



Water Quality Monitoring at Mississippi National River and Recreation Area

2012 Summary Report

Natural Resource Data Series NPS/GLKN/NRDS—2013/577



ON THE COVER

U.S. Army Corps of Engineers dredging operation at Spring Lake, Mississippi River, November 2012.
Photograph by: D. VanderMeulen



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Abstract

In 2012, the Great Lakes Inventory and Monitoring Network (GLKN or Network) monitored water quality at five sites on the Mississippi River during ice-free months (April–November), with additional monitoring at six sites on the St. Croix and Namekagon rivers in April, July, and October. Water quality monitoring at the two national parks associated with these large rivers – Mississippi National River and Recreation Area (MISS) and St. Croix National Scenic Riverway (SACN) – is a subset of a larger water quality monitoring effort by Network staff at national parks in the western Great Lakes region. The primary monitoring objective at MISS and SACN is to track water quality in order to describe the current status and trends of common limnological parameters on large rivers and select tributaries. GLKN staff hopes to be able to provide early warnings of change, which may then provide justification for increased monitoring, research, or management action.

Field measurements included depth profiles of temperature, pH, conductivity, and dissolved oxygen; and water clarity. Water samples were collected for laboratory analyses of nutrients (total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica), major ions (calcium, sodium, magnesium, potassium, sulfate, chloride), dissolved organic carbon, alkalinity, and total chlorophyll-*a* (Chl-*a*). When applicable, flow measurements at or near Network monitoring sites were obtained from active flow gages operated by the United States Geological Survey or the United States Army Corps of Engineers.

In this report, monitoring results from 2012 at MISS are compared with federal, regional, and site-specific water quality standards, when applicable. Some of these standards are proposed and under review, while others have been approved by the states of Minnesota and/or Wisconsin. Descriptive statistics for data collected from MISS in 2012 are shown in Appendix A. The water quality monitoring at SACN in 2012 was conducted at a subset of sites and was limited to only three sampling events. That work and the more intensive monitoring underway at SACN in 2013 will be described in a future report.

Monitoring results from MISS in 2012 show that water clarity, nutrients, and Chl-*a* are strongly linked to precipitation patterns and resultant river flow. That is, during periods of heavy precipitation and high flows, nutrient levels are substantially higher and Chl-*a* levels and water clarity are much lower. In general, water quality decreases from upstream to downstream, with a marked decrease in water quality below the confluence with the Minnesota River.

State of Minnesota water quality standards for temperature, pH, dissolved oxygen, nitrate-nitrite nitrogen, ammonia, and chloride were not exceeded. However, regional and site-specific water clarity (total suspended solids), nutrient, and Chl-*a* standards, including both draft and finalized criteria, were sometimes exceeded at all monitored sites. Comparisons between GLKN and Metropolitan Council Environmental Services (MCES) water quality data revealed that average values for water clarity, nutrient, and Chl-*a* data collected during similar periods were somewhat higher at MCES sites. Because of the higher sampling frequency for MCES (weekly) in comparison with GLKN (monthly), MCES monitoring results likely depict actual river conditions more accurately.

Acknowledgments

Substantial support for the water quality work in 2012 was provided by staff of Mississippi National River and Recreational Area and St. Croix National Scenic Riverway. Material support included use of lab and office equipment and space, and field sampling equipment. I would like to extend special thanks to primary field staff from the parks—Lark Weller and Michelle Prosser—as well as other park staff who assisted with fieldwork and logistics. I would also like thank Dean Tucker from NPS-WRD in Ft. Collins, CO, for his patience and guidance with water quality database issues, and Joan Elias, GLKN program manager for aquatic-based monitoring, for her guidance and leadership. Lastly, I would like to thank Rick Damstra, Brenda Moraska Lafrancois, and Lark Weller for their suggestions that improved this document.

Introduction

The Great Lakes Inventory and Monitoring Network (Network or GLKN hereafter) measured water quality variables and collected water samples for laboratory analysis at the Mississippi National River and Recreation Area (MISS) in 2012. Limited water quality monitoring at a subset of previously-established sites was also conducted at St. Croix National Scenic Riverway (SACN) in 2012.

The Network's large rivers water quality monitoring protocol (Magdalene et al. 2008a) was first implemented at MISS in 2006, with subsequent monitoring at the park in 2008 and 2010. Reports summarizing those efforts are described in Elias and Sieracki (2007), VanderMeulen (2009), and VanderMeulen (2011), respectively.

The large rivers water quality monitoring protocol encompasses the following:

- core suite (temperature, dissolved oxygen, conductivity, pH, water clarity)
- water level/flow
- advanced suite (alkalinity, dissolved organic carbon, silica, chloride, sulfate, calcium, sodium, potassium, magnesium, total chlorophyll-a, total phosphorus, total nitrogen, ammonium-nitrogen, nitrate+nitrite-nitrogen, total suspended solids)
- primary productivity (as estimated by total chlorophyll-a measurements)
- nutrient dynamics (as measured by the phosphorus and nitrogen species)

Diatom monitoring, though not included within the water quality monitoring protocol, is closely tied to it, and is done according to methods set forth in Ramstack et al. 2008.

The overall goal of the large rivers water quality monitoring program is to contribute to an understanding of the health of ecosystems and provide insights on water resources issues in the parks. The Network's objectives for monitoring water quality of rivers, listed in order of priority, are:

- Monitor flow to determine changes in mean monthly and mean annual flow.
- Monitor mean annual concentrations of core and advanced suite parameters, accounting for seasonality in water quality conditions.
- Relate current water quality conditions to known historical conditions.
- Analyze water quality parameters for trends, and correlate any observed trends with potential causes (such as weather, climate, land use, point sources, exotic species, and atmospheric deposition).

This report summarizes the Network's activities related to water quality monitoring at MISS in 2012. Water quality monitoring is scheduled to alternate annually between MISS and SACN, but additional funding provided by SACN allowed for quarterly monitoring in 2012 at six sites on the St. Croix and Namekagon rivers in what normally would have been an off-year. This quarterly monitoring facilitates continuity of our sampling effort and will enhance our ability to analyze inter-annual variability and detect trends in future years. That work and the more intensive monitoring undertaken

at SACN in 2013 will be described in a future report. Results from previous years from both MISS and SACN (Elias and Sieracki 2007; VanderMeulen and Elias 2008; VanderMeulen 2009, 2011, 2012) can be found on the GLKN website (<http://science.nature.nps.gov/im/units/glkn/index.cfm>).

Methods

Sampling Locations

The Network selected five sites for long-term monitoring (Figure 1). These sites are all located on the mainstem of the Mississippi River. The sites were selected in consultation with staff from other monitoring agencies, such as the Minnesota Pollution Control Agency (MPCA) and the Metropolitan Council Environmental Services (MCES), primarily to fill spatial gaps in monitoring coverage (Magdalene et al. 2008a). The sites, identified by river mile (e.g., UM880, UM868), are described in detail in Magdalene et al. (2008a) and Elias and Sieracki (2007).

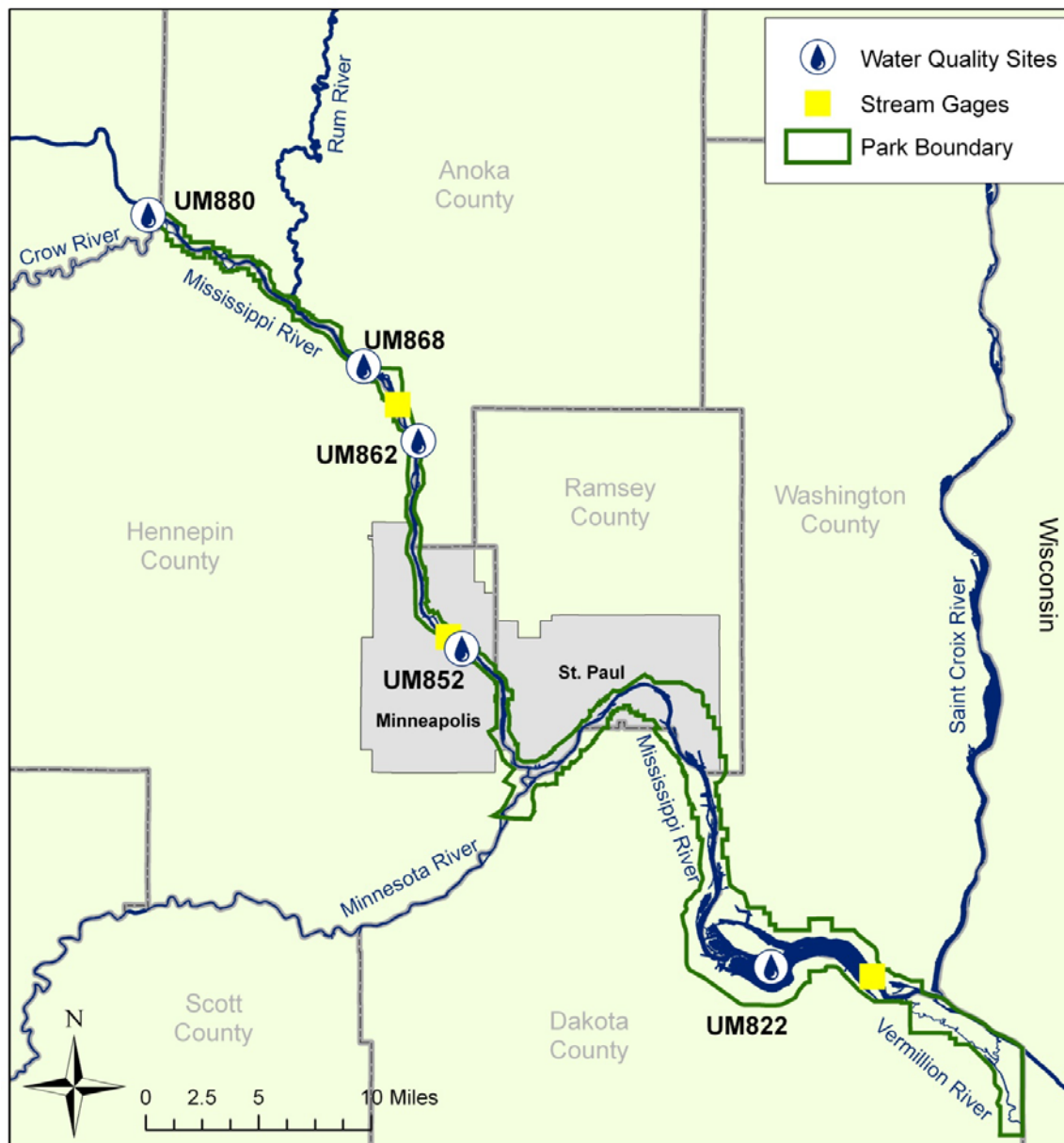


Figure 1. Location of water quality monitoring sites and streamflow gaging stations in the Mississippi National River and Recreation Area.

Field Methods

Network staff conducted monthly water quality sampling at each site throughout the open water season in 2012 (Table 1). Samples were not collected in March (per Magdalene et al. 2008a) due to unsafe, iced-up conditions on the rivers. Whenever feasible, monitoring was conducted at the deepest part of the channel and the centroid of flow, typically in the center of the channel. In a few instances high water, unsafe currents, boat traffic, or weather prohibited sampling in the center of the channel, and sampling occurred closer to the riverbank.

Table 1. Dates of water quality sampling at Mississippi National River and Recreation Area in 2012.

