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Mississippi River-Winona Watershed Water Quality Data Compilation and Trend Analysis Report

Final Report 2012

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Prepared for Whitewater Watershed Joint Powers Board

Mississippi River-Winona Watershed Civic Engagement Continuation, Restoration Protection & Document Development Project

CLEAN WATER LAND & LEGACY AMENDMENT

County of Olmsted

Minnesota Pollution Control Agency

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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United States Fish and Wildlife
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Winona County
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Executive Summary

Project Purpose and Scope

The Whitewater Watershed Joint Powers Board (WJPB) received Clean Water and Legacy Amendment funds from the Minnesota Pollution Control Agency for the project entitled "Mississippi River-Winona Watershed Civic Engagement Continuation, Restoration, Protection and Document Development Project". The WJPB contracted with Olmsted County with the primary goal to compile existing water quality data in the watershed and statistically analyze the data for trends and other significant features. Additionally, as part of the work plan, Olmsted County identified data gaps or limitations and provided recommendations for addressing them in the future.

Phase I: Data Collection, Compilation, Standardization and Review of Historic Reports

For the first phase of the project, Olmsted County contacted staff from local cities and counties, state agencies and universities to compile all sources of data for the Mississippi River-Winona watershed. Olmsted County collected monitoring data from 6 agencies and 136 unique monitoring sites from 225 different programs (Appendix A). Approximately 20,000 sampling events have taken place within the watershed with nearly 296,000 discrete data points with nutrient, metal, nonmetal, physical, radiochemical, pesticide, bacteriological, and biological data. Most of the data was collected by the Citizen Stream Monitoring Project through the Minnesota Pollution Control Agency (34,000 transparency and physical readings) and the Minnesota Department of Agriculture's pesticide monitoring program (219,000 data points). A database with all of the collected data was developed (Appendix A).

Additionally, as part of the data collection and compilation phase, Olmsted County staff organized a workshop for local and state agency staff to present on current and future planned monitoring projects within the Mississippi Winona Watershed. Olmsted County staff reviewed, collected data, asked questions of attending staff regarding their monitoring projects and collected additional data from agency representatives.

Phase II: Analyses

The second phase of the project included analyzing the spatial distribution of data and completing statistical analyses and long term trend analyses where sufficient data and period of record allowed. Mapping the data and analyzing the data by its spatial distribution allowed staff to narrow down the trend possibilities based on the geographic distribution of data.

The period of record for the stream flow monitoring data collected during this project began in 1932 and the water quality monitoring data began in 1961. To analyze the data for significant trends, a unique site must have more than a year long record for a given parameter. Of the data collected, there were 24 sites with chemical or discharge data that fit this requirement. The majority of the monitoring stations with sufficient data for analyses are found within the Garvin Brook and Whitewater watersheds and there are approximately 12 unique sites on seven stream reaches that have an adequate period of record for a long-term trend analysis.

In general, the analyses did not include data collected during 2011 or 2012 due to the data quality review procedures required for entry into the Minnesota Pollution Control Agency's EQUIS database. The analyses also did not include data from monitoring sites on the Mississippi River.

Findings

There is no continuous long term record of discharge data in the watershed. Five sites have sufficient flow records to assess stream discharge trends. Where trends were identified, the trends were in all cases increasing. A higher correlation was found between annual stream discharge and the Palmer Drought Severity Index (PDSI) than with annual precipitation.

At the two sites where sufficient total suspended solids (TSS) and biochemical oxygen demand (BOD) data is available, there is a decreasing trend in both parameters. One of those sites also has a decreasing trend in total phosphorus (TP). Suspended sediment concentration (SSC) data was available for only one site and no trend was found.

Twenty-one sites have adequate stream transparency data to assess trends but no trends were found.

There are six sites that have sufficiently long records of nitrate data to allow assessment of seasonal patterns and long-term trends. A slight seasonal pattern is found in nitrate with lower concentrations found during the growing season. All of the sites have a long-term increasing trend in nitrate concentrations. Where adequate nitrate data is available, a high correlation is found between stream nitrate concentration and the percent of cropland in the drainage area.

There was adequate chloride data to assess long term trends at three sites. All have increasing trends in chloride concentrations. The trend appears to be leveling off at the site with the longest record. Sodium concentrations tend to correlate with chloride and are increasing.

Three sites have adequate sulfate data to assess trends. One site has no trend, one site a downward trend, and the site with the longest record shows an increasing sulfate trend until about 1985 and thereafter a decreasing trend.

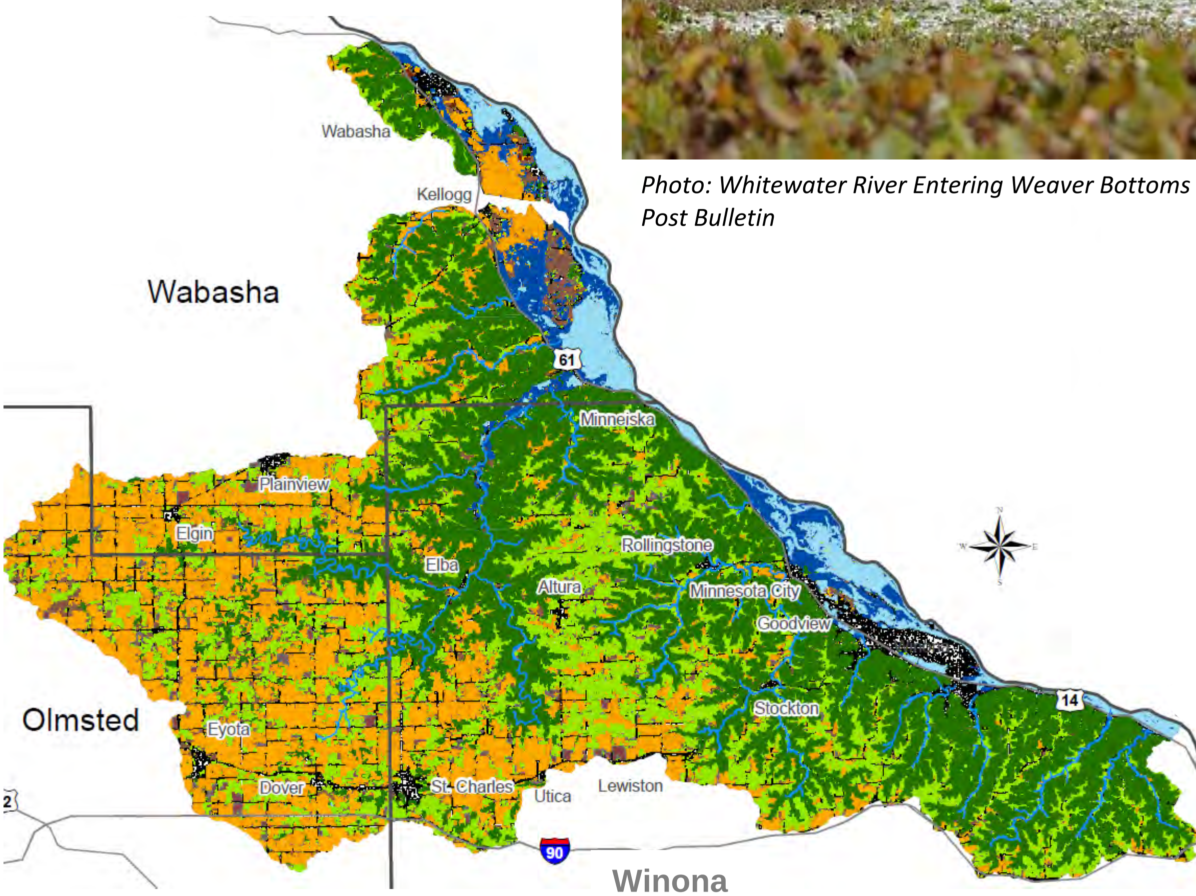
Two sites had significant pesticide data. While no trend analysis was completed, the data suggests that there has been a downward trend in recent years.

Introduction

Mississippi River-Winona Watershed Profile

The Mississippi River-Winona watershed covers approximately 419,000 acres in Wabasha, Winona, and Olmsted counties in southeastern Minnesota. The Whitewater River falls within this watershed and is well known for Whitewater State Park and as a popular trout fishing destination. The Mississippi River-Winona Watershed lies in the driftless area in Southeastern Minnesota. It is comprised of twenty-one sub-watersheds whose area is defined by the US Natural Resources Conservation Service using a 12 digit identifier or hydraulic unit code (HUC). The watershed includes all of the Whitewater and a number of smaller watersheds that generally drain directly into the Mississippi River. The Mississippi-Winona Watershed is part of an 8 digit HUC that extends into Wisconsin. The watershed drains gently rolling to steeply sloped karst topography underlain by limestone, sandstone and shale.

Photo: Whitewater River Entering Weaver Bottoms Courtesy John Weiss, Post Bulletin



Land Cover Key	
	Cropland
	Pasture
	Developed
	Aquatic
	Grassland
	Forested

Figure 1 Land Cover in the Mississippi River-Winona Watershed

Land Use in the Mississippi River-Winona Watershed is a mix of agriculture (46%), largely in the upland areas in the western portion of the watershed with forest and grassland (38%) covering the steeper and more dissected terrain[1]. The watershed also contains the Cities of Wabasha and Winona, as well as a number of smaller communities. The western portion of the watershed is part of the Rochester Plateau, with gently rolling land that is largely row cropped. The eastern portion of the watershed contains steep valleys with wooded slopes. Cropland in the eastern areas is discontinuous on hilltops and in valleys dominated by hay and pasture[2].

Dairy and cattle are the major livestock types in the Mississippi River-Winona watershed with average livestock percentages of dairy (59%), cattle (24%) and other livestock (17%) in Olmsted, Winona and Wabasha counties[3].

The Whitewater river flows generally northeast, through the Whitewater Wildlife Management Area, and discharges into the Mississippi River at Weaver Bottoms, an important Mississippi River backwater and nationally significant waterfowl staging area.

Overview of Current Projects

The Whitewater River and Garvin Brook are currently undergoing studies through the Minnesota Pollution Control Agency, called Total Maximum Daily Load Studies (TMDLs) because they are too turbid (cloudy) to meet state water quality standards. To protect stream aquatic life, these projects will set reduction targets to meet water quality standards for sediment suspended in the water column. Additionally, many streams in the watershed have bacteria and mercury levels that exceed state standards. Projects are underway to reduce bacteria and mercury levels in the streams (Appendix A).

Monitoring stations in the watershed are also currently part of the following ongoing programs and projects:

- Sub-Watershed Pollutant Load Monitoring Network (MPCA)
- Stressor Identification Project (MPCA)
- Stream Habitat Program (MDNR)
- Stream Assessment-Risk Map Integration Project (MDNR)
- Prioritization Scheme for Bank Erosion Sites Study (MDA Grant Funded)

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[1] United States Department of Agriculture, National Agricultural Statistics Service (NASS) *Cropland Data Layer* 29 January 2013 <http://www.nass.usda.gov/research/Cropland/docs/JohnsonPE&RS_Nov2010.pdf>

[2] Minnesota Pollution Control Agency. Watershed Division. *Mississippi River-Winona Watershed at a Glance*. MPCA, 19 Sept. 2012. Web. 11 Dec. 2012. <http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/mississippi-river-winona.html#overview>.

[3] Minnesota Department of Agriculture. Agricultural Marketing Services Division. *Olmsted County Agricultural Profile*. 13 Jan. 2013 <http://www.mda.state.mn.us/Global/MDADocs/food/business/econrpt-olmstedcnty.aspx> *Winona County Agricultural Profile*. <http://www.mda.state.mn.us/Global/MDADocs/food/business/econrpt-winonacnty.aspx> *Wabasha County Agricultural Profile*. <http://www.mda.state.mn.us/food/business/agmktg research/~/media/Files/food/business/countyprofiles/econrpt-wabasha.ashx>

Trend Analysis

1.0

Trends in River Discharge and Precipitation

1.1 Trends in Stream Discharge

Stream discharge trends are particularly important because there are a number of water quality parameters which are highly dependent upon flow, particularly those related to suspended sediment such as total suspended solids (TSS), turbidity, total phosphorus (TP), and transparency. In contrast, dissolved parameters such as total dissolved solids (TDS), anions such as nitrate, chloride and sulfate, and cations such as calcium and magnesium are generally less dependent on flow, but do show the effects of dilution during high stream discharge events. To analyze this relationship further, Olmsted County completed an assessment of historic stream discharge in the Mississippi River-Winona Watershed (Appendix B).

Five United States Geological Survey (USGS) monitoring stations have sufficient flow records to assess stream discharge trends. Table 1 and Figure 2 summarize the trend at each site. Figure 3 illustrates the increasing stream discharge trend for the USGS site on the Whitewater River near Beaver (05377500) from 1939-1953 and (05376800) from 1975-1999. Additionally, Appendix B includes the detailed statistical analysis for trends in river discharge and precipitation.

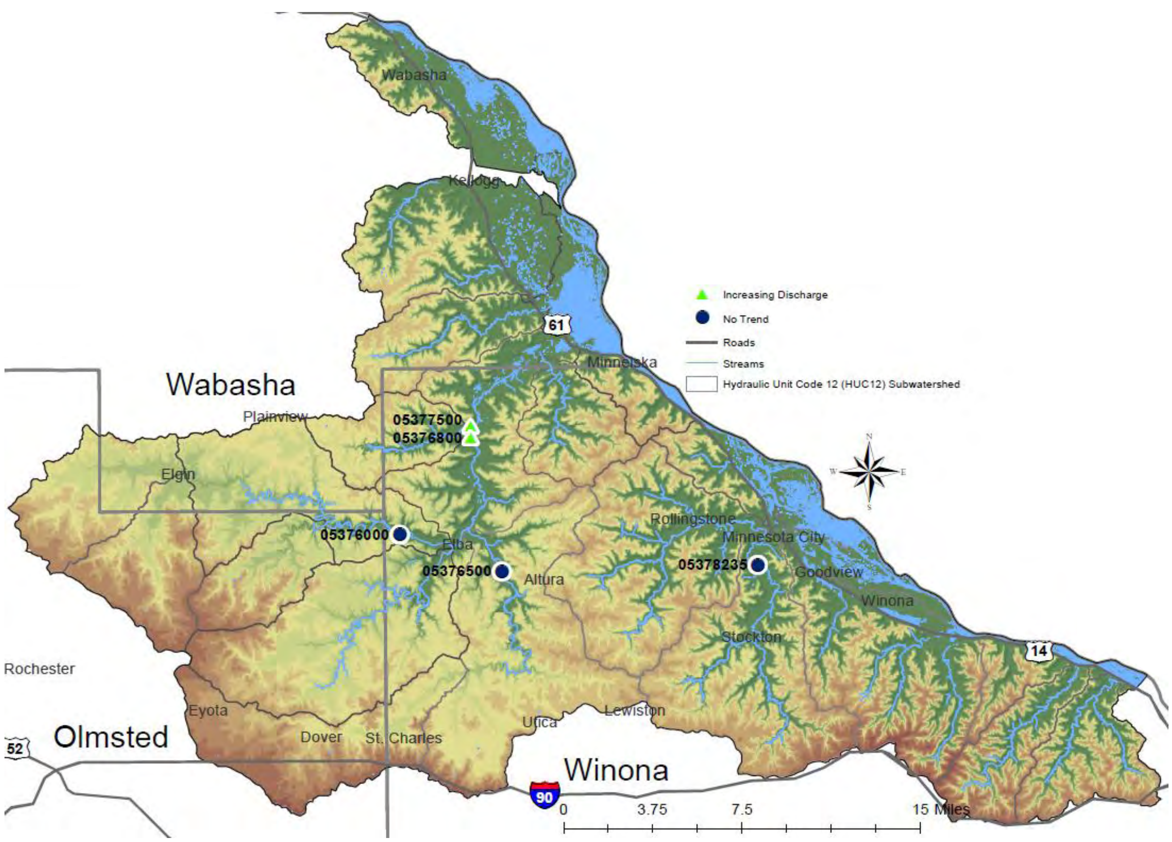

Figure 2: Trends in Stream Discharge in the Mississippi River-Winona Watershed

Table 1: Trends in Stream Discharge at USGS Stations in the Mississippi-Winona River Watershed

USGS ID	Station Name	Period of Record	Discharge Trend (CFS)
5377500	Whitewater River At Beaver*	1939-1953	Upward Trend
5376800	Whitewater River Near Beaver*	1975-1999	Upward Trend
5376500	South Fork Whitewater River Near Altura	1940-1970	No Trend
5376000	North Fork Whitewater River Near Elba	1967-1993	No Trend
5378235	Garvin Brook Near Minnesota City	1982-1991	No Trend

*05377500 and 05376800 are in the same vicinity. 05377500 was discontinued and 05376800 was put online.

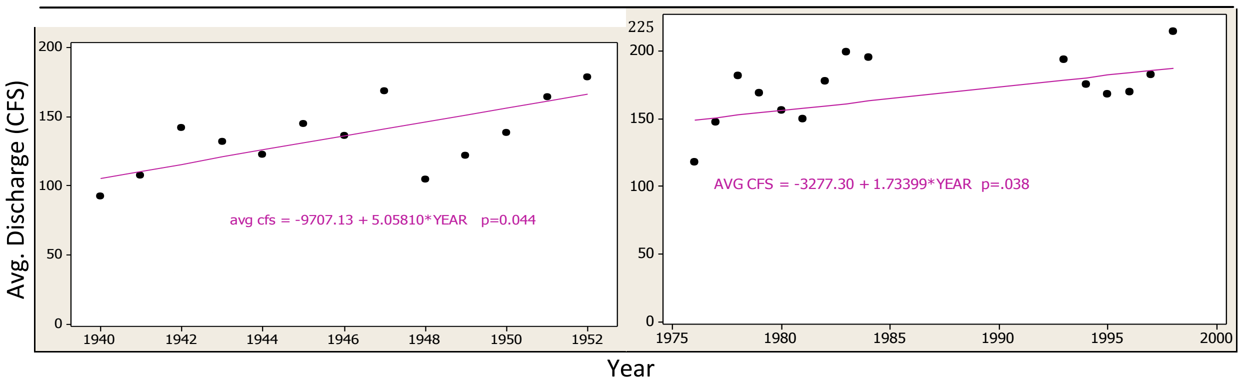

Figure 3 Flow Trend for the USGS stations on the Whitewater River near Beaver (05377500) from 1939-1953 and (05376800) from 1975-1999

There is no continuous long term record of discharge data in the Mississippi River-Winona Watershed. Where trends were identified, the trends were in all cases increasing. Relatively short records and large inter-annual variability may be masking other possible trends. Due to the lack of long-term, continuous data it cannot be determined whether flow across the entire watershed has increased or decreased in the last 10-20 years. However, the Palmer Drought Severity Index (PDSI) was found to correlate with annual flows and the PDSI itself is increasing. This supports the increasing trends that were identified in Table 1.

The Department of Natural Resources (MDNR) and MPCA have returned to monitoring a number of historic stream discharge sites as part of their Cooperative Stream Gaging Network (Appendix A). Data from those sites will allow trend analyses in the future.

1.2 Trends in Precipitation

The available data was analyzed to identify any correlation between long term precipitation records and yearly discharge for the Mississippi River-Winona Watershed. Since the 1950’s, there has been an upward yearly trend in precipitation within the region. This increase in precipitation also supports the increasing trend in stream discharges. A statistical analysis was completed for each of the five sites identified in Table 1 correlating annual stream discharge to annual precipitation (Appendix B). The analysis of available data did not find a high correlation between annual precipitation and stream discharge at any of the sites. However, a higher correlation was found between the Palmer Drought Severity Index (PDSI) and annual stream flow for the five Mississippi River-Winona Watershed sites that were analyzed (Appendix B).

1.3 Trends in Palmer Drought Severity Index (PDSI) for Climate Region 5

The PDSI is a measurement of dryness based on recent precipitation and temperature and is effective in identifying drought conditions. This correlation suggests that the PDSI is a better surrogate than annual precipitation in reconstructing stream flows in the Mississippi River-Winona Watershed. While no effort was made in this study to reconstruct annual stream flow records, the PDSI could be used for this purpose with the ultimate goal of estimating annual loads of sediment, nutrients, etc.

2.0 *Trends in Parameters Related to Suspended Sediment*

In Southeastern Minnesota, the patterns of suspended-sediment concentration reflect influencing factors such as climate (especially rainfall) and the properties of the rocks and soils that are exposed to erosion. Sediment loads in streams are also largely driven by flood and other high flow events.

Water quality parameters related to suspended sediment include total phosphorous (TP), total Kjeldahl nitrogen (TKN), transparency, biochemical oxygen demand (BOD) and turbidity. In the Mississippi River-Winona Watershed, these parameters were systematically measured on a consistent basis by the United States Geological Survey (USGS) at their monitoring site on the North Fork Whitewater River near Elba (05376000) from 1970-1993, and by the Minnesota Pollution Control Agency's (MPCA) Milestone Site Monitoring Program at two sites--Garvin Brook SW of Minnesota City (S000-828) from 1981-2001 and the South Fork Whitewater River site near Utica (S000-288) from 1974-1994.

The sediment data from the Mississippi River-Winona Watershed monitoring is reported by the USGS as the suspended sediment concentration (SSC) and by the MPCA as total suspended solids (TSS), turbidity and transparency. The USGS uses an integrated sampling method to measure the suspended sediment concentration (SSC) in the stream profile. Daily concentrations are used to calculate daily loads from stream discharge and those daily loads are summed to calculate yearly loads.

The MPCA measures total suspended solids (TSS) at the laboratory along with the other water quality parameters. The MPCA also measures turbidity and transparency in the field. At the three Mississippi River-Winona Watershed sites, TSS, turbidity and transparency correlate directly with suspended sediment concentrations (SSC) in the low concentration range. At higher flows and with higher suspended sediment, TSS does not correlate well with turbidity and transparency.

The statistical analysis of suspended sediment concentration and/or loads at monitoring stations in the Mississippi River-Winona Watershed is detailed in Appendix B and the resulting trends are outlined below (Table 2 and Figure 4).

The MPCA milestone site near Utica on the South Fork of the Whitewater River shows a decreasing trend in both total suspended solids (TSS) and biochemical oxygen demand (BOD). The overall trend at the milestone site of Garvin Brook SW of Minnesota City also shows a decrease in concentrations of TSS, total phosphorus (TP) and BOD (Appendix I). The USGS site on the North Fork of the Whitewater River near Elba (05376000) does not show a trend for SSC, however, the period of record ended in 1993.

Table 2: Suspended Sediment Trends at Monitoring Stations in the Mississippi-Winona Watershed

Station ID	Site Description	Period of Record	Suspended Sediment Trends
S000-288	South Fork Whitewater near Utica	1974-1994	Decreasing concentrations in TSS & BOD
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2001	Decreasing concentrations in TSS, TP & BOD
5376000	North Fork Whitewater River near Elba	1970-1993	No Trend in SSC or load

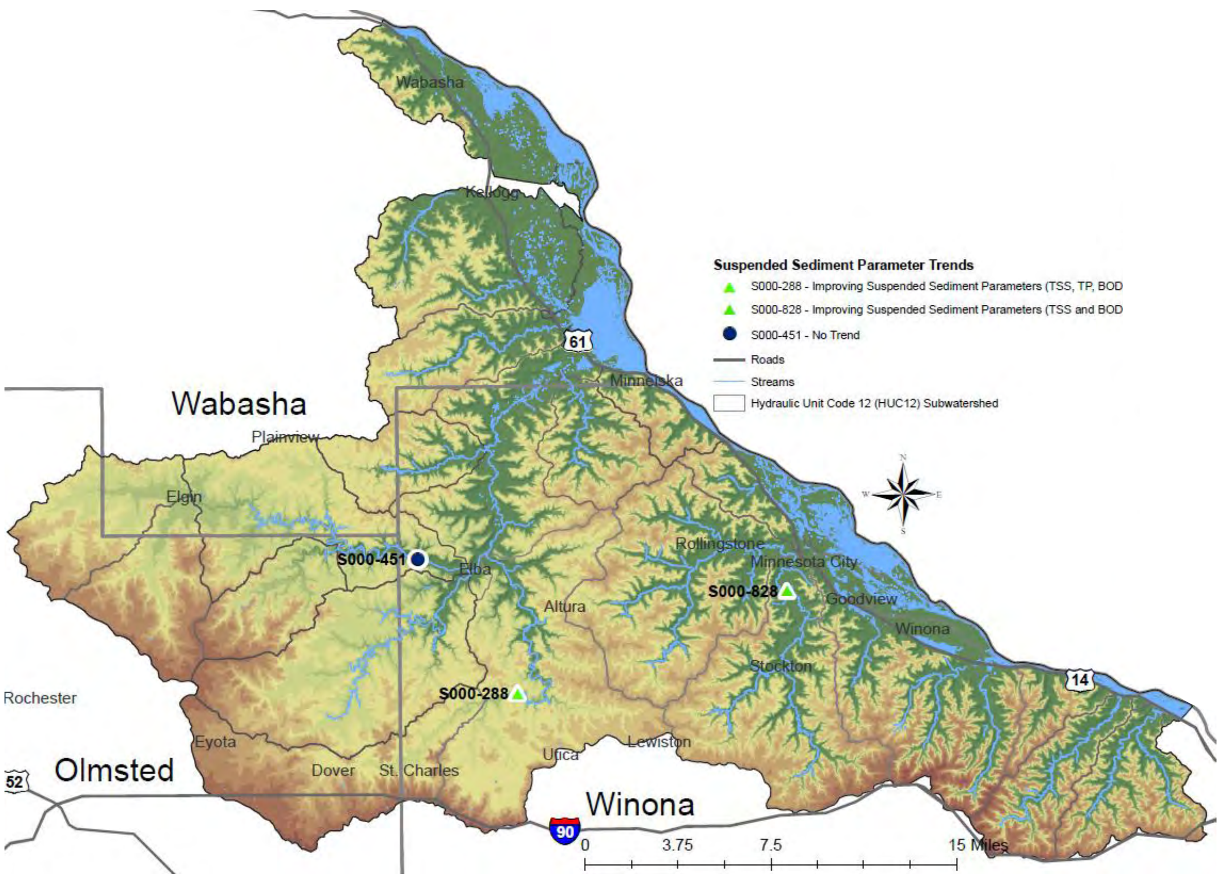

Figure 4 Trends in Suspended Sediment Related Parameters in Mississippi River-Winona Watershed

Additionally, the MPCA manages the Citizen Stream Monitoring Program (CSMP) which encourages citizens to adopt a section of stream and regularly collect transparency readings. In 2011, there were 97 stations that had been monitored in the watershed for stream transparency. Twenty-one of those stations had sufficient data for statistical analysis, however, none of them showed a trend in transparency[4]. This is likely because transparency, like sediment concentrations, is highly dependent upon stream flows. The variability in flows may mask any possible trend in transparency.

The only long-term mass sediment load record in the Mississippi River-Winona Watershed is the North Fork Whitewater River site near Elba from 1968 to 1990. The 23-year sediment record is analyzed in Appendix B. There is large annual variability with most of the sediment moving during large events such as the flood of 1974 (Figure 5).

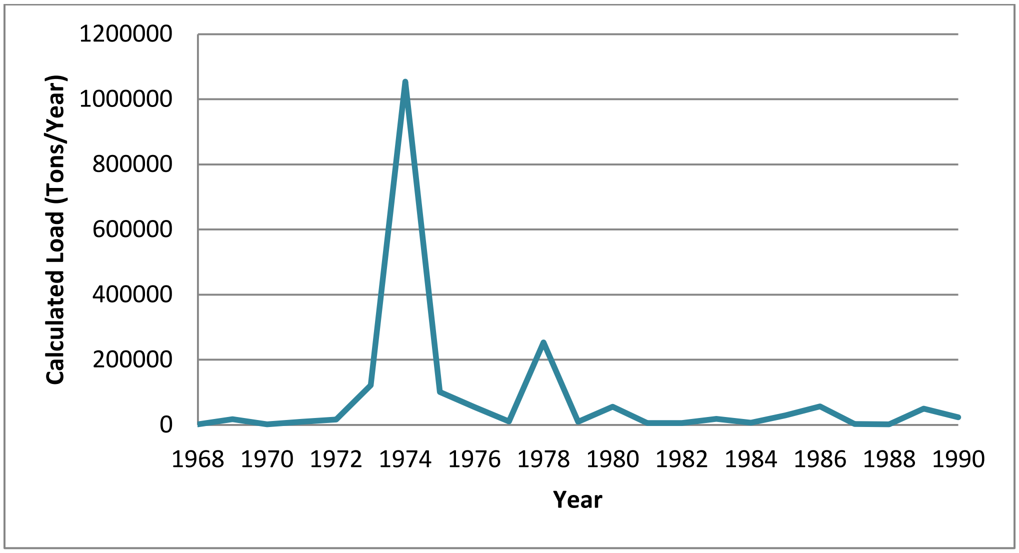

Figure 5 Suspended Sediment Load (Tons/Year) at the North Fork Whitewater near Elba (05376000)

3.0 *Trends in Nitrate*

3.1 Nitrate Data

Nitrate[5] is a nutrient which at elevated levels in water can have harmful effects on humans and animals and lead to eutrophication of water bodies. Nitrate is the primary dissolved pollutant in the watershed, and it has the largest and most comprehensive period of record. Nitrate concentrations are less dependent on flow than parameters related to suspended sediment, and therefore less monitoring data is needed to reasonably estimate loads.

3.2 Seasonal and Long-Term Trends in Nitrate

There are six sites in the watershed that have sufficiently long records to allow assessment of seasonal patterns and long-term trends (Figure 6). A longer record is available by combining four data sources for the North Fork Whitewater River monitoring site near Elba (Figure 6).

3.2.1 Seasonal Nitrate Trends

[4] Minnesota Pollution Control Agency. *2010 Report on the Water Quality of Minnesota Streams: Citizen Stream Monitoring Program.* By Laurie Sovell, D. Richter, M. Nichols, and K. Vang. St. Paul, MN: MPCA 2011 Print.
[5] For purposes of this report, when the term “nitrate” is used, values are reported as Nitrogen (N), and analyses often include both nitrite and nitrate as N.

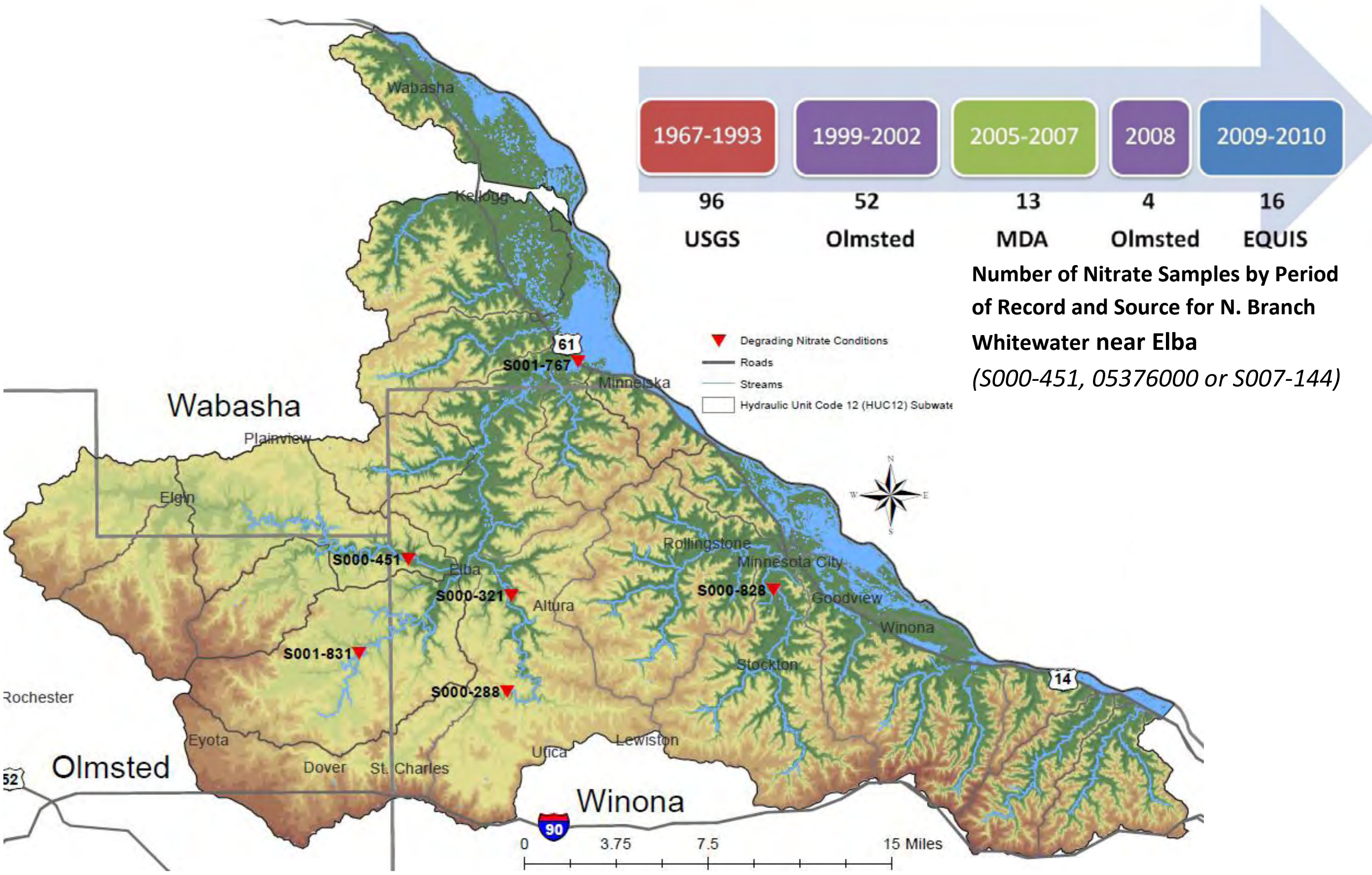

Figure 6 Trends in Nitrate Concentration in the Mississippi River-Winona Watershed

A slight seasonal pattern is found in nitrate with lower concentrations during the growing season (Figure 7 and Appendix C). This is likely due to plant utilization of the nutrient during the growing season.

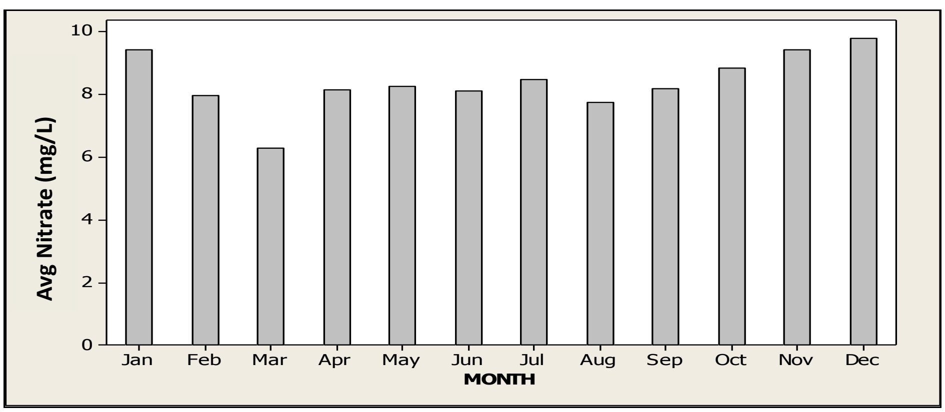

Figure 7 Seasonal Nitrate Pattern at Middle Fork Whitewater River North of St. Charles (S001-831)

3.2.2 Long-Term Nitrate Trends

Table 3 outlines the six sites with sufficient data for statistical trend analysis. All of the monitoring sites have an increasing trend in nitrate concentration (Appendix D). The percent increase in nitrate concentrations is similar at all of the sites in the Mississippi River-Winona Watershed. For example, the nitrate concentration at the South Fork Whitewater River near Utica (S000-288) has increased from 4.2 to 11 mg/L from 1974-2011 and the site on North Fork Whitewater River near Elba (S000-451) has increased from <1 mg/L to 6mg/L from 1967 to 2010 (Figure 8). This trend tracks with historic nitrogen fertilizer sales and a zero nitrate would correspond with approximately the year 1957.

Table 3: Nitrate Trends at Monitoring Stations in the Mississippi River-Winona Watershed

Station ID	Site Description	Period of Record	Nitrate Trends
S000-288	South Fork Whitewater River near Utica	1974-2008	Increasing Trend
S000-828 & 05378235	Garvin Brook S.W. of Minnesota City	1983-2009	Increasing Trend
S000-321	South Fork Whitewater River near Altura	1992-2011 (missing 1997-2004 period)	Increasing Trend
S001-831	Whitewater Middle Fork North of St. Charles	1993-2011	Increasing Trend
5376000, S000-451, & S007-144	North Fork Whitewater River near Elba	1967-2010 (missing 1993-1999 and 2002-2005 period)	Increasing Trend
LTRMP	Whitewater River at Weaver Hwy 61	1993-2008	Slight Increasing Trend

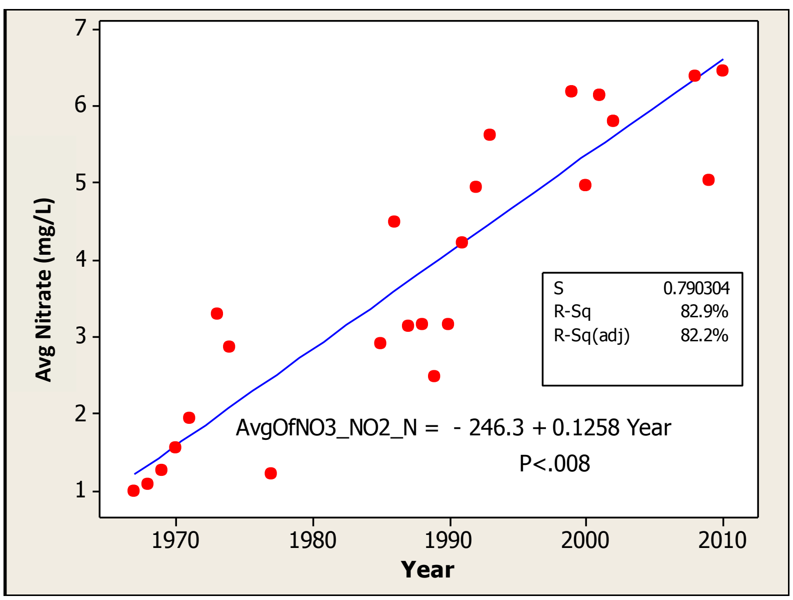

Figure 8 Nitrate Trend for North Fork Whitewater River near Elba (05376000, S000-451 and S007-144)
Note: Missing period of record in early 1980's

3.3 <u>Correlation between Nitrate and Discharge</u>

In contrast with total suspended solids (TSS) and the parameters associated with suspended solids, nitrate concentrations are not highly dependent on flow. Nitrate concentrations vary annually by only milligrams per liter at a given monitoring site. In contrast, TSS can be as much as 1,000 times greater in events versus low flow.

Table 4 outlines the three sites that have sufficient data to examine the relationship between nitrate and daily stream discharge (Appendix C).

Table 4 Correlation between Nitrate Concentrations and Daily Discharge at Mississippi River-Winona Watershed Monitoring Sites

Station ID	Site Description	Period of Record	Nitrate/Discharge Correlation
S000-828 & 05378235	Garvin Brook SW of Minnesota City	1981-2008[6]	No Correlation
S001-831	Middle Fork Whitewater River North of St. Charles	2007-2012	Strong Correlation
5376000, **S000-451, & S007-144**	North Fork Whitewater River Near Elba	1967-1993	No Correlation

At low to moderate discharge (base flow), there is a lower variability of nitrate concentrations. Higher variability and lower concentrations are seen during high flows (Figure 9).

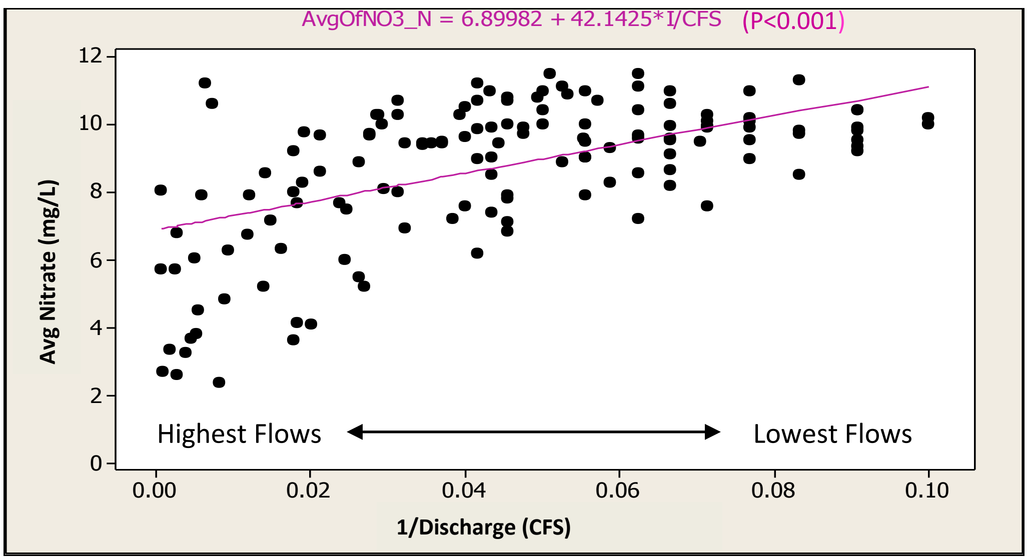

Figure 9 Nitrate vs. Inverse of Discharge at the Middle Fork Whitewater River North of St. Charles (S001-831)

3.4 Nitrate Concentration versus Landcover

The MPCA has identified a strong correlation between nitrate concentrations and percent of row crop acres in watersheds in southeastern Minnesota[7]. About 30 of the 100 sites used in the MPCA study were in the Mississippi River-Winona Watershed. The MPCA correlation indicates that a watershed with

[6] Period of record available at the start of this project. This site is still operating.

[7] Minnesota Pollution Control Agency. Rochester. *The Relationship of Nitrate-Nitrogen Concentrations in Trout Stream to Row Crop Land Use in Karstland Watersheds of Southeast Minnesota*. By Justin Watkins, Nels Rasmussen, Gregory Johnson, and Brian Beyerl. Rochester MN: MPCA, 2010.

a landcover of approximately 60 percent corn and soybeans results in an average concentration of 10 mg/L nitrate in the stream discharge. The current Minnesota Department of Health (MDH) drinking water standard for nitrate is 10 mg/L.

Fifteen monitoring sites in the watershed have adequate nitrate data in 2008-2009 to statistically analyze the correlation between nitrate concentration and landcover. The 2009 National Agriculture Statistics Service (NASS) land cover was used to identify the percent of cropland in each of the 12 sub-watersheds (HUC12) that contained active monitoring locations during the 2008-2009 period. A high degree of correlation was found between nitrate concentration and percent cropland (Appendix E). Figure 10 illustrates the correlation between stream nitrate concentrations and the percent cropland in the Mississippi River-Winona Watershed (HUC12s).

Nitrate concentrations were slightly higher than the MPCA identified in their study. This may be due to the MPCA's focus on trout streams which receive larger contributions from deeper aquifers.

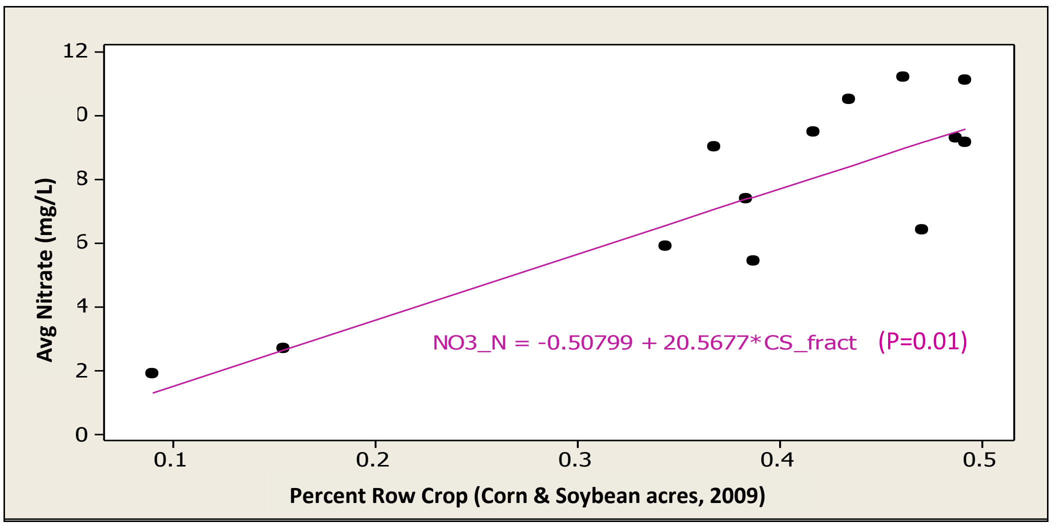

Figure 10 Stream Nitrate vs Percent of Drainage Area in Corn and Soybeans (15 Sites)

Sub-watersheds with higher than predicted stream nitrate levels include Logan Creek, Middle Fork Whitewater River north of St. Charles, and the South Fork Whitewater River sites near Utica, Altura, and Dover. These sites tend to be in the upper reaches of the watershed where there is a greater percent cropland and where groundwater contributing to streams is from shallower aquifers with higher nitrate concentrations. Sites in the lower watershed such as the North Fork Whitewater River near Elba, have lower than predicted nitrate. Like the trout streams studied by the MPCA, the streams in these sub-watersheds are cut into deeper bedrock layers and receive groundwater from deeper, more naturally protected aquifers (Figure 11).

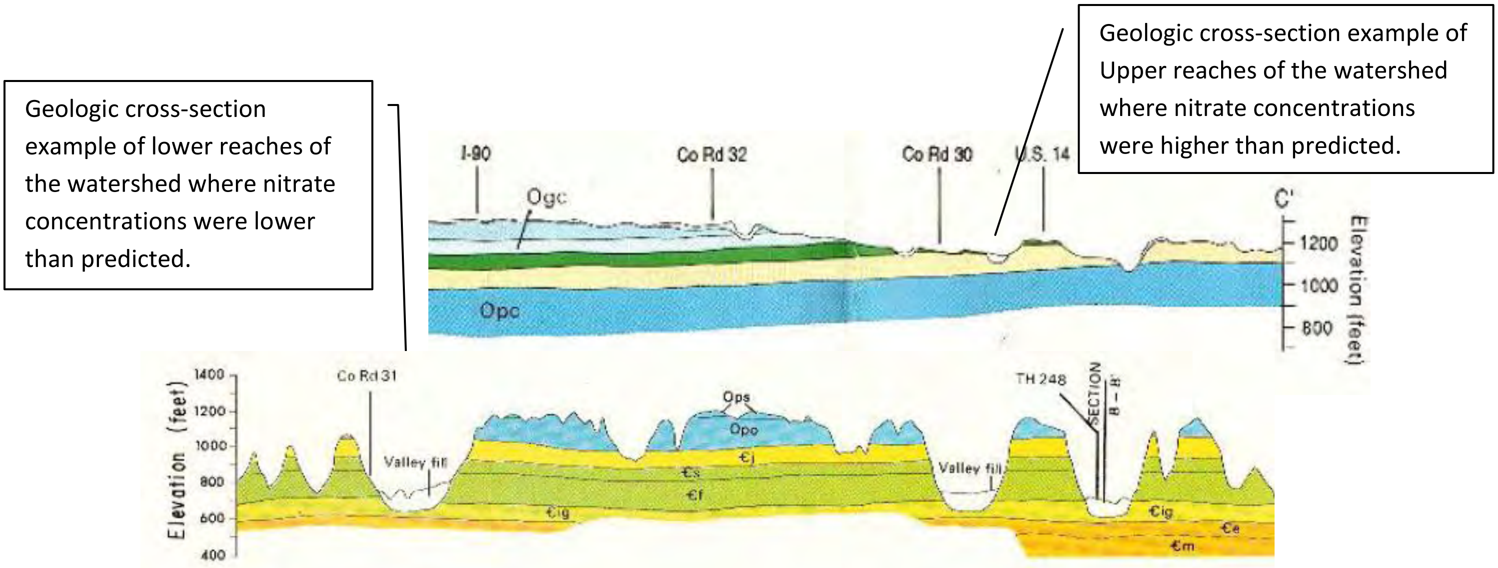

Figure 11 Geologic Cross-Section of Upper and lower Mississippi River-Winona Watershed streams

To test the reliability of the nitrate prediction, 17 of the HUC12s in the Mississippi River-Winona Watershed were sampled on 12/12/2012 at the point in which the stream discharges from the watershed—the "pour point"(Figure 12). A strong correlation was found between nitrate concentration and percentage of cropland (Appendix E). This analysis suggests that a watershed containing 100 percent cropland would be expected to have a stream nitrate concentration at the stream pour point of approximately 20 mg/L. This concentration is comparable to that found in tile drainage under corn and soybean rotation by the University of Minnesota in southeastern Minnesota[8]. Under current cropping practices, the tile drainage studies suggest that 20 mg/L could be approximately the maximum nitrate concentration that will be found in streams in agricultural watersheds. It also suggests that the increasing nitrate trends in Mississippi River-Winona Watershed streams may soon begin to level off.

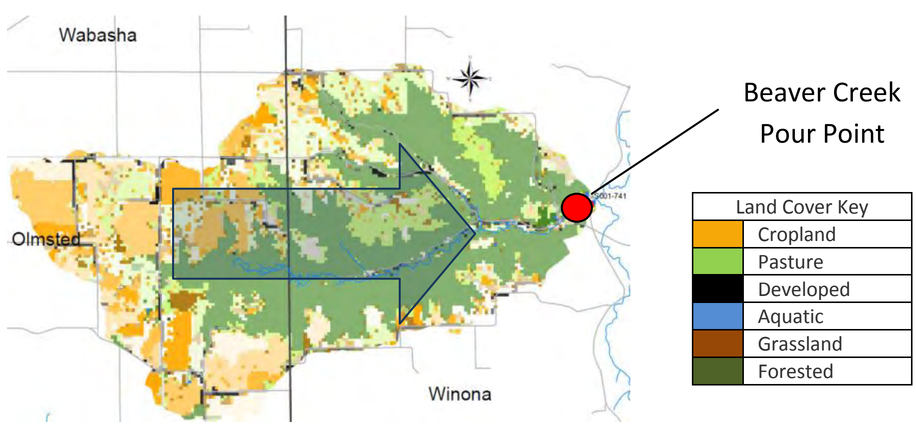

Figure 12 Landcover and Stream Sampling Point (Pour Point) Example for Beaver Creek HUC-12

[8] Randall, G and Vetch, J. *Nitrogen Management to Minimize Nitrate Losses to Water Resources,* Southern Research and Outreach Center, Waseca, MN. Nutrients in our Environment, Feb 18, 2010.

A study completed by Olmsted County found that water softener salt (NaCl), road salt (NaCl), and potassium chloride (KCl) fertilizer[9] account for nearly all of the chloride used in the county. The relative contribution to stream chloride concentrations by these three sources were all of similar proportions but were found to vary by land use and season. The same is likely true for the Mississippi River-Winona Watershed area outside of Olmsted County.

The only sites with a significant period of chloride data are the MPCA Milestone Monitoring Program sites on the South Fork Whitewater River near Utica (S000-288) and Garvin Brook SW of Minnesota City (S000-828), the USGS monitoring site on the North Fork Whitewater River near Elba (05376000 of S000-451), and the Long Term Research Monitoring Station on the Whitewater River near Weaver on Hwy 61 (LTRMP). Each site shows an increasing trend in chloride (Table 5 and Appendix H). Since the early 1980's, chloride levels have increased at the Garvin Brook Milestone site (S000-828) by about 0.2 mg/L per year and at the Utica site (S000-288) by about 0.7 mg/L per year. The Elba site was monitored by the USGS from 1967-1993, by Olmsted County in 1999-2002 and again in 2008 (S007-144). Chloride has increased at this site from 1 mg/L in the 1960's to about 20 mg/L in 2010. The chloride concentrations appear to be leveling off at this site (Figure 13 and Appendix H).

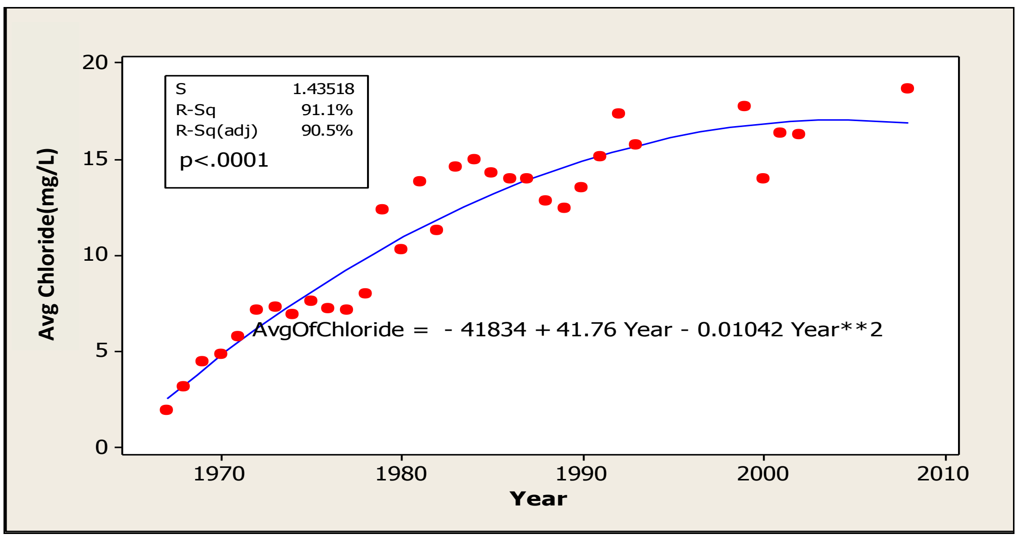

Figure 13 Chloride Trend for North Fork Whitewater River near Elba (S000-451)

Sodium concentrations tend to correlate with chloride and are increasing (Appendix H). While there is a natural, low background concentration of sodium in local waters, the increasing levels found in Mississippi River-Winona streams are likely from road and softener salt.

[9] Wilson, Robert J. *A Chloride Budget for Olmsted County Minnesota: A Mass Balance Approach in an Environment Dominated by Anthropogenic Sources, Typical of the Temperate US Midwest.* Thesis. Minnesota State University-Mankato, 2008.

Table 5: Chloride and Sulfate Trends in the Mississippi River-Winona Watershed

Station ID	Site Description	Period of Record	Chloride & Sulfate Trends
S000-288	South Fork Whitewater River near Utica	1974-1977, 2007-2008	Upward trend in Cl Downward trend in SO_4
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2007-2009	Upward trend in Cl No trend in SO_4
5376000, S000-451 & S007-144	North Fork Whitewater River near Elba	1967-1993, 1999-2002, 2008	Upward trend in Cl Downward trend in SO_4
LTRMP	Whitewater River at Weaver Hwy 61	1993-2002	Upward trend in Cl. Note: Not enough SO_4 data for analysis

Some of the sulfate in southeastern Minnesota streams and groundwater is naturally contributed by dissolved rock (iron pyrite and gypsum) and some is contributed by acid rain.

The longest record of sulfate data is from the USGS site on the North Fork of the Whitewater River near Elba. During the period from 1974 to about 1985, there is an increasing trend and from 1985 until 2008 there is a decreasing trend (Appendix G and Figure 14). This trend likely illustrates the impact of acid rain control measures in the Clean Air Act. Figure 15 illustrates the monitoring sites with sulfate and chloride trends in the watershed

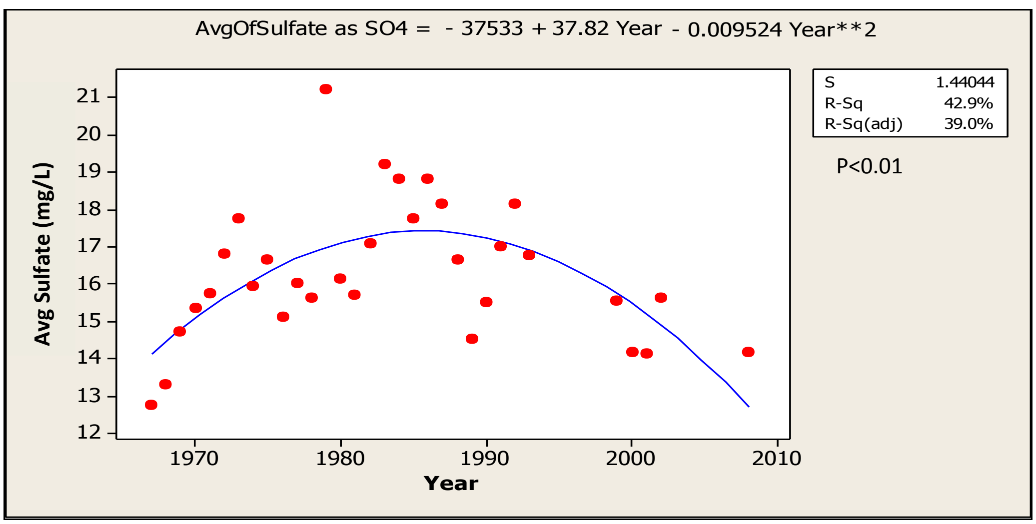

Figure 14 Sulfate Time Series for the North Fork Whitewater River near Elba (S000-451)

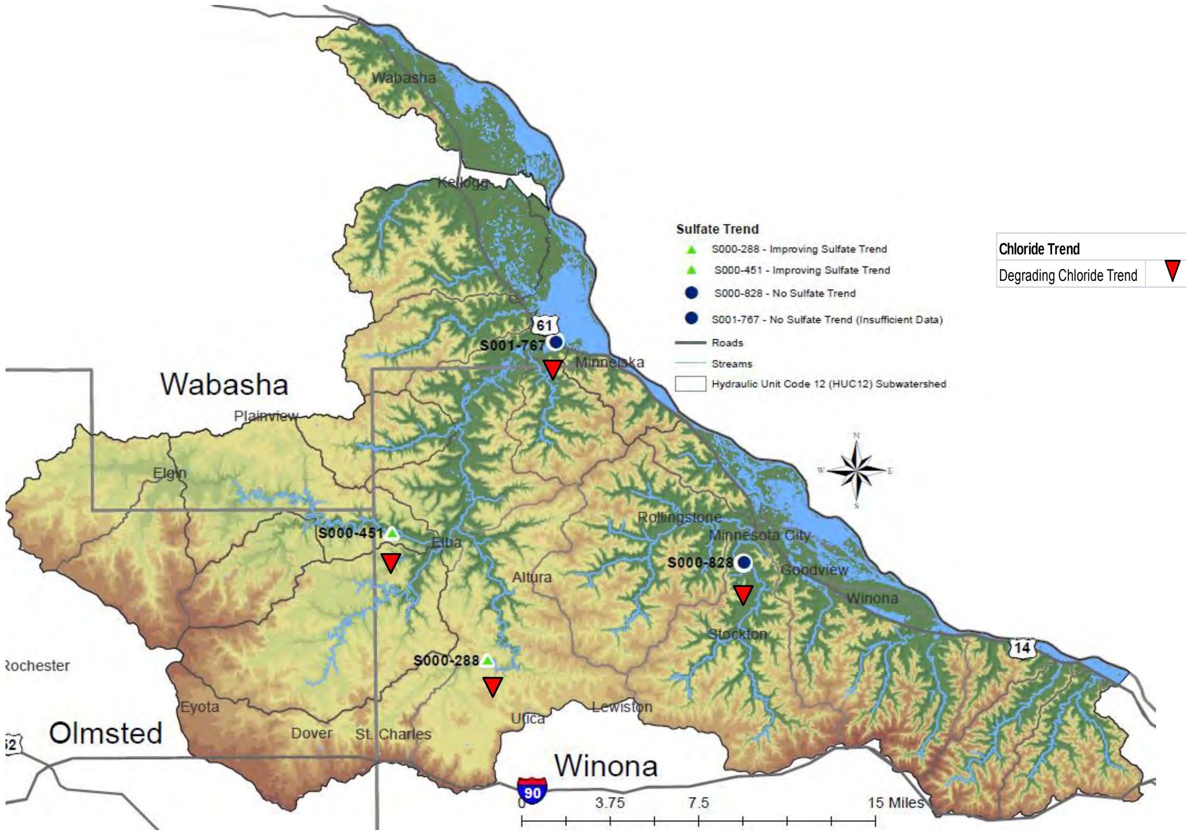

Figure 15 Trends in Sulfate and Chloride in the Mississippi River-Winona Watershed

4.0 *Bacteriological, Pesticide and Biological Data*

Bacteriological, pesticide and biological data was collected from multiple agencies. The data sources are included in Appendix A. Bacteriological data sources were noted in Appendix A but no attempt was made to assess trends due to the complexity of the data. A synopsis of the data available for fisheries monitoring in the watershed is outlined in Appendix A.

