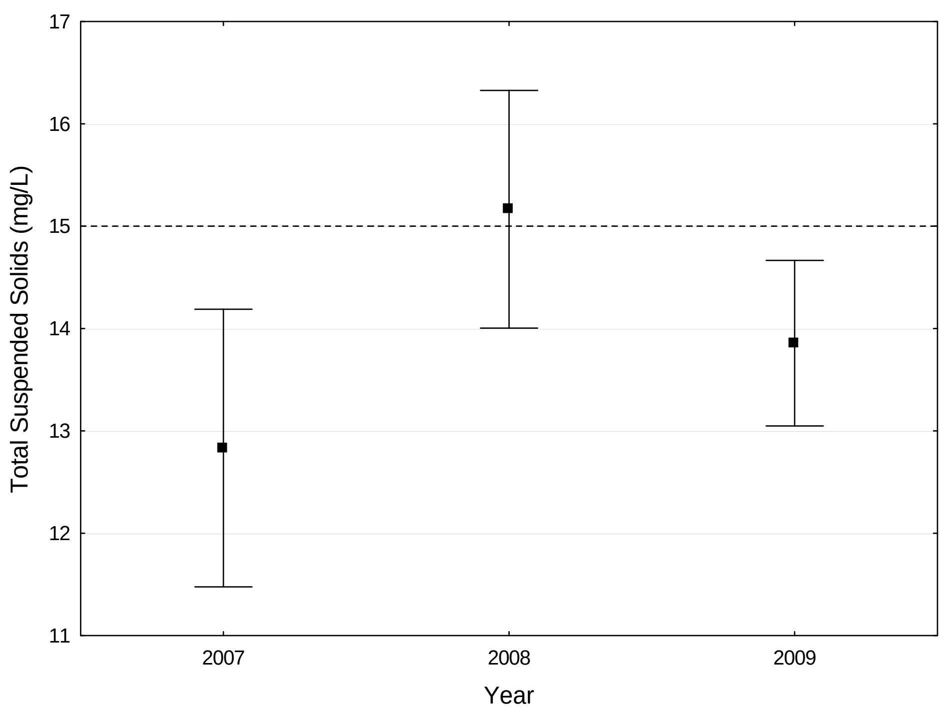


Figure 97. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010103-505. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010103-501 (Sandy River to Willow River) Temporal Trends

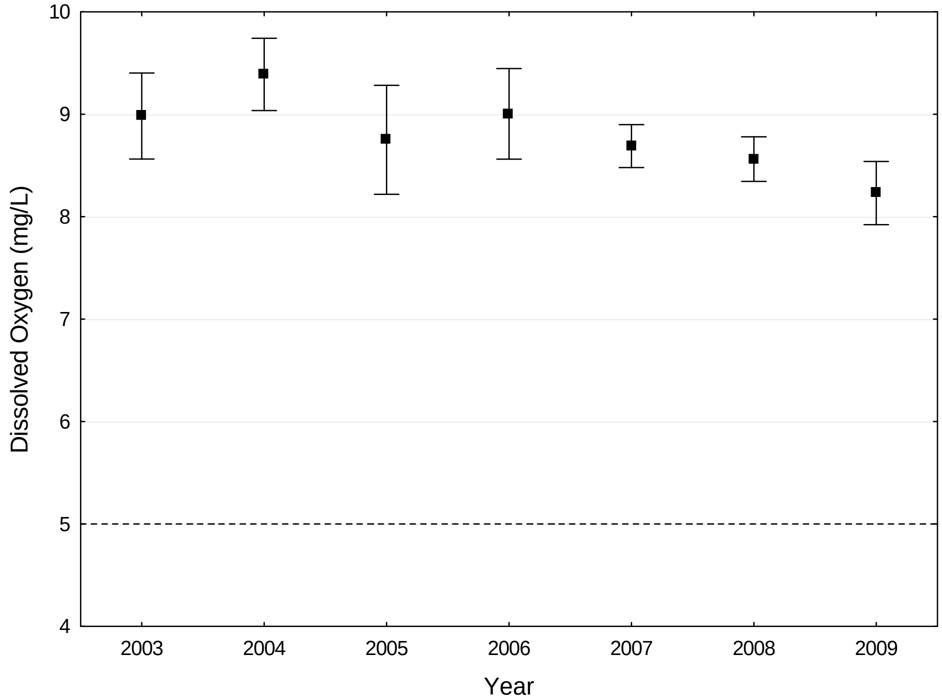


Figure 98. Mean ±SE dissolved oxygen concentration per year on 07010103-501. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

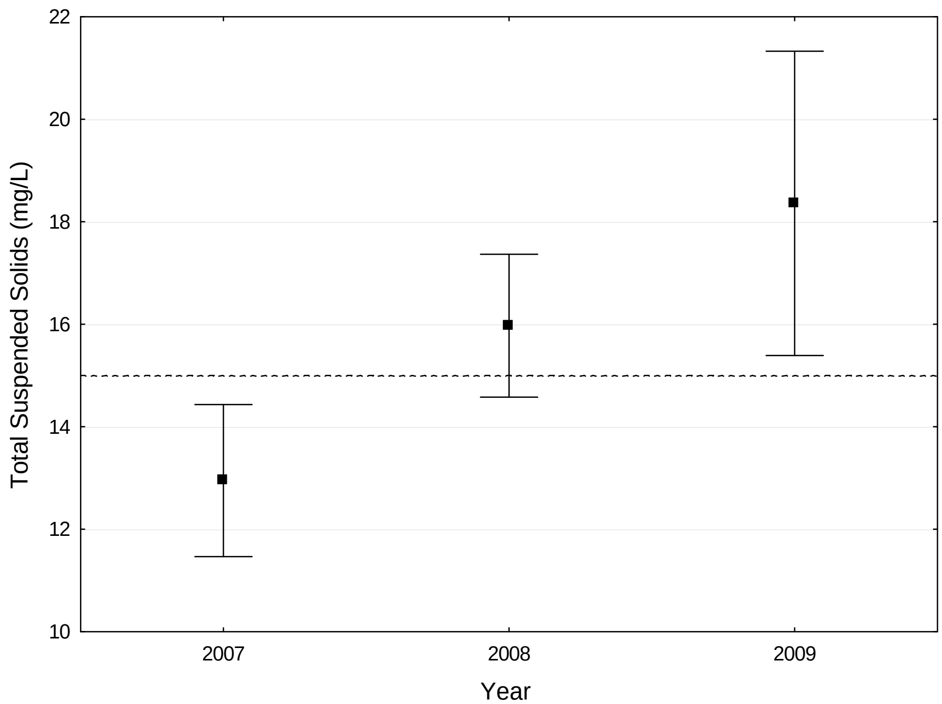


Figure 99. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010103-501. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010104-503 (Rice River to Little Willow River) Temporal Trends

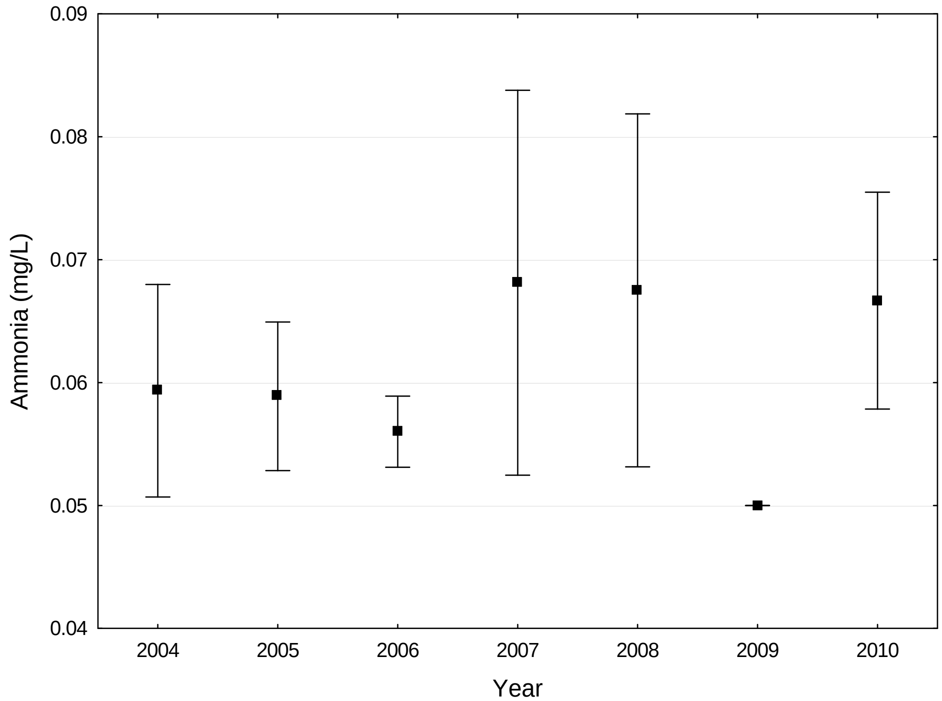


Figure 100. Mean ±SE ammonia concentration per year on 07010104-503. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

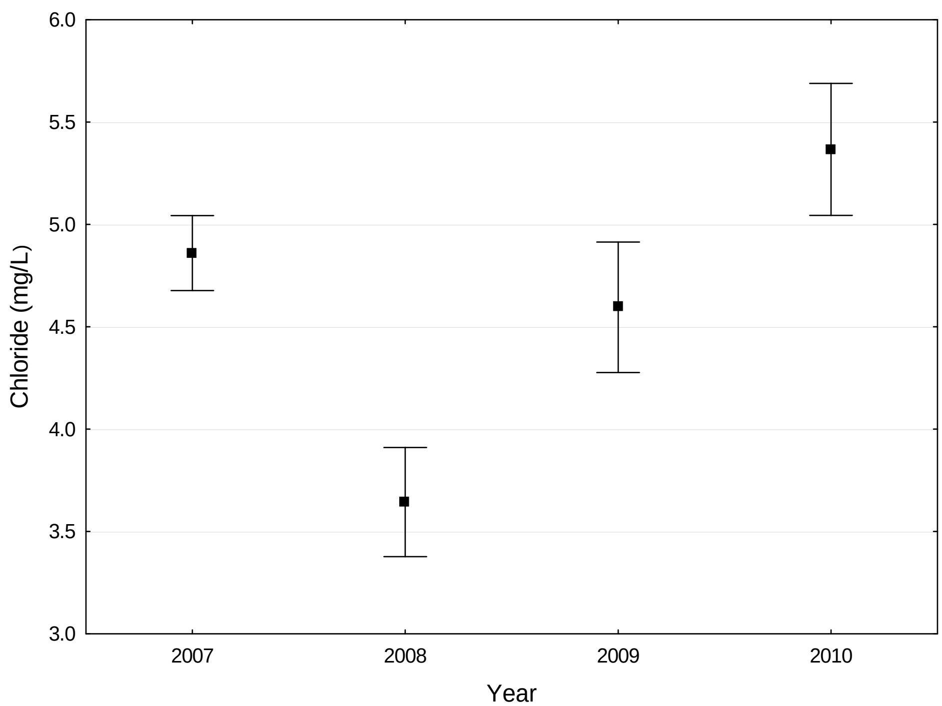


Figure 101. Mean ±SE chloride concentration per year on 07010104-503. The water quality standard for chloride is 230 mg/L.