Sampling Dates
4/11 – 4/12
5/8 – 5/9
6/7 – 6/8
7/5 – 7/6
8/9 – 8/10
9/10 – 9/11
10/11 – 10/12
11/8 – 11/9

During every visit profile data on temperature, dissolved oxygen concentration, specific conductance, and pH were collected near the surface and at 0.5 or 1 m intervals with a Hydrolab multiprobe (sonde). In addition, Network staff measured water clarity using a transparency tube and/or Secchi disc, recorded environmental conditions (e.g., wave height, sky cover, air temperature, wind speed and direction), and collected a GPS coordinate at each site. Field personnel and multiprobe instrumentation information were also noted for each site.

The multiprobe was calibrated daily for specific conductance and pH, and prior to sampling at each site for dissolved oxygen and depth. The temperature probe was checked with a NIST-calibrated thermometer prior to the season and was found to read within acceptable limits (Ledder and Elias 2008). A brass chain with precise length markers was used to check previously marked depth increments on the nylon rope attached to the Secchi disc.

Water samples for laboratory analysis were collected at a depth of 0-2 m using an integrated tube sampler (MPCA 2004, WDNR 2004). When the water was 1-2 m deep, the tube sampler was deployed on an angle to collect a sample from the full water column. When the water was <1 m deep, an elbow-deep grab sample was collected. Water was composited in a 9 L high density polyethylene carboy that had been cleaned in the lab prior to sampling and rinsed three times with native river water on-site. See Magdalene et al. (2008b) for details on collection and handling of water samples.

Water samples were collected for analysis of nutrients, Chl-*a*, and total suspended solids (TSS) during all site visits (Table 2). The remaining parameters were measured quarterly (April, July, and October) during the sampling season. Near-bottom total phosphorus (TP) samples were not collected as water was well-mixed throughout the water column at all sites.

Table 2. Water quality parameters measured and abbreviations used in text. **Bold** font indicates parameters measured quarterly in April, July, and October; remaining parameters were measured monthly.

Parameter	Abbreviation	Parameter	Abbreviation
Alkalinity	Alk	Total Nitrogen	TN
Calcium	Ca⁺²	Ammonium-Nitrogen	NH ₄ -N
Chloride	Cl⁻	Nitrate+Nitrite-Nitrogen	NO ₃ +NO ₂ -N
Total Chlorophyll- <i>a</i>	Chl- <i>a</i>	Total Suspended Solids	TSS
Dissolved Organic Carbon	DOC	Specific Conductance	SC25
Magnesium	Mg⁺²	Dissolved Oxygen	DO
Potassium	K⁺	pH	pH
Silica	SiO₂	Temperature	Temp
Sodium	Na⁺	Secchi Disc Depth	Secchi
Sulfate	SO₄⁻²	Transparency Tube	T-tube
Total Phosphorus	TP		

Analytical Laboratories

GLKN contracted with White Water Associates (WWA) and the St. Croix Watershed Research Station (SCWRS) for analytical laboratory services. The SCWRS is the field research station of the Science Museum of Minnesota and is also responsible for analyzing samples collected for the Network's protocol to monitor diatoms (Ramstack et al. 2008). WWA analyzed samples for major ions, dissolved organic carbon (DOC), dissolved silica (SiO₂), and TSS; SCWRS analyzed samples for nutrients and Chl-*a*. All samples were processed and handled according to standard operating procedures (Magdalene et al. 2008b) and as detailed in the 2007 annual water quality report (VanderMeulen and Elias 2008).

Data Handling

Methods for using laboratory data below detection limit in statistical analyses are numerous and diverse (e.g., Helsel 1990, Helsel and Cohen 1988). Although statistical analyses were not conducted on water quality data collected in 2012, summary statistics such as mean and standard deviation were calculated. The following rules for censored data results were applied:

- For values < detection limit, value assigned = 0.5 X detection limit
- For values > detection limit but < lower reporting limit, values assigned = 0.5 X lower reporting limit
- For values > upper reporting limit (only applicable to transparency tube readings), values assigned = 1.1 X upper reporting limit

Data below detection or lower quantification limits were included in summary statistics for MISS (Table 3). Forty percent (16 out of 40) of the values reported for NH₄-N at MISS were below the laboratory reporting and/or detection limit (11 and 4 ug/L, respectively). Twenty percent (8 out of 40) of the values reported for T-tube were above the upper reporting limit (>120 cm).

Steps to ensure quality assurance and quality control (QA/QC) were undertaken routinely, according to standard operating procedures for monitoring water quality (Ledder and Elias 2008). The measurement sensitivity of the Hydrolab sonde was calculated prior to the field season; the sonde was calibrated daily following acceptance criteria and a calibration log was maintained with the instrument; measurements taken in the field with the sonde were saved electronically and backed-up on paper data sheets; duplicate field measurements were taken at the rate of approximately 10%; duplicate water samples were collected at the rate of approximately 10%; and equipment blanks were obtained prior to and during the field season to ensure Network staff were not introducing any contamination to the samples. Network quality assurance criteria stipulate that analytical results for water sample duplicates should be within 10% of each other for all parameters except nutrients, Chl-*a*, and total suspended solids, which should be within 30% of each other (Ledder and Elias 2008). In addition, the contract laboratories conducted their own QA/QC work, including blanks, duplicates, and spikes, and generated QA/QC reports that accompanied water sample results.

Data Analysis

Data relative to flow and precipitation, both current and historic, were obtained from the U.S. Geological Survey (USGS; http://waterdata.usgs.gov/usa/nwis/uv?site_no=05288500) and a weather station located at the Minneapolis-St. Paul International Airport (http://www.climateanalyzer.org/glkn/minneapolis_airport), respectively. MCES water quality data were obtained from MCES's Environmental Information Management System (<http://es.metc.state.mn.us/eims>). Summary statistics for Network water quality data were calculated using the National Park Service water quality database NPSTORET. Microsoft Excel software was used to calculate summary statistics for MCES water quality data, and to generate graphical figures. Water quality data from Network sites were compared with data from long-term MCES sites co-located in specific river stretches or Navigation Pools within MISS boundaries. Data were also compared with federal and/or state water quality standards, where applicable. Appendix A contains descriptive statistics for all data collected at MISS in 2012. All data from 2012 and past years are posted in the U.S. Environmental Protection Agency's STORET database and can be accessed at http://www.epa.gov/storet/dw_home.html.

Results

Impairments

Sections of the Mississippi River within the MISS boundaries are on the 303(d) List of Impaired Waters for Minnesota due to exceedances for water clarity, fecal coliform bacteria, mercury, polychlorinated biphenyl (PCB), and perflourooctane sulfonate (PFOS) (MPCA 2008, Magdalene et al. 2008a, NPS 1995). Additional impairments for excess sediment and nutrients are described below. Mercury, PCBs, and PFOS are currently being monitored in bald eagle blood and feathers by GLKN staff under a separate protocol, and in river water by other regulatory agencies. Fecal coliform bacteria are monitored by several other agencies within park boundaries. However, nutrient and water clarity monitoring is being conducted by GLKN staff as a component of the Large Rivers Water Quality Monitoring Protocol (Magdalene et al. 2008a), and by other organizations that conduct water quality monitoring at MISS.

Flow and Precipitation

Four streamflow gages currently operate on the mainstem of the Mississippi River within MISS park boundaries: near Anoka, Minnesota (UM864); at St. Anthony Falls, Minnesota (UM853); in St. Paul, Minnesota (UM840), and at Lock & Dam #2 (UM815) in Hastings, Minnesota (see Figure 1). The sites near Anoka (site # 05288500) and in St. Paul (site # 05331000) are operated by the U.S. Geological Survey, while the other two sites are controlled by the U.S. Army Corps of Engineers (USACE). Flows at water quality monitoring sites UM868 and UM862 are best represented by the streamflow gage near Anoka, MN, while flows at sites UM852 and UM822 are approximated by the streamflow gages at UM853 and UM815, respectively. Flow at water quality monitoring site UM880 is best represented by subtracting flow values from the Crow and Rum rivers (site #'s 05280000 and 05286000, respectively), from those of the streamflow gage near Anoka, MN.

A comparison of long-term (1932-2009) and 2012 mean monthly flow conditions at the Anoka site during months when water quality was monitored by Network staff show that flow was below average in April 2012, increased dramatically in May and June, decreased but remained well above average in July, approximated the long-term average in August, and dropped below average for the rest of the monitoring season (Figure 2). Although not shown, this pattern for these years was also present at the three downstream streamflow gaging sites within park boundaries. The pattern of higher flows in late winter and spring from snowmelt and spring/early summer storms, with diminishing flows until late in the year is consistent with that found by Lafrancois et al. (2013) where 30 years (1976-2005) of discharge data for the Mississippi River at Anoka, MN, were assessed for seasonal trends.

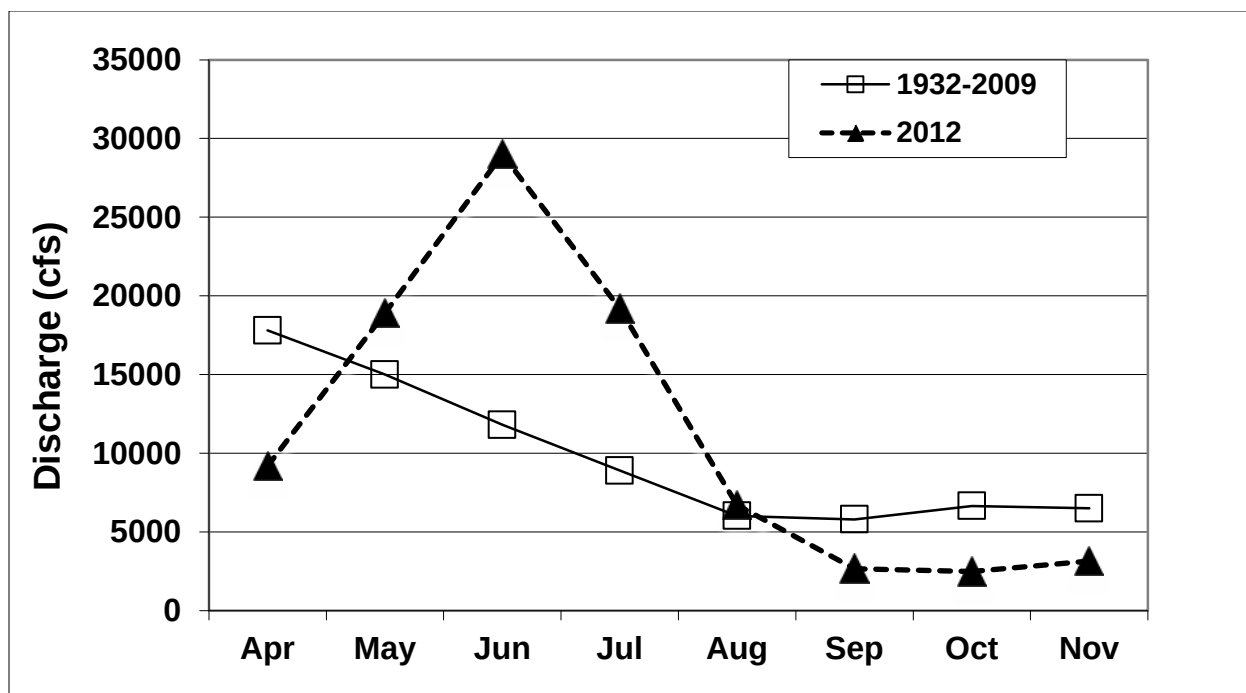


Figure 2. Historic (1932-2009) and recent (2012) mean monthly Mississippi River discharge at Anoka, MN, during the 2012 water quality monitoring season and during the period of flow record. cfs = cubic feet per second.

