



St. Croix National Scenic Riverway Water Quality Monitoring

2011 Summary Report

Natural Resource Data Series NPS/GLKN/NRDS—2012/366



ON THE COVER

Top: Namekagon River at Phipps Landing near Hayward, Wisconsin, July 2012. Bottom: St. Croix River just above the dam at St. Croix Falls, Wisconsin, June 2012. Photos by D. VanderMeulen



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September 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

VanderMeulen, D. 2012. St. Croix National Scenic Riverway water quality monitoring: 2011 summary report. Natural Resource Data Series NPS/GLKN/NRDS—2012/366. National Park Service, Fort Collins, Colorado.

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Abstract

Long-term water quality monitoring at the St. Croix National Scenic Riverway (SACN) is conducted as part of a large rivers water quality monitoring protocol, implemented by the Great Lakes Inventory and Monitoring Network (Network, or GLKN). This protocol is a component of a larger water quality monitoring effort by Network staff at seven other national parks in the western Great Lakes region. The primary objective of the large rivers water quality monitoring program is to describe the current status and trends of common limnological parameters on large rivers and select tributaries. GLKN staff will use this information to provide early warnings of change, which may then provide justification for increased monitoring, research, or management action.

Monthly water quality sampling was conducted at 13 sites on the St. Croix River and select tributaries in 2011 during ice-free months (April through November). Additionally, sediment samples were collected at SACN and Mississippi National River and Recreation Area in the fall of 2011 for analysis of diatom communities.

Field measurements included water clarity and depth profiles of temperature, pH, conductivity, and dissolved oxygen. 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*. 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.

This report compares monitoring results 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 State of Minnesota and/or Wisconsin. All data collected in 2011 are included in appendices.

Results indicate that water quality at sites in the upper river is relatively unimpacted and near EPA (U.S. Environmental Protection Agency) reference conditions, while Lake St. Croix in the lower river is being impacted by excess nutrients (phosphorus). Tributaries to the St. Croix River, including the Snake, Apple, Willow, and Kinnickinnic rivers, also appear to be impacted by excess nutrients.

Park-specific comments and recommendations relating to the sampling season are provided. The Network expects to continue monitoring at St. Croix National Scenic Riverway every other year, with monitoring in off-years contingent on additional funding. Future monitoring will be used to assess current conditions as they relate to water quality standards, and to continue to develop a long-term dataset to identify and assess trends in water quality over time.

Acknowledgements

Substantial support for the water quality work in 2011 was provided by staff of the St. Croix National Scenic Riverway. Material support included use of lab and office equipment and space. I would like to extend special thanks to primary field staff from the park: Michelle Prosser and Liesel Virchow. I would also like thank Dean Tucker from NPS-WRD in Ft. Collins, CO, for his patience and guidance with water quality database issues. Lastly, I would like to thank Joan Elias, Ted Gostomski, and Rick Damstra from the Great Lakes I&M Network for their review and suggestions that improved this document.

Introduction

The Great Lakes Inventory and Monitoring Network measured water quality variables and collected water samples for laboratory analysis at the St. Croix National Scenic Riverway (SACN) in 2011. The Network's Large Rivers Water Quality Monitoring Protocol (Magdalene et al. 2008a) was first implemented at the Mississippi National River and Recreation Area (MISS) in 2006, with subsequent monitoring at the park in 2008 and 2010. Monitoring began at SACN in 2007, with off-year monitoring in 2008 and 2010, and full-season monitoring in 2009 and 2011. Reports summarizing monitoring efforts prior to 2011 are described in Elias and Sieracki (2007), VanderMeulen and Elias (2008), and VanderMeulen (2009, 2011).

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)

The Network also monitors diatoms (an additional vital sign) in river and lake bottom sediments (Ramstack et al. 2008) under a cooperative agreement with the St. Croix Watershed Research Station. Diatom monitoring is closely tied to water quality monitoring and aids in the interpretation of water quality results.

The overall goal of the monitoring program for water quality of large rivers 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 SACN in 2011. Results from previous years (Elias and Sieracki 2007, VanderMeulen and Elias 2008, VanderMeulen 2009, VanderMeulen 2011) can be found on the GLKN website (<http://science.nature.nps.gov/im/units/glkn/index.cfm>)

Methods

Sampling Locations

The Network originally selected 11 sites for long-term monitoring, and added two additional sites after the first month of sampling in 2007, for a total of 13 water quality monitoring sites (Table 1; Figure 1). During the site selection process, three upper SACN sites and three lower SACN sites on the St. Croix River were randomly chosen (Table 1). The remaining seven sites were chosen non-randomly in consultation with members of the St. Croix Basin Water Resources Team (Basin Team), which is composed of federal, state, and regional water resources professionals. Water quality monitoring at these seven sites is designed to fill spatial gaps in monitoring coverage, and to serve as integrator sites for contributions from select large tributaries. All SACN sites are described in detail by Magdalene et al. (2008a) and VanderMeulen and Elias (2008); and the site selection process is explained in Magdalene et al. (2008a).

Table 1. St. Croix National Scenic Riverway water quality monitoring sites.

Site	Description
SACNa	added in 2007; integrator for upper St. Croix River
SACNb	added in 2007; integrator for Namekagon River above Hayward, WI
SACN01	randomly selected; Namekagon River
SACN02	randomly selected; integrator site
SACN03	Snake River; high priority tributary site
SACN04	randomly selected; integrator site
SACN05	integrator for river north of St. Croix Falls
SACN06	Apple River; high priority tributary site
SACN07	randomly selected site, Lake St. Croix (Bayport, MN)
SACN08	Willow River (Lake Mallalieu); high priority tributary site
SACN09	randomly selected site, Lake St. Croix (Hudson, WI)
SACN10	Kinnickinnic River; high priority tributary site
SACN11	randomly selected site; Lake St. Croix (Prescott, WI)

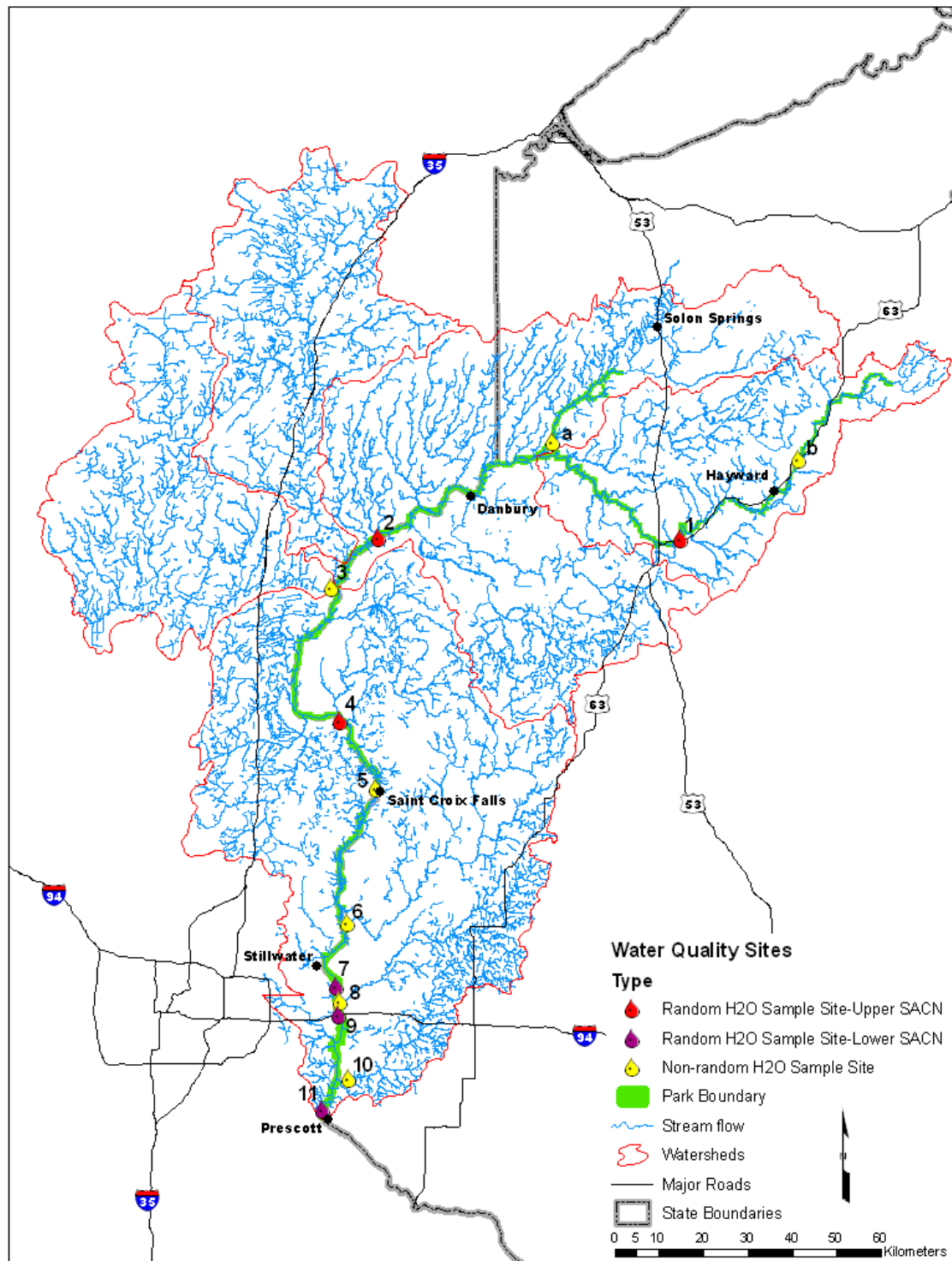


Figure 1. Location of water quality monitoring sites in St. Croix National Scenic Riverway, including sites on the Namekagon River (b,1), St. Croix River (a, 2,4,5), Snake River (3), Apple River (6), Lake St. Croix (7,9,11), Willow River (Lake Mallalieu-8), and the Kinnickinnic River (10).

Field Methods

Network staff conducted monthly water quality sampling at each site throughout the open water season in 2011 (Table 2). Samples were not collected in March (per Magdalene et al. 2008a) due to unsafe, iced-up conditions on the river and its tributaries. Whenever feasible, monitoring was conducted at approximately the deepest part of the channel and the centroid of flow. 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 2. Dates of water quality sampling at St. Croix National Scenic Riverway in 2011.

Month	Dates
April	11–14
May	9–13
June	6–9
July	11–14
August	8–11
September	6–9
October	3–6
November	7–10

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. We also measured water clarity using a transparency tube and/or Secchi disc, took a GPS reading, recorded environmental conditions (e.g., wind speed and direction, wave height, sky cover, air temperature), and noted field personnel and instrumentation.

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. In some instances an elbow-deep grab samples was collected when high current inhibited use of an integrated tube sampler. 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 sample 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, total chlorophyll-*a* (chl-*a*), and total suspended solids (TSS) during all site visits (Table 3). The remaining parameters were measured three times (April, July, and October) during the sampling season. Also, a near-bottom water

sample was collected in July at thermally-stratified lake-like sites with a Van Dorn sampler for analysis of total phosphorus.

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 diatom monitoring protocol (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).

Table 3. Water quality parameters measured and abbreviations used in text. **Bold** font indicates parameters measured 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		

Sediment Sampling

Bottom sediment samples were collected at areas of sediment deposition at SACN and MISS (Edlund et al. 2011) in late summer/fall. Sediment samples were also collected at select sites at Apostle Islands National Lakeshore and Indiana Dunes National Lakeshore and are included in a separate data summary report (Elias and Damstra 2012). Samples were collected with a drop corer and were handled and processed according to standard operating procedures (Ramstack et al. 2008). The bottom sediment samples will be analyzed for diatom community assemblages by researchers at SCWRS. Results from this project will facilitate our understanding of changes in water quality, as particular diatom species exist only under certain water quality conditions. Diatoms serve as indicators of water quality by responding to environmental stressors with changes in community composition. Analysis of diatom communities complements our discreet water quality sampling, as diatoms integrate environmental conditions throughout their lives.

Data Handling

Methods for using laboratory data below or above detection limits (i.e., censored data) 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 2011, summary statistics such as mean and standard deviation were calculated. The following rules for censored data results were applied for parameters collected monthly when uncensored data were collected at least six out of the eight months of the sampling season:

- 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

Censored data results were not included in summary statistics for parameters that were only collected three times during the monitoring season (i.e., quarterly samples).

Most values below detection and reporting limits were for $\text{NH}_4\text{-H}$ across all sites. Many values for transparency tube measurements were above the detection limit (>120 cm), especially in the upper river, Wisconsin tributaries (excluding the Willow River), and the most downstream site on the St. Croix River at Prescott, WI.

Quality Assurance and Quality Control

Steps to ensure quality assurance and quality control (QA/QC) were undertaken routinely, according to standard operating procedures (Ledder and Elias 2008) for monitoring water quality. 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 TSS, 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.

Results and Discussion

Data relative to flow, general water quality results, and comparisons of 2011 data with past results collected by NPS are presented below. Data are compared with federal and/or state water quality standards, where applicable. Appendix A contains a summary of all data collected at SACN in 2011. Appendix B contains a summary of data collected at select sites from 2007–2011 in April, July, and November. All data from 2011 and past years are posted in the Environmental Protection Agency’s STORET database and can be accessed at http://www.epa.gov/storet/dw_home.html.

Impairments

The entire section of the St. Croix River within Minnesota is on the state’s 303(d) list for mercury (MPCA 2008), and the St. Croix River below St. Croix Falls is on Wisconsin’s 303(d) list for PCBs (Magdalene et al. 2008). In 2008, both states placed Lake St. Croix on their respective 303(d) lists for excess nutrients (phosphorus), and the lake is now the subject of an interstate total maximum daily load study (TMDL) for excess phosphorus (MPCA and WDNR 2012). Mercury and PCBs are currently being monitored in bald eagle feather and blood samples by GLKN staff under a separate protocol (Route et al. 2009), and in river water by other regulatory agencies. However, nutrient monitoring is being conducted by GLKN staff as a component of the Large Rivers Water Quality Monitoring Protocol (Magdalene et al. 2008).