5.1 Biological Data

Appendix I includes a comparison of parameters, including biological parameters, from the two MPCA Milestone Monitoring sites--South Fork Whitewater River near Utica (S000-288) and the Garvin Brook site SW of Minnesota City (S000-828) (Table 6 and Appendix I). These sites were compared because they had varied upland landcover and sufficient data for analysis. The land use varied at the sites with 16% cropland at the Garvin Brook site SW of Minnesota City and 47% cropland at the South Fork Whitewater River near Utica. The South Fork Whitewater River site near Utica also receives discharge from the St. Charles, Dover, Eyota sewage treatment plant.

Nitrate (NO_3), total phosphorus (TP), and chlorophyll a levels are much higher at the Utica site, while biochemical oxygen demand (BOD), transparency, total Kjeldahl nitrogen (TKN), and E.coli are slightly higher than the Garvin Brook site. Total suspended solids (TSS) and turbidity are lower at Utica.

Dissolved oxygen (DO), phenophytin, and fecal coliform (FC) concentrations show no difference between the two sites.

Table 6: Comparison of Milestone Monitoring Stations in the Mississippi River-Winona Watershed.

Station ID	Site Description	Period of Record	Differences between the two sites
S000-288	South Fork Whitewater River near Utica	1974-2008	NO_3, TP, and Chlorophyll-a (**higher**) BOD, transparency, Total Kjeldahl Nitrogen (TKN), and E-coli **(slightly higher)**
S000-828 & 05378235	Garvin Brook SW of Minnesota City	1983-2009	TSS and turbidity higher DO, Phenophytin, and Fecal coliform **(no difference)**

5.2 Pesticide Data

Pesticide data was available from 25 different sites. Nearly all of the data was from two Minnesota Department of Agriculture monitoring sites—The Middle Branch Whitewater River north of St. Charles (S001-831) and the South Fork Whitewater River near Altura (S000-321) (Appendix J).

The South Fork Whitewater River near Altura (S000-321) is monitored specifically for the purpose of assessing trends in atrazine and its breakdown products (deisopropylatrazine and desethylatrazine). While no trend analysis has been completed at this site the data suggests that there has been a downward trend in recent years.

Summary of Long-Term Water Quality Trends

Table 7 Long Term Water Quality Trends in the Mississippi River-Winona Watershed

Location	Whitewater River near Beaver	South Fork Whitewater near Altura	North Fork Whitewater near Elba	Garvin Brook near Minnesota City	Middle Branch Whitewater North of St.	South Fork Whitewater River near Utica	Whitewater River at Weaver Hwy 61
Site ID	5376800	5376500 & S000-321	5376000 & S000451	5378235 & S000-828	S001-831	S000-288	LTRMP
Annual Discharge	↓	→	→	→			
Suspended Sediment			→				
Total Suspended Solids (TSS)				↑		↑	
Total Phosphorus (TP)				↑		→	
Ammonia (NH_4)				↑		↑	
Biological Oxygen Demand (BOD)				↑		↑	
Nitrate (NO_3-N)		↓	↓	↓	↓	↓	↓
Chloride (Cl)			↓	↓		↓	↓
Sodium (Na)			↓				↓
Sulfate (SO_4)			↑	→		↑	

Water Quality Trends	
Improving	↑
Degrading	↓
No Trend	→
Insufficient Data to Calculate a Trend	

Recommendations

In general, the greatest benefit in long-term trend monitoring will be realized by focusing on the sites that already have sufficient data for trend analyses. The recommendations below identify those sites as well as specific parameters to consider sampling in future monitoring efforts.

Trends in River Discharge:

Extend the monitoring record at sites where there are historical stream discharge records by installing or maintaining continuous flow monitoring equipment. Sites include the Whitewater River near Beaver (5376800), South Fork Whitewater near Altura (5376500), North Fork Whitewater near Elba (5376000), and Garvin Brook near Minnesota City (5378235).

Maintain the continuous flow monitoring equipment at the Middle Branch Whitewater north of St. Charles (S001-831).

Use the Palmer Drought Severity Index (PDSI) as a surrogate for reconstructing annual stream discharges where there are gaps in the discharge records. While no effort was made in this study to reconstruct annual stream flow records, the PDSI could be used for this purpose with the ultimate goal of estimating annual loads of sediment, nutrients, etc.

Trends in Parameters Related to Suspended Sediment:

Extend the suspended sediment concentration (SSC) monitoring record at the U.S. Geological Survey (USGS) site 5376000 on the North Branch Whitewater near Elba using a monitoring protocol comparable to that followed by the USGS during the period 1968 to 1993. Monitoring should be done for a minimum of 10 years so that sufficient data is collected for a long term trend analysis that assesses the loading rate impact of contemporary land use and tillage practices.

Extend the total suspended sediment (TSS) monitoring record at the MPCA Milestone monitoring sites at Garvin Brook near Minnesota City (S000-828) and the South Branch Whitewater River near Utica (S000-288).

Expand the monitoring parameters related to suspended sediments at sites where there are continuous flow monitoring equipment installed. Sites include the Whitewater River near Beaver (5376800), South Fork Whitewater River near Altura (5376500), South Fork Whitewater River near Utica (S000-288), North Fork Whitewater River near Elba (5376000), Middle Fork Whitewater River north of St. Charles (S001-831), and Garvin Brook near Minnesota City (5378235 or S000-828). Recommended parameters include total phosphorus (TP), total Kjeldahl nitrogen (TKN), biological oxygen demand (BOD), transparency, and turbidity.

Trends in Nitrate, Chloride, Sulfate, and Sodium:

Extend the monitoring record at sites where there is already adequate data for chemical concentration trend analyses. Sites include the MPCA Milestone sites; South Branch Whitewater near Utica (S000-288) and Garvin Brook at Minnesota City (S000-828); Middle Fork Whitewater north of St. Charles (S001-831); North Branch Whitewater near Elba (S000-451); and the Long-term Research Monitoring Program site near Weaver on Hwy. 61 (LTRMP). Expand monitoring parameters to include those needed for a “complete analysis”. Recommended parameters include anions (sulfate, chloride, nitrate, nitrite, fluoride, phosphate, and silica) and cations (calcium, magnesium, sodium, and potassium), as well as alkalinity, hardness, temperature, pH, conductivity, iron and manganese. Sampling frequency should be sufficient to characterize base and event flows.

Expand the monitoring parameters at sites where continuous flow monitoring equipment is installed to include those needed for a complete analysis. Sites include Whitewater River near Beaver (5376800), South Fork Whitewater near Altura (5376500), North Fork Whitewater near Elba (5376000), and Garvin Brook near Minnesota City (5378235). Sampling frequency should be sufficient to calculate annual loads.

Identify and study the sources of variance seen in the correlation between nitrate stream concentrations at pour points and upstream land use – particularly the impact of groundwater contributions to streams.

Identify and quantify the sources of variance between well water monitoring nitrate concentrations and stream pour point nitrate concentrations. A map of water well nitrate results in the Mississippi River-

Winona Watershed is included in Appendix A. This map illustrates that high nitrate concentrations (>10 mg/L) in wells were comparable to nitrate concentrations at the stream pour point in HUC12s in the upland areas where cropland is dominant. However, greater variation was seen between stream pour point and well nitrate concentrations in the HUC12s that drain directly into the Mississippi River. In that setting, wells located near watershed divides had substantially higher nitrate concentrations than was measured at the pour points.

Assess the potential to use the sulfate trend results from the North Fork Whitewater River near Elba (S000-451) as a residence time indicator in assessing the age of well water. The Olmsted County water database already contains hundreds of sulfate test results from wells in the watershed and could be used as a baseline for characterizing the age of the water.

Trends in Bacteriological, Pesticide, and Biological Parameters:

Continue to monitor E. coli at the sites monitored in 2011 and 2012 for the Whitewater Watershed Bacteria Reduction Project. Monitor at a frequency necessary to evaluate conformance with bacteriological standards.

Extend the pesticide monitoring record by maintaining the MDA monitoring sites at the Middle Fork Whitewater north of St. Charles (S001-831) and at the South Fork Whitewater near Altura (S000-321).

This study did not evaluate biological parameters so no specific recommendations are being made regarding monitoring sites, frequency, or parameters.

Table 8 Recommended Future Monitoring Sites and Parameters

Recommended Future Monitoring Sites		Recommended Parameters				
		River Discharge	Suspended Sediment Parameters (1)	Complete Analyses (2)	Bacteria	Pesticides
Whitewater River near Beaver	5376800 & S001-742	X	X	X		
South Fork Whitewater near Altura	5376500 & S000-321	X	X	X		X
North Fork Whitewater near Elba	5376000 & S000-451	X	X	X		
Garvin Brook near Minnesota City	5378235 & S000-828	X	X	X	X	
Middle Branch Whitewater North of St. Charles	5376100 & S001-831	X	X	X		X
South Fork Whitewater River near Utica	S000-288		X	X	X	
Whitewater River at Weaver Hwy 61	LTRMP & S001-767			X		

(1) Suspended sediment parameters: total phosphorus (TP), total Kjeldahl nitrogen (TKN), biological oxygen demand (BOD), transparency, and turbidity.

(2) Complete analyses: anions (sulfate, chloride, nitrate, nitrite, fluoride, phosphate, and silicates) and cations (calcium, magnesium, sodium and potassium) as well as alkalinity, hardness, temperature, pH, conductivity, and iron (ferrous and ferric)

Figure 16 Recommended Future Monitoring Locations in the Mississippi River-Winona Watershed

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Appendix A

Mississippi River-Winona Watershed Data Sources and Maps

Appendix A - Table of Contents

Mississippi-River Winona Watershed Data Sources by Project, Monitoring Agency and Date

SOURCE	SITE_DESCRIPTION	START	END	SITE_ID	HUC_12	Website (If available)
EQUIS	N FK WHITEWATER R AT MN-42 AT ELGIN	09/10/1980	09/10/1980	S000-776	070400030302	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
OENVR	WHITEWATER R, NF AT 65TH ST NE BRG, 2.5 MI SW OF ELGIN, MN	1999-2002	2008	S007-145	070400030302	Data will be in EQUIS in 2013
DNR	Logan Branch of Whitewater River nr Elgin, CR2	7/30/2001	12/31/2007	H40037001	070400030303	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	LOGAN BR N FK WHITEWATER R AT CSAH-10, 5.5 MI S OF PLAINVIEW	5/25/2000	8/28/2002	S002-072	070400030303	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	LOGAN BR N FK WHITEWATER R AT CSAH 2, 6 MI S OF PLAINVIEW	03/01/2004	10/31/2004	S002-546	070400030303	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
OENVR	LOGAN BR N FK WHITEWATER R AT CSAH-10, 5.5 MI S OF PLAINVIEW	1999-2002	2008	S002-072	070400030303	Data will be in EQUIS in 2013
DNR/MPCA	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	8/17/1977	12/31/2012	H40017001, S000-451	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
DNR/MPCA	N.Fork WW@ Elba, Whitewater Dr 40017002 and S007-114 (EQUIS)	Oct, 2012	Present	H40017002, S007-114	070400030304	http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=40017002
EQUIS	NF WHITEWATER TRIB- CSAH-25 2 MI SE OF PLAINVIEW	08/17/1977	9/1/1983	S000-452	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R AT CSAH-4 3 MI S OF PLAINVIEW	08/17/1977	09/10/1980	S000-453	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER R-RD BTN S25/30 2.5 MI E OF ELGIN	08/17/1977	09/10/1980	S000-454	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R AT CR-73 1.5 MI E OF ELGIN	08/17/1977	09/10/1980	S000-455	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R IN T108NR12WS26NWQSWQ AT ELGIN	08/17/1977	09/10/1980	S000-456	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER R IN MID OF S3 5 MI S OF PLAINVIEW	09/10/1980	09/10/1980	S000-774	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER TRIB IN S34NWQSEQ SE OF PLAINVIEW	09/10/1980	09/01/1983	S000-775	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER-E OF CARLEY ST PK CMPGD E OF ELGIN	9/1/1983	8/28/2002	S000-978	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER R BLW TRIB S34NWQ SE OF PLAINVIEW	09/01/1983	09/01/1983	S000-981	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	NF WHITEWATER BTN S33/34 3.5 MI SE OF PLAINVIEW	09/01/1983	09/01/1983	S000-982	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R AT HWY 74 AT ELBA, MN	4/6/2001	9/3/2008	S001-745	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N BR WHITEWATER R, 1/3 MI S OF CSAH-4, 5 MI SE OF PLAINVIEW	7/6/2004	10/30/2009	S001-833	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R W OF CSAH 4, 2.75 MI S OF PLAINVIEW, MN	8/18/2001	9/28/2006	S001-879	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	LOGAN BR N FK WHITEWATER R AT MOUTH, 5 MI SE OF PLAINVIEW	03/02/2004	10/22/2004	S002-545	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R, NF AT CARLEY STATE PK, 2.75 MI S OF PLAINVIEW	4/11/2007	9/28/2008	S004-708	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R, NF JUST UPSTM OF TR-29 IN FAIRWATER	06/23/2008	06/23/2008	S005-341	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	2005	2007	S000-451	070400030304	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
OENVR	WHITEWATER R, NF AT TR-29 (FAIRWATER RD), 7.5 MI SE OF PLAINVIEW	1999-2002	2008	S007-144	070400030304	Data will be in EQUIS in 2013
USGS	NORTH FORK WHITEWATER RIVER NEAR ELBA, MN	1961-1993	2012	5376000	070400030304	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376000
DNR/MPCA	Middle Branch WW, St. Charles, CR 107 formerly 05376100 (USGS)	9/21/1986	Present	H40019001, S001-831	070400030305	http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=40019001
EQUIS	WHITEWATER R, MID FK AT STATE PARK RD 5 MI N OF ST. CHARLES	4/5/2001	10/12/2009	S001-769	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MIDDLE FK WHITEWATER R, AT BRG AT MN-74, AT ELBA	7/5/2003	9/3/2008	S001-825	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MID FK WHTWTR R, 1/2 MI N OF CR-152, 5 MI N OF ST. CHARLES	4/1/2001	8/24/2010	S001-832	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNN TRIB TO MF WHTWTR R, 1 MI S CSAH-2, 3 1/2 MI E L VALLEY	05/10/2001	11/14/2001	S001-842	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MID FK WHITEWATER R ON CSAH-9 BRG, 3.5 MI NW OF DOVER	04/18/2004	09/14/2004	S002-073	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MID FK WHITEWATER R AT CSAH-10 BRG, 3.5 MI N OF DOVER	03/20/2002	11/13/2008	S002-074	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	CROW SPRING TO WHTWTR R M FK, NO CSAH-9 4.5 MI NW ST CHARLES	10/20/2003	10/20/2003	S003-707	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	CROW SPRING TO WHTWTR R M FK, W CR-107, 5 MI NW ST CHARLES	05/21/2003	10/20/2003	S003-708	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R M FK, SE OF QUINCY ROAD NE, 5 MI NW ST CHARLES	05/21/2003	10/20/2003	S003-709	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R M FK, W OF CR-107, 5 MI NW OF ST CHARLES	10/20/2003	10/20/2003	S003-710	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	TROUT RUN JUST E OF MN-74, 5 MI N OF ST. CHARLES	07/22/2005	07/22/2005	S004-011	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	TROUT RUN, JUST E OF MN-74, 5 MI N OF ST. CHARLES	07/22/2005	07/22/2005	S004-012	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BEACH AT WHITEWATER STATE PARK (I.E., NOT STREAM CHANNEL)	06/02/2005	08/10/2005	S004-611	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS		06/02/2005	08/10/2005	S004-612	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	1993	2011	S001-831	070400030305	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
OENVR	Mid Fk of WW River, SE portion of Section 26, Quincy TWSHP CR 153	8/16/1972	7/25/1973		070400030305	Data will be in EQUIS in 2014
USGS	MIDDLE FORK WHITEWATER RIVER NR ST. CHARLES, MN	1988	1992	5376100	070400030305	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376100
USGS	MIDDLE FK WHITEWATER R AT ST PARK NR ST CHARLES,MN	1986	1996	5376110	070400030305	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376110
USGS	MIDDLE FORK WHITEWATER RIVER AT ELBA, MN	1969	1980	5376200	070400030305	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376200
DNR/MPCA	S.Fork, Dover on US14 (40021001)	3/15/2011	2012	40021001	070400030306	http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=40021001

SOURCE	SITE_DESCRIPTION	START	END	SITE_ID	HUC_12	Website (If available)
EQUIS	SF WHITEWATER R AT CR-119 2 MI NE OF ST CHARLES	8/7/1974	6/25/2009	S000-323	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SF WHITEWATER R RD BTN S8/17 1 MI N OF ST CHARLES	08/07/1974	08/07/1974	S000-324	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWATER R AT MN-74 AT ST CHARLES	08/07/1974	08/07/1974	S000-325	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SF WHITEWATER R US-14 IN S23 2 MI W OF ST CHARLS	08/07/1974	08/07/1974	S000-326	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWATER R AT CSAH-10 AT DOVER	08/07/1974	10/14/2008	S000-327	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWATER R AT US-14 AT EYOTA	08/07/1974	10/07/2010	S000-328	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWATER R AT CSAH-7 AT EYOTA	08/07/1974	08/07/1974	S000-329	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWTR R, 500 FT N OF US-14, 1/2 MI W OF ST. CHARLES	6/19/2002	6/25/2009	S001-824	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHTWTR R, ST. CHARLS TNSHP RD 17, 1/2 MI N ST. CHARLES	4/1/2001	6/25/2009	S001-826	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS		02/10/1999	11/11/2005	S003-604	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	HDWTRS SPRING & TRIB TO S FK WHITEWATER R IN S30, N OF I-90	02/10/1999	10/31/2005	S003-605	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	HDWTRS SPRING & TRIB AT POND OTLT TO SF WHITEWATER R	04/27/2000	11/02/2000	S003-624	070400030306	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
OENVR	S FK WHITEWATER R AT MN-74 AT ST CHARLES	1999-2002	2008	S000-325	070400030306	Data will be in EQUIS in 2013
OENVR	WHITEWATER R, MF AT CR-152 BRG, 5 MI NW OF ST. CHARLES, MN	1999-2002	2008	S007-140	070400030306	Data will be in EQUIS in 2013
OENVR	WHITEWATER R, SF AT US-14 CULVERT, 1 MI NW OF DOVER, MN	1999-2002	2008	S007-146	070400030306	Data will be in EQUIS in 2013
OENVR	South Fork Whitewater River, SE corner, Sec. 15, bridge CR 10, N of Dover	1972-1973	1980		070400030306	Data will be in EQUIS in 2014
DNR/MPCA	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	8/7/1974	12/31/2012	H40024001, S000-321	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	5/21/1974	6/25/2009	S000-288	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SF WHITEWATER- TRAIL XING S6NWQ 4 MI S OF ALTURA	08/07/1974	08/07/1974	S000-322	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	S FK WHITEWATER R AT CSAH 26, 1 MI E OF ELBA, MN	10/3/2002	9/3/2008	S001-743	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R, S FK, AT CSAH 37, 1.75 MI SE OF ELBA, MN	6/28/2003	6/23/2008	S002-406	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	1992	Present	S000-321	070400030307	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	SOUTH FORK WHITEWATER RIVER NEAR ALTURA, MN	1961-1963	1991	5376500	070400030307	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376500
EQUIS	BEAVER CR AT HWY 74, 4.6 MI N OF ELBA, MN	4/6/2001	11/25/2009	S001-741	070400030308	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BEAVER CK OFF WHITEWATER TOWNSHIP RD 1, 7.5 MI NW OF ALTURA	7/28/2005	11/25/2009	S003-562	070400030308	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BEAVER CK JUST S OF TWNSHP RD 16, 5.5 MI SE OF PLAINVIEW	05/19/2008	10/29/2009	S005-072	070400030308	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	Beaver Crk at Beaver MN	1940	1980	5377000	070400030308	http://waterdata.usgs.gov/nwis/inventory/?site_no=05377000
EQUIS	TROUT CK JUST W OF CSAH-31, 4 MI E OF BEAVER, MN	05/19/2008	10/29/2009	S005-077	070400030309	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	TROUT CREEK NEAR WEAVER, MN	2004	2004	5377508	070400030309	http://waterdata.usgs.gov/nwis/inventory/?site_no=05377508
DNR/MPCA	Whitewater near Beaver, CSAH 30 formerly 05376800 (USGS)	6/21/1974	Present	H40016001,S001-742	070400030310	http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=40016001
EQUIS	WHITEWATER R. CSAH-30 AT BEAVER	7/25/1973	6/23/2008	S000-267	070400030310	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	N FK WHITEWATER R AT CSAH 26, 0.4 MI NE OF ELBA, MN	4/6/2001	9/3/2008	S001-744	070400030310	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	WHITEWATER RIVER NEAR BEAVER, MN	92	2012	5376800	070400030310	http://waterdata.usgs.gov/nwis/inventory/?site_no=05376800
USGS	DEERING VALLEY CREEK NEAR WHITMAN, MN	2004	2004	5377550	070400030310	http://waterdata.usgs.gov/nwis/inventory/?site_no=05377550
USGS	WHITEWATER RIVER AT BEAVER, MN	1935	1956	5377500	070400030310	http://waterdata.usgs.gov/nwis/inventory/?site_no=05377500
USGS	WHITEWATER RIVER AT WEAVER, MN	1971	1971	5377510	070400030310	http://waterdata.usgs.gov/nwis/inventory/?site_no=05377510
DNR/MPCA	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	6/10/2002	Present	H40009001, S001-532	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	ROLLINGSTONE CK. NEAR MINNESOTA CITY	06/16/1981	06/16/1981	S000-840	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MIDDLE VLY CK NEAR MIDDLE VALLEY RD, 2 MI SE OF ROLLINGSTONE	10/11/2000	11/06/2000	S001-533	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SPELTZ CR IN ROLLINGSTONE, MN	7/18/2001	10/31/2010	S001-717	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	ROLLINGSTONE CR AT CSAH 248 IN ROLLINGSTONE, MN	07/17/2001	09/12/2001	S001-718	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SPELTZ CR IN EAST SIDE OF ROLLINGSTONE, MN	05/06/2002	09/28/2002	S001-951	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNN STRM TO SPELTZ CK, 1.5 MI NW OF ROLLINGSTONE	5/25/2007	10/24/2010	S004-664	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SPELTZ CK AT CSAH-25, 1.25 MI NW OF ROLLINGSTONE	5/25/2007	10/24/2010	S004-801	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SPELTZ CK AT TWP RD 22, 0.5 MI NW OF ROLLINGSTONE	5/25/2007	10/24/2010	S004-802	070400030501	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	Straight Valley Creek, Near Rollingstone MN	1959	1985	5378300	070400030501	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378300
USGS	STRAIGHT VALLEY CREEK NEAR ROLLINGSTONE, MN	1959	1985	5378300	070400030501	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378300
USGS	ROLLINGSTONE CREEK NEAR MINNESOTA CITY, MN	1969	2008	5378400	070400030501	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378400
DNR/MPCA	GARVIN BROOK NEAR MINNESOTA CITY	6/16/1981	12/31/2012	H40008002, S000-829	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
DNR/MPCA	Garvin Brook nr Minnesota City, CSAH23	1/1/2003	4/1/2007	H40008001	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html

SOURCE	SITE_DESCRIPTION	START	END	SITE_ID	HUC_12	Website (If available)
EQUIS	GARVIN BROOK AT MINNESOTA CITY	6/16/1981	08/26/2002	S000-826	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK NEAR MINNESOTA CITY	6/16/1981	06/23/1982	S000-827	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	6/16/1981	4/23/2009	S000-828	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK NEAR STOCKTON	06/16/1981	06/23/1982	S000-830	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK AT STOCKTON	6/16/1981	10/14/2009	S000-831	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK AT STOCKTON	6/16/1981	3/4/1983	S000-832	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BROOK AT THE ARCHES	06/16/1981	06/23/1982	S000-833	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNNAMED CREEK AT STOCKTON	6/16/1981	8/26/2002	S000-834	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	PETERSON CREEK AT THE ARCHES	6/16/1981	8/26/2002	S000-839	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNNAMED CREEK NEAR STOCKTON	06/16/1981	06/23/1982	S000-842	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	06/16/1981	3/4/1983	S000-844	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	06/16/1981	06/23/1982	S000-845	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	06/16/1981	06/23/1982	S000-846	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK NEAR US-14, 1/2 MI W OF STOCKTON	4/23/2001	10/12/2003	S001-528	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	STOCKTON VALLEY CK, 1 MILE S OF STOCKTON	5/8/2000	10/15/2010	S001-529	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNN TRIB TO GARVIN BK, 1.5 MI W OF STOCKTON	05/18/2000	7/8/2005	S001-531	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK AT RR BRIDGE, 2.6 MI SW OF STOCKTON, MINNESOTA	05/23/2000	8/26/2002	S003-687	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK UPST OF US-61 IN MN CITY, MN	5/12/2005	9/24/2010	S003-784	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK, 0.5 MI S OF US-14, 2.5 MI NE OF LEWISTON	07/22/2005	07/28/2005	S004-013	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK, 300 FT UPSTM OF RAILROAD BRG IN STOCKTON	8/11/2008	9/27/2010	S005-586	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GARVIN BK AT CSAH-23 IN STOCKTON	6/13/2008	10/15/2010	S005-587	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	1991-1993	2005-2006	S000-828	070400030502	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	STOCKTON VALLEY CREEK AT STOCKTON, MN	1982	1985	5378230	070400030502	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378230
USGS	GARVIN BROOK NEAR MINNESOTA CITY, MN	1982	1985	5378235	070400030502	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378235
USGS	GARVIN BROOK BLW US 61 AT MINNESOTA CITY, MN	1981	1981	5378245	070400030502	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378245
USGS	GARVIN BROOK AT STOCKTON, MN	1982	1991	5378220	070400030502	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378220
USGS	GARVIN BROOK ABOVE MINNESOTA CITY, MN	1935	1981	5378240	070400030502	http://waterdata.usgs.gov/nwis/inventory/?site_no=05378240
EQUIS	MISSISSIPPI RIVER AT BRIDGE ON MN-60 AT WABASHA	6/29/1967	6/4/1968	S000-131	070400030601	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MISSISSIPPI R. BY KELLOGG	9/1/1971	4/8/1974	S000-218	070400030601	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	SNAKE CK 0.7 MI S OF HWY 61	03/24/2007	10/21/2007	S001-449	070400030602	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GORMAN CR 1 MI S OF KELLOGG, MN	5/1/2001	10/21/2007	S001-704	070400030602	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	EAST INDIAN CK 100 YDS SW OF US-61 AND CR-84 6 MI SE KELLOGG	8/2/2008	9/23/2010	S005-390	070400030603	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	EAST INDIAN CREEK TRIBUTARY NEAR WEAVER, MN	1962	1985	5375800	070400030603	http://waterdata.usgs.gov/nwis/inventory/?site_no=05375800
EQUIS	MISSISSIPPI R LOCK & DAM #5 3 MI SE OF MINNEISKA	5/21/1974	9/10/2008	S000-287	070400030604	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WHITEWATER R AT RAILROAD BRG AT MOUTH, 0.5 MI SE OF WEAVER	4/19/2001	9/20/2010	S001-767	070400030604	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDNR	WHITEWATER R AT HWY 61 BRIDGE (LTRMP)	1997	2008		070400030604	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MISSISSIPPI R. BY WINONA	8/29/1962	1/31/2011	S000-096	070400030606	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WINONA (SOUTH BAY)	06/23/2010	06/23/2010	85-0011-01-102	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	WINONA (NORTH BAY)	06/23/2010	06/23/2010	85-0011-02-101	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GILMORE CR, 1.1 MI S OF WINONA, MN	6/29/2005	9/30/2010	S001-728	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	PLEASANT VALLEY CR E OF CSAH-17, 3.5 MI S OF WINONA, MN	6/25/2003	8/1/2009	S002-398	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	GILMORE CK AT VILA AVENUE IN WINONA, MN	05/23/2007	08/27/2007	S003-791	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	PLEASANT VALLEY CK AT CLINTON DR N, 2 MI S OF WINONA, MN	4/3/2006	10/7/2010	S003-792	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	PLEASANT VALLEY CK AT HOLLER HILL RD IN WINONA, MN	4/3/2006	10/7/2010	S003-793	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	E BURNS VALLEY CK OFF E BURNS VALLEY RD IN WINONA, MN	7/22/2005	9/26/2007	S003-800	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	E BURNS VALLEY CK AT CSAH 105 IN WINONA, MN	5/28/2005	9/18/2010	S003-806	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	UNN STM TO PLEASANT VALLEY CK AT CSAH-17, 2.5 MI S OF WINONA	3/24/2006	10/20/2007	S004-246	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	E BURNS VALLEY CK AT E BURNS VALLEY RD, 3.2 MI S OF WINONA	07/01/2009	10/07/2009	S006-127	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	E BURNS VALLEY CK, E OF E BURNS VALLEY RD 4.6 MI S OF WINONA	07/01/2009	10/07/2009	S006-128	070400030607	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
USGS	GILMORE CREEK AT WINONA, MN	1940	1991	5379000	070400030607	http://waterdata.usgs.gov/nwis/inventory/?site_no=05379000

SOURCE	SITE_DESCRIPTION	START	END	SITE_ID	HUC_12	Website (If available)
EQUIS	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	6/6/2006	10/30/2007	S004-245	070400030608	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	2005	2006	S004-245	070400030608	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BIG TROUT CK (PICKWICK CK) E OF CSAH-7, 1.3 MI S OF PICKWICK	04/23/2006	10/29/2006	S004-240	070400030609	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BIG TROUT CK (PICKWICK CK) 130 FT DWNSTRM OF CSAH-7 BRG	04/23/2006	10/29/2006	S004-243	070400030609	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BIG TROUT CK(PICKWICK CK) UPSTM OF US-61 2 MI NE OF PICKWICK	04/23/2006	10/29/2006	S004-244	070400030609	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BIG TROUT CK (PICKWICK CK), 0.16 MI SW OF PICKWICK MILL	04/23/2006	10/29/2006	S004-247	070400030609	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	BIG TROUT CK (PICKWICK CK) AT CSAH-7 BRG AT PICKWICK MILL	04/23/2006	10/29/2006	S004-248	070400030609	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
EQUIS	MISSISSIPPI R LOCK & DAM #6 AT TREMPEALEAU, WIS	8/29/1962	4/29/2009	S000-095	070400030610	http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html

Key:

EQUIS	MPCA Database: http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	Minnesota Department of Agriculture
USGS	United States Geological Survey
Olm	Olmsted County Environmental Resources
MDNR	Minnesota Department of Natural Resources

Mississippi-River Winona WatershedReports, Other Data Sources and On-Going Projects

REPORTS			
Agency	**Name of Report**	**Start**	**End**
UFWS & USACOE	**Weaver Bottoms Rehabilitation Project Resource Analysis Program**	1986	1995
NRCS	**Whitewater River Sedimentation Sites**		
MPCA	**Whitewater River Watershed National Monitoring Program Report**	1995	2005
Ryan C. Budlong	**The Use of Spatial Data in Creating a Riparian Buffer Suitability Model: Whitewater River Watershed, Minnesota**		
Mississippi River-Winona Watershed	**Mississippi River–Winona Watershed Citizen Summit**	2012	
Brian A. Nerbonne, Bruce Vondracek Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, University	**Effects of Local Land Use on Physical Habitat, Benthic Macroinvertebrates, and Fish in the Whitewater River, Minnesota, USA**	2001	
Denton Bruening- MDA	**Survey of Farmers within the Middle Fork of the Whitewater River.**	1999	
Denton Bruening- MDA	**2005 Nutrient and Pesticide Management Assessment of Producers in the Middle Branch and South Branch Watersheds of the Whitewater River**	2008	
McGhie & Betts Environmental Services, Inc.	**Farmer-led Watershed Council Pilot Project Mapping Analysis Summary**	2001	
Megan Kranz-McGuire, Project Coordinator In cooperation with the MPCA and the United States EPA	**South Branch Bacteria Reduction Project: Final Report**	2005	2009
Natalie Siderius -Whitewater River Watershed Project	**Environment and Natural Resources Trust Fund 2012-2013 Request for Proposals (RFP)**	2012	2013
Barr Engineering, Co.	**Agricultural Watershed Restoration Project, Logan Creek Watershed: Final Report**	2010	
MPCA	**Whitewater River Watershed National Monitoring Program Project Final Report**	2010	
Unknown	**Whitewater River Watershed Section 319 National Monitoring Program Project**	2007	
White Water Watershed	**Whitewater Watershed Resident Survey: Summary of Results**	2009	
Board of Water and Soil Resources, Whitewater Watershed Joint Powers Board	**Whitewater Watershed Bacteria Reduction**	2007	2009
University of Minnesota, Winona	**Garvin Brook Biological Monitoring**		Ongoing
Zenk Read Trygstad & Associates, Inc	**Floodwater Channelization & Diversion Options for Stockton, MN**	2009	

Other Data Sources			
Agency	**Details of Project**	**Start**	**End**
Dr. Newman/Muck (UofMN)	**Nitrate in SE MN Trout Streams (10 sites in the WW, 1 grab sample in 1990)**	1990	1990
MDNR	**Trout Population Assessments**		
	East Burns Valley Creek	2003	2003
	West Burns Valley Creek	2003	2003
	Burns Valley Creek (Main)	2003	2003
	Main Branch Whitewater River	2003	2003
MDNR Fisheries	**Historical Fish Population Studies (Contact: Steven Klotz, Lanseboro Fisheries)**		
MDNR Fisheries	**1996 and 2003 Fish Sampling Data (Contact: Neil Haugerud, River Ecologist MDNR Fergus Falls)**	1996	2003
Minnesota Geological Survey	**County Well Index, Nitrate Data in Springs, Mississippi-Winona Watershed**		
MDNR Fisheries	**Crystal Springs Hatchery Data (Contact: Adam Moticak, Hatchery Supervisor)**		

Current/On-Going Projects (12/31/2012)			
Agency	**Name of Project**	**Start**	**End**
MPCA	**Sub-Watershed Pollutant Load Monitoring Network: Mike Walerak (TSS, SVS, Turbidity, DOP, TP, NO3 + NO2, TKN, pH, Temp, Cond, DO,**	**2010**	**Ongoing**
MDA	**Prioritization Scheme for Bank Erosion Sites (Bank Erosion Mechanics in the Whitewater) funded by an MDA grant. Contact: Adam Birr (MDA) and Chris Lenhart (U of MN)**	**2011**	**Ongoing**
MDNR	**Stream Assessment-Risk Map Integration. Contact: Suzanne Jiwani and Salam Murtada (MDNR)**		**Ongoing**
MPCA	**Stressor Identification Project (Tiffany Shauls)**		**Ongoing**
	S. Branch Whitewater at CR-37 (continuous temp data)		**Ongoing**
	S. Branch Whitewater upstream of Lamberton Mill Rd. (continuous temp data)		**Ongoing**
	Small Tributary in WW State Park near Marnach House (continuous temp data)		**Ongoing**
	N. Branch Whitewater Upstream Elgin Near Viola (continuous temp data)		**Ongoing**
	S. Branch Whitewater downstream St. Charles (D.O, Temp, Cond, pH-2 week interval)		**Ongoing**
	Crow Spring at 10th Street (D.O, Temp, Cond, pH-2 week interval)		**Ongoing**
	M. Branch Whitewater at 10th Street (D.O, Temp, Cond, pH-2 week interval)		**Ongoing**
	S. Branch Whitewater Near Crystal Springs (D.O, Temp, Cond, pH-2 week interval)		**Ongoing**
MDNR	**Stream Habitat Program (Kevin Zytkovicz): Geomorphic Measurments**		**Ongoing**
MDNR	**Watershed Conceptual Data Model Project (Rick Lorenzen)**		**Ongoing**

Note: This list only reflects the data and information provided to Olmsted County Environmental Resources during the data compilation phase of the project and should not be considered a complete lists.

Key:

EQUIS	MPCA Database: http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	Minnesota Department of Agriculture
USGS	United States Geological Survey
Olm	Olmsted County Environmental Resources
MDNR	Minnesota Department of Natural Resources
NRCS	Natural Resource Conservation Service
MPCA	Minnesota Pollution Control Agency
USFWS	United States Fish and Wildlife Service
USACOE	United States Army Corps of Engineers

Mississippi-River Winona Watershed Data Sources by Parameter Group

Location ID	Source	Location Description	Program Description	Period		Counts										
				Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
85-0011-01-102	EQUIS	WINONA (SOUTH BAY)	Clean Water Legacy Surface Water Monitoring	2010	2010	4	3		2		2					
85-0011-02-101	EQUIS	WINONA (NORTH BAY)	Clean Water Legacy Surface Water Monitoring	2010	2010		1		2							
S000-095	EQUIS	MISSISSIPPI R LOCK & DAM #6 AT TREMPEALEAU, WIS	Ambient Trace Metals	2008	2009	19				6	8	21	3	3		
S000-095	EQUIS	MISSISSIPPI R LOCK & DAM #6 AT TREMPEALEAU, WIS	Minnesota Milestone Site River Monitoring Program	1999	2008	441	137		88	12	64			7		
S000-095	EQUIS	MISSISSIPPI R LOCK & DAM #6 AT TREMPEALEAU, WIS	MPCA Stream Monitoring Program Project	1962	1998	1324	939	40	320	171	615	513	98	9	68	79
S000-095	EQUIS	MISSISSIPPI R LOCK & DAM #6 AT TREMPEALEAU, WIS	Southeast Regional Fecal Study 2007	2007	2007	45			15							
S000-096	EQUIS	MISSISSIPPI R. BY WINONA	Major Watershed Pollutant Load Monitoring Network	2008	2011	306	156			33	56					
S000-096	EQUIS	MISSISSIPPI R. BY WINONA	MPCA Stream Monitoring Program Project	1962	1985	77	22	1	19		33					10
S000-131	EQUIS	MISSISSIPPI RIVER AT BRIDGE ON MN-60 AT WABASHA	MPCA Stream Monitoring Program Project	1967	1968	70	35	1	14	7	28					7
S000-218	EQUIS	MISSISSIPPI R. BY KELLOGG	MPCA Stream Monitoring Program Project	1971	1974	210	107	23	60	107	151	224	60	4	6	28
S000-267	EQUIS	WHITEWATER R. CSAH-30 AT BEAVER	MPCA Stream Monitoring Program Project	1973	1974	79	48	2	20	39	59	80	20			10
S000-267	EQUIS	WHITEWATER R. CSAH-30 AT BEAVER	Multiparameters in SE MN Trout Streams	2008	2008	2										
S000-287	EQUIS	MISSISSIPPI R LOCK & DAM #5 3 MI SE OF MINNEISKA	Minnesota Milestone Site River Monitoring Program	1999	2008	462	126		80		58			3		
S000-287	EQUIS	MISSISSIPPI R LOCK & DAM #5 3 MI SE OF MINNEISKA	MPCA Stream Monitoring Program Project	1974	1998	905	942	2	239	171	187	309	41	23	2	9
S000-287	EQUIS	MISSISSIPPI R LOCK & DAM #5 3 MI SE OF MINNEISKA	US Army Corps of Engineers Lock & Dam Transparency	2006	2006	38										
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Ambient Trace Metals	2008	2009	23				6	8	21	3	3		
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Citizen Stream Monitoring Plus Program	2005	2005	8										
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Citizen Stream Monitoring Program	2002	2002	914										
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Minnesota Milestone Site River Monitoring Program	1999	2008	371	128		78		55			1		
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	MPCA Stream Monitoring Program Project	1974	1998	1185	993	199	285	174	567	309	43	24	2	9
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Southeast Regional Fecal Study 2007	2007	2007	45			15							
S000-288	EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Whitewater Watershed S Branch Bacteria Reduction	2007	2009	74			24							
S000-321	EQUIS	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	MPCA Intensive Survey 742703	1974	1974	8	4		4	4	4					1
S000-321	EQUIS	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2001	258			93							
S000-321	EQUIS	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	Whitewater River TMDL	2009	2010	104	26				8					
S000-321	EQUIS	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	Whitewater Watershed S Branch Bacteria Reduction	2007	2009	53			17							
S000-322	EQUIS	SF WHITEWATER- TRAIL XING S6NWQ 4 MI S OF ALTURA	MPCA Intensive Survey 742703	1974	1974	8	4		4	4	4	1				1
S000-323	EQUIS	SF WHITEWATER R AT CR-119 2 MI NE OF ST CHARLES	MPCA Intensive Survey 742703	1974	1974	8	4		4	4	4	1				1
S000-323	EQUIS	SF WHITEWATER R AT CR-119 2 MI NE OF ST CHARLES	Whitewater Watershed S Branch Bacteria Reduction	2007	2009	90			23							
S000-324	EQUIS	SF WHITEWATER R RD BTN S8/17 1 MI N OF ST CHARLS	MPCA Intensive Survey 742703	1974	1974	3		1	4	4	4	6	2	2		
S000-325	EQUIS	S FK WHITEWATER R AT MN-74 AT ST CHARLES	MPCA Intensive Survey 742703	1974	1974	3		1	4	3	4	6	2	2		
S000-326	EQUIS	SF WHITEWATER R US-14 IN S23 2 MI W OF ST CHARLS	MPCA Intensive Survey 742703	1974	1974	8	4		3	4	4		1			1
S000-327	EQUIS	S FK WHITEWATER R AT CSAH-10 AT DOVER	Citizen Stream Monitoring Program	2006	2008	179										
S000-327	EQUIS	S FK WHITEWATER R AT CSAH-10 AT DOVER	MPCA Intensive Survey 742703	1974	1974	8	4		3	1	3		1			1
S000-328	EQUIS	S FK WHITEWATER R AT US-14 AT EYOTA	Citizen Stream Monitoring Program	2010	2010	132										
S000-328	EQUIS	S FK WHITEWATER R AT US-14 AT EYOTA	MPCA Intensive Survey 742703	1974	1974	8	4		3	1	2		1			1
S000-329	EQUIS	S FK WHITEWATER R AT CSAH-7 AT EYOTA	MPCA Intensive Survey 742703	1974	1974	8	4		3	1	2		1			1
S000-451	EQUIS	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	MPCA Intensive Survey 772715	1977	1977	4	5		2							
S000-451	EQUIS	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	56			91							
S000-451	EQUIS	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	Whitewater River TMDL	2009	2010	115	32				8					
S000-452	EQUIS	NF WHITEWATER TRIB- CSAH-25 2 MI SE OF PLAINVIEW	MPCA Intensive Survey 772715	1977	1977	5	5		2		1	4				
S000-452	EQUIS	NF WHITEWATER TRIB- CSAH-25 2 MI SE OF PLAINVIEW	MPCA Intensive Survey 802718	1980	1980	5	5									
S000-452	EQUIS	NF WHITEWATER TRIB- CSAH-25 2 MI SE OF PLAINVIEW	MPCA Intensive Survey 832706	1983	1983	6	6		1		2					

				Period		Counts										
Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
S000-453	EQUIS	N FK WHITEWATER R AT CSAH-4 3 MI S OF PLAINVIEW	MPCA Intensive Survey 772715	1977	1977	4	5		2							
S000-453	EQUIS	N FK WHITEWATER R AT CSAH-4 3 MI S OF PLAINVIEW	MPCA Intensive Survey 802718	1980	1980	1	5									
S000-454	EQUIS	NF WHITEWATER R-RD BTN S25/30 2.5 MI E OF ELGIN	MPCA Intensive Survey 772715	1977	1977	4	5		2							
S000-454	EQUIS	NF WHITEWATER R-RD BTN S25/30 2.5 MI E OF ELGIN	MPCA Intensive Survey 802718	1980	1980	1	5									
S000-455	EQUIS	N FK WHITEWATER R AT CR-73 1.5 MI E OF ELGIN	MPCA Intensive Survey 772715	1977	1977	4	5		2							
S000-455	EQUIS	N FK WHITEWATER R AT CR-73 1.5 MI E OF ELGIN	MPCA Intensive Survey 802718	1980	1980	3	5									
S000-456	EQUIS	N FK WHITEWATER R IN T108NR12WS26NWQSWQ AT ELGIN	MPCA Intensive Survey 772715	1977	1977	5	5		2		1	4				
S000-456	EQUIS	N FK WHITEWATER R IN T108NR12WS26NWQSWQ AT ELGIN	MPCA Intensive Survey 802718	1980	1980	1	5									
S000-774	EQUIS	NF WHITEWATER R IN MID OF S3 5 MI S OF PLAINVIEW	MPCA Intensive Survey 802718	1980	1980	1	5									
S000-775	EQUIS	NF WHITEWATER TRIB IN S34NWQSEQ SE OF PLAINVIEW	MPCA Intensive Survey 802718	1980	1980	5	5									
S000-775	EQUIS	NF WHITEWATER TRIB IN S34NWQSEQ SE OF PLAINVIEW	MPCA Intensive Survey 832706	1983	1983	6	6		1		2					
S000-776	EQUIS	N FK WHITEWATER R AT MN-42 AT ELGIN	MPCA Intensive Survey 802718	1980	1980	1	5									
S000-826	EQUIS	GARVIN BROOK AT MINNESOTA CITY	MPCA Stream Monitoring Program Project	1981	1981	8	6		4	3	2	7	1			
S000-826	EQUIS	GARVIN BROOK AT MINNESOTA CITY	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2001	2002	30			43							
S000-827	EQUIS	GARVIN BROOK NEAR MINNESOTA CITY	MPCA Stream Monitoring Program Project	1981	1982	27	20		9		6			2		
S000-828	EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	Ambient Trace Metals	2008	2009	25				8	10	28	4	4		
S000-828	EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	Citizen Stream Monitoring Program	2002	2005	96										
S000-828	EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	Minnesota Milestone Site River Monitoring Program	1999	2003	385	135		92		56			2		
S000-828	EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	MPCA Stream Monitoring Program Project	1981	1998	1500	885	203	205	74	545	56	12	112		
S000-828	EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	169			99							
S000-829	EQUIS	GARVIN BROOK NEAR MINNESOTA CITY	Garvin Brook Turbidity TMDL	2009	2009	137	34									
S000-829	EQUIS	GARVIN BROOK NEAR MINNESOTA CITY	MPCA Stream Monitoring Program Project	1981	1989	39	30		6		10			1		
S000-830	EQUIS	GARVIN BROOK NEAR STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	24	13		6		8			1		
S000-831	EQUIS	GARVIN BROOK AT STOCKTON	Citizen Stream Monitoring Program	2002	2009	432										
S000-831	EQUIS	GARVIN BROOK AT STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	23	13		6	3	8	7	1	1		
S000-831	EQUIS	GARVIN BROOK AT STOCKTON	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2001	2002	167			40							
S000-832	EQUIS	GARVIN BROOK AT STOCKTON	MPCA Stream Monitoring Program Project	1981	1983	113	62	5	28		34	10	1	8		
S000-833	EQUIS	GARVIN BROOK AT THE ARCHES	MPCA Stream Monitoring Program Project	1981	1982	24	13		6		8			1		
S000-834	EQUIS	UNNAMED CREEK AT STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	23	13		6		8			1		
S000-834	EQUIS	UNNAMED CREEK AT STOCKTON	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2001	2002	168			41							
S000-839	EQUIS	PETERSON CREEK AT THE ARCHES	Citizen Stream Monitoring Program	2002	2002	65										
S000-839	EQUIS	PETERSON CREEK AT THE ARCHES	MPCA Stream Monitoring Program Project	1981	1982	24	13		6		8			1		
S000-839	EQUIS	PETERSON CREEK AT THE ARCHES	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2001	2002	168			39							
S000-840	EQUIS	ROLLINGSTONE CK. NEAR MINNESOTA CITY	MPCA Stream Monitoring Program Project	1981	1981	11	6		3		4					
S000-842	EQUIS	UNNAMED CREEK NEAR STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	24	13		6		8			1		
S000-844	EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	MPCA Stream Monitoring Program Project	1981	1983	119	69	5	31		36	10	1	9		
S000-845	EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	18	13		6		4			1		
S000-846	EQUIS	STOCKTON VALLEY CK. NEAR STOCKTON	MPCA Stream Monitoring Program Project	1981	1982	18	13		6		4			1		
S000-978	EQUIS	NF WHITEWATER-E OF CARLEY ST PK CMPGD E OF ELGIN	MPCA Intensive Survey 832706	1983	1983	6	6		1		2					
S000-978	EQUIS	NF WHITEWATER-E OF CARLEY ST PK CMPGD E OF ELGIN	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	53			92							
S000-981	EQUIS	NF WHITEWATER R BLW TRIB S34NWQ SE OF PLAINVIEW	MPCA Intensive Survey 832706	1983	1983	6	6		1		2					
S000-982	EQUIS	NF WHITEWATER BTN S33/34 3.5 MI SE OF PLAINVIEW	MPCA Intensive Survey 832706	1983	1983	6	6		1		2					
S001-449	EQUIS	SNAKE CK 0.7 MI S OF HWY 61	Citizen Stream Monitoring Program	2007	2007	100										
S001-528	EQUIS	GARVIN BK NEAR US-14, 1/2 MI W OF STOCKTON	Citizen Stream Monitoring Program	2001	2001	502										
S001-529	EQUIS	STOCKTON VALLEY CK, 1 MILE S OF STOCKTON	Citizen Stream Monitoring Program	2000	2010	623										

				Period		Counts										
Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
S001-529	EQUIS	STOCKTON VALLEY CK, 1 MILE S OF STOCKTON	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	352			99							
S001-531	EQUIS	UNN TRIB TO GARVIN BK, 1.5 MI W OF STOCKTON	Citizen Stream Monitoring Program	2000	2005	58										
S001-532	EQUIS	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	Citizen Stream Monitoring Program	2010	2010	432										
S001-532	EQUIS	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	Garvin Brook Turbidity TMDL	2009	2009	160	40		1							
S001-532	EQUIS	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2002	2002	75			12							
S001-533	EQUIS	MIDDLE VLY CK NEAR MIDDLE VALLEY RD, 2 MI SE OF ROLLINGSTONE	Citizen Stream Monitoring Program	2000	2000	23										
S001-704	EQUIS	GORMAN CR 1 MI S OF KELLOGG, MN	Citizen Stream Monitoring Program	2001	2007	613										
S001-717	EQUIS	SPELTZ CR IN ROLLINGSTONE, MN	Citizen Stream Monitoring Program	2008	2010	1029										
S001-718	EQUIS	ROLLINGSTONE CR AT CSAH 248 IN ROLLINGSTONE, MN	Citizen Stream Monitoring Program	2001	2001	31										
S001-728	EQUIS	GILMORE CR, 1.1 MI S OF WINONA, MN	Citizen Stream Monitoring Program	2005	2010	1431										
S001-728	EQUIS	GILMORE CR, 1.1 MI S OF WINONA, MN	Multiparameters in SE MN Trout Streams	2008	2008	2										
S001-741	EQUIS	BEAVER CR AT HWY 74, 4.6 MI N OF ELBA, MN	Citizen Stream Monitoring Plus Program	2005	2005	11										
S001-741	EQUIS	BEAVER CR AT HWY 74, 4.6 MI N OF ELBA, MN	Citizen Stream Monitoring Program	2001	2009	1877										
S001-742	EQUIS	WHITEWATER R AT CSAH 30, 4.5 MI N OF ELBA, MN	Citizen Stream Monitoring Plus Program	2005	2005	12										
S001-742	EQUIS	WHITEWATER R AT CSAH 30, 4.5 MI N OF ELBA, MN	Citizen Stream Monitoring Program	2001	2009	1453										
S001-742	EQUIS	WHITEWATER R AT CSAH 30, 4.5 MI N OF ELBA, MN	Major Watershed Pollutant Load Monitoring Network	2008	2011	307	157			42	60					
S001-743	EQUIS	S FK WHITEWATER R AT CSAH 26, 1 MI E OF ELBA, MN	Citizen Stream Monitoring Plus Program	2005	2005	8										
S001-743	EQUIS	S FK WHITEWATER R AT CSAH 26, 1 MI E OF ELBA, MN	Citizen Stream Monitoring Program	2002	2008	678										
S001-744	EQUIS	N FK WHITEWATER R AT CSAH 26, 0.4 MI NE OF ELBA, MN	Citizen Stream Monitoring Plus Program	2005	2005	9										
S001-744	EQUIS	N FK WHITEWATER R AT CSAH 26, 0.4 MI NE OF ELBA, MN	Citizen Stream Monitoring Program	2001	2008	1006										
S001-745	EQUIS	N FK WHITEWATER R AT HWY 74 AT ELBA, MN	Citizen Stream Monitoring Plus Program	2005	2005	9										
S001-745	EQUIS	N FK WHITEWATER R AT HWY 74 AT ELBA, MN	Citizen Stream Monitoring Program	2001	2008	1011										
S001-767	EQUIS	WHITEWATER R AT RAILROAD BRG AT MOUTH, 0.5 MI SE OF WEAVER	Citizen Stream Monitoring Program	2001	2003	367										
S001-767	EQUIS	WHITEWATER R AT RAILROAD BRG AT MOUTH, 0.5 MI SE OF WEAVER	Major Watershed Pollutant Load Monitoring Network	2007	2007	10	4				3					
S001-767	EQUIS	WHITEWATER R AT RAILROAD BRG AT MOUTH, 0.5 MI SE OF WEAVER	MissRiver Winona Intensive Watershed Monitoring	2010	2010	12	4		2	3	3					
S001-769	EQUIS	WHITEWATER R, MID FK AT STATE PARK RD 5 MI N OF ST. CHARLES	Citizen Stream Monitoring Plus Program	2005	2005	7										
S001-769	EQUIS	WHITEWATER R, MID FK AT STATE PARK RD 5 MI N OF ST. CHARLES	Citizen Stream Monitoring Program	2001	2009	1035										
S001-824	EQUIS	S FK WHITEWTR R, 500 FT N OF US-14, 1/2 MI W OF ST. CHARLES	Citizen Stream Monitoring Plus Program	2005	2005	11										
S001-824	EQUIS	S FK WHITEWTR R, 500 FT N OF US-14, 1/2 MI W OF ST. CHARLES	Citizen Stream Monitoring Program	2002	2006	1269										
S001-824	EQUIS	S FK WHITEWTR R, 500 FT N OF US-14, 1/2 MI W OF ST. CHARLES	Whitewater Watershed S Branch Bacteria Reduction	2007	2009	91			24							
S001-825	EQUIS	MIDDLE FK WHITEWATER R, AT BRG AT MN-74, AT ELBA	Citizen Stream Monitoring Plus Program	2005	2005	7										
S001-825	EQUIS	MIDDLE FK WHITEWATER R, AT BRG AT MN-74, AT ELBA	Citizen Stream Monitoring Program	2003	2008	647										
S001-826	EQUIS	S FK WHTWTR R, ST. CHARLS TNSHP RD 17, 1/2 MI N ST. CHARLES	Citizen Stream Monitoring Plus Program	2005	2005	11										
S001-826	EQUIS	S FK WHTWTR R, ST. CHARLS TNSHP RD 17, 1/2 MI N ST. CHARLES	Citizen Stream Monitoring Program	2003	2008	1393										
S001-826	EQUIS	S FK WHTWTR R, ST. CHARLS TNSHP RD 17, 1/2 MI N ST. CHARLES	Whitewater Watershed S Branch Bacteria Reduction	2007	2009	96			24							
S001-831	EQUIS	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	Citizen Stream Monitoring Program	2001	2001	337										
S001-831	EQUIS	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	322			93							
S001-831	EQUIS	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	Whitewater River Middle Fork/Crow Spring Project	2003	2003	6	10		6	13				3		
S001-831	EQUIS	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	Whitewater River TMDL	2009	2010	103	32				12					
S001-832	EQUIS	MID FK WHTWTR R, 1/2 MI N OF CR-152, 5 MI N OF ST. CHARLES	Citizen Stream Monitoring Plus Program	2005	2005	14										
S001-832	EQUIS	MID FK WHTWTR R, 1/2 MI N OF CR-152, 5 MI N OF ST. CHARLES	Citizen Stream Monitoring Program	2001	2010	1781										
S001-833	EQUIS	N BR WHITEWATER R, 1/3 MI S OF CSAH-4, 5 MI SE OF PLAINVIEW	Citizen Stream Monitoring Plus Program	2005	2005	10										
S001-833	EQUIS	N BR WHITEWATER R, 1/3 MI S OF CSAH-4, 5 MI SE OF PLAINVIEW	Citizen Stream Monitoring Program	2004	2009	1125										
S001-842	EQUIS	UNN TRIB TO MF WHTWTR R, 1 MI S CSAH-2, 3 1/2 MI E L VALLEY	Citizen Stream Monitoring Program	2001	2001	100										

				Period		Counts										
Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
S001-879	EQUIS	N FK WHITEWATER R W OF CSAH 4, 2.75 MI S OF PLAINVIEW, MN	Citizen Stream Monitoring Plus Program	2005	2005	10										
S001-879	EQUIS	N FK WHITEWATER R W OF CSAH 4, 2.75 MI S OF PLAINVIEW, MN	Citizen Stream Monitoring Program	2001	2006	717										
S001-951	EQUIS	SPELTZ CR IN EAST SIDE OF ROLLINGSTONE, MN	Citizen Stream Monitoring Program	2002	2002	149										
S002-072	EQUIS	LOGAN BR N FK WHITEWATER R AT CSAH-10, 5.5 MI S OF PLAINVIEW	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	54			93							
S002-073	EQUIS	MID FK WHITEWATER R ON CSAH-9 BRG, 3.5 MI NW OF DOVER	Citizen Stream Monitoring Program	2004	2004	137										
S002-074	EQUIS	MID FK WHITEWATER R AT CSAH-10 BRG, 3.5 MI N OF DOVER	Citizen Stream Monitoring Plus Program	2005	2005	5										
S002-074	EQUIS	MID FK WHITEWATER R AT CSAH-10 BRG, 3.5 MI N OF DOVER	Citizen Stream Monitoring Program	2002	2008	601										
S002-398	EQUIS	PLEASANT VALLEY CR E OF CSAH-17, 3.5 MI S OF WINONA, MN	Citizen Stream Monitoring Program	2003	2009	1376										
S002-406	EQUIS	WHITEWATER R, S FK, AT CSAH 37, 1.75 MI SE OF ELBA, MN	Citizen Stream Monitoring Program	2003	2003	69										
S002-406	EQUIS	WHITEWATER R, S FK, AT CSAH 37, 1.75 MI SE OF ELBA, MN	Multiparameters in SE MN Trout Streams	2008	2008	2										
S002-545	EQUIS	LOGAN BR N FK WHITEWATER R AT MOUTH, 5 MI SE OF PLAINVIEW	Logan Creek Subwatershed Project	2004	2004	180	59		20		20					
S002-546	EQUIS	LOGAN BR N FK WHITEWATER R AT CSAH 2, 6 MI S OF PLAINVIEW	Logan Creek Subwatershed Project	2004	2004	168	81		28		9					
S003-562	EQUIS	BEAVER CK OFF WHITEWATER TOWNSHIP RD 1, 7.5 MI NW OF ALTURA	Citizen Stream Monitoring Plus Program	2005	2005	6										
S003-562	EQUIS	BEAVER CK OFF WHITEWATER TOWNSHIP RD 1, 7.5 MI NW OF ALTURA	Citizen Stream Monitoring Program	2005	2009	966										
S003-604	EQUIS		Whitewater River Watershed Nat Monitoring Program	1999	2005	385	572		19		166					
S003-605	EQUIS	HDWTRS SPRING & TRIB TO S FK WHITEWATER R IN S30, N OF I-90	Whitewater River Watershed Nat Monitoring Program	1999	2005	304	455		16		127					
S003-624	EQUIS	HDWTRS SPRING & TRIB AT POND OTLT TO SF WHITEWATER R	Whitewater River Watershed Nat Monitoring Program	2000	2000				3							
S003-687	EQUIS	GARVIN BK AT RR BRIDGE, 2.6 MI SW OF STOCKTON, MINNESOTA	Whitewater River and Garvin Brook Pilot Turbidity TMDL	2000	2002	352			94							
S003-707	EQUIS	CROW SPRING TO WHTWTR R M FK, NO CSAH-9 4.5 MI NW ST CHARLES	Whitewater River Middle Fork/Crow Spring Project	2003	2003	2	4		2	5	4			1		
S003-708	EQUIS	CROW SPRING TO WHTWTR R M FK, W CR-107, 5 MI NW ST CHARLES	Whitewater River Middle Fork/Crow Spring Project	2003	2003	4	7		4	10	8			2		
S003-709	EQUIS	WHITEWATER R M FK, SE OF QUINCY ROAD NE, 5 MI NW ST CHARLES	Whitewater River Middle Fork/Crow Spring Project	2003	2003	4	7		4	10	8			2		
S003-710	EQUIS	WHITEWATER R M FK, W OF CR-107, 5 MI NW OF ST CHARLES	Whitewater River Middle Fork/Crow Spring Project	2003	2003	2	4		2	5	4			1		
S003-784	EQUIS	GARVIN BK UPST OF US-61 IN MN CITY, MN	Citizen Stream Monitoring Program	2005	2010	1055										
S003-791	EQUIS	GILMORE CK AT VILA AVENUE IN WINONA, MN	Citizen Stream Monitoring Program	2007	2007	68										
S003-792	EQUIS	PLEASANT VALLEY CK AT CLINTON DR N, 2 MI S OF WINONA, MN	Citizen Stream Monitoring Program	2006	2010	606										
S003-792	EQUIS	PLEASANT VALLEY CK AT CLINTON DR N, 2 MI S OF WINONA, MN	Winona County Cold Water Trout Stream Monitoring	2006	2006	11					4					
S003-793	EQUIS	PLEASANT VALLEY CK AT HOLLER HILL RD IN WINONA, MN	Citizen Stream Monitoring Program	2006	2010	574										
S003-793	EQUIS	PLEASANT VALLEY CK AT HOLLER HILL RD IN WINONA, MN	Winona County Cold Water Trout Stream Monitoring	2006	2006	10					3					
S003-800	EQUIS	E BURNS VALLEY CK OFF E BURNS VALLEY RD IN WINONA, MN	Citizen Stream Monitoring Program	2005	2007	433										
S003-806	EQUIS	E BURNS VALLEY CK AT CSAH 105 IN WINONA, MN	Citizen Stream Monitoring Program	2005	2010	1435										
S004-011	EQUIS	TROUT RUN JUST E OF MN-74, 5 MI N OF ST. CHARLES	Grazing Lands Improvement Porject	2005	2005	4			1		1					
S004-012	EQUIS	TROUT RUN, JUST E OF MN-74, 5 MI N OF ST. CHARLES	Grazing Lands Improvement Porject	2005	2005	4			1		1					
S004-013	EQUIS	GARVIN BK, 0.5 MI S OF US-14, 2.5 MI NE OF LEWISTON	Grazing Lands Improvement Porject	2005	2005	8			2		2					
S004-240	EQUIS	BIG TROUT CK (PICKWICK CK) E OF CSAH-7, 1.3 MI S OF PICKWICK	Citizen Stream Monitoring Program	2006	2006	51										
S004-240	EQUIS	BIG TROUT CK (PICKWICK CK) E OF CSAH-7, 1.3 MI S OF PICKWICK	Winona County Cold Water Trout Stream Monitoring	2006	2006	11										
S004-243	EQUIS	BIG TROUT CK (PICKWICK CK) 130 FT DWNSTRM OF CSAH-7 BRG	Citizen Stream Monitoring Program	2006	2006	70										
S004-243	EQUIS	BIG TROUT CK (PICKWICK CK) 130 FT DWNSTRM OF CSAH-7 BRG	Winona County Cold Water Trout Stream Monitoring	2006	2006	9										
S004-244	EQUIS	BIG TROUT CK(PICKWICK CK) UPSTM OF US-61 2 MI NE OF PICKWICK	Citizen Stream Monitoring Program	2006	2006	65										
S004-245	EQUIS	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	Citizen Stream Monitoring Program	2006	2007	69										
S004-245	EQUIS	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	Winona County Cold Water Trout Stream Monitoring	2006	2006	3										
S004-246	EQUIS	UNN STM TO PLEASANT VALLEY CK AT CSAH-17, 2.5 MI S OF WINONA	Citizen Stream Monitoring Program	2006	2007	504										
S004-246	EQUIS	UNN STM TO PLEASANT VALLEY CK AT CSAH-17, 2.5 MI S OF WINONA	Winona County Cold Water Trout Stream Monitoring	2006	2006	8					6					
S004-247	EQUIS	BIG TROUT CK (PICKWICK CK), 0.16 MI SW OF PICKWICK MILL	Citizen Stream Monitoring Program	2006	2006	70										
S004-247	EQUIS	BIG TROUT CK (PICKWICK CK), 0.16 MI SW OF PICKWICK MILL	Winona County Cold Water Trout Stream Monitoring	2006	2006	1										
S004-248	EQUIS	BIG TROUT CK (PICKWICK CK) AT CSAH-7 BRG AT PICKWICK MILL	Citizen Stream Monitoring Program	2006	2006	70										