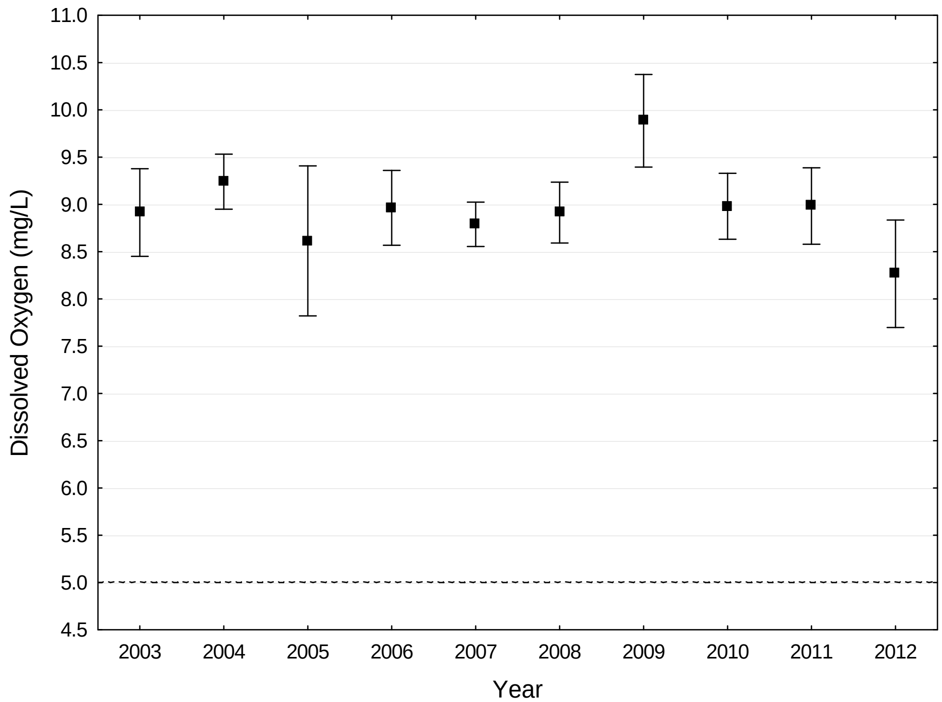


Figure 102. Mean ±SE dissolved oxygen concentration per year on 07010104-503. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

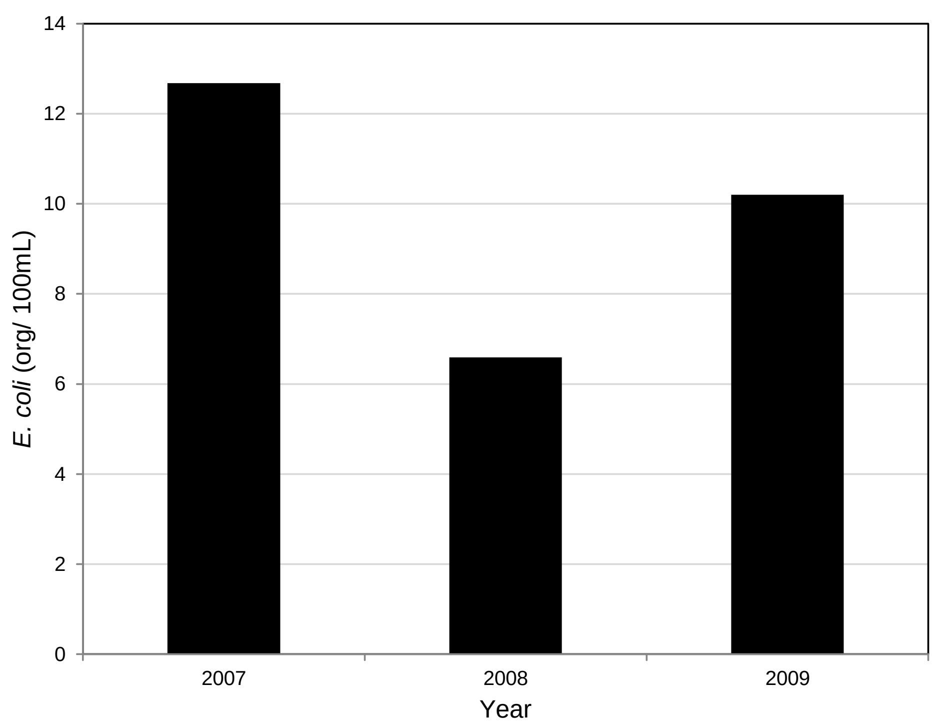


Figure 103. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010104-503. The water quality standard for *E. coli* is 126 organisms/ mL.

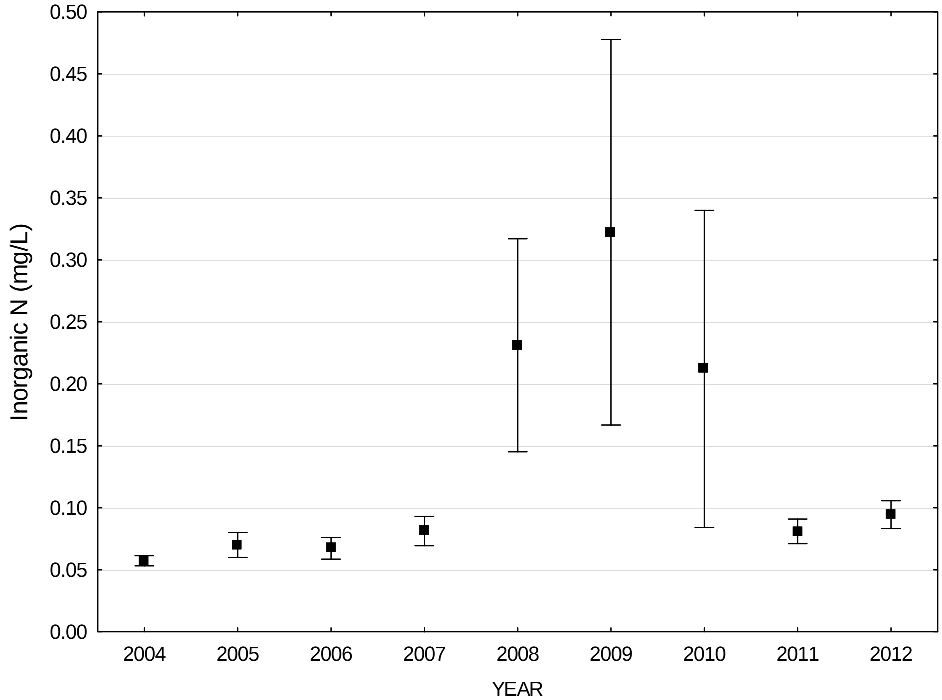


Figure 104. Mean ±SE inorganic N concentration per year on 07010104-503. The water quality standard for inorganic N is 10 mg/L.

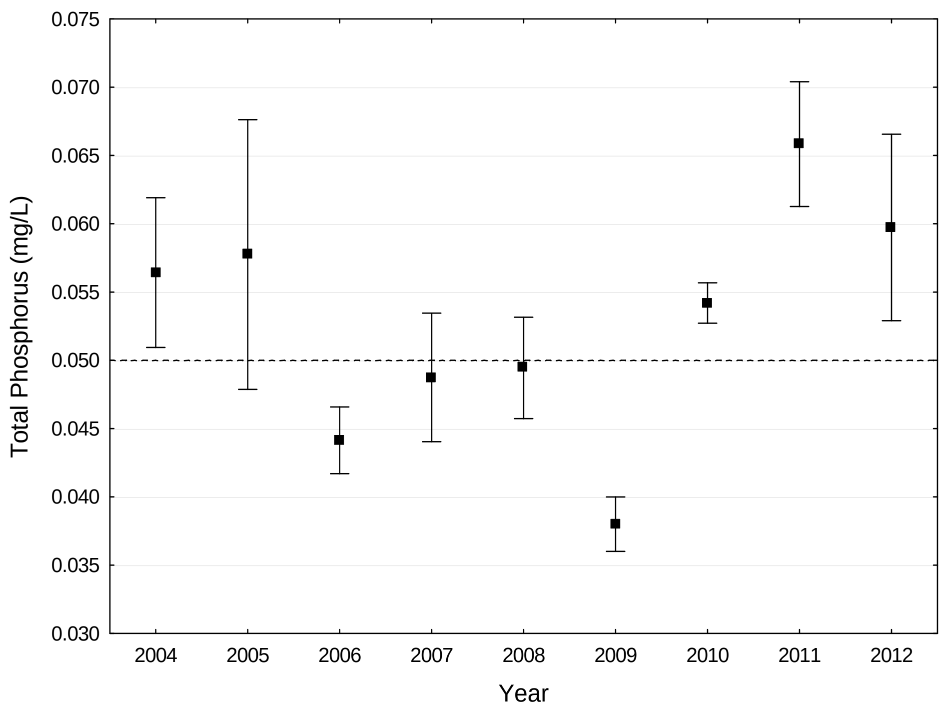


Figure 105. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010104-503. The dotted line indicates the proposed water quality standard (0.05 mg/L).

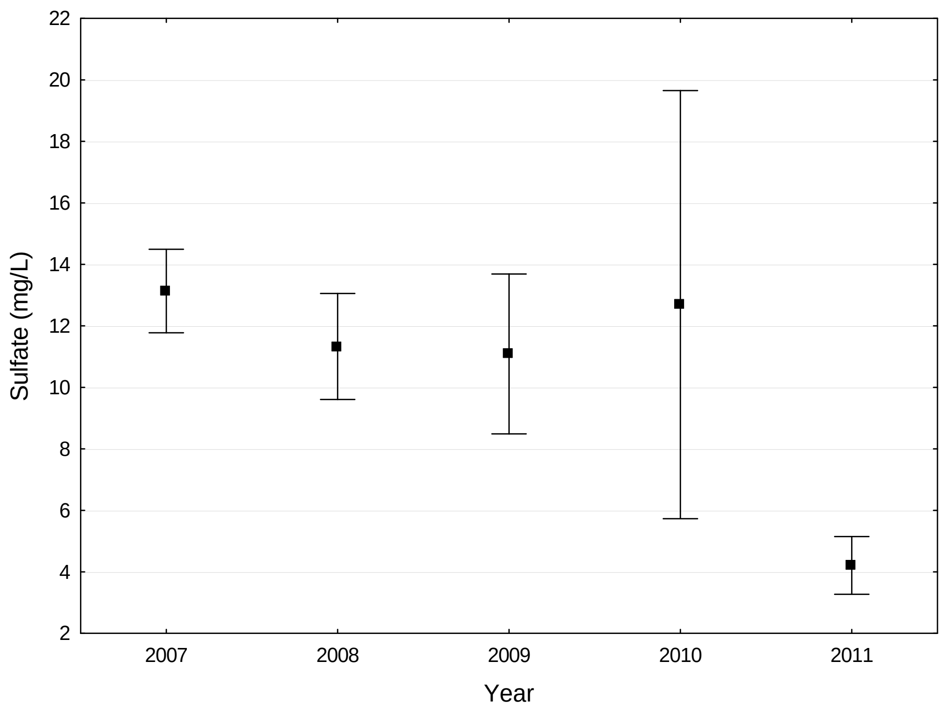


Figure 106. Mean ±SE sulfate concentration per year on 07010104-503. The water quality standard for sulfate is 250 mg/L.

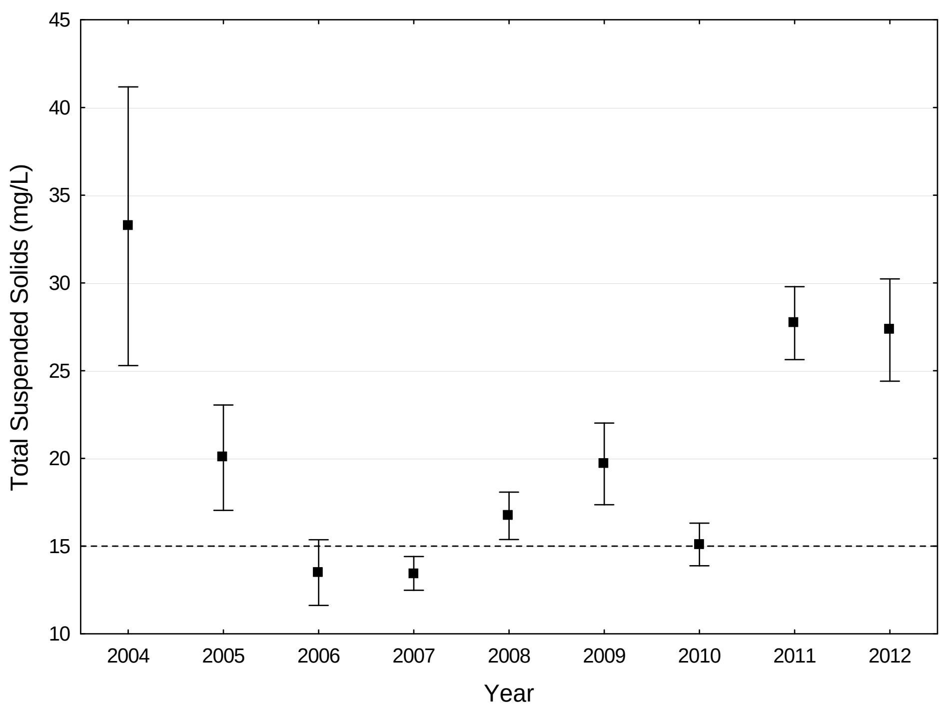


Figure 107. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010104-503. The dotted line indicates the water quality standard (15 mg/L).