Flow

Eight U.S. Geological Survey streamflow gages currently operate within or near SACN park boundaries (Table 4). The streamflow gage on the St. Croix River (Norway Point) near Grantsburg, WI, is presently operated by the U.S. Army Corps of Engineers with only river stage information available online. The gages on the Namekagon River near Trego, WI, and on the Apple River near Somerset, WI, are maintained by dam operators, with periodic flow measurements collected by USGS as a measure of quality control.

Table 4. Active U.S. Geological Survey streamflow gage sites at St. Croix National Scenic Riverway. * = maintained by dam operators; ** = river stage only, operated by the U.S. Army Corps of Engineers.

Site #	Period of Record	Location
05331833	1996-present	Namekagon River near Leonards, WI
05332500*	1927-present	Namekagon River near Trego, WI
05333500	1914-present	St. Croix River at Danbury, WI
05336000**	2008-present	St. Croix River near Grantsburg, WI
05340500	1902-present	St. Croix River at St. Croix Falls, WI
05341500*	1914-1970, 1986-present	Apple River near Somerset, WI
05342000	1916-present	Kinnickinnic River near River Falls, WI
05341550	2011-present	St. Croix River at Stillwater, MN
05344490	2008-present	St. Croix River at Prescott, WI

Flow in 2011 in the Namekagon and St. Croix rivers was higher than average from snowmelt in late winter/early spring into the fall, and near average for the remainder of 2011 (Figure 2).

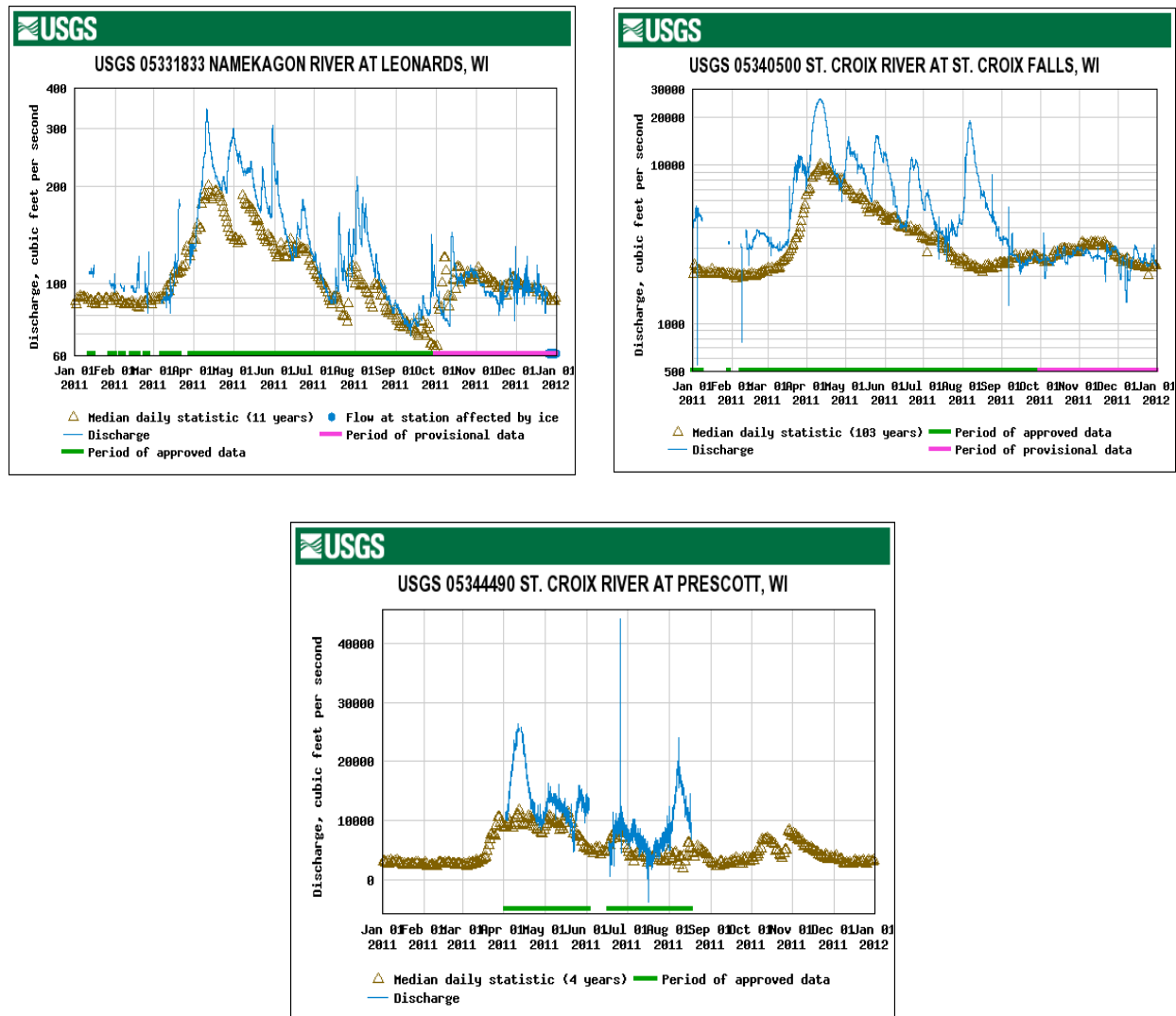


Figure 2. Historic and 2011 daily median discharge of the Namekagon River at Leonards, WI (a), and the St. Croix River at St. Croix Falls, WI (b), and at Prescott, WI (c). Figures generated online using USGS graphing tools on 13 June 2012.

Water Quality

Water quality monitoring results from 2011 are discussed in the next three sections of this report. These sections are categorized as general observations, temporal variability – comparison across seasons, and spatial variability – comparison of sites. Given the diverse nature of all 13 of the monitoring sites at SACN, when examining water quality patterns within the three categories it often is more instructive to just consider select water quality monitoring sites on the mainstem river sites, upstream to downstream. Three of the sites (SACN07, 09, and 11) are located on Lake St. Croix while the other three are mainstem river locations on the Namekagon (SACN01) and St. Croix (SACN02 and 04) rivers. The hydrologic and channel morphology conditions of these and the other monitoring sites are described below.

General Observations

The thirteen water quality monitoring sites at SACN can be broken down into two general categories based mainly on hydrology and channel morphology:

- **Lake and Riverine Impoundment sites** – These sites are generally >3 m deep, have little to no evidence of flow through visual observation, and have the potential to stratify thermally. Sites that exhibit these conditions are the three stations on Lake St. Croix (SACN07, SACN09, and SACN11), and the two impoundments above the dams at St. Croix Falls (St. Croix River) and North Hudson (Lake Mallalieu on the Willow River) (SACN05 and SACN08, respectively). All of these sites will be referred to as ‘lake sites’.
- **River sites** – These sites are generally <3 m deep, have obviously flowing water, and are well-mixed. Sites that exhibit these conditions are the two stations on the Namekagon River (SACNb and SACN01), three stations on the St. Croix River north of St. Croix Falls (SACNa, SACN02, and SACN04), and the remaining stations on the Snake, Apple, and Kinnickinnic Rivers (SACN03, SACN06, and SACN10, respectively). These sites will be referred to as ‘river sites.’

Range and average values of field and laboratory variables measured in 2011 at all thirteen sites are shown in Table 5; all data are shown in Appendix A. The next few paragraphs are devoted to a discussion of noteworthy results from 2011 across all sites and over the complete sampling season. Seasonal (temporal) and geographic (spatial) trends and comparisons to water quality standards will be addressed later in this document.

Alkalinity, Specific Conductivity, and Cations/Anions

Alkalinity is a term that refers to the buffering capacity of a solution. The buffering capacity is essentially the ability of the solution (water) to resist changes in pH through additions of acids or bases. Mean alkalinity values at the river sites ranged from a low of 38.7 mg/L at the CCC Bridge in the upper St. Croix River (SACNa) to 214.0 mg/L at the Kinnickinnic River (SACN10). Mean alkalinity values at the lake sites ranged from a low of 67.0 mg/L above the dam at St. Croix Falls, WI (SACN05) to 146.7 mg/L at Lake Mallalieu (SACN08-Lake Mallalieu). Alkalinity values at both river and lake sites indicate that waters at SACN are reasonably well-buffered, especially in the lower portion of the basin, except for relatively low alkalinity water in the Upper St. Croix River above the confluence with the Namekagon River.

Table 5. Range and mean values of field and laboratory variables measured at St. Croix National Scenic Riverway, 2011. N = number of samples. Field measurements are transparency tube, Secchi depth, pH, specific conductance (SC25), dissolved oxygen (DO), and temperature. Near-surface ($\leq 1.2\text{m}$) values were used for pH, specific conductance, DO, and temperature. ND = not detected. Dash (-) = not measured or calculated.

Variable	N	SACNa		SACNb		SACN01		SACN02		SACN03	
		range	mean	range	mean	range	mean	range	mean	range	mean
Temperature ($^{\circ}\text{C}$)	8	5.4-27.9	16.6	4.0-20.6	12.9	4.6-24.2	15.0	4.4-24.2	16.4	6.9-28.2	17.7
DO (mg/L)	8	7.2-12.6	9.4	8.4-12.7	9.8	6.0-12.0	8.8	5.6-12.0	8.5	7.5-13.2	9.8
pH (std. units)	8	6.9-7.9	7.6	7.5-8.1	7.8	7.3-8.0	7.7	7.0-7.6	7.4	7.0-8.6	7.9
SC25 ($\mu\text{S}/\text{cm}$)	8	46.8-119.5	94.6	89.7-162.2	139.4	110.0-182.3	157.6	66.0-158.0	126.8	84.3-260.5	169.8
TSS (mg/L)	8	1-8	3.4	ND-11	3.7	2-16	6.3	2-8	5.5	1-17	6.4
Trans. Tube (cm)	8	82- >120	-	85.3- >120	-	61.1- >120	-	67.0- >120	-	73.6- >120	-
Secchi Depth (m)	8	-	-	-	-	-	-	-	-	-	-
TP ($\mu\text{g}/\text{L}$)	8	14.14-51.14	23.5	16.3-40.04	24.11	18.77-55.5	28.99	24.34-68.09	36.21	21.49-104.4	57.19
Chl-a ($\mu\text{g}/\text{L}$)	8	0.25-2.12	1.13	0.43-4.56	1.79	0.73-4.51	2.21	2.31-6.60	3.50	1.72-13.08	4.99
TN ($\mu\text{g}/\text{L}$)	8	259.7-1073.0	515.7	235.4-810.7	458.5	327.1-1040.0	552.8	380.4-1209.0	639.2	641.9-1201.0	942.7
$\text{NO}_3+\text{NO}_2\text{-N}$ ($\mu\text{g}/\text{L}$)	8	ND-33.9	-	24.9-175.0	76.2	50.9-178.7	118.3	25.6-70.3	56.1	19.4-192.4	99.3
$\text{NH}_4\text{-N}$ ($\mu\text{g}/\text{L}$)	8	ND-19.2	-	ND-27.8	-	ND-34.2	-	ND-36.2	-	ND-25.6	-
DOC (mg/L)	3	5.8-12.0	9.0	5.2-10.0	6.8	4.7-10.0	6.8	6.3-12.0	9.8	12.0-18.0	14.3
Alkalinity (mg/L)	3	20.0-52.0	38.7	40.0-72.0	60.7	42.0-79.0	56.0	28.0-62.0	47.7	38.0-102.0	72.0
Cl^- (mg/L)	3	1.4-2.6	2.1	2.4-3.2	2.9	3.8-5.7	5.0	2.0-4.3	3.3	2.9-7.4	4.9
SO_4^{-2} (mg/L)	3	2.30-3.88	3.22	3.50-5.27	4.54	3.79-5.03	4.50	2.40-4.02	3.35	2.20-4.45	3.08
Ca^+ (mg/L)	3	6.0-14.1	10.8	11.7-20.3	16.9	14.5-21.8	19.2	8.3-18.2	14.4	9.8-27.1	18.9
Mg^{+2} (mg/L)	3	1.86-4.24	3.24	3.24-5.79	4.82	4.11-6.52	5.65	2.65-5.72	4.62	3.73-10.50	7.17
K^+ (mg/L)	3	0.36-0.62	0.46	0.53-0.78	0.63	0.66-1.00	0.78	0.60-0.79	0.67	1.05-1.53	1.33
Na^{+2} (mg/L)	3	1.38-2.68	2.07	1.92-2.76	2.42	2.79-3.76	3.43	1.76-3.01	2.50	2.25-4.85	3.40
SiO_2 (mg/L)	3	6.93-8.86	7.99	8.93-13.80	11.78	9.99-12.60	11.33	8.28-10.90	9.61	7.99-9.48	8.55

Table 5. Range and mean values of field and laboratory variables measured at St. Croix National Scenic Riverway, 2011. N = number of samples. Field measurements are transparency tube, Secchi depth, pH, specific conductance (SC25), dissolved oxygen (DO), and temperature. Near-surface (<1.2m) values were used for pH, specific conductance, DO, and temperature. ND = not detected. Dash (-) = not measured or calculated (continued).