				Period		Counts										
Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
S004-248	EQUIS	BIG TROUT CK (PICKWICK CK) AT CSAH-7 BRG AT PICKWICK MILL	Winona County Cold Water Trout Stream Monitoring	2006	2006	9										
S004-611	EQUIS	BEACH AT WHITEWATER STATE PARK (I.E., NOT STREAM CHANNEL)	Whitewater State Park Bacteria Monitoring	2005	2005	2			3		1					
S004-612	EQUIS		Whitewater State Park Bacteria Monitoring	2005	2005	2			3		1					
S004-664	EQUIS	UNN STRM TO SPELTZ CK, 1.5 MI NW OF ROLLINGSTONE	Citizen Stream Monitoring Program	2007	2010	749										
S004-708	EQUIS	WHITEWATER R, NF AT CARLEY STATE PK, 2.75 MI S OF PLAINVIEW	Citizen Stream Monitoring Program	2007	2008	192										
S004-801	EQUIS	SPELTZ CK AT CSAH-25, 1.25 MI NW OF ROLLINGSTONE	Citizen Stream Monitoring Program	2007	2010	761										
S004-802	EQUIS	SPELTZ CK AT TWP RD 22, 0.5 MI NW OF ROLLINGSTONE	Citizen Stream Monitoring Program	2007	2010	763										
S004-802	EQUIS	SPELTZ CK AT TWP RD 22, 0.5 MI NW OF ROLLINGSTONE	Multiparameters in SE MN Trout Streams	2008	2008	2										
S005-072	EQUIS	BEAVER CK JUST S OF TWNSHP RD 16, 5.5 MI SE OF PLAINVIEW	Multiparameters in SE MN Trout Streams	2008	2009	24					5					
S005-077	EQUIS	TROUT CK JUST W OF CSAH-31, 4 MI E OF BEAVER, MN	Multiparameters in SE MN Trout Streams	2008	2009	29					6					
S005-341	EQUIS	WHITEWATER R, NF JUST UPSTM OF TR-29 IN FAIRWATER	Multiparameters in SE MN Trout Streams	2008	2008	2										
S005-390	EQUIS	EAST INDIAN CK 100 YDS SW OF US-61 AND CR-84 6 MI SE KELLOGG	Citizen Stream Monitoring Program	2008	2010	326										
S005-586	EQUIS	GARVIN BK, 300 FT UPSTM OF RAILROAD BRG IN STOCKTON	Citizen Stream Monitoring Program	2008	2010	612										
S005-587	EQUIS	GARVIN BK AT CSAH-23 IN STOCKTON	Citizen Stream Monitoring Program	2008	2010	690										
S006-127	EQUIS	E BURNS VALLEY CK AT E BURNS VALLEY RD, 3.2 MI S OF WINONA	Citizen Stream Monitoring Program	2009	2009	128										
S006-128	EQUIS	E BURNS VALLEY CK, E OF E BURNS VALLEY RD 4.6 MI S OF WINONA	Citizen Stream Monitoring Program	2009	2009	128										

Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
85-0011-01-102	MDA	WINONA (SOUTH BAY)	Pesticide Monitoring Program	2010	2011	--	--	368	--	--	--	--	--	--	--	--
S000-288	MDA	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	Pesticide Monitoring Program	1991	1993	--	--	1656	--	--	--	--	--	--	--	--
S000-321	MDA	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	Pesticide Monitoring Program	1992	2011	2	306	49864	--	--	--	--	--	--	--	--
S000-451	MDA	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	Pesticide Monitoring Program	2005	2007	1	39	2392	--	--	--	--	--	--	--	--
S000-828	MDA	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	Pesticide Monitoring Program	2005	2005	--	24	3128	--	--	--	--	--	--	--	--
S001-831	MDA	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	Pesticide Monitoring Program	1993	2011	209	1729	158608	--	--	--	--	--	--	--	--
S004-245	MDA	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	Pesticide Monitoring Program	2005	2006	--	24	1472	--	--	--	--	--	--	--	--
S006-655	MDA	TROUT CREEK ADJACENT TO CSAH-31, 11.5 MI E OF PLAINVIEW, MN	Pesticide Monitoring Program	2010	2010	--	--	368	--	--	--	--	--	--	--	--
S006-689	MDA	WHITEWATER R, N FK, AT CSAH-2, .7 MI S OF ELGIN, MN (10EM059)	Pesticide Monitoring Program	2010	2010	--	--	184	--	--	--	--	--	--	--	--
SP00032	MDA	TROUT VALLEY CK SPRING, 550 FT EOF CSAH-31, 8.4 MI SE OF KELLOGG	Pesticide Monitoring Program	2011	2011	--	4	736	--	--	--	--	--	--	--	--

Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
WW01.3M	DNR	Whitewater River Near Weaver on Hwy 61 bridge	Long Term Research Monitoring Program	1996	2008	1573	955	--	--	849	856	--	--	--	--	--

Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
S000-325	Olm	S FK WHITEWATER R AT MN-74 AT ST CHARLES	Olmsted County Surface Water Monitoring Network	1999	2008	6	53	1	8	2	106	--	--	--	--	--
S002-072	Olm	LOGAN BR N FK WHITEWATER R AT CSAH-10, 5.5 MI S OF PLAINVIEW	Olmsted County Surface Water Monitoring Network	1999	2008	6	48	1	8	--	96	--	--	--	--	--
S007-140	Olm	WHITEWATER R, MF AT CR-152 BRG, 5 MI NW OF ST. CHARLES, MN	Olmsted County Surface Water Monitoring Network	1999	2008	6	46	1	8	--	92	--	--	--	--	--
S007-144	Olm	WW R, NF AT TR-29 (FAIRWATER RD), 7.5 MI SE OF PLAINVIEW, MN	Olmsted County Surface Water Monitoring Network	1999	2008	6	56	1	8	2	112	--	--	--	--	--
S007-145	Olm	WHITEWATER R, NF AT 65TH ST NE BRG, 2.5 MI SW OF ELGIN, MN	Olmsted County Surface Water Monitoring Network	1999	2008	6	46	1	8	--	92	--	--	--	--	--
S007-146	Olm	WHITEWATER R, SF AT US-14 CULVERT, 1 MI NW OF DOVER, MN	Olmsted County Surface Water Monitoring Network	1999	2008	6	38	1	8	--	76	--	--	--	--	--
11	Olm	M. Fork of WW River, SE Sect 26, Quincy TSHP under bridge of CR 153	Olmsted County Surface Water Monitoring Network	1972	1973	71	34	--	12	--	33	--	--	--	--	--
11A	Olm	S. Fork WW River, SE , Sect 15, under bridge of CR 10, north of Dover	Olmsted County Surface Water Monitoring Network	1972	1980	72	40	--	16	--	32	--	--	--	--	--

				Period		Counts										
Location ID	Source	Location Description	Program Description	Start	End	Phys	Nutr	Pest	Bio	Metal[1]	NonMetal[1]	Metal[2]	Nonmetal[2]	OrgC	Radio	MBAS
5376000	USGS	NORTH FORK WHITEWATER RIVER NEAR ELBA, MN	Unknown	1967	2012	2174	340	--	--	1086	1227	116	--	--	--	--
5376100	USGS	MIDDLE FORK WHITEWATER RIVER NR ST. CHARLES, MN	Unknown	1988	1992	210	--	--	--	--	--	--	--	--	--	--
5376500	USGS	SOUTH FORK WHITEWATER RIVER NEAR ALTURA, MN	Unknown	1961	1991	29	6	--	--	15	12	19	--	--	--	--
5376800	USGS	WHITEWATER RIVER NEAR BEAVER, MN	Unknown	1975	2012	138	--	--	--	--	--	--	--	--	--	--
5377508	USGS	TROUT CREEK NEAR WEAVER, MN	Unknown	2004	2004	7	3	--	--	5	5	--	--	--	--	--
5377550	USGS	DEERING VALLEY CREEK NEAR WHITMAN, MN	Unknown	2004	2004	7	3	--	--	5	5	--	--	--	--	--
5378230	USGS	STOCKTON VALLEY CREEK AT STOCKTON, MN	Unknown	1982	1985	122	--	--	--	--	--	--	--	--	--	--
5378235	USGS	GARVIN BROOK NEAR MINNESOTA CITY, MN	Unknown	1982	1985	148	--	--	--	--	--	--	--	--	--	--
5378245	USGS	GARVIN BROOK BLW US 61 AT MINNESOTA CITY, MN	Unknown	1981	1981	7	--	--	--	--	3	1	--	--	--	--

Key:

EQUIS	MPCA Database: http://pca-gis02.pca.state.mn.us/eda_surfacewater/index.html
MDA	Minnesota Department of Agriculture
USGS	United States Geological Survey
Olm	Olmsted County Environmental Resources

Note: MDNR not included in parameter counts due to a lack of information

Mississippi-Winona Parameter Key

Physical
Apparent color
Biochemical oxygen demand
Carbonaceous biochemical oxygen demand
Chemical oxygen demand
Chloride
Distance from/to
Flow
Oxidation reduction potential(ORP)
pH
Precipitation
Precipitation 24hr prior to monitoring event
Settleable solids
Specific conductance
Stream condition(text)
Stream Physical Appearance, Minnesota
Stream physical appearance
Stream recreational suitability
Stream stage
Temperature ,air
Temperature ,water
Total dissolved solids
Total solids
Total suspended solids
Total volatile solids
Transparency,tube with disk
Turbidity

Nutrients
Ammonia-nitrogen
Inorganic nitrogen
Kjeldahl nitrogen
Nitrate
Nitrite
Organic Nitrogen
Ortho-phosphate
Phosphorus

Biological
Chlorophyll-a,corrected for pheophytin
Chlorophyll-a,uncorrected for pheophytin
Coliform/Streptococcus ratio,fecal
Enterococcus
Escherichia coli
Fecal Coliform
Fecal Streptococcus Group Bacteria
Pheophytin-a
Total Coliform

Inorganic: Major Metal
Calcium
Calcium carbonate
Hardness,Ca,Mg
Magnesium
Potassium
Sodium

Inorganic: Major Non-Metal
Alkalinity
Bicarbonate
Chloride
Dissolved oxygen(DO)
Dissolved oxygen saturation
Fluoride
Silicate
Sulfate
Sulfide
Silica

Inorganic: Minor Metal
Aluminum
Barium
Cadmium
Chromium
Chromium (VI)
Copper
Iron
Lead
Manganese
Mercury
Nickel
Silver
Zinc

Inorganic: Minor Non-Metal
Arsenic
Boron
Cyanide
Selenium

Organic Carbon
Oil and Grease
Organic Carbon
Petroleum Phenols

Radiochemical
Alpha particle
Beta particle

Methylene Blue Active Sub
MBAS

Pesticide, Herbicide and Fungicide
2-Chloro-4-isopropylamino-6-amino-s-triazine
2-Choro-6-ethylamino-4-amino-s-triazine
Alachlor
Aldrin
Aroclor1254
Atrazine
Butylate
Carbaryl
Carbofuran
Chlorothalonil
Chlorpyrifos
Chlorpyrifos-methyl
Cyanazine
Diallate
Diazinon
Dieldrin
Ethalfluralin
Fonofos
Lindane
Linuron
Methylparathion
Metolachlor
Metribuzin
p,p'-DDE
p,p'-DDT
Pendimethalin
Petroleumphenols
Prometon
Propachlor
Propazine
S-Ethyldipropylthiocarbamate
Simazine
Terbufos
Trifluralin
Phorate
Endrin

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Minnesota Department of Natural Resources (MDNR) Biological Monitoring Summary

Mississippi River Fish Monitoring
DNR Fisheries – Lake City

Annual Fish Sampling in Pools 5, 5A, 6 and 7

- All fish species
- seining in backwater areas
- Main channel and side channel electrofishing

Annual Qualitative Habitat Index

- Backwater areas only
- Emergent and submergent plants

Fish Contaminant collections every 5 years (for consumption guidelines)

Trout Stream Sampling
DNR Fisheries – Lake City and Lanesboro Offices

All trout streams sampled every 3 to 6 years

- 1 to 3 stations per stream
- Stream or backpack electrofisher
- Population Estimate (depletion)at each station
- Qualitative Habitat Evaluation Index (QHEI)
- Frequency of survey and number of stations depends on size/importance of stream.

Long-Term Trout Stream Monitoring

Long-term monitoring stations on select Trout Streams (Fish, invertebrates, habitat, geomorphology, water quality)

Mississippi-River Winona Streams in the MNDNR Lanesboro Long-Term Monitoring Program

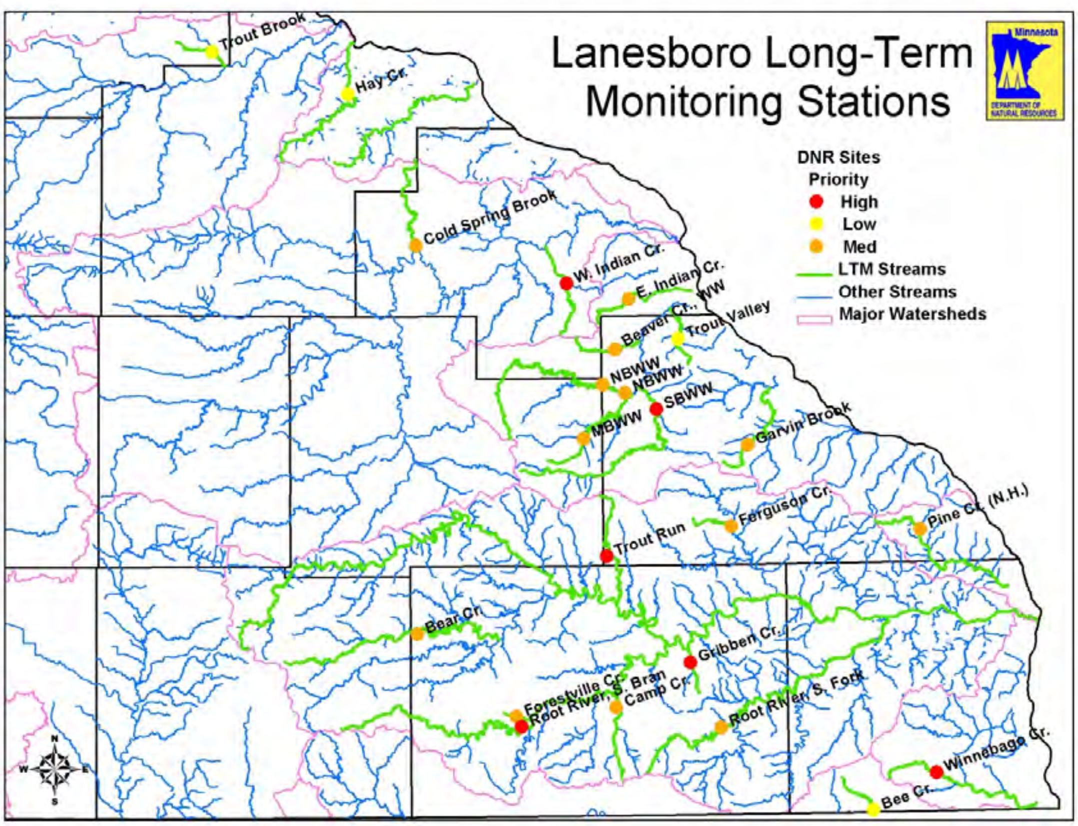
Stream Name	Stream Mile	Length of Station (ft)	Years of data collection	N	Season for fisheries assessment	Species of interest
Whitewater River, South Branch	3.5	2,260	1981-2009	25	Spring	BNT
Beaver Creek	3.5	1,078	1971-2009	31	Fall	BNT
East Indian Creek	7.0	660	2003-2009	7	Fall	BNT, BKT
Garvin Brook	2.8	830	1985-2009	25	Fall	BNT
Whitewater River, North Branch	1.2	1,750	1990-2009	15	Fall	BNT
Trout Valley Creek	5.3	912	2003-2009	7	Fall	BNT, BKT

Mississippi-River Winona Watershed Stream Data Collection Schedule for the Long-Term Monitoring Program

Stream Name	County	Priority	Aquatic Invert.	Discharge	Channel Morph.	Veg.	Water Quality	Water Quality Station
Whitewater River, South Branch	Winona	1	*	*	*	*	*	X
Beaver Creek	Winona	2	Even	2011	2011	2011	Survey only	
East Indian Creek	Wabasha	2	Even	2010	2010	2010	Survey only	
Garvin Brook	Winona	2	Odd	2010	2010	2010	Survey only	
Whitewater River, North Branch	Winona	2	Even	2010	2010	2010	Survey only	X
Trout Valley Creek	Winona	3	Odd	2012	2012	2012	Survey only	

1= High
2=Medium
3=Low
*=Annually

Lanesboro Long-Term Monitoring Stations



Ecological and Water Resources: Stream Habitat Program:

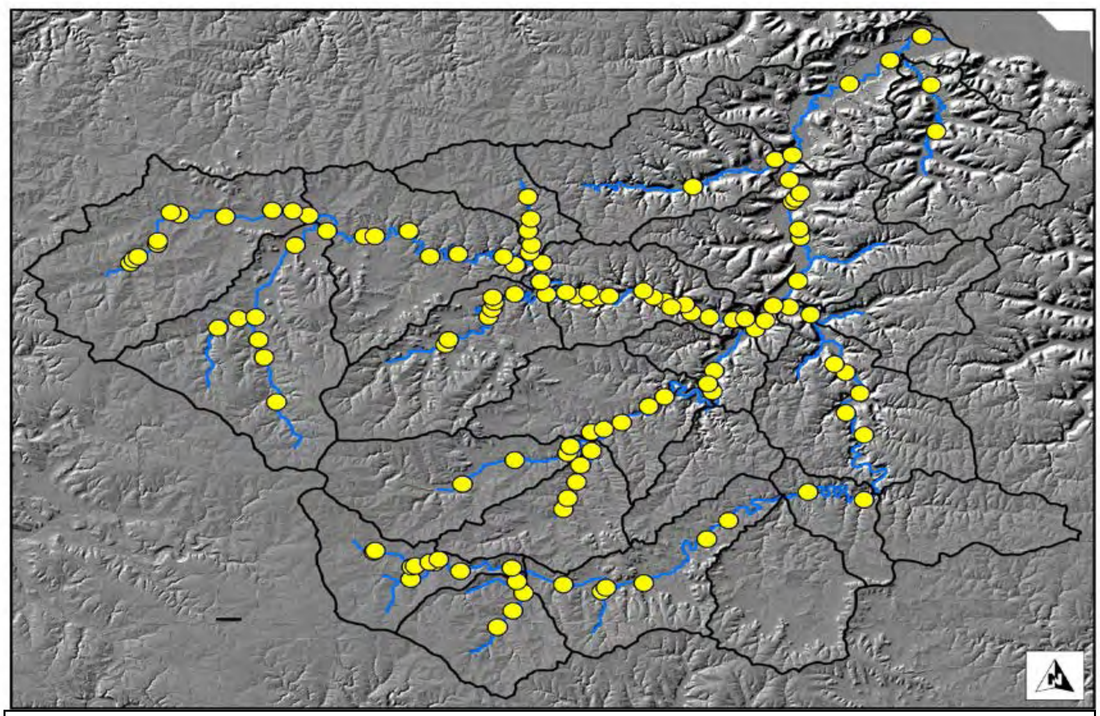
Contact Kevin Zytokovicz- DNR Hydrographer

Watershed Assessment of River Stability and Sediment Supply (WARSSS)

- http://water.epa.gov/scitech/datait/tools/warsss/index.cfm

Restoration projects important for improving aquatic biodiversity and healthy ecosystem

- Watershed based geomorphic assessment of perennial channels
- Goal is to have initial report completed Spring of 2013



MDNR Stream habitat Program, Fall 2012 Whitewater River Geomorphic Assessment

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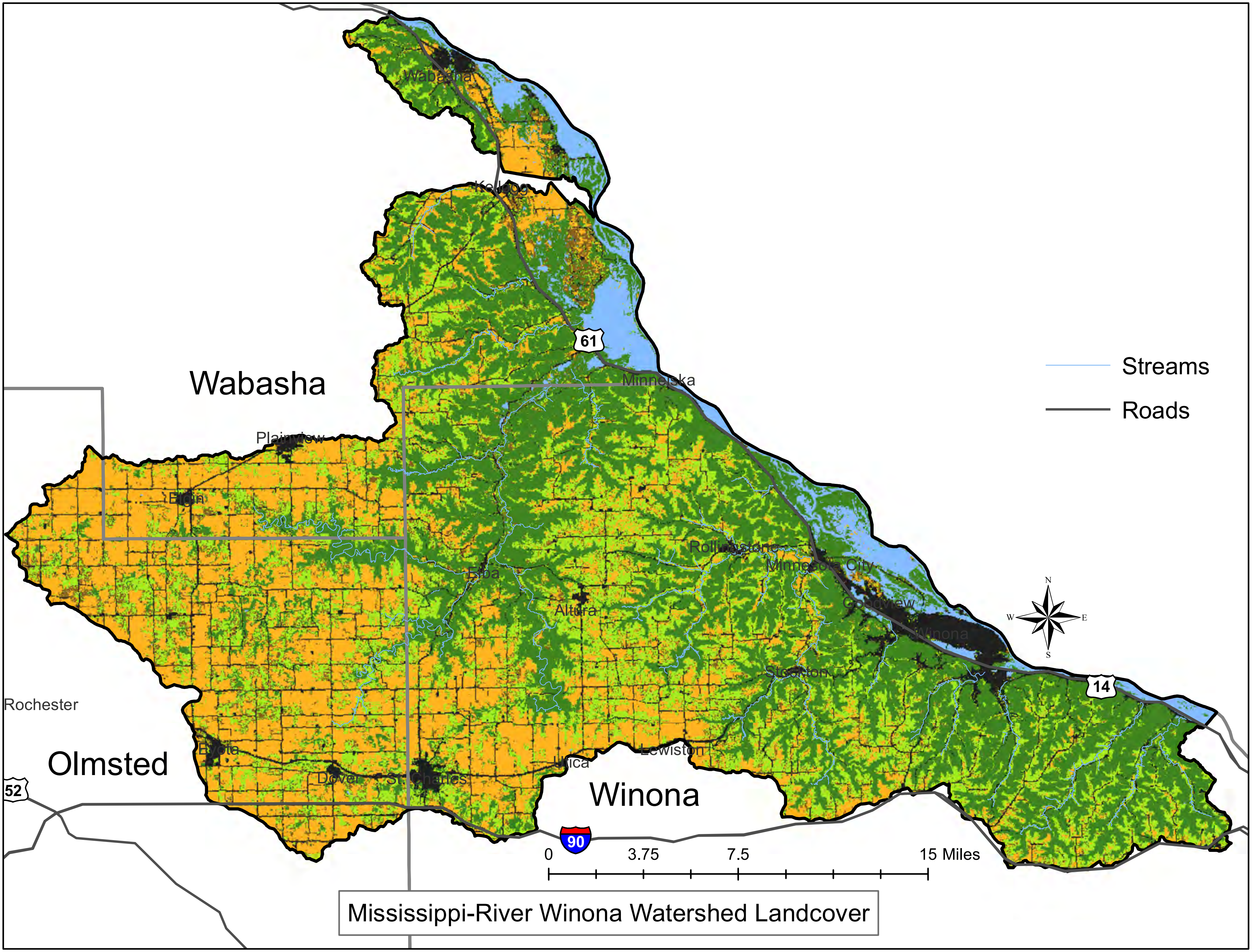

Mississippi-River Winona Watershed Landcover

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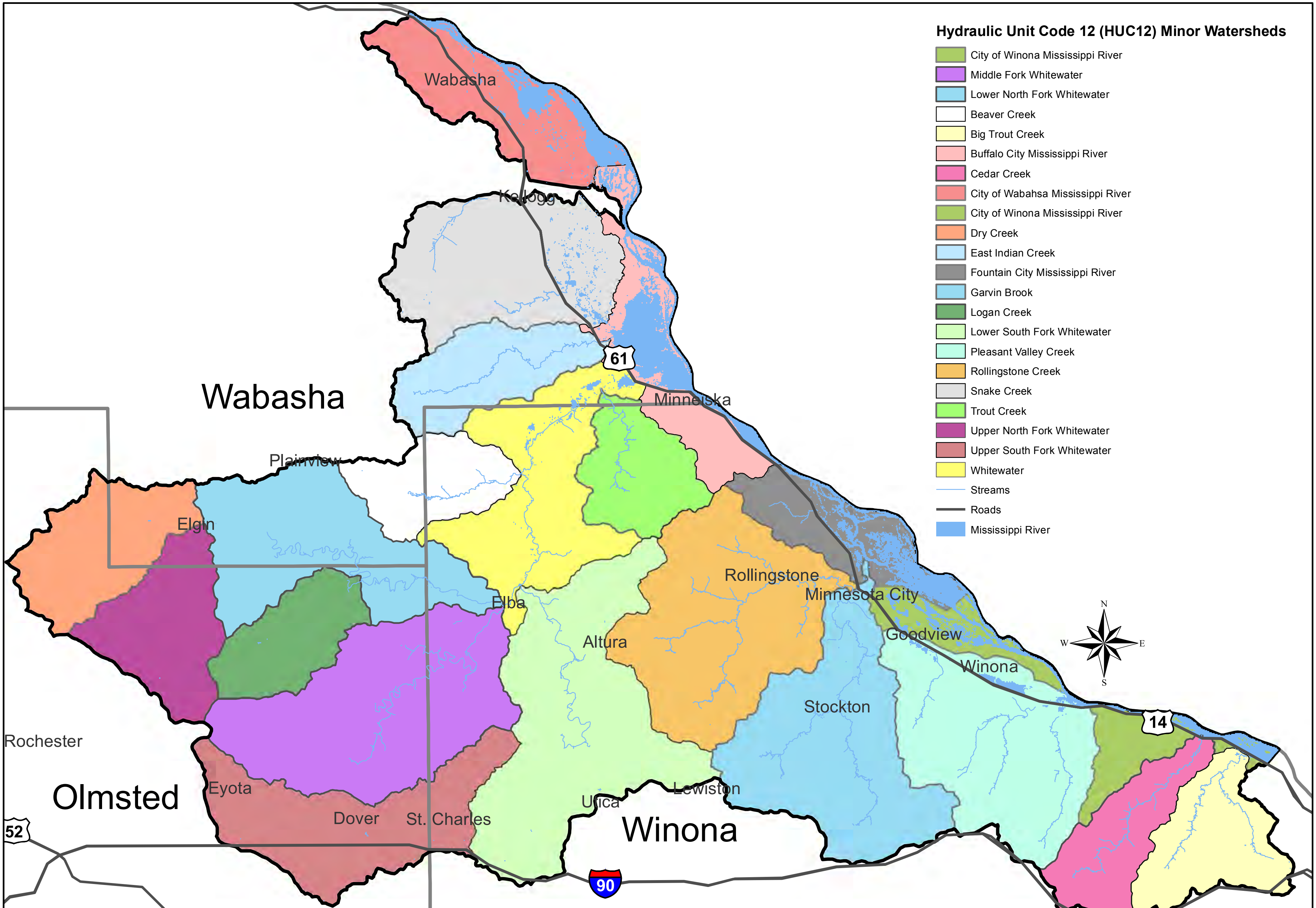

Hydraulic Unit Code 12 (HUC12) Minor Watersheds
Mississippi-River Winona Watershed

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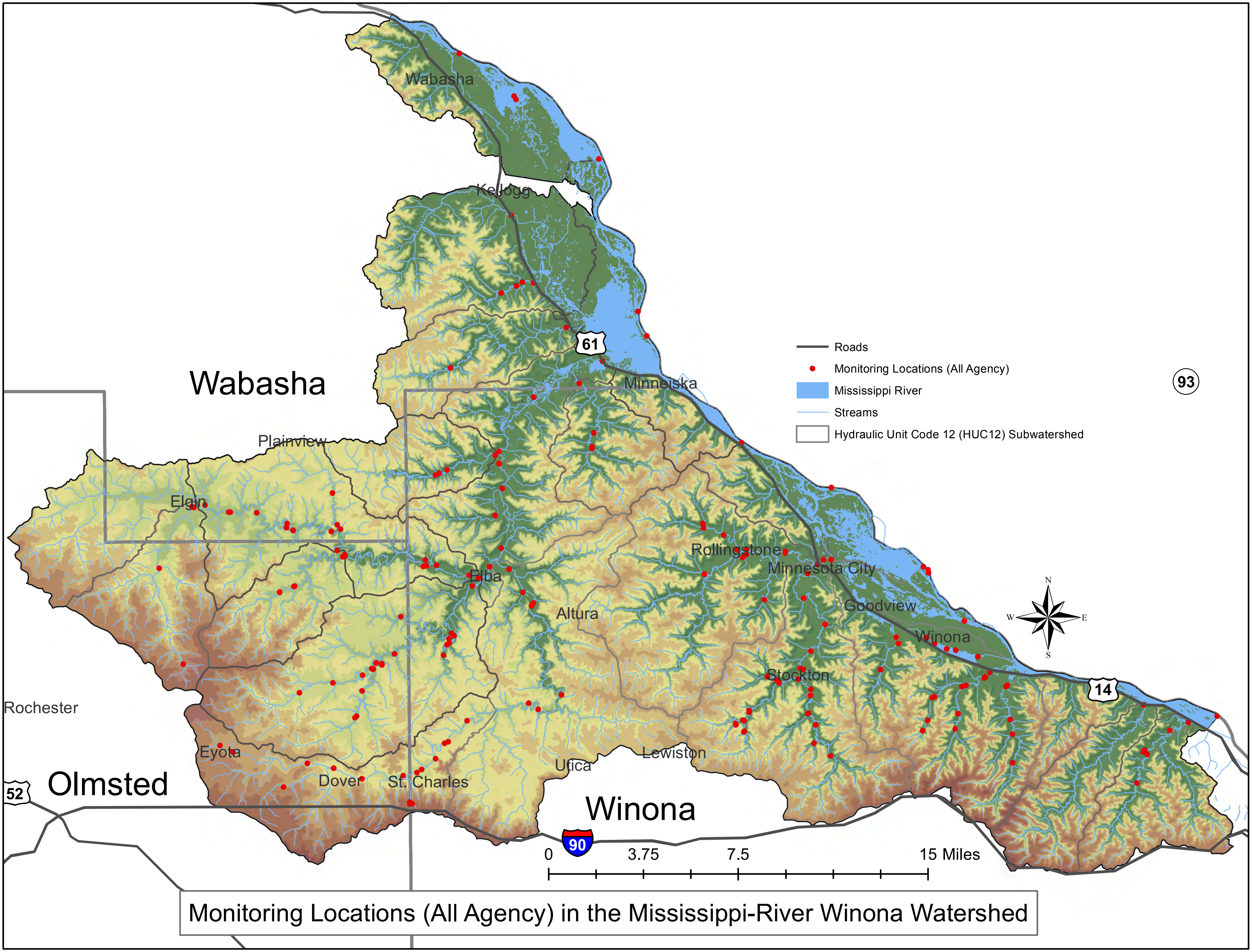
Wabasha
Kellogg
61
Minneiska
Roads
Monitoring Locations (All Agency)
Mississippi River
Streams
Hydraulic Unit Code 12 (HUC12) Subwatershed
93
Wabasha
Plainview
Elgin
Rollingstone
Minnesota City
Elba
Altura
Goodview
Winona
Stockton
14
Rochester
Eyota
Dover
St. Charles
Utica
Lewiston
52
Olmsted
Winona
90
0
3.75
7.5
15 Miles
N
S
E
W
Monitoring Locations (All Agency) in the Mississippi-River Winona Watershed

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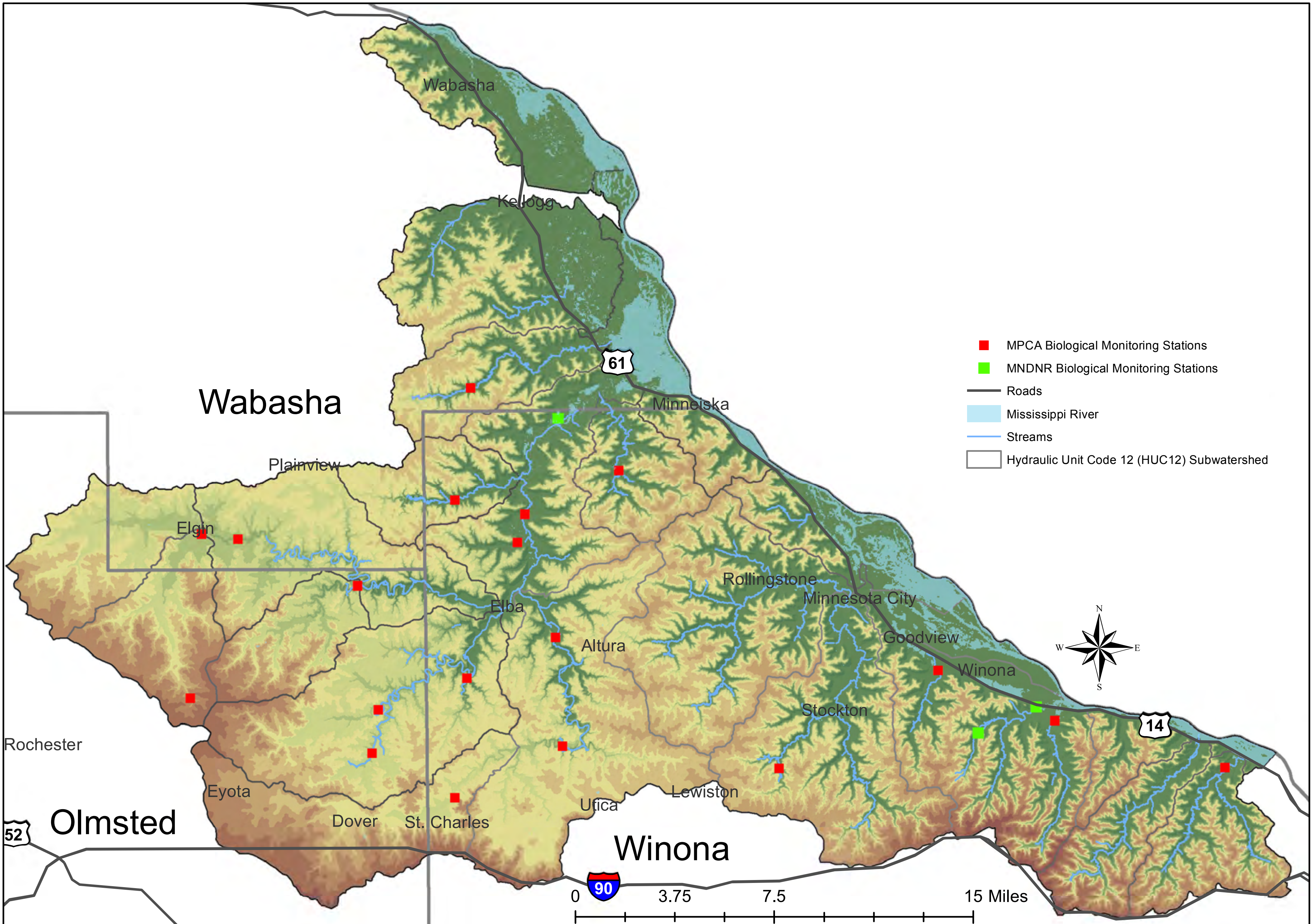

MDNR and MPCA Biological Monitoring Locations in the Mississippi-River Winona Watershed

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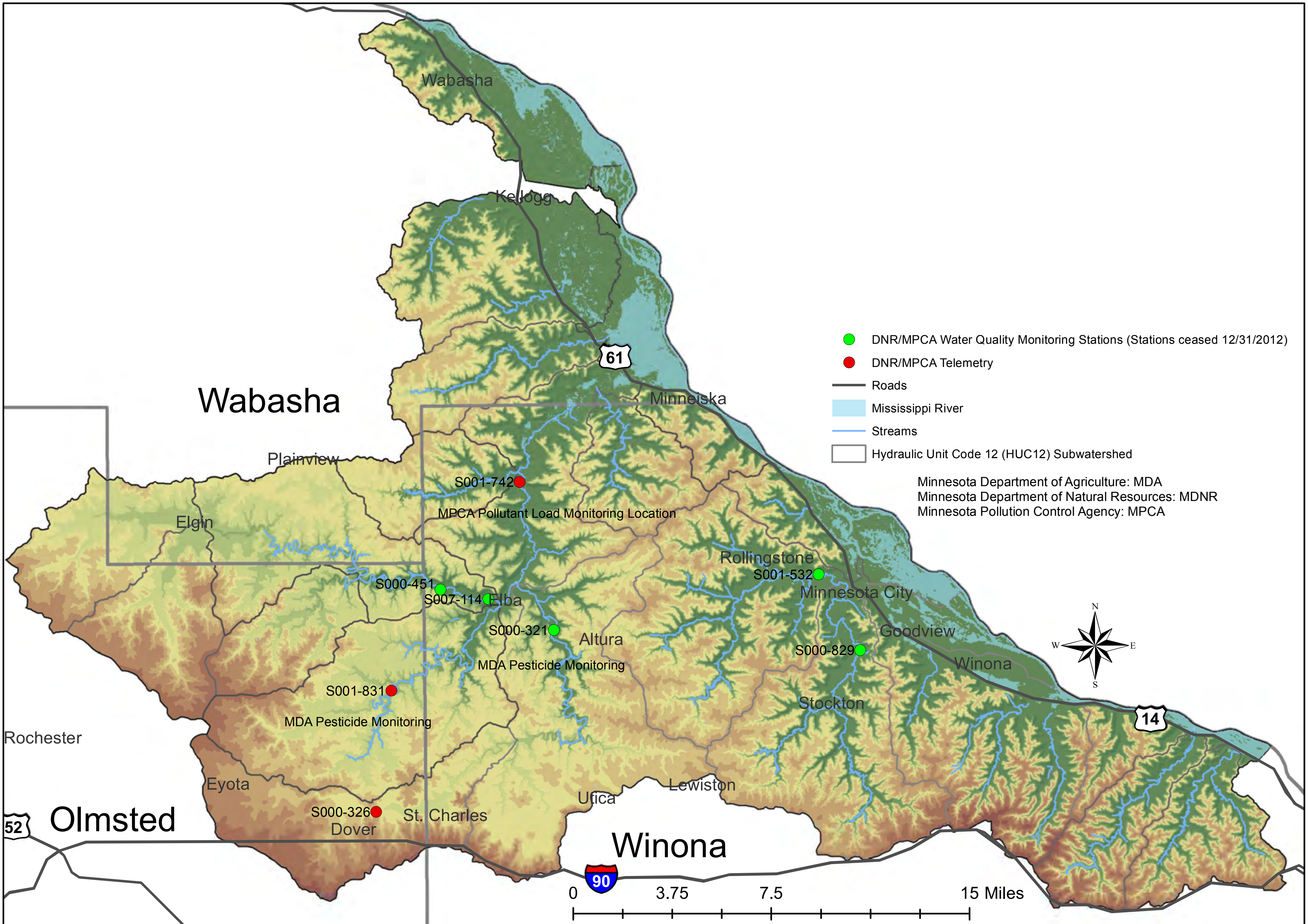

Current Active Monitoring Locations in the Mississippi-River Winona Watershed

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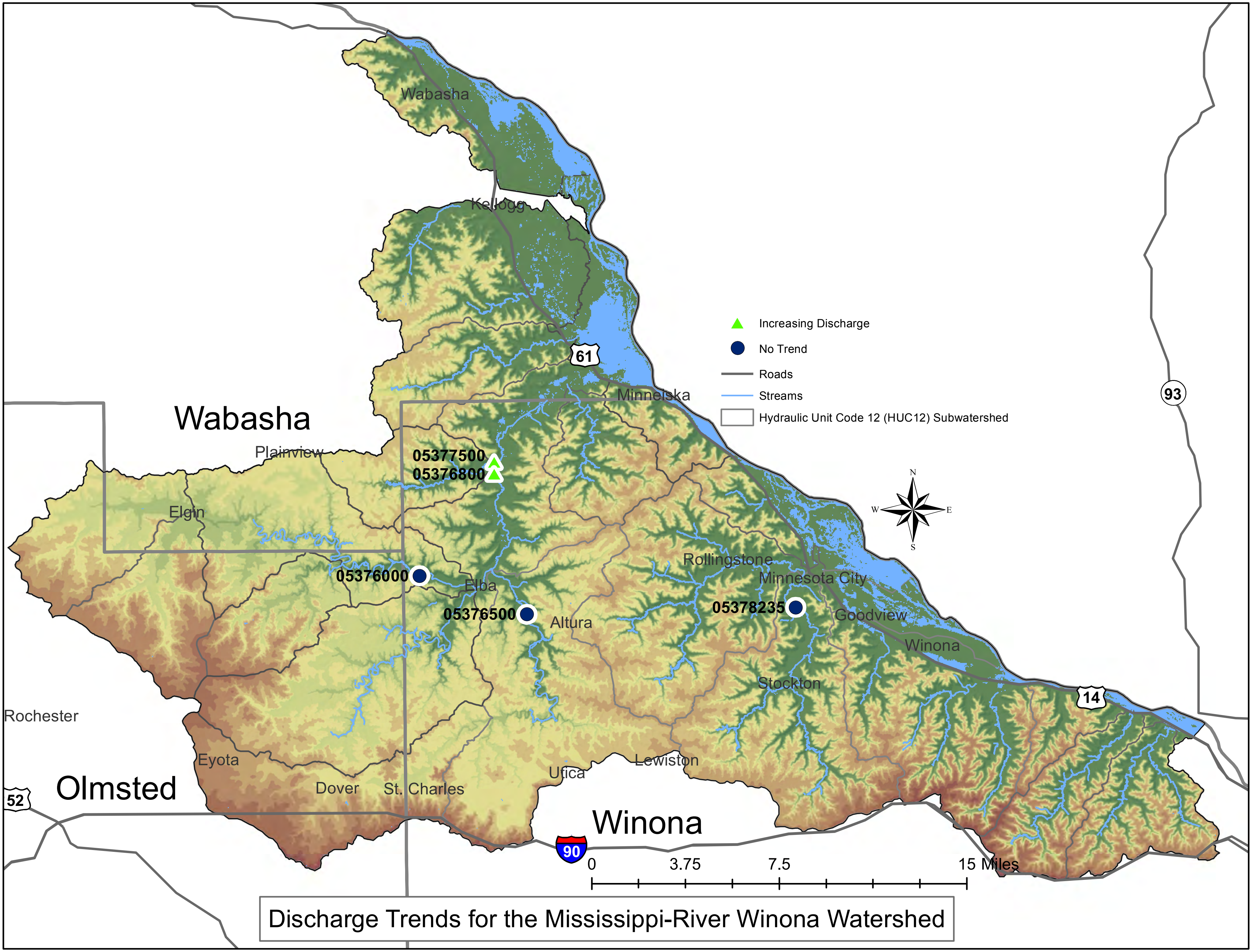

Discharge Trends for the Mississippi-River Winona Watershed

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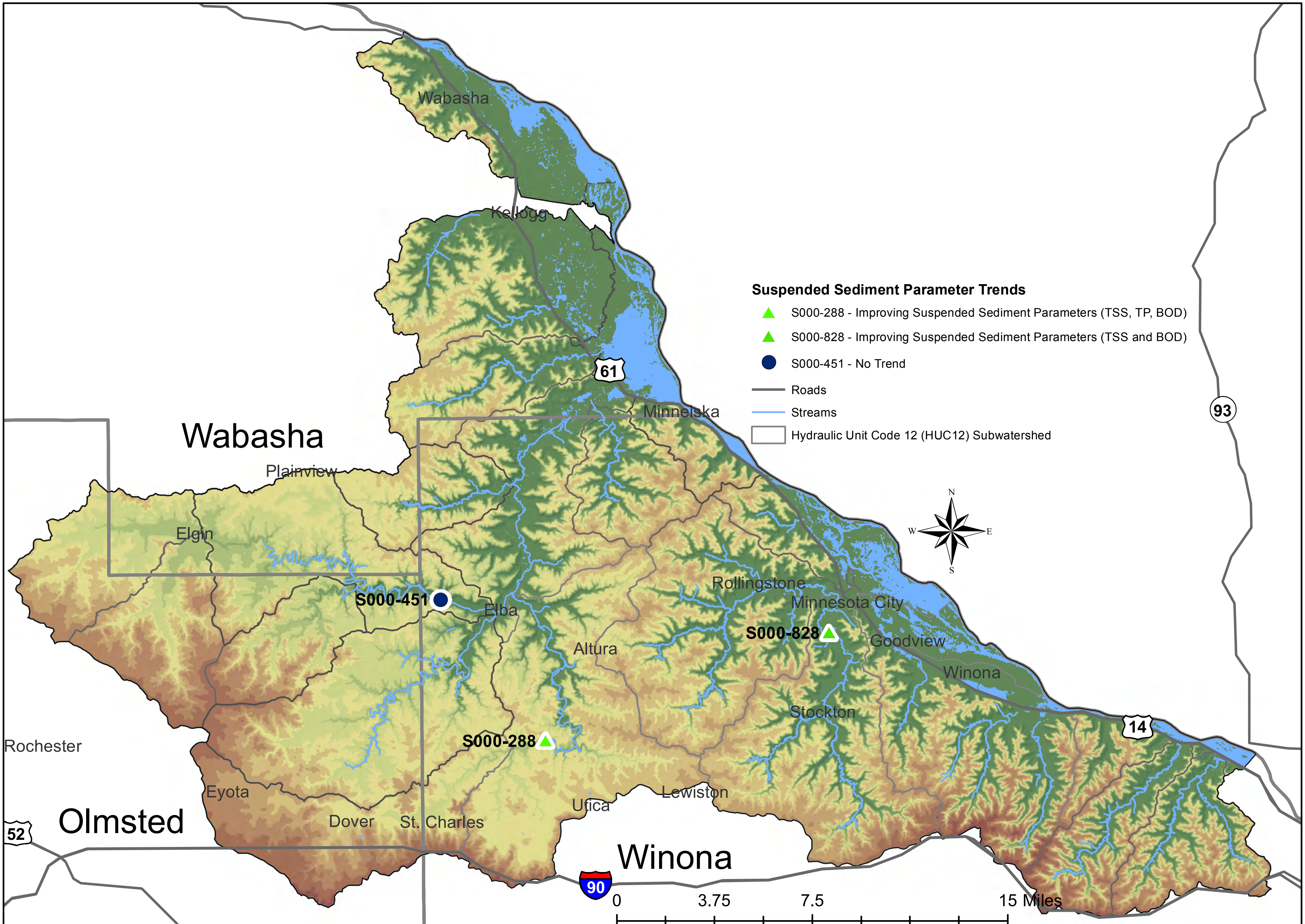

Parameters Related to Suspended Sediment Trends for the Mississippi-River Winona Watershed

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Nitrate Trends for the Mississippi-River Winona Watershed

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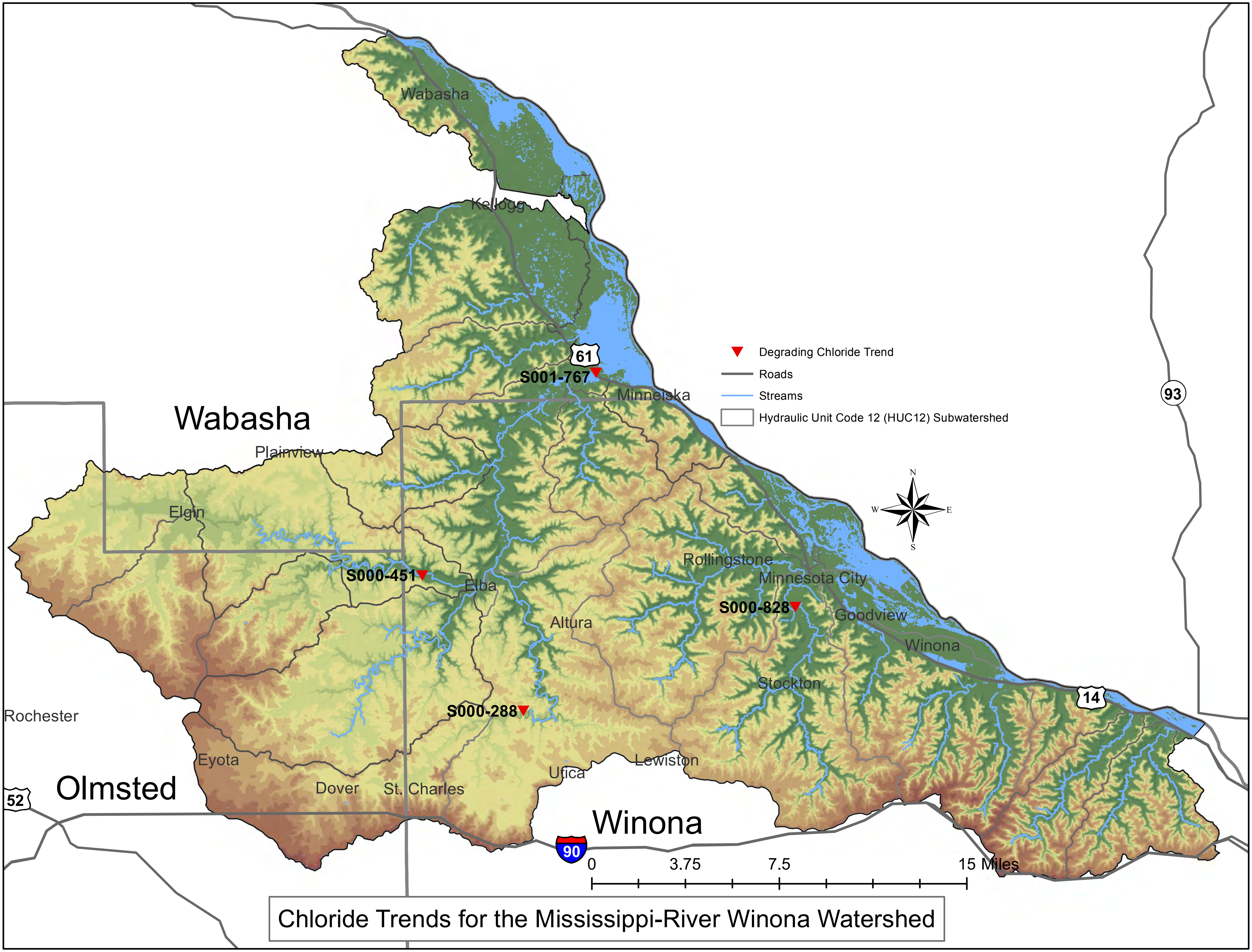

Chloride Trends for the Mississippi-River Winona Watershed

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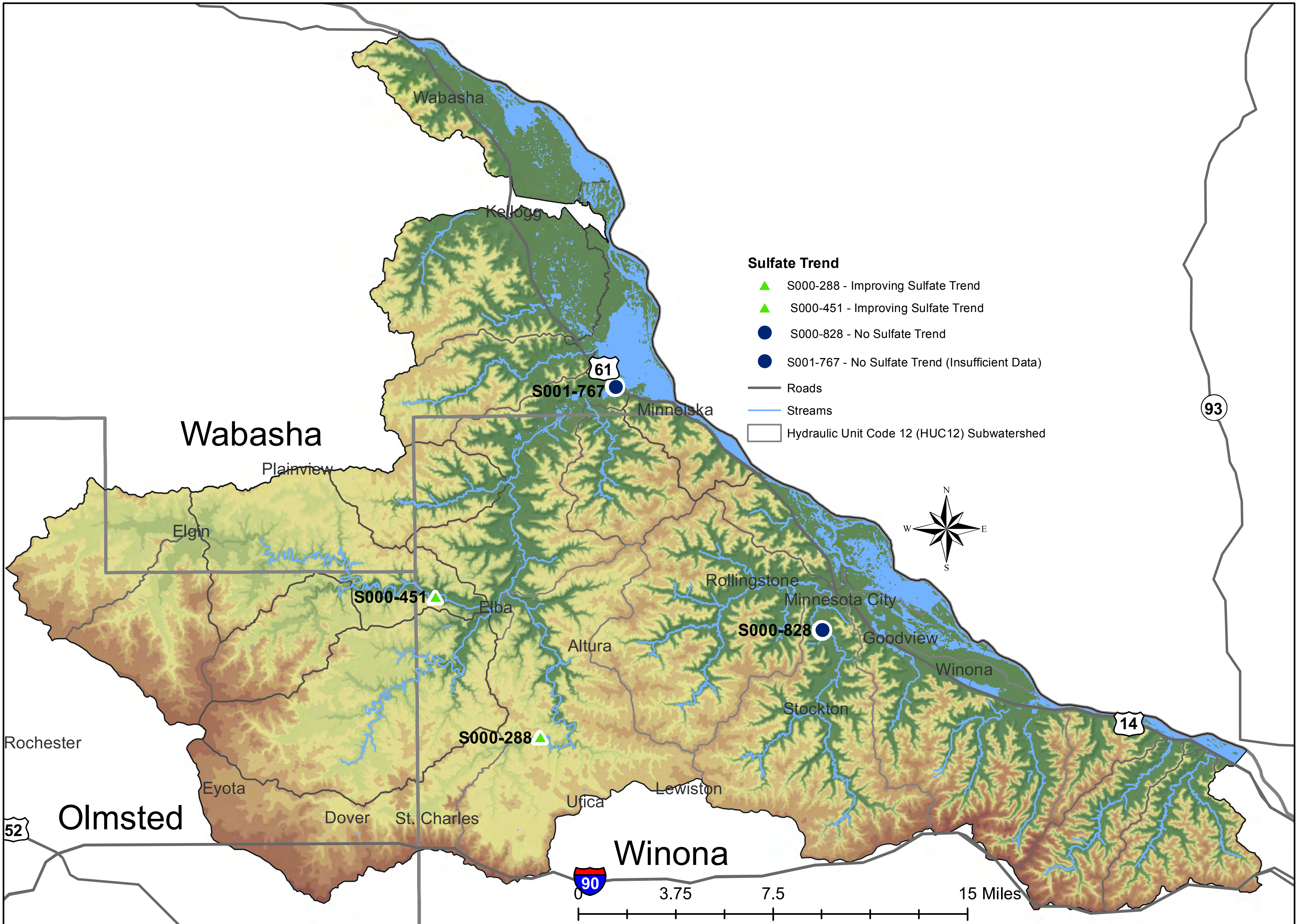

Sulfate Trends for the Mississippi-River Winona Watershed

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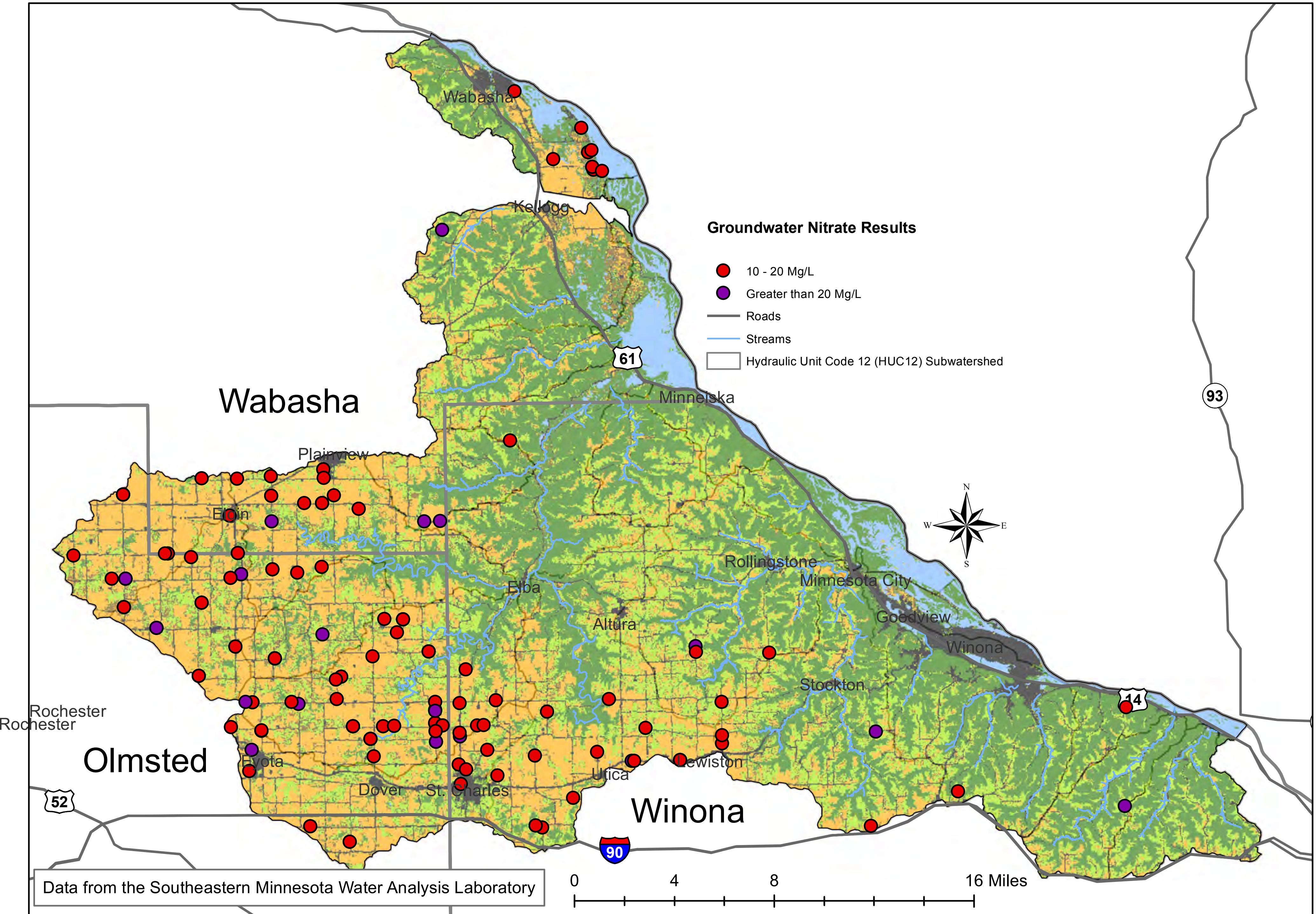

Groundwater Nitrate Concentrations for the Mississippi-River Winona Watershed

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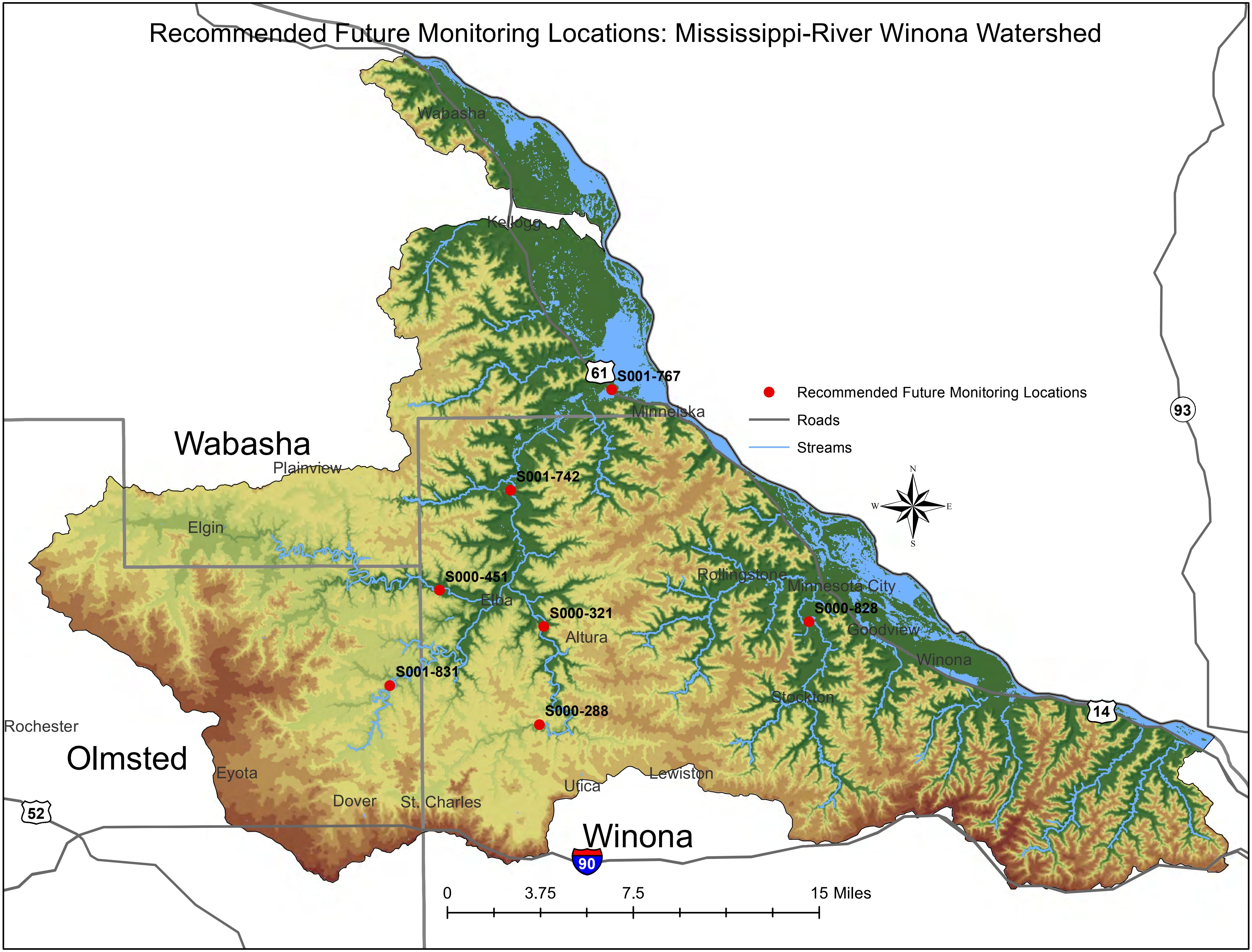
Recommended Future Monitoring Locations: Mississippi-River Winona Watershed
Recommended Future Monitoring Locations
Roads
Streams
Wabasha
Kellogg
S001-767
Minneiska
Wabasha
Plainview
S001-742
Elgin
S000-451
Elba
S000-321
Altura
Rollingstone
Minnesota City
S000-828
Goodview
Winona
S001-831
Stockton
S000-288
Rochester
Olmsted
Eyota
Dover
St. Charles
Utica
Lewiston
Winona
61
93
14
52
90
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7.5
15 Miles

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Appendix B: Trends in River Discharge and Precipitation

B.1 Estimating Loading

Trends for water quality constituents can be calculated based on concentrations, or based on mass loads. A number of parameters are highly dependent upon flow, particularly those related to suspended sediment (total suspended solids (TSS), turbidity, total phosphorus (TP), and transparency). In contrast, dissolved constituents (total dissolved solids (TDS), anions and cations) are generally less dependent on flow, but do show the effects of dilution during high stream discharge events. Constituents such as nitrate (NO_3) show a pattern reflecting both dilution and “washout”, which tends to result in concentrations not being heavily related to flow. Most parameters also show a seasonal pattern, which is also in part a reflection of discharge.