F. Crow Wing County

AUID 07010104-501 (Pine River to Brainerd Dam) Temporal Trends

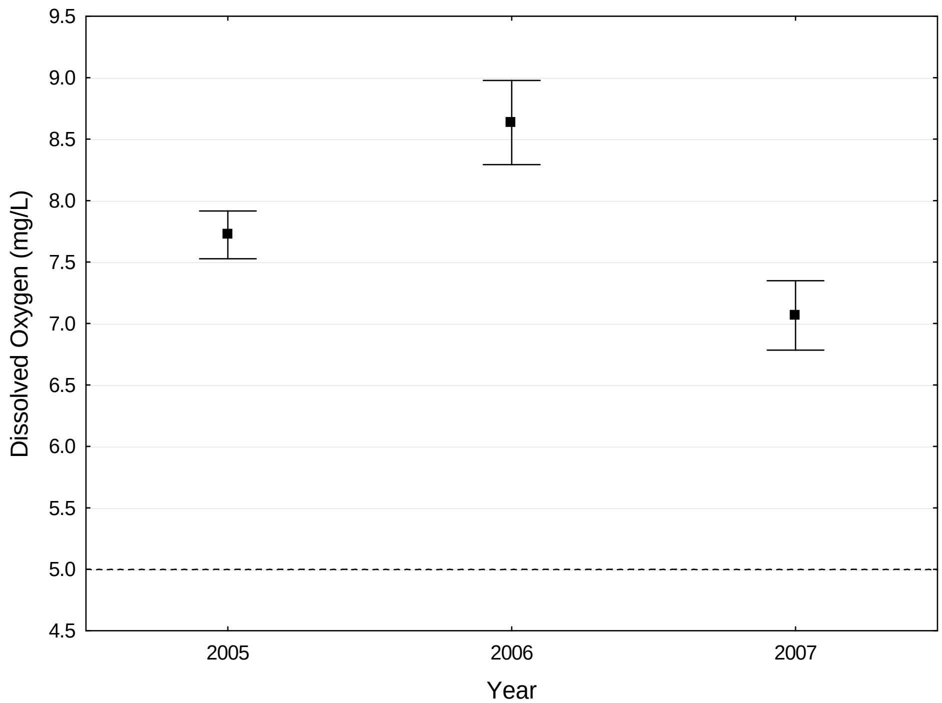


Figure 108. Mean ±SE dissolved oxygen concentration per year on 07010104-501. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

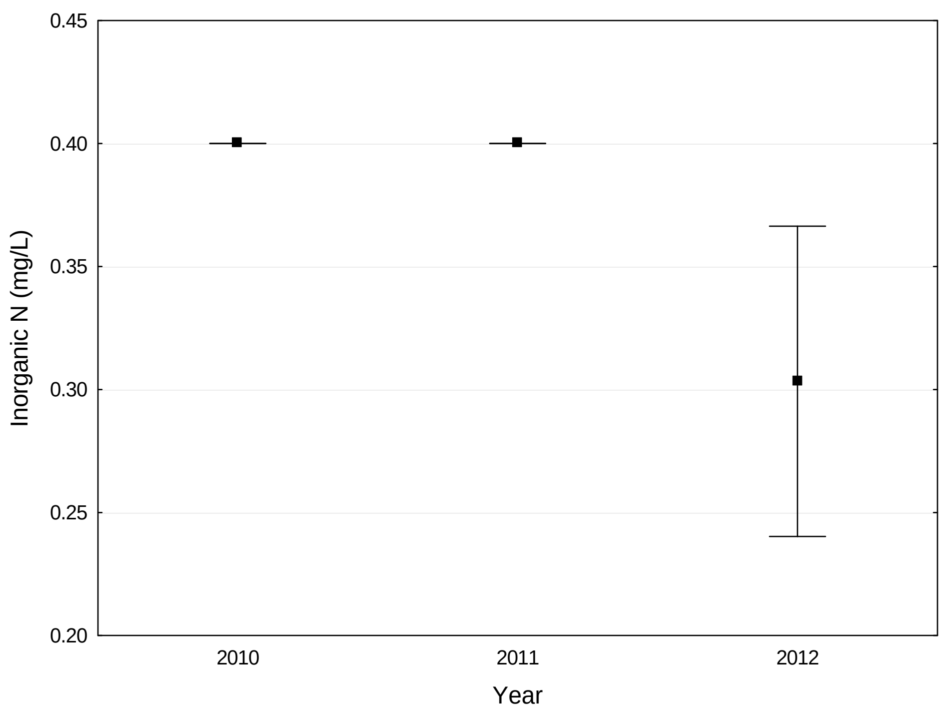


Figure 109. Mean ±SE inorganic N concentration per year 07010104-501. The water quality standard for inorganic N is 10 mg/L.

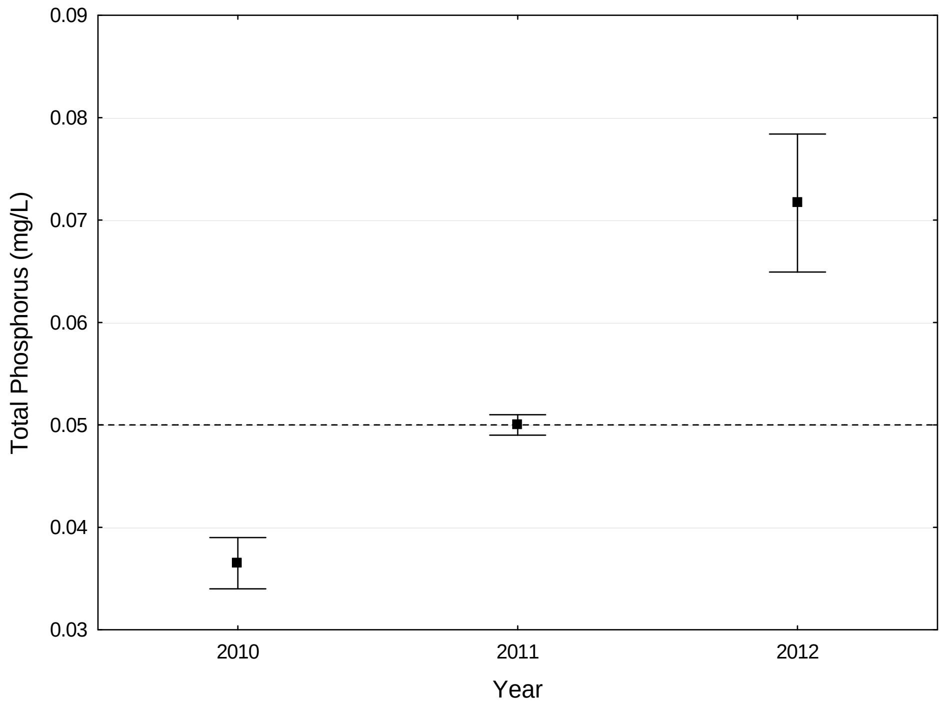


Figure 110. Growing season (June-Sept) mean ±SE total phosphorus concentration per year 07010104-501. The dotted line indicates the proposed water quality standard (0.05 mg/L).

AUID 07010104-516 (Brainerd Dam to Crow Wing River) Temporal Trends

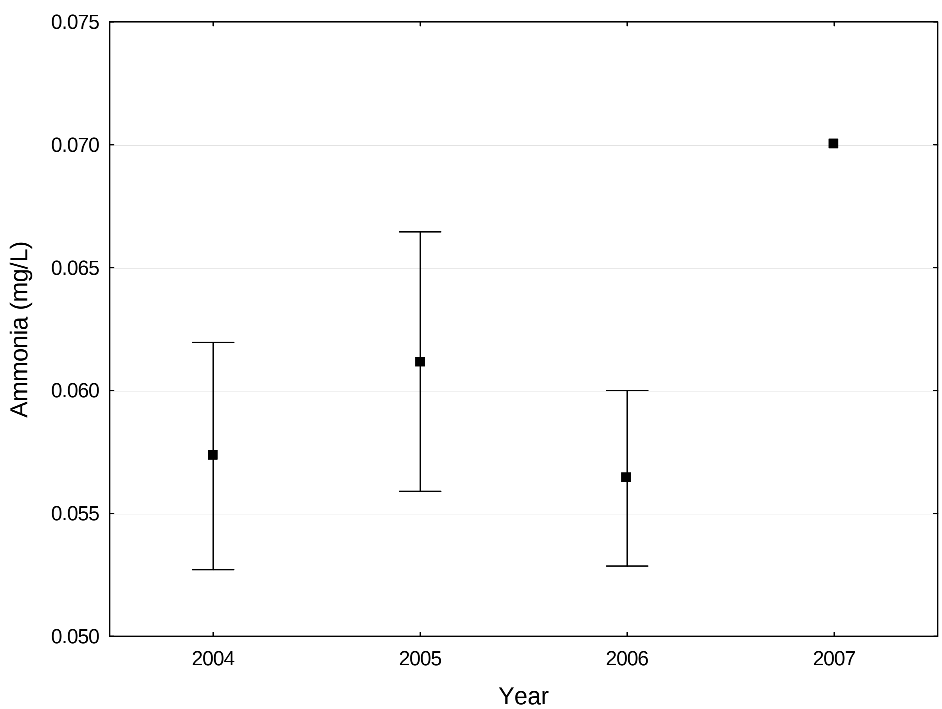


Figure 111. Mean ±SE ammonia concentration per year on 07010104-516. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

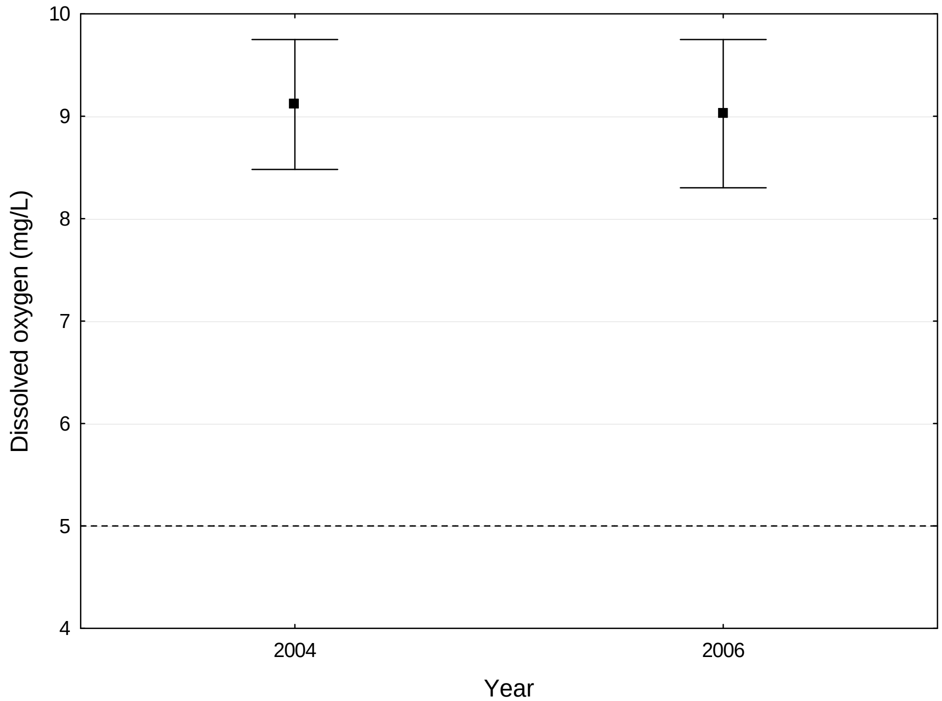


Figure 112. Mean ±SE dissolved oxygen concentration per year on 07010104-516. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