Variable	N	SACN04		SACN05		SACN06		SACN07		SACN08	
		range	mean	range	mean	range	mean	range	mean	range	mean
Temperature (°C)	8	4.9-24.9	16.8	6.1-26.3	17.3	5.1-23.2	16.4	8.4-27.0	18.7	5.6-24.7	17.8
DO (mg/L)	8	6.3-12.3	8.7	6.2-11.7	8.7	6.9-13.0	9.2	5.9-12.5	8.9	9.9-16.8	13.5
pH (std. units)	8	7.2-7.9	7.6	7.1-8.0	7.6	7.6-8.1	7.9	7.1-8.3	7.6	7.9-8.9	8.6
SC25 (µS/cm)	8	75.2-183.0	139.2	83.2-200.1	155.5	174.4-297.7	265.4	91.1-230.2	164.0	252.9-420.5	359.6
TSS (mg/L)	8	2-9	6.1	2-11	5.1	2-11	4.5	3-6	4.5	3-17	9.8
Trans. Tube (cm)	8	62.7- >120	92.7	69.0- >120	92.5	88.3- >120	-	57.6-98.1	83.0	47.8- >120	80.0
Secchi Depth (m)	8	-	-	1.0-2.8(n=6)	0.7	-	-	0.8-1.6	1.3	0.7-2.3	1.2
TP (µg/L)	8	21.82-77.47	40.16	22.42-78.33	40.56	31.45-105.9	59.49	30.0-71.89	48.84	30.63-100.3	57.68
Chl-a (ug/L)	8	1.49-5.29	3.21	2.06-5.96	3.64	2.37-10.42	5.67	2.72-10.99	6.70	5.72-32.87	17.25
TN (µg/L)	8	432.9-1246.0	718.8	503.9-1213.0	774.9	940.6-1321.0	1162.0	702.2-1177.6	900.38	2149-3885	2883
NO ₃ +NO ₂ -N (µg/L)	8	42.9-145.4	88.8	68.6-189.5	139.8	409.2-780.8	636.7	87.3-299.8	194.4	1356-3039	2128
NH ₄ -N (µg/L)	8	ND-24.5	-	ND-32.1	-	ND-76.8	-	ND-87.0	-	ND-70.3	-
DOC (mg/L)	3	5.8-14.0	10.9	6.9-13.0	11.0	4.8-7.1	5.6	6.7-15.0	11.2	2.3-6.1	4.1
Alkalinity (mg/L)	3	31.0-67.0	50.3	34.0-88.0	67.0	81.0-137.0	113.7	38.0-101.0	70.7	106.0-175.0	146.7
Cl ⁻ (mg/L)	3	2.6-4.9	3.9	3.1-6.1	4.9	6.1-10.0	8.6	3.6-8.0	5.7	10.3-16.4	14.3
SO ₄ ⁻² (mg/L)	3	2.40-4.52	3.50	2.70-4.91	3.82	4.50-6.56	5.73	3.00-5.73	4.12	8.32-12.20	10.31
Ca ⁺ (mg/L)	3	9.0-21.0	15.9	9.7-23.7	17.9	20.7-32.4	28.1	10.9-25.9	18.9	27.5-42.2	34.5
Mg ⁺² (mg/L)	3	3.17-7.01	5.46	3.40-7.81	6.02	7.54-14.10	11.65	3.71-9.46	6.69	12.2-23.3	19.0
K ⁺ (mg/L)	3	0.78-1.03	0.93	0.85-1.09	0.99	1.01-1.68	1.36	0.93-1.18	1.05	1.44-3.12	2.00
Na ⁺² (mg/L)	3	2.09-3.76	2.99	2.18-4.06	3.27	3.29-4.60	4.12	2.46-4.78	3.56	4.26-5.77	5.23
SiO ₂ (mg/L)	3	8.06-11.00	9.99	8.26-11.20	10.02	9.59-17.00	14.00	8.76-10.70	9.85	10.90-14.30	12.67

Table 5. Range and mean values of field and laboratory variables measured at St. Croix National Scenic Riverway, 2011. N = number of samples. Field measurements are transparency tube, Secchi depth, pH, specific conductance (SC25), dissolved oxygen (DO), and temperature. Near-surface (<1.2m) values were used for pH, specific conductance, DO, and temperature. ND = not detected. Dash (-) = not measured or calculated (continued).

Variable	N	SACN09		SACN10		SACN11	
		range	mean	range	mean	range	mean
Temperature (°C)	8	7.9-26.4	17.9	5.7-16.3	12.5	5.3-26.0	17.6
DO (mg/L)	8	5.1-11.7	8.5	9.9-13.0	9.9	5.0-10.9	7.8
pH (std. units)	8	7.1-7.9	7.5	8.0-8.3	8.1	7.1-7.7	7.4
SC25 (µS/cm)	8	98.4-244.5	170.5	502.0-519.7	513.1	145.4-257.9	188.4
TSS (mg/L)	8	1-5	3.4	3-9	5.1	1-3	2.5
Trans. Tube (cm)	8	53.9- >120	95.0	>120	>120	91.7- >120	-
Secchi Depth (m)	7	0.9-1.8	1.5	-	-	1.5-2.0	1.8
TP (µg/L)	8	32.36-71.63	48.77	29.28-48.68	37.09	34.24-65.32	43.61
Chl-a (ug/L)	8	2.73-11.39	7.52	1.42-3.74	2.82	1.92-9.76	4.21
TN (µg/L)	8	833.6-1250.0	1028.0	5463-6068	5730	913.3-1318	1129
NO ₃ +NO ₂ -N (µg/L)	8	128.3-415.2	270.9	4915-5554	5216	243-693.5	442.6
NH ₄ -N (µg/L)	8	ND-92.1	-	ND-30.1	-	ND-72.5	-
DOC (mg/L)	3	8.4-14.0	11.1	2.0-2.4	2.2	10.0-14.0	11.7
Alkalinity (mg/L)	3	39.0-102.0	71.0	194.0-252.0	214.0	60.0-99.0	78.3
Cl ⁻ (mg/L)	3	4.1-8.8	6.3	22.6-22.8	22.7	6.2-8.6	7.1
SO ₄ ⁻² (mg/L)	3	3.18-5.89	4.37	19.00-19.70	19.27	4.25-5.67	4.77
Ca ⁺² (mg/L)	3	11.825.7	19.0	55.2-57.7	56.2	17.2-26.6	21.0
Mg ⁺² (mg/L)	3	4.10-10.0	7.11	25.8-26.8	26.4	6.08-10.0	7.69
K ⁺ (mg/L)	3	0.93-1.31	1.11	1.37-1.56	1.49	0.85-1.61	1.20
Na ⁺ (mg/L)	3	2.57-4.67	3.61	7.54-8.36	8.01	3.50-4.51	3.92
SiO ₂ (mg/L)	3	9.01-11.40	10.34	11.20-14.20	12.63	9.86-13.30	11.29

Specific conductance is a measure of water's ability to conduct electricity. Waters with higher concentrations of ions will have higher specific conductance values. Listed in order of importance, the anions CO_3^{-2} , SO_4^{-2} , and Cl^- , and the cations Ca^{+2} , Mg^{+2} , Na^+ , and K^+ are the major contributors to specific conductivity in the St. Croix River basin. A marked difference in mean specific conductance values was observed for samples from the Apple, Willow (Lake Mallalieu), and Kinnickinnic Rivers (265.4 $\mu\text{S}/\text{cm}$, 359.6 $\mu\text{S}/\text{cm}$, and 513.1 $\mu\text{S}/\text{cm}$, respectively) compared to the other water quality monitoring sites, which were all less than 188.4 $\mu\text{S}/\text{cm}$. Because conductivity is related to the concentration of ions, it is not surprising that concentrations of measured anions (SO_4^{-2} , Cl^-) and cations (Ca^{+2} , Mg^{+2} , Na^+ , K^+) were correlated to values of specific conductance (Table 5). Much of the calcium (Ca^{+2}) and sulfate (SO_4^{-2}) was most likely weathered from the underlying clay-rich, calcareous glacial deposits and sedimentary rocks, especially in the Apple, Willow, and Kinnickinnic watersheds (Juckem 2007). Concentrations of the remaining anions and cations are derived through weathering of the surrounding rocks and soils, and from anthropogenic inputs including fertilizers and runoff from urban and industrial areas (Stark et al. 2000).

Nitrate+Nitrite-Nitrogen

The Apple (SACN06), Willow (SACN08-Lake Mallalieu), and Kinnickinnic (SACN10) rivers had very high concentrations of $\text{NO}_3+\text{NO}_2\text{-N}$, with mean values ranging from 1,162 $\mu\text{g}/\text{L}$ at SACN06 to 5,216 $\mu\text{g}/\text{L}$ at SACN10 (Table 5 and Appendix A). In comparison, site SACN11 in Pool 4 of Lake St. Croix, which integrates water quality for the complete St. Croix Basin, had a mean $\text{NO}_3+\text{NO}_2\text{-N}$ value of 442.6 $\mu\text{g}/\text{L}$. The watersheds associated with these tributaries are dominated by agriculture and increasing development. In addition, soils generally are coarse textured and highly permeable, which makes groundwater more susceptible to $\text{NO}_3+\text{NO}_2\text{-N}$ loading via fertilizer application (Juckem 2007). This is especially evident in the Kinnickinnic River, which not only has highly permeable soils but is underlain by carbonate bedrock, making this watershed more susceptible to groundwater contamination (Juckem 2007).

Chlorophyll-a

Chlorophyll pigment (chl-*a*) concentrations can be used to estimate algal biomass, and serve as a basis for evaluation of overall productivity. Chl-*a* concentration in samples from all 13 monitoring sites over the 2011 monitoring season varied widely, with generally lower values at river sites versus lake sites, and higher chl-*a* in the summer compared with spring and fall across all sites.

These differences are demonstrated by comparing mean monthly chl-*a* values for three mainstem river sites (Namekagon and St. Croix rivers) with three Lake St. Croix sites (Figure 3). Except for a small increase in early spring shortly after ice-out, mean chl-*a* was low over the whole monitoring season for the river sites, likely due to the low residence time of water at those sites. Like the river sites, chl-*a* increased in the lake sites in early spring and declined until July, but unlike the river sites, chl-*a* increased from mid-summer through the fall at the lake sites. Even though summer and fall temperatures at the river and lake sites are similar, the relatively higher residence time of water in Lake St. Croix as compared to free-flowing river sites creates conditions more suitable for algal growth and reproduction. However, the overall increase in chl-*a* at the lake sites from July to November was relatively small, and overall productivity of Lake

St. Croix was somewhat reduced through the summer due to high river flows, and in the fall due to cooling water temperatures and a shorter light period.

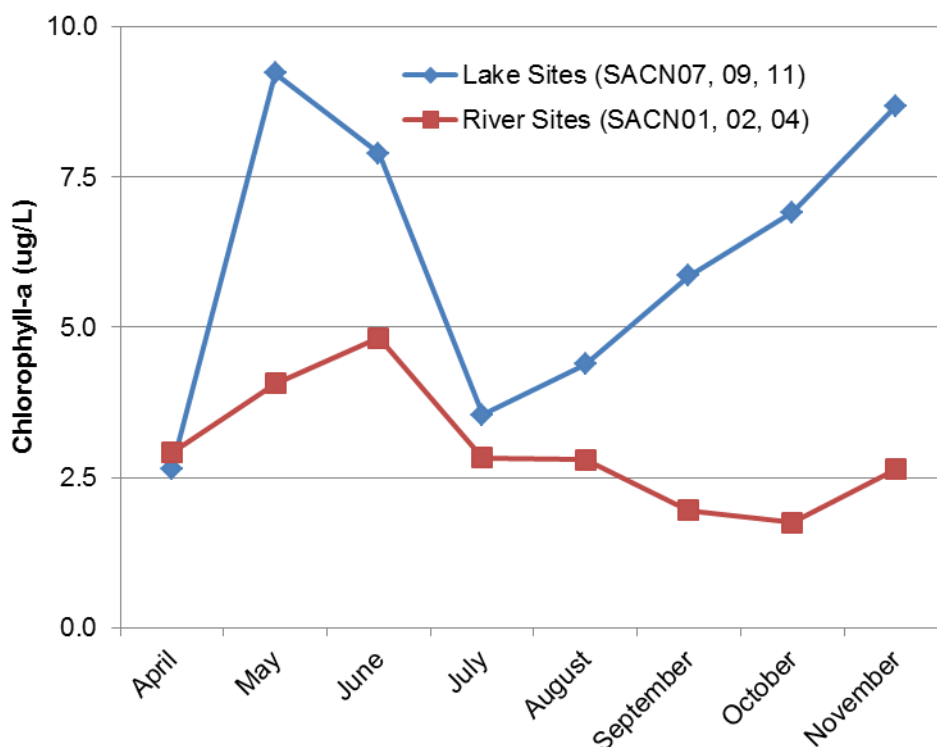


Figure 3. Mean chlorophyll-a concentration for select sites, St. Croix National Scenic Riverway, 2011.

Dissolved Organic Carbon

Mean dissolved organic carbon (DOC) for the river sites ranged from a low of 2.2 mg/L at the Kinnickinnic River (SACN10) to a high of 14.3 mg/L at the Snake River (SACN03) (Table 5). Sources of DOC for vegetated streams and rivers are both allochthonous and autochthonous (Hauer and Lamberti 2006). DOC for the lake sites ranged from a low of 4.1 mg/L at Lake Mallalieu (SACN08) to a high of 11.7 mg/L at Lake St. Croix at Prescott, WI (SACN11). DOC values >3 mg/L are high enough to attenuate light and thus reduce photosynthesis (Schindler and Gunn 2004), which is of greater relevance at the lake sites where an abundance of nutrients has the potential to fuel excessive algal growth.

Temporal Variability – Comparison Across Seasons

Temperature and Dissolved Oxygen

Profiles of temperature and dissolved oxygen concentration show all eight river sites were well mixed throughout the open-water season. However, at the lakes sites, the upper and lower stations on Lake St. Croix (SACN07, 11) and the station on Lake Mallalieu (SACN08) became stratified with respect to temperature and dissolved oxygen by mid-summer. Water temperature

and dissolved oxygen were the most stratified during the August sampling event (Figure 4), with near-bottom dissolved oxygen levels at 1.62, 0.17, and 2.61 mg/L, respectively.