To estimate loads, both concentration and discharge data are needed. A common technique is to use a set of daily measurements of discharge and parameter concentrations to create a load curve, i.e. a regression which relates concentration to load. The curve is then used to predict loads for days not having measured values for the target parameter. Daily calculations are summed to yield a yearly load. Unfortunately, continuous stream flow (discharge) data are available for only a few sites in the Mississippi River-Winona Watershed and only for limited periods of time.

If yearly stream flow is relatively constant or at least does not have a trend, load estimates can be made using a much smaller data set of discharge and concentration measurements than when a trend is involved. Recent studies have indicated, however, that most rivers in Minnesota and Wisconsin which have a large agricultural component show trends in discharge as well as a change in the fraction of rainfall which appears in stream flow[1]. Unfortunately, the Mississippi River-Winona Watershed was not included in these studies due to limited stream flow data.

B.2 Trend in precipitation and Palmer Drought Severity Index (PDSI) for Major Watershed Unit 40 (0704003)

Figure B1 shows the long term record of yearly precipitation for the DNR major watershed unit 0704003 (MW40)2. Since the 1950’s there is an upward yearly trend with more precipitation occurring in extreme events. There is also a trend toward increasing year-to year variability, particularly since about 1990. Annual discharge correlates well with the annual average Palmer Drought Severity Index (PDSI) at the five sites identified in Table B1. The PDSI is a measurement of dryness based on recent precipitation and temperature and is proven effective in determining drought conditions. Figure B2 shows the historical increasing trend for the PDSI in region 5 which encompasses the Mississippi River-Winona Watershed. Note that both precipitation and PDSI show statistically significant upward trends ($p<.05$).

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[1] Lenhart, C., Nieber, J, Peterson, H, Titov, M. *Quantifying Differential Streamflow Response of Minnesota Ecoregions to Climate Change and Implications for Management*, U of M Dept. of Bioproducts and Biosystems Engineering, Aug 2011.

[2] Minnesota Department of Natural Resources, Division of Waters. *Basin Averaged Monthly Precipitation Totals for DNR Watersheds.* June 2010. <http://deli.dnr.state.mn.us/metadata.html?id=L390006230201>

Five Mississippi River-Winona Watershed tributaries have flow records long enough to assess trends over time (Table B1).

Table B1: Trends in Stream Discharge at USGS Stations in the Mississippi River-Winona Watershed

USGS ID	USGS Station Name	Period of Record	Discharge Trend (CFS)
5377500	Whitewater River At Beaver*	1939-1953	Upward Trend
5376800	Whitewater River Near Beaver*	1975-1985 and	Upward Trend
5376500	South Fork Whitewater River Near Altura	1940-1970	No Trend
5376000	North Fork Whitewater River Near Elba	1967-1993	No Trend
5378235	Garvin Brook Near Minnesota City	1983-1990	No Trend

*05377500 and 05376800 are in the same vicinity. 05377500 was discontinued and 05376800 was put online.

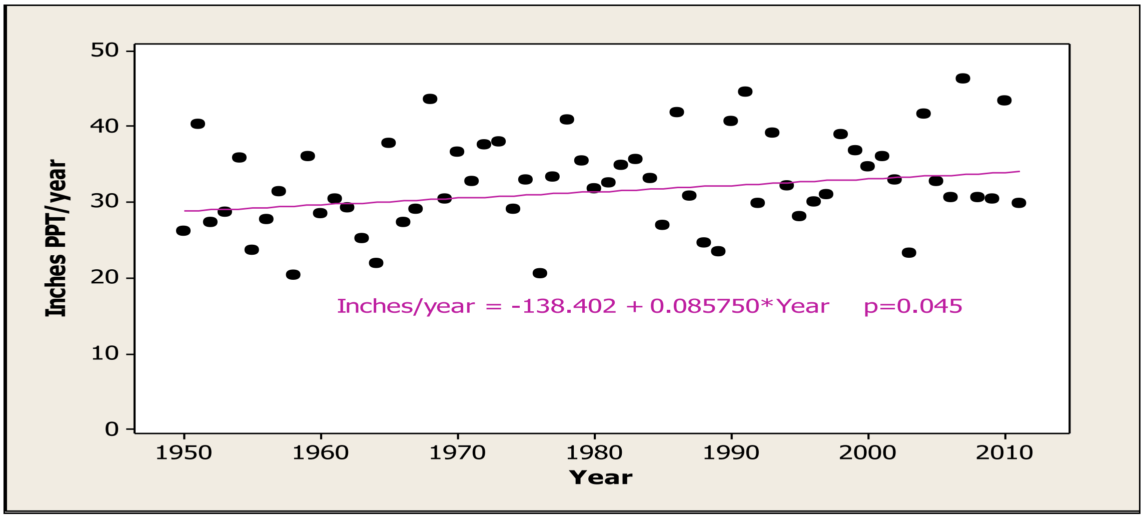

Figure B1 MW 40 Precipitation versus Year 1950-2010 (Akritas-Theil-Sen Regression)

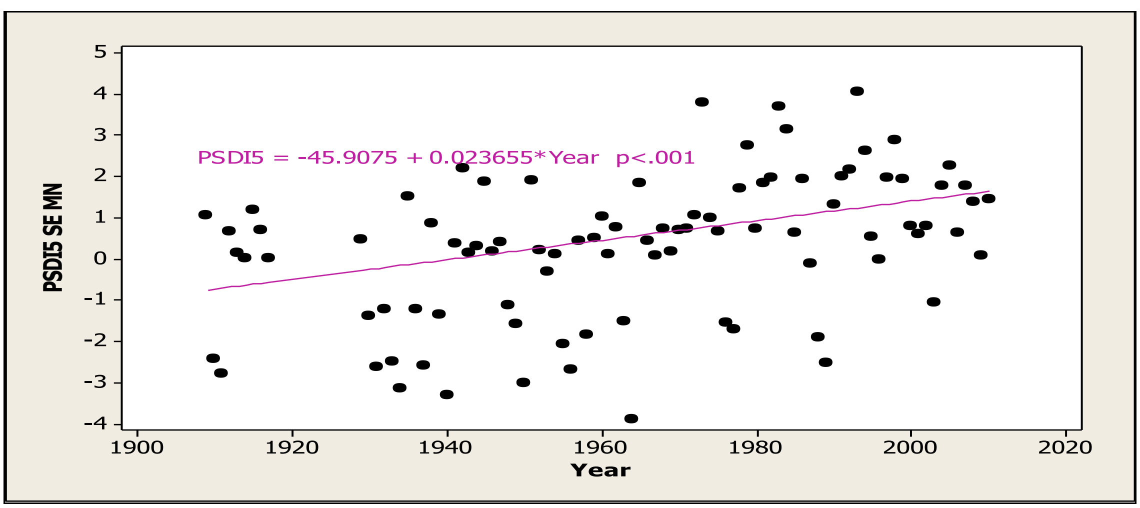

Figure B2 Palmer Drought Severity Index for Region 5 (PDSI5) versus Year 1900-2010 (Akritas-Theil-Sen Regression)

Figure B3 for the North Fork Whitewater River near Elba (USGS 05376000) shows no statistical trend. Figure B4 shows no correlation of yearly discharge (CFS) for this site with annual precipitation. However average annual PDSI is a good predictor of annual discharge at 05376000, as shown in Figure B5. For all streams where flow data is available, PDSI on an annual basis correlates better with annual stream discharge than annual precipitation. Note relationship in Figure B5 is log-linear.

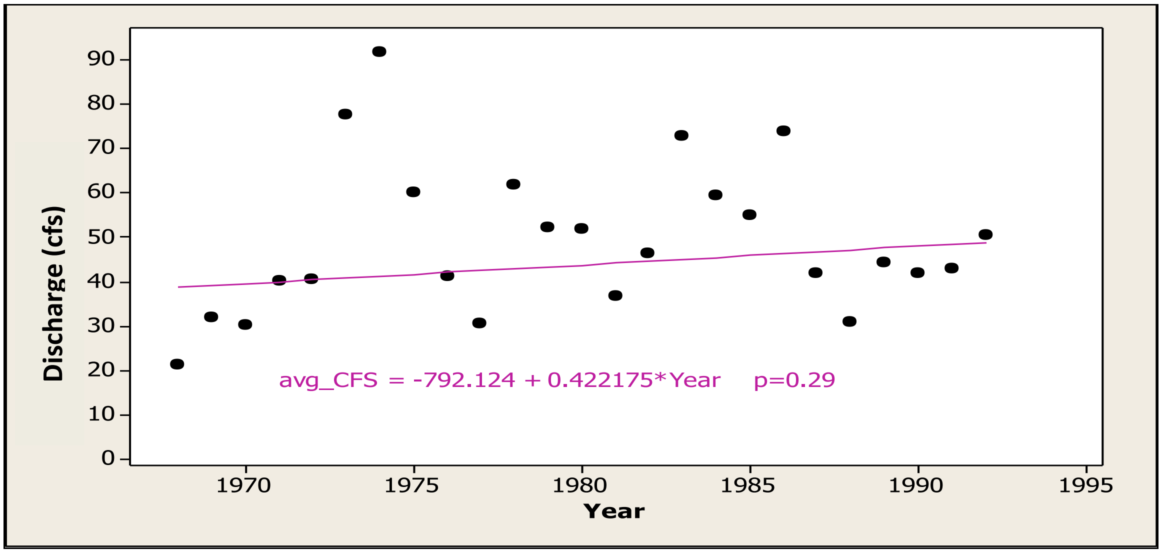

Figure B3 Discharge Plot for North Fork Whitewater River near Elba (05376000) 1967-1993
(Akritas-Theil-Sen Line Regression)

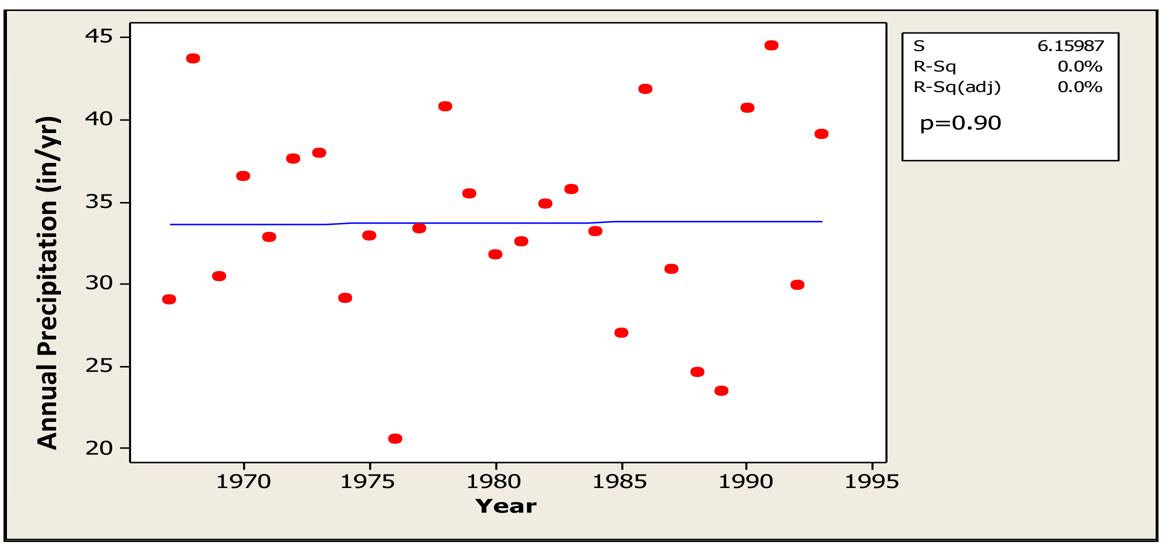

Figure B4 Plot of Precipitation for North Fork Whitewater River near Elba (05376000) 1967-1993
(Regression)

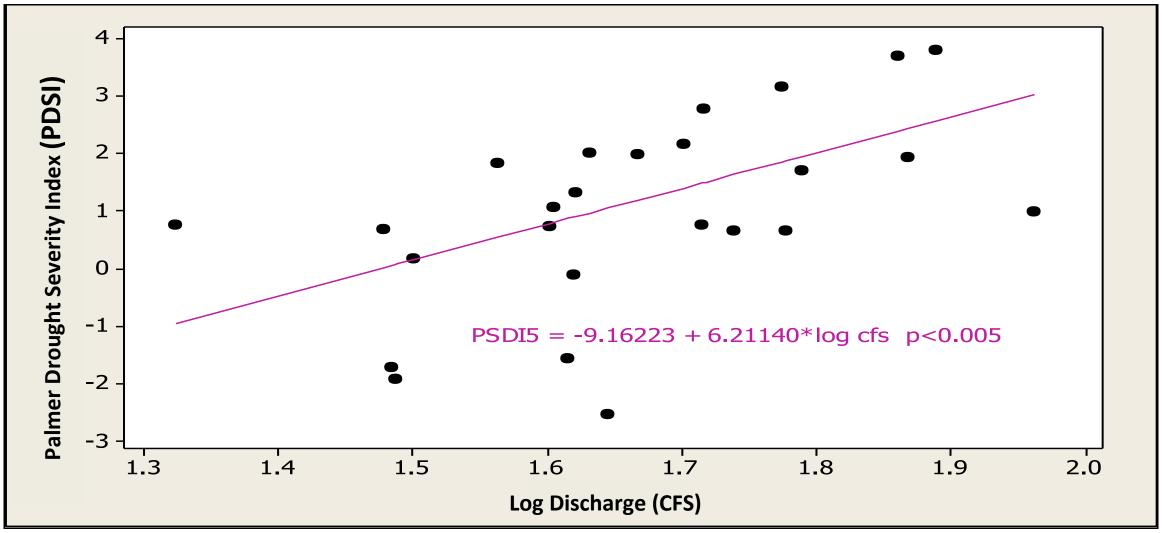

Figure B5 Correlation of PDSI with Discharge at North Fork Whitewater River near Elba (05376000) (Akritas-Theil-Sen Regression)

Figure B6 shows a statistical trend in flow for the Whitewater River at Beaver (05377500) for the period 1940-1952. As with the Elba site (05376000), this site shows a correlation with PDSI but not with MW40 annual precipitation.

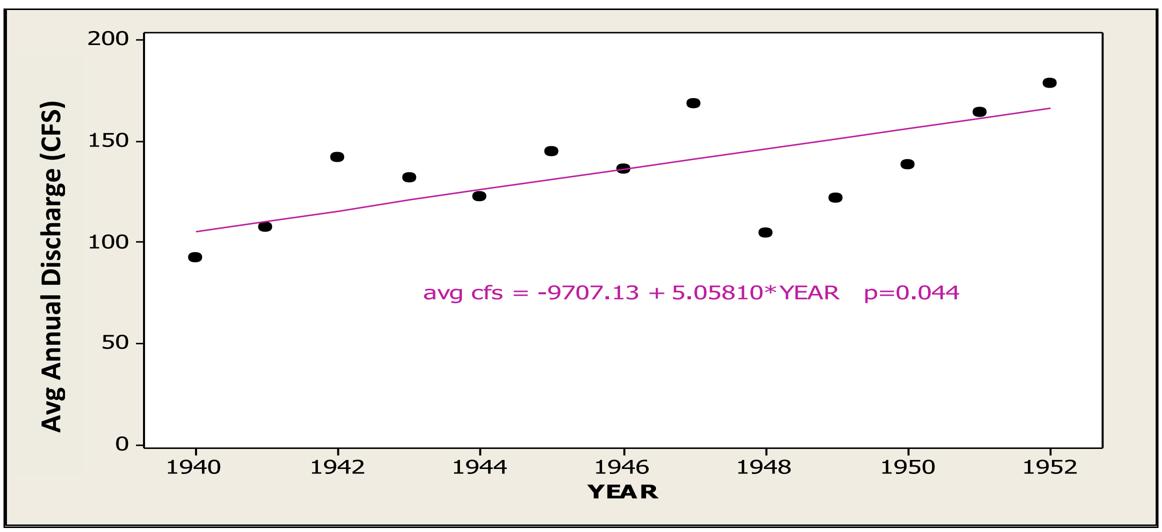

Figure B6 Flow Trend for the Whitewater River at Beaver (05377500) 1939-1953 (Regression)

Figure B7 shows the annual stream flow for the Whitewater River site near Beaver (05376800), covering the periods 1975-1985 and 1993-1999. A statistical increase in flow is calculated for this site. As with the 05376000 site above, the annual discharge correlates with the PDSI (Figure B8), but discharge does not correlate with the annual precipitation for MW40. This also illustrates that PDSI can be used to estimate the annual flow for the years of missing record (1985-1992).

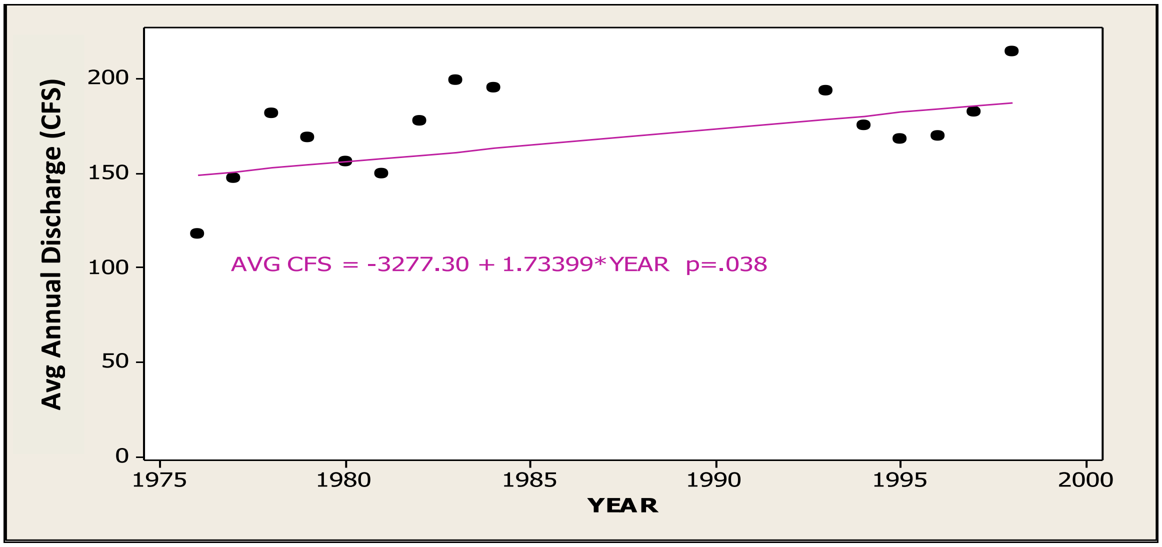

Figure B7 Stream Flow Record for Whitewater River near Beaver (05376800) 1975-1999 (Discontinuous Record). (Akritas-Theil-Sen Regression)

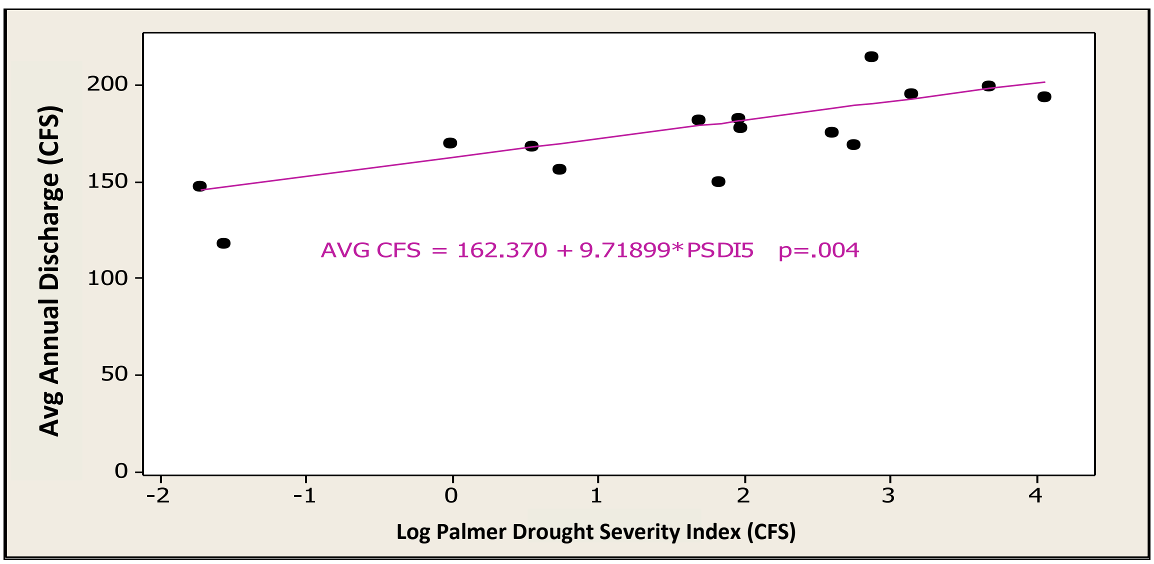

Figure B8 Correlation of Annual Stream Discharge with PDSI at Whitewater River near Beaver (05376800) (Fitted Line Plot)

Figure B9 shows the time series for annual flow at the South Fork Whitewater River site near Altura (053765000) from 1940-1970. No statistical trend is seen at this site. Year to year variability may mask any long term trend. Figure B10 shows the time series for the site at Garvin Brook near Minnesota City (05378235). No trend is seen here, however the discharge record is short. Both the Altura and Garvin Brook sites show a correlation with the PDSI.

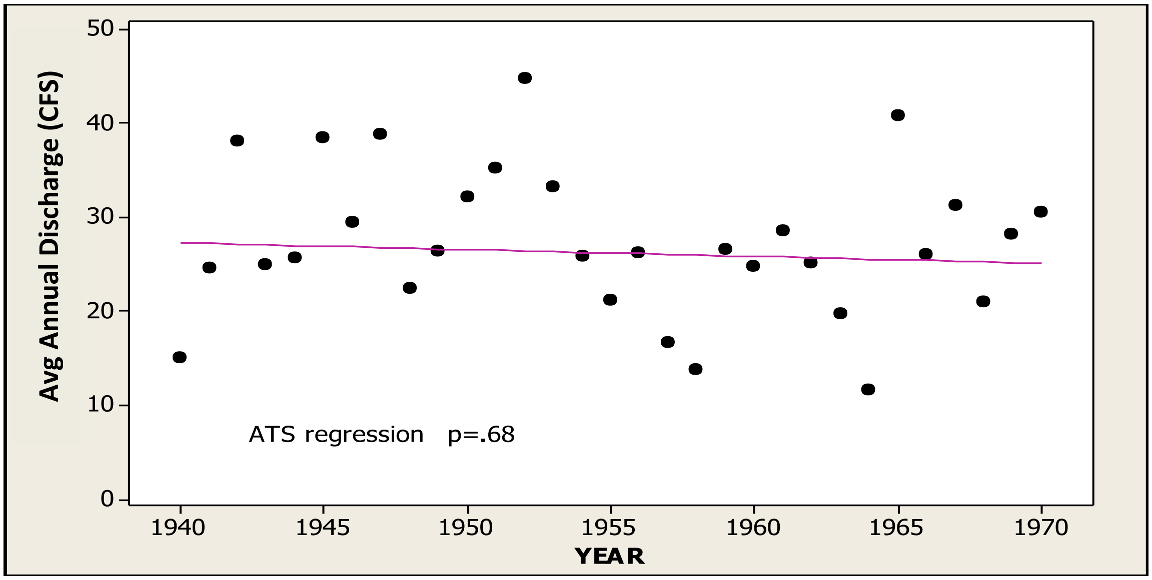

Figure B9 Annual Stream Discharge at South Fork Whitewater River near Altura (05376500) 1940-1970 (Fitted Line Plot)

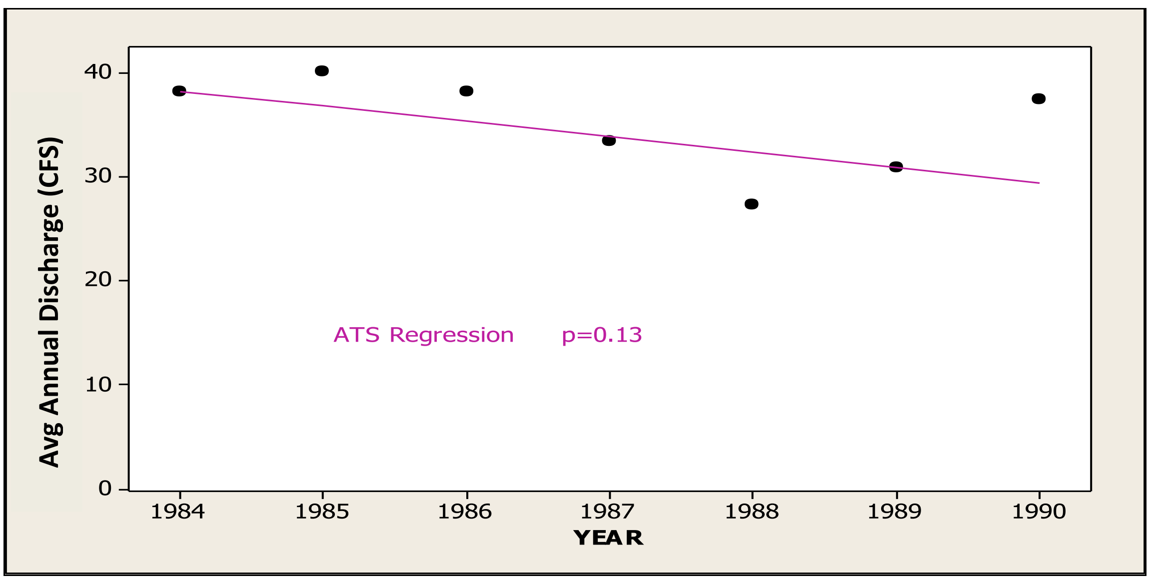

Figure B10 Annual Stream Discharge at Garvin Brook near MN City (05378235) 1983-1990 (Fitted Line Plot)

B.3 Suspended Sediment and Discharge (CFS): North Fork Whitewater River near Elba (05376000)

The only long term record for suspended sediment (SS) in the Mississippi River-Winona Watershed is for the United States Geological Survey (USGS) station on the North Fork of the Whitewater River near Elba (0537600) from 1968-1993. Approximately 250 paired measurements of SS and discharge (CFS) are represented, or about 1 measurement per month. A partial SS_CFS record is from the USGS website: a complete record (unofficial) was provided by Bill Thompson of MPCA (2012). A load curve for this site was constructed by calculating a load of each day by multiplying the CFS by SS concentration and a conversion factor to obtain tons SS/day. Figure B11 shows the relationship between CFS (daily) and SS load. The relationship is log-log. SS concentration itself increases with stream velocity, i.e. more material can be suspended as laminar flow converts to turbulent flow. Higher stream velocity is also associated with increased water depth and cross sectional area. Hence SS load is exponentially related to CFS. The linear regression represented in Figure B11 is highly significant (rsq=83%). Eighty-three percent (83%) of the variability in the data is represented by the line.

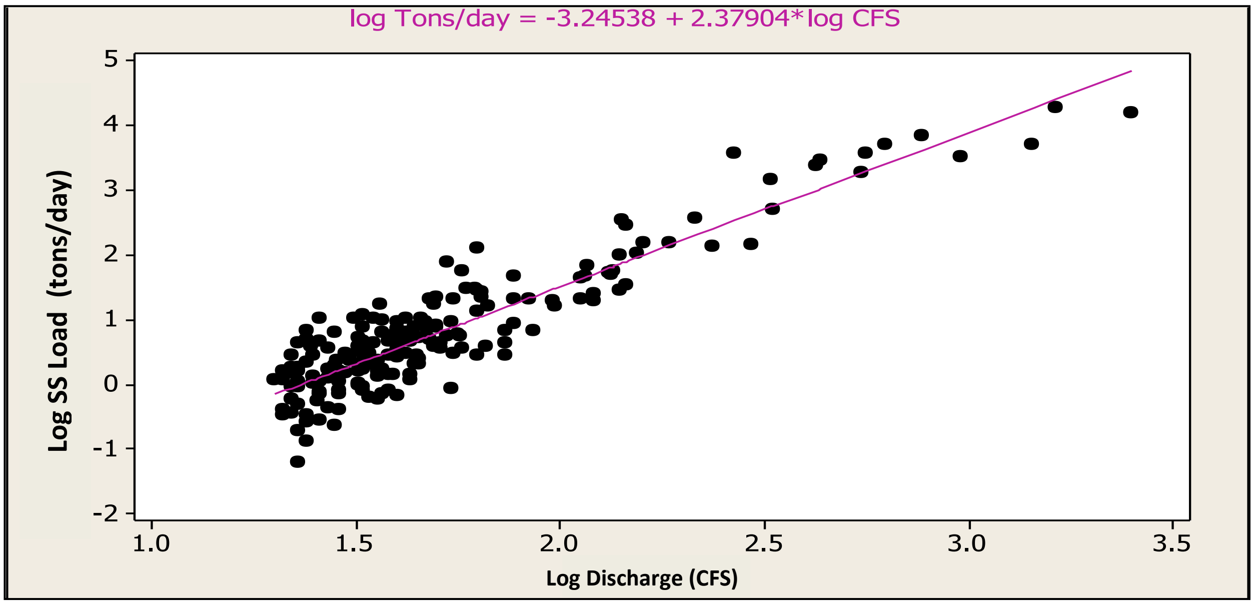

Figure B11 Suspended Sediment load Curve for North Fork Whitewater River near Elba 1968-1990 (Akritas-Theil-Sen)

This curve is used to calculate daily (or monthly) SS loads from daily (or monthly) discharge averages. The daily or monthly loads are summed to obtain yearly loads. The log-log relationship requires a "bias correction" for the summed load, since the average in log units is a geometric mean or median in linear units. Table B2 shows the yearly SS loads for Elba. Note that a few years account for most of the 2 decade total load, particularly the very wet years of 1973-1975 (Figure B12). Also note the very small loads in the drought years of 1970 and 1988. Table B2 also includes calculations for loads on a watershed acre and crop acre basis. An average of about 1.3 tons/watershed acre/year of sediment is calculated. Over twice this amount is calculated for crop acres (2.9 tons/ crop acre/year).

Table B2 Calculated Yearly Suspended Sediment loads on North Fork Whitewater River near Elba (05376000)

Year	Year CFS-days	Calc. Load (tons/year)	tons/acre/yr	Crop basis tons/acre
1968	7715	1548	0.02	0.05
1969	11577	17093	0.26	0.59
1970	11005	1800	0.03	0.06
1971	14690	9443	0.15	0.32
1972	14803	16359	0.25	0.56
1973	26164	121194	1.87	4.17
1974	32187	1053652	16.30	36.22
1975	21756	101387	1.57	3.49
1976	14684	54348	0.84	1.87
1977	11123	10574	0.16	0.36
1978	21499	253389	3.92	8.71
1979	18994	9143	0.14	0.31
1980	17965	56227	0.87	1.93
1981	13139	5891	0.09	0.20
1982	16729	5392	0.08	0.19
1983	26578	18044	0.28	0.62
1984	21772	6911	0.11	0.24
1985	19930	28849	0.45	0.99
1986	26799	57001	0.88	1.96
1987	15235	2497	0.04	0.09
1988	11270	2035	0.03	0.07
1989	15238	50076	0.77	1.72
1990	14746	23144	0.36	0.80
AVERAGE=	17635	82869	**1.28**	**2.85**
max	32187	1053652	16.3	36.2
min	7715	1548	0.02	0.05
median	15238	17093	0.26	0.59
2 decade total	405598	1905996	29	66

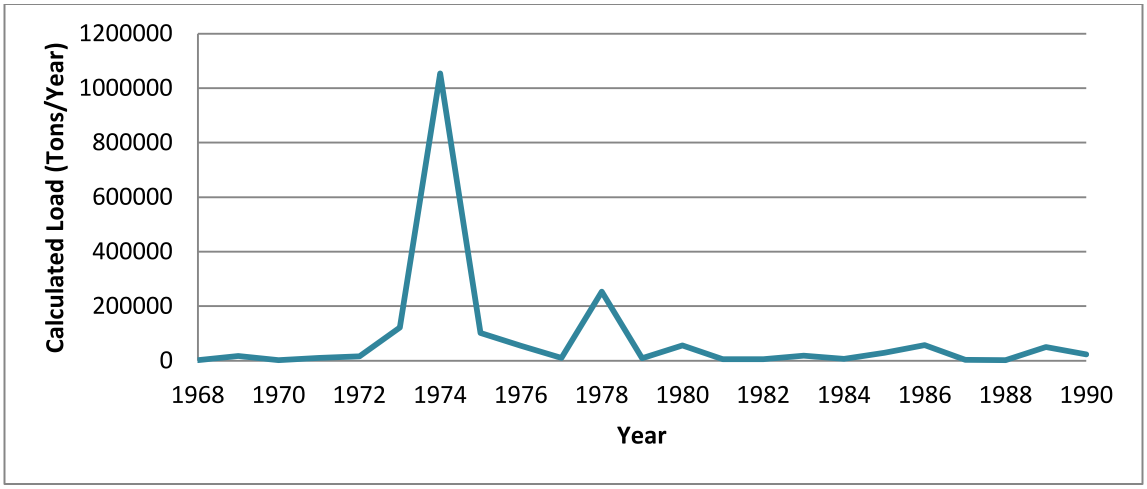

Figure B12 Suspended Sediment Load (Tons/Year) for the North Fork Whitewater River near Elba

B.4 Conclusions

Discharge data for Whitewater River tributaries are somewhat limited for purposes of assessing long term trends. Relatively short records and large inter-annual variability may mask possible trends. However, all sites with several years of record show correlations with the PDSI. The PDSI, in turn, shows a long term upward trend toward increasing wet conditions. These correlations and studies of other rivers in the upper Midwest suggest that Whitewater streams are likely to have long term increasing trends in discharge[3]. If this trend is real, it needs to be accounted for in trend calculations of parameter concentrations and loads.

The correlation of PDSI with annual stream flow for Mississippi River-Winona Watershed sites shown above suggests that PDSI can be used as a surrogate to reconstruct (estimate) stream flow on an annual basis. Such reconstructions would be normalized to watershed areas. Reconstructed annual estimates could be useful to assess possible trends in loads when stream flow itself is suspected to be changing.

The data from the Whitewater River near Elba (05376000) illustrates a distinct difference between SS and most dissolved constituents in surface waters. First, a large number of measurements of SS concentrations are needed, especially during high stream discharge events, to obtain a good estimate of yearly SS loads. Second, large year-to year stream flow variability tends to mask any trends in loads. Third, the log-log nature of SS with discharge also means that even if a trend in SS concentration is seen, it may not necessarily be associated with a statistical trend in SS load on a yearly basis. Lastly, a number of parameters such as TP, turbidity, TSS, transparency, total Kjeldahl nitrogen (TKN), biochemical oxygen demand (BOD), and coliform tend to be correlated with SS. Hence the same precautions noted for SS also apply to these parameters. In particular, trends in concentration need to be distinguished from trends in load when stream flow itself is changing or is quite variable.

[3] Lenhart, C., Nieber, J, Peterson, H, Titov, M. *Quantifying Differential Streamflow Response of Minnesota Ecoregions to Climate Change and Implications for Management*, U of M Dept. of Bioproducts and Biosystems Engineering, Aug 2011.

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Appendix C: Seasonal Nitrate (NO_3) Patterns

C.1: Seasonal Nitrate Patterns

Six sites in the Mississippi River-Winona Watershed have sufficiently long records to allow assessment of seasonal patterns (Table C1).

Table C1 Mississippi River-Winona Watershed Sites with Multi-Year NO_3 Records

Site ID	Location	Years of Record
S000-321 (EQUIS & MDA)	S. Fork Whitewater near Altura	1992-2012
S000-451 (EQUIS & USGS 05376000)	N. Fork Whitewater near Elba	1967-2011
S000-828 (EQUIS)	Garvin Brook Southwest (SW) of Minnesota City	1981-2008
S000-288 (EQUIS)	S. Fork Whitewater near Utica	1976-2011
S001-831 (MDA & Hydstra)	Middle Fork Whitewater North of St. Charles	1999-2012
LTRMP (MDNR) or S001-767 (EQUIS)	Whitewater near Weaver Hwy. 61	1993-2008

As seen in Figures C1-C7, the sites at Garvin brook SW of Minnesota City, Middle Fork Whitewater River North of St Charles, and South Fork near Altura and Utica show statistically significant higher NO_3 concentrations in winter months (Dec, Jan, and Feb) than in summer months (June, July, August). This is based on Mann-Whitney rank sum tests for median concentrations and a 95% significance level. Spring and fall months show concentrations between winter and summer concentrations. The site on the Whitewater River near Weaver on highway 61 (LTRMP) and the North Fork Whitewater site near Elba appear to show the same patterns in their respective figures, however, the seasonal differences are not statistically significant at the 95% level.

NO_3 concentrations tend to be higher in the winter months (Dec.-Jan.) and lower in the summer months (June-Aug.). This pattern is commonly attributed to the effect of plant uptake during the growing season and of shallow groundwater base flow after the growing season.

Figures C1-C3 show the data for the monitoring stations on the North Fork Whitewater River near Elba (S000-451 or 05376000). Note that the various sampling organizations and time frames at this site show some differences but are generally consistent in showing the seasonal pattern of higher nitrate concentrations in winter. The period sampled by Olmsted County also shows a minimum nitrate concentration in February (Figure C2).

In Figure C4, the Garvin Brook site SW of Minnesota City (S000-828) shows the same seasonal pattern with a minimum nitrate concentration in February, while the South Fork Whitewater River near Altura (S000-321) has a minimum in March (Figure C5). The Middle Fork Whitewater River North of St. Charles (S001-831) site also shows the minimum NO_3 concentration in March (Fig. C6). Figure C7 represents the entire Whitewater River Basin near Weaver Bottoms, and shows little seasonal pattern, with summer levels only slightly higher than winter levels. This site also shows the NO_3 minimum concentration in March.

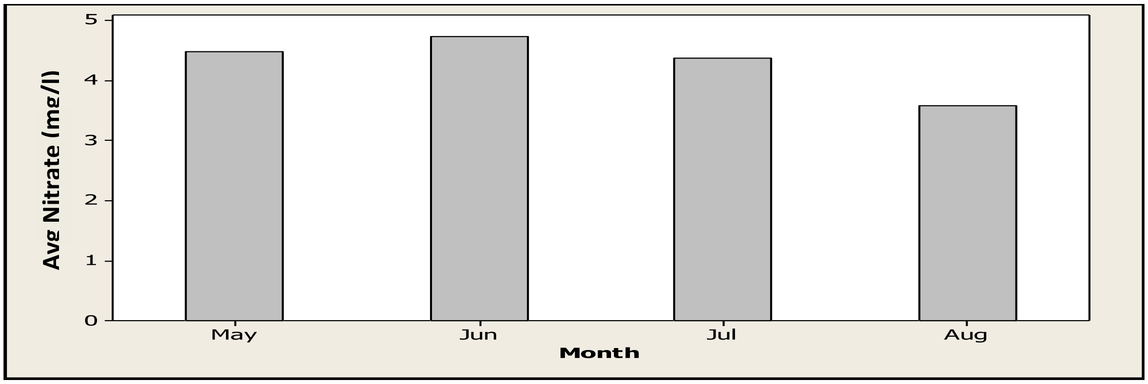

Figure C1 North Fork Whitewater River near Elba (S000-451) MN Department of Agriculture (MDA) Seasonal Nitrate Pattern (2000-2007)

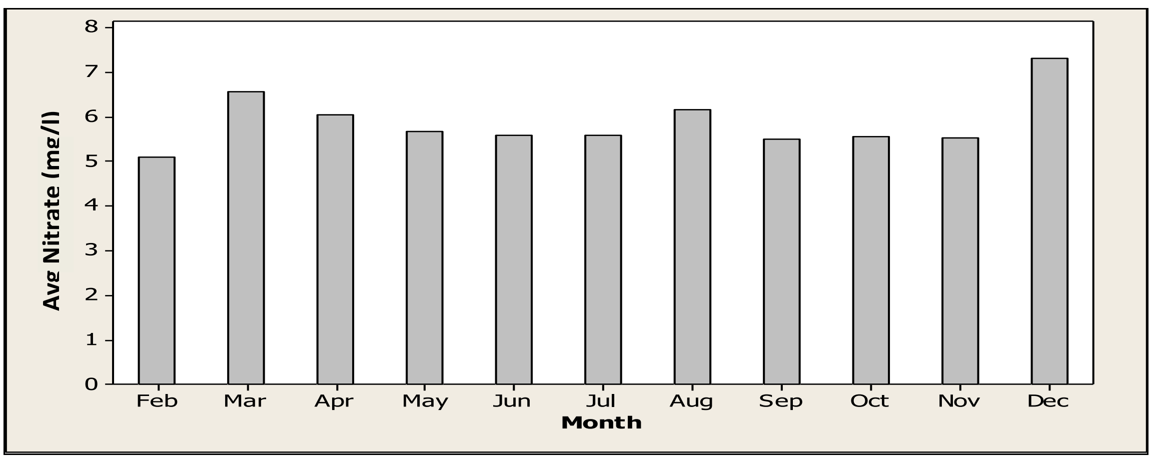

Figure C2 North Fork Whitewater River near Elba (S007-144)) Olmsted County Seasonal Nitrate Pattern (1999-2002 and 2008)

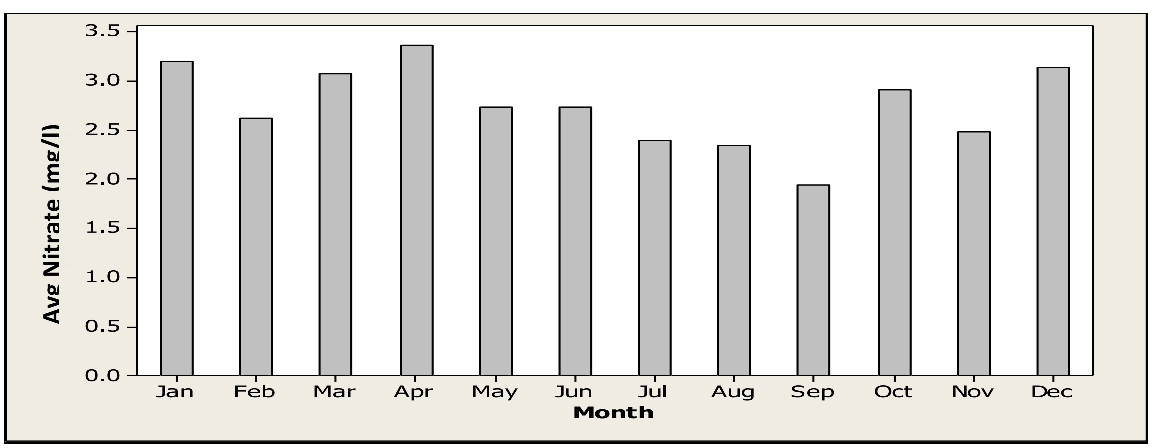

Figure C3 North Fork Whitewater River near Elba (05376000) United States Geological Survey (USGS) Seasonal Nitrate Pattern (1967-1993)

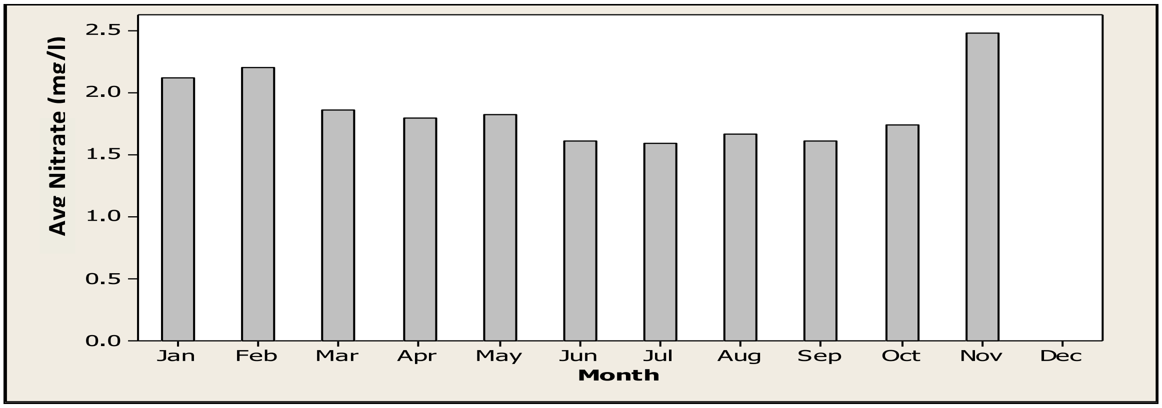

Figure C4 Garvin Brook Site SW of Minnesota City (S000-828) Seasonal Nitrate Pattern

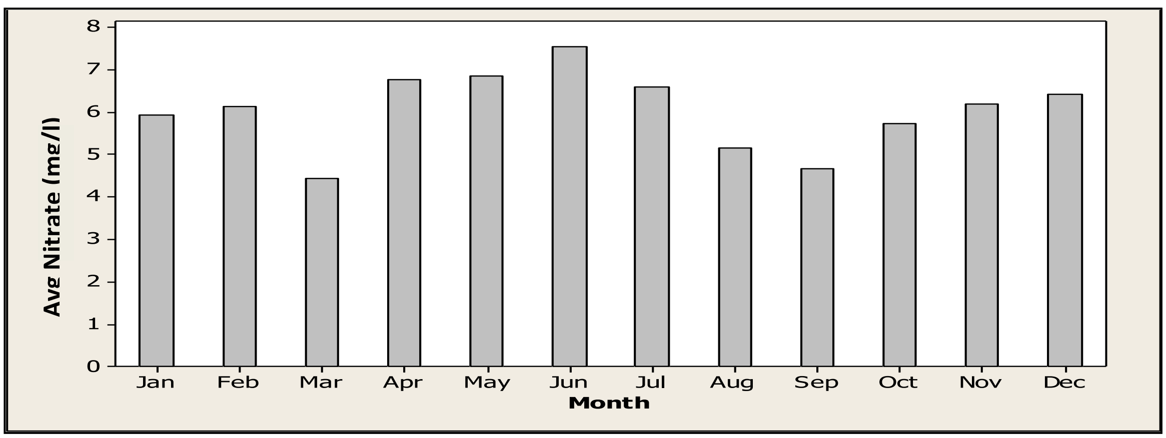

Figure C5 South Fork Whitewater River near Altura (S000-321) Seasonal Nitrate Pattern

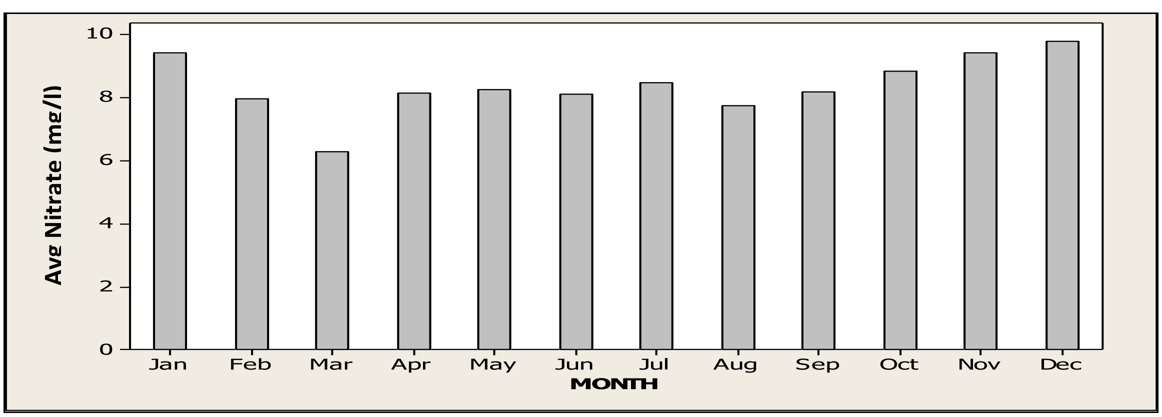

Figure C6 Middle Fork Whitewater River North of St. Charles (S001-831) Seasonal Nitrate Pattern

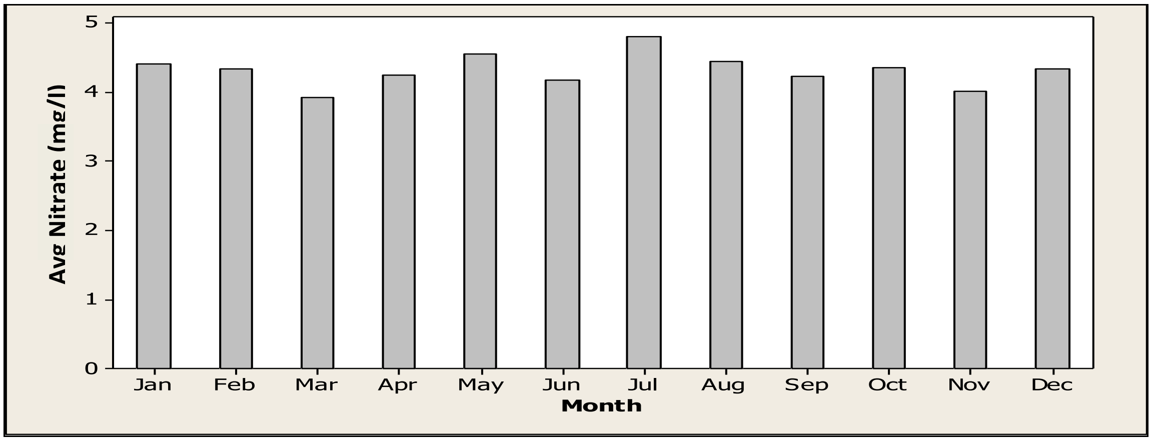

Figure C7 Long Term Research Monitoring Program (LTRMP) near Weaver Bottoms on HWY 61 Seasonal Nitrate Pattern

C.2 Relationship of Nitrate Concentration with Stream Discharge

Three sites have sufficient data to examine the relationship between nitrate (NO_3) concentrations and daily discharge (Table C1). The North Fork Whitewater River site near Elba (05376000) (1967-1993), shown in Figure C8, does not suggest any relationship between NO_3 concentration with discharge (CFS). However, given that NO_3 concentrations are increasing on average during the period of record, any pattern may be masked.

Table C2 Mississippi River-Winona Watershed Monitoring Stations with Correlation between Nitrate Concentrations and Daily Discharge

Station ID	Site Description	Period of Record	Nitrate/Discharge Correlation
S000-828 & 05378235	Garvin Brook SW of Minnesota City	1981-2008[1]	No Correlation
S001-831	Middle Fork Whitewater River North of St. Charles	2007-2012	Strong Correlation
5376000, S000-451, & S007-144	North Fork Whitewater River Near Elba	1967-1993	No Correlation

[1] Period of record available at the start of this project. This site is still operating.

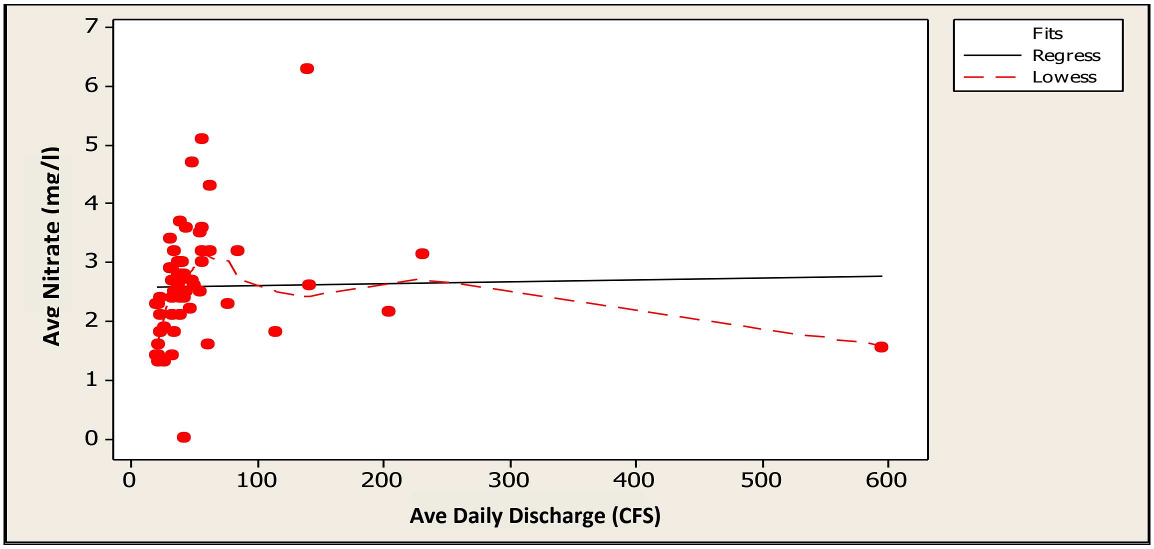

Figure C8 Nitrate vs. Daily Discharge at the North Fork Whitewater River near Elba (05376000)

Figure C9 shows the relationship between NO_3 and discharge (CFS) at the Middle Fork Whitewater River North of St. Charles (S001-831) (2007-2012). The linear regression shown would not meet the underlying assumptions of the statistical method. The graph merely depicts the inverse relationship between NO_3 concentration and flow. Figure C10 shows a non-parametric regression for NO_3 mg/L versus 1/discharge (CFS), which depicts an inverse relationship. The relationship is highly statistically significant ($p<.001$) based on Akritas-Theil-Sen regression. It is important to note that at low to moderate discharge (base flow), there is a lower variability of NO_3 concentrations, with higher variability and lower concentrations associated with event flows. This pattern may reflect a combination of 1) snow-melt dilution, 2) pulse washout from soils with events, and 3) dilution by runoff at high flows.