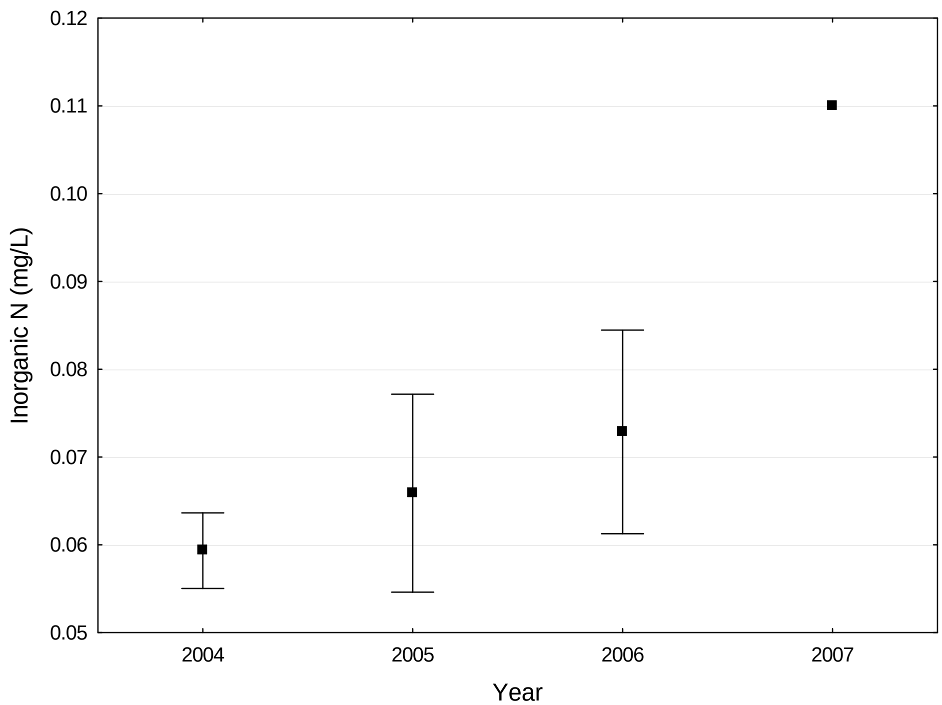


Figure 113. Mean ±SE concentration of inorganic N per year on 07010104-516. The water quality standard for inorganic N is 10 mg/L.

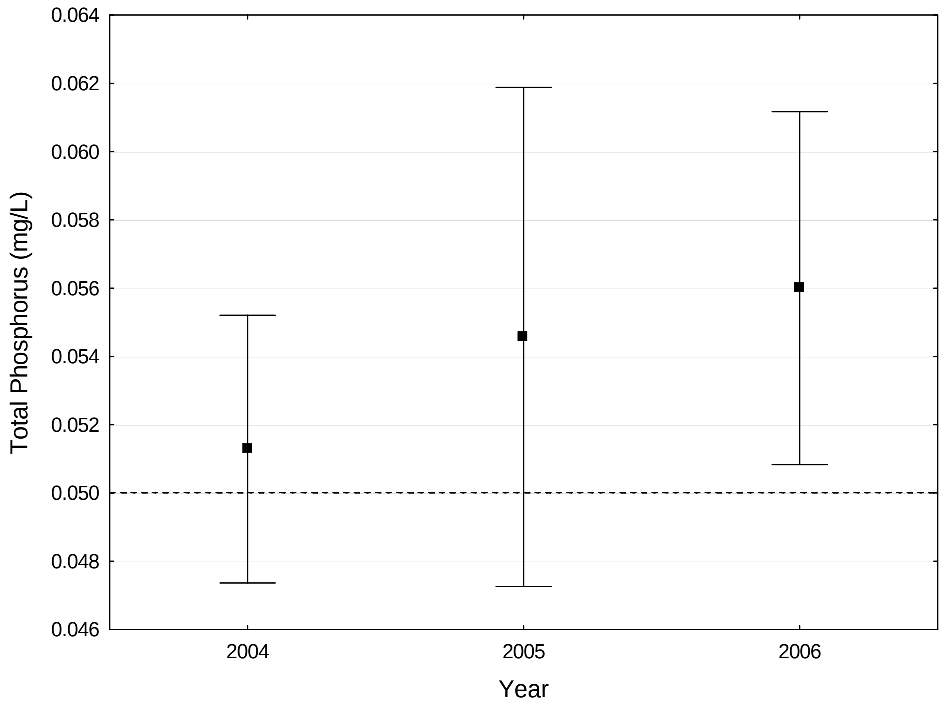


Figure 114. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010104-516. The dotted line indicates the proposed water quality standard (0.05mg/L).

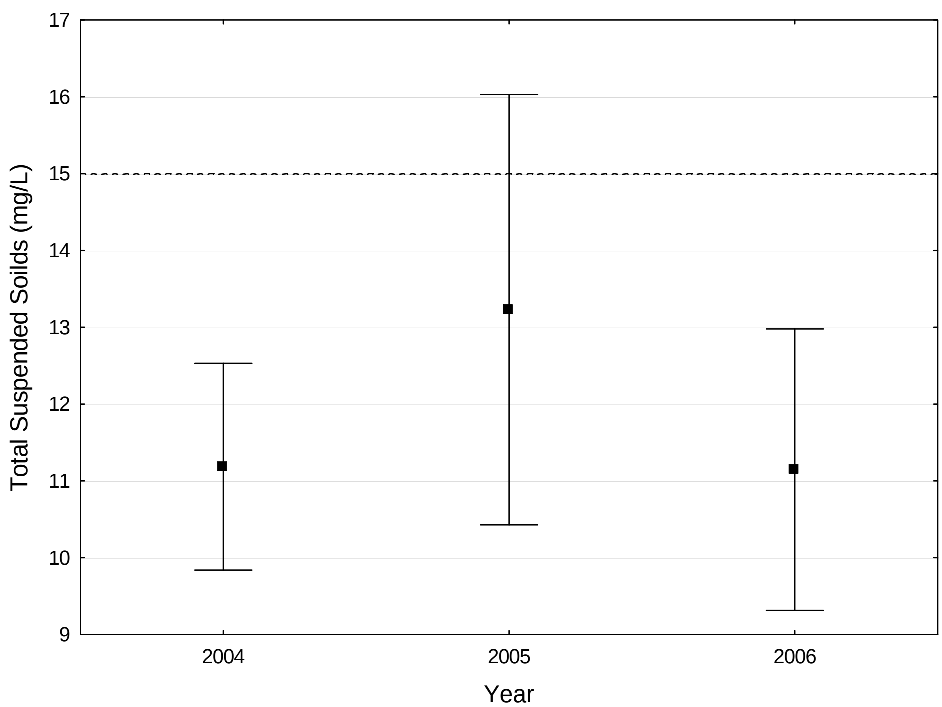


Figure 115. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010104-516. The dotted line indicates the water quality standard (15 mg/L).

G. Morrison County

AUID 07010104-577 (Crow Wing/Morrison County border to Fletcher Creek) Temporal Trends

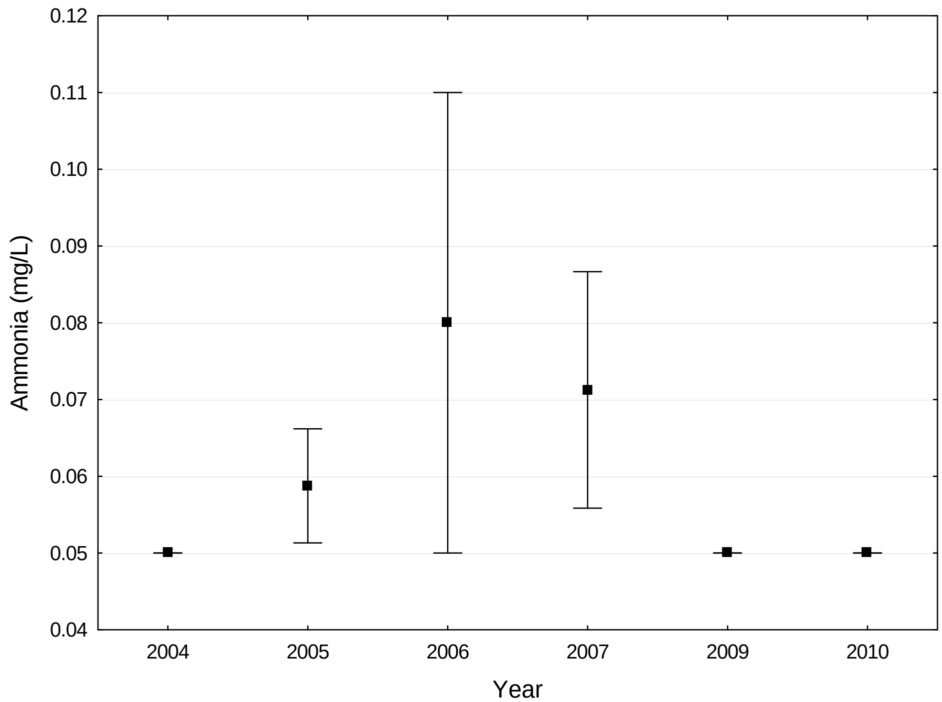


Figure 116. Mean ±SE ammonia concentration per year on 07010104-577. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

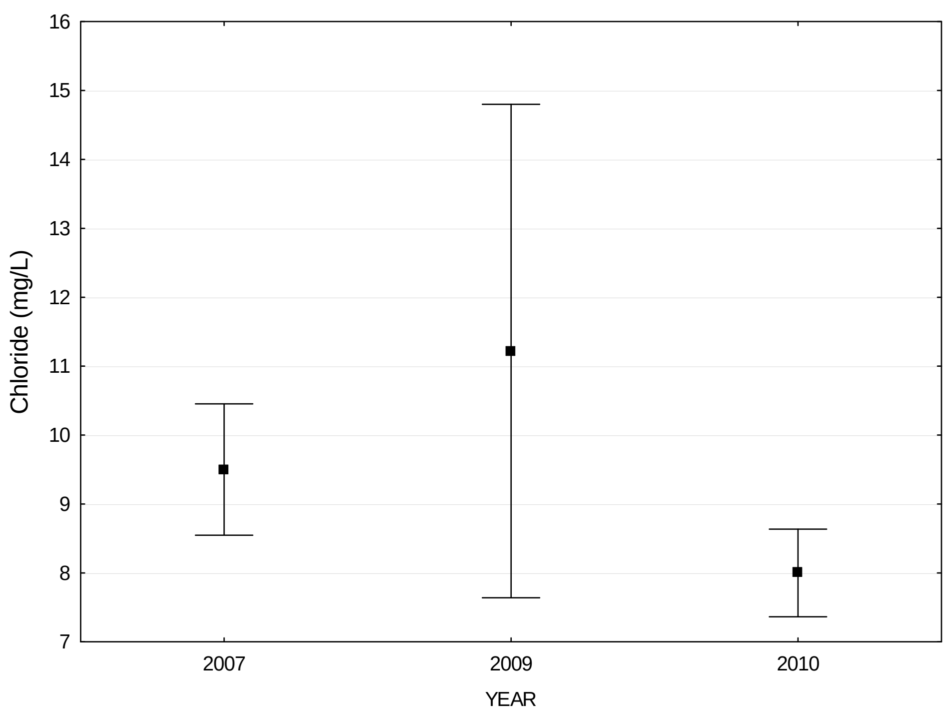


Figure 117. Mean ±SE chloride concentration per year on 07010104-577. The water quality standard for chloride is 230 mg/L.