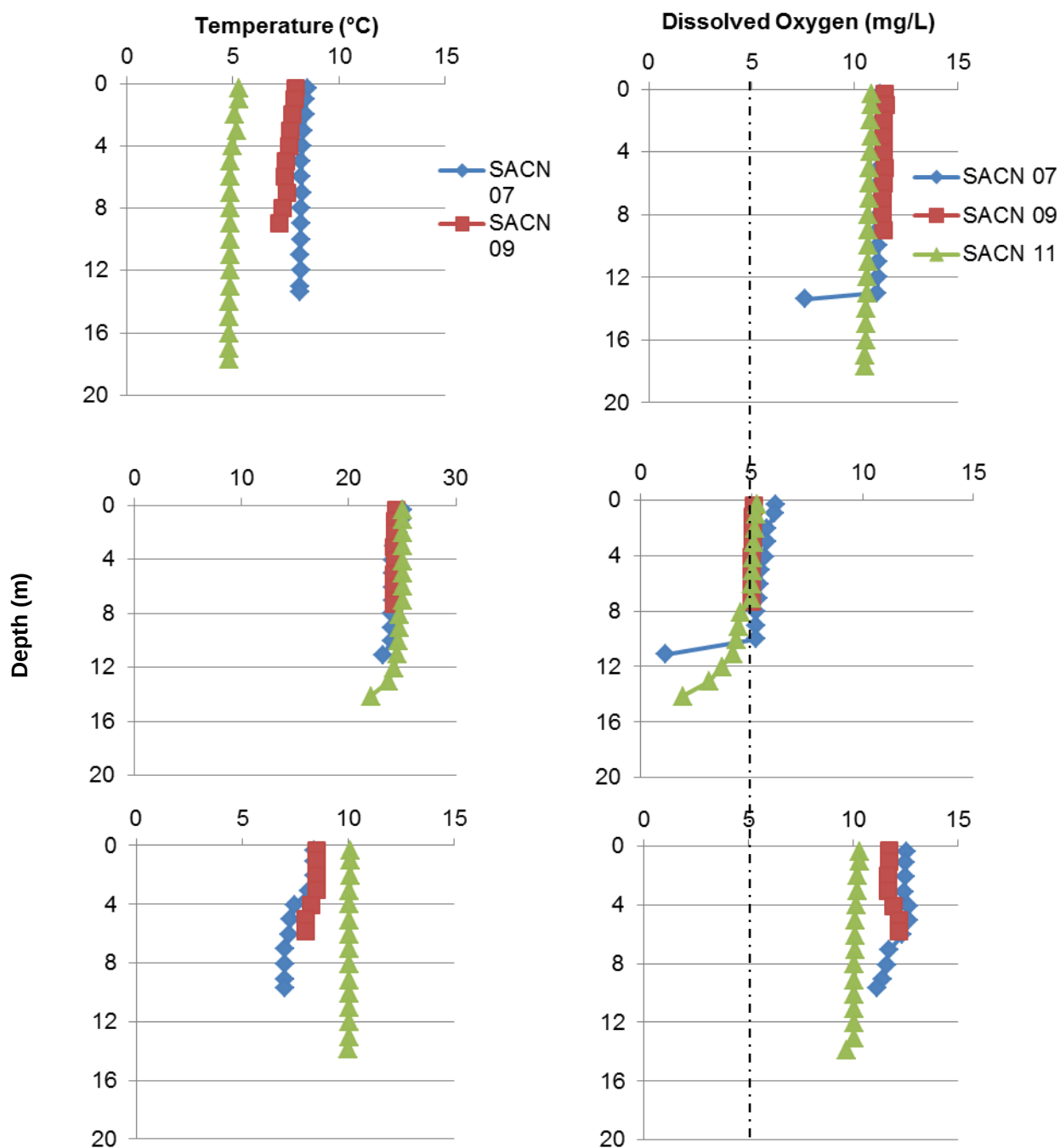


Figure 4. Temperature and dissolved oxygen values for ‘lake-like’ sites at St. Croix National Scenic Riverway in April (top), August (middle), and November (bottom), 2011. Dotted line across the dissolved oxygen graphs indicates the 5 mg/L daily minimum standard for Class 2B waters in Minnesota.

Dissolved oxygen levels <5 mg/L as a daily minimum are considered below the standard for Class 2B waters (Minnesota water quality standards), and may be detrimental to aquatic life. Stratified waters with low (<5 mg/L) oxygen levels were also found at several sites in Lake St. Croix during August sampling in 2005 and 2006 by volunteers working with NPS staff (Brenda Moraska Lafrancois, personal communication), and by volunteers working for Metropolitan Council Environmental Services(MCES) since 2007 (Kent Johnson, personal communication). The potential for stratification at lake sites is increased during years of high air temperatures and low flow. Moreover, multiple lines of evidence point towards a situation where the four pools within Lake St. Croix exhibit stratification with respect to temperature and dissolved oxygen from early summer to late fall, with cold anaerobic water in the lower half of the water column and warmer free-flowing aerobic water flowing over the top of the pools, until the pools turnover in September and October.

Anaerobic conditions in the lower water column of stratified waters typically lead to a substantial decrease in pH, increased specific conductivity, and the release of soluble phosphorus from the sediment. Both near-surface and bottom (ca. 1 m from bottom) TP samples were collected in July at lake sites that exhibited some evidence of thermal stratification and low oxygen concentrations below the thermocline (Table 6). In 2007, though not shown in Table 6, sites SACN07 and SACN11 had much higher concentrations of TP near the bottom compared to near the surface (VanderMeulen and Elias 2007). However, from 2009 to 2011, near-surface and near-bottom TP concentrations for these sites were similar, except for samples collected at SACN07 in 2009 (Table 6). Therefore, an increase in soluble phosphorus in the lower water column (as it is released from sediment) does not occur consistently during low oxygen conditions. Increased soluble phosphorus concentration in the lower water column may be a function not only of low oxygen conditions but also the amount of time at which oxygen has been depleted. In 2007 bottom TP samples were collected in August, which may have allowed more time for soluble phosphorus concentrations to build up during low oxygen conditions.

Table 6. Near-surface (0–2 m) and bottom (ca. 1 m from bottom) total phosphorus (TP) values in July for select sites at St. Croix National Scenic Riverway. Bottom TP samples collected ≤ 1 m from sediment-water interface.

Site	Year	Depth (m)	TP ($\mu\text{g/L}$)
SACN07	2009	Near surface	35.0
		Bottom	99.8
	2010	Near surface	69.0
		Bottom	66.9
	2011	Near surface	58.3
		Bottom	61.7
SACN11	2009	Near surface	75.3
		Bottom	74.6
	2010	Near surface	49.1
		Bottom	55.9
	2011	Near surface	36.2
		Bottom	49.0

Nutrients

A large portion of the annual nutrient and sediment loading to the St. Croix River occurs during snowmelt runoff and storm events (Lenz et al. 2001, Robertson and Lenz 2002), and during leaf senescence in the fall. Therefore, for the 2011 monitoring season at SACN, the increases and decreases in nutrient concentrations should reflect seasonal hydrology. Site SACN11, which integrates all upstream conditions in the river, is used to illustrate this point (Figure 5). Nutrient concentrations at this site were relatively low (in comparison to prior years) in early spring, were somewhat constant (TP) or slowly increased (TN) throughout the summer due to large and sustained precipitation events, and eventually declined in late fall after leaf senescence.

Precipitation in the form of snow was much lower than usual in the winter of 2010/2011, with little-to-no snowpack in the St. Croix River watershed. The relatively low nutrient levels in the spring are likely due to the fact that the sparse amount of snow on the ground in late winter was melted by mid-March (Figure 2), leading to an earlier than usual “first flush” of nutrient runoff that likely was missed by sampling in April. Nutrient levels throughout the rest of the sampling season were relatively consistent with above average precipitation in the spring, summer, and early fall, followed by fall leaf senescence and declining precipitation in late fall/early winter.

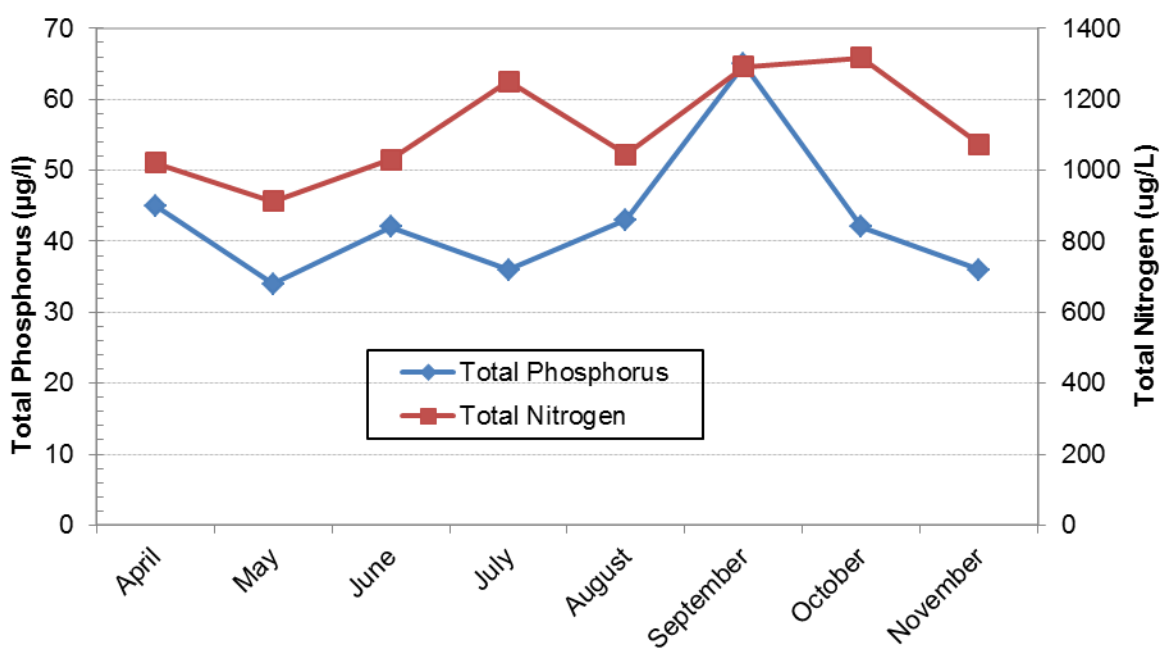


Figure 5. Total phosphorus and total nitrogen concentrations at site SACN11, St. Croix National Scenic Riverway, 2011.

Total Suspended Solids

Total suspended solids, along with transparency tube and Secchi disc measurements are used by GLKN to assess water clarity across all sites at SACN. Total suspended solids in a water sample consist of organic and inorganic particles large enough to be suspended in the water column. Organic particles are usually associated with suspended algae or detritus while inorganic particles result from erosion of soils. Mean TSS at the river sites was high in the spring,

remained high throughout the summer, and declined in the fall, while mean TSS at the lake sites was low throughout the monitoring season (Figure 6). It is likely that TSS values at the river sites are mainly due to suspended inorganic particles and, to a lesser extent, diatomaceous algae, with higher levels in the spring and summer due to higher flows, and declining TSS in the fall with lower river flow. In contrast, TSS at the lake sites likely is dominated by the overall productivity of the lake, and productivity as measured by chl-*a* increased from mid-summer through the fall at the lake sites. However, the overall increase in chl-*a* at the lake sites from July to November was relatively small, and is not reflected in the low and basically constant mean TSS values for the lake sites over the monitoring season.

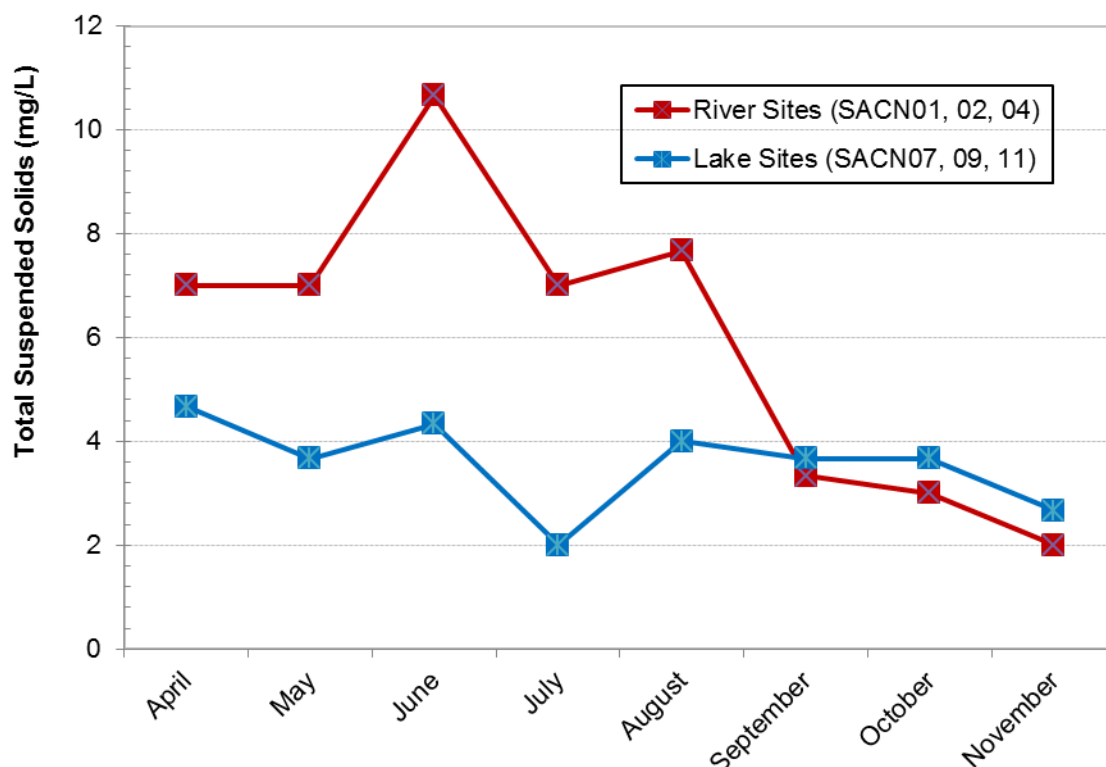


Figure 6. Mean total suspended solids at St. Croix National Scenic Riverway at select river (SACN01, 02, 04) and lake (SACN07, 09, 11) sites in 2011.

pH

The pH of natural waters is defined as the logarithm of the reciprocal of the concentration of free hydrogen ions. As pH decreases below 7.00 waters become progressively more acidic; as pH increases above 7.00 waters become more basic. Because organisms can only tolerate a pre-defined range of pH values, the mean and range of pH values at a given site often determine which organisms can exist there. At SACN in 2011, mean monthly near-surface pH values were generally lower in early spring, increased in the summer, were highest in the fall, and began to decrease in late fall/early winter (Figure 7). The increase in pH in late summer and the fall is due to increased water temperatures (less dissolved CO₂) and less dissolved organic carbon (i.e., lower concentration of organic acids), as well as conditions of higher primary productivity. The

lower mean pH value in August likely resulted from a large rain event just prior to monitoring. The pH of rain water is naturally slightly acidic, ranging from 5.0 to 6.0, and can cause a temporary decrease in the pH of surface waters during large or sustained rain events.