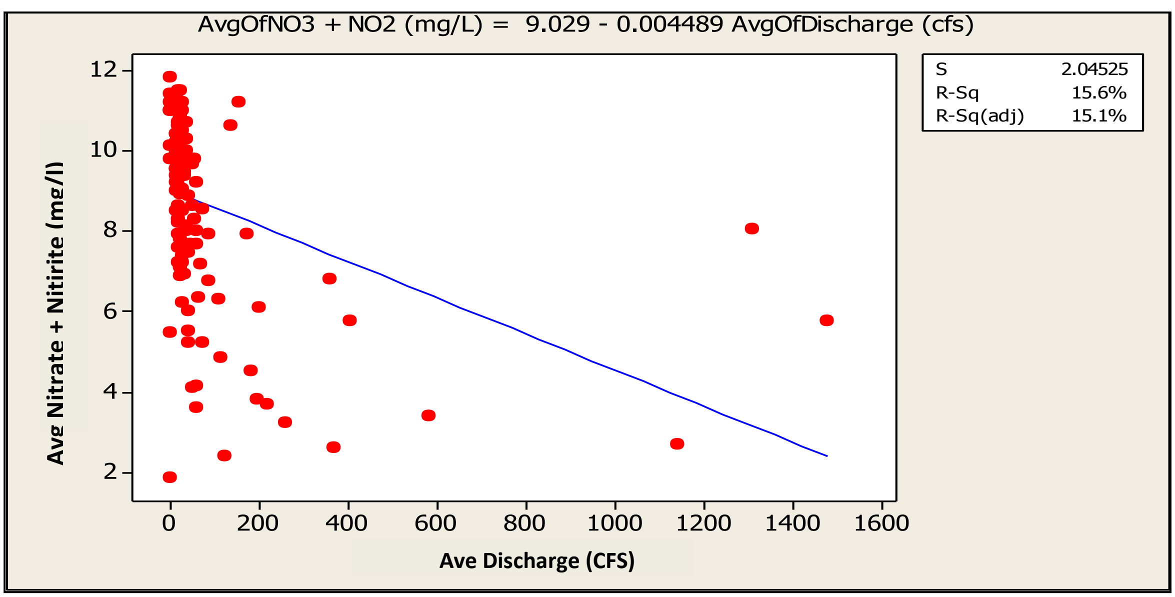

Figure C9 Regression of Nitrate with Stream Discharge at the Middle Fork Whitewater River North of St. Charles Site (S001-831) (Fitted Line Plot)

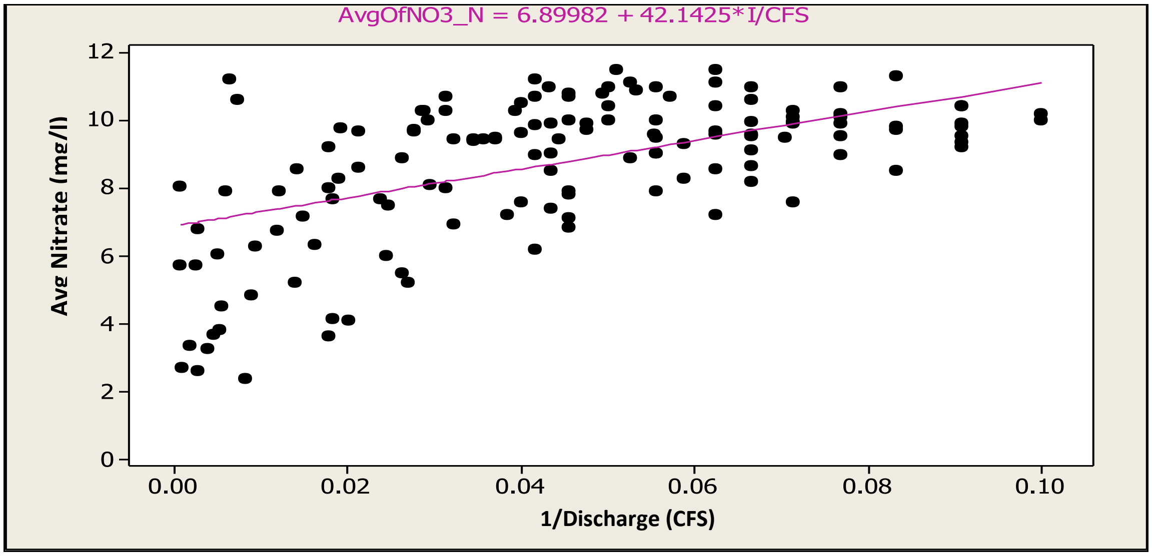

Figure C10 Non parametric Regression for Nitrate vs. Inverse of Discharge at the Middle Fork Whitewater River North of St. Charles Site (S001-831) (Akritas-Theil-Sen Regression)

Figure C11 shows the relationship of NO_3 concentration with flow at Garvin Brook SW of Minnesota City (S000-828). There is no statistical relationship at 90% or higher level of significance. As with the 05376000, North Fork Whitewater site near Elba, if there is any pattern, NO_3 may be being diluted at higher flows.

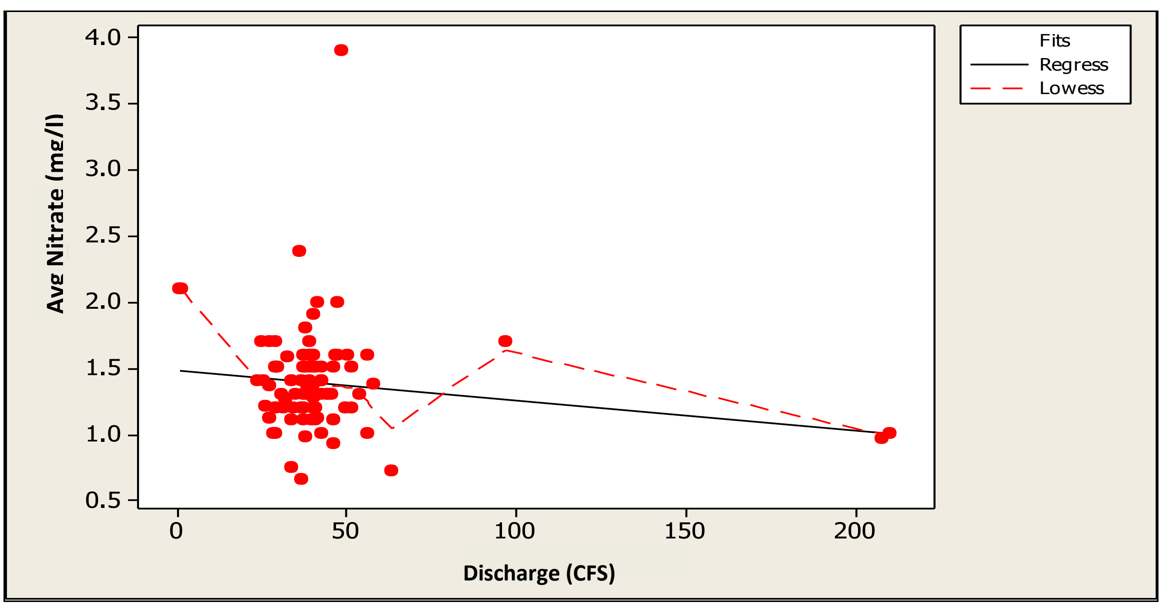

Figure C11 Nitrate vs. Discharge (CFS) at Garvin Brook SW of Minnesota City (S000-828)

C.3 Prediction of Nitrate Loading

Mississippi River-Winona Watershed streams have more than half of their yearly discharge occurring in a few major events. Thus a weighted concentration of a dissolved constituent is needed to calculate a yearly mass load, unless there is little or no variability of concentration with discharge. As seen above, NO_3 concentrations in Whitewater River streams do have a seasonal pattern and a weak inverse relationship with stream discharge illustrated above at the Middle Fork Whitewater River site north of St. Charles. Thus, yearly loads in NO_3 must account for both flow and the relationship of concentration to flow where a relationship exists.

The Middle Fork Whitewater River north of St. Charles (S001-831) record includes both NO_3 concentrations and daily discharge (CFS) values for 20-60 days/year (2007-2011). These data can be used to calculate yearly NO_3 mass loads in several different ways, as illustrated in Table C3. First the average NO_3 concentration can be multiplied by the average discharge (CFS) and a conversion factor to yield a yearly load (Column 4 in Table C3).This results is an overestimate of NO_3 load, since events represent a large fraction of flow. Second, a median yearly load is represented in column 5 by multiplying the median daily load by 365 days. This is much lower than the average calculation, but tends to underestimate the true load. Third, each pair of NO_3 and discharge values can be used to calculate a load for that day, and that day used to represent the period between samples. Adding all periods yields a “weighted” sum for the year (column 6). This would be the preferred method if paired nitrate-discharge samples were representative of the stream discharge curve, or a large number of daily pairs were available. Otherwise, the large event flows will tend to result in overestimation of yearly load. Lastly, the paired NO_3 and discharge data can be used to create a regression equation for predicting nitrate load from discharge, as shown in Figure C12 and calculated in Column 7. The regression method is preferred when a limited number of samples are available. The yearly load includes a correction for transformation bias (resulting from the log-log relationship between load and discharge). The Middle Fork Whitewater River north of St. Charles (S001-831) nitrate load ranges from 133 to 244 tonnes/year or 18 to 33 lbs/year for each acre in the watershed above the sample site (2007-2011 period).

It should be noted that while NO_3 concentrations decrease at high discharge levels, discharges increases at a much higher rate during events. NO_3 load is the product of concentration and flow and therefore nitrate loads increase significantly during runoff events.

Table C3 Calculation of Yearly Nitrate loads at Middle Fork Whitewater River north of St. Charles (S001-831)

Year	Med load tonnes / day	CFS/Day	Avg CFS X Avg Load Tonnes	Med x 365 Tonnes	Yearly Sum Tonnes	Regression Load Tonnes	Regression NO_3 lb/ acre/year
2007	0.39	14	956	142	516	**133**	18
2008	0.73	29	872	267	461	**244**	33
2009	0.42	16	161	154	181	**149**	20
2010	0.52	21	290	190	196	**188**	26
2011	0.65	25	413	235	295	**221**	30
overall	0.54	21	539	197	330	**187**	26

Load units are metric tonnes / day or year
CFS- Cubic feet per second

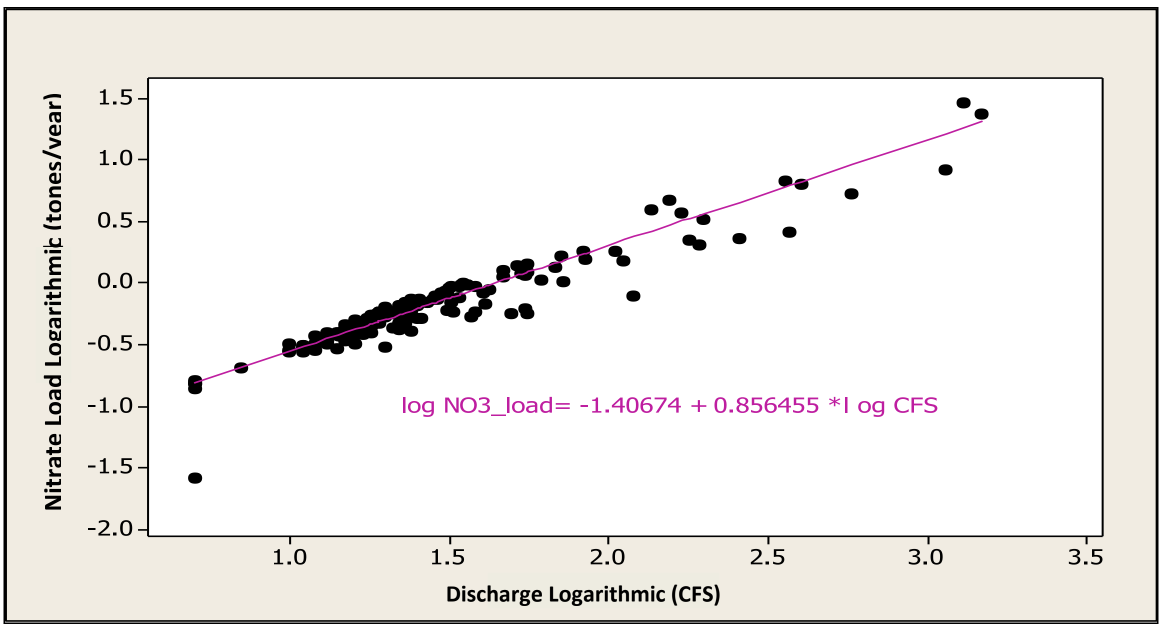

Figure C12 Nitrate Load Curve for Middle Fork Whitewater River north of St. Charles S001-831 (Non-Parametric Regression) p<0.001

Appendix D: Long Term Trends in Nitrate (NO_3)

Several Mississippi River-Winona Watershed sites have sufficiently long records to determine statistically significant trends over time. Two sites are Minnesota Pollution Control Agency (MPCA) Milestone Monitoring Program sites. Table D1 and D2 show trend data calculated by the MPCA. Nitrate trends for these milestone monitoring program sites and other Mississippi River-Winona Watershed sites are also examined below.

Table D1 Trends at Garvin Brook Southwest (SW) of Minnesota City from 1983 – 2009 (S000-828)

	Total Suspended Solids (TSS)	Total Phosphorus (TP)	Nitrate-Nitrogen (NO_3_N)	Ammonia (NH_3)	Biochemical Oxygen Demand (BOD)	Chloride (Cl)
Overall trend	**decrease**	**decrease**	**increase**	**decrease**	**decrease**	**increase**
Slope	-0.0385082	-0.0139937	0.030947	-0.009	-0.017	0.0362
Number of Years	26	26	26	26	26	26
Average Annual Change	-3.8%	-1.4%	3.1%	-0.9%	-1.7%	3.7%
Total Change	-63%	-30%	124%	-21%	-36%	156%
P-value	0.00	0.00	0.00	0.01	0.03	0.00
1995 - 2009 trend	**decrease**	**no trend**	**increase**	**no trend**	**no trend**	little data
Slope	-0.09662		0.02519			
Number of Years	8	12	12	12	12	12
Average Annual Change	-9.2%		2.6%			
Total Change	-54%		35%			
P-value	0.00	0.92	0.00	0.92	0.84	
Median First 10 Years	59	0.1	1.3	0.07	1.5	6
Median Most Recent 10 Years	21	0.1	2.2	<.05	0.8	13

[1] Data taken from MPCA Milestone Monitoring Program Presentation to the Basin Alliance for the Lower Mississippi in MN. Data taken from the EQUIS database was used for all other analyses and figures of Milestone sites in this report.

The MPCA trends are calculated using a seasonal Kendall non-parametric statistical test. This test examines each month separately to calculate an overall trend. Garvin Brook (S000-828) shows statistically significant increases for nitrate (NO_3) and chloride (Cl) from 1983 to 2009. The NO_3 trend is quite pronounced, so that it can be seen using yearly averages rather than monthly values (Figure D1). Yearly NO_3 averages at S000-828 show a highly statistical trend with yearly average NO_3 increasing from 1.1 to 2.6 mg/L since 1982. As seen in Table D1, some years have negative values for the increase, which results in the annual average change being lower than the two decade overall change.

The data for the MPCA milestone site on the South Fork Whitewater River near Utica (S000-288) is shown in Table D2, and a graph of the NO_3 trend is shown in Figure D2. Nitrate has increased at S000-288 from 4.2 mg/L in 1974 to 11 mg/L in 2011. Both milestone sites have more than doubled in NO_3 concentrations since the 1980's.

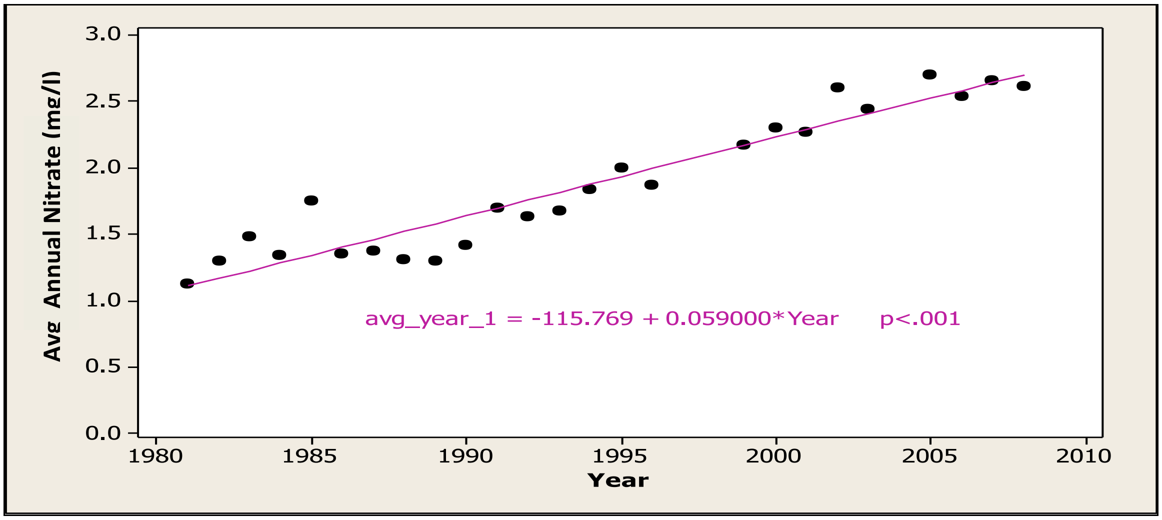

Figure D1 Nitrate trend at Garvin Brook SW of Minnesota City (S000-828) **(Akritas-Theil Nonparametric Regression)**

Table D2 South Fork Whitewater River near Utica (S000-288) from 1974 - 2008

	Total Suspended Solids (TSS)	Total Phosphorus (TP)	Nitrate-Nitrogen (NO_3_N)	Ammonia (NH_3)	Biochemical Oxygen Demand (BOD)	Chloride (Cl)
Overall Trend	**decrease**	**no trend**	**increase**	**decrease**	**decrease**	**increase**
Slope	-0.021		0.019	-0.037	-0.029	0.019
Number Of Years	35	35	35	35	35	35
Average Annual Change	-2.1%		2.0%	-3.6%	-2.8%	1.9%
Total Change	-53%		101%	-73%	-64%	94%
P-Value	0.01	0.53	0.00	0.00	0.00	0.01
1995 - 2009 Trend	**no trend**	**no trend**	**increase**	**no trend**	**decrease**	little data
Slope			0.025		-0.063	
Number Of Years	11	11	14	14	11	1
Average Annual Change			2.5%		-6.1%	
Total Change			41%		-50%	
P-Value	0.69	0.70	0.00	0.50	0.07	
Median First 10 Years	31	0.5	7	0.10	2.3	27
Median Most Recent 10 Years	13	0.5	11	<.05	1.0	43

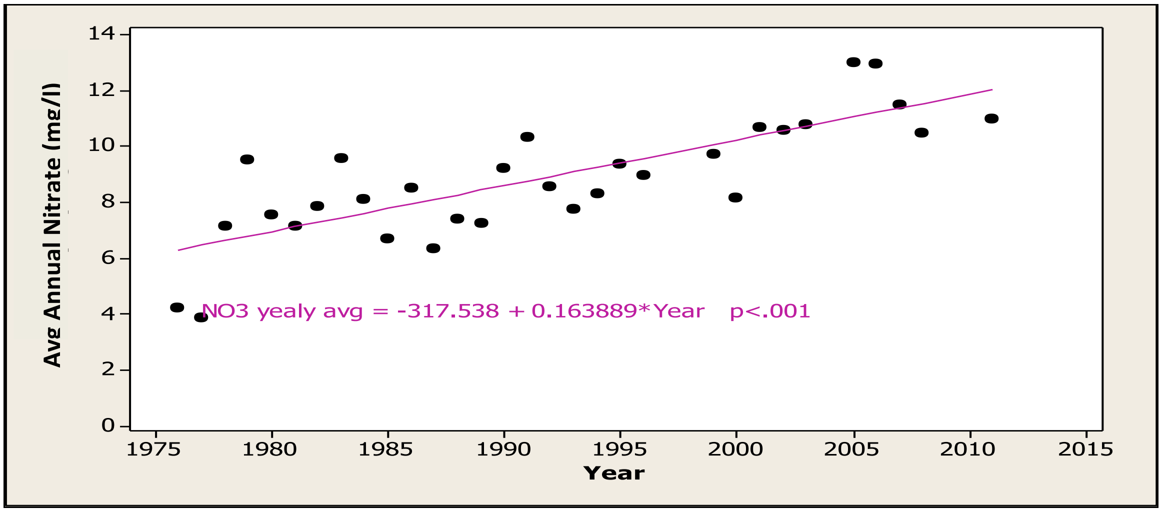

Figure D2 Nitrate Trend for South Fork Whitewater River near Utica (S000-288)
(Akritas-Theil-Sen Non-Parametric Regression)

Figure D3 shows the NO_3 trend for the South Fork Whitewater River near Altura (S000-321). A statistical trend (P<0.001) is seen here despite the missing record 1997-2004. A slightly different way of addressing the change is to test the NO_3 difference between the early and later records. A Mann-Whitney test for the difference in NO_3 medians for the pre 1997 (5.7mg/l) versus post 2004 (7.2mg/L) shows high significance (p=0.008). Both statistical methods indicate an upward trend in NO_3.

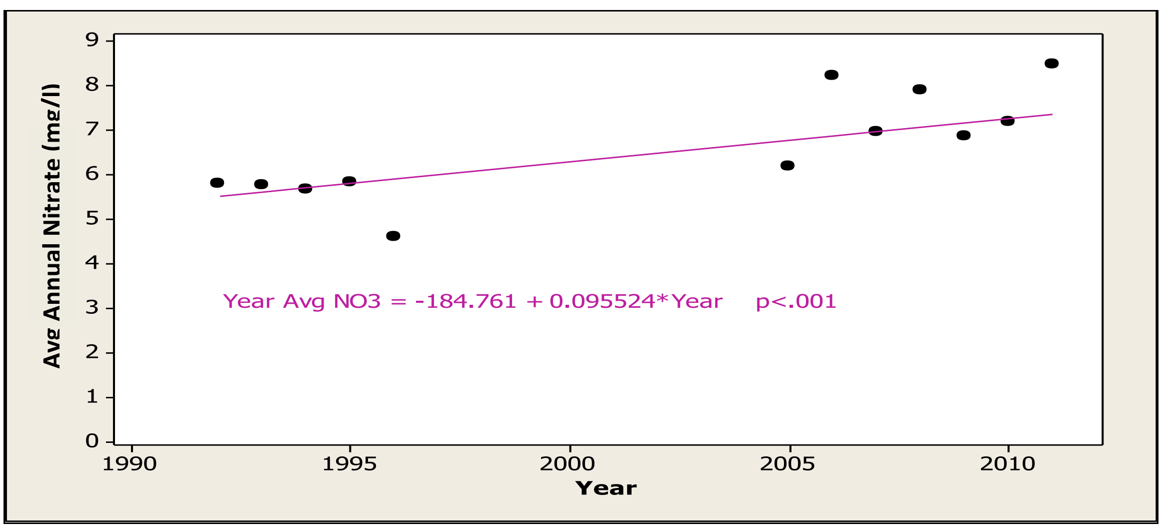

Figure D3 Nitrate Trend for South Fork Whitewater River near Altura (S000-321) (Akritas-Theil-Sen Non-Parametric Regression)

Figure D4 shows the trend for the North Fork Whitewater River near Elba [(05276000 (USGS), S000-451 (MPCA) and S007-144 (Olmsted)]. This site was originally sampled by the United States Geological Survey (USGS) from 1967 to 1993, by Olmsted County in 1999-2002 and 2008, and by Minnesota Department of Agriculture (MDA) in 2009 and 2010. Figure D4 represents a composite of all samples, and shows a linear regression with very high statistical significance (Rsq=83%, p<0.008). Unlike the previous sites, this site's data meets the underlying assumptions of ordinary least squares regression so that non-parametric methods are not needed. Nitrate has increased from less than 1 mg/L in the 1960's to over 6 mg/L in 2010.

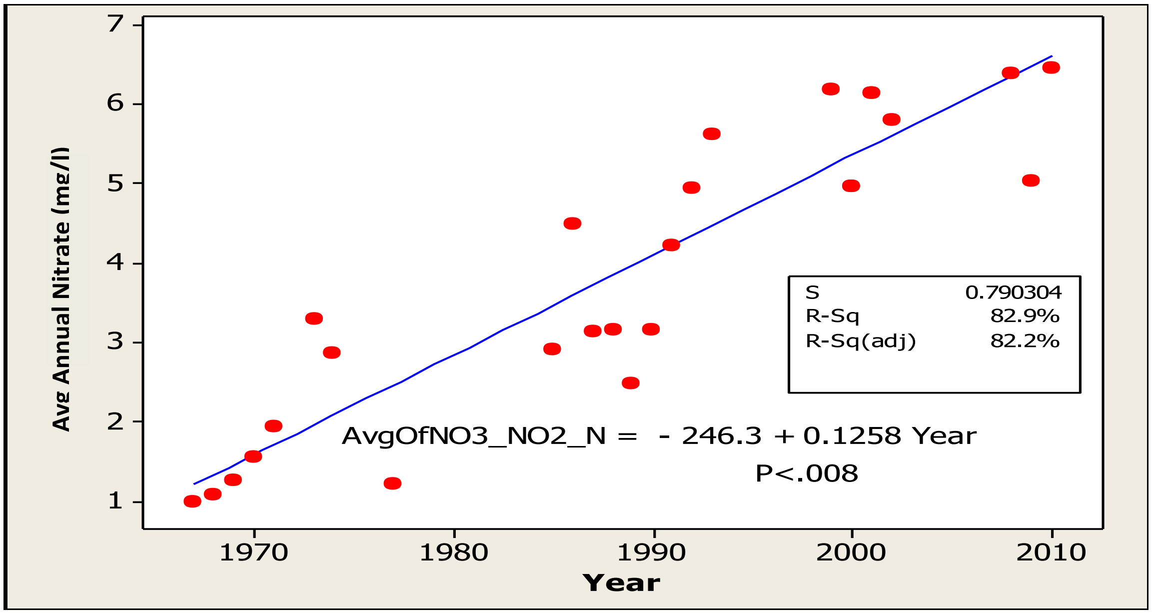

Figure D4 Nitrate Trend for North Fork Whitewater River near Elba (05376000, S000-451 and S007-144) *Note: Missing period of record in early 1980's*

It should be noted that the intercepts to the regression lines in Figures D1 and D4 above trace back to the time period 1958-1962, which is quite consistent with the time period in which commercial fertilizer began significant use in Minnesota (Figure D5)[1].

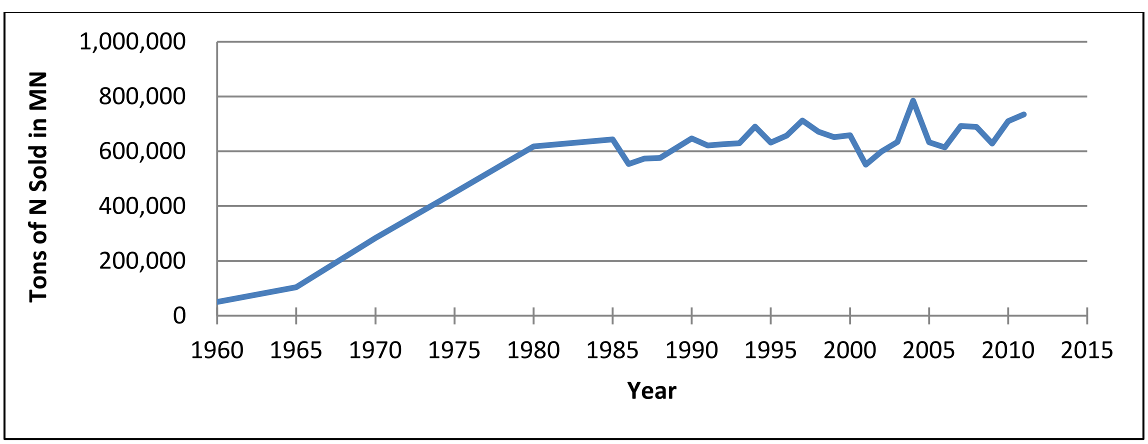

Figure D5 Nitrogen Fertilizer Sales in Minnesota Reported by the MN Dept. Of Agriculture

[1] Montgomery, B. *Nitrates in Groundwater-Filtering Out the Facts.* Minnesota Agriculture and Nitrates Forum. Minnesota. 25 July 2013. Lecture.

Figure D6 shows the NO_3 data for the Middle Fork Whitewater River North of St. Charles (S001-831). This site has been frequently sampled by MDA from 1993 to 2012 and by Olmsted County from 1999-2002 and in 2008. The 2007-2011 MDA data was used previously to calculate NO_3 loads in Appendix C. The scatter plot in Figure D6 does not indicate a statistically significant trend when yearly averages are used. When monthly data are used a significant trend is seen ($P<0.001$), as shown in Figure D7. Based on the monthly data, nitrate has increased from 7.4 mg/L in the early 1990's to 9-10 mg/L today. A seasonal Kendall test also showed a significant NO_3 trend with the monthly data ($p<.001$), but a Kendall test with the yearly averaged NO_3 values shows no statistical significance ($P=0.44$).

Where MDA and Olmsted data overlap time periods, the sample values are not statistically different (Mann Whitney, $p=0.42$). In particular, the 2008-2009 time periods, used in Appendix E to examine NO_3 concentrations in streams compared to land use, do not show MDA and Olmsted data to be different.

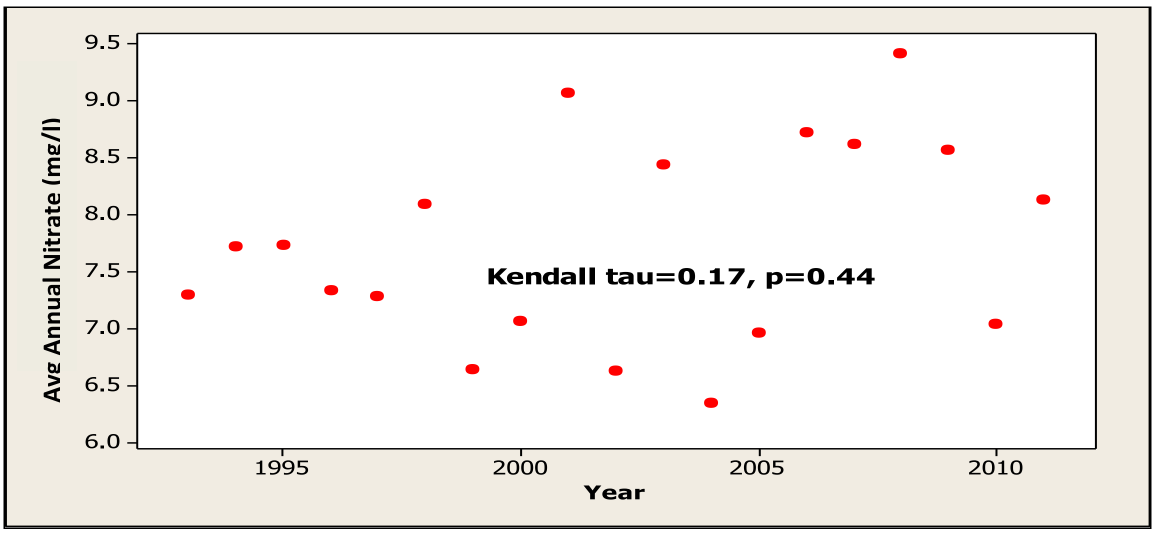

Figure D6 Scatter plot of Yearly Average Nitrate Concentration vs. Year for Middle Fork Whitewater River north of St. Charles (S001-831)

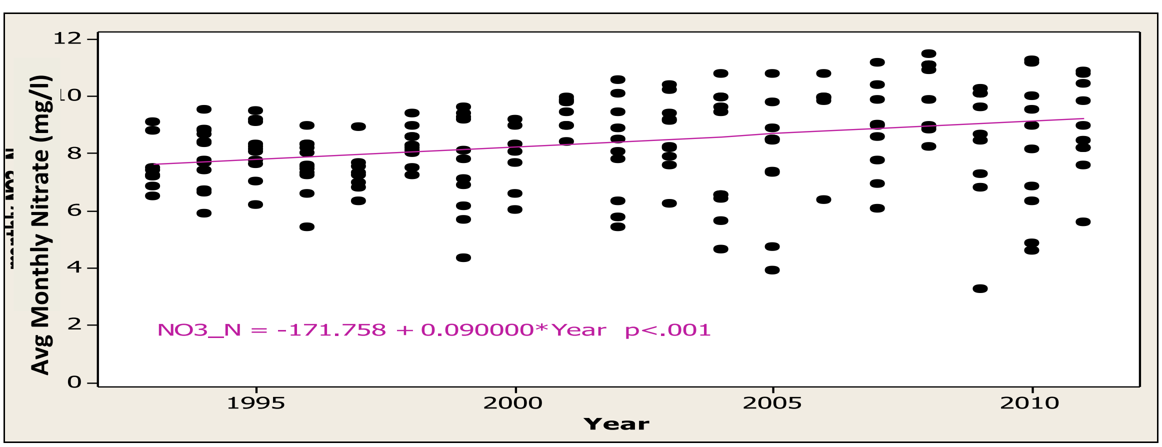

Figure D7 Trend with Monthly Average NO_3 Levels at Middle Fork Whitewater River north of St. Charles

The Long Term Research Monitoring Program (LTRMP) site on the Whitewater River at Hwy 61 near Weaver receives water from the entire Whitewater River Watershed. The site was sampled by MDNR from 1993 to 2008. Using yearly average NO_3 values (Figure D8), the trend is not statistically significant (p=0.16). However, when all monthly averages are used in Figure D9, the non-parametric regression is significant (P<.001). This shows the importance of counting all samples when a trend is suspected. A seasonal Kendall test for Nitrate at the LTRMP site near Weaver also shows a highly statistically significant upward trend (P<0.0001). Nitrate concentration increases from about 4 mg/L in the early 1990's to about 6 mg/L in 2008. Like the S001-831 site sampled by MDA, the LTRMP site near Weaver shows considerable nitrate concentration variability between samples. However, the increasing nitrate trend is still seen when seasonal and monthly averages are examined statistically.

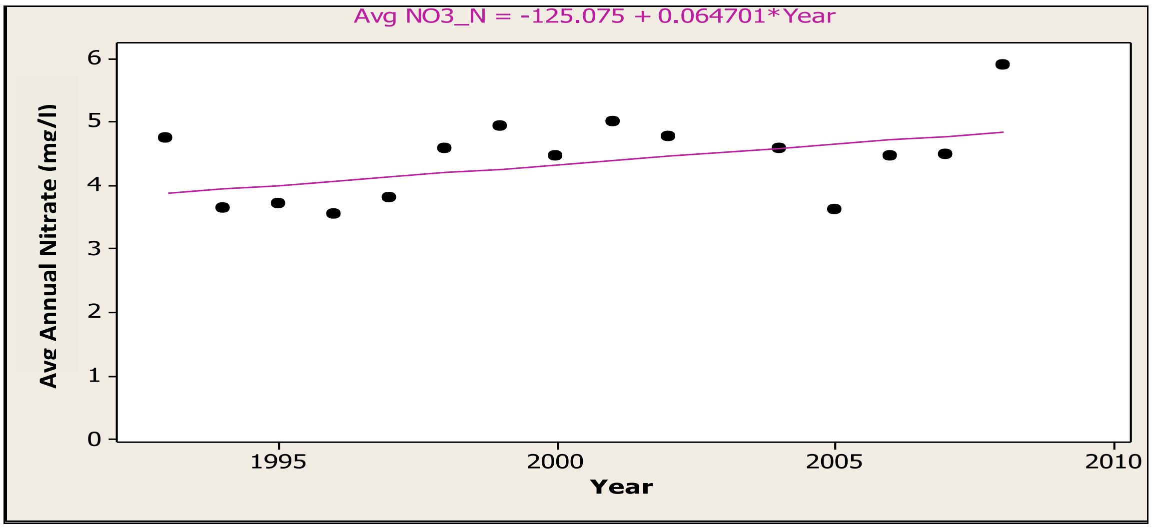

Figure D8 Nitrate Trend for the Whitewater River at Weaver Bottoms on Hwy 61 (LTRMP)
(Akritas-Theil-Sen Regression)

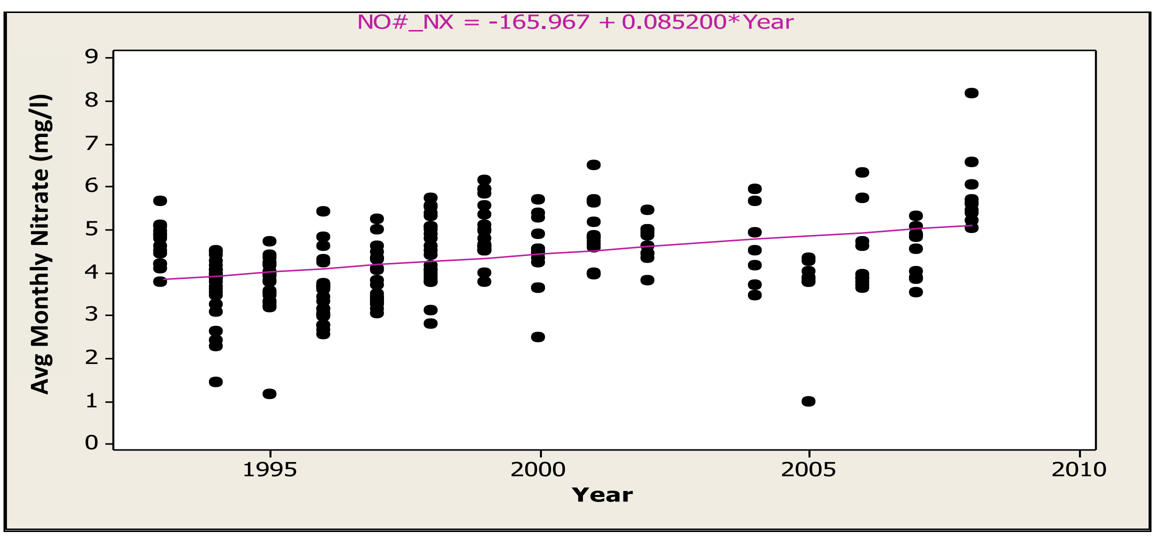

Figure D9 Nitrate Trend for the Whitewater River at Weaver Bottoms on Hwy 61 (LTRMP)
(All Monthly Data)

In summary, all Mississippi River-Winona Watershed sites with sufficient data to assess statistical trends show upward NO_3 concentration trends. All sites show year-to year variability in average concentration. A significant portion of this variability may be related to variability in annual stream flow as discussed in Appendix B. The magnitude of increase in nitrate concentration at each site varies, but is generally proportional to the decadal average for that site.

Appendix E: Nitrate (NO_3) and Land Use

E.1 Nitrate versus Land Use

Land use in the Mississippi River-Winona Watershed is a mix of agriculture (46%), forest and grassland covering steeper terrains (38%), the cities of Wabasha and Winona, as well as a number of smaller communities (NASS 2009).

A Minnesota Pollution Control Agency (MPCA) report on nitrate (NO_3) in Southeastern Minnesota Trout Streams, found a significant correlation (Rsq=68%) between base flow NO_3 concentrations and the percent of the watersheds in corn and soybean (CSB) production[1]. Thirty of the sites analyzed in this report were in the Mississippi River-Winona Watershed. Figure E1 shows the regression for NO_3 versus percent CSB production representing 100 stations on watersheds in SE MN. Over two-thirds of the variability is explained by the regression line, and the intercept is essentially "zero". The regression slope (0.16) suggests that a watershed with about 60% CSB would have a base flow NO_3 level of 10 mg/L which is the current safe drinking water standard established by the Minnesota Department of Health (MDH). In addition, the regression intercept representing little or no agriculture in a watershed, calculates to a "background" NO_3 level which is at or below the detection limit for NO_3 (~0.2 mg/L) by standard analytical methods [2].

To examine the relationship of Land use (LU) with steam NO_3 concentrations in the Mississippi River-Winona Watershed, data for 15 sites were used along with National Agriculture Statistical Service (NASS) land cover to develop a regression model similar to that determined in the Watkins report (Figure E2). To control for the known upward trend in NO_3 over time, the 2008-2009 time period was chosen and was analyzed based on the 2009 NASS data (Table E1). The years which have the most overlapping NO_3 data (2008 and 2009) are used for analysis. Both 2008 and 2009 are similar in precipitation (~30 inches) and PDSI values (1.37 and 0.09). This supports the compositing of NO_3 data for these years. In contrast, 2010 was a wetter year (~44 inches of precipitation) and higher stream discharges were seen in nearby SE MN rivers such as the Root[3,4].

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[1] Minnesota Pollution Control Agency. Rochester. *The Relationship of Nitrate-Nitrogen Concentrations in Trout Stream to Row Crop Land Use in Karstland Watersheds of Southeast Minnesota*. By Justin Watkins, Nels Rasmussen, Gregory Johnson, and Brian Beyerl. Rochester MN: MPCA, 2010.

[2] Rice, Eugene W., and Laura Bridgewater. *Standard Methods for the Examination of Water and Wastewater.* Washington, D.C.: American Public Health Association, 2012. Print.

[3] Lenhart, C., Nieber, H etal, *Quantifying Differential Streamflow Response of Minnesota Ecoregions to Climate Change and Implications for Management*, U of M Dept. of Bioproducts and Biosystems Engineering, Aug 2011.

[4] Minnesota Department of Natural Resources, Division of Waters. *Basin Averaged Monthly Precipitation Totals for DNR Watersheds.* June 2010. <http://deli.dnr.state.mn.us/metadata.html?id=L390006230201>

Table E1 2008-2009 Mississippi River-Winona Watershed Monitoring Stations Average Nitrate Concentrations and Percent Cropland

Station ID	Location	%Cropland	Avg. NO_3
S001-532	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	14%	1.9
S000-828	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	16%	2.6
S000-829	GARVIN BROOK NEAR MINNESOTA CITY	17%	2.7
WW01.3M	HWY 61 near Weaver	37%	5.9
S002-072	LOGAN BR N FK WHITEWATER R AT CSAH-10, 5.5 MI S OF PLAINVIEW	39%	9.0
S000-321	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	42%	7.4
S001-742	WHITEWATER R AT CSAH 30, 4.5 MI N OF ELBA, MN	42%	5.5
S000-325	S FK WHITEWATER R AT MN-74 AT ST CHARLES	46%	9.5
S000-288	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	47%	10.5
S007-144	WHITEWATER R, NF AT TR-29 (FAIRWATER RD), 7.5 MI SE OF PLAINVIEW	50%	6.4
S000-451	N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	50%	5.0
S007-145	WHITEWATER R, NF AT 65TH ST NE BRG, 2.5 MI SW OF ELGIN, MN	52%	9.3
S001-831	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	53%	9.2
S007-140	WHITEWATER R, MF AT CR-152 BRG, 5 MI NW OF ST. CHARLES, MN	53%	11.1
S007-146	WHITEWATER R, SF AT US-14 CULVERT, 1 MI NW OF DOVER, MN	54%	11.2

Both regressions in Figures E1 and E2 show increases in variance with increasing CSB fraction, a situation which violates an underlying assumption of linear regression and requires either a non-parametric regression or conversion to log units to obtain better regression diagnostics. The regression line in Figure E2 is shown here for comparison with the Watkins regression. The Mississippi River-Winona Watershed slope is higher (20.6x CSB fraction) than the Watkins slope (16 x CSB fraction), however, the intercept in both regression lines are essentially "zero". The difference in slopes could partially reflect the use of yearly average NO_3 levels for 2008-2009 versus base flow values used in the Watkins regression. The difference likely also reflects the fact that "trout streams" targeted by Watkins are in more dissected terrain. In this setting, stream base flow is a mix of recent shallow groundwater and older, deeper aquifer (Prairie du Chein or Jordan) groundwater which does not reflect NO_3 from recent agriculture.

A regression plot of the Mississippi River-Winona Watershed NO_3 data versus the fraction of "all crop acres" including pasture in 2008-2009 is shown in Figure E3. In this figure, non-parametric regression using log-log units is employed, which addresses the variance problem and yields better regression diagnostics (about 85% of the variability is explained by the log regression line). The equation in Figure E3 does a better job of predicting the actual average NO_3 concentrations than does the linear or log-log model using CSB only. Models using "All crops" appear slightly better than those using CSB fraction. The intercepts for zero "Fraction" (or near zero for the log-log regression) correspond to NO_3 levels near or below zero. The ninety-five percent confidence interval for the intercept in the CSB fraction case using linear least squares regression is $-3 < \text{Intercept} < +2.5$mg/l NO_3. Non-parametric regression confidence limits for the intercept are not readily calculated, but they are likely to be in the same range as in the least squares case. The fact that the linear intercept is "centered" on a slightly negative value suggests that nitrate concentration in a river reach with essentially no agriculture should be close to zero (or below the common detection limit of 0.2 mg/L NO_3). Indeed, streams in northern Minnesota and Wisconsin with essentially no agriculture commonly have NO_3 levels of only a few tenths of a mg/L[5].

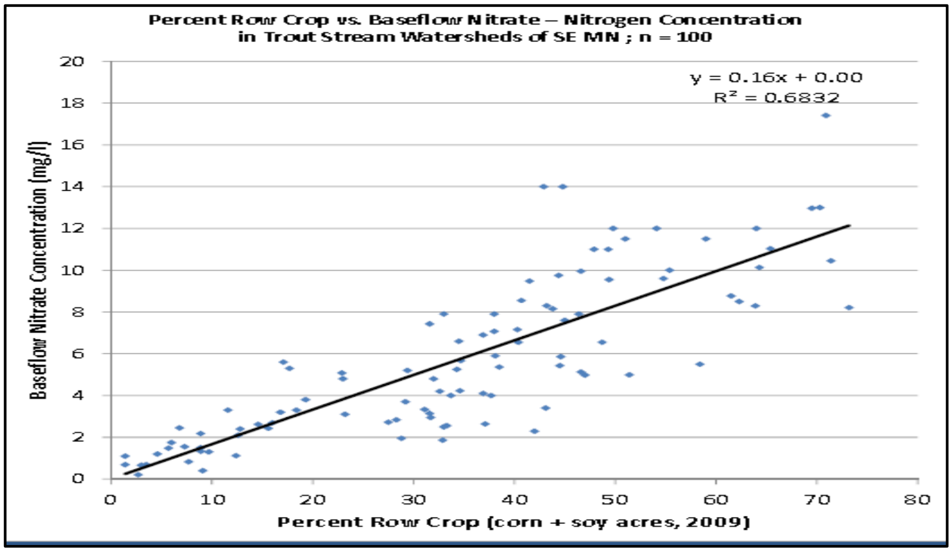

Figure E1 Base flow Nitrate Versus Corn and Soybean Agriculture for 100 Southeastern MN Trout Streams (MPCA, Watkins 2011) **(Linear Regression)**

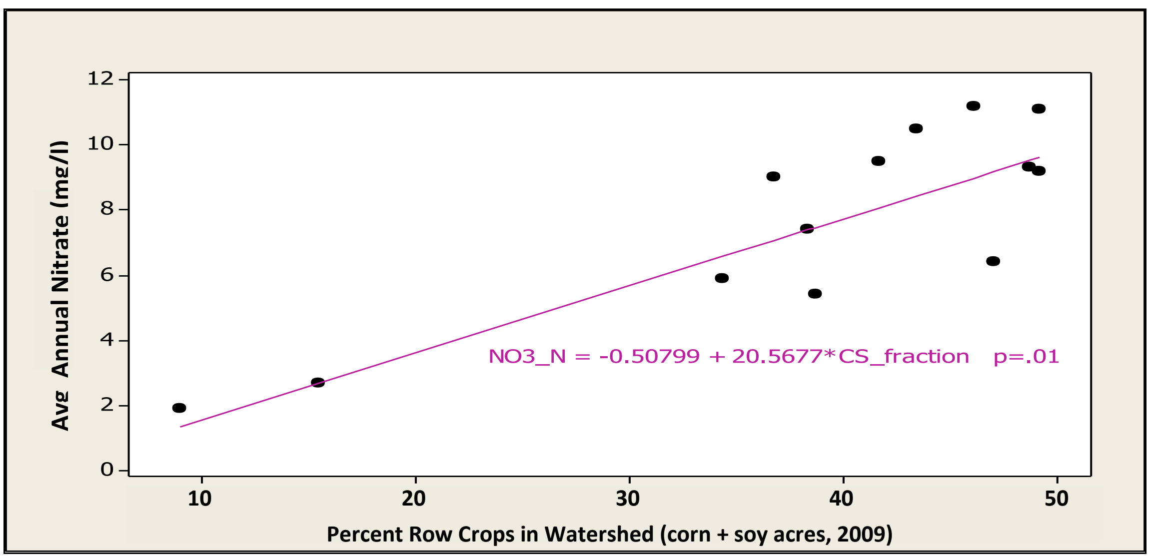

Figure E2 Regression of 2008-2009 Nitrate versus Corn/Soybean Agriculture for 15 Mississippi-River Winona Streams **(Akritas-Theil-Sen Regression)**

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[5] Gruber, N; Galloway, J. *An Earth-System perspective of the global nitrogen cycle.* Nature 451, 293-296 (17 January 2008) | doi: 10.1038/nature06592; Published online 16 January 2008.

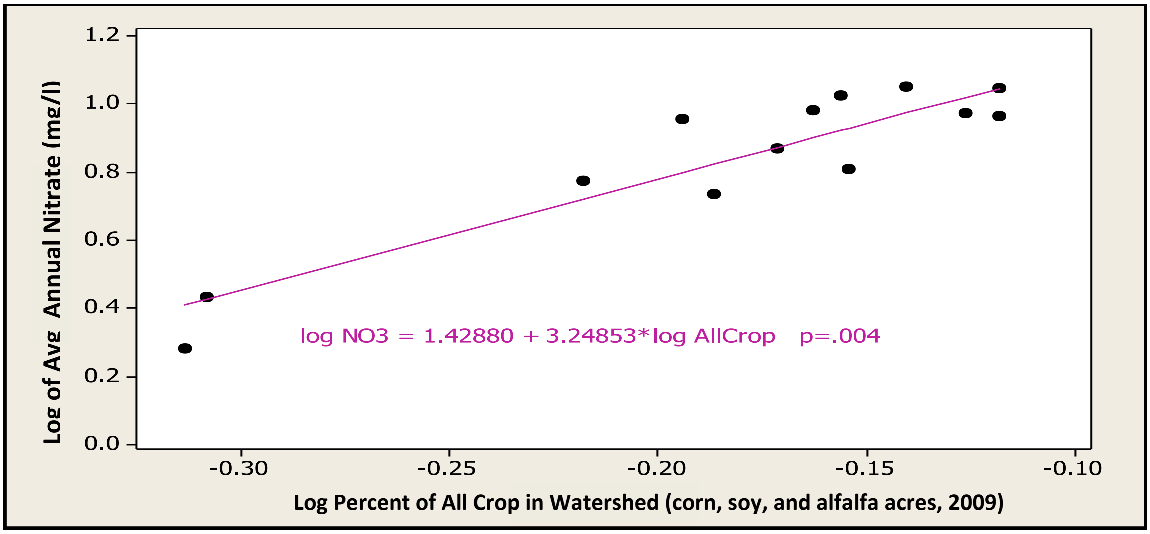

Figure E3 Stream Nitrate versus All-Crop Fraction in Mississippi River-Winona Watershed (Akritas-Theil-Sen Regression log-log units)

Several other NO_3 regression models were examined, including corn only and CSB plus alfalfa. These models did not improve the linear regression values and all required log-log non parametric methods to obtain the best diagnostics. The equation in Figure E3 is considered the best for prediction of NO_3 from land use.

To test the reliability of the nitrate prediction, 17 of the HUC12s in the Mississippi River-Winona Watershed were sampled on 12/12/12 at the point in which the stream discharges from the watershed—the "pour point Table E2 lists the stations sampled, and the measured and predicted NO_3 levels based on the regression line in Figure E4. As in Figure E3, the "All Crop" fraction was used as the dependent variable. The regression line in Figure E4 has a lower slope than that in Figure E3. This lower slope may be attributed to the drought experienced in 2012.

Figure E5 compares the linear regression models for Watkins, the 2008-2009 data and 2012 sampling, using CSB fraction as the dependent variable for consistency with Watkins' original report. The 2008-2009 period had a higher slope, while the 2012 sampling and Watkins slopes are more alike. The difference is likely attributed to the difference in base flow nitrate versus yearly average nitrate.

As shown in Appendix D, all sites examined in the Mississippi River-Winona Watershed show an increase in NO_3 concentration over time. To illustrate this pattern in relation to land use (LU), linear regressions were conducted in Figure E6 using NO_3 data from 1981, 1999, and the above 2008-2009 period. The LU data used for these regression lines included "all crops without pasture" in order to compare similar data sets from different times. The slopes increase from 1981 to 2009, and the most recent decadal increase is smaller than the average of that for the previous two decades. All regressions have intercepts very close to "zero". As discussed previously, background NO_3 levels for streams with essentially no agriculture are near or below the common detection limit (0.2 mg/l NO_3).

Table E2 2008-2009 Nitrate Results from Mississippi River-Winona Watershed HUC12 Pour Point Sampling (12/12/2012)

Sampling Location	Site ID #	Nitrate (mg/l)		Percent of Watershed	
		Measured	Predicted	All Cropland	Corn/ Soybean
Dry Creek (2nd Avenue NE in Elgin)	NA	8.3	5.5	59	65
North Fork Whitewater River (MN-42 in Elgin)	S000-776	10.2	7.6	69	45
Garvin Brook (near Minnesota City)	S000-827	3.4	3.4	48	15
Rollingstone Creek (Middle Valley Rd Bridge 1.5 Mi NW of Minn City)	S001-532	2.9	3.6	49	9.2
Gorman Creek (1 Mi S of Kellogg)	S001-704	3.5	2.7	42	16
Beaver Creek(Hwy 74, 4.6 Mi N of Elba)	S001-741	3.5	3.6	49	23
North Fork Whitewater River (Hwy 74 at Elba)	S001-745	5.1	5.8	61	34
Whitewater River (Railroad Bridge, 0.5 Mi SE of Weaver)	S001-767	4.9	7.3	68	47
Middle Fork Whitewater River (MN-74 Bridge at Elba)	S001-825	7.3	8.1	71	42
Snake Creek (US-61, 4 Mi S of Kellogg)	S003-454	2.4	1.6	33	11
Pleasant Valley Ck at Holler Hill Rd In Winona	S003-793	1.2	0.9	26	1.8
East Burns Valley Creek at CSAH 105 in Winona	S003-806	1.2	1.1	29	1.8
Big Trout/Pickwick Creek Upstream of US-61, 2 Mi NE of Pickwick	S004-244	1.1	1.6	33	3.9
Cedar Valley Creek, Upstream of South-Bound US-61 Lane	S004-245	1.2	1.7	34	5.5
East Indian Creek 100 Yds SW of US-61 and CR-84, 6 Mi SE of Kellogg	S005-390	2.1	2.9	44	14
Trout Creek outlet To Whitewater River at 564th St, 11.5 Mi NE of Plainview	S006-531	1.9	2.4	40	6.3

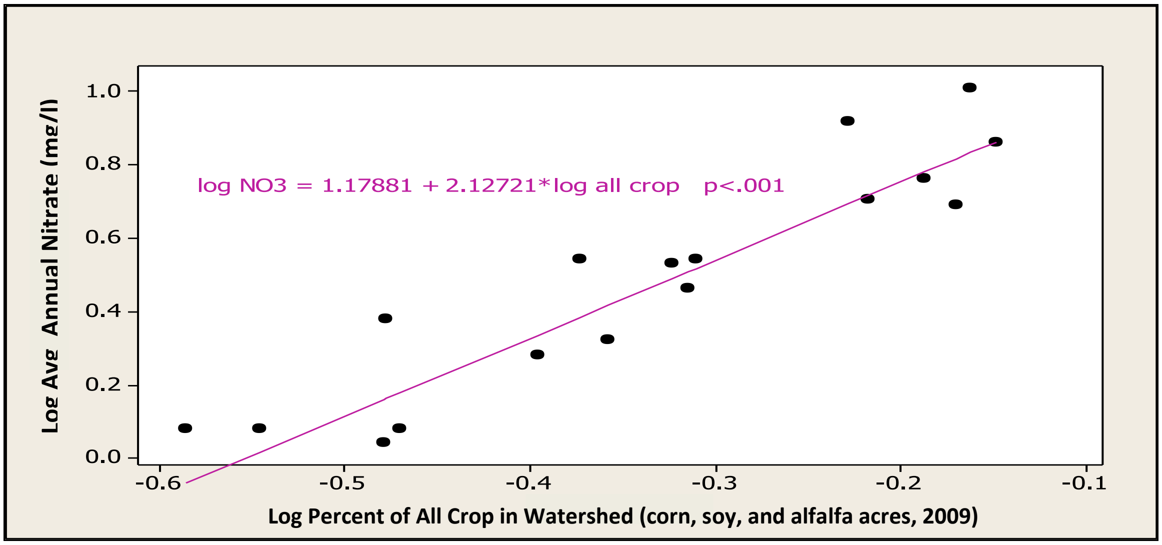

Figure E4 Nitrate versus All Cropland Synoptic Sampling (12.12.12) (Akritas-Theil-Sen Regression)

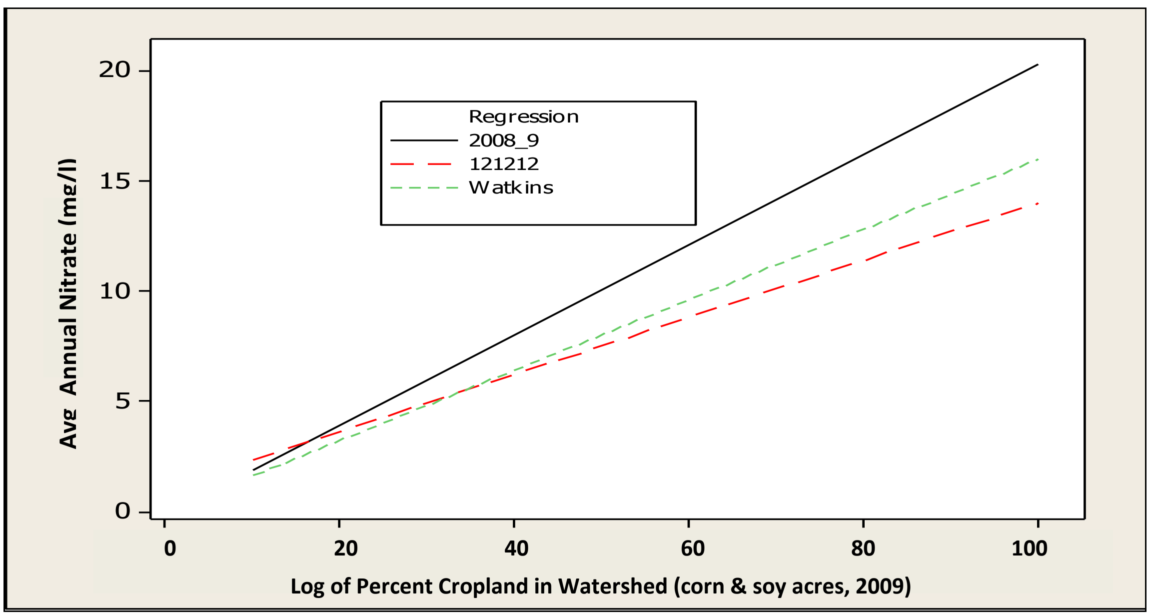

Figure E5 Comparison of Regression lines for Nitrate versus CSB Fraction (2008-2009, Watkins 2011, and 12.12.12 synoptic sampling)

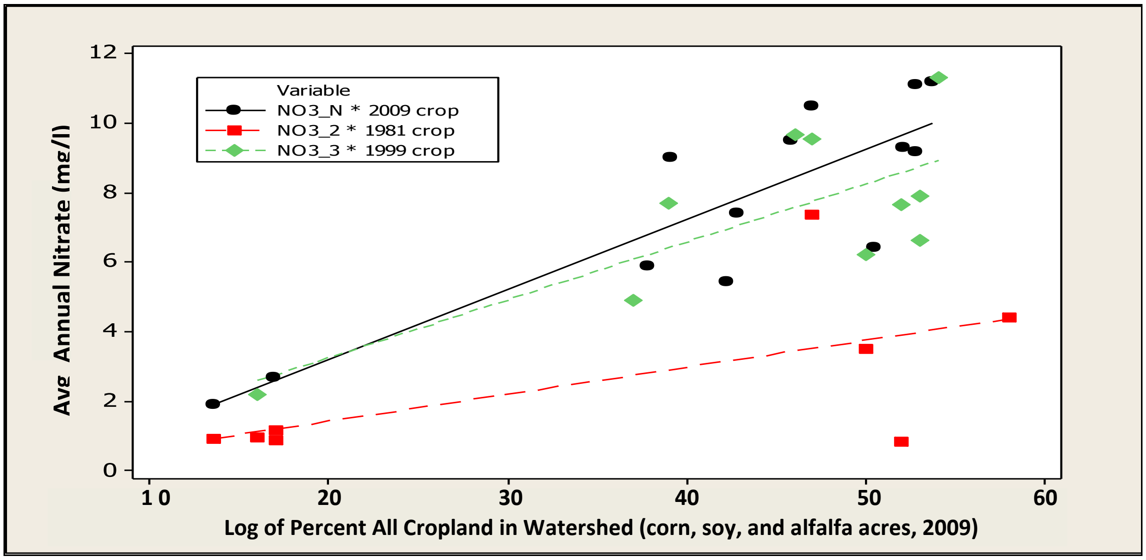

Figure E6 Nitrate vs. Cropland without Pasture for three time periods (1981, 1999 and 2008-2009) (Linear Regression)

E. 2 Conclusions

Nitrate concentrations in Mississippi River-Winona Watershed streams are strongly correlated with Agricultural Land Use in the upstream watershed. As explained in Section E.1, the log-log regression using "all cropland" results in the best correlation. Nitrate for Mississippi-River Winona sites in 2008-2009 shows a larger regression slope with LU than that of Watkins (MPCA) and that of a synoptic sampling of 17 sites in December 2012. All Nitrate regressions vs. corn and soybean fraction show intercepts at essentially zero. Regressions comparing three time periods (1981, 1999 and 2009) show the same increasing trend for NO_3 over time as found in Appendix D. The data in this Appendix do not indicate whether the upward trend in NO_3 concentrations will continue, or whether some plateau will be reached consistent with the agricultural land use in the watershed. The future of NO_3 levels will be addressed in Appendix F.