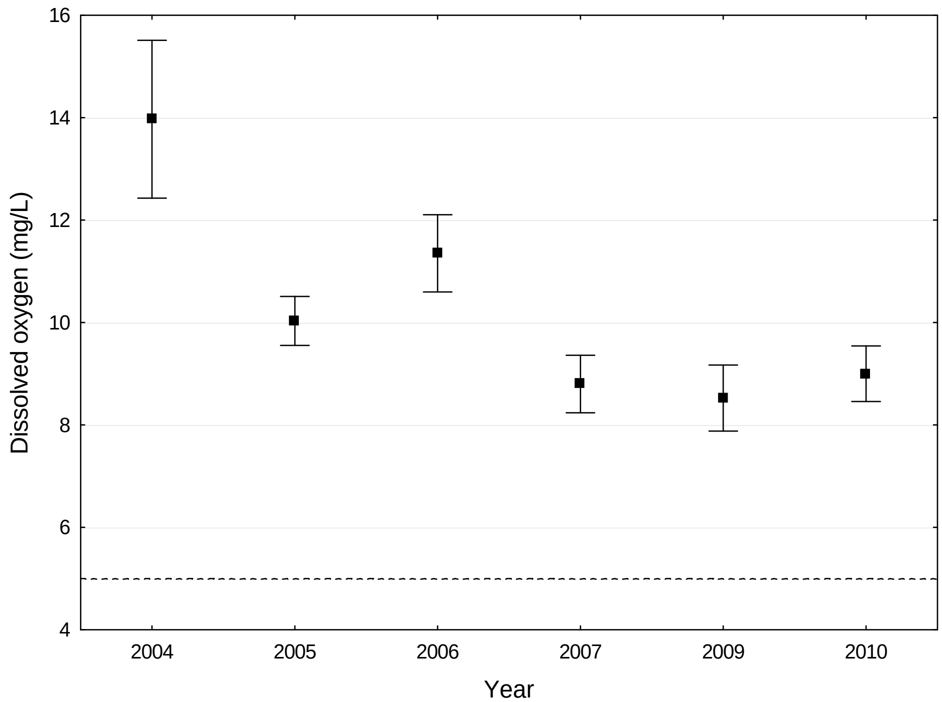


Figure 118. Mean ±SE dissolved oxygen concentration per year on 07010104-577. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

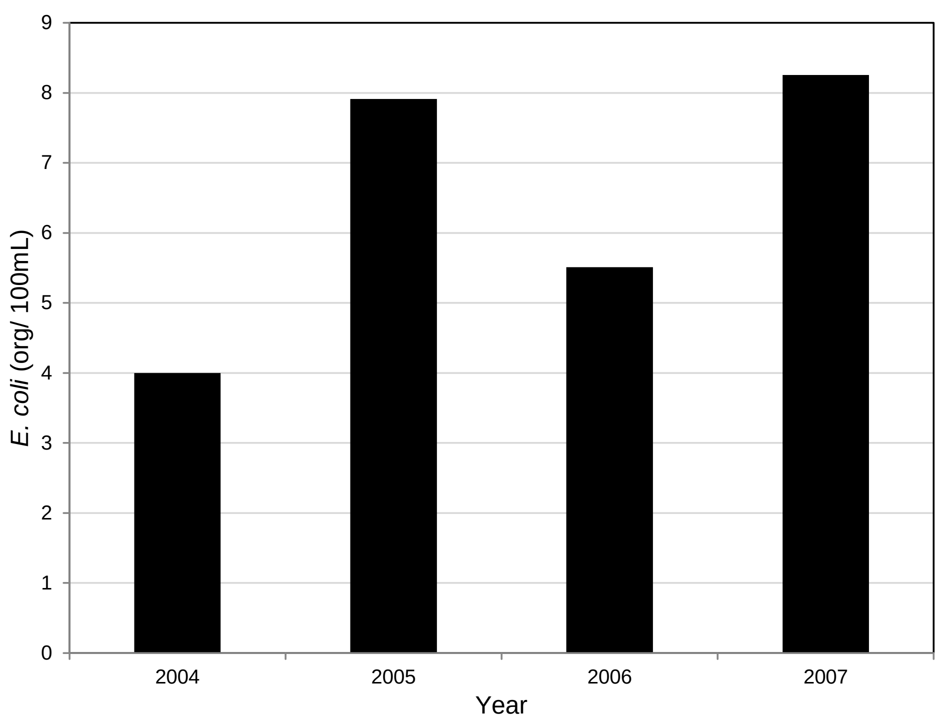


Figure 119. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010104-577. The water quality standard for *E. coli* is 126 organisms/100mL.

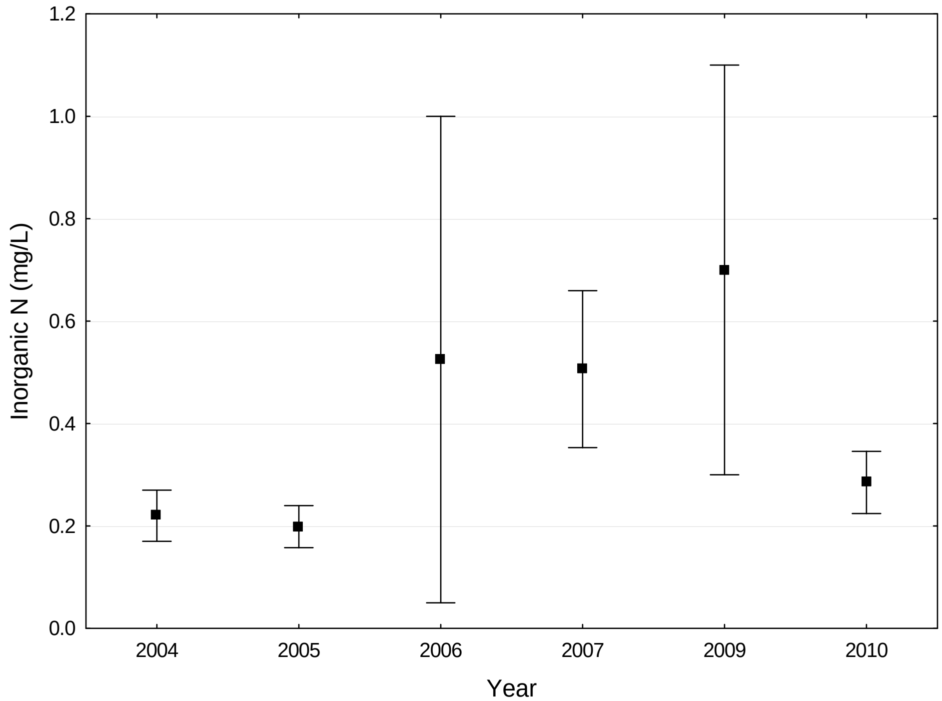


Figure 120. Mean ±SE inorganic N concentration per year on 07010104-577. The water quality standard for inorganic N is 10 mg/L.

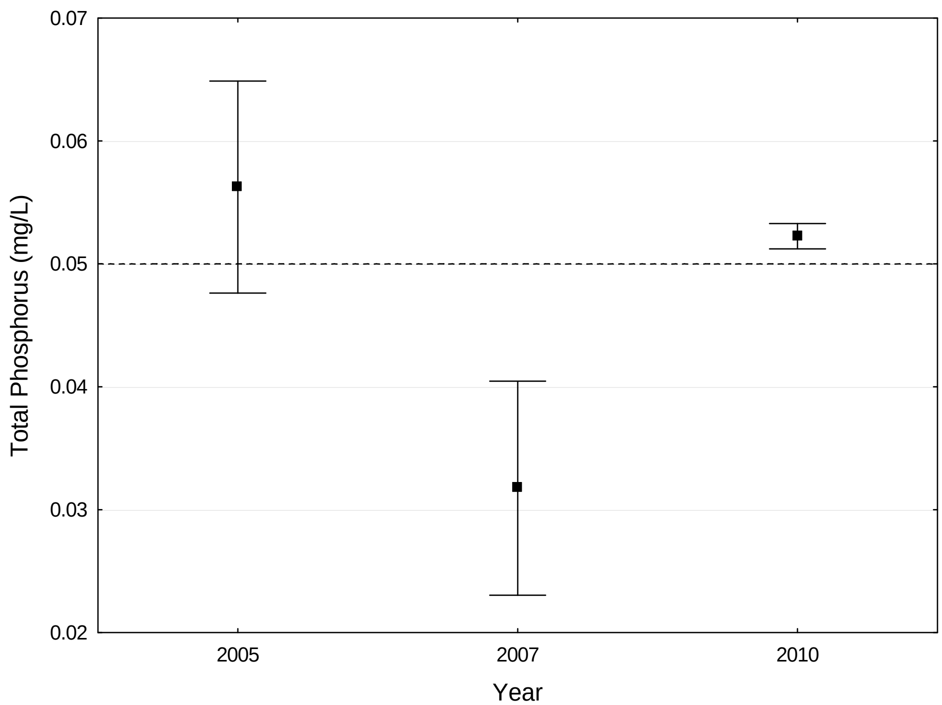


Figure 121. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010104-577. The dotted line indicates the proposed water quality standard (0.05 mg/L).

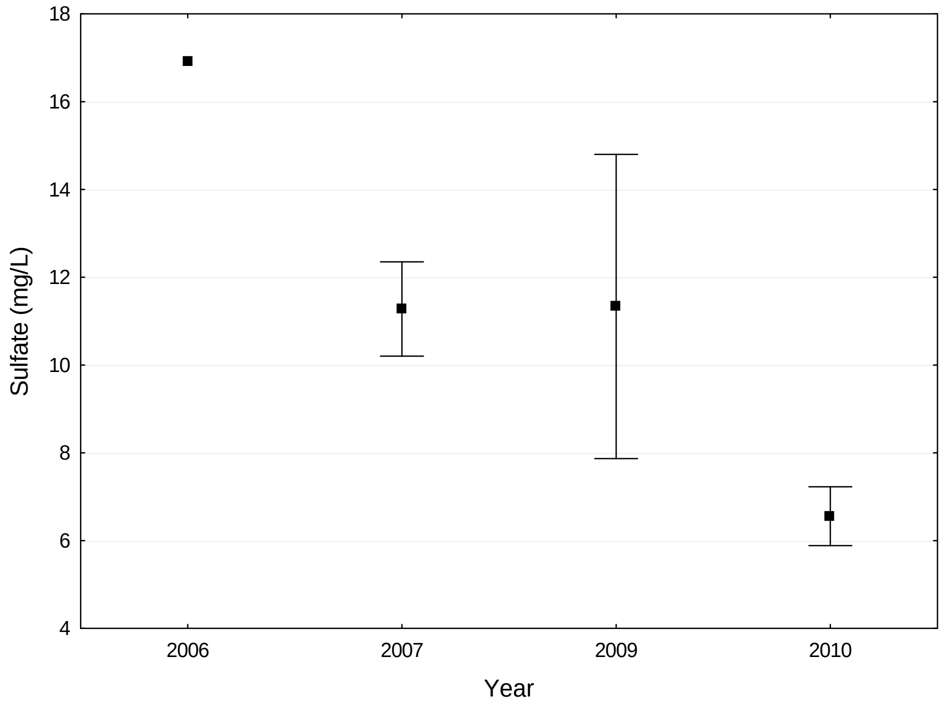


Figure 122. Mean ±SE sulfate concentration per year on 07010104-577. The water quality standard for sulfate is 250 mg/L.

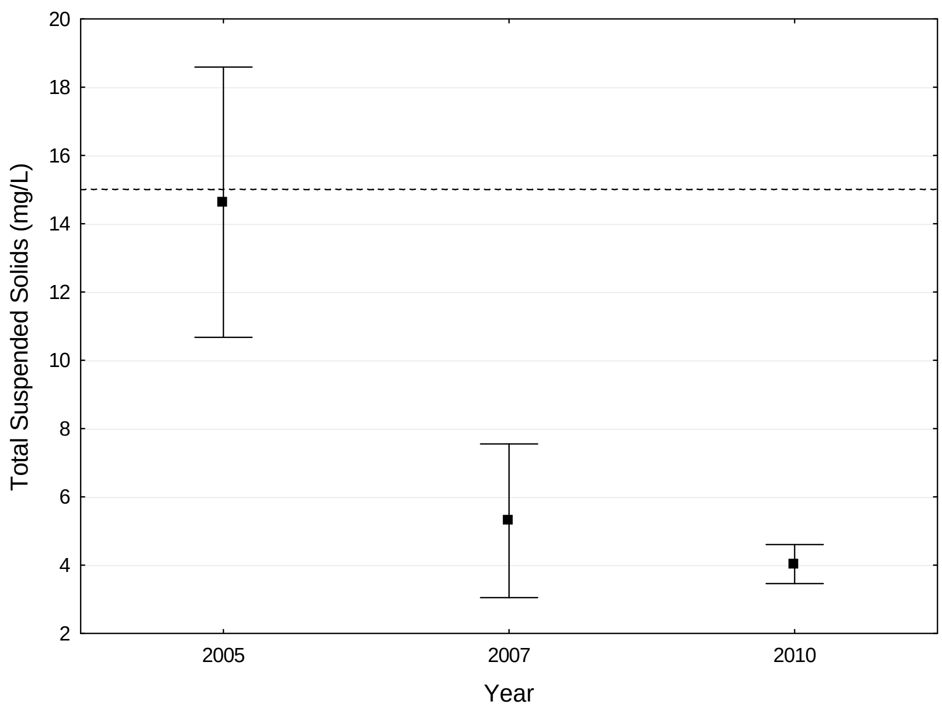


Figure 123. Growing season mean ±SE total suspended solids concentration per year on 07010104-577. The dotted line indicates the water quality standard (15 mg/L).