The seasonal changes in river flow can best be explained by comparing monthly precipitation amounts for 2012 with a 30-year (1981-2010) record of mean monthly values (Figure 3). In 2012, precipitation in April, June, and July was near normal, while in May it was about six inches above normal. Precipitation was well below normal from August through November, resulting in drought conditions for the second half of the monitoring season.

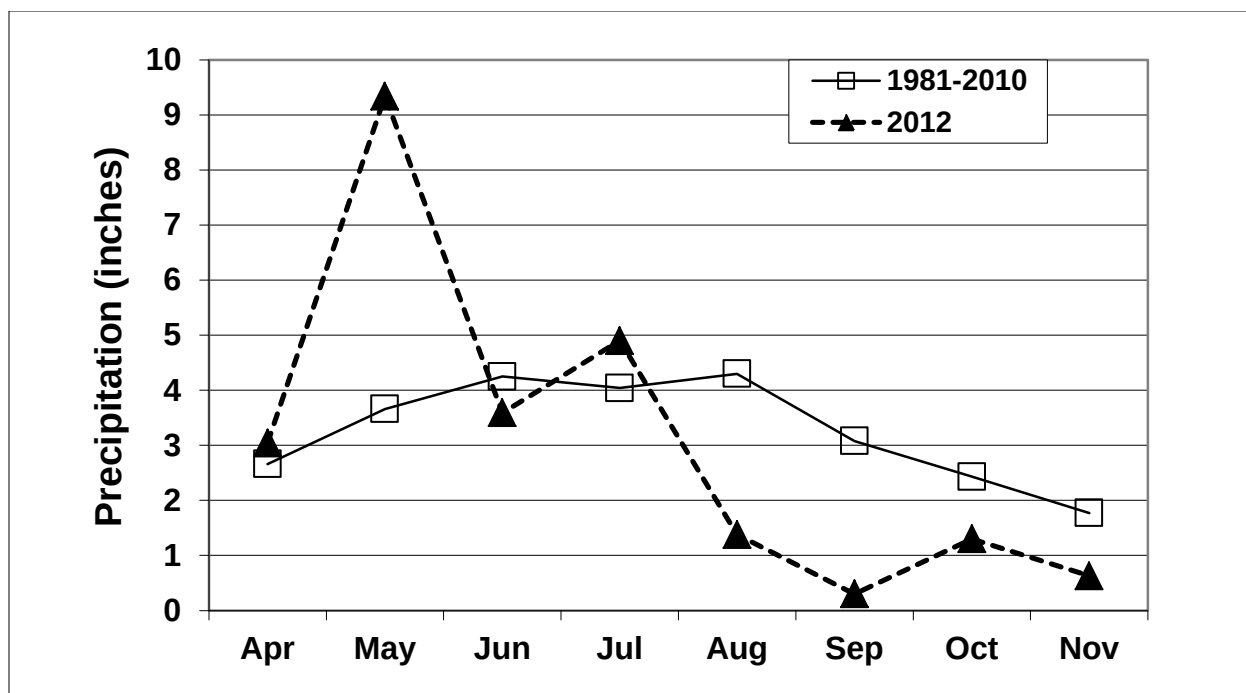


Figure 3. Monthly precipitation for 2012 (April–November) and mean (normal) monthly precipitation for a 30-year (1981-2010) period as measured at the Minneapolis-St. Paul International Airport.

Water Quality

General

Water quality at site UM822 differs substantially from that at the four upstream sites (Table 3). Concentrations of nutrients, ions, and total suspended solids were typically much higher at UM822, while T-tube measurements were consistently lower. UM822 is the only Network monitoring site located below the confluence with the Minnesota River, a tributary with high nutrient concentrations (Minnesota River Basin Data Center 2001) and 303(d)-listed for high turbidity and low dissolved oxygen (MPCA 2008). The Minnesota River contributes an additional 50% to the flow of the Mississippi River at the two rivers' confluence (Moody and Battaglin 1995).

Table 3. Mean values of measured parameters at Mississippi National River and Recreational Area, April to November 2012 (standard deviation in parentheses). See Table 2 for sampling frequency for each variable.

Variable	UM880	UM868	UM862	UM852	UM822
Chl-a (ug/L)	4.0 (2.0)	8.1 (4.8)	9.2 (6.8)	11.3 (7.5)	17.9 (9.6)
TP (µg/L)	**	78.9 (36.1)	86.8 (46.0)	85.1 (39.8)	124 (56.2)
TN (µg/L)	1026 (414.1)	1299 (276.5)	1338 (329.4)	1510 (566.6)	2943 (1627)

Table 3. Mean values of measured parameters at Mississippi National River and Recreational Area, April to November, 2012 (standard deviation in parentheses). See Table 2 for sampling frequency for each variable (continued).

Variable	UM880	UM868	UM862	UM852	UM822
NO ₃ +NO ₂ -N (µg/L)	451.8 (178.3)	506.7 (178.5)	500.4 (190.7)	660.7 (405.1)	1889 (1463)
NH ₄ -N (µg/L)	10.6 (8.0) ^{*,4}	12.2 (12.4) ^{*,3}	11.2 (13.2) ^{*,5}	17.6 (20.1) ^{*,4}	79.9 (82.0)
TSS (mg/L)	10.4 (9.1)	15 (12.2)	13.4 (11.4)	15 (11.6)	48 (79.3)
DOC (mg/L)	11.8 (7.1)	11.8 (7.1)	11.5 (6.5)	11.5 (6.5)	10.3 (4.8)
Alkalinity (mg/L)	145.7 (43.3)	153.3 (37.9)	153.3 (37.9)	156.7 (40.4)	170 (26.5)
Cl ⁻ (mg/L)	7.7 (8.6)	9.4 (10.3)	9.6 (10.6)	11.0 (12.4)	26.1 (32.5)
SO ₄ ⁻² (mg/L)	11.7 (6.5)	13.8 (5.5)	14.0 (5.1)	15.3 (6.5)	51 (7)
Ca ⁺² (mg/L)	40 (12.3)	42.7 (11.2)	42.3 (9.9)	44 (11.4)	52.7 (9.7)
Mg ⁺² (mg/L)	14.3 (5.0)	15.7 (4.9)	15.7 (4.0)	15.7 (4.0)	21.7 (4.5)
K ⁺ (mg/L)	2.2 (0.7)	2.5 (0.8)	2.5 (0.7)	2.5 (0.6)	3.7 (1.1)
Na ⁺ (mg/L)	8.3 (4.4)	9.7 (5.1)	9.7 (5.1)	10.6 (5.3)	25.5 (16.3)
SiO ₂ (mg/L)	7.8 (1.2)	7.9 (1.8)	7.8 (1.9)	7.6 (2.1)	8.9 (3.1)
T-Tube (cm)	88.4 (40.2) ^{*,3}	69.9 (40.3) ^{*,2}	68.0 (40.7) ^{*,2}	67.1 (35.3) ^{*,1}	36.6 (17.4)
pH (std. units)	8.0 (0.2)	8.1 (0.3)	8.1 (0.3)	8.2 (0.2)	8.1 (0.3)
SC25 (µS/cm)	308.5 (73.1)	349.2 (61.5)	331.7 (65.6)	360.3 (64.3)	527.2 (87.8)
DO (mg/L)	8.8 (1.5)	9.5 (2.1)	10.2 (2.1)	10.6 (1.5)	9.4 (2.3)
Temperature (°C)	18.1 (6.6)	17.0 (6.9)	18.7 (7.2)	16.7 (6.9)	18.1 (7.0)

(^{*,n}) = censored data used to calculate mean; n=number of censored values.

** = not available; one or more values failed QA/QC checks.

Water Clarity

Water clarity was assessed by determining the concentration of TSS (Figure 4) and through the use of a T-tube. As expected, there was a highly negative correlation between T-tube measurements (see Table 3) and TSS. That is, with higher TSS concentrations, water clarity and T-tube values decrease. For simplicity's sake, only TSS will be used to describe seasonal and longitudinal patterns in water clarity.

TSS concentrations were fairly low in April due to a below average snowpack and early peak spring runoff, which had already taken place well before the water quality monitoring occurred. Peak TSS values occurred in May for all sites except UM880, which peaked in June. In general, TSS steadily

declined at all sites for the rest of the sampling season. Analysis of thirty years of TSS values at Mississippi River sites within the park shows a highly positive correlation between river flows and the level of suspended sediments in the water (Lafrancois et al. 2013).

TSS levels at site UM822, the only site in Pool 2 and below the confluence with the Minnesota River, were much higher than those at the other monitoring sites in early spring and summer, and somewhat higher than those at the other sites in most instances for the rest of the year. The majority of sediment contributing to high TSS in Pool 2 of the Mississippi River originates in the Minnesota River basin, which on average contributes 75% of the TSS load to the South Metro Mississippi River (MPCA 2012). Land use in the Minnesota River basin is dominated by agriculture. This has led to increased sediment load in the Minnesota River and its tributaries through increased erosion of soil resulting from altered hydrology (e.g., drain tiling) and surface runoff (MPCA 2012). Long-term records of annual mean TSS values for Mississippi River sites above and below the confluence of the Minnesota River indicate that TSS is much higher below the confluence than above, with the Minnesota River being the single most important factor in explaining TSS patterns within the park (Lafrancois et al. 2013).

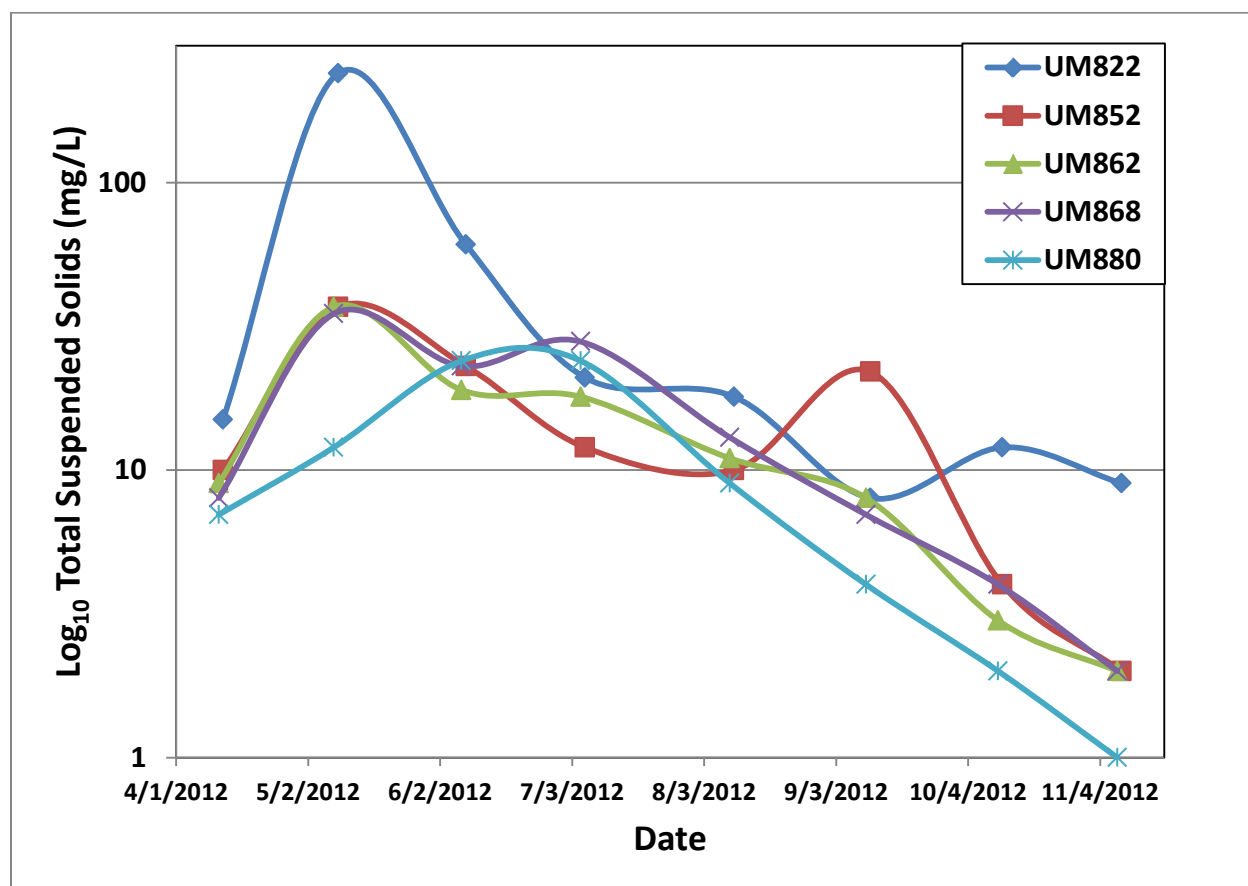


Figure 4. Total suspended solids at Mississippi National River and Recreation Area water quality monitoring sites in 2012.