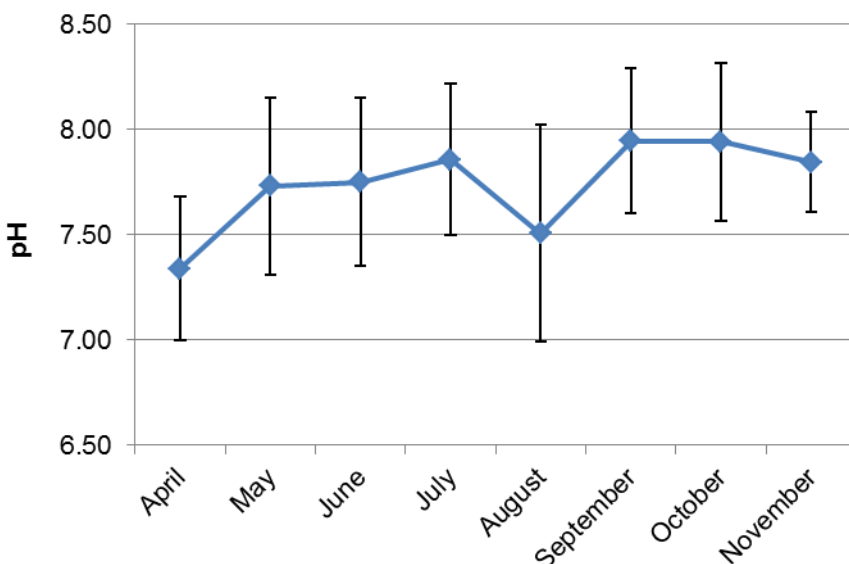


Figure 7. Mean monthly near-surface (depth ≤ 1.2 m) pH across all water quality monitoring sites at St. Croix National Scenic Riverway in 2011. Error bars are ± 1 standard deviation.

Long-Term Data

Off-year sampling in 2008 and 2010 at the six randomly-selected sites (Magdalene et al. 2008a) allowed for comparison of data over a five-year period (2007–2011, Appendix B). Continuation of off-year sampling will allow for more timely analysis of the inherent variability and potential trends at these sites. In addition, since these sites were randomly selected as part of the sampling design (Magdalene et al. 2008), statistically-defendable inferences of trends (or lack thereof) across SACN are possible.

Spatial Variability – Comparison of Sites

River sites SACN01, 02, 04, and lake sites SACN07, 09, and 11 were used to assess spatial variability of water quality parameters measured in 2011 (Table 7). Temperature, specific conductivity, water clarity, TP, TN, alkalinity, cations, and anions typically increased from upstream to downstream. No clear patterns were evident among these six sites for DO, pH, chl-*a*, DOC, and silica. However, an examination of only those sites on Lake St. Croix (SACN07, 09, and 11) shows DO and pH generally decreased and silica increased from upstream to downstream. From a hydrologic and channel morphology perspective, Lake St. Croix is fundamentally different from the other three upstream river-like sites. Historically, TSS and TP have been consistently higher at the site near the head of the lake (SACN07), due to allochthonous input from upstream sources (Kent Johnson, personal communication). TP decreases as it is taken up by algae, which then settle out in the slow-moving waters.

Table 7. Mean values of select water quality variables from sites on the mainstem of the St. Croix National Scenic Riverway, 2011. Water quality monitoring sites are listed upstream to downstream, left to right. Sites SACN01, 02, and 04 are river sites, and sites SACN07, 09, and 11 are lake sites. Site SACN01 is on the Namekagon River near Earl, WI, and well upstream of the river's confluence with the St. Croix River near Danbury, WI. Near-surface (≤ 1.2 m) values were used for pH, specific conductance, DO, and temperature. Dash (-) = not measured or calculated.

Variable	N	SACN01	SACN02	SACN04	SACN07	SACN09	SACN11
Temperature (°C)	8	15.0	16.4	16.8	18.7	17.9	17.6
DO (mg/L)	8	8.8	8.5	8.7	8.9	8.5	7.8
pH (std. units)	8	7.7	7.4	7.6	7.6	7.5	7.4
SC25 (μ S/cm)	8	157.6	126.8	139.2	164.0	170.5	188.4
TSS (mg/L)	8	6.3	5.5	6.1	4.5	3.4	2.5
Trans. Tube (cm)	8	-	-	92.7	83.0	>120	-
Secchi Depth (m)	8	-	-	-	1.3	1.5	1.8
TP (μ g/L)	8	29.0	36.2	40.2	48.8	48.8	43.6
Chl-a (μ g/L)	8	2.2	3.5	3.2	6.7	7.5	4.2
TN (μ g/L)	8	552.8	639.2	718.8	900.4	1028.0	1129
NO ₃ +NO ₂ -N (μ g/L)	8	118.3	56.1	88.8	194.4	270.9	442.6
NH ₄ -N (μ g/L)	8	-	-	-	-	-	-
DOC (mg/L)	3	6.8	9.8	10.9	11.2	11.1	11.7
Alkalinity (mg/L)	3	56.0	47.7	50.3	70.7	71.0	78.3
Cl ⁻ (mg/L)	3	5.0	3.3	3.9	5.7	6.3	7.1
SO ₄ ⁻² (mg/L)	3	4.5	3.4	3.5	4.1	4.4	4.8
Ca ⁺² (mg/L)	3	19.2	14.4	15.9	18.9	19.0	21.0
Mg ⁺² (mg/L)	3	5.7	4.6	5.5	6.7	7.1	7.7
K ⁺ (mg/L)	3	0.8	0.7	0.9	1.1	1.1	1.2
Na ⁺ (mg/L)	3	3.4	2.5	3.0	3.6	3.6	3.9
SiO ₂ (mg/L)	3	11.3	9.6	10.0	9.9	10.3	11.3

Designated Uses and Water Quality Standards

The State of Minnesota lists the entire St. Croix River as an Outstanding Resource Water. The State of Wisconsin has listed the St. Croix River as an Outstanding Resource Water, except between the St. Croix Falls city limits to one mile below the STH 243 Bridge at Osceola, where it is listed as an Exceptional Resource Water (a category of lesser protection). Wisconsin also lists the Namekagon River as an Outstanding Resource Water.

The water quality of the St. Croix River and its tributaries is protected by state-specific water quality criteria. Whether the water quality standards of Minnesota, Wisconsin, or both apply depends on the location of the water quality monitoring site. A summary of state-specific water quality standards was compiled by Ledder (2005) for the Network during development of the Network's monitoring plan (Route and Elias 2007). In the following sections water quality monitoring results from SACN in 2011 are compared with federal standards, the criteria listed in Ledder's (2005) state-specific summary, and other recently developed state and site-specific standards.

Minnesota

The State of Minnesota has assigned designated use classes for the portion of the St. Croix River that forms the border between Minnesota and Wisconsin, and on Minnesota tributaries flowing into the St. Croix River. For the St. Croix River, waters north of Taylors Falls, Minnesota, are designated Class 1B, 2Bd, 3B, 3C, 4A, 4B, 5, and 6, while waters south of Taylors Falls are designated Class 1C, 2Bd, 3B, 3C, 4A, 4B, 5, and 6. Water quality monitoring site SACN03 near the mouth of the Snake River is designated Class 2B, 3B, 4A, 4B, 5, and 6.

The State of Minnesota has established criteria for some water quality parameters based on the designated uses (MnRule 7050.0220). These criteria apply to some sampling sites within SACN (Table 8; note that Minnesota state water quality standards are not applicable for sites SACNa, b, 01, 06, 08, and 10).

Table 8. Minnesota water quality standards (MnRule 7050.0220) for monitored variables, based on designated use classifications (MnRule 7050.0200) that apply to St. Croix National Scenic Riverway 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. The most conservative values are used when differences occur among use classifications.

Water Quality Parameter	Designated Water Use Classifications
	1B & C, 2Bd, 3B, 3C, 4A, 4B, 5, 6 (sites 2, 3 ¹ 4, 5, 7, 9, 11)
Temperature (°F)	± 5 of natural
pH (standard units)	6.50–8.50
Dissolved oxygen (mg/L)	5 daily min
Specific conductance (µS/cm)	1000
Nitrate+nitrite nitrogen (mg/L-N) - Federal drinking water standard	10
Nitrate+nitrite nitrogen (mg/L-N) – draft acute/chronic toxicity standard for MN ²	41/4.9
Ammonia, unionized (ug/L-N)	40
Chloride (mg/L) ³	860/230
Sulfate (mg/L)	10, for wild rice
Sodium (% total cations)	60%

¹Site 3 has designated water use classifications 2B, 3B, 4A, 4B, 5, and 6.

²Draft criteria (Monson and Preimesberger 2010). Draft acute value (maximum standard) is for a 1-day duration, and the draft chronic value is for a 4-day duration.

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

Dissolved oxygen concentrations were less than 5 mg/L below the thermocline in July and August (Figure 4) for sites SACN07 and SACN11, and for SACN11 in September. Although not

thermally stratified in 2011, dissolved oxygen concentrations were at or just below 5 mg/L at SACN09 in July and August. All other standards listed in Table 8 were met during the 2011 sampling season.

Wisconsin

The State of Wisconsin categorizes all waters of the state according to the following designated uses (NR 102.04):

- Fish and Other Aquatic Life Uses – Cold water communities, warm water sport fish communities, warm water forage communities, limited forage fish communities, limited aquatic life (marginal surface water).
- Recreational Use – A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion determining suitability for recreational use.
- Public Health and Welfare – All surface waters shall meet the human threshold and human cancer criteria specified in NR 105.08 and NR 105.09, respectively.
- Wildlife Use – All surface waters shall be classified for wildlife uses and meet the wildlife criteria specified in NR 105.07.

In accordance with Wisconsin's NR102 Uses and Designated Standards, "the St. Croix River has high scenic and aesthetic value and is used for recreation, fishing, hydropower, commercial shipping, stock and wildlife water supply, and waste assimilation. Its water shall meet the standards and requirements for recreational use and fish and aquatic life. ...standards for public water supply shall be met downstream of the north line of Polk County."

The three parameters that apply to the suite of water quality characteristics monitored by the Network are dissolved oxygen, pH, and phosphorus. NR 102.04(4) states that "dissolved oxygen may not be lowered to less than 5 mg/L at any time. Dissolved oxygen in classified trout streams...may not be artificially lowered to less than 6.0 mg/L, nor 7.0 mg/L during spawning. ...pH shall be maintained between 6.0 to 9.0 with no change greater than 0.5 units outside estimated natural seasonal maximum and minimum." NR 102.06 was enacted in December 2010 and identifies water quality criteria for total phosphorus for surface waters, including but not limited to streams, rivers, reservoirs, and lakes. Wisconsin total phosphorus standards applicable to monitoring sites at SACN range from 40 µg/L to 100 µg/L, depending on the location of the site (Table 9).

Wisconsin standards for dissolved oxygen were met at most applicable monitoring sites; exceptions were two stations (SACN07 and SACN11) on Lake St. Croix that had low dissolved oxygen levels in the lower water column during summer stratification (discussed earlier), and SACN09, where dissolved oxygen was at or just below the standard in July and August. Wisconsin standards for pH were not exceeded, but pH values at the Willow River (Lake Mallalieu, SACN08) were near the standard of 9.0 from May through September, with near surface monthly means ranging from 8.7 to 8.9. Mean TP concentrations at sites SACNa, b, 01, 02, 04, 05, 06, and 10 did not exceed Wisconsin TP standards in 2011 (Table 9).

Lake St. Croix (SACN07, 09, 11) and the Willow River (Lake Mallalieu, SACN08) will be subject to site-specific TP standards (Table 9). These standards were derived through

development of TMDL plans currently being implemented (MPCA and WDNR 2012) or under review (WDNR 2011). Mean summer (June–September) TP for SACN08 in 2011 was 62 ug/L, exceeding the draft standard of 45 ug/L. Mean summer TP for Lake St. Croix (SACN07, 09, 11) was 54.1 ug/L, exceeding the standard of 40 ug/L.

Table 9. Wisconsin (total phosphorus [TP] only) and Minnesota eutrophication and water clarity standards for rivers and lakes applicable at St. Croix National Scenic Riverway water quality monitoring sites^{1,2}. Dash (-) = not applicable.

Site	Wisconsin	Minnesota			
	TP (ug/L)	TP (ug/L)	Chl- <i>a</i> (ug/L)	Secchi Disc (m)	TSS (mg/L)
SACNa	75 ³	-	-	-	-
SACNb	75 ³	-	-	-	-
SACN01	75 ³	-	-	-	-
SACN02	100 ³	55 ⁶	10 ⁶	-	15 ⁷
SACN03	-	100 ⁶	20 ⁶	-	30 ⁷
SACN04	100 ³	55 ⁶	10 ⁶	-	15 ⁷
SACN05	100 ³	55 ⁶	10 ⁶	-	15 ⁷
SACN06	100 ³	-	-	-	-
SACN07	40 ²	40 ⁴	14 ⁵	1.4 ⁵	-
SACN08	45 ¹	-	-	-	-
SACN09	40 ⁴	40 ⁴	14 ⁵	1.4 ⁵	-
SACN10	75 ³	-	-	-	-
SACN11	40 ⁴	40 ⁴	14 ⁵	1.4 ⁵	-

¹Based on the Draft Willow River TMDL (WDNR 2011).