AUID 07010104-519 (Little Falls Dam to Swan River) Temporal trends

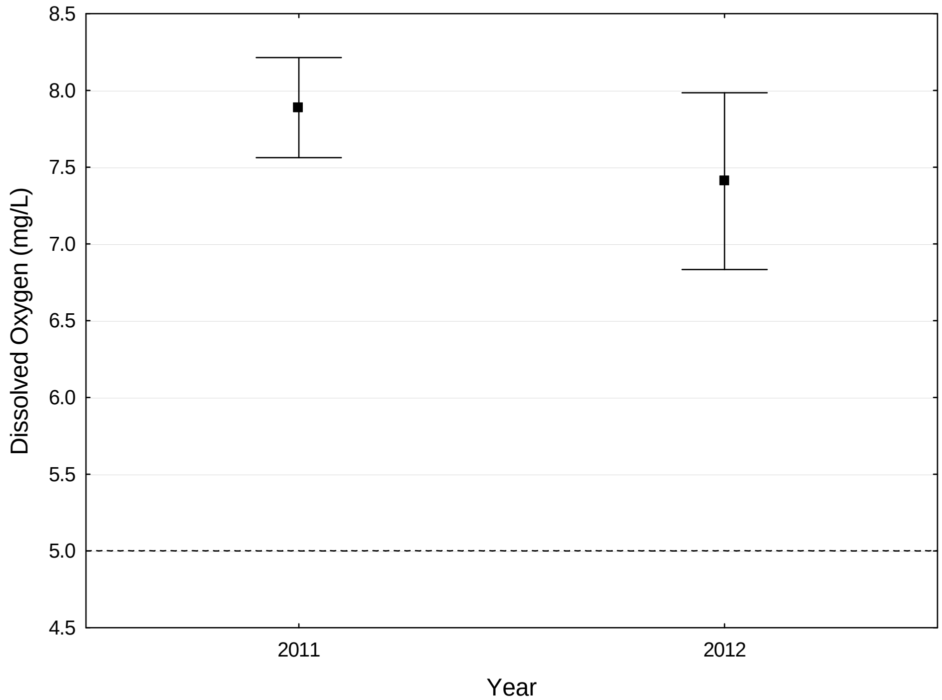


Figure 124. Mean ±SE dissolved oxygen concentration per year on 07010104-519. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

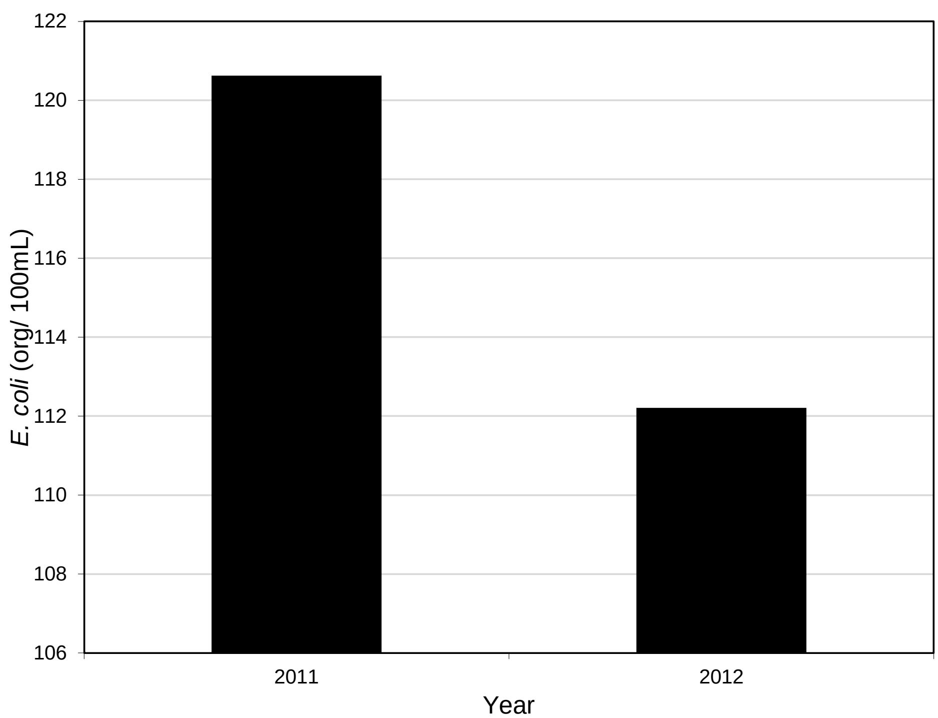


Figure 125. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010104-519. The water quality standard for *E. coli* is 126 organisms/100mL.

AUID 07010201-501 (Swan River to Two River) Temporal Trends

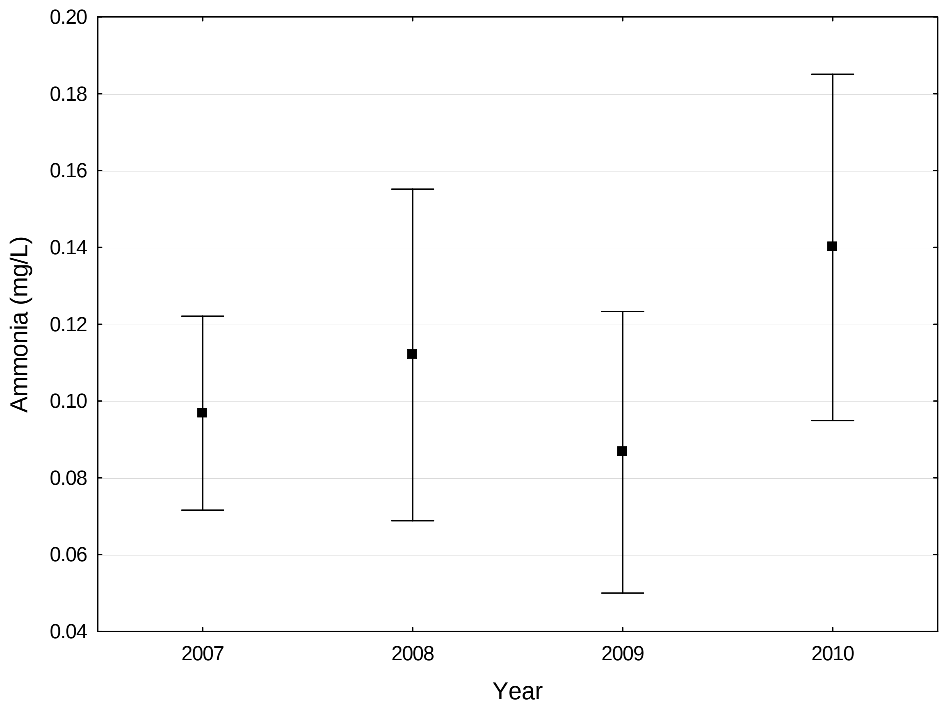


Figure 126. Mean ±SE ammonia concentration per year on 07010201-501. The water quality standard is for unionized ammonia (0.04 mg/L), which is a fraction of the total ammonia above.

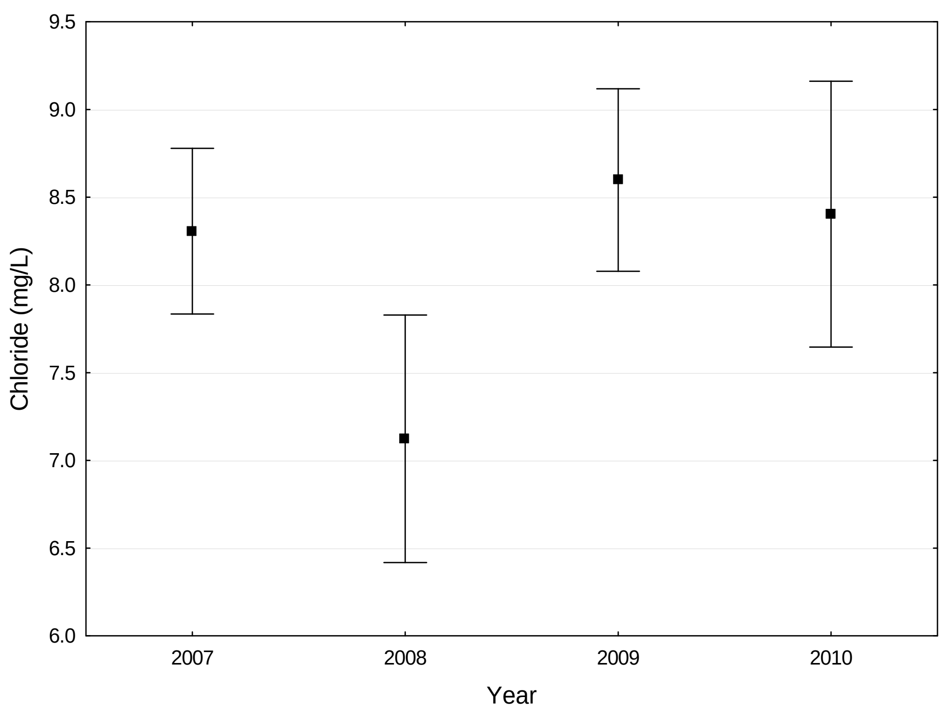


Figure 127. Mean ±SE chloride concentration per year on 07010201-501. The water quality standard for chloride is 230 mg/L.

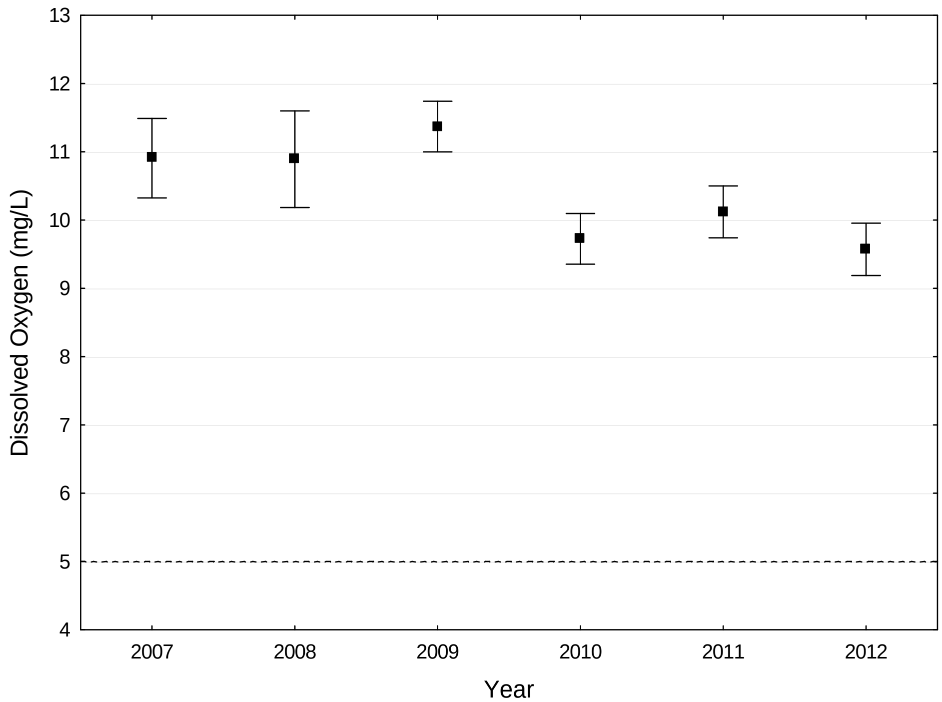


Figure 128. Mean ±SE dissolved oxygen concentration per year on 07010201-501. The dotted line indicates the water quality standard for dissolved oxygen (>5.0 mg/L).