Nutrients: Total Phosphorus (TP) and Nitrate-Nitrite-Nitrogen (NO₃+NO₂-N)

Seasonal and longitudinal patterns in TP concentrations are shown in Figure 5. As with TSS, TP increased dramatically from April to May as a result of large precipitation events, and generally decreased throughout the rest of the monitoring season. Long-term records indicate that TP is typically highest in March and April, lowest in May, higher in late spring/early summer due to storm events, and gradually decreases throughout the rest of the year (Lafrancois et al. 2013). For any given month of sampling, TP levels increased going downstream, with a large increase at site UM822, which is downstream of the confluence with the Minnesota River. On average TP concentrations in the Mississippi River below the Minnesota River confluence are approximately double those above the confluence (Lafrancois et al. 2013).

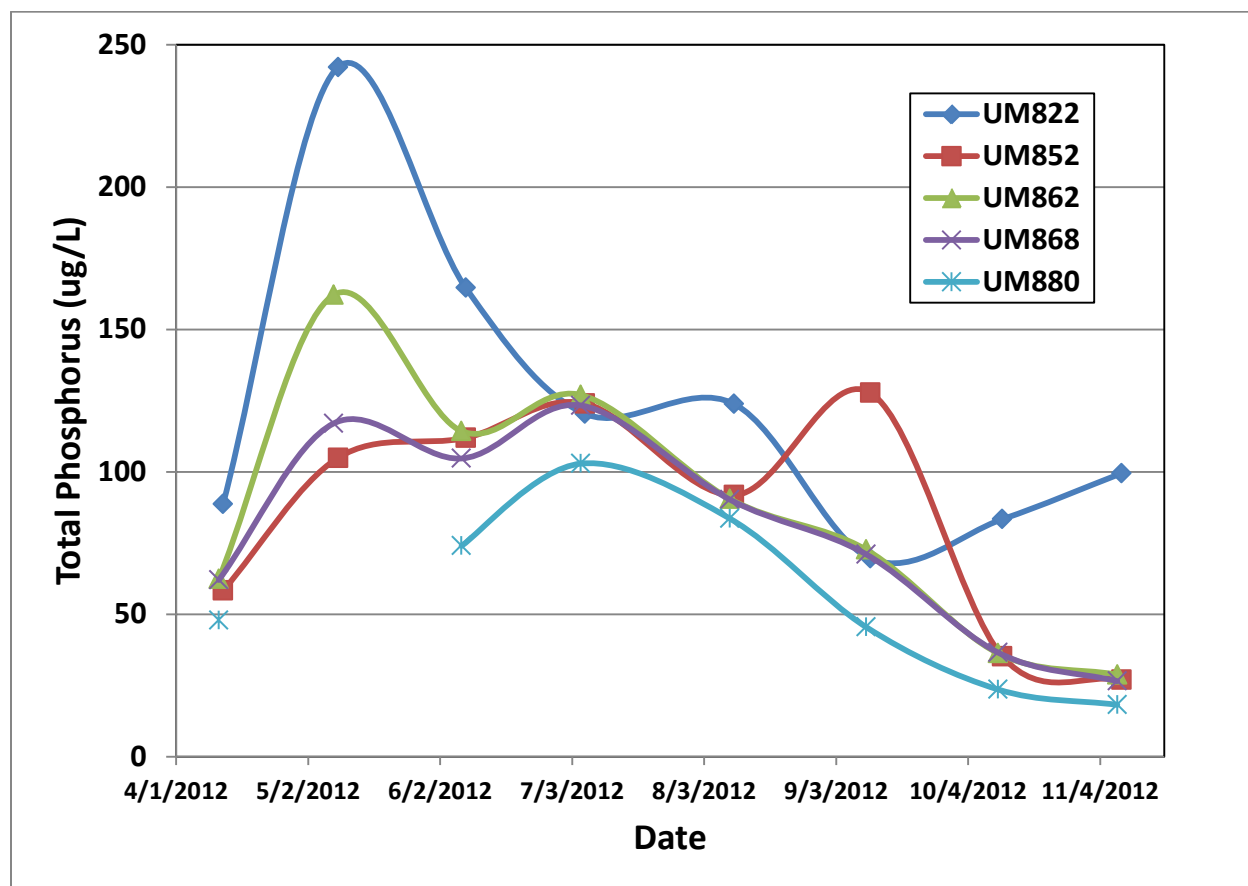


Figure 5. Total phosphorus at Mississippi National River and Recreation Area water quality monitoring sites in 2012. Total phosphorus value for UM880 not available for May.

In general, NO₃+NO₂-N concentrations peaked in May, decreased for a few months, and slowly increased from late summer to late fall (Figure 6). An exception to this was seen at site UM880, where NO₃+NO₂-N concentrations decreased from April to July without a peak in May. Analysis of long-term records shows that a large peak NO₃+NO₂-N concentration typically occurs in June, which is attributed to seasonal applications of nitrogen-based fertilizers on agricultural lands (Lafrancois et al. 2013). Clearly, the excessive amount of precipitation in May influenced NO₃+NO₂-N concentrations across most of the sites in comparison to long-term norms.

As expected, NO₃+NO₂-N concentrations were much higher at the single site (UM822) below the confluence with the Minnesota River as compared to sites above. The highly agricultural Minnesota River basin is the main contributor of NO₃+NO₂-N to the Mississippi River within park boundaries (Lafrancois et al. 2013).

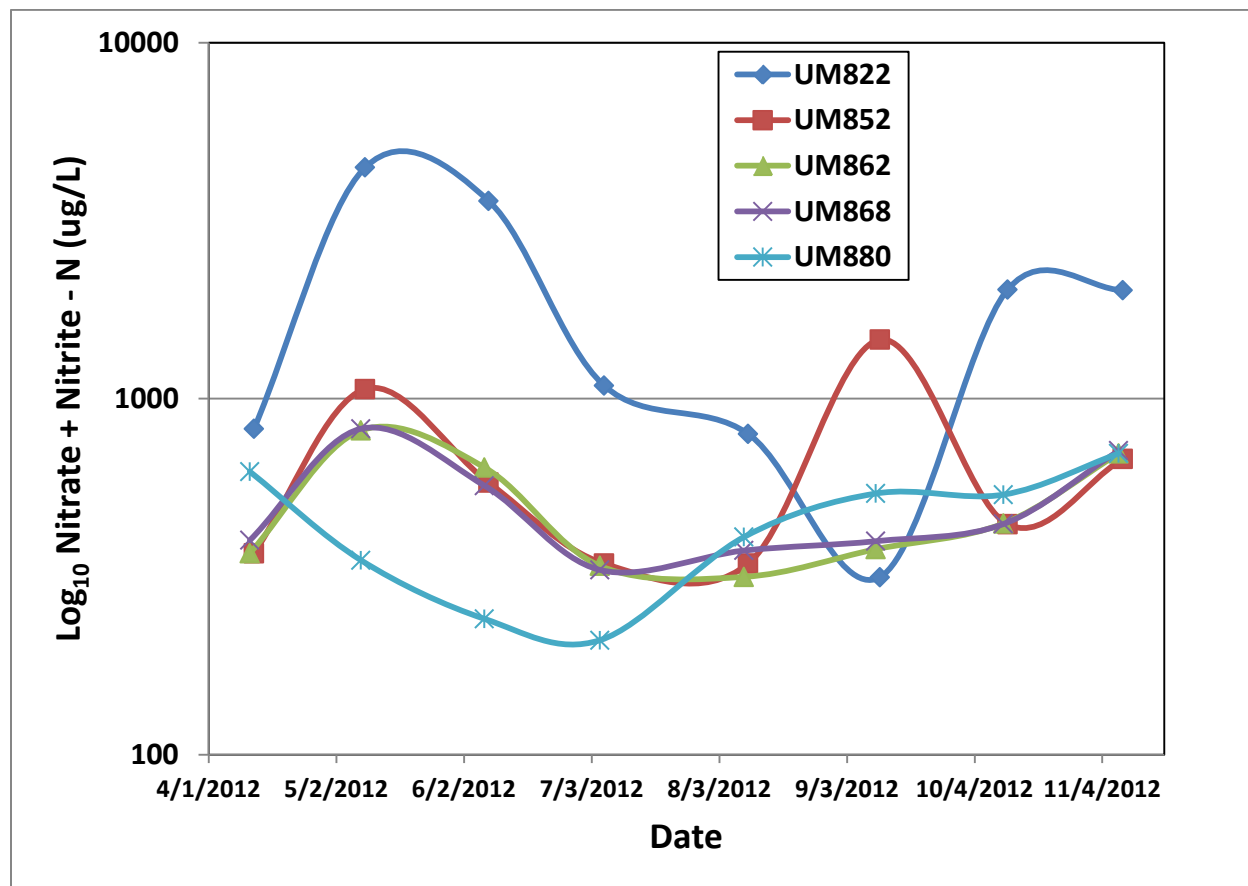


Figure 6. Nitrate-Nitrite-N at Mississippi National River and Recreation Area water quality monitoring sites in 2012.

Algal Biomass: Chlorophyll-a (Chl-a)

The concentration of Chl-*a*, the primary photosynthetic pigment in all green plants including phytoplankton, is a reasonable measure of algal biomass in water (e.g., Wetzel 2001, Wetzel and Likens 2000). Chl-*a* concentrations are expected to be dynamic, reflecting changes in algal abundance through the ice-free growing season.

For all sites except UM880, Chl-*a* concentrations were higher in April, declined dramatically in May, stayed at low levels but slowly increased throughout the summer, peaked again in September, and declined in October and November (Figure 7). At UM880 Chl-*a* levels were low throughout the monitoring season. Long-term records indicate that Chl-*a* usually peaks in May and again in September, with lower levels in June and July (Lafrancois et al. 2013). In 2012, algal growth in May was likely limited by high river flows and low light conditions with poor water clarity. Lower flows and improving water clarity led to increased growth throughout the summer and into the fall.