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Appendix F: Upper Limit of Nitrogen Concentrations in Streams

The purpose of this appendix is to summarize the nitrate trend data and the correlation with land use in the context of fertilizer use and field studies. The focus of this section is on the aggregate loading that results in the stream nitrate levels seen in Appendices C-E. This analysis does not address site specific nitrate levels associated with septic systems, community sewage treatment discharges, spills, and animal operations. While the nitrate trends in the data are universally increasing, there are physical limits to the maximum nitrate concentration in the streams, and based on this information, it appears that nitrate concentrations in the watershed are approaching those limits.

In Appendix C, the Nitrate- Nitrogen (NO_3) mass loadings for the Middle Fork Whitewater River North of St. Charles (S001-831) were calculated at 18 to 33 lb N/upstream watershed acre/year for the 2007-2011 period. The average NO_3 load at this site is 26 lbs N/acre/year. Forty-eight percent (48%) of the watershed land was dedicated to corn and soybeans in 2009. In Appendix D, stream NO_3concentration was seen to be highly correlated with agricultural land use. Extrapolating the S001-831 values to a "hypothetical stream reach" with 100% corn plus soybeans should result in a load of about 52 lbs NO_3 /acre/year. The next paragraph discusses how this number compares to agronomy data for corn in the Mississippi River-Winona Watershed.

In 2009 and 2010, corn yields for Winona and Wabasha counties averaged about 170 bushels/acre[1, 2]. Assuming that the corn acres in these counties received the average statewide nitrogen (N) fertilizer application of 143 lbs/acre[3], and that corn today has about 7% protein[4], these two counties would represent 101 lbs N in corn grain, and an unused amount of 42 lbs N/acre. These numbers are consistent with agronomic studies showing corn N utilization efficiencies seldom exceeding 70%[5,6]. Figure F1 illustrates the nitrogen fertilizer application rate for the Midwestern United States. The next paragraph discusses where the nitrogen is transported and where other N sources exist in the watershed.

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[1] Minnesota Department of Agriculture. Agricultural Marketing Services Division. *Olmsted County Agricultural Profile*. 13 Jan. 2013 <http://www.mda.state.mn.us/Global/MDADocs/food/business/econrpt-olmstedcnty.aspx> *Winona County Agricultural Profile*. <http://www.mda.state.mn.us/Global/MDADocs/food/business/econrpt-winonacnty.aspx> *Wabasha County Agricultural Profile*. <http://www.mda.state.mn.us/food/business/agmktg research/~/media/Files/food/business/countyprofiles/econrpt-wabasha.ashx>

[2] United States Department of Agriculture. Minnesota National Agricultural Statistics Service. Minnesota County Estimates. NASS/USDA, 2012. Web. 29 Jan. 2013. <http://www.nass.usda.gov/statistics_by_state/Minnesota/Publications/County_Estimates/index.asp>

[3] Montgomery, B. *Nitrates in Groundwater-Filtering Out the Facts*, MN Agriculture and Nitrates Forum, Rochester, MN, July 25, 2012. Lecture

[4] DeVillex, P, Foster, W. *2011 Purdue Corn and Soybean Performance Trials*. Purdue University Department of Agronomy, Agricultural Research Programs, 2011. Web. Winter 2013.

[5] Sawyer, J, etal, *Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn*. Iowa State Extension Service, Apr. 2006. <www.extension.iastats.edu?Publications/2015.pdf>

[6] Follett. R. F. and Hatfield, J.L., *Nitrogen in the Environment: Sources, Problems and Management. In Optimizing Nitrogen Management in Food and Energy Production and Environmental Protection*: Proceedings of the 2nd international Nitrogen Conference on Science and Policy. The Scientific World S2 1 (2001): 920-26. Print.

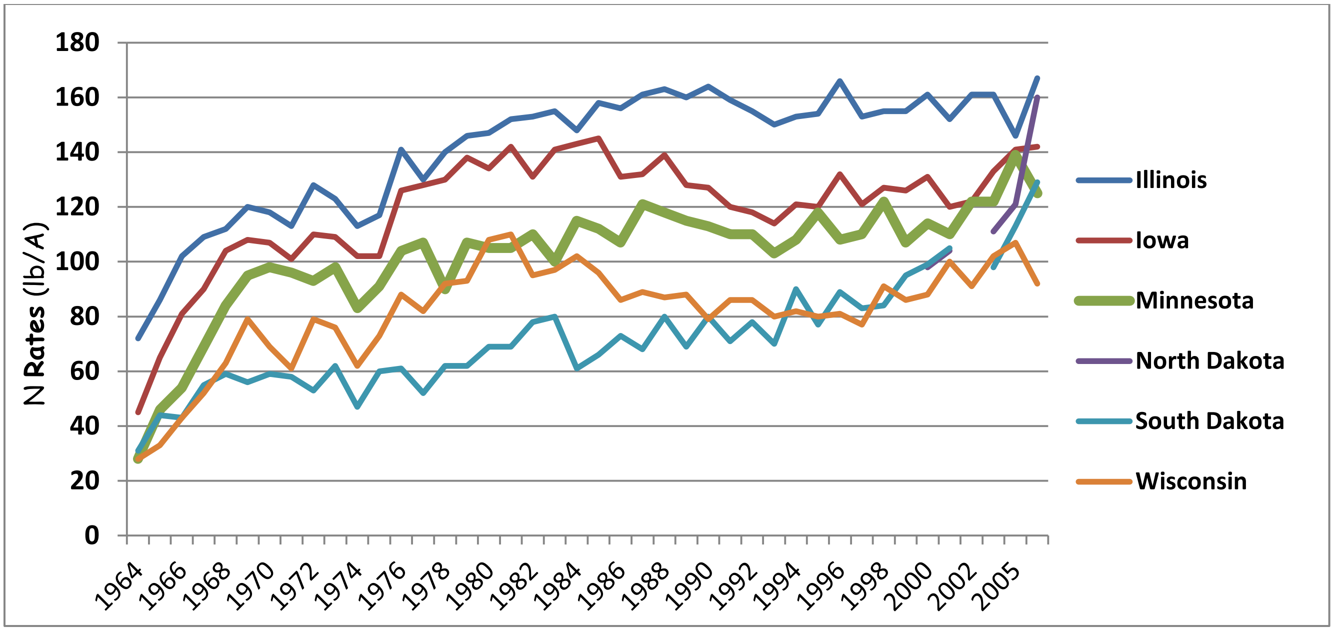

Figure F1 Nitrogen Fertilizer Rates for the Midwestern United States

Although commercial N fertilizer in the Mississippi River-Winona Watershed is almost entirely applied to corn, additional N is captured in agriculture by soybeans and alfalfa. These legumes fix atmospheric N and convert it into plant protein, most of which is fed to livestock. Most of the corn and soybeans may be actually exported from the area, but a good portion of the corn, and soybeans (in the form of soy meal), and essentially all of the alfalfa hay, is fed to livestock locally. The contained N is converted to meat or dairy protein products which are then exported. Manure from livestock however, remains in the local area. Thus the "excess fertilizer N" calculated above is likely a low number for a watershed with animal agriculture. To further complicate the situation, some N, regardless of original source, is denitrified in wet soils and other anaerobic conditions. Thus the corn fertilizer N excess is only a rough estimate of what might actually be ultimately found in streams. Given the uncertainties, the 42 lbs N/acre excess from fertilizer is reasonably close to the 52 lbs N/acre calculated from the S001-831 data extrapolated to a hypothetical 100% corn-soybean watershed.

Another way to examine stream NO_3 loads is to look at agricultural tile drainage. Such drainage at the "field" level essentially represents the base flow situation of a small stream with 100% corn plus soybeans in its upper watershed drainage, at least on a yearly or multi-year average basis. Using the same agronomic data above, theoretical NO_3 loads can be calculated. The Mississippi River-Winona Watershed receives an average of 30 inches of precipitation per year, and discharge records show that about 10 inches of this precipitation appears as stream flow[7,8]. This calculates to about 1 million kilograms (kg) of stream flow per acre/year. Forty-two lb N/acre "excess" is 19 kg, so that average stream NO_3 concentration should be about 20 mg/L if all the excess ended up in stream flow. This

[7] Minnesota Dept of Natural Resources, basin-averaged monthly precipitation totals for DNR Watersheds - DNR Level 04 - HUC 08 - Majors <http://deli.dnr.state.mn.us/metadata.html?id=L390006230201>

[8] Lenhart, C., Nieber, H etal, Quantifying differential streamflow response of Minnesota ecoregions to climate change and implications for management", U of M Dept of Bioproducts and Biosystems Engineering, Aug 2011.

concentration is essentially the same concentration predicted by the regressions in Appendix E for 100% corn plus soybeans in a watershed.

A number of studies have looked at agricultural tile drainage, and all show that fertilized corn (or other crops such as potatoes) generates tile drainage containing NO_3 at 12 to well over 30 mg/L[9, 10, 11]. Flow weighted, NO_3 levels in tile drainage are typically in the 20 mg/L range for corn or corn-soybean rotations. This is the same value calculated above from both the agronomic data above and the empirical NO_3 data from the S001-831 site.

Appendix D found that all Mississippi River-Winona Watershed sites with sufficient records show an upward trend in NO_3 concentrations. How long will this trend continue, and at what level will they tapper off? On the fertilizer input side, commercial N use has been increasing only slightly in MN in the last two decades[12,13]. Corn grain yield, in contrast, has been increasing much faster. Agronomists commonly point to this pattern as an increase in fertilizer efficiency, at least in terms of "bushels of corn per unit of N input". However, the protein content of corn in hybrids today is less than it was 10 years ago, dropping from over 9% protein in the 1990's to under 7% in 2011[11, 2]. The Nitrogen use efficiency has remained essentially the same, so that the increase in bushels of corn per acre is accompanied by roughly the same N inputs and excesses. Industry sources indicate that corn breeding for "starch" over protein is likely to continue, but there are fundamental biological limitations. Thus the trend of increasing NO_3 in streams may level off, reflecting a roughly constant N excess unless agricultural patterns change.

The NO_3 trend analyses in Appendices C- E do not indicate that a "leveling off" is imminent. If the "excess Nitrogen" is approaching a steady state level, it would be expected that stream concentrations should start to stabilize. Thus the question remains as to the time lag between N sources and stream concentrations. Several studies have looked at such time lags[4, 5]. In general smaller watersheds appear to have only a year or two lag, while larger watersheds can have a time lag of up to a decade.

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[9] Randall, G and Vetch, J. *Nitrogen Management to Minimize Nitrate Losses to Water Resources*. Southern Research and Outreach Center, Waseca, MN, Nutrients in our Environment, Feb 18, 2010.

[10] Randall, G. *Nutrient, Crop, and Water Management Practices for Minimizing Nitrate Losses to Surface Water*, CPM Short Course and MCPR Trade Show, Minneapolis, Dec, 6, 2007.

[11] Sawyer, J, etal, *Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn*. Iowa State Extension Service, Apr. 2006. <www.extension.iastats.edu?Publications/2015.pdf>

[12] Montgomery, B, *Nitrates in Groundwater-Filtering Out the Facts*. MN Agriculture and Nitrates Forum, Rochester, MN, July 25, 2012.

[13] David, M., Drinkwater, L., and Gregory, M. *Sources of Nitrate Yields in the Mississippi River Basin*., Journal of Environmental Quality, 39: 1657-1667, July 20, 2010.

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Appendix G: Trends in Sulfate (SO_4)

Sulfate (SO_4) in southeastern (SE) Minnesota surface and ground waters is present as a natural background component. Most of this natural SO_4 is thought to be derived from native rocks, particularly shales. Iron pyrite (FeS_2) is a common mineral in shales, which oxidizes to soluble SO_4 and Iron (Fe) oxides upon weathering (exposure to air and water). Sulfate may also originate from the mineral gypsum ($CaSO_4$), which occurs as a trace component of limestone and sandstone.

Sulfate in MN streams is at least in part attributable to human activities. Prior to the Clean Air Act, little or no controls existed for sulfur emissions associated with use of fossil fuels, so that sulfur dioxide (SOx) was a major air pollutant. Sulfur oxides were deposited as acid rain over widespread areas, and SO_4 appeared in surfaces waters. After the 1990 amendments of the Clean Air Act, major coal burning sources either switched to low sulfur coal or applied scrubbing technology to capture SOx emissions. The National Atmospheric Deposition Program (NADP) has been monitoring acid rain in precipitation throughout the US since the late 1970's. Accompanying the implementation of the Clean Air Act has been a decrease in SO_4 in precipitation.

Three sites in the Mississippi River-Winona Watershed have sufficient data to examine trends for SO_4 in streams (Table G1).

Table G1 Sulfate Trends at Monitoring Stations in the Mississippi River-Winona Watershed

Station ID	Site Description	Period of Record	Sulfate Trends
S000-288	South Fork Whitewater near Utica	1974-2008	Downward trend SO_4
S000-828	Garvin Brook SW of Minnesota City	1981-2008	No trend SO_4
5376000 & **S000-451**	North Fork Whitewater River near Elba	1967-2010	Downward trend in

Figure G1 shows the SO_4 trend at the Garvin Brook site SW of Minnesota City (S000-828). Although there appears to be a downward trend, it is not statistically significant. The year-to year variability may mask any possible trend here. A comparison of the pre-1990 to post 2005 time periods also shows *no* statistical difference in median concentrations. Figure G2 shows the SO_4 time series for the South Fork Whitewater River near Utica (S000-288). A statistically significant decrease in SO_4 concentration is seen in the non-parametric regression line at the Utica site. The statistically significant decrease in sulfate is confirmed by comparing the two time periods.

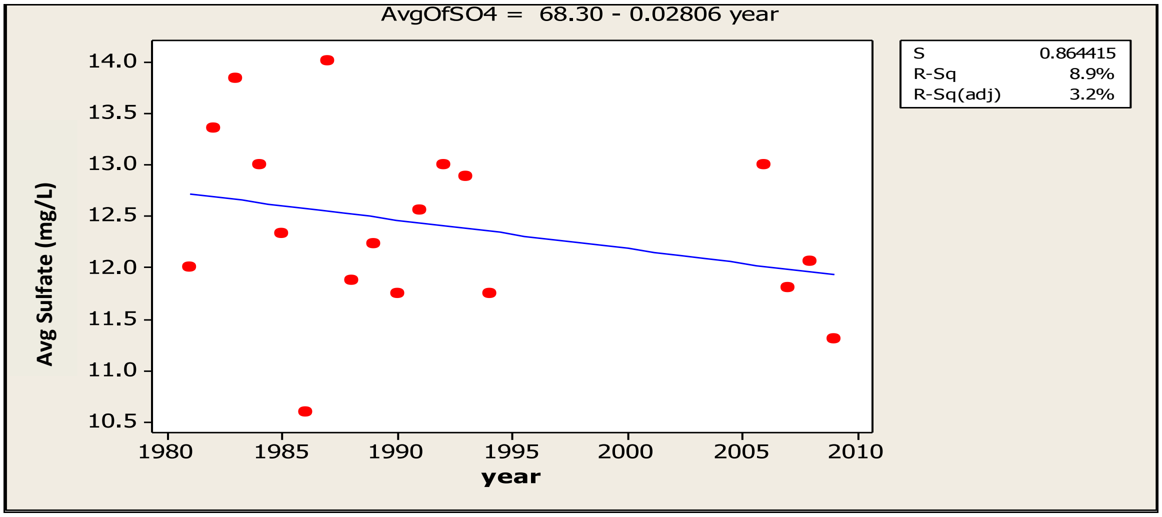

Figure G1 Sulfate Time Series at Garvin Brook SW of Minnesota City (S000-828)

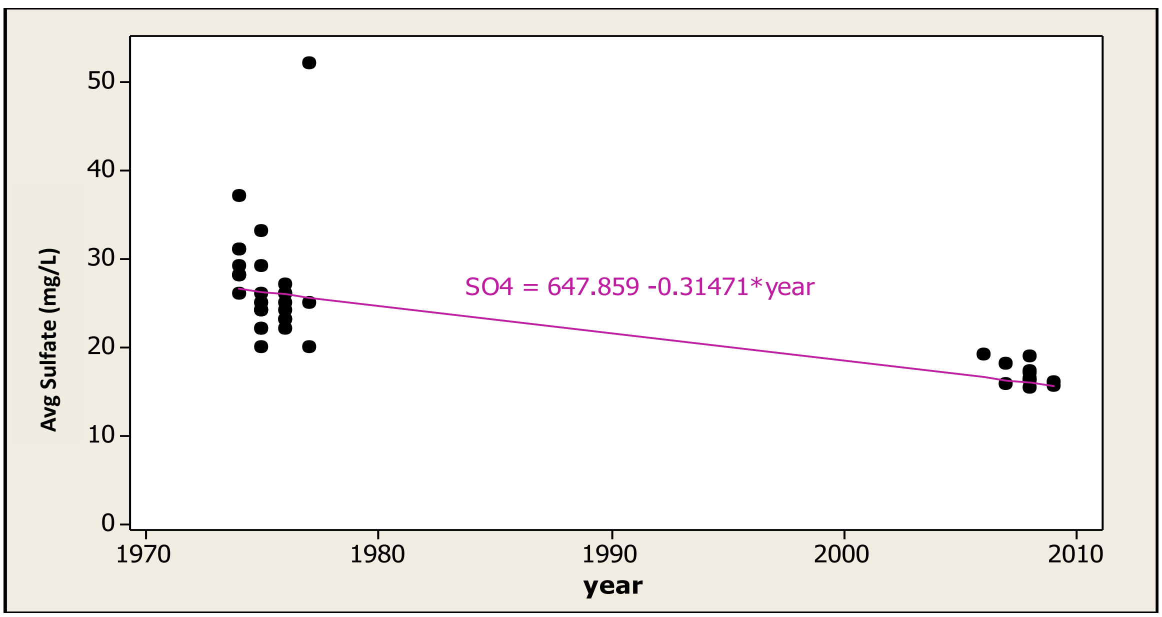

Figure G2 Sulfate Time Series at South Fork Whitewater River near Utica (S000-288)
(Akritas-Theil-Sen Regression)

Figure G3 shows the pattern for SO_4 with time at the North Fork Whitewater River Site near Elba (S000-451). The quadratic regression in the figure is highly significant ($p<.01$). At Elba, a peak SO_4 concentration of about 20 mg/L is seen in the early 1980's. Extrapolating to the 1950's yields about 12 mg/L , and today SO_4 is about 14 mg/L in the Mississippi River-Winona Watershed. At the Garvin Brook site, SO_4 today is about 12 mg/L, and at Utica it is about 16 mg/L. These data suggest the "background" SO_4 is in the range of 12-16 mg/L in the Mississippi River-Winona Watershed.

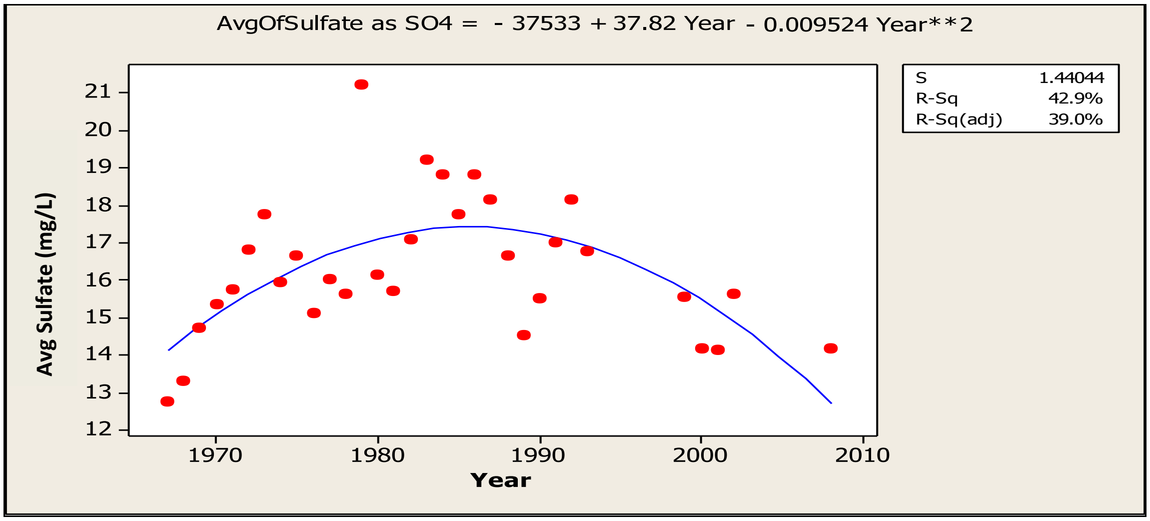

Figure G3 Sulfate Time Series for the North Fork Whitewater River near Elba (S000-451)
(Quadratic Regression)

Sulfate data are limited in the Mississippi River-Winona Watershed. Where there is a consistent period of record, sulfate increased from the 1960s to mid-1980s and has since declined. This pattern is consistent with the NADP data for SO_4 atmospheric deposition. Today, SO_4 levels are likely tapering off to a background level of about 12-16 mg/L.

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Appendix H: Trends in Chloride (Cl) and Sodium (Na)

H.1 Trends in Chloride and Sodium

A study completed by Olmsted County found that three sources account for nearly all of the chloride in the county streams and groundwater. First is winter road salt (NaCl) and summer dust control salt ($CaCl_2$). This source is related to type and density of roads. Second is common salt (NaCl) used in the regeneration step of domestic water softening. Most southeastern (SE) Minnesota potable water sources have high hardness (calcium (Ca) and magnesium (Mg)) in surface and ground water. This Cl source is related to the density of urban and suburban households. Third is potassium fertilizer (KCl), which is used in crop production. All of these sources have been increasing in MN in recent decades, with large year-to year variability primarily associated with winter weather. Regardless of the source, Cl is highly mobile and quickly moves to ground and surface waters. Chloride has no common insoluble salts and is not involved in either biological or oxidation-reduction processes. The associated cations sodium (Na), potassium (K), and calcium (Ca) are much less mobile and are largely retained by soils. Currently, Cl is not present at levels in Mississippi-River Winona streams to be considered a major health or ecological concern, but Cl increase is a good indicator of the intensity of human activities.

Sodium is present naturally in surface and ground water at 2-3 mg/L, but levels above about 4 mg/L are associated with increases in Cl (which has a background less than 1 mg/L).

Time series data for Cl in Mississippi-River Winona streams is limited mainly to four sites. The two MPCA Milestone Monitoring Program sites at Garvin Brook SW of Minnesota City (S000-828) and the South fork Whitewater River near Utica (S000-288) show upward Cl trends (Table H1 and H2). Milestone trends are examined statistically using the Seasonal Kendall procedure. This seasonal test uses all months and is more sensitive in detecting trends than is the Kendall test simply using yearly averages. Figure H1 for Garvin Brook shows that the Cl trend is statistically significant ($p<0.001$), even when yearly averages are used. At Utica, the statistical significance of the yearly average Cl concentrations is $p=0.08$ (better than 90% but not 95% significance). A Mann-Whitney rank sum test for the median Cl level for the 1970's (27 mg/L) vs. the 2008 period (43 mg/L) yields a p-value of 0.001, indicating a significant Cl difference between the two periods. At Garvin Brook, the average increase since 1998 is about 0.2 mg/L/year. At Utica, the average increase is about 0.7 mg/L/year.

Table H1 Garvin Brook (CSAH-23) South West of Minnesota City (1983 - 2009)

	TSS	TP	NO_3_N	NH_3	BOD	Cl
overall trend	**decrease**	**decrease**	**increase**	**decrease**	**decrease**	**increase**
slope	-0.0385082	-0.0139937	0.030947	-0.009	-0.017	0.0362
number of years	26	26	26	26	26	26
average annual change	-3.8%	-1.4%	3.1%	-0.9%	-1.7%	3.7%
total change	-63%	-30%	124%	-21%	-36%	156%
p-value	0.00	0.00	0.00	0.01	0.03	0.00
1995 - 2009 trend	**decrease**	**no trend**	**increase**	**no trend**	**no trend**	little data
slope	-0.09662		0.02519			
number of years	8	12	12	12	12	12
average annual change	-9.2%		2.6%			
total change	-54%		35%			
p-value	0.00	0.92	0.00	0.92	0.84	
median first 10 years	59	0.1	1.3	0.07	1.5	6
median most recent 10 years	21	0.1	2.2	<.05	0.8	13

Table H2 Whitewater River South Fork near Utica (WWR-26) (1974 - 2008) Missing Period 1985-1999

	TSS	TP	NO_3_N	NH_3	BOD	Cl
overall trend	**decrease**	**no trend**	**increase**	**decrease**	**decrease**	**increase**
slope	-0.02133543		0.01995029	-0.037	-0.02888	0.018865
number of years	35	35	35	35	35	35
average annual change	-2.1%		2.0%	-3.6%	-2.8%	1.9%
total change	-53%		101%	-73%	-64%	94%
p-value	0.01	0.53	0.00	0.00	0.00	0.01
1995 - 2009 trend	**no trend**	**no trend**	**increase**	**no trend**	**decrease**	little data
slope			0.0247531		-0.06302	
number of years	11	11	14	14	11	1
average annual change			2.5%		-6.1%	
total change			41%		-50%	
p-value	0.69	0.70	0.00	0.50	0.07	
median first 10 years	31	0.5	7	0.10	2.3	27
median most recent 10 years	13	0.5	11	<.05	1.0	43

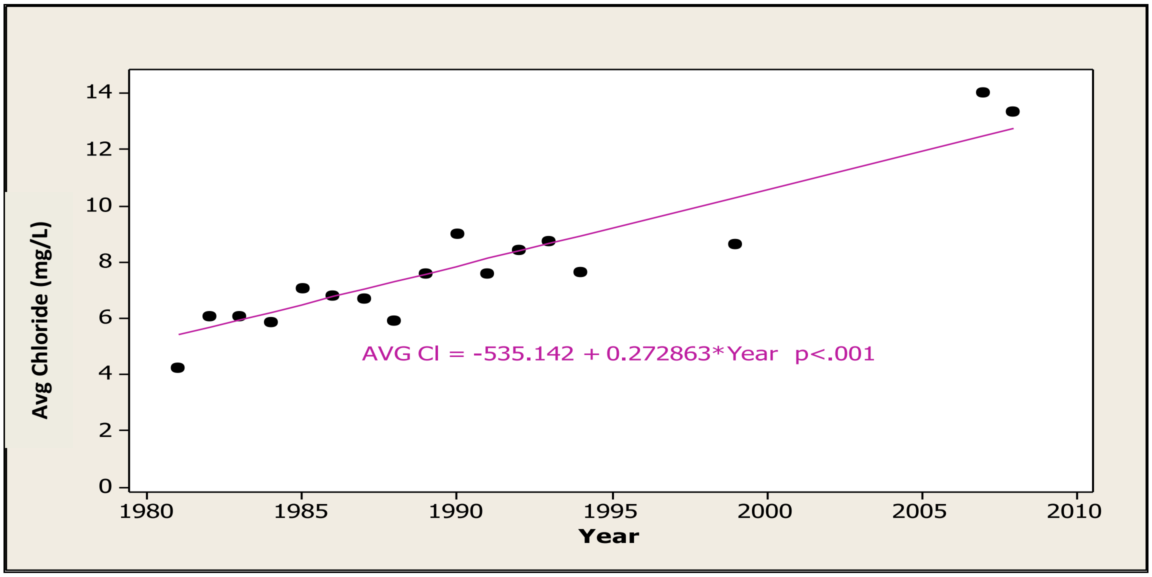

Figure H1 Chloride Trend for Garvin Brook (S000-828) (Akritas-Theil-Sen Regression)

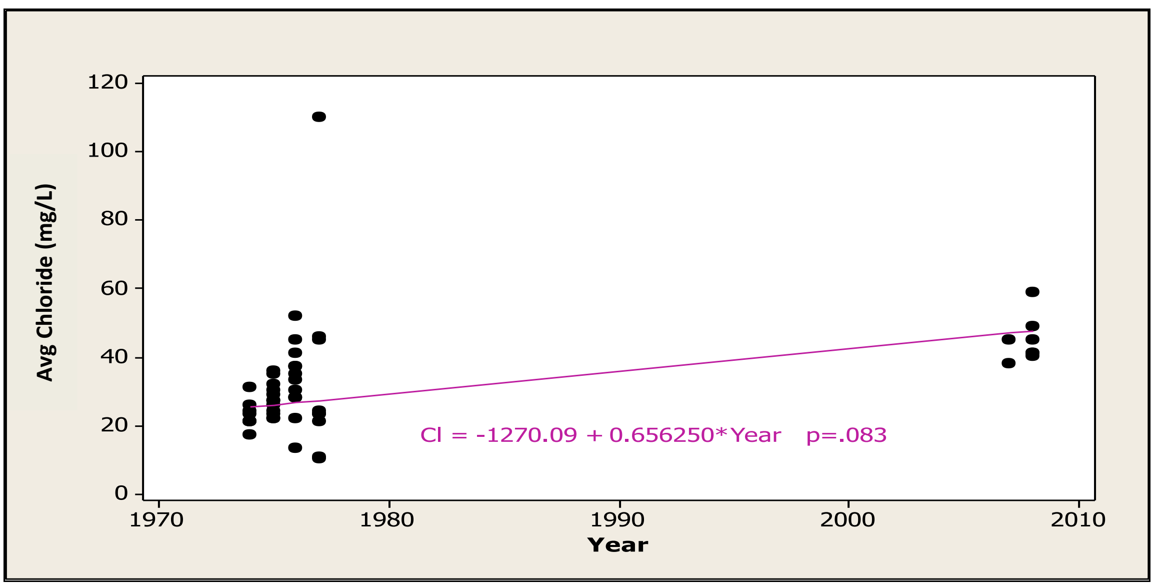

Figure H2 Chloride Trend for Utica (S000-288) (Akritas-Theil-Sen Regression)

Figure H3 shows the trend for the North Fork Whitewater River near Elba (S000-451). This site was originally sampled for Cl by the United States Geological Survey (USGS) from 1967 to 1993, and then by Olmsted county in 1999 to 2003 and again in 2008. Figure H3 represents a composite of all samples, and shows a quadratic regression with very high statistical significance (Rsq=91%, P<0.0001). The Cl time series data meet the underlying assumptions of least squares regression so that non-parametric methods are not needed. Chloride has increased from less than 1 mg/L in the 1960's to about 20 mg/L in 2010. The intercept in the regression line is the year 1954, a year quite consistent with state and national trends in salt and fertilizer use[1]. Figure H3 shows the Cl concentration for the site on the North Fork Whitewater River near Elba tapering off, perhaps reflecting the decline of Cl source contributions.

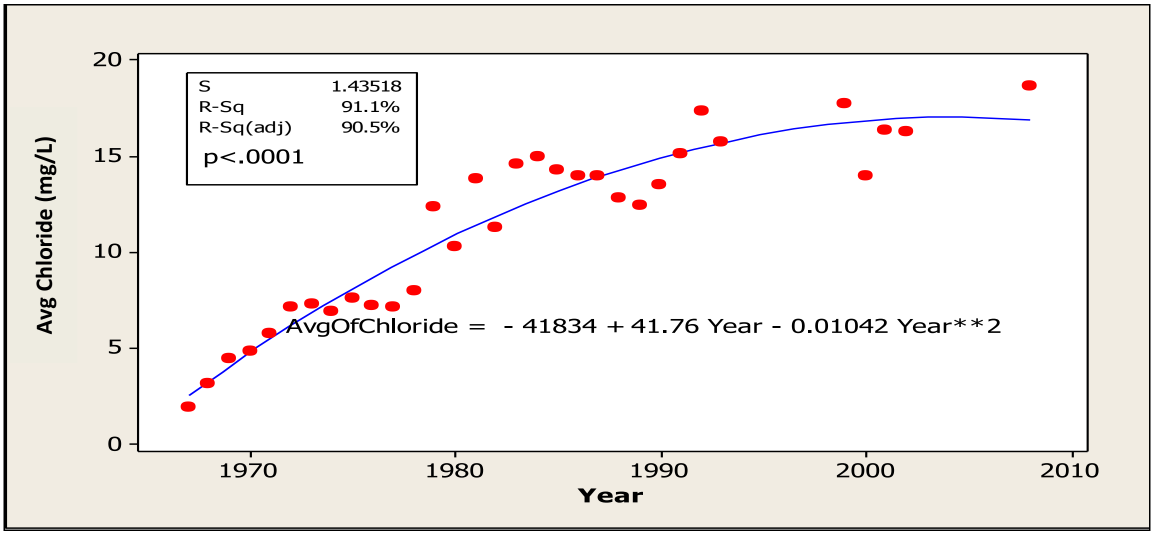

Figure H3 Chloride Trend for North Fork Whitewater River near Elba (S000-451) **(Quadratic Regression)**

Figure H4 shows the Cl trend for the Long Term Research Monitoring Project site on the Whitewater River near Weaver (Hwy 61), based on monthly averages from 1993 to 2002. This Cl record does not continue past 2002, so that any tapering off since then cannot be assessed at this site. Note the increasing variability of monthly averages after 1998.

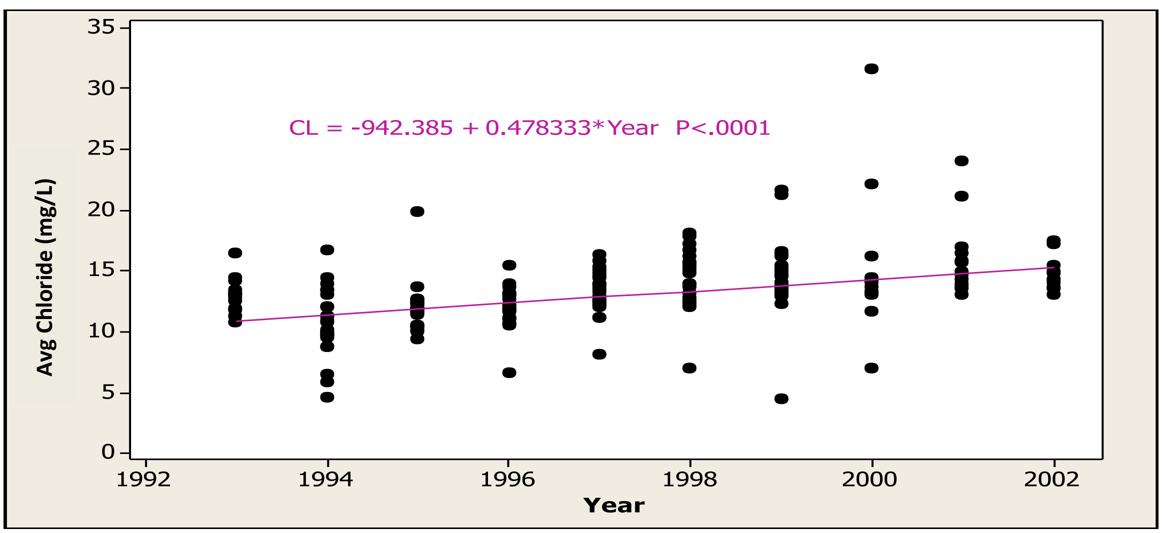

Figure H4 Monthly Average Chloride Trend for the Long Term Research Monitoring Program Site on the Whitewater River near Weaver on Hwy 61 **(Akritas-Theil-Sen Regression)**

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[1] United States Geological Survey. *Historical Statistics for Mineral and Material Commodities in the United States*. By Thomas D. Kelly and Grecia R. Matos. USGS, 2011. < http://minerals.usgs.gov/ds/2005/140/>

As noted above, sodium (Na) is present naturally at low levels in surface waters, and is highly correlated ($P<0.01$) with Cl concentrations. Figure H5 shows this relationship for the Whitewater River near Weaver. On a mole-to mole basis Na increases at about 30% of Cl. The intercept suggests a level of 3.5 mg/L Na at "zero" Cl. Figure H6 shows the Na to Cl relationship for the North Fork Whitewater River near Elba (S000-451). At this site, Na increases at a rate of about 40% of Cl on a mole basis. The Na background here is 2.8 mg/L. There is no correlation between potassium (K) and Cl for either the Weaver or the Elba site. This could suggest that the excess of Cl over Na from human activities is attributable to KCl fertilizer, where K is retained in soils or removed (exported) in crops. Also, Na from sodium chloride (NaCl) could be retained partially in soils.

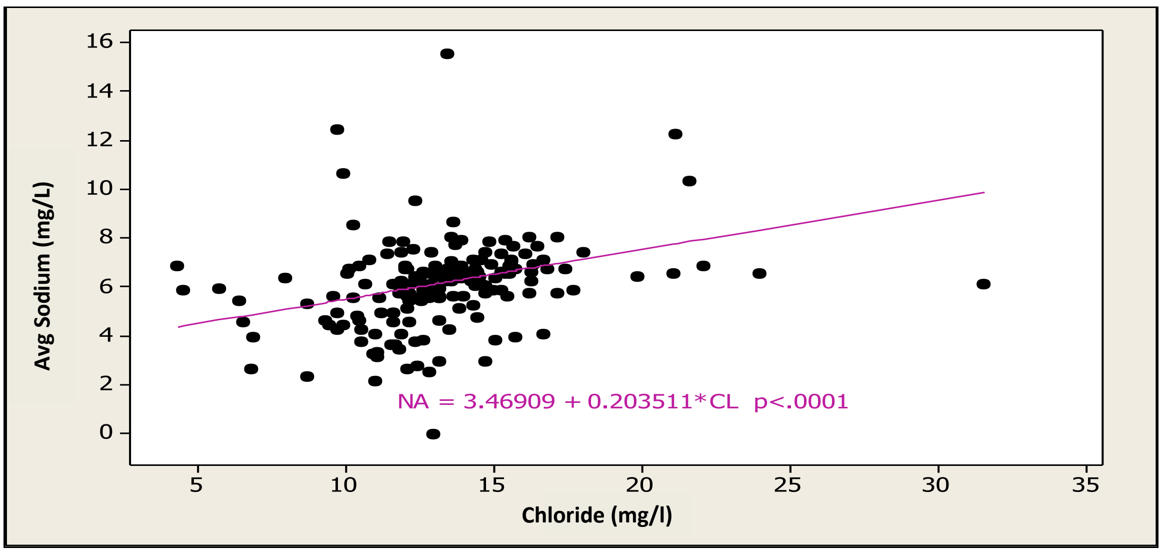

Figure H5 Relationship between Sodium (Na) and Chloride (Cl) at the Long Term Research Monitoring Site on the Whitewater River near Weaver on Highway 61 **(Akritas-Theil-Sen Regression)**

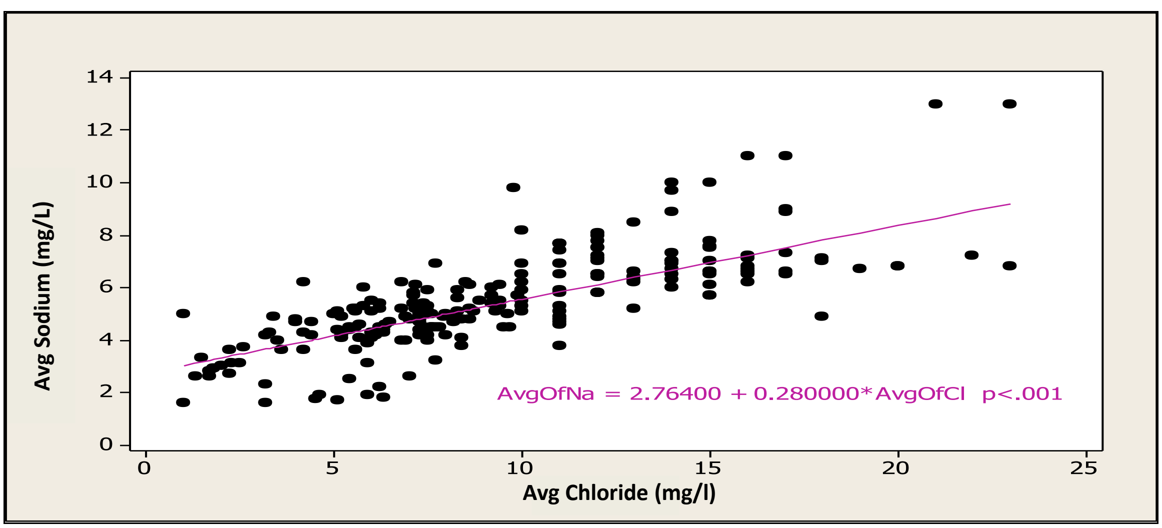

Figure H6 Sodium versus Chloride on the Middle Fork Whitewater River near Elba (S000-451) **(Akritas-Theil-Sen Regression)**

H.2 Conclusion

In conclusion, Mississippi River-Winona Watershed sites with sufficient data to assess statistical trends show upward concentration trends for both Cl and Na. The North Fork Whitewater River site near Elba indicates that Cl is tapering off in recent years, while other sites do not show a pattern. Sodium levels correlate well with Cl levels, but Na is only about 30 to 40% of Cl on a mole basis for sites in the Mississippi-Winona Watershed. Year-to year variability in monthly and yearly average concentrations likely reflects variability in winter weather, which is the driving factor of road salt.

Not shown here is the strong correlation of Cl with NO_3 for the Elba and Weaver sites. Since the sources for NO_3 and Cl are not fundamentally related, the correlation simply reflects the fact that both result from human activities.

Appendix I: Trends in Water Quality Parameters at Milestone Monitoring Program Sites

Trends in nitrate (NO_3) and chloride (Cl) for Minnesota Pollution Control Agency (MPCA) Milestone Monitoring Program sites, Garvin Brook SW of Minnesota City (S000-828) and the South Fork Whitewater River near Utica (S000-288), were discussed in appendices D and H. The tables in those Appendices also show decreasing trends for total suspended solids (TSS), biochemical oxygen demand (BOD), & ammonia (NH_3) at both sites. Garvin Brook also shows a decreasing trend for total phosphorus (TP).

MPCA also collected data for a number of other parameters at the milestone sites. Table I1 details the median values for 12 parameters at Garvin Brook (1983-2009) and Utica (1974-2008). For each parameter, Mann-Whitney non-parametric tests were applied to see if there are statistically significant differences between the sites. In column 4 of Table I1, a probability value from the Mann-Whitney test indicates whether the medians differ for each parameter. Column 5 in the table indicates the direction and magnitude of parameter differences. Median NO_3, TP, and Chlorophyll a (Chloro_a) levels are much higher at Utica, while median BOD, transparency, total Kjeldahl nitrogen (TKN), and E-coli are slightly higher. TSS and turbidity are lower at Utica. DO, pheophytin (Pheo), and fecal coliform (FC) show no difference between the two sites. The Utica site is downstream of wastewater treatment facilities at St. Charles, and the South Fork Whitewater at Utica represents a largely agricultural subwatershed compared to that of Garvin Brook.

Table I1 Median values and differences for water parameters-Utica and Garvin Brook

Parameter	Garvin Brook	Utica	pval	Utica/Garvin
BOD	1.2	1.5	0.002	slightly higher
Chloro_a	1.99	4.82	0.009	much higher
Transp	56	40	0.000	slightly lower
TKN	0.57	0.69	0.041	slightly higher
DO	10.4	10.4	0.13	same
NO_3_N	1.58	8.8	0.000	much higher
Pheo	2.51	3.37	0.23	same
TP	0.11	0.47	0.000	much higher
FC	600	490	0.23	same
Ecoli	430	650	0.080	slightly higher
TSS	33	13	0.000	lower
Turbidity	13.8	7.1	0.000	lower

Units for BOD, TKN, DO, TP, and TSS are mg/L, Units for Chloro_a and Pheo are ug/L
Turbidity is NTU, transparency is 0-100 scale.

The higher levels of NO_3, TP, and Chloro_a are consistent with wastewater treatment plant and/or agricultural influences at Utica compared to Garvin Brook. BOD, fecal coliform, Ecoli, and TKN are not greatly different at the two sites. This would indicate that wastewater treatment facilities are effectively treating organics in domestic sewage. TP and NO_3 are much higher at Utica, reflecting either wastewater treatment facilities or agriculture, or both. Somewhat surprisingly, median TSS and turbidity are higher at Garvin than at Utica. Further, median transparency is also higher at Garvin. This seems contradictory since transparency is inversely related to TSS and turbidity. The nature and distributions of suspended material(s) at the two sites appear to be different.

Several parameters are related to suspended solids, including turbidity, transparency, TP, TKN, and BOD. In Table I2, pairs of parameters are examined statistically and the patterns indicated. Note that regression relationships between variables for the two sites are often similar. For example, TSS vs. turbidity or transparency show similar slopes and intercepts. In the case of TKN vs. TSS , BOD vs. TKN and TSS vs. TP, slopes are similar and only intercepts differ. Bacteria and Chloro_a show poor correlations with TSS.

Tables I3 and I4 present the Milestone descriptive statistics. Note that most parameters have highly non-normal distributions. Values are generally strongly "tailed" to the right or higher direction (median values are generally lower than average or mean values).

Table I2 Relationships between parameters at Garvin Brook and S. Fork Whitewater River near Utica

Parameters		Median Ratios		Slopes	Intercepts	Slopes	Intercepts		Utica/Garvin	Utica/Garvin
X	Y	Garvin Br	Utica	Garvin	Garvin	Utica	Utica	relation	slopes	intercepts
TSS	turb	2.4	1.8	0.24	2.7	0.30	3.9	linear	slightly higher	slightly higher
TSS	trans	1848	520	0.0033	0.009	0.0048	0.013	inverse	slightly higher	slightly higher
TSS	TKN	58	19	0.0062	0.210	0.0069	0.49	linear	same	higher
BOD	TKN	2.1	2.2	0.34	0.074	0.4	0.18	linear	slightly higher	higher
TSS	Ecoli	0.077	0.020	30.5	-112	0	0	linear	N/A	N/A
TSS	FC	0.055	0.027	0	0	0	0	none	N/A	N/A
BOD	TKN	2.11	2.17	0.39	0.074	0.40	0.18	linear	same	higher
TSS	BOD	28	9	0.0096	0.8	0	0	linear	N/A	N/A
TSS	TP	308	28	0.0015	0.051	0.0014	0.48	linear	same	much higher
NO3_N	TKN	2.8	12.8	0	0	0	0	none	N/A	N/A
TSS	Chloro_a	17	3	0	0	0	0	none	N/A	N/A

Table I3 Descriptive statistics for Water Parameters –Garvin Brook

Variable	N	N*	Mean	SE Mean	StDev	Min	Q1	Median	Q3	Max
BOD (mg/L)	136	207	1.9	0.2	2.1	0.3	0.8	1.2	1.8	15.0
Chl-a (ug/L)	63	280	4.3	1.0	7.9	0.1	1.1	2.0	4.7	58.8
Stream Trans	123	220	54	2	24	1	44	56	60	100
DO (mg/L)	196	147	10.5	0.1	1.7	6.1	9.1	10.4	11.6	15.0
TKN (mg/L)	159	184	1.8	0.3	4.2	0.0	0.3	0.6	1.0	27.6
NO2NO3 (mg/L)	225	118	1.7	0.0	0.6	0.1	1.3	1.6	2.1	3.9
pH	0	343	*	*	*	*	*	*	*	*
Pheo	16	327	2.8	0.3	1.1	1.2	2.1	2.5	3.2	5.0
TP (mg/L)	201	142	0.6	0.1	1.6	0.0	0.1	0.1	0.2	9.7
FC	215	128	4098	1078	15802	4	170	600	2200	192000
TSS (mg/L)	281	62	258	49	821	2	16	33	87	6200
Turb	282	61	91	21	344	1	5	14	27	2800
Ecoli	49	294	749	115	807	4	100	430	1400	2600

Table I4 Descriptive Statistics for Water parameters-S. Fork Whitewater near Utica

Variable	N	N*	Mean	SE Mean	StDev	Min	Q1	Median	Q3	Max
BOD (mg/L)_1	196	302	2.1	0.1	1.7	0.5	1.0	1.5	2.6	9.6
Chl-a (ug/L)_1	19	479	8.0	2.0	8.9	1.3	3.4	4.8	7.2	36.7
Stream Trans_	212	286	42	2	25	0	23	40	60	100
DO (mg/L)_1	269	229	10.9	0.1	2.4	6.1	9.0	10.4	12.9	18.9
TKN (mg/L)_1	145	353	1.0	0.1	1.1	0.1	0.5	0.7	1.2	8.4
NO2NO3 (mg/	240	258	8.5	0.2	2.8	0.9	6.6	8.8	11.0	16.0
pH_1	0	498	*	*	*	*	*	*	*	*
Pheo_1	18	480	4.7	1.3	5.5	1.3	2.2	3.4	4.9	25.6
TP (mg/L)_1	244	254	0.55	0.02	0.39	0.07	0.33	0.47	0.67	3.10
TSS (mg/L)_1	252	246	52	11	168	1	5	13	33	1900
Turb_1	114	384	23	6	67	0	3	7	17	500
FC_1	237	261	5608	1763	27144	4	95	490	1650	370000
Ecoli_1	92	406	1500	454	4357	4	303	650	1175	39000

N=measured, N*= missing

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Appendix J: Pesticide Trends

Over 95% of the 219,265 pesticide test results in Appendix A are from just two Minnesota Department of Agriculture monitoring sites. 158,608 results are from site S001-831 on the Middle Branch Whitewater north of St. Charles, and 49,864 are from site S000-321 on the South Fork Whitewater near Altura. An additional 10,706 pesticide results are from nine other MDA monitoring sites, and 87 miscellaneous pesticide results are from 15 sites sampled by the Minnesota Pollution Control Agency or Olmsted County. Testing was completed for 36 different pesticides.

Site S001-831 on the Middle Branch Whitewater north of St. Charles has been monitored continuously since 1991. Due to variations in seasonal flow, rainfall timing (compared to pesticide applications), and rainfall intensity, it is difficult to complete trend analysis for pesticide detections in streams. Figure J1 illustrates the atrazine levels at site S001-831. The highest concentrations were found during the period 1999 to 2005.

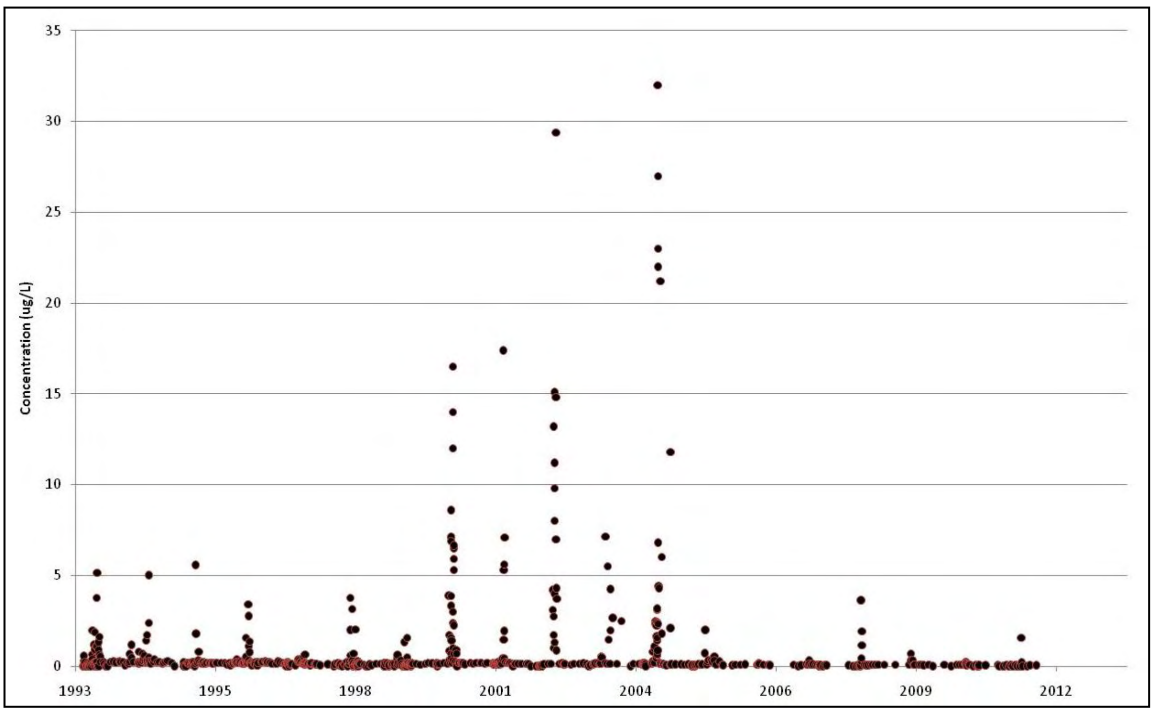

Figure J1 Atrazine Concentrations in the Middle Branch Whitewater River north of St. Charles (Site S001-831)

Site S000-321 on the South Fork Whitewater near Altura has been monitored since 2000. This site is monitored by the MDA specifically for the purpose of assessing pesticide trends. Figure J2 illustrates the levels of atrazine and its breakdown products, deisopropylatrazine and desethylatrazine at site S000-321. The MDA staff note that the data suggests that there has been a downward trend in atrazine and its breakdown products in recent years.