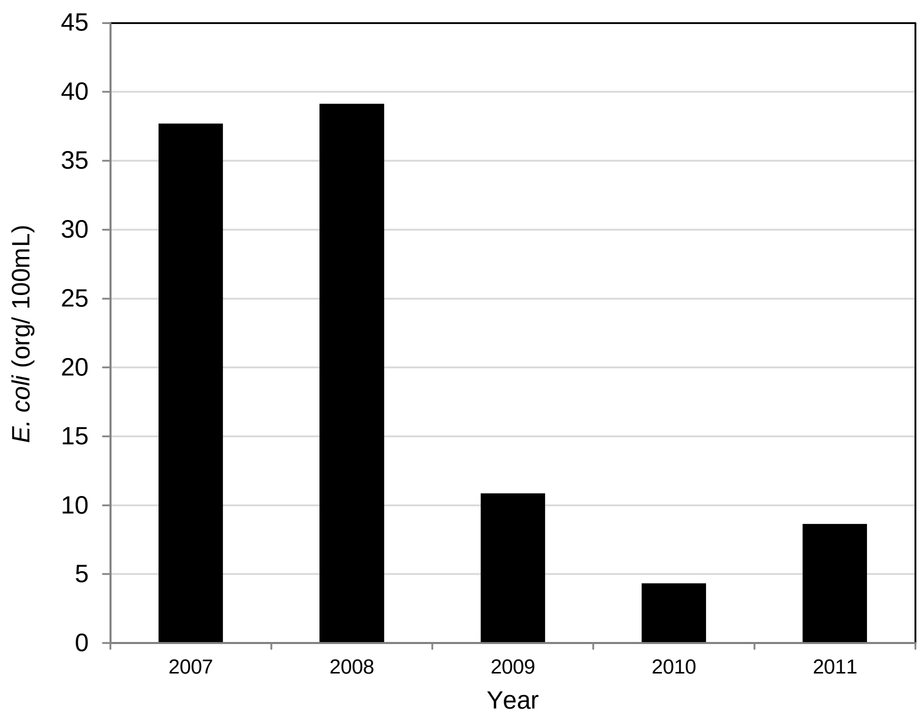


Figure 129. Growing season (Apr-Oct) mean *E. coli* concentration per year on 07010201-501. The water quality standard for *E. coli* is 126 organisms/100mL.

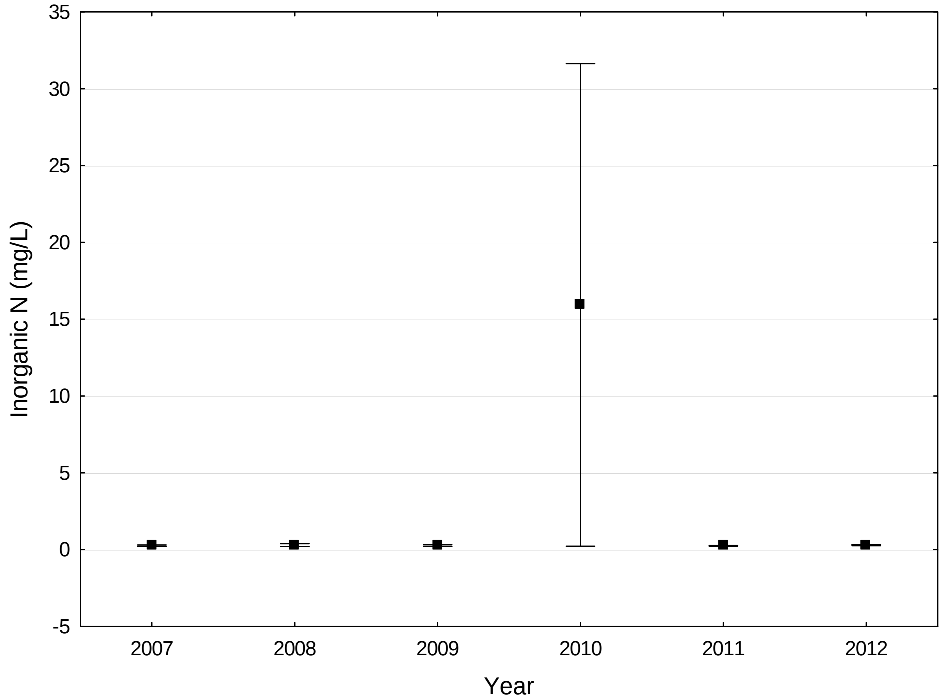


Figure 130. Mean ±SE inorganic N concentration per year on 07010201-501. The water quality standard for inorganic N is 10 mg/L.

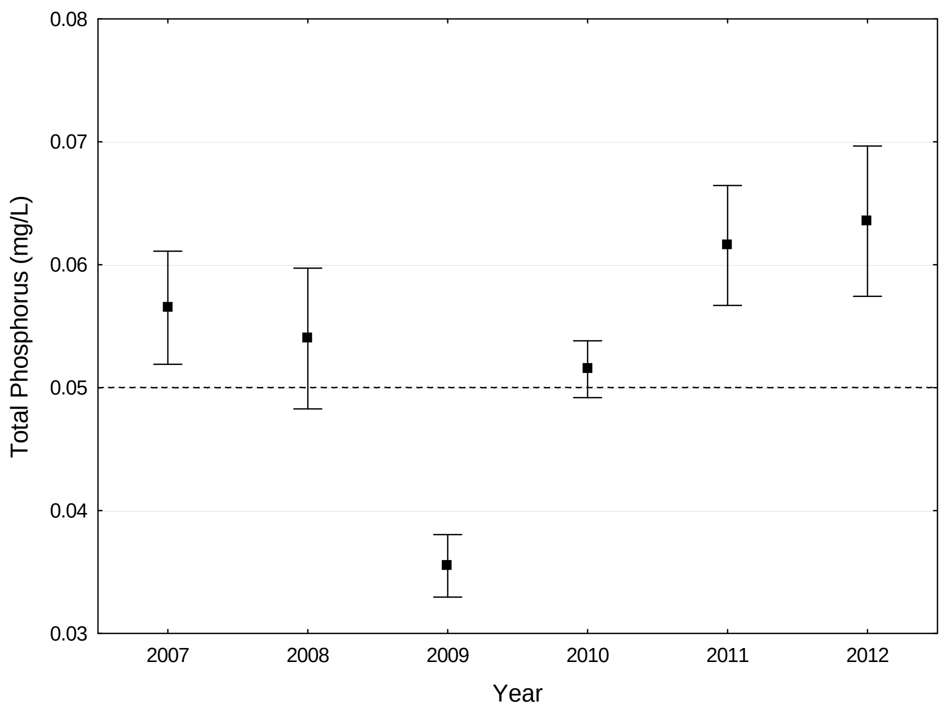


Figure 131. Growing season (June-Sept) mean ±SE total phosphorus concentration per year on 07010201-501. The dotted line indicates the proposed water quality standard (0.05 mg/L).

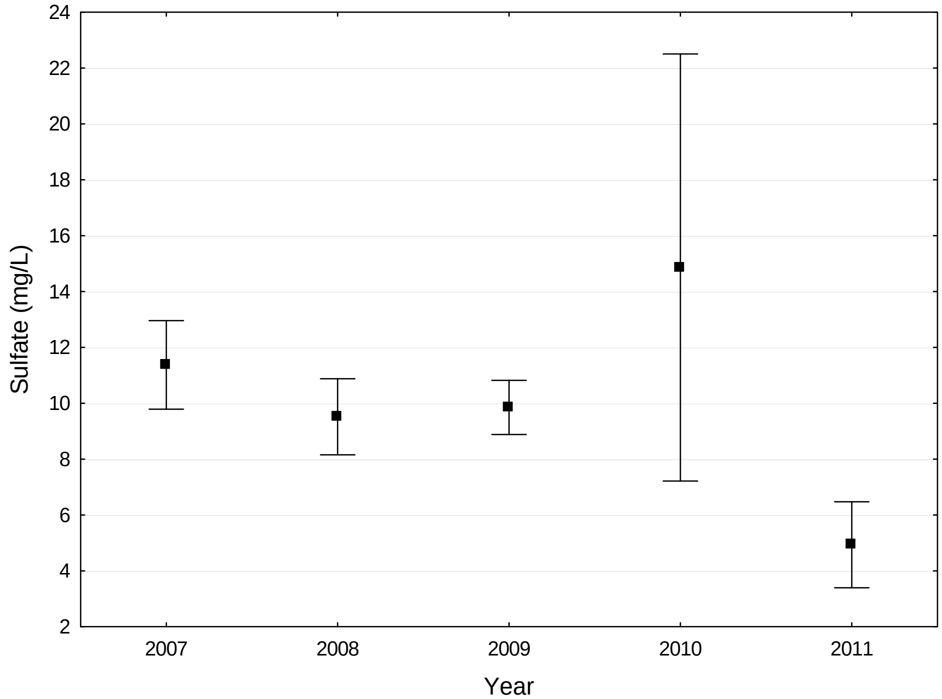


Figure 132. Mean ±SE sulfate concentration per year on 07010201-501. The water quality standard for sulfate is 250 mg/L.

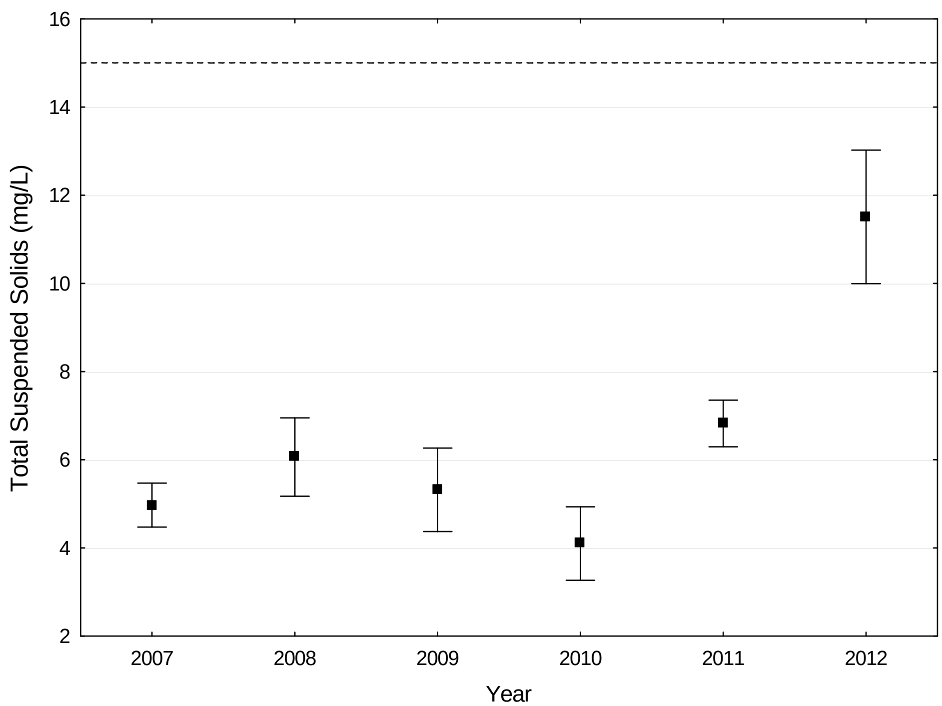


Figure 133. Growing season (Apr-Sept) mean ±SE total suspended solids concentration per year on 07010201-501. The dotted line indicates the water quality standard (15 mg/L).

12. HUC 07010101 2013 WATER QUALITY DATA

Seventeen reaches and nine lakes occur along the mainstem of the Mississippi River in HUC 07010101. Data for the supplementary water quality analysis of the mainstem of the Mississippi were only collected on four of the seventeen reaches and four of the lakes in 2013 (Figure 134).