²Draft Minnesota criteria for diurnal DO flux and BOD are also provided in Heiskary et al. (2010) but are not shown since these parameters are not monitored by GLKN staff.

³Based on WDNR phosphorus standards published December 2010 (WDNR 2010).

⁴Based on the Lake St. Croix Nutrient TMDL (MPCA and WDNR 2012).

⁵Based on Deep Lake Eutrophication Standards (NCHF) for MN (Minnesota Rule 7050.0222 Subp. 4. Class 2B Waters).

⁶Based on draft nutrient criteria for rivers in Minnesota (Heiskary et al. 2010, Heiskary and Parson 2010).

⁷Based on draft TSS criteria for Minnesota rivers (Heiskary and Parson 2010, Markus 2010).

Lake St. Croix is also subject to chl-*a* and Secchi disc criteria as per Minnesota Rules Chapter 7050. In 2011, mean summer chl-*a* and Secchi disc values at Lake St. Croix were 5.4 ug/L and 1.4 m, respectively, within reference criteria.

As stated earlier, in 2010 the MPCA developed draft eutrophication and TSS standards for rivers. SACN sites 02, 04, and 05 fall within Minnesota's North River Nutrient Region, with its associated draft values for TP, chl-*a*, and TSS. SACN site 03 at the Snake River falls within the Central River Nutrient Region, with higher standards for eutrophication and TSS (Table 9). The draft eutrophication and TSS standards were not exceeded at these sites in 2011.

Federal

Water quality eutrophication standards for Minnesota and Wisconsin (see Table 9) are both regional and site-specific, and are designed to protect aquatic life. State water quality standards are (and continue to be) informed in part by the development of nutrient reference criteria by the U.S. Environmental Protection Agency (USEPA). The reference criteria are based on the 25th percentile of all data in a particular ecoregion (USEPA 2000a, 2000b, 2000c, 2000d, 2001). In some cases the reference criteria are stringent, especially when the dataset from which they were derived consisted largely of data collected from relatively unimpacted pristine waters.

Conversely, the reference criteria may not be adequate to protect designated uses if the dataset from which they were derived contained data mostly collected from highly impacted waters. Reference criteria are designed to act as a starting point for states and tribes for establishment of their own criteria for water quality standards. We compare our water quality data collected at SACN to ecoregion-specific benchmarks proposed by the USEPA because the criteria are designed to be protective of designated uses and they typically represent good water quality conditions.

The USEPA has recommended nutrient reference criteria for two broad categories of water resources: rivers and streams, and lakes and reservoirs (Table 10). Water quality sites in the upper reaches of the park (SACNa, b, 01, and 02) generally were at or somewhat exceeded nutrient reference conditions, which is not unexpected since nutrient levels are typically positively correlated with higher flows, such as those that occurred at SACN in 2011. Mainstem and tributary sites farther downstream (SACN03, 04, 06, and 10) exceeded nutrient reference conditions throughout the sampling season. As discussed earlier, mean NO₃+NO₂-N concentration in the Kinnickinnic River was much higher (5.22 mg/L) than the recommended reference criterion (1.97 mg/L). However, mean TP concentration (37.1 µg/L) was below the recommended reference criterion (118.13 µg/L). Nutrient and water clarity reference criteria were also exceeded on most occasions for the lake sites at SACN, and, as discussed earlier, Lake St. Croix has been listed by Minnesota and Wisconsin as impaired for excessive nutrients (phosphorus).

Table 10. U.S. Environmental Protection Agency recommended nutrient and water clarity reference criteria for water quality monitoring sites at St. Croix National Scenic Riverway (USEPA 2000a, 2000b, 2000c, 2000d, 2001).

Water Resource	Ecoregion/ subecoregion	Site	TN (mg/L)	NO₃+NO₂-N (mg/L)	TP (µg/L)	Secchi disc (m)
Rivers & Streams	VII/47	10	3.26	1.965	118.13	-
	VII/51	06	0.71	0.13	28.75	-
	VIII/50	a, b, 01, 02, 03, 04	0.44	0.03	12	-
Lakes & Reservoirs	VII/51	07, 08, 09, 11	0.81	0.008	20	3.2
	VIII/50	05	0.40	0.003	9.69	4.2

It is worth noting that the USEPA's reference criteria for TP applicable to site SACN10 (118.13 ug/L) is *higher* than the State of Wisconsin's TP eutrophication standard (75 ug/L) for that site. Ecoregion VI, subcoregion 47, is dominated by extensive highly productive cropland with nutrient-rich soils (USEPA 2000b). Elevated nutrient concentrations are a significant water quality problem in this ecoregion, and the dataset used to derive nutrient reference conditions was probably heavily represented by data from water samples collected from impacted waters. The State of Wisconsin's more restrictive total phosphorus water quality standard represents a refinement of the USEPA's starting point and is more likely to be protective of aquatic life than the USEPA's nutrient reference condition criteria.

Quality Assurance and Quality Control

Network quality assurance criteria stipulate 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). Most 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 (Table 11). 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 11. List of water quality samples from St. Croix National Scenic Riverway in 2011 not meeting Network quality assurance criteria.

Site	Sample Date	Parameter	Relative Percent (%) Difference	Values	Detection Limit
B	4/11/11	K ⁺	10.7	0.53, 0.59 mg/L	0.08 mg/L
07	10/5/11	Chl- <i>a</i>	71.2	3.9, 8.3 ug/L	0.14 ug/L
09	11/9/11	TSS	100.0	1, 3 mg/L	1 mg/L

Comments and Recommendations

All sampling took place as scheduled at SACN in 2011, which represents the third full season of monitoring at the park since GLKN implemented the Large Rivers Protocol in 2007. All data are available to the public through the USEPA's STORET database. A summary of water quality data from SACN for 2011 is provided in Appendix A. A comparison of results from 2007 through 2011 is provided in Appendix B.

The next section outlines some developments in Minnesota and Wisconsin that may be relevant to the water quality monitoring effort at SACN, followed by some site-specific and general comments.

Statewide

Minnesota

The State of Minnesota draft river nutrient criteria (Heiskary et al. 2010) uses long-term historical water quality data to propose regional river nutrient criteria. The St. Croix River upstream of Stillwater, MN, along the Minnesota-Wisconsin border, is assigned to the Northern River Nutrient Region, based on analysis of long-term water quality data collected statewide. Minnesota has also developed regionally-based draft standards for total suspended solids (Markus 2010) based on the same river nutrient regions used to develop river nutrient criteria. Monitoring sites at which these draft standards apply are shown in Table 9.

Wisconsin

In December 2010, the State of Wisconsin enacted NR 102.06, which sets standards for total phosphorus in surface waters of the state (lakes, rivers, streams). As shown earlier (see Table 9), these standards are applicable to many of the Network's water quality monitoring sites at SACN, and the State will use them to determine impairment (or lack thereof) caused by total phosphorus in the future.

Site-specific

The Lake St. Croix TMDL is a joint effort between the states of Minnesota and Wisconsin that sets limits for annual loading of total phosphorus to the lake. The plan was recently approved by the USEPA and sets TP load limits for sub-watersheds within the St. Croix Basin. A draft TMDL for the Willow River is also being reviewed by the State of Wisconsin, and once approved and implemented should lead to improved water quality in the Willow River, including Lake Mallalieu.

Mean summer (June-September) TP for the Willow River (Lake Mallalieu, SACN08) in 2011 was 62.0 ug/L, exceeding the draft standard of 45 ug/L. Mean summer TP for Lake St. Croix (SACN07, 09, 11) was 37.9 ug/L, which is less than the draft standard of 40 ug/L. Future monitoring at SACN will allow for additional comparisons with State and site-specific water quality criteria and be valuable in assessing future impairments or improvements. The Network expects to continue monitoring water quality in SACN, with the next full season of water quality monitoring scheduled to take place in 2013.

General

Researchers from other organizations are increasingly utilizing water quality data collected at SACN by GLKN staff, as it relates to ongoing research and analysis. Examples of projects include a baseline assessment of zooplankton abundance and diversity in Lake St. Croix prior to invasion by Asian carp (four species present a threat to the Great Lakes region, but two are of particular concern at SACN: silver carp [*Hypophthalmichthys molitrix*] and bighead carp [*Hypophthalmichthys nobilis*]); a nutrient and ecological health assessment of Lake St. Croix; and an effort to model productivity and fish habitat responses to changes in nutrient loading and climate in Lake St. Croix. These and similar projects are important collaborations among agencies that help GLKN and SACN address key monitoring questions proposed in the Large Rivers Water Quality Monitoring Protocol (Magdalene et al. 2008a).

Monthly (April–November) water quality monitoring took place in 2007, 2009, and 2011, and represents three full monitoring years of water quality data. Consideration should be given to conducting a more in-depth analysis of change, using statistical methods such as repeated-measures, time-series, regression, and others. At a minimum, an analysis of correlation between flow and GLKN water quality parameters should be completed to better understand annual and/or seasonal variability as it relates to river flow.

Lastly, the GLKN water quality monitoring effort at SACN should be re-assessed in the context of water quality monitoring conducted by other agencies and organizations to avoid duplication of effort. If duplication of effort is occurring, and the water quality monitoring by other agencies is determined to be of high quality and long-term in nature, then some consideration should be given for GLKN to stop monitoring at these sites and potentially begin monitoring at other spatially underrepresented areas of the river.

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Appendix A: Descriptive statistics for monitoring sites in the St. Croix National Scenic Riverway, as entered in NPStoret.



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_01

Station Name: Namekagon River at North Road Just West of Earl, WI

Analysis for 2011

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	4/11/2011 - 10/3/2011	3	0	3	42	79	56	---	20.07	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2011 - 11/7/2011	8	3	8	1.5	34.19	12.55	---	10.44	---	---	---	---
Calcium	mg/l	4/11/2011 - 10/3/2011	3	0	3	14.5	21.8	19.23	---	4.104	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	0.7332	4.51	2.207	---	1.215	---	---	---	---
Chloride_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	3.8	5.7	5.033	---	1.069	---	---	---	---
DO%_HL_MS5.0	%	4/11/2011 - 11/7/2011	15	0	15	71.5	95.7	88.66	89.8	7.538	71.68	87.5	94.1	95.7
DO_HL_MS5.0	mg/l	4/11/2011 - 11/7/2011	15	0	15	6.01	12.03	8.821	9.25	1.836	6.028	7.43	9.74	12.02
DOC	mg/l	4/11/2011 - 10/3/2011	3	0	3	4.7	10	6.767	---	2.836	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2011 - 11/7/2011	15	0	15	109.9	182.3	155.9	154.2	25.7	110	138.3	179.7	181.2
Magnesium	mg/l	4/11/2011 - 10/3/2011	3	0	3	4.11	6.52	5.647	---	1.335	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	50.92	178.7	118.3	---	41.19	---	---	---	---
pH_HL_MS5.0	None	4/11/2011 - 11/7/2011	15	0	15	7.29	8.02	7.637	7.64	0.2176	7.296	7.48	7.72	7.96
converted pH	None					7.29	8.02	7.587	7.64	0.0133	7.296	7.48	5.126	5.137
H+ computed from pH	µeq/l					0.0095	0.0513	0.0259	0.0229	0.0133	0.011	0.0191	0.0331	0.0506
Potassium	mg/l	4/11/2011 - 10/3/2011	3	0	3	0.66	1	0.7767	---	0.1935	---	---	---	---
Silicate	mg/l	4/11/2011 - 10/3/2011	3	0	3	9.99	12.6	11.33	---	1.306	---	---	---	---
Sodium	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.79	3.76	3.43	---	0.5543	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	3.79	5.03	4.503	---	0.6407	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2011 - 11/7/2011	15	0	15	4.62	24.21	14.9	12.24	6.674	4.626	9.52	21.07	24.2
Total Nitrogen_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	327.1	1040	552.8	---	236.2	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	18.77	55.5	28.99	---	12.05	---	---	---	---
Total Suspended Solids	mg/l	4/11/2011 - 11/7/2011	8	0	8	2	16	6.25	---	4.713	---	---	---	---
Transparency Tube	cm	4/11/2011 - 11/7/2011	8	4	8	61.05	132	111.1	---	26.84	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_02

Station Name: St. Croix River Just Upstream from Norway Point Boat Landing

Analysis for 2011

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	4/13/2011 - 10/4/2011	3	0	3	28	62	47.67	---	17.62	---	---	---	---
Ammonium_SCRS	µg/l	4/13/2011 - 11/8/2011	8	3	8	1.5	36.16	12.39	---	11.78	---	---	---	---



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_02

Station Name: St. Croix River Just Upstream from Norway Point Boat Landing

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Calcium	mg/l	4/13/2011 - 10/4/2011	3	0	3	8.3	18.2	14.43	---	5.358	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	2.31	6.6	3.5	---	1.345	---	---	---	---
Chloride_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	2	4.3	3.3	---	1.179	---	---	---	---
DO%_HL_MS5.0	%	4/13/2011 - 11/8/2011	26	0	26	65.9	94.3	86.55	88.95	8.066	66.21	85.38	90.82	94.23
DO_HL_MS5.0	mg/l	4/13/2011 - 11/8/2011	26	0	26	5.59	12.06	8.51	8.53	1.891	5.614	6.935	9.92	12.03
DOC	mg/l	4/13/2011 - 10/4/2011	3	0	3	6.3	12	9.767	---	3.044	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/13/2011 - 11/8/2011	26	0	26	65.8	158.4	123.5	125.8	32.55	66.1	100.4	153.7	157.9
Magnesium	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.65	5.72	4.617	---	1.707	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	25.56	70.31	56.11	---	15.14	---	---	---	---
pH_HL_MS5.0	None	4/13/2011 - 11/8/2011	26	0	26	6.97	7.63	7.4	7.485	0.2016	7.047	7.278	7.552	7.606
converted pH	None					6.97	7.63	7.351	7.485	0.0241	7.047	7.277	5.138	5.152
H+ computed from pH	µeq/l					0.0234	0.1072	0.0446	0.0327	0.0241	0.0248	0.028	0.0528	0.0897
Potassium	mg/l	4/13/2011 - 10/4/2011	3	0	3	0.6	0.79	0.6733	---	0.1021	---	---	---	---
Silicate	mg/l	4/13/2011 - 10/4/2011	3	0	3	8.28	10.9	9.61	---	1.31	---	---	---	---
Sodium	mg/l	4/13/2011 - 10/4/2011	3	0	3	1.76	3.01	2.503	---	0.6577	---	---	---	---
Sulfate_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.4	4.02	3.347	---	0.8439	---	---	---	---
Temp_HL_MS5.0	°C	4/13/2011 - 11/8/2011	26	0	26	4.37	24.39	16.16	16.4	6.586	4.41	9.348	21.79	24.36
Total Nitrogen_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	380.4	1209	639.2	---	256.2	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	24.34	68.09	36.21	---	14.1	---	---	---	---
Total Suspended Solids	mg/l	4/13/2011 - 11/8/2011	8	0	8	2	8	5.5	---	2.138	---	---	---	---
Transparency Tube	cm	4/13/2011 - 11/8/2011	8	3	8	67	132	107.7	---	25.12	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_03