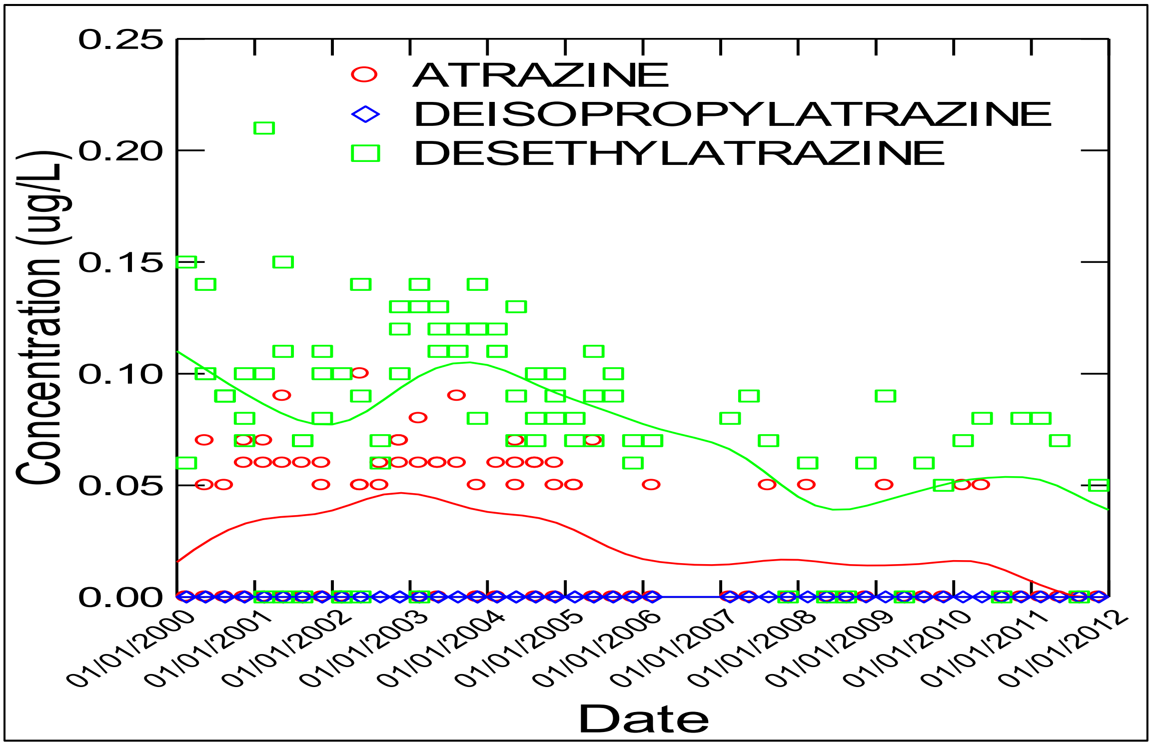

Figure J2 Atrazine and its Breakdown Products Concentrations at the South Fork Whitewater River near Altura (S000-321)

Appendix K

Synoptic Sampling of the

Mississippi River-Winona Watershed

December 12, 2012

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Synoptic Sampling of the Mississippi-River Winona Watershed (12.12.12)

Name/Site #	Address	State/ EQUiS ID #	Latitude	Lat/Long	Sample Date	Sample Time	Sampled By	NO3	Fl	Cl	SO4	Time	Temp-C	pH	SpC-mS/cm	Salin-PSS	DO%-Sat	DO-mg/L
1	N FK WHITEWATER R AT MN-42 AT ELGIN	S000-776	-92.249611	44.127778	12/12/2012	8:50	T. Lee	10.2	0.13	20.4	21.1	8:55:20	0.27	8.08	0.645	0.3	99.7	13.95
2	Dry Creek 2nd Avenue NE	NA	NA	NA	12/12/2012	9:00	T. Lee	8.3	0.12	43.3	19.9	9:10:15	1.39	7.7	0.773	0.37	64.2	8.69
3	MIDDLE FK WHITEWATER R, AT BRG AT MN-74, AT ELBA	S001-825	-92.027611	44.080806	12/12/2012	9:30	T. Lee	7.3	0.17	15	20.4	9:35:29	1.86	8.47	0.587	0.28	105	14.05
4	N FK WHITEWATER R AT HWY 74 AT ELBA, MN	S001-745	-92.022389	44.085111	12/12/2012	9:50	T. Lee	5.1	0.18	13.7	18.8	9:42:41	2.18	8.37	0.591	0.28	101	13.39
5	Middle FK and North FK Whitewater Converge	NA	NA	NA	12/12/2012	10:00	T. Lee	5.8	0.12	14.2	20	9:51:28	2.04	8.39	0.59	0.28	108.7	14.34
6	BEAVER CR AT HWY 74, 4.6 MI N OF ELBA, MN	S001-741	-92.008000	44.155694	12/12/2012	10:10	T. Lee	3.5	0.13	7.9	16.2	10:07:25	2.56	8.4	0.548	0.26	106	13.9
7	TROUT CREEK OUTLET TO WW RIVER AT 564TH ST, 11.5 MI NE OF PLAINVIEW	S006-531	-91.940641	44.196254	12/12/2012	10:30	T. Lee	1.9	0.12	6.8	14.3	10:36:19	2.77	8.51	0.547	0.26	99.4	12.98
8	WHITEWATER R AT RAILROAD BRG AT MOUTH, 0.5 MI SE OF WEAVER	S001-767	-91.921806	44.208694	12/12/2012	10:25	T. Lee	4.9	0.11	13.8	17.9	10:26:49	0.92	8.54	0.579	0.27	100.2	13.76
9	GORMAN CR 1 MI S OF KELLOGG, MN	S001-704	-91.992889	44.293000	12/12/2012	10:45	T. Lee	3.5	0.16	9.4	12.1	10:54:46	0.14	8.58	0.376	0.17	98.8	13.89
10	SNAKE CK AT US-61, 4 MI S OF KELLOGG, MN	S003-454	-91.975888	44.254035	12/12/2012	11:00	T. Lee	2.3	N.D	6	14.6	11:06:31	3.5	8.51	0.574	0.27	99.3	12.71
10D	SNAKE CK AT US-61, 4 MI S OF KELLOGG, MN	S003-454	-91.975888	44.254035	12/12/2012	11:00	T. Lee	2.4	0.07	5.5	14.3							
11	EAST INDIAN CK 100 YDS SW OF US-61 AND CR-84 6 MI SE KELLOGG	S005-390	-91.950440	44.228140	12/12/2012	11:10	T. Lee	2.1	0.15	5.3	13.9	11:17:26	0.99	8.53	0.537	0.25	96.4	13.22
12	ROLLINGSTONE CK AT MIDDLE VLY RD BRG, 1.5 MI NW OF MN CITY	S001-532	-91.778389	44.097889	12/12/2012	11:35	T. Lee	2.9	0.08	12.5	18.3	11:44:23	0.89	8.5	0.563	0.26	95.3	13.07
13	GARVIN BROOK NEAR MINNESOTA CITY	S000-827	-91.760750	44.085250	12/12/2012	11:50	T. Lee	3.4	0.11	12.4	15.9	11:57:37	1.28	8.56	0.548	0.26	97.7	13.28
14	E BURNS VALLEY CK AT CSAH 105 IN WINONA, MN	S003-806	-91.622233	44.023785	12/12/2012	12:40	T. Lee	1.2	0.1	11.8	16.2	12:43:17	3.34	8.63	0.525	0.25	104.9	13.49
15	PLEASANT VALLEY CK AT HOLLER HILL RD IN WINONA, MN	S003-793	-91.605025	44.018707	12/12/2012	12:50	T. Lee	1.4	0.1	15.2	18.6	12:55:19	3.42	8.52	0.561	0.26	99.4	12.74
15D	PLEASANT VALLEY CK AT HOLLER HILL RD IN WINONA, MN	S003-793	-91.605025	44.018707	12/12/2012	12:50	T. Lee	1.3	0.12	15.1	18							
16	BIG TROUT CK(PICKWICK CK) UPSTM OF US-61 2 MI NE OF PICKWICK	S004-244	-91.460873	43.996268	12/12/2012	13:05	T. Lee	1.1	0.07	6.8	15	13:12:17	2.84	8.57	0.5	0.23	101.7	13.25
17	CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	S004-245	-91.496106	44.006768	12/12/2012	13:15	T. Lee	1.2	0.11	7.7	19.3	13:22:21	2.53	8.53	0.546	0.26	98.5	12.94

Key:
NO3, Fl, Cl, SO4 Units: Mg/L
Circ: Quanta Circulator on or off
Batt V: Battery Voltage
D: Duplicate/Quality Assurance Sample
NA: Information not available

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Percent Cropland in Mississippi-River Winona HUC 12 Subwatershed Areas

HUC-12	% Cropland	% NonCropland	Total Acres
Dry Creek	67.1%	32.9%	15,407.77
Upper North Fork Whitewater	50.4%	49.6%	14,861.51
Middle Fork Whitewater	46.3%	53.7%	34,162.78
Upper South Fork Whitewater	46.2%	53.8%	22,805.07
Lower North Fork Whitewater	41.5%	58.5%	25,158.42
Logan Creek	38.5%	61.5%	11,083.65
Lower South Fork Whitewater	34.7%	65.3%	36,694.24
Beaver Creek	25.9%	74.1%	10,609.14
Snake Creek	17.0%	83.0%	24,772.35
Garvin Brook	16.1%	83.9%	31,012.56
City of Wabasha	15.7%	84.3%	17,029.30
East Indian Creek	15.4%	84.6%	13,089.96
Rollingstone Creek	13.7%	86.3%	32,488.00
Trout Creek	11.2%	88.8%	11,199.84
Whitewater	8.7%	91.3%	23,313.97
Cedar Valley Creek	6.7%	93.3%	11,407.43
Big Trout Creek	4.8%	95.2%	13,419.79
Buffalo City	3.4%	96.6%	16,100.39
Pleasant Valley Creek	2.6%	97.4%	29,063.19
Fountain City	1.8%	98.2%	12,035.42
City of Winona	1.6%	98.4%	13,119.40
Total Watershed Acres	**418,834**		

Key	
Not Cropland	**Cropland**
Pasture/Grass	Alfalfa
Pasture/Hay	Barley
Developed	Corn
Open Water	Dry Beans
Wetlands	Fallow/Idle Cropland
Grassland	Oats
Forested	Other Crops
	Other Hay/Non Alfalfa
	Peas
	Soybeans
	Spring Wheat
	Sweet Corn
	Winter Wheat

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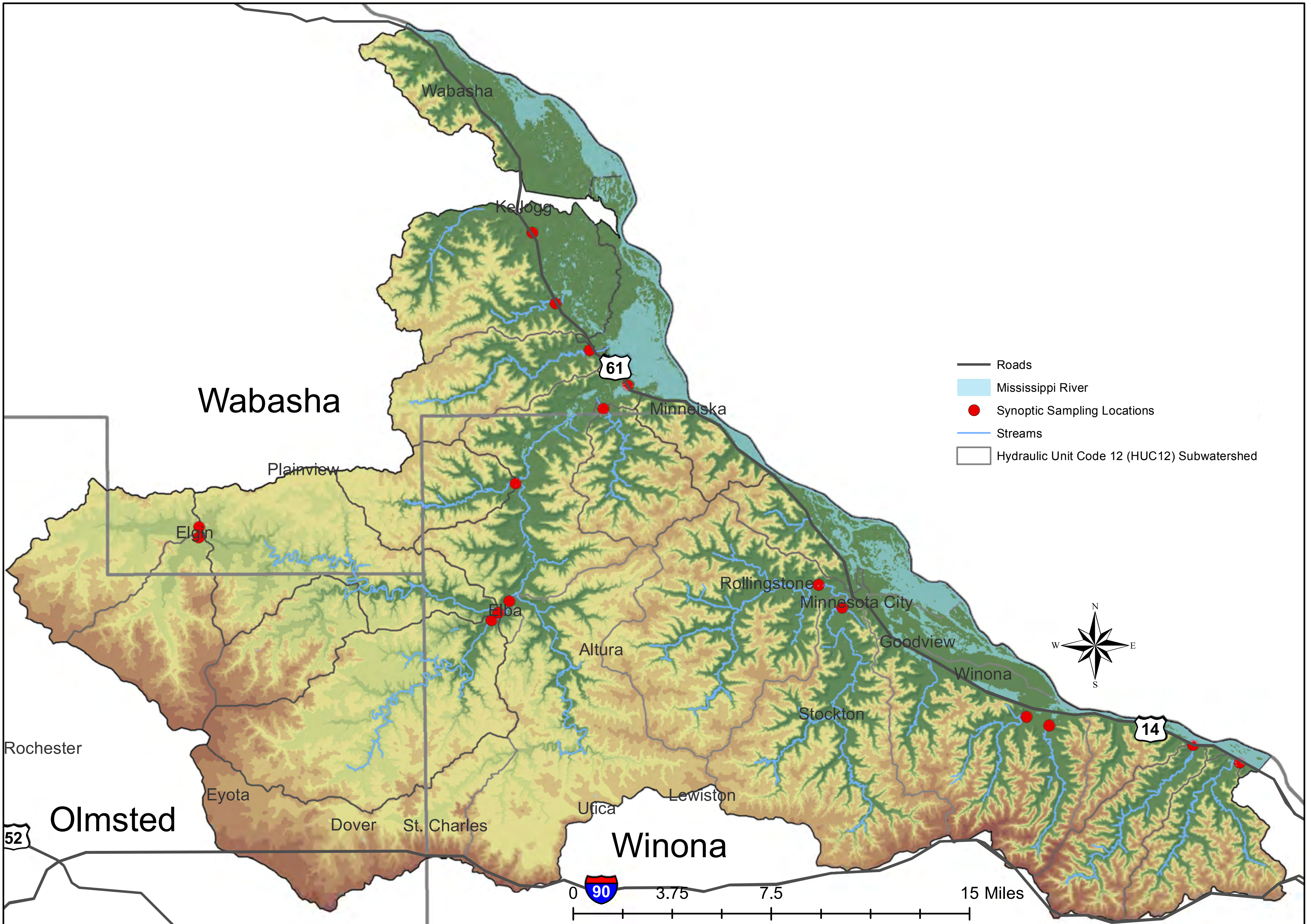

Synoptic Sampling Locations (12.12.12) in the Mississippi-River Winona Watershed

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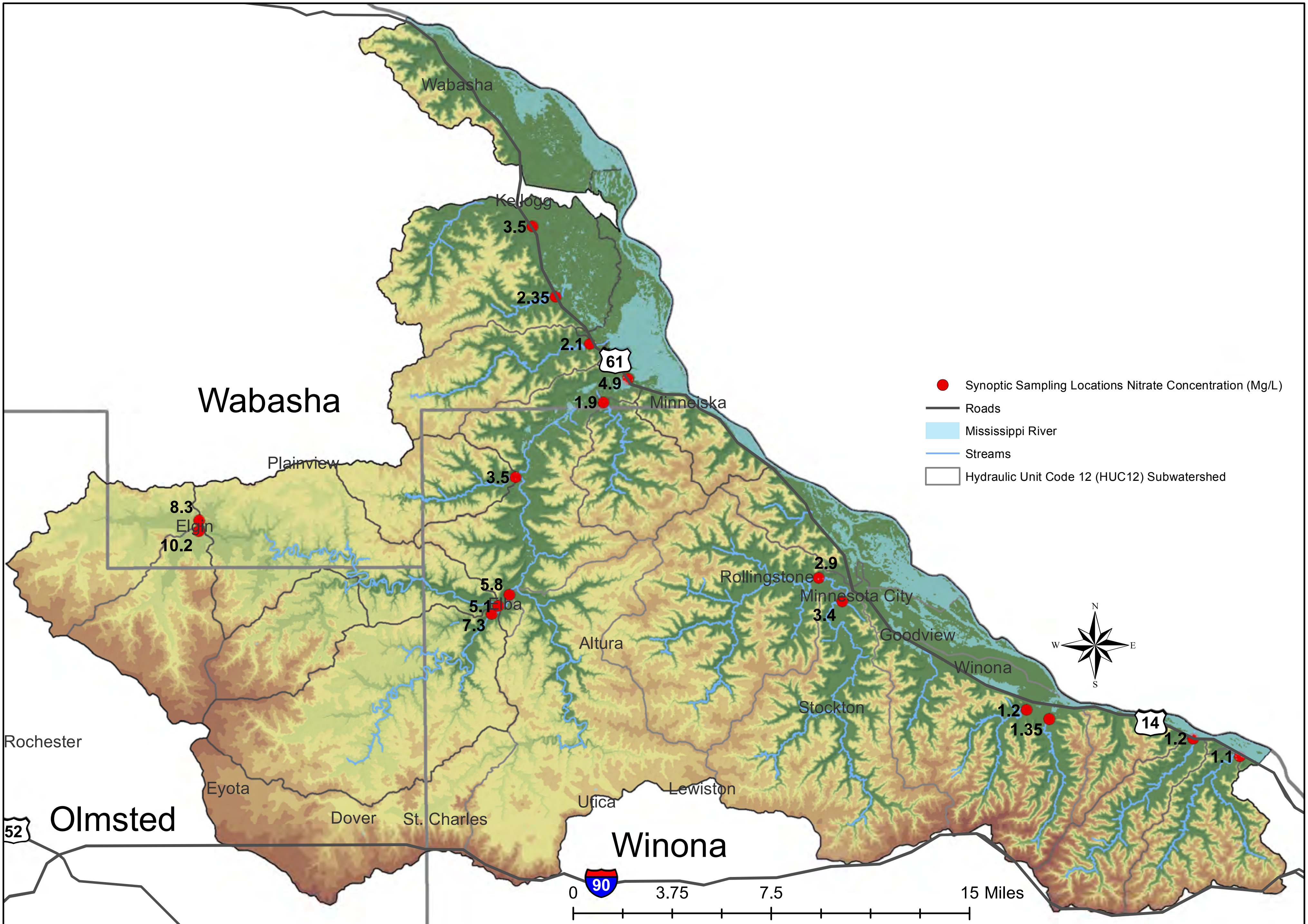

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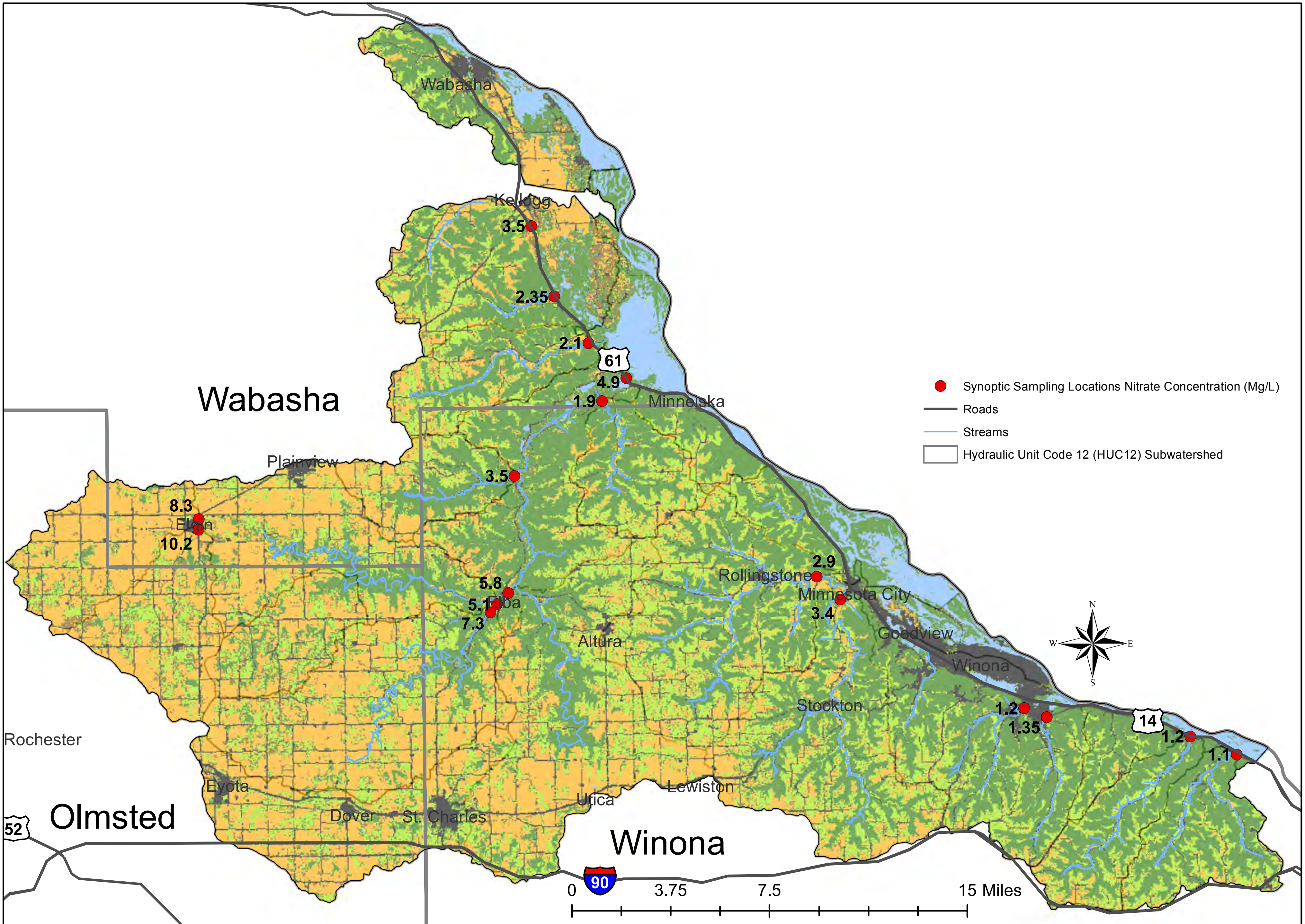

Synoptic Sampling Locations (12.12.12) in the Mississippi-River Winona Watershed

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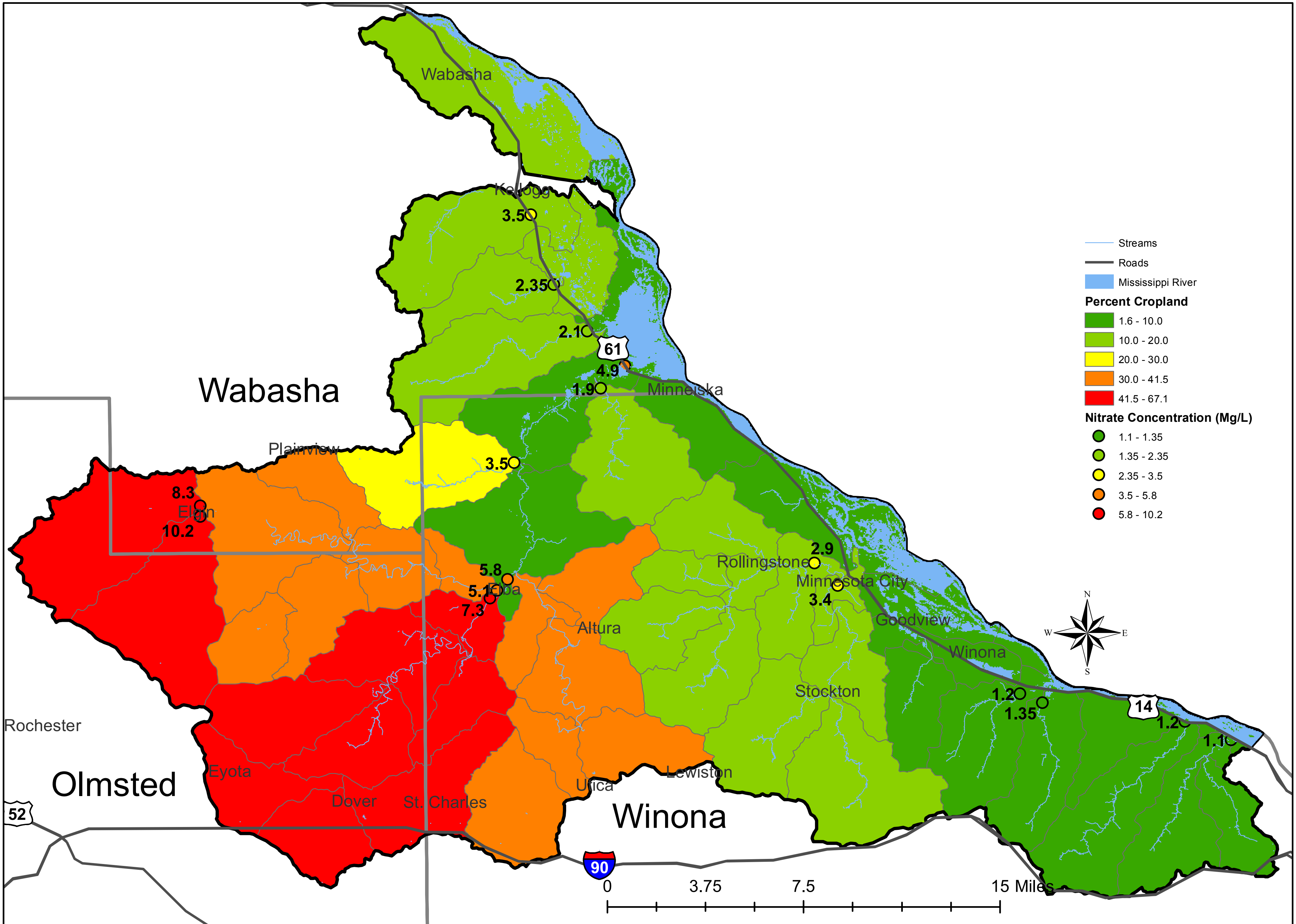

Synoptic Sampling Nitrate Concentrations Vs. Percent Cropland in the Mississippi-River Winona Watershed

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Appendix L

Mississippi River - Winona Watershed Workshop , Public Presentations and Summary Handout

Appendix L – Mississippi River-Winona Watershed Workshop and Presentations

ENVIRONMENTAL RESOURCES DEPARTMENT
2122 CAMPUS DR SE - SUITE 200
ROCHESTER, MN 55904-4744
WWW.CO.OLMSTED.MN.US/ER
507•328•7070

Thursday, November 15th 2012

Mississippi-Winona Watershed Workshop
Hosted by Olmsted County Environmental Resources

Olmsted County Campus
2122 Campus Drive SE, Rochester MN 55904
Conference Room A & B
UPDATED: 9:00 a.m to 12:00 p.m

Agenda:

8:45 - 9:00 a.m	Check-In
9:00 – 9:15 a.m	Welcome and background on Whitewater Joint Powers Board Work (Sheila Harmes)
9:15 – 9:30 a.m	Phase I: Overview of data compilation to date (Caitlin Meyer, Olmsted County)
9:30 – 9:45 a.m	DNR Overview (Dan Henely, MDNR)
9:45 – 10:00 a.m	MDA Overview (David Tollefson, MDA)
10:00 – 10:15 a.m	USGS Overview (Invited)
10:15 – 10:30 a.m	MPCA Turbidity TMDL Overview (Bill Thompson, MPCA)
10:30 -- 10:45 a.m	Sub-watershed Pollutant Load Monitoring Network (Mike Walerak, MPCA)
10:45 – 11:15 a.m	Overview of trend analysis to date (Kimm Crawford)
11:15 – 12:00 p.m	Phase II: Trend Analysis and Discussion
12:00 – 1:00 p.m	Lunch for those who would like to stay

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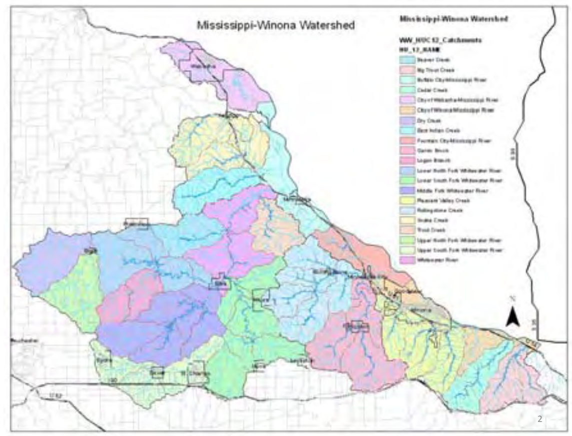
Mississippi-Winona Watershed

1



2

Phase 1: What the Data Shows

- Sources
- Spatial Distribution
- Period of Record
- Summary Mapping

3

Sources: Data Collection

Contacted:

USGS
MDA
MPCA
MDNR
SWCDs
NRCS
Universities
County Water Planners

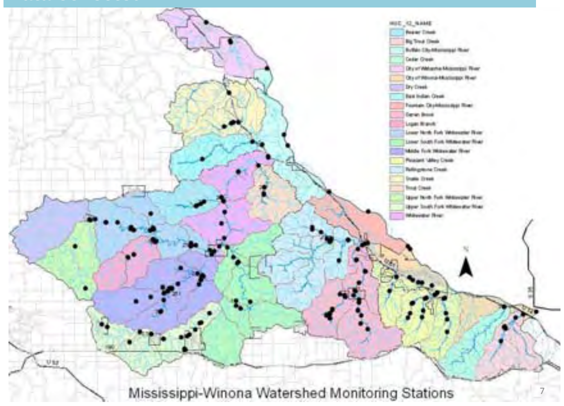
4

5

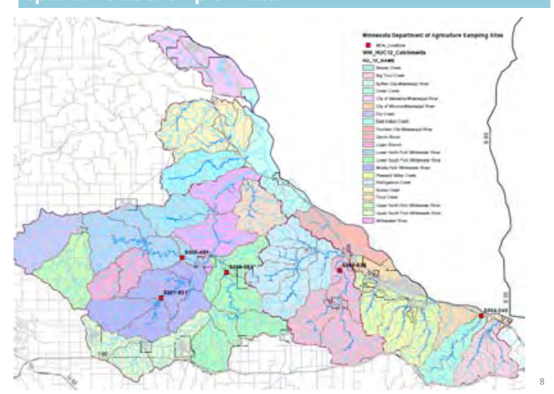
Impairments: Turbidity, Nitrates, Fecal Coliform

6

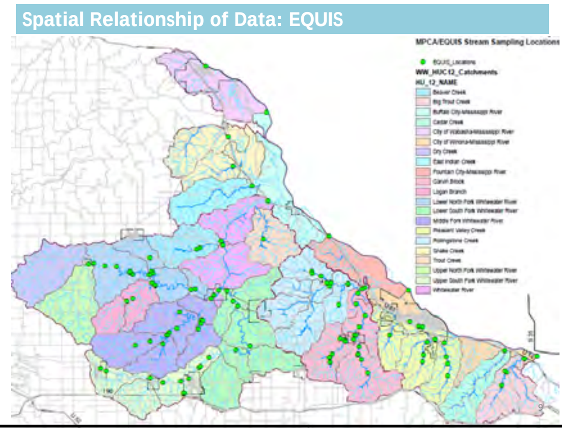
Data Collected



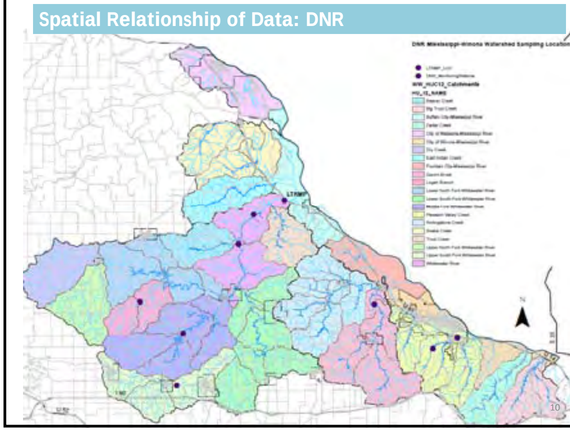
Spatial Relationship of Data: MDA



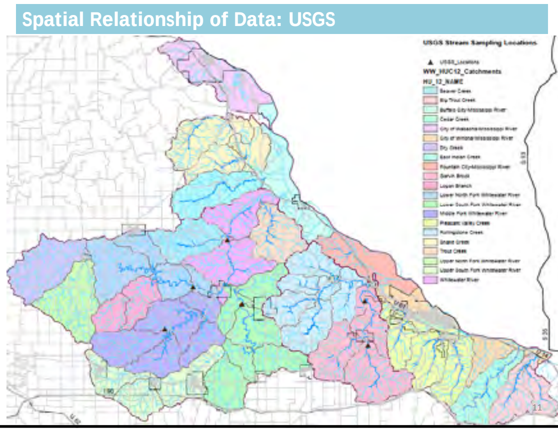
Spatial Relationship of Data: EQUIS



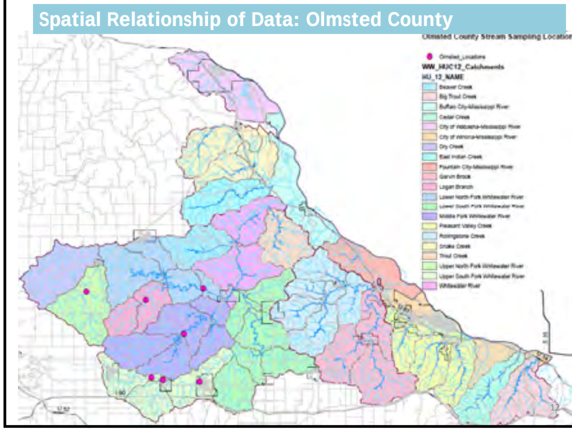
Spatial Relationship of Data: DNR



Spatial Relationship of Data: USGS



Spatial Relationship of Data: Olmsted County



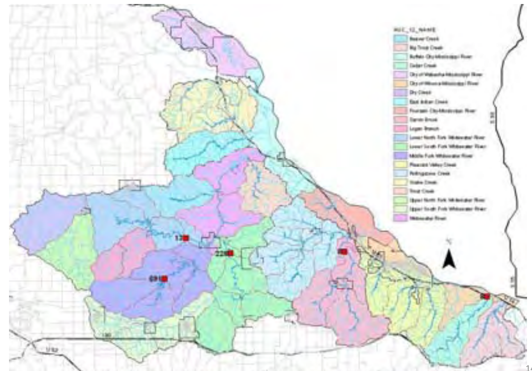
Counts

Top 10 Nitrate Sites by Count

AGENCY	LOCATION_DESCRIPTION	LOCATION_ID	PERIOD_RECORD_START	PERIOD_RECORD_END	Nitrate_Count
Hydstra	WW MidBranch at St. Charles	S001-831	4/1/1993	2/29/2012	740
MDA	MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	S001-831	1993	2011	691
EQUIS	WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	S000-288	5/21/1974	6/25/2009	254
LTRMP	WW on hwy 61 bridge	WW01.3M	4/30/1993	9/15/2008	246
MDA	S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	S000-321	1992	2011	228
EQUIS	GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	S000-828	6/16/1981	4/23/2009	182
Hydstra	WW at Beaver, CSAH30	S001-742	4/6/2001	7/30/2012	109
USGS	NORTH FORK WHITEWATER RIVER NEAR ELBA, MN	5376000	1961-1993	2012	96
EQUIS	WHITEWATER R AT CSAH 30, 4.5 MI N OF ELBA, MN	S001-742	4/6/2001	2/14/2011	36
EQUIS	LOGAN BR N FK WHITEWATER R AT CSAH 2, 6 MI S OF PLAINVIEW	S002-546	03/01/2004	10/31/2004	26

13

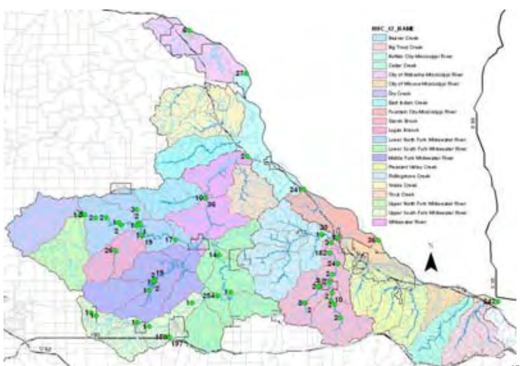
Counts



MDA Mississippi-Winona Watershed Nitrate Counts by Station

14

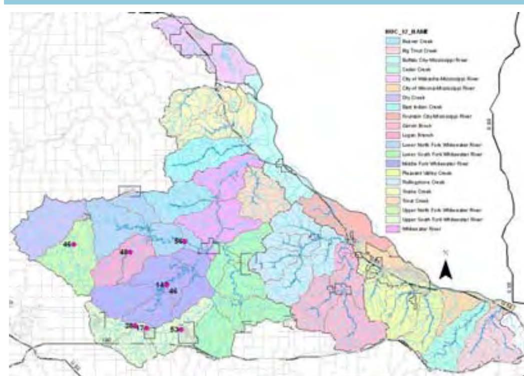
Counts



EQUIS Mississippi-Winona Watershed Nitrate Counts by Station

15

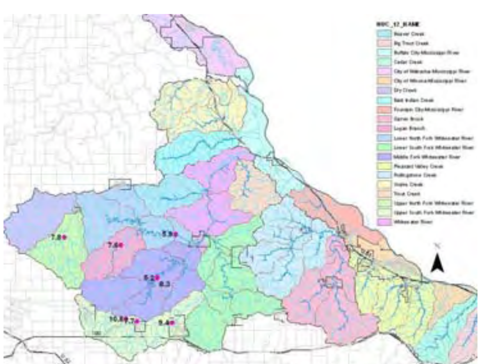
Counts



Olmsted Mississippi-Winona Watershed Nitrate Counts by Station

16

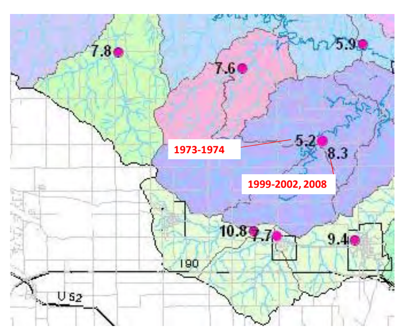
Averages



Olmsted Mississippi-Winona Watershed Nitrate Averages by Station

17

Period of Record



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Period of Record

Example: Nitrate Data
Middle Fork Whitewater North of St. Charles (S001-831)

MN Dept. of Ag.: 1994 → **691** → Present

MPCA/EQUIS: 2000-2003 (**3**), 2009-2010 (**18**)

712 Total Nitrate Values 1994-Present

Gaging Station: 1988-Present (USGS-Hydstra)

Period of Record

Example: Nitrate Data
S000-451 and S007-144 North Fork Whitewater W. of Elba

1967-1993	1999-2002	2005-2007	2008	2009-2010
96	**52**	**13**	**4**	**16**
USGS	**Olmsted**	**MDA**	**Olmsted**	**EQUIS**

81 Total Nitrate Values 1967-Present

By the End of the Project…

- Final Report
- Final Presentation
- Data Compilation
- Shape Files and Maps

Contact Information

Caitlin Meyer
Olmsted County Environmental Resources
507-328-6396
meyer.caitlin@co.olmsted.mn.us

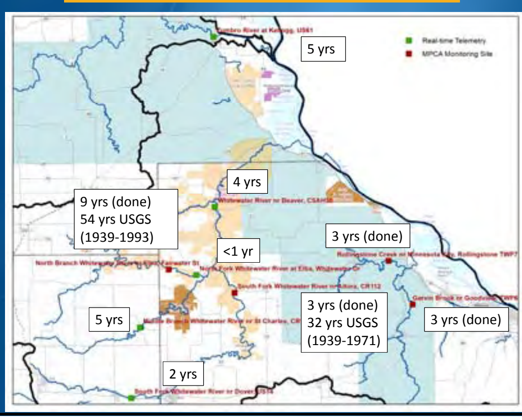
Mississippi River-Winona Watershed Monitoring: DNR Overview

Daniel Henely
Monitoring Hydrologist
DNR: Ecological and Water Resources

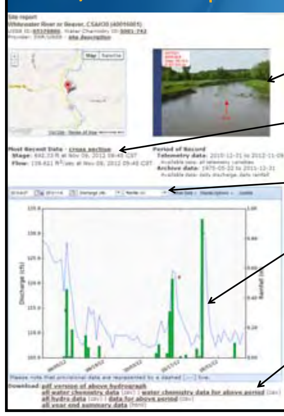
DNR/MPCA Cooperative Stream Gaging Website

http://www.dnr.state.mn.us/waters/csg/index.html

Current Stream Monitoring Network



DNR/MPCA Cooperative Stream Gaging Website



Browse photos of site

Current stage and provisional discharge

Select dates, data type, show gagings, etc

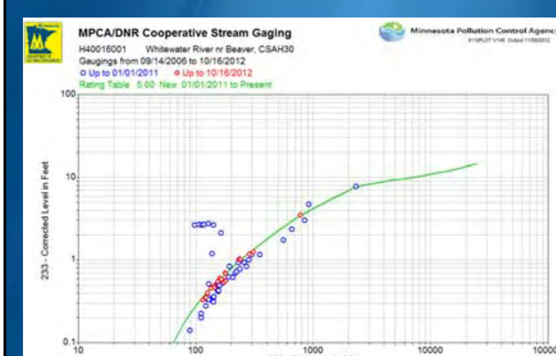
Dashed line indicates provisional discharge, will turn solid for published data

Various options for downloading from website

Whitewater River Stream Network

- In 2013, DNR will be upgrading telemetry equipment at M.B. Whitewater R. nr St. Charles and installing new Flood Warning Gage near the State Park's Group Camp
- 2 additional precipitation only monitoring sites will be added with telemetry in the upper watershed (location TBD)
- Each site will have satellite telemetry for real time web feed as well as a phone line for alarm callouts to park and emergency managers
- Beaver, MN site is used as a Clean Water Indicator Gage for the weekly Stream Flow Report representing Major Watershed 40.

Rating Development



Monitoring Equipment

N.B. Whitewater R. near Elba, MN
Installed October 2012

Whitewater River near Beaver, MN
Installed June 2008

Trout Streams by Fisheries Area Office

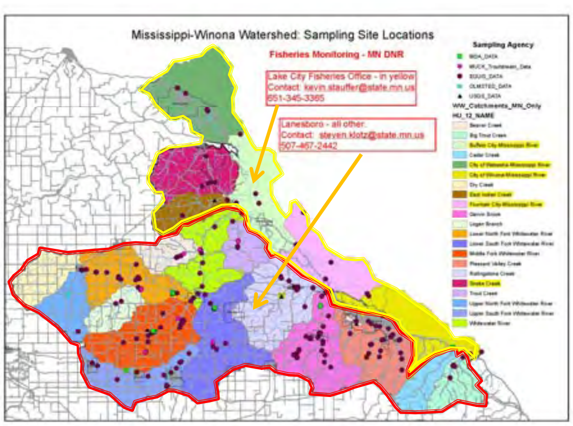
Stream/watershed	Kittle Number	Management	Comments
East Indian Creek	M-032	Lake City	
Snake Creek	M-032.5	Lake City	
Gorman Creek	M-033	Lake City	
Zumbro River	M-034	Lake City	All tributaries – Olmsted County
Brewery Creek	M-038	Lake City	
King's Creek	M-039	Lake City	
Second Creek	M-040	Lake City	
Miller Creek	M-041	Lake City	
Gilbert Creek	M-042	Lake City	
Wells Creek	M-043	Lake City	All tributaries
Bullard Creek	M-045	Lake City	
Hay Creek	M-046	Lake City	
Spring Creek	M-047	Lake City	
Cannon River	M-048	Lake City	All tributaries – Goodhue County
Bee Creek	I-006	Lanesboro	
Iowa River, Upper	I-023	Lanesboro	All tributaries – Fillmore County
Winnebago Creek	M-001	Lanesboro	All tributaries
Crooked Creek	M-004	Lanesboro	All tributaries
Wildcat Creek	M-007	Lanesboro	
Root River	M-009	Lanesboro	All tributaries – Fillmore/Houston County
Pine Creek (New Harford)	M-011	Lanesboro	All tributaries
Dakota Creek	M-014	Lanesboro	
Miller Valley Creek	M-015	Lanesboro	
Richmond Creek	M-016	Lanesboro	
Pickwick Creek	M-017	Lanesboro	All tributaries
Cedar Valley Creek	M-018	Lanesboro	
Homer Creek	M-021	Lanesboro	
Gilmore Creek	M-024	Lanesboro	All tributaries
Rollingstone Creek	M-026	Lanesboro	All tributaries
Deering Valley Creek	M-027	Lanesboro	
Latsch Creek	M-028	Lanesboro	
Whitewater River	M-031	Lanesboro	All tributaries

DNR Fisheries

- Contact Information
  - Lanesboro Office: Steve Klotz
    - Area Fisheries Supervisor
    - Email: steven.klotz@state.mn.us
  - Lake City Office: Kevin Stauffer
    - Area Fisheries Supervisor
    - Email: kevin.stauffer@state.mn.us

Mississippi River Fish Monitoring DNR Fisheries – Lake City

- Annual Fish Sampling in Pools 5, 5A, 6 and 7
  - All fish species
  - seining in backwater areas
  - Main channel and side channel electrofishing
  - Backwater overwintering areas by electrofishing
- Annual Qualitative Habitat Index
  - Backwater areas only
  - Emergent and submergent plants
- Fish Contaminant collections every 5 years (for consumption guidelines)



Trout Stream Sampling

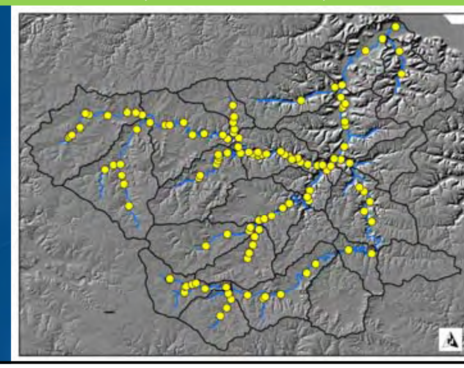
- All trout streams sampled every 3 to 6 years
- 1 to 3 stations per stream
- Stream or backpack electrofisher
- Population Estimate (depletion)at each station
- Qualitative Habitat Evaluation Index (QHEI)
- Frequency of survey and number of stations depends on size/importance of stream.

Long-term Monitoring Stations on Trout Streams

- Only on a subset of SE MN streams.
- LTM components include:
  - Fish
  - Invertebrates
  - Habitat
  - Geomorphology
  - Water Quality

MN-DNR, Stream Habitat Program

Whitewater River – geomorphic assessment
Representative Site Index Map, Fall 2012



Ecological and Water Resources: Stream Habitat Program

- Watershed Assessment of River Stability and Sediment Supply (WARSSS)
  - http://water.epa.gov/scitech/datait/tools/warsss/index.cfm
- Restoration projects important for improving aquatic biodiversity and healthy ecosystem
- Contact: Kevin Zytkovicz- DNR Hydrographer
  - kevin.zytkovicz@state.mn.us

WARSSS Provides a unified framework to understand and discuss cumulative watershed impacts within the watershed system; across systems

- Watershed based geomorphic assessment of perennial channels
- Goal is to have initial report completed Spring of 2013

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MDA's Monitoring and Assessment Unit Activities within the Mississippi-Winona Watershed

David Tollefson
MDA Hydrologist
david.tollefson@state.mn.us

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Today

- Analyte overview
- 2011 statewide program summary:
  – Where, when and how we sample
- Mississippi-Winona
  – Ground water summary
  – Surface water summary
- Publications – where to find them

2

What are we looking for in 2012?

MDA Lab analyzes for:

- Pesticides
  - GC-MS (pesticides)
  - LC-MS/MS (pesticides)
  - LC-MS (glyphosate)
  - Nutrients and sediment

- University of Wisconsin Steven's Point
  - ELISA screening method for acetochlor (limited to the Le Sueur River)

3

2012 Analytical Methods

- GC/MS – results are reported in **parts per billion (ppb)** or micrograms/Liter (ug/L)
- LC-MS/MS – results are reported in **parts per trillion (ppt)** or nanograms/Liter (ng/L)
- Nutrients and sediment
- GC-MS/MS – currently in development
- **All data is stored in MPCA's EQuIS database and available via web-based MPCA's EDA**

4

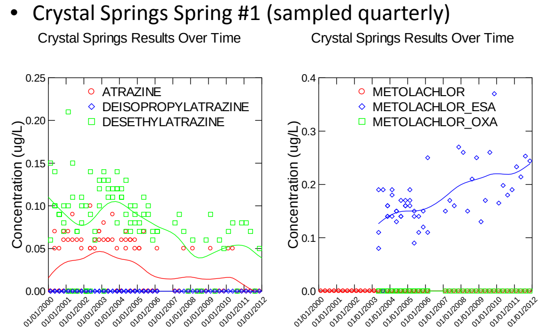
Groundwater Monitoring

- Started in 1985
- Target most sensitive areas in each PMR
- Redesigned in 2000
  - New sites
  - New wells
  - Many nested wells
- 178 sites across the state
- Use springs and domestic wells in SE
- Designed to track trends
- Extremely rare long-term data (as long as 27 years)

5

Whitewater MDA Groundwater Monitoring

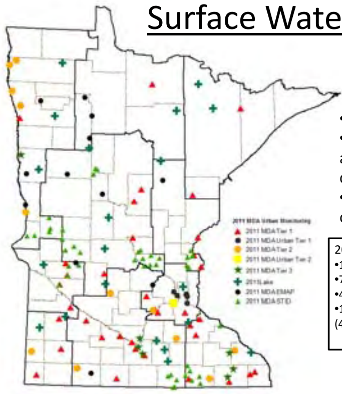
- Crystal Springs Spring #1 (sampled quarterly)



Atrazine + Degradates HRL= 3 ug/L, Metolachlor HRL = 300 ug/L, Metolachlor Degradates HBV = 800 ug/L

6

Surface Water Monitoring



- Started in 1991
- Utilizes a combination of grab and automated samplers to collect samples
- Focus on critical pesticide run-off period (May – August)

2011 Pesticide Sample Locations
- 138 Locations
- 789 Pesticide Samples
- 40410 individual analyses
- 14 Samples above standards or benchmarks (4 chemicals)

MINNESOTA DEPARTMENT OF AGRICULTURE 7

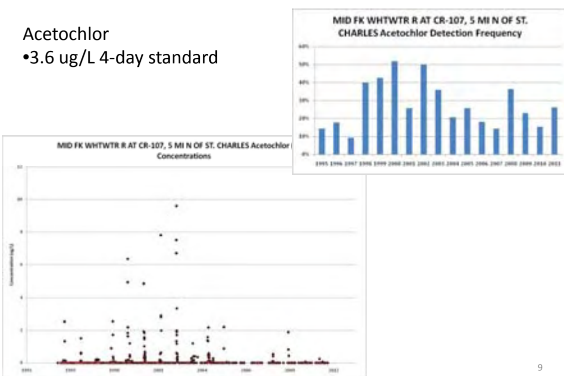
Mississippi River -Winona MDA Surface Water Monitoring

LOC_DESC	SYS_LOC_CODE	First Sample	Last Sample	Total Samples
CEDAR VALLEY CK, UPSTM OF SOUTH-BOUND US-61 LANE	S004-245	2005	2006	8
GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	S000-828	1991	1993	9
GARVIN BROOK AT CSAH-23, SW OF MINNESOTA CITY	S000-828	2005	2006	8
MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES	S001-831	1993	Active	862 +
N FK WHITEWATER R 0.15 MI W TR-16, 2.2 MI W OF ELBA	S000-451	2005	2007	13
S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA	S000-321	1992	Active	271 +
TROUT CREEK ADJACENT TO CSAH-31, 11.5 MI E OF PLAINVIEW, MN	S006-655	2010	2010	2
TROUT VALLEY CK SPRING, 550 FEET EAST OF CSAH-31, 8.4 MI SE OF KELLOGG, MN.	SP00032	2011	2011	4
WHITEWATER R S FK N OF CR-115 3.5 MI NW OF UTICA	S000-288	1991	1993	9
WHITEWATER R, N FK, AT CSAH-2, .7 MI S OF ELGIN, MN (10EM059)	S006-689	2010	2010	1
WINONA (SOUTH BAY)	85-0011-01-102	2010	2011	2

8

MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES
"Middle Branch of the Whitewater"

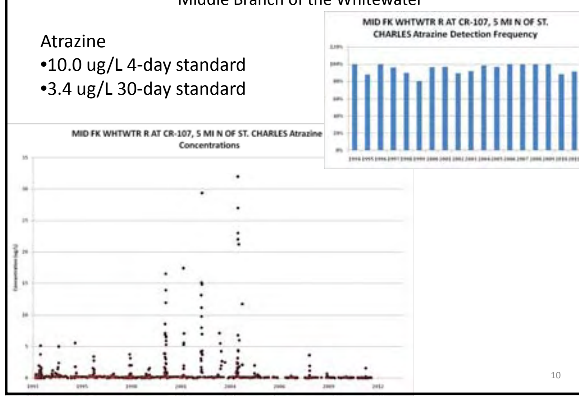
Acetochlor
- 3.6 ug/L 4-day standard



9

MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES
"Middle Branch of the Whitewater"

Atrazine
- 10.0 ug/L 4-day standard
- 3.4 ug/L 30-day standard



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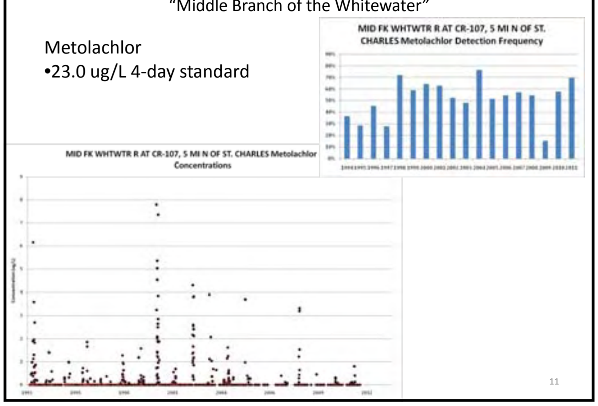
MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES
"Middle Branch of the Whitewater"

Metolachlor
- 23.0 ug/L 4-day standard



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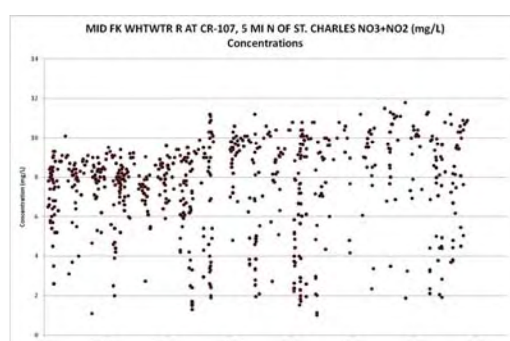
MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES
"Middle Branch of the Whitewater"



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MDA Future Plans:

- Ground water:
  - Continue quarterly sampling at Crystal Spring #1
- Surface water:
  - Tier 2: S FK WHITEWATER R AT CR-112 2 MI W OF ALTURA
    - 8-16 grab stormflow samples collected May through August
  - Tier 3: MID FK WHTWTR R AT CR-107, 5 MI N OF ST. CHARLES
    - 20-30 samples annually, automated storm sampling and base flow grabs
  - Further integration into the MPCA Intensive Watershed Approach when possible

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http://www.mda.state.mn.us/monitoring

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Turbidity TMDL Overview – Mississippi-Winona Watershed Workshop: 11.15.12 Rochester

Many…many involved along the way

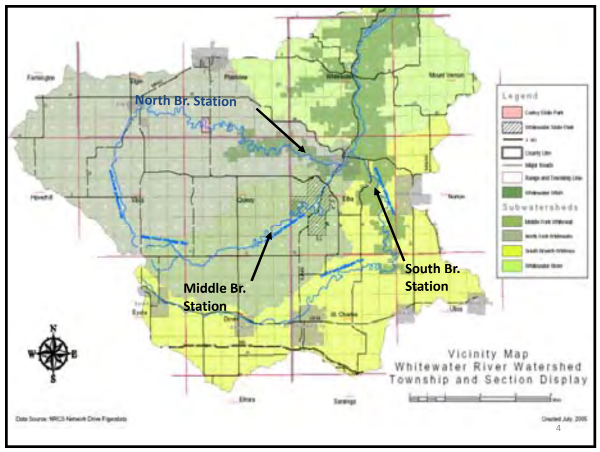
- WW-JPB and staff (Paul W. field work 09-10)
- USDA (Bob Bird, Laurie Svien, Doug Christianson, Stafford Happ, DCs, et)
- MDNR (Kevin Z., Mark E., Jon C., Larry G., John H., etc.)
- MPCA (Khalil, Nels, Tiffany, Justin, Greg, Pat, etc)
- MDA (Dave T., Denton B., etc.)
- WSU (Neil M.)

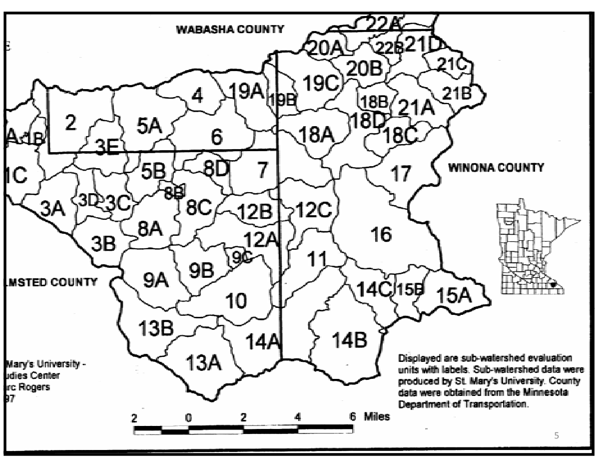
Turbidity TMDL, Watershed Sediment Budget Revision Project, and Stream Stability Work Plan

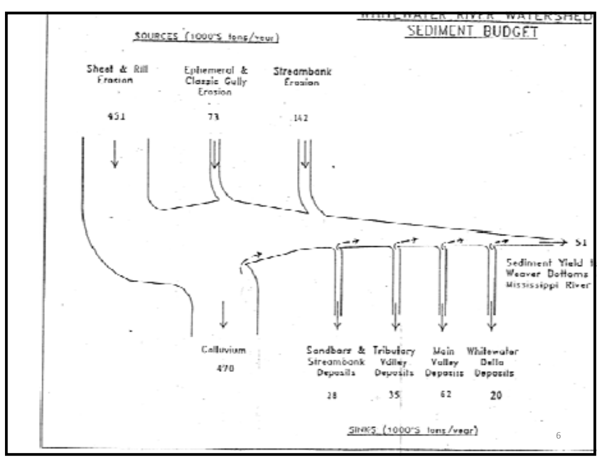
- Address 10 listings in WWW
- Timeframe: '08-'11
- Budget: $100,000
- Who: MPCA, WW-JPB
- Assistance: MDNR, NRCS, MDA
- Project Goals:
  - A) Assess/Revise WWW Sed. Budget
  - B) Public participation
  - C) Develop mgt. strategies to address sediment pollutant sources

Project Activities
Water monitoring (Paul)
Sediment Budget
- Upland erosion
- Crop residues
- Sheet/Rill; Gully
- Stream channel
- Erosion modeling (GIS, LIDAR)
- Use of existing data

Data Analysis
Communication
Reporting
Implementation Planning







SEDIMENT BUDGET – WHAT, WHY?

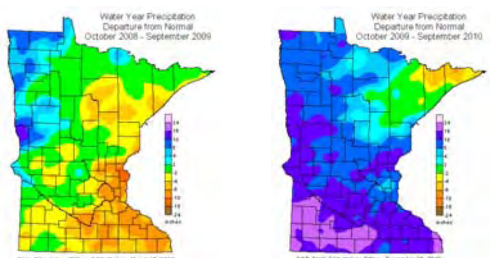
- Distributed Sediment Budget Model (Trimble 1993)
- Distribution of sediment and energy varies within a basin, and so stream processes will vary based on locale, landuse, climate
- Organized, structured process to estimate sources, sinks, yields, and transport
- Assist planning and land/water conservation
- Sets up tributary and Lower Valley categories

7

8

2009,2010 Water Year Comparision

Water Year 2009 **Water Year 2010**



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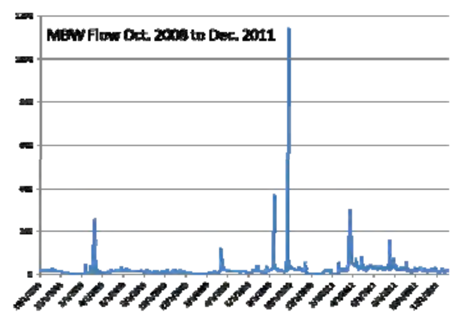

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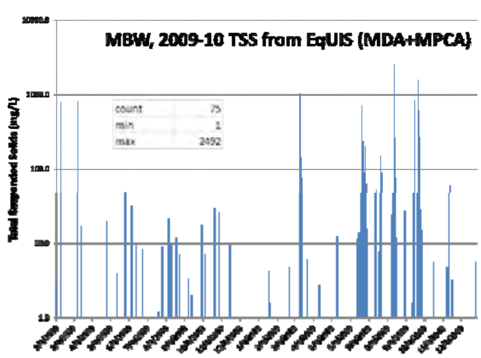

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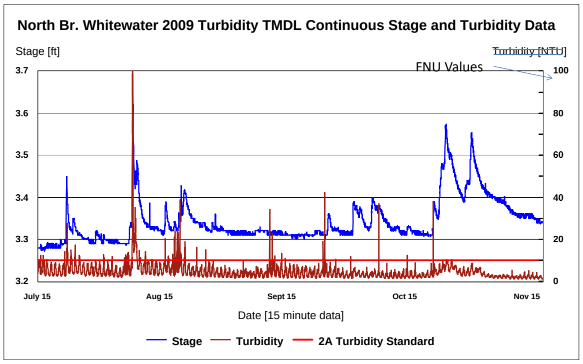
Many Terms and Turns…

- *Sediment Concentration* (TSS, Total Suspended Solids; SSC, Suspended Sediment Concentration)
- *Turbidity*
- NTU is 10, the WQS Nephelometric Turbidity Units
- FNU = Formazin N. Unit (from DTS-12s)
- NTRU = lab unit from MDH lab, N. Turbidity Ratio Units.
- For MBW, 10 NTU = 20 mg/L TSS
- For NBW, 10 NTU = 13 mg/L TSS (regressions)

12



Graph by Paul Wotzka

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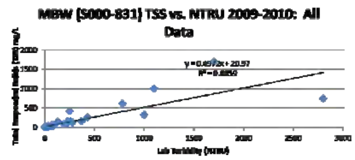
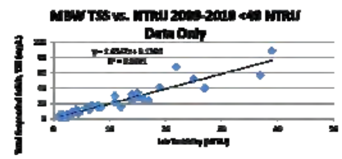
TSS and Lab Turbidity Regressions





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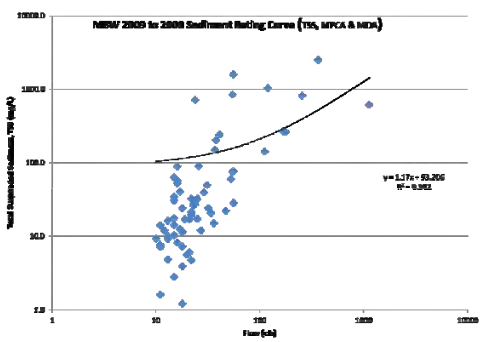

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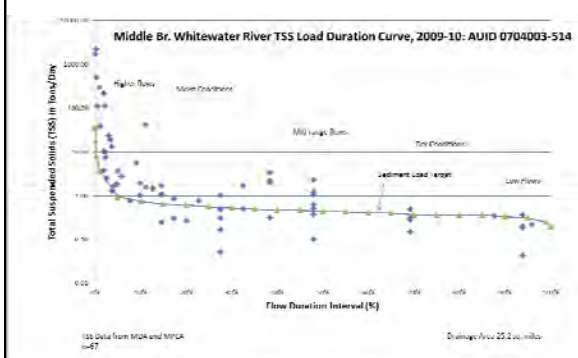

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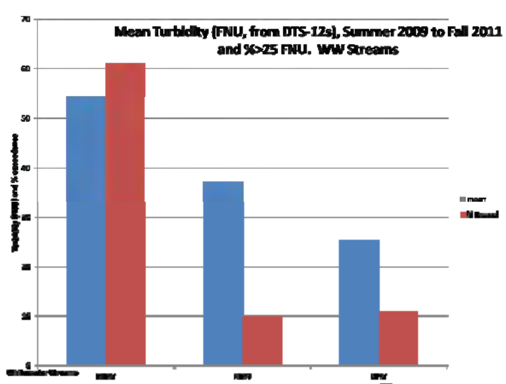

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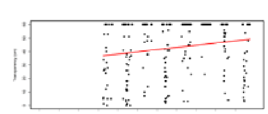
Citizen Stream Monitoring, Transparency Tube….Secchi Tube

Trend Analysis Overview

- 97 Stations in Miss.-Winona watershed with 2011 data
- 21 of these have enough data for seasonal Kendall test for trend
- No trend is detected in any of these 21 sites

What I showed in 2010, Willis Van Norman, MBW Trend



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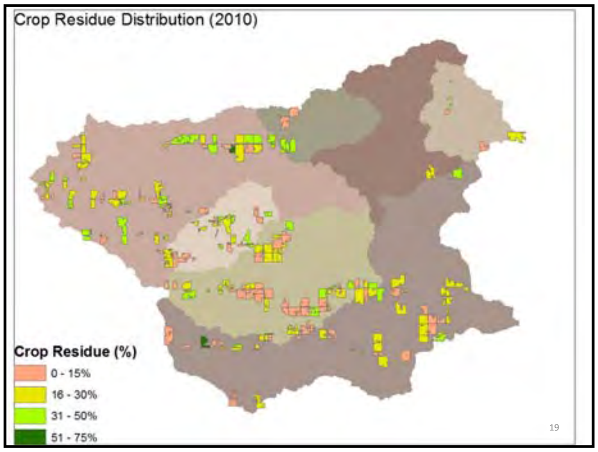
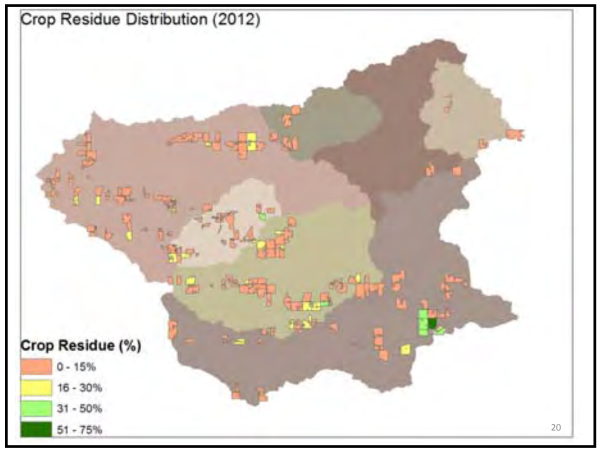
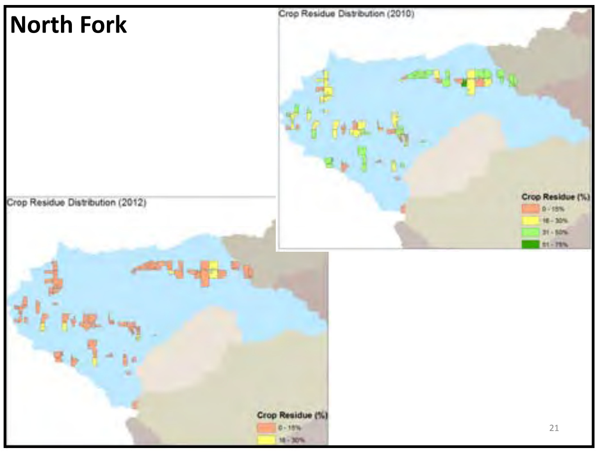
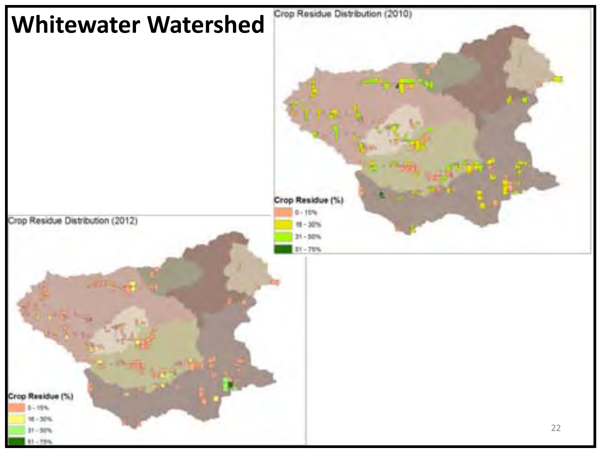


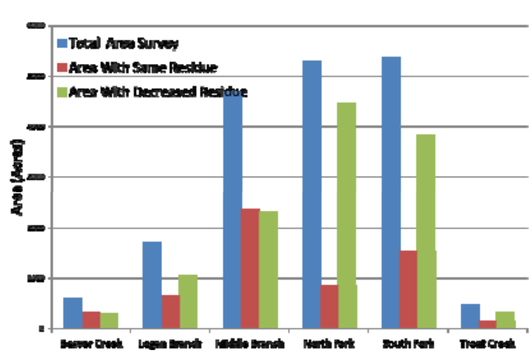


North Fork



Whitewater Watershed





	Total Area Survey	Area With Same Residue	Area With Decreased Residue
	Acre	Acre (%)	
North Fork	5313.4	850.3 (16%)	4463.2 (84%)
Whitewater	18174.9	5878.9 (32.3%)	12296 (67.7%)

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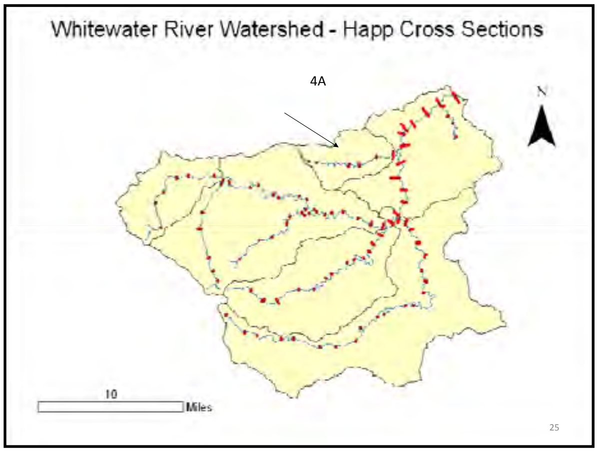
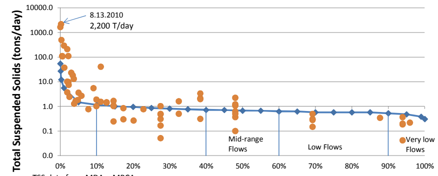


Middle Branch Whitewater River TSS Load Duration Curve, 2009-2010: (AUID 0704003-514)



TSS data from MDA + MPCA
n=67

Drainage Area 25.2 sq. miles

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SITE SELECTION CRITERIA

- *Land Use/Land Type*
- *Size (Minimum 100 mi^2)*
- *Nodes*
- *Historical Data Local Significance*
- *Existing Stream Gages*

2

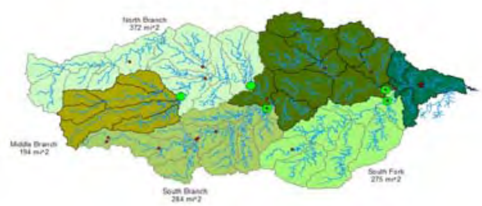
Parameters To Be Collected

Water Chemistry
TSS, TVSS, TP, DOP,N02+NO3, TKN, Turbidity

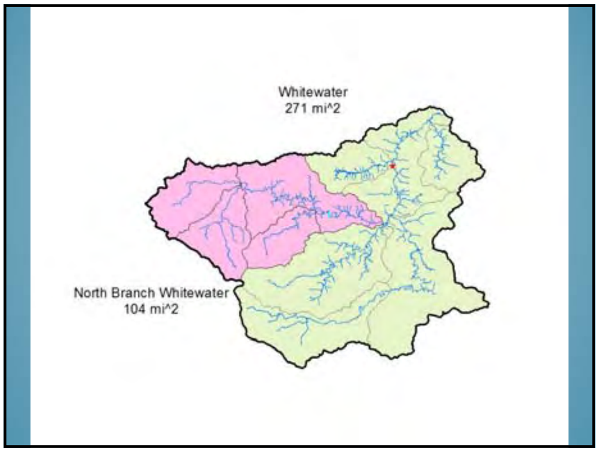
Field Measurements
Temp, DO, pH, Sp. Conductance, Secchi Tube

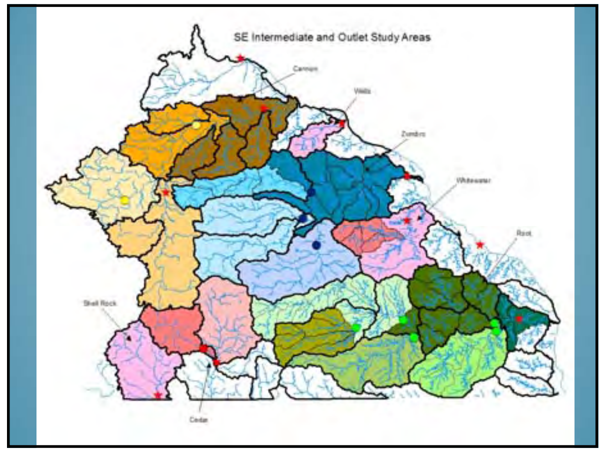
3

Root River



Cannon River


Whitewater
271 mi^2
North Branch Whitewater
104 mi^2


SE Intermediate and Outlet Study Areas
Cannon
Wells
Zumbro
Whitewater
Root
Shell Rock
Cedar

OVERVIEW

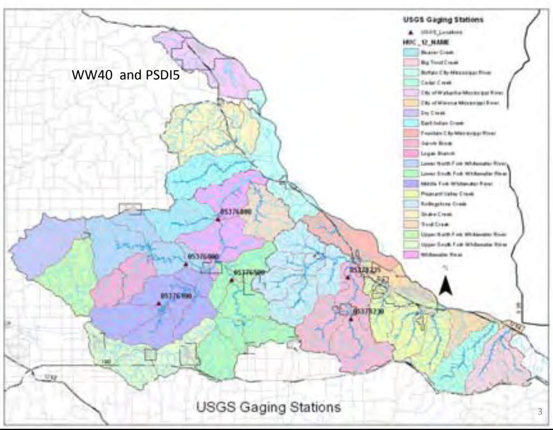
- Historic precipitation and stream flow
- Trends over time-focus on NO3
- Other parameters- Cl, TSS, TP, TKN, Turbidity, Transparency
- Geographic trends-agriculture and NO3
- Questions and Open discussion

1

Why is stream discharge important?