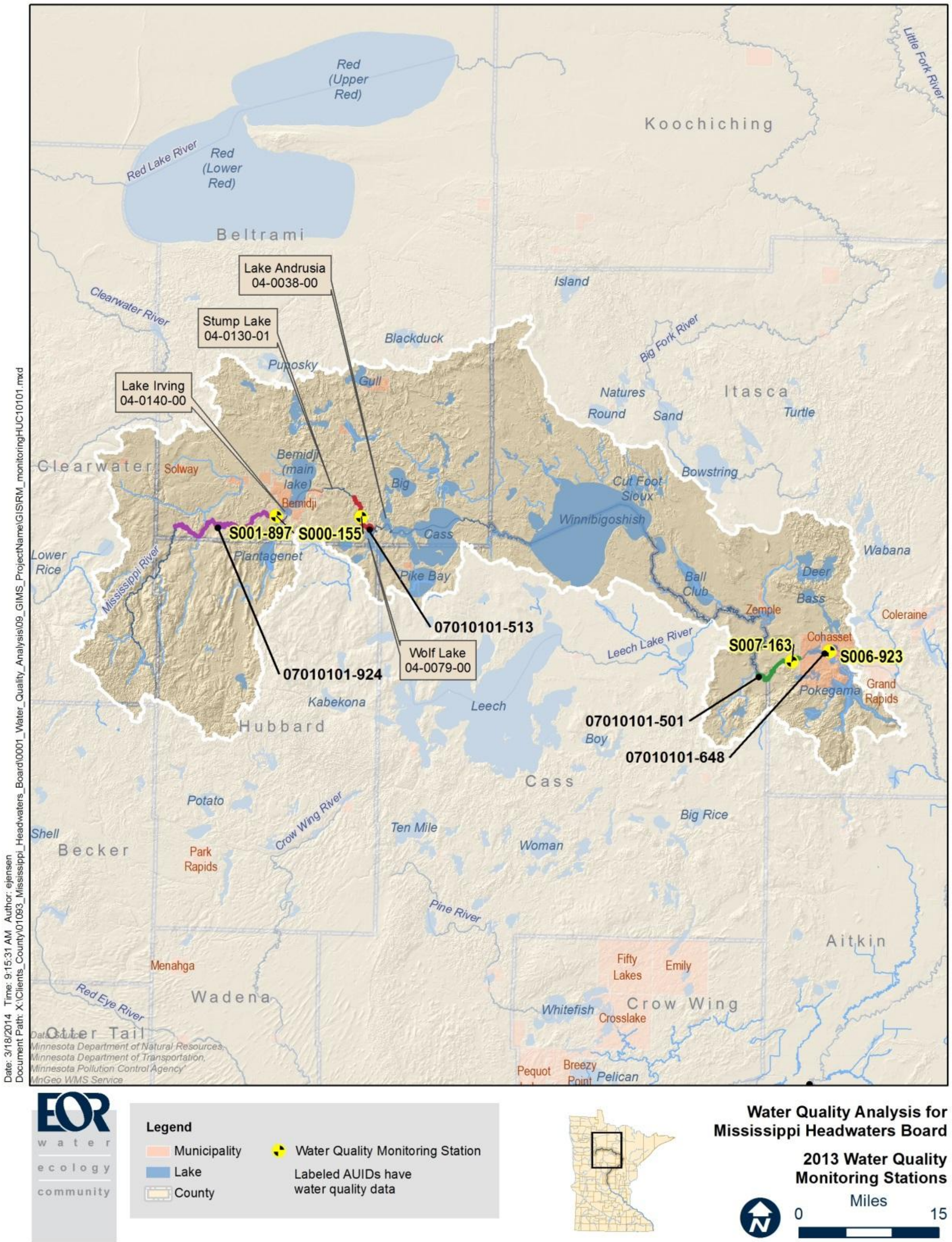


Figure 134. Map of HUC 07010101 showing AUIDs and monitoring stations.

A. Data Inventory

Water quality data was collected on four reaches and four lakes of the mainstem of the Mississippi River in HUC 07010101 in 2013 for eight pollutants (Table 61). Data was collected during the growing season (May-September) at one station along each reach (Figure 134).

Table 61. Water quality data inventory for river reaches and lakes in HUC 07010101 in 2013.

AUID	Name	Station	Month	Ammonia	Chloride	DO	E. coli	Inorganic-N	TP	Sulfate	TSS
07010101-924	Unnamed Creek to Schoolcraft River	S001-897	5	1	1	1		1	1	1	1
			6	3	3	3	4	3	3	3	3
			7	2	2	3	3	2	2	2	2
			8	2	2	3	4	2	2	2	2
			9	1	1	1		1	1	1	1
04-0140-00	Lake Irving	04-0140-00-204	6						6		
			7						7		
			8						8		
			9						9		
04-0130-01	Stump Lake	04-0130-01-203	5		1	8		1	2	1	1
			6		1	8		1	2		1
			7		1			1	2		1
			8		1	8		1	2		1
			9		1			1	2		1
07010101-513	Stump Lake to Wolf Lake	S000-155	5	1	1	1		1	1	1	1
			6	2	2	3	3	2	2	2	2
			7	2	2	3	3	2	2	2	2
			8	2	2	3	3	2	2	2	2
			9	1	1	1		1	1	1	1
04-0079-00	Wolf Lake	04-0079-00-201	6						2		
			7						1		
			8						1		
			9						1		
04-0038-00	Lake Andrusia	04-0038-00-203	6						2		
			7						1		
			8						1		
			9						1		
07010101-501	Vermillion River to Blackwater Lake	S007-163	8	2	2			2	2	2	
07010101-648	Blackwater Lake to Bass Brook	S006-923	8	2	2			2	2	2	

B. Water Quality Analysis

Only data collected from stations located directly on the mainstem of the Mississippi River was analyzed. Data for ammonia, chloride, dissolved oxygen, *E. coli*, inorganic nitrogen, total phosphorus, sulfate, and total suspended solids were only collected on four of the seventeen mainstem reaches. Data for each pollutant are summarized by reach below.

Ammonia

Ammonia data was only collected on three of the four reaches in 2013 (Table 62). The standard for ammonia is based on the concentration of unionized ammonia (0.04 mg.L), rather than total ammonia. The data presented in Table 62 is for total ammonia. The sample collected on 07010101-648 is the only sample that may exceed the standard for unionized ammonia; however, this cannot be determined because data was not collected for temperature, pH, or salinity.

Table 62. Ammonia data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	9	1	0.06		0.06	0.06	0.06	0.06	0.06
07010101-501	8	1	1.70		1.70	1.70	1.70	1.70	1.70
07010101-648	8	1	14.00		14.00	14.00	14.00	14.00	14.00

Chloride

Chloride data was collected on all four reaches between May and September 2013 (Table 63). The standard of 230 mg/L was met on all reaches.

Table 63. Chloride data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	5	1	2.83		2.83	2.83	2.83	2.83	2.83
	6	2	2.69	0.29	2.48	2.48	2.69	2.89	2.89
	7	2	2.33	0.14	2.23	2.23	2.33	2.43	2.43
	8	2	2.27	0.23	2.10	2.10	2.27	2.43	2.43
	9	1	3.72		3.72	3.72	3.72	3.72	3.72
07010101-513	5	1	7.43		7.43	7.43	7.43	7.43	7.43
	6	2	6.71	0.21	6.56	6.56	6.71	6.85	6.85
	7	2	6.28	0.02	6.26	6.26	6.28	6.29	6.29
	8	2	6.48	0.02	6.46	6.46	6.48	6.49	6.49
	9	1	6.79		6.79	6.79	6.79	6.79	6.79
07010101-501	8	2	2.43	1.70	1.22	1.22	2.43	3.63	3.63
07010101-648	8	2	3.89	0.52	3.52	3.52	3.89	4.25	4.25

Dissolved Oxygen

Dissolved oxygen data was collected on two mainstem reaches in HUC 07010101 between May and September 2013 (Table 64). All samples collected met the standard of > 5.0 mg/L.

Table 64. Dissolved oxygen data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	5	1	7.30		7.30	7.30	7.30	7.30	7.30
	6	3	5.16	0.17	4.97	4.97	5.20	5.31	5.31
	7	3	6.14	0.71	5.69	5.69	5.78	6.96	6.96
	8	3	6.45	0.97	5.33	5.33	7.00	7.02	7.02
	9	1	7.42		7.42	7.42	7.42	7.42	7.42
07010101-513	5	1	10.82		10.82	10.82	10.82	10.82	10.82
	6	3	8.80	1.50	7.10	7.10	9.41	9.90	9.90
	7	3	6.72	0.47	6.24	6.24	6.75	7.17	7.17
	8	3	5.64	0.84	4.68	4.68	6.02	6.22	6.22
	9	1	6.64		6.64	6.64	6.64	6.64	6.64

Escherichia coli

E. coli data was collected on two reaches between June and August 2013 (Table 65). All data collected met the standard of 126 org/100mL.

Table 65. *E. coli* data summary on all reaches

AUID	Month	N	Geo Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	6	3	19.81	6.00	17.32	36.00	36.00	36.00	6.00
	7	3	25.17	22.00	3.51	25.00	29.00	29.00	22.00
	8	4	35.82	16.50	37.62	43.50	79.50	91.00	14.00
07010101-513	6	3	4.16	2.00	5.51	3.00	12.00	12.00	2.00
	7	3	11.96	9.00	5.51	10.00	19.00	19.00	9.00
	8	3	12.97	12.00	1.00	13.00	14.00	14.00	12.00

Inorganic Nitrogen

Inorganic N was collected on three reaches in HUC 07010101 in 2013 (Table 66) Data was collected during one month, May or August on each reach. All samples collected met the standard of 10 mg/L.

Table 66. Inorganic N data summary on all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	8	2	0.05	0.00	0.05	0.05	0.05	0.05	0.05
07010101-513	5	1	0.08		0.08	0.08	0.08	0.08	0.08
07010101-648	8	2	0.06	0.01	0.05	0.05	0.06	0.07	0.07

Total Phosphorus

Total phosphorus data were collected on four reaches within HUC 07010101 (Table 67). Data were collected between May and September, although the standard of 0.05mg/L is only applicable for June through September. Data collected on reach 07010101-501 and 07010101-648 significantly exceeded the standard. Samples collected on 07010101-924 exceed the standard in the month of July.

Table 67. Total phosphorus data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	5	1	0.02		0.02	0.02	0.02	0.02	0.02
	6	2	0.04	0.01	0.03	0.03	0.04	0.04	0.04
	7	2	0.07	0.01	0.06	0.06	0.07	0.08	0.08
	8	2	0.03	0.00	0.03	0.03	0.03	0.04	0.04
	9	1	0.05		0.05	0.05	0.05	0.05	0.05
07010101-513	6	1	0.02		0.02	0.02	0.02	0.02	0.02
	7	2	0.02	0.00	0.02	0.02	0.02	0.02	0.02
	8	2	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	9	1	0.01		0.01	0.01	0.01	0.01	0.01
07010101-501	8	2	1.51	2.10	0.02	0.02	1.51	2.99	2.99
07010101-648	8	2	1.91	2.65	0.03	0.03	1.91	3.78	3.78

Sulfate

Sulfate data was collected on four reaches of the mainstem of the Mississippi River in HUC 07010101 in 2013 (Table 68). All of the samples collected met the standard of 250 mg/L.

Table 68. Sulfate data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	5	1	1.95		1.95	1.95	1.95	1.95	1.95
	6	1	1.31		1.31	1.31	1.31	1.31	1.31
07010101-513	5	1	2.05		2.05	2.05	2.05	2.05	2.05
	6	2	2.09	0.02	2.07	2.07	2.09	2.10	2.10
	7	2	1.62	0.29	1.41	1.41	1.62	1.82	1.82
	8	2	1.65	0.11	1.57	1.57	1.65	1.72	1.72
	9	1	1.46		1.46	1.46	1.46	1.46	1.46
07010101-501	8	1	1.18		1.18	1.18	1.18	1.18	1.18
07010101-648	8	1	10.20		10.20	10.20	10.20	10.20	10.20

Total Suspended Solids

TSS data was collected on two reaches between May and September 2013 (Table 69). All samples collected met the TSS standard of 15 mg/L.

Table 69. Total suspended solids data summary for all reaches

AUID	Month	N	Mean (mg/L)	St Dev	Min	Q25	Median	Q75	Max
07010101-924	5	1	2.80	2.80		2.80	2.80	2.80	2.80
	6	2	2.60	2.40	0.28	2.60	2.80	2.80	2.40
	7	2	2.80	1.60	1.70	2.80	4.00	4.00	1.60
	8	2	1.60	1.20	0.57	1.60	2.00	2.00	1.20
	9	1	1.60	1.60		1.60	1.60	1.60	1.60
07010101-513	5	1	3.20	3.20		3.20	3.20	3.20	3.20
	6	2	3.40	2.80	0.85	3.40	4.00	4.00	2.80
	7	2	1.60	1.20	0.57	1.60	2.00	2.00	1.20
	8	1	1.20	1.20		1.20	1.20	1.20	1.20
	9	1	1.60	1.60		1.60	1.60	1.60	1.60