Station Name: Snake River Approx. 1/2 Mile Upstream of the St. Croix River

Analysis for 2011

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	4/11/2011 - 10/3/2011	3	0	3	38	102	72	---	32.19	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2011 - 11/7/2011	8	3	8	1.5	25.62	10.65	---	9.226	---	---	---	---
Calcium	mg/l	4/11/2011 - 10/3/2011	3	0	3	9.81	27.1	18.87	---	8.675	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	1.72	13.08	4.985	---	3.978	---	---	---	---



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_03

Station Name: Snake River Approx. 1/2 Mile Upstream of the St. Croix River

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Chloride_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.9	7.4	4.933	---	2.281	---	---	---	---
DO%_HL_MS5.0	%	4/11/2011 - 11/7/2011	12	0	12	85.5	131.4	105.3	108.6	12.2	87.24	96.35	112.1	125.9
DO_HL_MS5.0	mg/l	4/11/2011 - 11/7/2011	12	0	12	7.52	13.25	9.77	9.735	2.171	7.547	7.74	11.9	13.24
DOC	mg/l	4/11/2011 - 10/3/2011	3	0	3	12	18	14.33	---	3.215	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2011 - 11/7/2011	12	0	12	84.3	260.7	179.3	167.7	55.68	92.85	137.8	228.9	260.6
Magnesium	mg/l	4/11/2011 - 10/3/2011	3	0	3	3.73	10.5	7.173	---	3.387	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	19.44	192.4	99.33	---	58.21	---	---	---	---
pH_HL_MS5.0	None	4/11/2011 - 11/7/2011	12	0	12	7.03	8.63	8.018	8.165	0.481	7.135	7.682	8.405	8.573
converted pH	None					7.03	8.63	7.738	8.167	0.0262	7.109	7.674	5.115	5.148
H+ computed from pH	µeq/l					0.0023	0.0933	0.0183	0.0068	0.0262	0.0027	0.004	0.0212	0.0778
Potassium	mg/l	4/11/2011 - 10/3/2011	3	0	3	1.05	1.53	1.333	---	0.2515	---	---	---	---
Silicate	mg/l	4/11/2011 - 10/3/2011	3	0	3	7.99	9.48	8.55	---	0.811	---	---	---	---
Sodium	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.25	4.85	3.403	---	1.325	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.2	4.45	3.083	---	1.2	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2011 - 11/7/2011	12	0	12	6.58	28.16	18.65	21.66	8.318	6.58	9.08	25.69	28.16
Total Nitrogen_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	641.9	1201	942.7	---	213.2	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	21.49	104.4	57.19	---	28.01	---	---	---	---
Total Suspended Solids	mg/l	4/11/2011 - 11/7/2011	8	0	8	1	17	6.375	---	5.29	---	---	---	---
Transparency Tube	cm	4/11/2011 - 11/7/2011	8	4	8	73.55	132	109.3	---	25.95	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_04

Station Name: St. Croix River About 1 Mile Above Nevers Dam Boat Landing

Analysis for 2011

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	4/13/2011 - 10/4/2011	3	0	3	31	67	50.33	---	18.15	---	---	---	---
Ammonium_SCRS	µg/l	4/13/2011 - 11/8/2011	8	3	8	1.5	24.54	9.77	---	7.806	---	---	---	---
Calcium	mg/l	4/13/2011 - 10/4/2011	3	0	3	9	21	15.93	---	6.214	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	1.49	5.29	3.209	---	1.257	---	---	---	---
Chloride_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.6	4.9	3.933	---	1.193	---	---	---	---
DO%_HL_MS5.0	%	4/13/2011 - 11/8/2011	29	0	29	74.8	97.7	88.76	91.8	7.467	75	84.2	94.05	97.5



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_04

Station Name: St. Croix River About 1 Mile Above Nevers Dam Boat Landing

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
DO_HL_MS5.0	mg/l	4/13/2011 - 11/8/2011	29	0	29	6.26	12.34	8.629	8.93	1.74	6.28	7.155	9.585	12.33
DOC	mg/l	4/13/2011 - 10/4/2011	3	0	3	5.8	14	10.93	---	4.474	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/13/2011 - 11/8/2011	29	0	29	74.9	183.7	132.2	128.3	38.29	75.2	103.5	173	182.3
Magnesium	mg/l	4/13/2011 - 10/4/2011	3	0	3	3.17	7.01	5.46	---	2.024	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	42.86	145.4	88.84	---	37.35	---	---	---	---
pH_HL_MS5.0	None	4/13/2011 - 11/8/2011	29	0	29	7.17	7.9	7.529	7.58	0.2661	7.18	7.215	7.77	7.89
converted pH	None					7.17	7.9	7.453	7.58	0.0206	7.18	7.215	5.142	5.144
H+ computed from pH	µeq/l					0.0126	0.0676	0.0352	0.0263	0.0206	0.0129	0.017	0.061	0.0661
Potassium	mg/l	4/13/2011 - 10/4/2011	3	0	3	0.78	1.03	0.9333	---	0.1343	---	---	---	---
Silicate	mg/l	4/13/2011 - 10/4/2011	3	0	3	8.06	11	9.987	---	1.669	---	---	---	---
Sodium	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.09	3.76	2.993	---	0.8433	---	---	---	---
Sulfate_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.4	4.52	3.5	---	1.062	---	---	---	---
Temp_HL_MS5.0	°C	4/13/2011 - 11/8/2011	29	0	29	4.9	24.93	16.58	15.57	6.659	4.94	9.22	21.98	24.89
Total Nitrogen_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	432.9	1246	718.8	---	258.4	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	21.82	77.47	40.16	---	18.06	---	---	---	---
Total Suspended Solids	mg/l	4/13/2011 - 11/8/2011	8	0	8	2	9	6.125	---	2.696	---	---	---	---
Transparency Tube	cm	4/13/2011 - 11/8/2011	8	2	8	62.65	132	92.69	---	27.1	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_05

Station Name: St. Croix River Just Upstream from the St. Croix Falls Dam

Analysis for 2011

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	4/13/2011 - 10/4/2011	3	0	3	34	88	67	---	28.93	---	---	---	---
Ammonium_SCRS	µg/l	4/13/2011 - 11/8/2011	8	4	8	1.5	32.12	11.54	---	11.14	---	---	---	---
Calcium	mg/l	4/13/2011 - 10/4/2011	3	0	3	9.67	23.7	17.86	---	7.303	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/13/2011 - 11/8/2011	8	0	8	2.06	5.96	3.644	---	1.346	---	---	---	---
Chloride_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	3.1	6.1	4.9	---	1.587	---	---	---	---
DO%_HL_MS5.0	%	4/13/2011 - 11/8/2011	52	0	52	72.5	101.6	88.94	89.95	7.22	73.63	85.8	94.22	95.65
DO_HL_MS5.0	mg/l	4/13/2011 - 11/8/2011	52	0	52	6.14	11.77	8.677	9.015	1.759	6.223	6.855	9.812	11.69
DOC	mg/l	4/13/2011 - 10/4/2011	3	0	3	6.9	13	10.97	---	3.522	---	---	---	---



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_05

Station Name: St. Croix River Just Upstream from the St. Croix Falls Dam

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
EC25_HL_MS5.0	μS/cm	4/13/2011 - 11/8/2011	52	0	52	82.5	202.6	152.9	154.2	42.23	83.73	119.9	194	200.8
Magnesium	mg/l	4/13/2011 - 10/4/2011	3	0	3	3.4	7.81	6.023	---	2.321	---	---	---	---
Nitrate+Nitrite_SCRS	μg/l	4/13/2011 - 11/8/2011	8	0	8	68.64	189.5	139.8	---	42.28	---	---	---	---
pH_HL_MS5.0	None	4/13/2011 - 11/8/2011	52	0	52	7.08	8.01	7.589	7.595	0.3081	7.103	7.21	7.85	7.917
converted pH	None					7.08	8.01	7.478	7.595	0.0253	7.103	7.207	5.142	5.149
H+ computed from pH	μeq/l					0.0098	0.0832	0.0333	0.0254	0.0253	0.0121	0.0141	0.0621	0.0789
Potassium	mg/l	4/13/2011 - 10/4/2011	3	0	3	0.85	1.09	0.99	---	0.1249	---	---	---	---
Secchi Depth	m	5/12/2011 - 11/8/2011	6	0	6	0.95	2.8	1.659	---	0.6976	---	---	---	---
Silicate	mg/l	4/13/2011 - 10/4/2011	3	0	3	8.26	11.2	10.02	---	1.553	---	---	---	---
Sodium	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.18	4.06	3.267	---	0.9737	---	---	---	---
Sulfate_Filtered	mg/l	4/13/2011 - 10/4/2011	3	0	3	2.7	4.91	3.823	---	1.105	---	---	---	---
Temp_HL_MS5.0	°C	4/13/2011 - 11/8/2011	52	0	52	5.75	26.63	16.56	15.78	6.752	5.971	9.552	21.72	25.64
Total Nitrogen_SCRS	μg/l	4/13/2011 - 11/8/2011	8	0	8	503.9	1213	774.9	---	223	---	---	---	---
Total Phosphorus_SCRS	μg/l	4/13/2011 - 11/8/2011	8	0	8	22.42	78.33	40.56	---	17.91	---	---	---	---
Total Suspended Solids	mg/l	4/13/2011 - 11/8/2011	8	0	8	2	11	5.125	---	3.227	---	---	---	---
Transparency Tube	cm	4/13/2011 - 11/8/2011	8	2	8	68.95	132	92.54	---	25.69	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_06

Station Name: Apple River Approx. 1/2 Mile Upstream of the St. Croix River

Analysis for 2011

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	4/14/2011 - 10/6/2011	3	0	3	81	137	113.7	---	29.14	---	---	---	---
Ammonium_SCRS	μg/l	4/14/2011 - 11/10/2011	8	1	8	4	76.84	36.93	---	26.58	---	---	---	---
Calcium	mg/l	4/14/2011 - 10/6/2011	3	0	3	20.7	32.4	28.1	---	6.437	---	---	---	---
chl_a(fluor)_SCRS	μg/l	4/14/2011 - 11/10/2011	8	0	8	2.37	10.42	5.668	---	2.954	---	---	---	---
Chloride_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	6.1	10	8.6	---	2.17	---	---	---	---
DO%_HL_MS5.0	%	4/14/2011 - 11/10/2011	10	0	10	83.5	103.3	94.65	96.1	5.782	84.02	89.6	97.98	102.9
DO_HL_MS5.0	mg/l	4/14/2011 - 11/10/2011	10	0	10	6.93	12.96	9.43	9.55	1.859	6.982	7.48	10.82	12.75
DOC	mg/l	4/14/2011 - 10/6/2011	3	0	3	4.8	7.1	5.567	---	1.328	---	---	---	---
EC25_HL_MS5.0	μS/cm	4/14/2011 - 11/10/2011	10	0	10	174.2	297.7	254.1	265.1	47.55	174.2	226.4	293.3	297.7



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_06

Station Name: Apple River Approx. 1/2 Mile Upstream of the St. Croix River

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Magnesium	mg/l	4/14/2011 - 10/6/2011	3	0	3	7.54	14.1	11.65	---	3.579	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	409.2	780.8	636.7	---	153.4	---	---	---	---
pH_HL_MS5.0	None	4/14/2011 - 11/10/2011	10	0	10	7.6	8.06	7.87	7.93	0.1698	7.604	7.685	8.028	8.059
converted pH	None					7.6	8.06	7.839	7.928	0.006	7.604	7.684	5.114	5.119
H+ computed from pH	µeq/l					0.0087	0.0251	0.0145	0.0118	0.006	0.0087	0.0094	0.0207	0.0249
Potassium	mg/l	4/14/2011 - 10/6/2011	3	0	3	1.01	1.68	1.363	---	0.3365	---	---	---	---
Silicate	mg/l	4/14/2011 - 10/6/2011	3	0	3	9.59	17	14	---	3.899	---	---	---	---
Sodium	mg/l	4/14/2011 - 10/6/2011	3	0	3	3.29	4.6	4.123	---	0.7242	---	---	---	---
Sulfate_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	4.5	6.56	5.73	---	1.087	---	---	---	---
Temp_HL_MS5.0	°C	4/14/2011 - 11/10/2011	10	0	10	5.06	23.24	15.66	14.66	5.968	5.617	10.64	22.05	23.21
Total Nitrogen_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	940.6	1321	1162	---	124.9	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	31.45	105.9	59.49	---	24.52	---	---	---	---
Total Suspended Solids	mg/l	4/14/2011 - 11/10/2011	8	0	8	2	11	4.5	---	2.777	---	---	---	---
Transparency Tube	cm	4/14/2011 - 11/10/2011	8	4	8	88.3	132	113.7	---	20.95	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_07