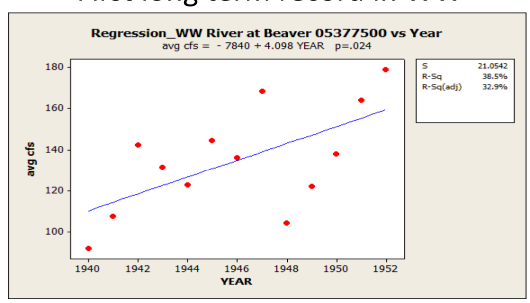
- A general trend toward increase flow in MN streams
- A general trend toward increased runoff- to-precipitation ratio
- Parameters relating to TSS (eg TP, TKN)are highly event or flow dependent
- Concentration for chemical parameters less related to flow but commonly have seasonal pattern
- Stream load calculations highly dependent on representative sampling for constituents which vary with flow
- Trends in concentration may not necessarily correspond to trends in loads

2



3

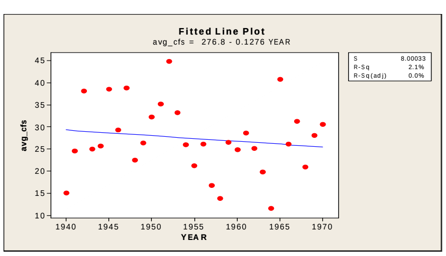
First long term record in WW



Increasing trend before 1950's

4

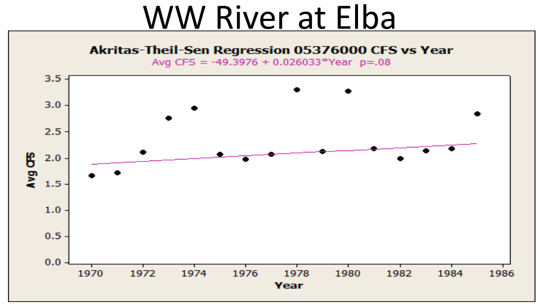
SF WW near Altura



Altura SF does not have significant time trend 1940-1970 p=.64

5

WW River at Elba

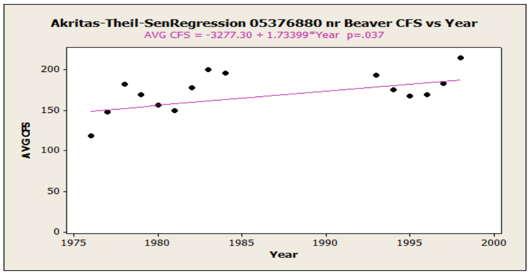


This site has first chemistry plus discharge , modest trend

6

WW River near Beaver

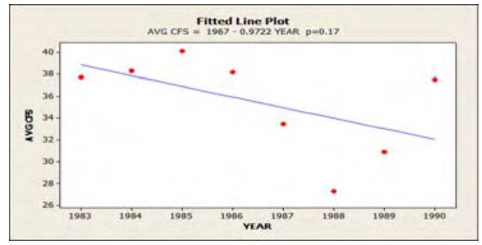
Fairwater site



Missing record 1985 to 1993

7

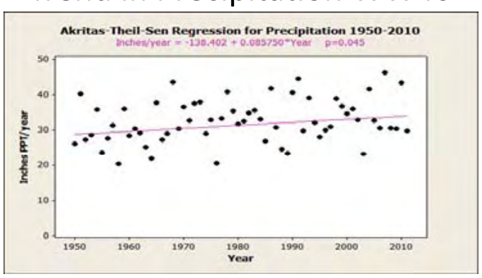
WW Garvin brook 05378235



No trend for Garvin 1983 to 1992, this is milestone site

8

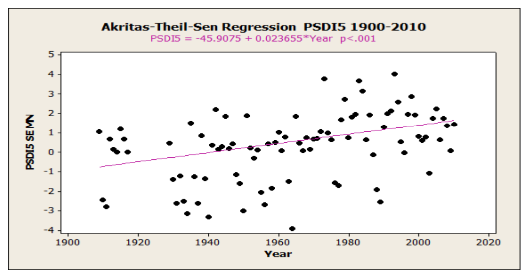
Trend in Precipitation WW40



Precipitation increase from 1930 to present, only since 1950 shown

9

Palmer Drought Severity Index PSDI5



PSDI5 increases through century, note droughts of early 1960's and 1988

10

Comments of River Discharges and climate

Most MN Rivers show increased flow since 1950

WW streams have mostly non-continuous record(s) over time

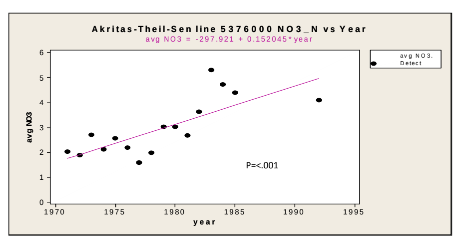
Little recent consistent discharge record for WW, or for much of SE MN

MN river yearly average CFS values generally correlate with PDSI and Precipitation

WW streams show better correlation with PSDI5 than with Preip40

11

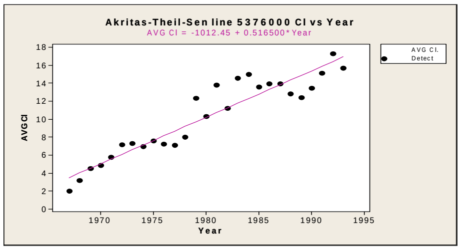
WW Elba 05376000 NO3_N



First comprehensive WQ study in WW. About 2 mg/l/decade NO3_N increase

12

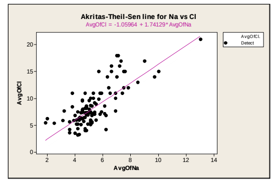
WW Elba 0537600 Cl trend

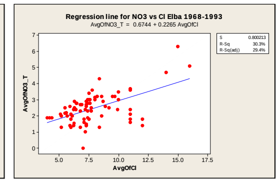


Cl upward trend ~5 mg/l/decade, correlates with NO3 trend

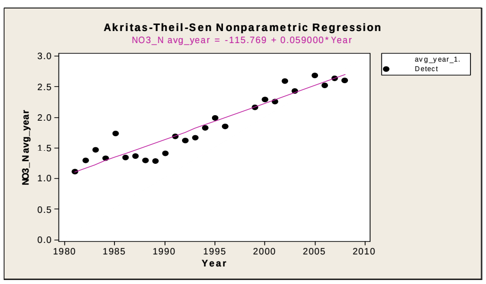
Certain WQ parameters correlate

Elba Na and Cl **Elba NO3 and Cl**





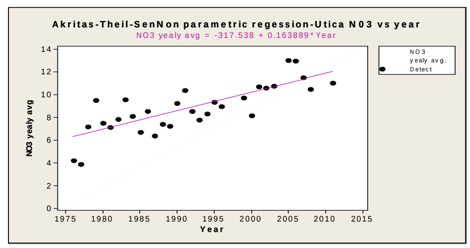
05378235 Garvin Brook NO3



NO3 upward trend ~0.6 mg/l/decade

This is MPCA milestone site- same result with Seasonal Kendall

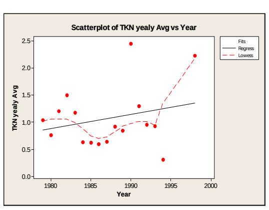
SF WW S000-288 near Utica-NO3

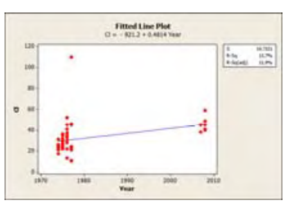


Upward trend ~1.6 mg/l/decade NO3_N, now exceed DW STD

MPCA milestone site, No discharge data here

TKN and Cl at Utica





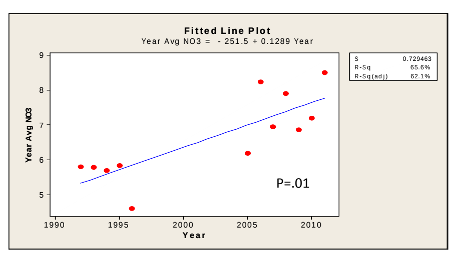
TKN no trend, variable with TSS

Cl data cover two time periods

KW test for 2 periods p=.001

!970's Cl=27 mg/l, 2008 Cl=43mg/l

SF WW near Altura S000-321 NO3

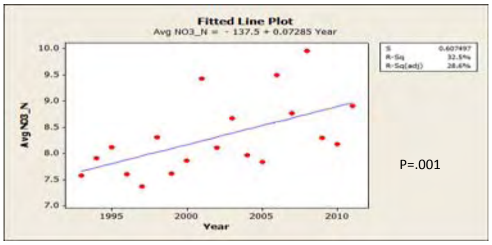


Trend NO3_N ~1.2 mg/l/decade , note missing period

KW test for two periods p=..001

This is MDA site

WW MF N of St Chas SOO1-831 NO3

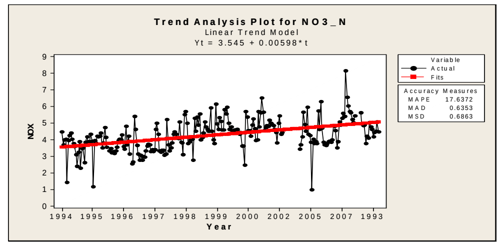


P=.001

NO3_N upward trend ~0.7 mg/l/decade, no discharge data here

This is MDA site, also Olmsted County

WW at Weaver SOOO-828



P=0.16 not significant, note large variability for NO3 data

This MNDNR site, no statistical trend for NO3 1990-2010

MPCA Milestone Sites in Whitewater-all parameters

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Whitewater River South Fork N of Cr-115, 3.5 Mi NW of Utica (WWR-26) (period of record 1974 - 2008)						
overall trend	decrease	no trend	increase	decrease	decrease	increase
average annual change	-2.1%		2.0%	-3.6%	-2.8%	1.9%
total change	-53%		101%	-73%	-64%	94%
1995 - 2009 trend	no trend	no trend	increase	no trend	decrease	little data
average annual change			2.5%		-6.1%	
total change			41%		-50%	
median concentrations first 10 years	31	0.5	7	0.10	2.3	27
median concentrations most recent 10 years	13	0.5	11	<.05	1.0	43
Garvin Brook at CSAH-23, SW of Minnesota City (GB-4.5) (period of record 1983 - 2009)						
overall trend	decrease	decrease	increase	decrease	decrease	increase
average annual change	-3.8%	-1.4%	3.1%	-0.9%	-1.7%	3.7%
total change	-63%	-30%	124%	-21%	-36%	156%
1995 - 2009 trend	decrease	no trend	increase	no trend	no trend	little data
average annual change	-9.2%		2.6%			
total change	-54%		35%			
median concentrations first 10 years	59	0.1	1	0.07	1.5	6
median concentrations most recent 10 years	21	0.1	2	<.05	0.8	13

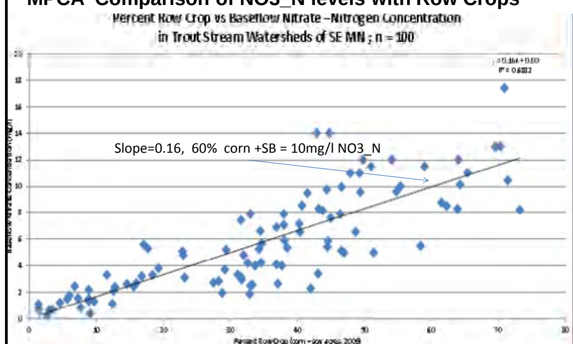
Both milestone sites show TSS decreases using seasonal Kendall

TP shows no trend, BOD shows decrease

Both sites show NO3_N increases with Seasonal Kendall

Cl upward trends for both site found in this analysis

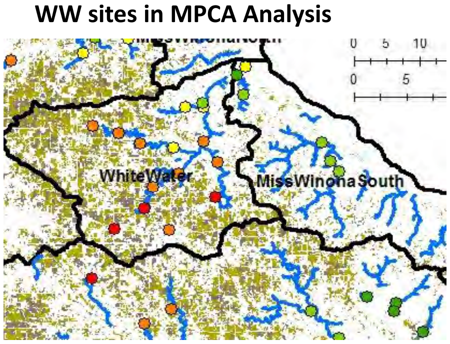
MPCA Comparison of NO3_N levels with Row Crops



16 of these sites are trout stream reaches in WW

Note increase in variance as % row crops increases, "buldge" in center

WW sites in MPCA Analysis



Some reasons for variability in MPCA Regression

Factors increasing N loads to streams

- Corn-soybean and corn alfalfa rotations vs continuous corn
- Corn for silage
- Cattle and swine numbers in watershed-crops used internally
- Actual N applications vs credits for legumes and manure
- Wastewater treatment facilities

Factors decreasing N loads to streams

- Reduced tillage and soil organic matter buildup
- Buffers and wetlands
- Denitrification
- Size of watershed and other land use

Other

- NO3 sampling and analytical uncertainity(~5%)
- Groundwater -and –surface watershed boundaries

Calculation of N load from corn

Precipitation in WW ~ 30 inches/year
Net runoff /infiltration as streamflow ~ 10 inches/year
Corn yield in Wabash and Winona Counties ~150 bu/acre 2010
N Fertilizer applications in WW ~ 143 lbs N/acre

Corn grain ~7% protein or 1.2% N
This calculates to ~70% efficiency of N uptake by harvested corn
Excess N is ~40 lbs/acre/year not accounted for in harvested grain

Excess N in stream flow calculates to ~20 mg/l as N
This is typical value observed in tile drainage in MN

100% corn in a watershed would result in 20 mg/l NO3_N
60% corn would result in 12 mg/l NO3_N

This simplified calculation is quite consistent with MPCA Regression
Factors for departing from line are is previous slide

25

Recent Corn Analyses

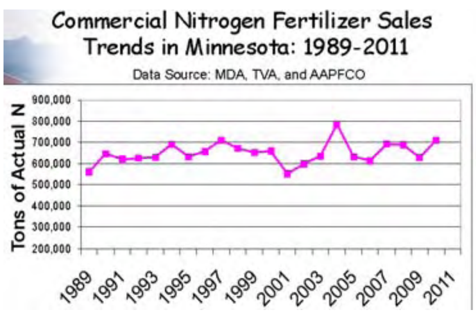
Comparison of corn hybrids 2002-2010

YEAR	COUNT	OIL%	PROTEIN%	MOISTURE%
2002	390	4.7(0.2)	9.7(0.5)	15
2010	112	3.5(0.4)	6.2(0.7)	15

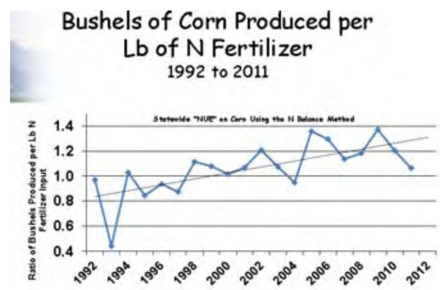
Corn Hybrid analysis data indicate that newer hybrids favor starch over protein

Lower Protein(and N) levels in corn allow increase bu/acre with about constant N fertilizer input

26

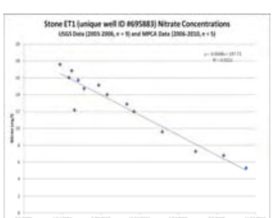


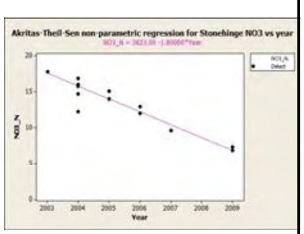
27



28

NO3_N Decreases in shallow groundwater after Ag retirement





This is small watershed above new high school in suburban Rochester
Shown is linear plot, log NO3 is slightly better
2-3 mg/l/year decrease, new samples in 2012

29

Closing Notes

Discharge-non continuous records, would need used precipitation and/or Palmer to create estimated flows

Nitrate- all sites show increases over time, some overlapping records, slight seasonal Pattern. Large variance at Weaver

Discharge dependent parameters-TSS, TP,TKN,NH3, Coliform, secchi- wide variance Requiring more samples or river stage analysis with samples

Other parameters- Cl and SO4 limited data but potential trends

Suggestions?

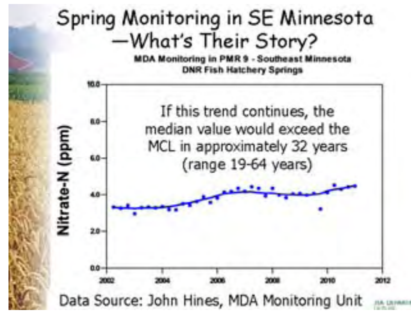
Suggestions for dealing with secchi data?

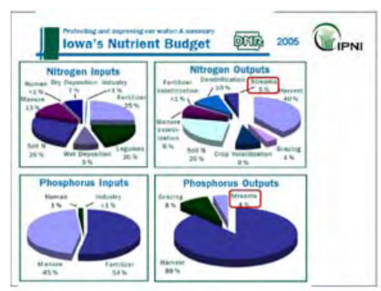
Other data we don't know about?

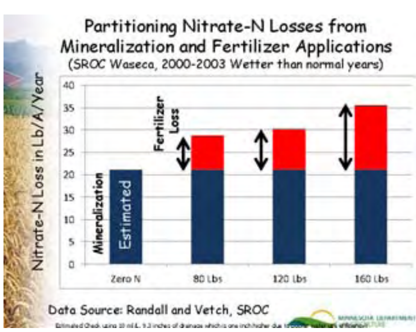
30

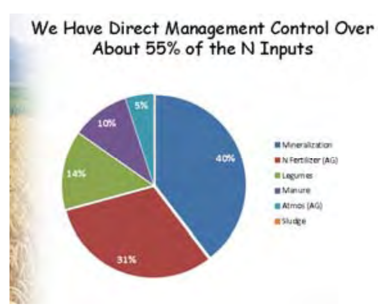
The Beginning of the End

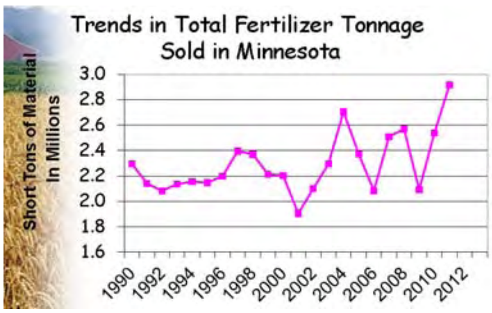
You can check out, but you can never leave !
Eagles, Hotel California











37

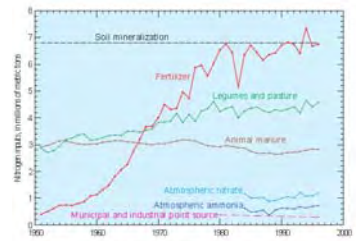
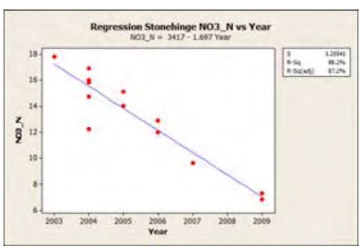


Figure 5. Annual nitrogen inputs to the Mississippi Basin from major sources

38



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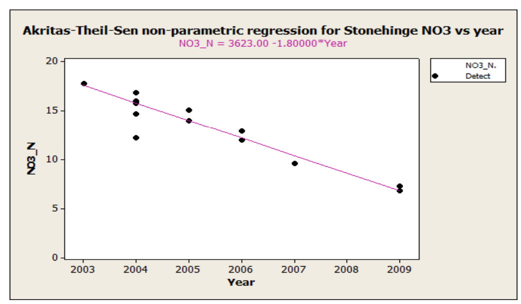
Stonehinge NO3_N following retirement of Ag land

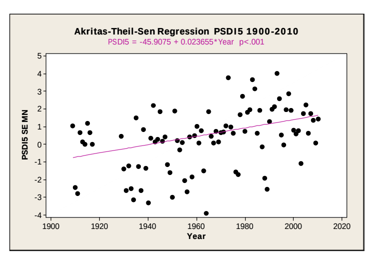


40

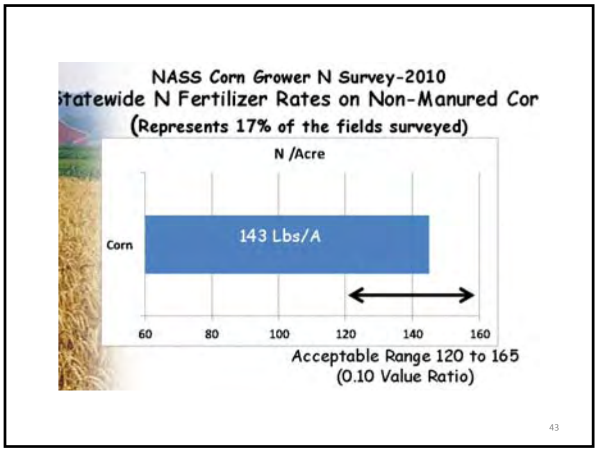
Table 1. Estimated nitrogen contribution to the Gulf of Mexico from specific sources in the Mississippi Basin (1980–96)
[Nitrate flux = 0.95 million metric tons per year; total nitrogen flux = 1.57 million metric tons per year]

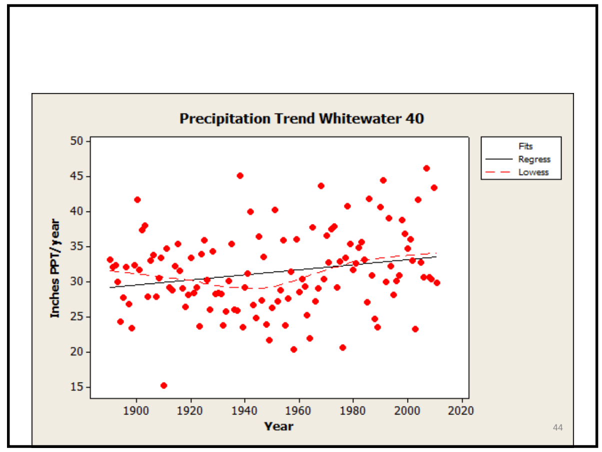
Source of nitrogen	Percentage of nitrate flux from source	Percentage of total nitrogen flux from source
Fertilizer and mineralized soil nitrogen	58 +/-9	50 +/-9
Animal manure	16+/-9	15 +/-10
Other, including atmospheric deposition, ground water, soil erosion, and urban runoff	16 +/-6	24 +/-6
Municipal and industrial point sources	9 +/-2	11 +/-2

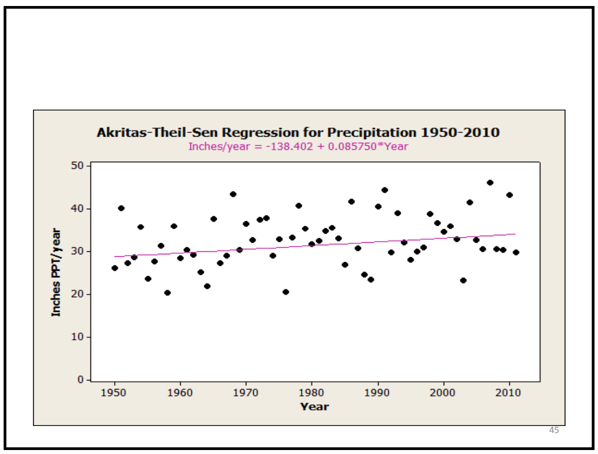
41

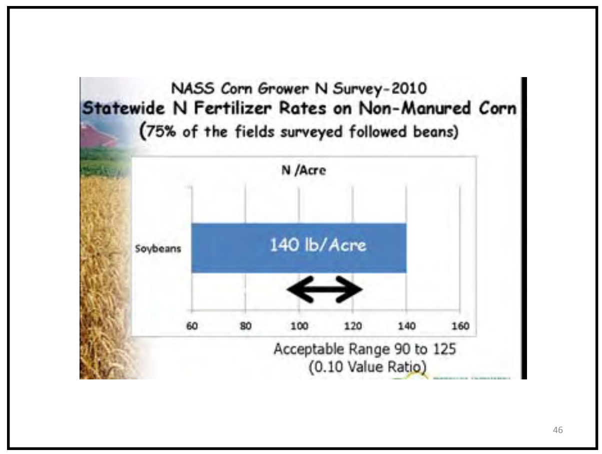


42


NASS Corn Grower N Survey-2010
Statewide N Fertilizer Rates on Non-Manured Cor
(Represents 17% of the fields surveyed)
N /Acre
Corn
143 Lbs/A
60
80
100
120
140
160
Acceptable Range 120 to 165
(0.10 Value Ratio)
43


Precipitation Trend Whitewater 40
Fits
Regress
Lowess
Inches PPT/year
50
45
40
35
30
25
20
15
1900
1920
1940
1960
1980
2000
2020
Year
44


Akritas-Theil-Sen Regression for Precipitation 1950-2010
Inches/year = -138.402 + 0.085750*Year
Inches PPT/year
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year
45


NASS Corn Grower N Survey-2010
Statewide N Fertilizer Rates on Non-Manured Corn
(75% of the fields surveyed followed beans)
N /Acre
Soybeans
140 lb/Acre
60
80
100
120
140
160
Acceptable Range 90 to 125
(0.10 Value Ratio)
46

MISSISSIPPI-RIVER WINONA WATERSHED

WATER QUALITY DATA COMPILATION & TREND ANALYSIS

February 19, 2013

Caitlin Meyer, Olmsted County Environmental Resources

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

CLEAN WATER LAND & LEGACY AMENDMENT

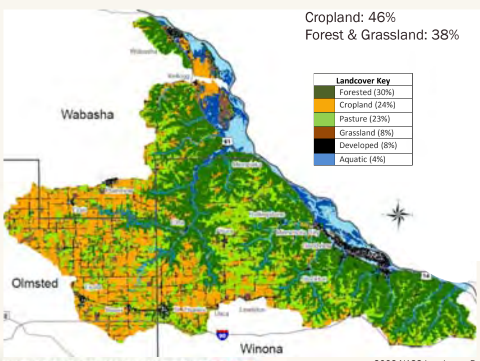
Mississippi-River Winona Watershed

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

2

Landcover

Cropland: 46%
Forest & Grassland: 38%



MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

2009 NASS Landcover Data

3

Background

- Sources
- Spatial Distribution
- Period of Record
- Summary Mapping

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

4

Data Collection

MN Pollution Control Agency	• Surface Water Data (all parameters)
MN Department of Natural Resources	• Biological • Stressor Identification
MN Department of Agriculture	• Pesticides • Nutrients
United States Geological Survey	• Discharge • Water Quality Parameters
Soil and Water Conservation Districts and Counties	• Crop and agricultural data • Water Quality Parameters
Universities	• Reports
United States Fish & Wildlife Service, Army Corps of Engineers	• Reports

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

5

Monitoring Locations

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

6

Overview of Trends Found

- Historic Precipitation & Discharge
- Trends Over Time
  - Nitrate, Chloride, Sulfate, Parameters Related to Suspended Sediment
- Geographic Trends
  - Landcover

Summary Trends

Improving Conditions

- Water Quality Parameter Concentrations are Decreasing

Degrading Conditions

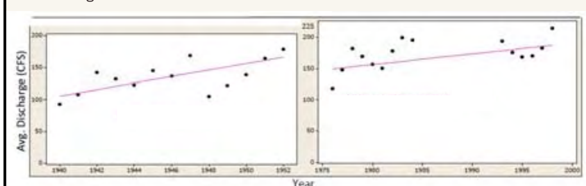
- Water Quality Parameter Concentrations are Increasing

Discharge Trends

USGS ID	Station Name	Period of Record	Discharge Trend (CFS)
5377500	Whitewater River At Beaver*	1939-1953	Discharge
5376800	Whitewater River Near Beaver* Note: Missing Period Of Record From 1985-1993	1975-1999	Discharge
5376500	South Fork Whitewater River Near Altura	1940-1970	No Trend
5376000	North Fork Whitewater River Near Elba	1967-1993	No Trend
5378235	Garvin Brook Near Minnesota City	1982-1991	No Trend

Summary Discharge Trends

Increasing Flow Trend for the Whitewater River Near Beaver

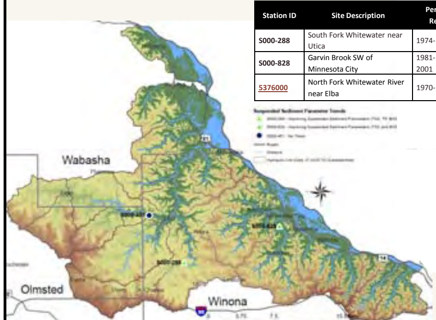


- **Finding**: No continuous, long-term record of data
- **Trend**: Where trends exist, flow trend is increasing
- **Recommendation**: Palmer Drought Severity Index (PDSI) could be used to reconstruct stream flows

Suspended Sediment & Related Parameter Trends

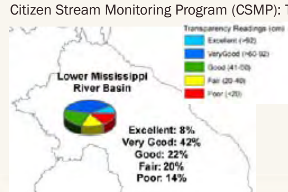
Total Suspended Solids (TSS), Total Phosphorous (TP), Total Kjeldahl Nitrogen (TKN), transparency, turbidity and Biochemical Oxygen Demand (BOD)

Station ID	Site Description	Period of Record	Suspended Sediment Trends
S000-288	South Fork Whitewater near Utica	1974-1994	TSS & BOD
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2001	TSS, TP & BOD
5376000	North Fork Whitewater River near Elba	1970-1993	No Trend in SSC or load



Suspended Sediment & Related Parameter Trends

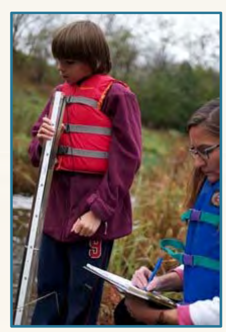
Citizen Stream Monitoring Program (CSMP): Transparency



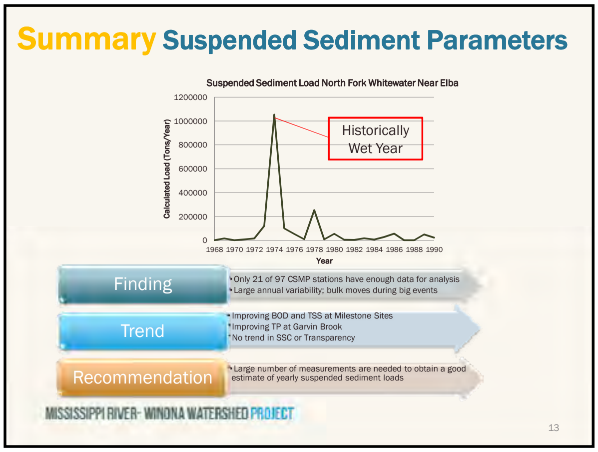
97 Stations in the Watershed

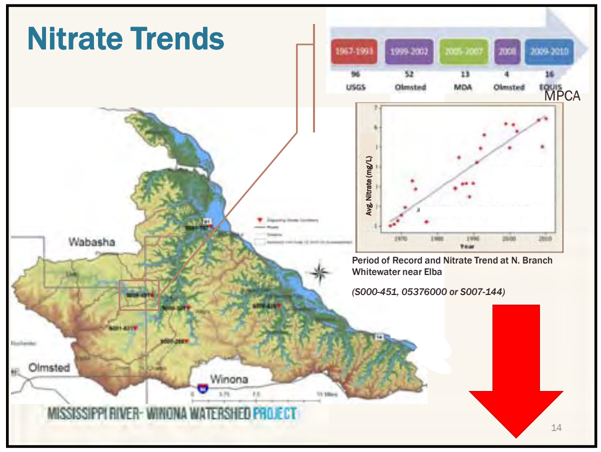
- 21 stations with enough data

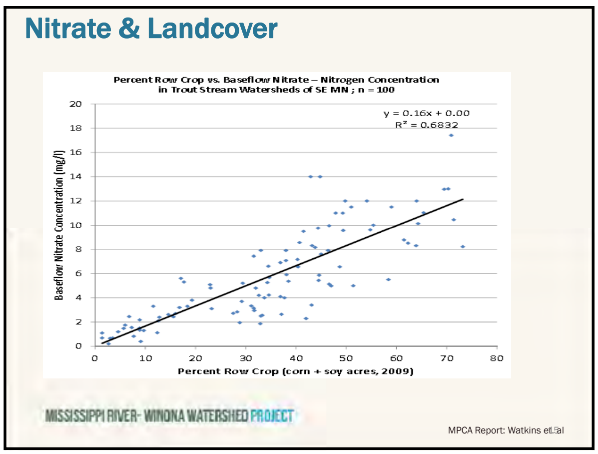
None Showed a Trend

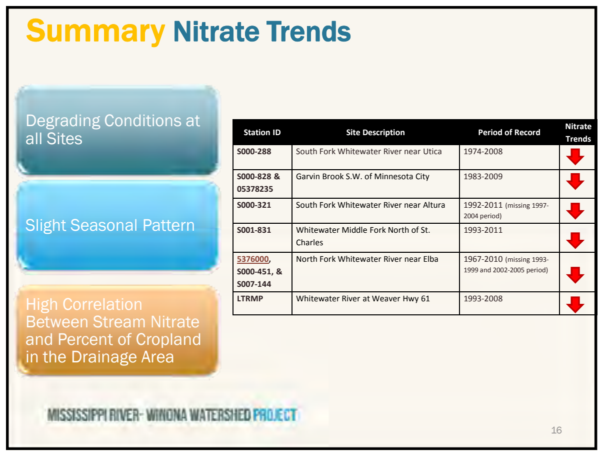


Provided by: 2010 MPCA Report on Water Quality of MN Streams

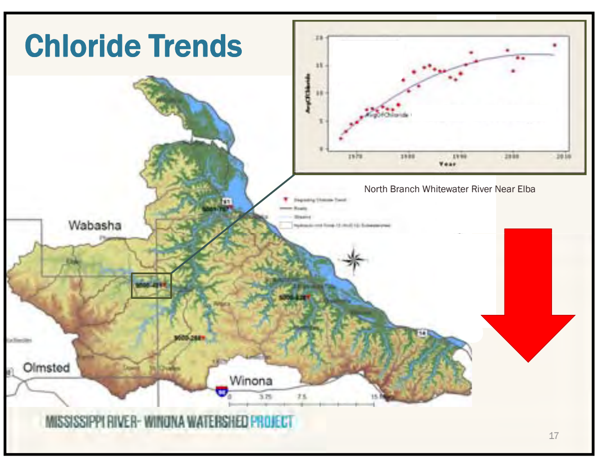


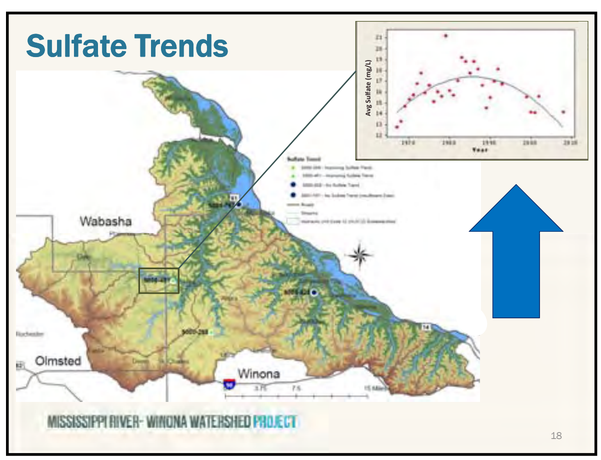






Station ID	Site Description	Period of Record	Nitrate Trends
S000-288	South Fork Whitewater River near Utica	1974-2008	
S000-828 & 05378235	Garvin Brook S.W. of Minnesota City	1983-2009	
S000-321	South Fork Whitewater River near Altura	1992-2011 (missing 1997-2004 period)	
S001-831	Whitewater Middle Fork North of St. Charles	1993-2011	
5376000, S000-451, & S007-144	North Fork Whitewater River near Elba	1967-2010 (missing 1993-1999 and 2002-2005 period)	
LTRMP	Whitewater River at Weaver Hwy 61	1993-2008	





Summary Chloride & Sulfate Trends

Station ID	Site Description	Period of Record	Chloride & Sulfate Trends
S000-288	South Fork Whitewater River near Utica	1974-1977, 2007-2008	↓ Cl ↑ SO_4
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2007-2009	↓ Cl → SO_4
5376000, S000-451 & S007-144	North Fork Whitewater River near Elba	1967-1993, 1999-2002, 2008	↓ Cl ↑ SO_4
LTRMP	Whitewater River at Weaver Hwy 61	1993-2002	↓ Cl Note: Not enough SO_4 data for analysis

Finding
- Sulfate Concentrations Appear to be Decreasing
- Chloride Concentrations Appear to be Increasing, but leveling off at the North Branch Whitewater Site Near Elba.

Trend
Degrading Chloride Conditions at all sites
Improving Sulfate Conditions at 2 of 3 sites

Recommendations
- Sulfate Could be Used to Determine the age of Water/aquifer contribution

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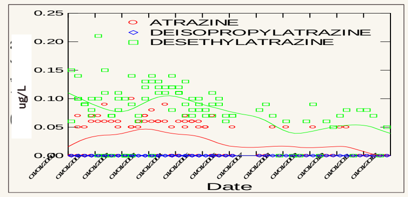
Pesticide Trends

Atrazine and its breakdown products concentrations at the South Fork Whitewater River near Altura (S000-321)



Finding
- Atrazine and breakdown products appear to be declining

Trend
- MDA notes that there appears to be a downward trend but further analysis is needed.

Recommendations
- Continue monitoring at the two MDA sites.
- Complete statistical analysis where possible.

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Recommended Future Monitoring

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Data Sources on the Web

Surface Water Monitoring Data – MN Pollution Control Agency

Cooperative Stream Gaging Data – MN Pollution Control Agency & MN Department of Natural Resources

United States Geological Survey Water Quality Data

Pesticide Monitoring Program – MN Department of Agriculture

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MISSISSIPPI-RIVER WINONA WATERSHED

WATER QUALITY DATA COMPILATION & TREND ANALYSIS

February 19, 2013

Caitlin Meyer, Olmsted County Environmental Resources

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

CLEAN WATER LAND & LEGACY AMENDMENT

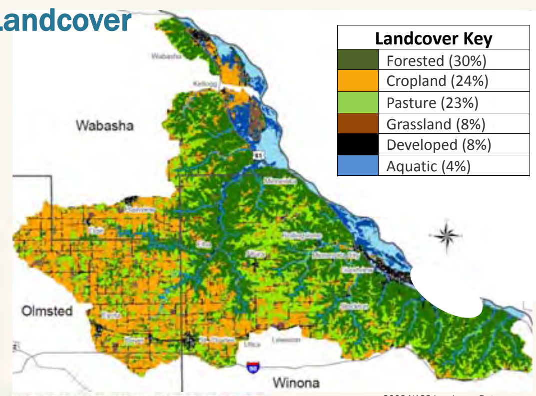
Mississippi-River Winona Watershed

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

419,000 acres

2

Landcover



Landcover Key
Forested (30%)
Cropland (24%)
Pasture (23%)
Grassland (8%)
Developed (8%)
Aquatic (4%)

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2009 NASS Landcover Data

3

Background

- Data Sources – 6 agencies
- Spatial Distribution – 136 sites
- Period of Record – 1932 to 2012

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Data Collection

MN Pollution Control Agency	• Surface Water Data (all parameters)
MN Department of Natural Resources	• Biological • Stressor Identification
MN Department of Agriculture	• Pesticides • Nutrients
United States Geological Survey	• Discharge • Water Quality Parameters
Soil and Water Conservation Districts and Counties	• Crop and agricultural data • Water Quality Parameters
Universities	• Reports
United States Fish & Wildlife Service, Army Corps of Engineers	• Reports

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Monitoring Locations

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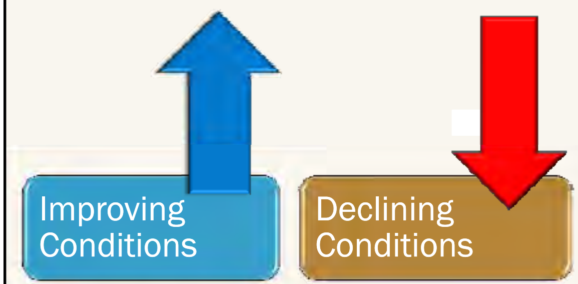
Overview of Trends Found

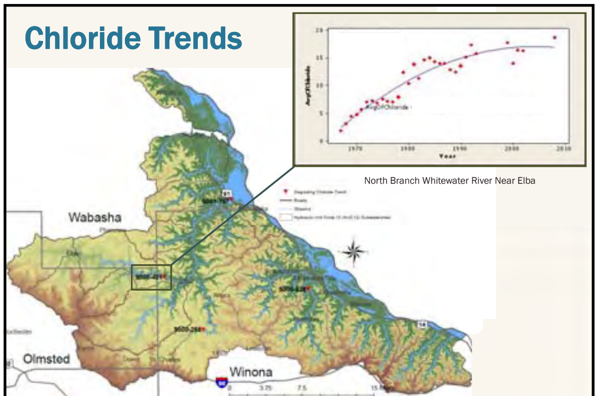
Trends Over Time
Chloride, Sulfate, Nitrate, Parameters Related to Suspended Sediment

Geographic Trends
Landcover

Summary Trends

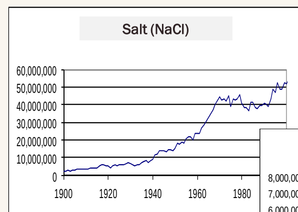


Chloride Trends

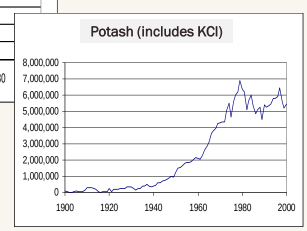


North Branch Whitewater River Near Elba

Chloride Use Trends

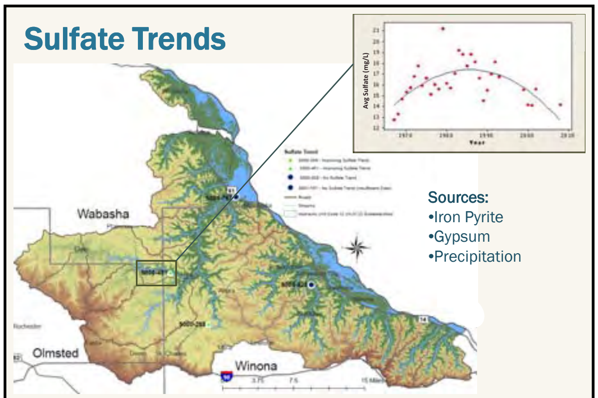


Sources:
- •Water Conditioning Salt
- •Road Salt
- •Potassium Chloride Fertilizer

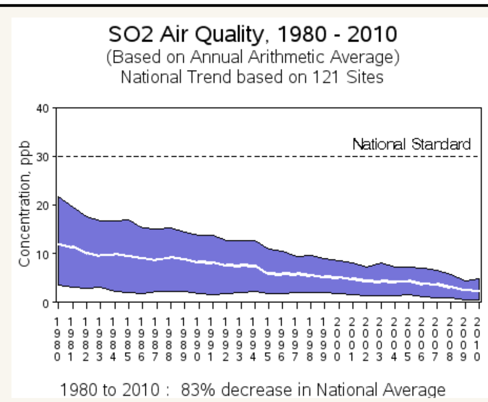


U.S. Geological Survey

Sulfate Trends



Sources:
- •Iron Pyrite
- •Gypsum
- •Precipitation



U.S. EPA

Summary Chloride & Sulfate Trends

Station ID	Site Description	Period of Record	Chloride & Sulfate Trends
S000-288	South Fork Whitewater River near Utica	1974-1977, 2007-2008	↓ Cl ↑ SO_4
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2007-2009	↓ Cl → SO_4
5376000, S000-451 & S007-144	North Fork Whitewater River near Elba	1967-1993, 1999-2002, 2008	↓ Cl ↑ SO_4
LTRMP	Whitewater River at Weaver Hwy 61	1993-2002	↓ Cl Note: Not enough SO_4 data for analysis

Finding
- Sulfate concentrations are decreasing
- Chloride concentrations are increasing, but appear to be leveling off at the North Branch Whitewater Site Near Elba

Trend
Degrading chloride conditions at all sites
Improving sulfate conditions at 2 of 3 sites

Recommendations
- Continue to monitor chloride and sulfate at these sites to determine whether these trends will continue

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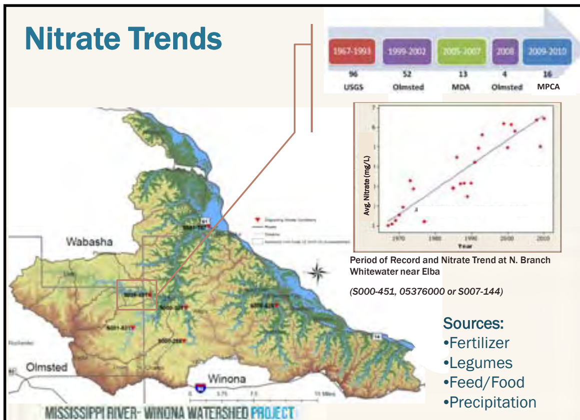
Nitrate Trends



Period of Record and Nitrate Trend at N. Branch Whitewater near Elba

(S000-451, 05376000 or S007-144)

Sources:
- Fertilizer
- Legumes
- Feed/Food
- Precipitation

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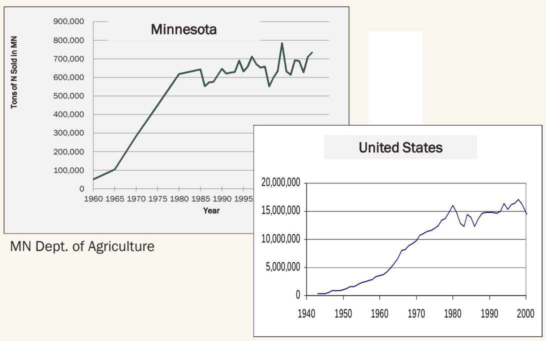
MN & U.S. Nitrogen Fertilizer Use



MN Dept. of Agriculture

U.S. Geological Survey

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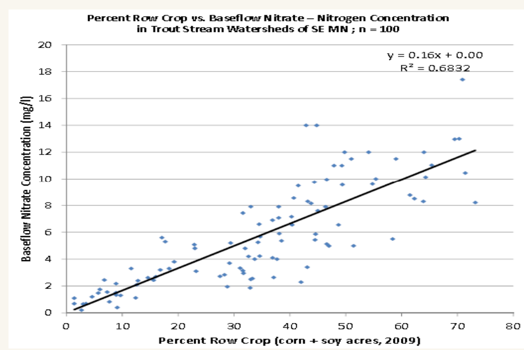
Nitrate & Landcover



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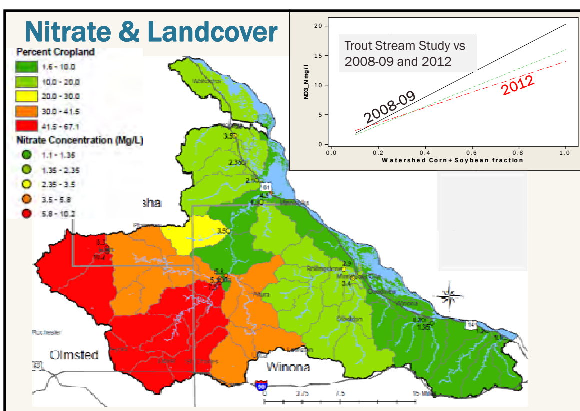
MPCA Report: Beyerl, Johnson, Watkins, Rasmussen

Nitrate & Landcover



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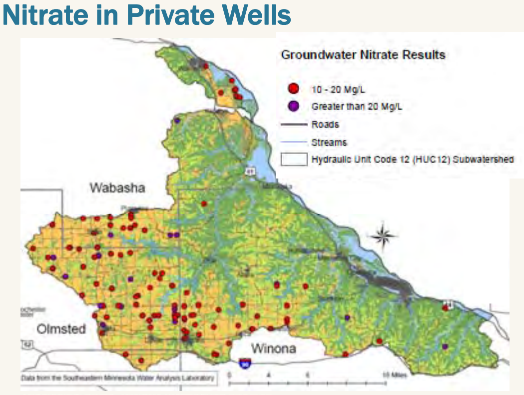
Nitrate in Private Wells



MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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Summary Nitrate Trends

Station ID	Site Description	Period of Record	Nitrate Trends
S000-288	South Fork Whitewater River near Utica	1974-2008	↓
S000-828 & 05378235	Garvin Brook S.W. of Minnesota City	1983-2009	↓
S000-321	South Fork Whitewater River near Altura	1992-2011 (missing 1997-2004 period)	↓
S001-831	Whitewater Middle Fork North of St. Charles	1993-2011	↓
5376000, S000-451, & S007-144	North Fork Whitewater River near Elba	1967-2010 (missing 1993-1999 and 2002-2005 period)	↓
LTRMP	Whitewater River at Weaver Hwy 61	1993-2008	↓

Finding
- Slight Seasonal Pattern
- High correlation between stream nitrate and % cropland in the drainage area

Trend
- Degrading conditions at every site with enough data. Nitrate concentrations are increasing.

Recommendation
- Continue to monitor nitrate concentrations at these sites to determine if the trend will begin to level off.

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Discharge Trends

USGS ID	Station Name	Period of Record	Discharge Trend (CFS)
5377500	Whitewater River At Beaver*	1939-1953	↓ Discharge
5376800	Whitewater River Near Beaver* Note: Missing Period Of Record From 1985-1993	1975-1999	↓ Discharge
5376500	South Fork Whitewater River Near Altura	1940-1970	→ No Trend
5376000	North Fork Whitewater River Near Elba	1967-1993	→ No Trend
5378235	Garvin Brook Near Minnesota City	1982-1991	→ No Trend

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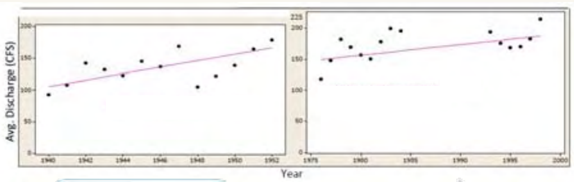
Summary Discharge Trends

Increasing Flow Trend for the Whitewater River Near Beaver



Finding
- No continuous, long-term record of data

Trend
- Where trends exist, flow trend is increasing

Recommendation
- Palmer Drought Severity Index (PDSI) could be used to reconstruct stream flows

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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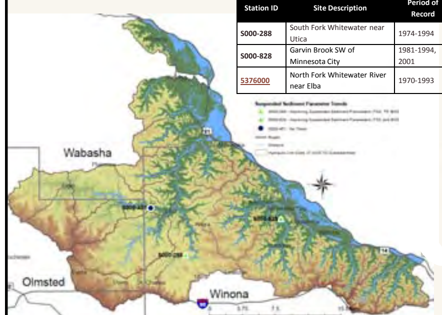
Suspended Sediment & Related Parameter Trends

Total Suspended Solids (TSS), Total Phosphorous (TP), Total Kjeldahl Nitrogen (TKN), transparency, turbidity and Biochemical Oxygen Demand (BOD)

Station ID	Site Description	Period of Record	Suspended Sediment Trends
S000-288	South Fork Whitewater near Utica	1974-1994	↑ TSS & BOD
S000-828	Garvin Brook SW of Minnesota City	1981-1994, 2001	↑ TSS, TP & BOD
5376000	North Fork Whitewater River near Elba	1970-1993	→ No Trend in SSC or load



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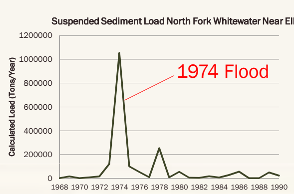
Summary Suspended Sediment Parameters



Finding
- Only 21 of 97 CSMP stations have enough data for analysis
- Large annual variability; bulk of sediment moves during high flow events

Trend
- Improving BOD and TSS at Milestone Sites
- Improving TP at Garvin Brook
- No trend in SSC or Transparency

Recommendation
- Large number of measurements are needed to obtain a good estimate of yearly suspended sediment loads

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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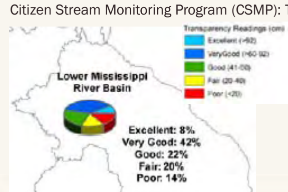
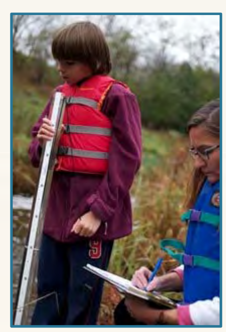
Suspended Sediment & Related Parameter Trends

Citizen Stream Monitoring Program (CSMP): Transparency



97 Stations in the Watershed
- 21 stations with enough data

None Showed a Trend



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Provided by: 2010 MPCA Report on Water Quality of MN Streams

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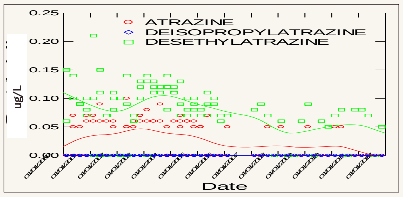
Pesticide Trends

Atrazine and its breakdown products concentrations at the South Fork Whitewater River near Altura (S000-321)



Finding
- Atrazine and breakdown products appear to be declining

Trend
- MDA notes that there appears to be a downward trend but further analysis is needed.

Recommendations
- Continue monitoring at the two MDA sites.
- Complete statistical analysis where possible.

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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Recommended Future Monitoring

Recommended Monitoring Sites		Recommended Parameters				
		River Discharge	Suspended Sediment Parameters (1)	Complete Analyses (2)	Bacteria	Pesticides
Whitewater River near Beaver	5376800	x	x	x		
South Fork Whitewater near Altura	5376500 & S000-321	x	x	x		x
North Fork Whitewater near Elba	5376000 & S000451	x	x	x		
Garvin Brook near Minnesota City	5378235 & S000-828	x	x	x	x	
Middle Branch Whitewater North of St. Charles	S001-831	x	x	x		x
South Fork Whitewater River near Utica	S000-288		x	x	x	
Whitewater River at Weaver Hwy 61	LTRMP			x		

MISSISSIPPI RIVER- WINONA WATERSHED PROJECT

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Data Sources on the Web

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United States Geological Survey Water Quality Data

Pesticide Monitoring Program – MN Department of Agriculture

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