For any given month Chl-*a* concentrations were progressively higher from upstream to downstream, especially at UM822 below the confluence with the Minnesota River. Chl-*a* levels in the Minnesota River are among the highest recorded for rivers worldwide (Heiskary and Wasley 2010), and the Minnesota River is the single most important factor for shaping longitudinal Chl-*a* patterns within the park (Lafrancois et al. 2013).

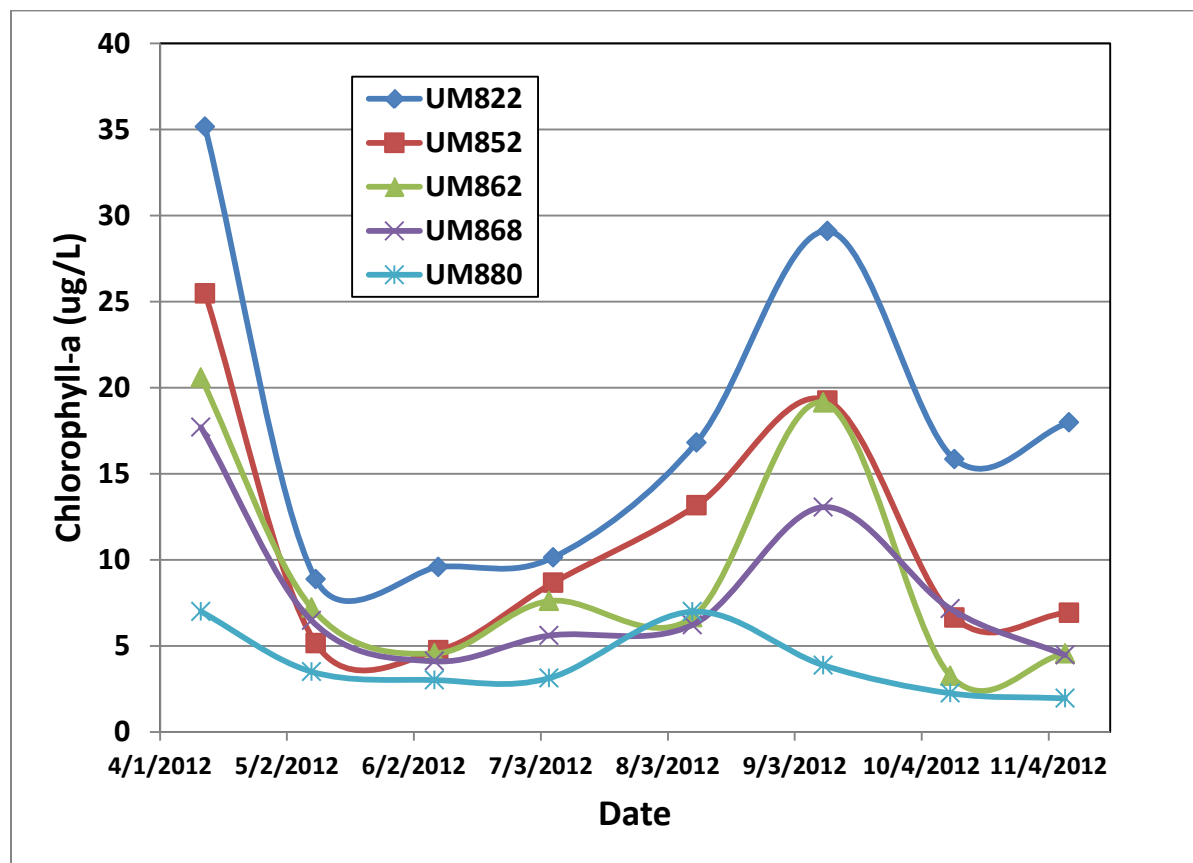


Figure 7. Chlorophyll-*a* levels at Mississippi National River and Recreation Area water quality monitoring sites in 2012.

Designated Uses, Water Quality Standards, and Data Comparisons

The State of Minnesota designates beneficial uses for all surface waters in the state (MPCA 2013a) as follows:

- Class 1 - protected for drinking
- Class 2 - protected for aquatic life and recreation
- Class 3 - protected for industrial uses
- Class 4 - protected for agricultural uses
- Class 5 - protected for aesthetics and navigation
- Class 6 - other uses
- Class 7 - limited resource value waters

Use classes 1, 2, 3, and 4 have subclasses. Of these, the Class 2 subclasses are most pertinent to natural resource considerations:

- 2A: Cold-water fisheries, trout waters, also protected as a source of drinking water
- 2Bd: Cool-and warm-water fisheries, also protected as a source of drinking water
- 2B: Cool-and warm-water fisheries (not protected for drinking water)
- 2C: Indigenous fish and associated aquatic community (not protected for drinking water)
- 2D: Wetlands (not protected for drinking water).

The sections of the Mississippi River where our sampling sites are located have multiple designations, as do all surface waters. Sites UM880, UM868, and UM862 are designated Class 1C, 2Bd, and 3B waters, protected for drinking water uses due to the municipal water intakes for the cities of Minneapolis and St. Paul, which are located at UM862. Sites UM852 and UM822 are designated Class 2B, 3B, 4A, 4B, 5, and 6 waters. The State of Minnesota has also established water quality standards for some water quality parameters to ensure that the designated uses for state waters are met (MPCA 2013b). Site-specific designated uses and water quality standards designed to protect those uses are shown in Table 4.

Table 4. Minnesota state water quality standards (MnRule 7050.0220) for monitored variables, based on designated use classifications (MnRule 7050.0200) that apply to Mississippi National River and Recreation Area water quality monitoring sites. All limits are maximum values, except dissolved oxygen (DO), which is a minimum allowable value, and pH, which is an allowable range of values.

Water Quality Parameter	Designated Water Use Classifications	
	1C, 2Bd, 3B (sites 880, 868, 862)	2B, 3B, 4A, 4B, 5, 6 (sites 852, 822)
Temperature (°F)	within 5 °F of natural	within 5 °F of natural
pH (SU)	6.5-9.0	6.5-8.5
Dissolved oxygen (mg/L)	5 daily min	5 daily min ¹
Nitrate+nitrite nitrogen (mg/L-N) - Federal drinking water standard	10	not applicable
Nitrate+nitrite nitrogen (mg/L-N) – <i>draft</i> acute/chronic toxicity standard for MN ²	41/4.9	41/4.9
Ammonia, unionized (ug/L-N)	40	40
Chloride (mg/L) ³	860/230	860/230

¹The standard is not less than 5 mg/l as a daily average from 4/1 through 11/30, and not less than 4 mg/l at other times.

²Draft criteria (Monson and Preimesberger 2010). Draft acute value (41 mg/L, maximum standard) is for a 1-day average; draft chronic value (4.9 mg/L) is for a 4-day average.

³Acute value (860 mg/L) maximum standard is for a 1-hour average; chronic value (230 mg/L) is for a 4-day average.

State of Minnesota water quality standards were not exceeded at MISS in 2012, except for pH values ranging from 8.61 to 8.65 at UM822 during the April monitoring. These exceeded the upper limit of 8.50. In April 2012, pH values across all sites ranged from 8.17 to 8.65. These higher than expected

pH values likely resulted from lower early spring flows resulting in very high algal production and Chl-*a* concentrations (see Figure 7) that reduced the amount of carbon dioxide in the water through photosynthesis, which had an overall effect of increased pH.

The Minnesota Pollution Control Agency (MPCA) developed draft eutrophication criteria for rivers, with distinct eutrophication criteria applied across different regions of the state (Table 5; Heiskary et al. 2013, Markus 2011). All sites within MISS fall within the Central River Nutrient Region. In order to assess for impairment and subsequent 303(d) listing, at least six water quality samples are collected in the summer (June through September) for a minimum of two summers. These data are combined with all available data for the most recent 10-year assessment period. Means are calculated and compared to the criteria. For a river reach to be listed as impaired, it must exceed the causative variable (TP) and one or more of the response variables (sestonic chlorophyll, 5-day biochemical oxygen demand [BOD5], DO flux, and/or pH) (Heiskary et al. 2013).

Table 5. Draft river nutrient criteria by River Nutrient Region for Minnesota. Values in bold are applicable to water quality monitoring sites within the Mississippi National River and Recreation Area, unless superseded by site specific criteria.

Region	Nutrient	Response Variables		
	TP (ug/L)	Chl-a (ug/L)	DO flux (mg/L)	BOD5 (mg/L)
North	≤50	≤7	≤3.0	≤1.5
Central	≤100	≤18	≤3.5	≤2.0
South	≤150	≤35	≤4.5	≤3.0

The State of Minnesota is also in the process of replacing its stream turbidity standards with another measure of water clarity—total suspended solids—which, unlike turbidity, is a concentration-based standard more appropriate to development of Total Maximum Daily Load (TMDL) plans (Heiskary and Parson 2010). As with the draft eutrophication criteria, river regions were used to assign TSS criteria of 15, 30, and 65 mg/L for the North, Central, and South regions, respectively. All sites within MISS are in the Central Region.

In 2010, site-specific eutrophication standards were proposed for Mississippi River Pools 1 through 8 (Heiskary and Wasley 2010). Site-specific TSS standards were also proposed for the Mississippi River from Lock and Dam 1 to Lock and Dam 4 (MPCA 2012). Regional and site-specific eutrophication and TSS standards, as they apply to Network water quality monitoring sites at MISS, are shown in Table 6.

MCES has been conducting water quality monitoring in and near MISS for several decades. The locations of Network water quality monitoring sites at MISS are primarily designed to cover spatial and temporal monitoring gaps within the more comprehensive MCES monitoring effort (MCES 2013a, Magdalene et al. 2008a, Lafrancois et al. 2013). In an effort to provide perspective and context to Network monitoring efforts, results as they apply to regional and site-specific eutrophication and water clarity standards are shown in Figures 8, 9, and 10. For comparison

purposes, MCES water quality data results collected during a similar period in 2012 (MCES 2013b) are also shown.

Table 6. Minnesota water clarity and eutrophication standards for rivers applicable at Mississippi National River and Recreation Area water quality monitoring sites¹.

Site	TSS (mg/L)	TP (ug/L) ²	Chl-a (ug/L) ²
UM 880	30 ³	100 ⁵	20 ⁵
UM 868	30 ³	100 ⁵	20 ⁵
UM 862	30 ³	100 ⁵	20 ⁵
UM 852	30 ³	100 ⁶	35 ⁶
UM 822	32 ⁴	125 ⁶	35 ⁶

¹Draft standards for diurnal DO flux and BOD are provided in Heiskary et al. (2013) but are not shown since these parameters are not monitored by GLKN staff.

²TP and Chl-a standards based on samples collected during the summer (June – September), with assessment for impairment based on exceedances of mean summer values for half or more of all summers in a 10-year period over a range of flow conditions.

³Draft TSS standards use an April - September assessment window for sites UM880, 868, 862, and 852 are based on concentrations not being exceeded more than 10% of the time over a 10-year period (Heiskary and Parson 2010, Markus 2011).

⁴Based on recently approved TSS TMDL for the Mississippi River from the confluence of the Minnesota River (UM844) to upper Lake Pepin (UM780) (MPCA 2012); summer mean (June – September) of less than 32 mg/L TSS in at least five summers over a 10- year period.

⁵Based on draft nutrient criteria for rivers in Minnesota (Heiskary et al. 2013, Heiskary and Parson 2010).

⁶Based on draft eutrophication criteria for pools 1-8 (Heiskary and Wasley 2010).

Mean TP levels for GLKN sites were below the draft standard (100 ug/L) above Pool 1 (i.e., above St. Anthony Falls) and slightly above the draft standard for Pool 1 (Figure 8). Mean TP levels for MCES sites in these two spatial categories were above and approximately the same as the draft standards, respectively. Mean TP concentrations for the GLKN site in Pool 2 was below the draft standard (125 ug/L) while the mean TP for MCES sites in Pool 2 was above the standard.

Despite the low number of samples (n=4) for NPS sites in Pools 1 and 2, mean TP levels were comparable to mean TP at MCES sites in those Pools. Mean TP for NPS sites above Pool 1 was somewhat lower than mean TP for the MCES site. Land use in the vicinity of MISS is heavily urbanized and suburbanized with major tributaries flowing from areas with intense agricultural use. As such, nonpoint source runoff from these land uses is currently contributing to the water quality impairments identified. The Rum and Crow rivers drain largely agricultural areas, and since NPS site UM880 is located above the confluence of these tributaries, the fact that its mean TP is lower than MCES site 871.6—which is downstream of these tributaries—is to be expected.

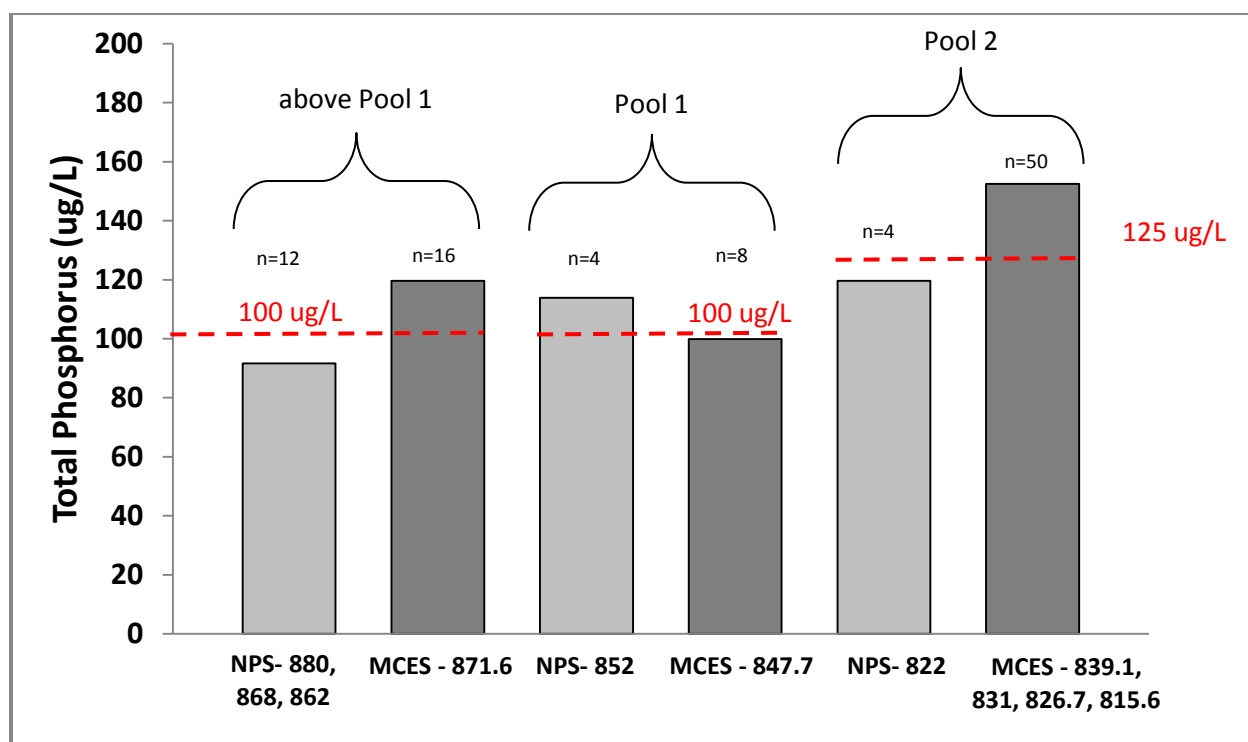


Figure 8. Mean total phosphorus, June through September 2012, for National Park Service (NPS) and Metropolitan Council Environmental Services (MCES) water quality monitoring sites above Pool 1 (NPS-880,868,862; MCES-871.6), Pool 1 (NPS-852; MCES-847.7), and Pool 2 (NPS-822, MCES-939.1,831,826.7,815.6). Dashed red line indicates site-specific or draft regional TP standard. n = number of samples.

Mean Chl-*a* concentrations for GLKN monitoring sites were below the draft Chl-*a* standards above Pool 1 (20 ug/L) and for Pools 1(35 ug/L) and 2 (35 ug/L) (Figure 9). Mean Chl-*a* for the MCES site above Pool 1 slightly exceeded (21.8 ug/L) the draft Chl-*a* standard, while mean Chl-*a* levels for MCES sites in Pools 1 and 2 were below the draft standards.

Mean Chl-*a* concentrations were lower at NPS sites than MCES sites for all three river regions. The discrepancy in mean Chl-*a* between NPS and MCES sites may be due to the low number of samples at NPS sites, timing of sampling between agencies, differences in field or lab methodology, or actual differences based on local differences among the sites.

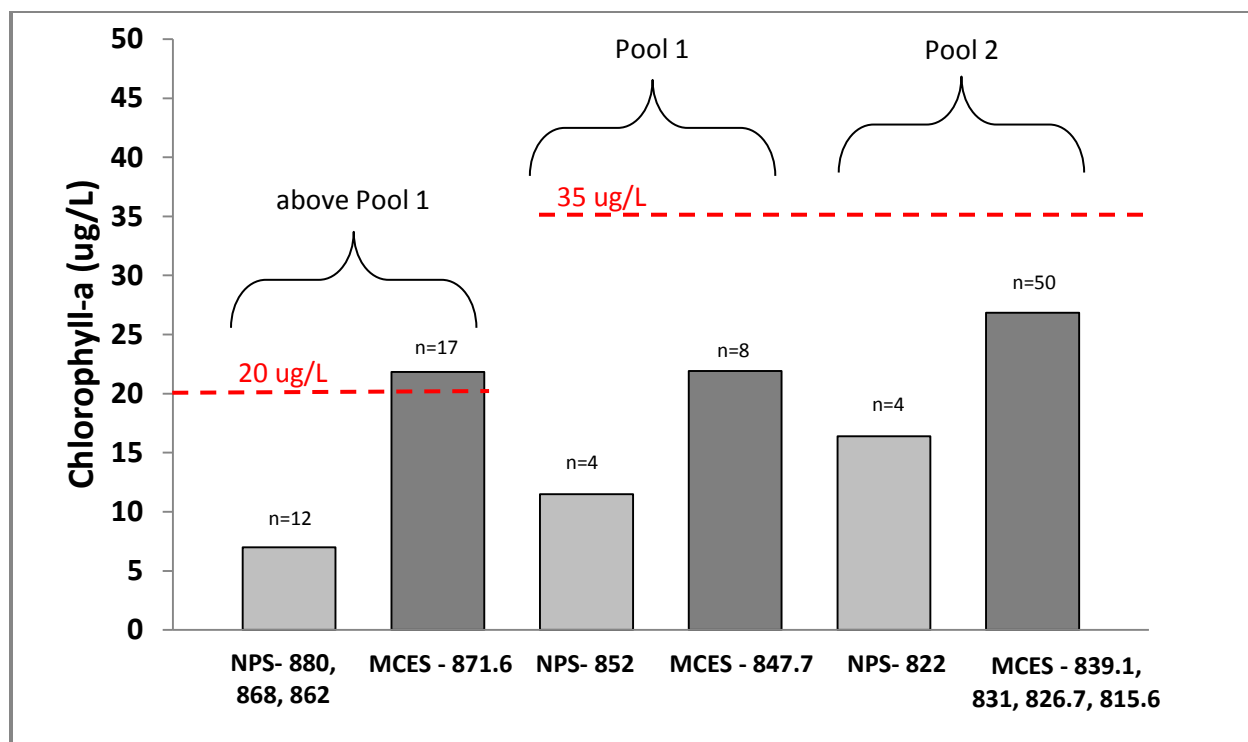


Figure 9. Mean chlorophyll-a, June through September 2012, for National Park Service (NPS) and Metropolitan Council Environmental Services (MCES) water quality monitoring sites above Pool 1 (NPS-880,868,862; MCES-871.6), Pool 1 (NPS-852; MCES-847.7), and Pool 2 (NPS-822, MCES-939.1,831,826.7,815.6). Dashed red line indicates site-specific or draft regional Chl-a standard. n = number of samples

Mean TSS (April-September) at NPS and MCES sites above the confluence with the Minnesota River was well below the proposed regional standard of 30 mg/L, with comparable values between agencies (Figure 10). Mean TSS for sites below the confluence of the Minnesota River were higher than those above, especially for TSS measured at MCES sites, which, unlike the NPS site (27.0 mg/L), was significantly higher (45.2 mg/L) than the TMDL standard of 32 mg/L. Approximately ten times more samples were collected at the MCES sites compared to the NPS site, so the mean TSS across the four MCES sites below the confluence with the Minnesota River is probably a more accurate depiction of the actual TSS in that region of the river when compared to mean TSS at the single NPS site.

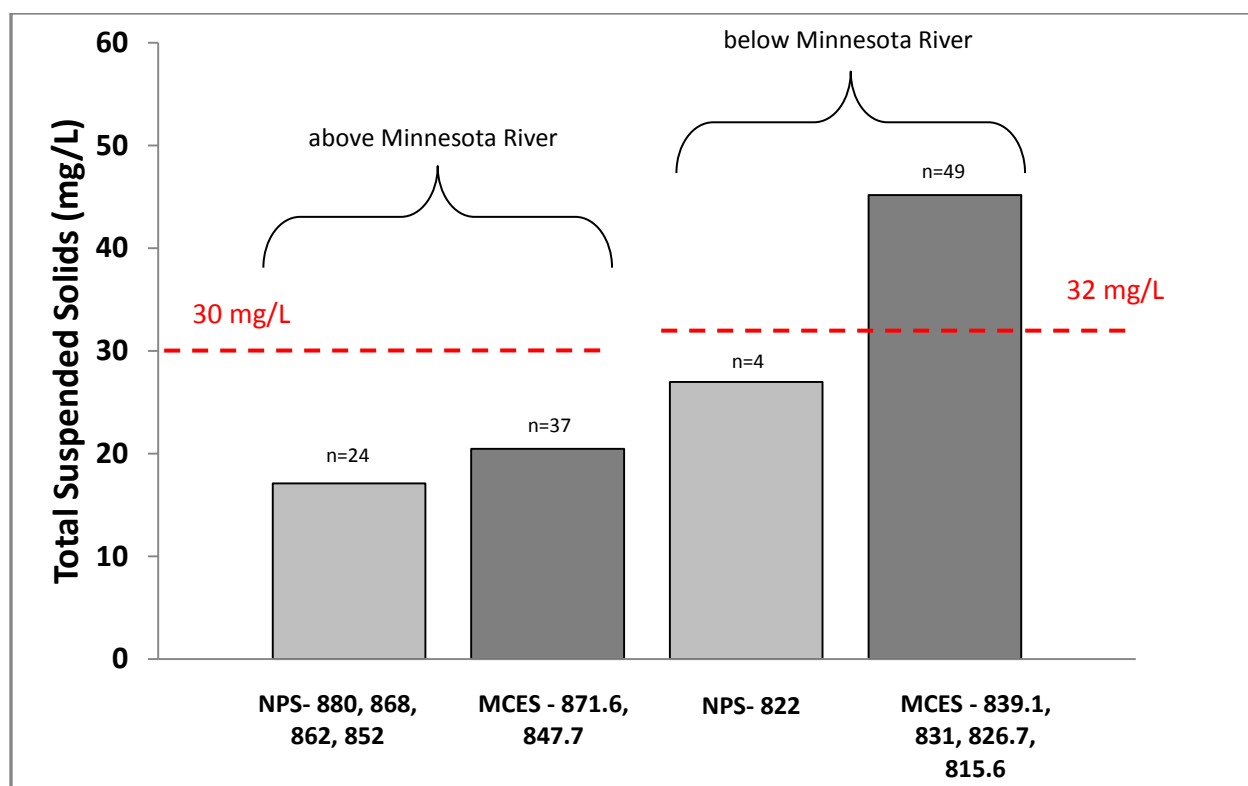


Figure 10. Mean total suspended solids for National Park Service (NPS) and Metropolitan Council Environmental Services (MCES) water quality monitoring sites above (NPS-880,868,862,852; MCES-871.6,847.7; April-September) and below (NPS-822; MCES-839.1,831,826.7,815.6; June-September) the confluence with the Minnesota River (river mile 844). Dashed red line indicates site-specific (32 mg/L) or draft regional (30 mg/L) TSS standard. n = number of samples.

Quality Assurance and Quality Control

Network quality assurance criteria state that analytical results for water sample duplicates should be within 10% of each other for all parameters except nutrients and Chl-*a*, which should be within 30% of each other (Ledder and Elias 2008). Almost all of our duplicates fell within the acceptable criteria. Those that did not meet quality assurance criteria were usually very close to laboratory detection or reporting limits. In such cases, actual small differences can result in large relative mean differences (e.g., the actual difference between 1 and 2 mg/L is small, but the relative mean difference is 67%). Values that did not meet our quality assurance criteria were flagged as such in the National Park Service database NPSTORET and are shown in Table 7. Duplicate values are not included with this report, but are available through the Environmental Protection Agency's STORET database, including those that do not meet our quality assurance criteria.

Table 7. Samples from Mississippi National River and Recreation Area in 2012 not meeting Network quality assurance criteria. RPD = relative percent difference

Site	Sample Date	Parameter	RPD	Comment
UM880	5/8/12	TP	-	sample handling error
UM880	5/8/12	TN	-	sample handling error
UM862	7/5/10	TSS	43.5%	18 mg/L, 28 mg/L

Monitoring Considerations

A number of organizations conduct water quality monitoring within the boundaries of the park, each with its own monitoring goals and objectives. MCES has been responsible for monitoring many water quality parameters at several sites within park boundaries since the mid-1970s. Their sampling occurs year-round on a weekly to semimonthly basis. To fill minor gaps in existing monitoring programs and establish a more substantial scientific presence in the corridor, the Network began conducting monitoring at five sites within the park in 2006. Our sampling occurs during ice-free months every other year, with 2012 being the fourth full season of water quality monitoring.

As described in detail in Lafrancois et al.'s (2013) report on water quality conditions and trends at MISS, differences in water quality among MCES sites above the confluence of the Minnesota River are almost negligible as compared to differences between sites above and below the confluence of the Minnesota River over a 30-year period of record (1976-2005). GLKN monitoring results show a similar pattern, in that water quality conditions within park boundaries are basically defined by whether monitoring on the Mississippi River takes place above or below the confluence with the Minnesota River (Elias and Sieracki 2007; VanderMeulen 2009, 2011).

This and other reports (e.g., VanderMeulen 2011, Lafrancois et al. 2013) show that with an adequate number of samples for each site, comparisons of Network and MCES data collected within the same year for sites located near each other reveal only minor differences that are likely attributable to differences in the timing of sample collection or very site-specific factors (e.g., urban runoff, reservoir catchment of nutrients and sediment, and within-lake nutrient dynamics). Therefore, water quality conditions at Network sites can be reasonably estimated through examination of water quality data from existing MCES sites.

With respect to long-term trends and current status of water quality pollutants that are negatively impacting the park (e.g., excess nutrients and sediment), biennial monthly data collected from Network sites do not add substantively to insights already available via the MCES dataset described in Lafrancois et al. (2013). Though the Network sites serve to fill in spatial gaps, the sampling frequency of the Network's monitoring program is much less intensive than that of the MCES monitoring program. Further, the current MCES water quality dataset fully addresses the measurable objectives and monitoring questions identified in the NPS Large Rivers Water Quality Monitoring Protocol (Magdalene et al. 2008). As long as MCES continues monitoring their existing sites at the current frequency and continues to provide timely access to their data, Network water quality monitoring efforts at the park are largely redundant. Network and Regional water quality staff should direct resources toward issue-specific monitoring (e.g., contaminants), coordination of monitoring efforts among agencies, or toward data synthesis, interpretation, and integration with biological monitoring activities in the corridor.

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Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

Station ID: MISS_UM822		Station Name: Mississippi River next to Spring Lake												
Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Alkalinity	mg/l CaCO ₃	4/12/2012 - 10/12/2012	3	0	3	140	190	170	---	26.46	---	---	---	---
Ammonium_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	16.77	222.1	79.86	---	81.56	---	---	---	---
Calcium	mg/l	4/12/2012 - 10/12/2012	3	0	3	42	61	52.67	---	9.713	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	8.877	35.15	17.94	---	9.555	---	---	---	---
Chloride_Filtered	mg/l	4/12/2012 - 10/12/2012	3	0	3	0.84	62.8	26.11	---	32.52	---	---	---	---
DO%_HL_MS5.0	%	4/12/2012 - 11/9/2012	34	0	34	79.6	139.5	99.23	96.7	14.53	80.05	92.85	100	130.2
DO_HL_MS5.0	mg/l	4/12/2012 - 11/9/2012	34	0	34	6.93	14.67	9.425	8.36	2.279	6.98	7.928	10.72	13.9
DOC	mg/l	4/12/2012 - 10/12/2012	3	0	3	7.6	16	10.43	---	4.821	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/12/2012 - 11/9/2012	34	0	34	386.9	647.8	527.2	557.3	87.8	387.6	449.7	625.3	646.6
Magnesium	mg/l	4/12/2012 - 10/12/2012	3	0	3	17	26	21.67	---	4.509	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	315.2	4459	1889	---	1463	---	---	---	---
pH_HL_MS5.0	None	4/12/2012 - 11/9/2012	34	0	34	7.74	8.64	8.134	8.13	0.2535	7.74	7.985	8.26	8.625
converted pH	None					7.74	8.64	8.066	8.131	0.0047	7.74	7.979	5.098	5.111
H+ computed from pH	µeq/l					0.0023	0.0182	0.0086	0.0074	0.0047	0.0024	0.0055	0.0105	0.0182
Potassium	mg/l	4/12/2012 - 10/12/2012	3	0	3	2.4	4.6	3.7	---	1.153	---	---	---	---
Silicate	mg/l	4/12/2012 - 10/12/2012	3	0	3	5.9	12	8.9	---	3.051	---	---	---	---
Sodium	mg/l	4/12/2012 - 10/12/2012	3	0	3	9.4	42	25.47	---	16.31	---	---	---	---
Sulfate_Filtered	mg/l	4/12/2012 - 10/12/2012	3	0	3	44	58	51	---	7	---	---	---	---
Temp_HL_MS5.0	°C	4/12/2012 - 11/9/2012	34	0	34	7.79	28.99	18.09	18.78	7.023	7.84	11.4	23.13	28.96
Total Nitrogen_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	1142	5850	2943	---	1627	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	69.56	242.1	124	---	56.16	---	---	---	---
Total Suspended Solids	mg/l	4/12/2012 - 11/9/2012	8	0	8	8	240	48	---	79.43	---	---	---	---
Transparency Tube	cm	4/12/2012 - 11/9/2012	8	0	8	6.45	63.1	36.62	---	17.4	---	---	---	---

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

Station ID: MISS_UM852		Station Name: Mississippi River near East River Flats Park in Minneapolis												
Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Alkalinity	mg/l CaCO3	4/12/2012 - 10/12/2012	3	0	3	110	180	156.7	---	40.41	---	---	---	---
Ammonium_SCRS	µg/l	4/12/2012 - 11/9/2012	8	4	8	1.5	59.38	17.57	---	20.14	---	---	---	---
Calcium	mg/l	4/12/2012 - 10/12/2012	3	0	3	31	52	44	---	11.36	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	4.75	25.48	11.25	---	7.521	---	---	---	---
Chloride_Filtered	mg/l	4/12/2012 - 10/12/2012	3	0	3	0.37	24.6	11.02	---	12.38	---	---	---	---
DO%_HL_MS5.0	%	4/12/2012 - 11/9/2012	39	0	39	101.8	117.1	109.1	109.1	4.893	102	103.5	113	116.9
DO_HL_MS5.0	mg/l	4/12/2012 - 11/9/2012	39	0	39	8.96	12.92	10.59	10.66	1.544	8.98	9.08	12.72	12.9
DOC	mg/l	4/12/2012 - 10/12/2012	3	0	3	7.6	19	11.5	---	6.497	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/12/2012 - 11/9/2012	39	0	39	252.6	436.1	360.3	392.4	64.29	253.6	315.3	429	436
Magnesium	mg/l	4/12/2012 - 10/12/2012	3	0	3	11	18	15.67	---	4.041	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	343.9	1464	660.7	---	405.1	---	---	---	---
pH_HL_MS5.0	None	4/12/2012 - 11/9/2012	39	0	39	7.73	8.48	8.161	8.2	0.2352	7.85	7.92	8.38	8.46
converted pH	None					7.73	8.48	8.097	8.201	0.0044	7.851	7.921	5.101	5.105
H+ computed from pH	µeq/l					0.0033	0.0186	0.008	0.0063	0.0044	0.0035	0.0042	0.012	0.0141
Potassium	mg/l	4/12/2012 - 10/12/2012	3	0	3	2	3.2	2.467	---	0.6429	---	---	---	---
Silicate	mg/l	4/12/2012 - 10/12/2012	3	0	3	6.4	10	7.633	---	2.05	---	---	---	---
Sodium	mg/l	4/12/2012 - 10/12/2012	3	0	3	4.7	15	10.57	---	5.297	---	---	---	---
Sulfate_Filtered	mg/l	4/12/2012 - 10/12/2012	3	0	3	7.8	20	15.27	---	6.543	---	---	---	---
Temp_HL_MS5.0	°C	4/12/2012 - 11/9/2012	39	0	39	7.67	27.72	16.73	15.5	6.862	7.69	9.75	23	27.71
Total Nitrogen_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	982.7	2636	1510	---	566.6	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/12/2012 - 11/9/2012	8	0	8	26.96	127.8	85.1	---	39.78	---	---	---	---
Total Suspended Solids	mg/l	4/12/2012 - 11/9/2012	8	0	8	2	37	15	---	11.63	---	---	---	---
Transparency Tube	cm	4/12/2012 - 11/9/2012	8	1	8	30.7	132	67.12	---	35.33	---	---	---	---

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

Station ID: MISS_UM862		Station Name: Mississippi River near St. Paul Water Works Pumping Station												
Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Alkalinity	mg/l CaCO ₃	4/11/2012 - 10/11/2012	3	0	3	110	180	153.3	---	37.86	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2012 - 11/8/2012	8	5	8	1.5	34.8	11.15	---	13.2	---	---	---	---
Calcium	mg/l	4/11/2012 - 10/11/2012	3	0	3	31	49	42.33	---	9.866	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	3.27	20.59	9.202	---	6.757	---	---	---	---
Chloride_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	0.36	21.2	9.587	---	10.62	---	---	---	---
DO%_HL_MS5.0	%	4/11/2012 - 11/8/2012	30	0	30	99.2	124	108.9	107.4	9.243	99.53	100.2	115.9	123.3
DO_HL_MS5.0	mg/l	4/11/2012 - 11/8/2012	30	0	30	7.63	13.47	10.17	9.655	2.12	7.66	8.332	12.77	13.4
DOC	mg/l	4/11/2012 - 10/11/2012	3	0	3	7.6	19	11.5	---	6.497	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2012 - 11/8/2012	30	0	30	244.3	427.3	331.7	313.3	65.57	247.9	277	400.6	425.6
Magnesium	mg/l	4/11/2012 - 10/11/2012	3	0	3	11	18	15.67	---	4.041	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	315.8	814.3	500.4	---	190.7	---	---	---	---
pH_HL_MS5.0	None	4/11/2012 - 11/8/2012	30	0	30	7.74	8.65	8.134	8.085	0.3468	7.74	7.75	8.462	8.603
converted pH	None					7.74	8.65	8.013	8.071	0.0065	7.74	7.75	5.111	5.111
H+ computed from pH	µeq/l					0.0022	0.0182	0.0097	0.0085	0.0065	0.0025	0.0034	0.0178	0.0182
Potassium	mg/l	4/11/2012 - 10/11/2012	3	0	3	1.9	3.3	2.467	---	0.7371	---	---	---	---
Silicate	mg/l	4/11/2012 - 10/11/2012	3	0	3	6.6	10	7.8	---	1.908	---	---	---	---
Sodium	mg/l	4/11/2012 - 10/11/2012	3	0	3	4.1	14	9.7	---	5.076	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	8.1	17	14.03	---	5.138	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2012 - 11/8/2012	30	0	30	7.75	27.98	18.74	20.69	7.217	8.01	11.34	25.26	27.95
Total Nitrogen_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	1001	1964	1338	---	329.4	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	28.76	162.1	86.75	---	45.95	---	---	---	---
Total Suspended Solids	mg/l	4/11/2012 - 11/8/2012	7	0	7	2	37	12.71	---	12.09	---	---	---	---
Transparency Tube	cm	4/11/2012 - 11/8/2012	8	2	8	33.3	132	67.95	---	40.74	---	---	---	---

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

Station ID: MISS_UM868		Station Name: Mississippi River upstream of the Coon Rapids Dam												
Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Alkalinity	mg/l CaCO3	4/11/2012 - 10/11/2012	3	0	3	110	180	153.3	---	37.86	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2012 - 11/8/2012	8	3	8	1.5	33.81	12.2	---	12.39	---	---	---	---
Calcium	mg/l	4/11/2012 - 10/11/2012	3	0	3	30	51	42.67	---	11.15	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	4.11	17.7	8.1	---	4.768	---	---	---	---
Chloride_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	0.41	20.7	9.403	---	10.34	---	---	---	---
DO%_HL_MS5.0	%	4/11/2012 - 11/8/2012	35	0	35	80.9	111.9	97.5	104.1	10.42	81.62	91	107	108.5
DO_HL_MS5.0	mg/l	4/11/2012 - 11/8/2012	35	0	35	6.19	12.22	9.482	9.42	2.13	6.246	7.61	11.87	12.15
DOC	mg/l	4/11/2012 - 10/11/2012	3	0	3	7.6	20	11.83	---	7.074	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2012 - 11/8/2012	35	0	35	244.9	428.5	349.2	369.6	61.46	247.4	312.9	408.5	423.7
Magnesium	mg/l	4/11/2012 - 10/11/2012	3	0	3	10	19	15.67	---	4.933	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	330.2	823.2	506.7	---	178.5	---	---	---	---
pH_HL_MS5.0	None	4/11/2012 - 11/8/2012	35	0	35	7.7	8.66	8.182	8.31	0.3	7.738	8	8.48	8.54
converted pH	None					7.7	8.66	8.081	8.31	0.0058	7.738	8	5.097	5.111
H+ computed from pH	µeq/l					0.0022	0.02	0.0083	0.0049	0.0058	0.0029	0.0033	0.01	0.0183
Potassium	mg/l	4/11/2012 - 10/11/2012	3	0	3	1.9	3.4	2.5	---	0.7937	---	---	---	---
Silicate	mg/l	4/11/2012 - 10/11/2012	3	0	3	6.7	10	7.9	---	1.825	---	---	---	---
Sodium	mg/l	4/11/2012 - 10/11/2012	3	0	3	4	14	9.667	---	5.132	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	7.5	17	13.83	---	5.485	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2012 - 11/8/2012	35	0	35	7.6	27.72	16.96	15.59	6.686	7.722	10.44	21.27	27.7
Total Nitrogen_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	975.6	1813	1299	---	276.5	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	26.49	123.3	78.92	---	36.07	---	---	---	---
Total Suspended Solids	mg/l	4/11/2012 - 11/8/2012	8	0	8	2	35	15	---	12.19	---	---	---	---
Transparency Tube	cm	4/11/2012 - 11/8/2012	8	2	8	33.9	132	69.92	---	40.28	---	---	---	---

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

Station ID: MISS_UM880		Station Name: Mississippi River just above the Crow River Confluence													
Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.	
Alkalinity	mg/l CaCO3	4/11/2012 - 10/11/2012	3	0	3	97	180	145.7	---	43.32	---	---	---	---	
Ammonium_SCRS	µg/l	4/11/2012 - 11/8/2012	8	4	8	1.5	21.63	10.62	---	7.977	---	---	---	---	
Calcium	mg/l	4/11/2012 - 10/11/2012	3	0	3	26	49	40	---	12.29	---	---	---	---	
chl_a(fluor)_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	1.96	7	3.967	---	1.969	---	---	---	---	
Chloride_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	0.66	17.2	7.653	---	8.561	---	---	---	---	
DO%_HL_MS5.0	%	4/11/2012 - 11/8/2012	34	0	34	87.8	102.7	93.48	93.05	4.476	87.9	89.38	96.2	100.8	
DO_HL_MS5.0	mg/l	4/11/2012 - 11/8/2012	34	0	34	6.84	11.84	8.804	8.235	1.536	6.865	7.66	10.28	11.08	
DOC	mg/l	4/11/2012 - 10/11/2012	3	0	3	7.5	20	11.83	---	7.077	---	---	---	---	
EC25_HL_MS5.0	µS/cm	4/11/2012 - 11/8/2012	34	0	34	195.2	400.5	308.5	303.6	73.14	204.4	240.3	384.1	395.2	
Magnesium	mg/l	4/11/2012 - 10/11/2012	3	0	3	8.4	17	14.13	---	4.965	---	---	---	---	
Nitrate+Nitrite_SCRS	µg/l	4/11/2012 - 11/8/2012	8	0	8	209.6	701.6	451.8	---	178.3	---	---	---	---	
pH_HL_MS5.0	None	4/11/2012 - 11/8/2012	34	0	34	7.66	8.39	8.02	8.04	0.2267	7.665	7.858	8.21	8.3	
converted pH	None					7.66	8.39	7.963	8.041	0.0058	7.666	7.857	5.105	5.115	
H+ computed from pH	µeq/l					0.0041	0.0219	0.0109	0.0091	0.0058	0.005	0.0062	0.0139	0.0216	
Potassium	mg/l	4/11/2012 - 10/11/2012	3	0	3	1.7	3	2.2	---	0.7	---	---	---	---	
Silicate	mg/l	4/11/2012 - 10/11/2012	3	0	3	6.5	8.9	7.833	---	1.222	---	---	---	---	
Sodium	mg/l	4/11/2012 - 10/11/2012	3	0	3	3.4	12	8.267	---	4.411	---	---	---	---	
Sulfate_Filtered	mg/l	4/11/2012 - 10/11/2012	3	0	3	4.2	16	11.73	---	6.543	---	---	---	---	
Temp_HL_MS5.0	°C	4/11/2012 - 11/8/2012	34	0	34	8.11	27.41	18.14	20.42	6.654	9.175	11.26	23.45	27.4	
Total Nitrogen_SCRS	µg/l	4/11/2012 - 11/8/2012	7	0	7	1029	1254	1171	---	78.5	---	---	---	---	
Total Phosphorus_SCRS	µg/l	4/11/2012 - 11/8/2012	7	0	7	18.18	102.9	56.52	---	31.46	---	---	---	---	
Total Suspended Solids	mg/l	4/11/2012 - 11/8/2012	8	0	8	1	24	10.38	---	9.149	---	---	---	---	
Transparency Tube	cm	4/11/2012 - 11/8/2012	8	3	8	39.9	132	88.37	---	40.22	---	---	---	---	

Reported Local Characteristics				
Local Name	STORET Name	Medium	Subject Taxon	Bio Part
Alkalinity	Alkalinity, Total (total hydroxide+carbonate+bicarbonate)	Water		
Ammonium_SCRS	Nitrogen, Ammonium (NH4) as N	Water		
Calcium	Calcium	Water		
chl_a(fluor)_SCRS	Chlorophyll a, free of pheophytin	Water		
Chloride_Filtered	Chloride	Water		

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

DO%_HL_MS5.0	Dissolved oxygen saturation	Water
DO_HL_MS5.0	Dissolved oxygen (DO)	Water
DOC	Carbon, organic	Water
EC25_HL_MS5.0	Specific conductance	Water
Magnesium	Magnesium	Water
Nitrate+Nitrite_SCRS	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	Water
pH_HL_MS5.0	pH	Water
Potassium	Potassium	Water
Silicate	Silicate	Water
Sodium	Sodium	Water
Sulfate_Filtered	Sulfur, sulfate (SO4) as SO4	Water
Temp_HL_MS5.0	Temperature, water	Water
Total Nitrogen_SCRS	Nitrogen	Water
Total Phosphorus_SCRS	Phosphorus	Water
Total Suspended Solids	Solids, Total Suspended (TSS)	Water
Transparency Tube	Transparency, tube with disk	Water

Results filtered for:

Organization = MISS: Mississippi National River and Recreation Area

Station = Include All Station Visit Results

Activities with Characteristic = Alkalinity

or Ammonium_SCRS
 or Calcium
 or chl_a(fluor)_SCRS
 or Chloride_Filtered
 or DO%_HL_MS5.0
 or DO_HL_MS5.0
 or DOC
 or EC25_HL_MS5.0
 or Magnesium
 or Nitrate+Nitrite_SCRS
 or pH_HL_MS5.0
 or Potassium
 or Silicate
 or Sodium
 or Sulfate_Filtered
 or Temp_HL_MS5.0
 or Total Nitrogen_SCRS

Appendix A. Descriptive statistics for monitoring sites in the Mississippi National River and Recreation Area, Minnesota, as entered in NPStoret.

or Total Phosphorus_SCRS
or Total Suspended Solids
or Transparency Tube

Only display results that meet characteristic criteria

Include Only Samples Not Checked as QC

Result Remark = (none)

Date (>=4/1/2012 and <=11/30/2012)

Value Status = Final

Censored Data Substitutions: *Non-detect=0.5* DetectionLimit, *Present >QL=1.1 * UpperQuantificationLimit, *Present <QL=0.5 * LowerQuantificationLimit

Missing Statistic Codes:

--- Computation requires 9 observations

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 607/122788, November 2013

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

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