Station Name: Pool #1 of Lake St. Croix near Bayport, MN

Analysis for 2011

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	4/12/2011 - 10/5/2011	3	0	3	38	101	70.67	---	31.56	---	---	---	---
Ammonium_SCRS	µg/l	4/12/2011 - 11/9/2011	8	2	8	4	86.97	27.52	---	27.9	---	---	---	---
Calcium	mg/l	4/12/2011 - 10/5/2011	3	0	3	10.9	25.9	18.87	---	7.543	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	2.72	10.99	6.696	---	2.853	---	---	---	---
Chloride_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	3.6	8	5.667	---	2.212	---	---	---	---
DO%_HL_MS5.0	%	4/12/2011 - 11/9/2011	98	0	98	2.5	119.8	81.39	81	21.79	60.45	70.4	95.95	106.2
DO_HL_MS5.0	mg/l	4/12/2011 - 11/9/2011	98	0	98	0.23	12.65	8.05	7.545	2.919	5.228	5.85	11.11	11.38
DOC	mg/l	4/12/2011 - 10/5/2011	3	0	3	6.7	15	11.23	---	4.203	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/12/2011 - 11/9/2011	98	0	98	90.8	231.4	158.5	147.4	49.69	91.78	115.9	209.4	227.9
Magnesium	mg/l	4/12/2011 - 10/5/2011	3	0	3	3.71	9.46	6.69	---	2.881	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	87.32	299.8	194.4	---	69.2	---	---	---	---



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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_07

Station Name: Pool #1 of Lake St. Croix near Bayport, MN

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
pH_HL_MS5.0	None	4/12/2011 - 11/9/2011	98	0	98	6.89	8.31	7.389	7.35	0.3302	7	7.155	7.608	7.802
converted pH	None					6.89	8.31	7.289	7.35	0.031	7	7.155	5.145	5.155
H+ computed from pH	µeq/l					0.0049	0.1288	0.0514	0.0447	0.031	0.0158	0.0247	0.07	0.1
Potassium	mg/l	4/12/2011 - 10/5/2011	3	0	3	0.93	1.18	1.053	---	0.125	---	---	---	---
Secchi Depth	m	4/12/2011 - 11/9/2011	8	0	8	0.775	1.6	1.259	---	0.3053	---	---	---	---
Silicate	mg/l	4/12/2011 - 10/5/2011	3	0	3	8.76	10.7	9.853	---	0.9932	---	---	---	---
Sodium	mg/l	4/12/2011 - 10/5/2011	3	0	3	2.46	4.78	3.557	---	1.165	---	---	---	---
Sulfate_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	3	5.73	4.117	---	1.431	---	---	---	---
Temp_HL_MS5.0	°C	4/12/2011 - 11/9/2011	98	0	98	7.01	27.01	16.58	16.81	6.802	8.15	8.42	22.22	25.18
Total Nitrogen VANDORN_SCRS	µg/l	7/12/2011 - 7/12/2011	1	0	1	1229	1229	1229	---	---	---	---	---	---
Total Nitrogen_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	702.2	1178	900.4	---	182.1	---	---	---	---
Total Phosphorus VANDORN_SCRS	µg/l	7/12/2011 - 7/12/2011	1	0	1	61.73	61.73	61.73	---	---	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	30	71.89	47.23	---	14.19	---	---	---	---
Total Suspended Solids	mg/l	4/12/2011 - 11/9/2011	8	0	8	3	6	4.5	---	0.9258	---	---	---	---
Transparency Tube	cm	4/12/2011 - 11/9/2011	8	0	8	57.55	98.05	83.01	---	14.65	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_08

Station Name: Lake Mallalieu (Willow River) Just East of Pub. Boat Launch

Analysis for 2011

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	4/14/2011 - 10/6/2011	3	0	3	106	175	146.7	---	36.12	---	---	---	---
Ammonium_SCRS	µg/l	4/14/2011 - 11/10/2011	8	3	8	1.5	70.28	19.15	---	23.87	---	---	---	---
Calcium	mg/l	4/14/2011 - 10/6/2011	3	0	3	27.5	42.2	34.5	---	7.375	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	5.72	32.86	17.25	---	9.903	---	---	---	---
Chloride_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	10.3	16.4	14.33	---	3.493	---	---	---	---
DO%_HL_MS5.0	%	4/14/2011 - 11/10/2011	35	0	35	76.6	201.4	135.5	144	30.72	92.12	107.5	152.1	188.1
DO_HL_MS5.0	mg/l	4/14/2011 - 11/10/2011	35	0	35	6.54	17.04	12.51	12.51	2.232	9.86	10.95	14.06	15.84
DOC	mg/l	4/14/2011 - 10/6/2011	3	0	3	2.3	6.1	4.067	---	1.914	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/14/2011 - 11/10/2011	35	0	35	252.3	420.6	364.7	365.8	47.7	255.5	344.9	404.4	420.4

Tuesday, September 04, 2012

Percentiles Calculated Using NIST Method

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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_08

Station Name: Lake Mallalieu (Willow River) Just East of Pub. Boat Launch

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Magnesium	mg/l	4/14/2011 - 10/6/2011	3	0	3	12.2	23.3	19	---	5.957	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	1356	3039	2128	---	532.7	---	---	---	---
pH_HL_MS5.0	None	4/14/2011 - 11/10/2011	35	0	35	7.75	8.9	8.498	8.6	0.341	7.9	8.28	8.79	8.838
converted pH	None					7.75	8.9	8.347	8.602	0.0043	7.9	8.284	5.082	5.102
H+ computed from pH	µeq/l					0.0013	0.0178	0.0045	0.0025	0.0043	0.0015	0.0016	0.0052	0.0126
Potassium	mg/l	4/14/2011 - 10/6/2011	3	0	3	1.44	3.12	2.003	---	0.9671	---	---	---	---
Secchi Depth	m	4/14/2011 - 11/10/2011	8	0	8	0.7	2.3	1.244	---	0.691	---	---	---	---
Silicate	mg/l	4/14/2011 - 10/6/2011	3	0	3	10.9	14.3	12.67	---	1.704	---	---	---	---
Sodium	mg/l	4/14/2011 - 10/6/2011	3	0	3	4.26	5.77	5.23	---	0.8418	---	---	---	---
Sulfate_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	8.32	12.2	10.31	---	1.942	---	---	---	---
Temp_HL_MS5.0	°C	4/14/2011 - 11/10/2011	35	0	35	5.61	24.66	18.03	19.36	6.219	5.63	14.97	23.92	24.07
Total Nitrogen_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	2149	3885	2883	---	561.1	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	30.63	100.3	57.68	---	24.42	---	---	---	---
Total Suspended Solids	mg/l	4/14/2011 - 11/10/2011	8	0	8	3	17	9.75	---	5.625	---	---	---	---
Transparency Tube	cm	4/14/2011 - 11/10/2011	8	2	8	47.8	132	79.99	---	35.33	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_09

Station Name: Pool #2 on Lake St. Croix Downstream of I94 Bridge in Hudson

Analysis for 2011

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	4/12/2011 - 10/5/2011	3	0	3	39	102	71	---	31.51	---	---	---	---
Ammonium_SCRS	µg/l	4/12/2011 - 11/9/2011	8	2	8	4	92.09	32.14	---	32.31	---	---	---	---
Calcium	mg/l	4/12/2011 - 10/5/2011	3	0	3	11.8	25.7	19.03	---	6.967	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	2.73	11.39	7.52	---	3.438	---	---	---	---
Chloride_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	4.1	8.8	6.333	---	2.359	---	---	---	---
DO%_HL_MS5.0	%	4/12/2011 - 11/9/2011	67	0	67	46.1	104.1	83.69	89.7	15.02	62.74	72.3	96.2	100.9
DO_HL_MS5.0	mg/l	4/12/2011 - 11/9/2011	67	0	67	3.84	12.16	8.189	7.68	2.562	5.016	6.08	11.37	11.64
DOC	mg/l	4/12/2011 - 10/5/2011	3	0	3	8.4	14	11.13	---	2.802	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/12/2011 - 11/9/2011	67	0	67	94.6	245.9	162.9	147.7	50.6	101.5	124.3	211.8	244.4
Magnesium	mg/l	4/12/2011 - 10/5/2011	3	0	3	4.1	10	7.11	---	2.952	---	---	---	---



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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_09

Station Name: Pool #2 on Lake St. Croix Downstream of I94 Bridge in Hudson

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Nitrate+Nitrite_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	128.3	415.2	270.9	---	115.2	---	---	---	---
pH_HL_MS5.0	None	4/12/2011 - 11/9/2011	67	0	67	7.09	7.97	7.455	7.43	0.2798	7.126	7.22	7.61	7.92
converted pH	None					7.09	7.97	7.378	7.429	0.0227	7.126	7.22	5.141	5.147
H+ computed from pH	µeq/l					0.0107	0.0813	0.0419	0.0372	0.0227	0.012	0.0245	0.0603	0.0748
Potassium	mg/l	4/12/2011 - 10/5/2011	3	0	3	0.93	1.31	1.113	---	0.1904	---	---	---	---
Secchi Depth	m	5/10/2011 - 11/9/2011	7	0	7	0.85	1.8	1.482	---	0.3648	---	---	---	---
Silicate	mg/l	4/12/2011 - 10/5/2011	3	0	3	9.01	11.4	10.34	---	1.217	---	---	---	---
Sodium	mg/l	4/12/2011 - 10/5/2011	3	0	3	2.57	4.67	3.61	---	1.05	---	---	---	---
Sulfate_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	3.18	5.89	4.373	---	1.384	---	---	---	---
Temp_HL_MS5.0	°C	4/12/2011 - 11/9/2011	67	0	67	7.2	26.43	17.08	18.53	6.783	7.704	8.52	23.17	24.48
Total Nitrogen_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	833.6	1250	1028	---	170.6	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	32.36	71.63	48.77	---	12.66	---	---	---	---
Total Suspended Solids	mg/l	4/12/2011 - 11/9/2011	8	0	8	1	5	3.75	---	1.488	---	---	---	---
Transparency Tube	cm	4/12/2011 - 11/9/2011	8	1	8	53.9	132	95.04	---	24.76	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_10

Station Name: Kinnickinnic River at County Highway F Bridge

Analysis for 2011

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	4/14/2011 - 10/6/2011	3	0	3	194	252	214	---	32.92	---	---	---	---
Ammonium_SCRS	µg/l	4/14/2011 - 11/10/2011	8	2	8	1.5	30.14	12.97	---	9.206	---	---	---	---
Calcium	mg/l	4/14/2011 - 10/6/2011	3	0	3	55.2	57.7	56.17	---	1.343	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	1.42	3.74	2.818	---	0.8242	---	---	---	---
Chloride_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	22.6	22.8	22.67	---	0.1155	---	---	---	---
DO%_HL_MS5.0	%	4/14/2011 - 11/10/2011	10	0	10	100.5	110	104.2	103.4	2.765	100.7	102.7	105.6	109.8
DO_HL_MS5.0	mg/l	4/14/2011 - 11/10/2011	10	0	10	9.91	12.97	11.04	10.74	0.9549	9.946	10.4	11.97	12.87
DOC	mg/l	4/14/2011 - 10/6/2011	3	0	3	2	2.4	2.167	---	0.2082	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/14/2011 - 11/10/2011	10	0	10	501.8	519.7	511.5	513.8	6.15	501.8	506.6	516.3	519.4
Magnesium	mg/l	4/14/2011 - 10/6/2011	3	0	3	25.8	26.8	26.43	---	0.5508	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	4915	5554	5216	---	226	---	---	---	---



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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_10

Station Name: Kinnickinnic River at County Highway F Bridge

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
pH_HL_MS5.0	None	4/14/2011 - 11/10/2011	10	0	10	7.95	8.25	8.117	8.11	0.0941	7.959	8.047	8.215	8.248
converted pH	None					7.95	8.25	8.108	8.108	0.0017	7.959	8.046	5.094	5.099
H+ computed from pH	µeq/l					0.0056	0.0112	0.0078	0.0078	0.0017	0.0056	0.0061	0.009	0.011
Potassium	mg/l	4/14/2011 - 10/6/2011	3	0	3	1.37	1.56	1.493	---	0.1069	---	---	---	---
Silicate	mg/l	4/14/2011 - 10/6/2011	3	0	3	11.2	14.2	12.63	---	1.504	---	---	---	---
Sodium	mg/l	4/14/2011 - 10/6/2011	3	0	3	7.54	8.36	8.007	---	0.4216	---	---	---	---
Sulfate_Filtered	mg/l	4/14/2011 - 10/6/2011	3	0	3	19	19.7	19.27	---	0.3786	---	---	---	---
Temp_HL_MS5.0	°C	4/14/2011 - 11/10/2011	10	0	10	5.67	16.29	12.04	11.94	3.546	5.969	8.66	15.8	16.24
Total Nitrogen_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	5463	6068	5730	---	180	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/14/2011 - 11/10/2011	8	0	8	29.28	48.68	37.09	---	6.553	---	---	---	---
Total Suspended Solids	mg/l	4/14/2011 - 11/10/2011	8	0	8	3	9	5.125	---	2.031	---	---	---	---
Transparency Tube	cm	4/14/2011 - 11/10/2011	8	8	8	132	132	132	---	0	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_11

Station Name: Pool #4 on Lake St. Croix near Prescott, WI

Analysis for 2011

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	4/12/2011 - 10/5/2011	3	0	3	60	99	78.33	---	19.6	---	---	---	---
Ammonium_SCRS	µg/l	4/12/2011 - 11/9/2011	8	1	8	1.5	72.5	39.46	---	23.02	---	---	---	---
Calcium	mg/l	4/12/2011 - 10/5/2011	3	0	3	17.2	26.6	20.97	---	4.97	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	1.92	9.76	4.208	---	2.702	---	---	---	---
Chloride_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	6.2	8.6	7.1	---	1.308	---	---	---	---
DO%_HL_MS5.0	%	4/12/2011 - 11/9/2011	130	0	130	2	98.8	70.62	74.45	19.71	50.84	56.22	86.6	90.5
DO_HL_MS5.0	mg/l	4/12/2011 - 11/9/2011	130	0	130	0.18	10.86	7.125	6.37	2.771	4.33	4.942	10.04	10.64
DOC	mg/l	4/12/2011 - 10/5/2011	3	0	3	10	14	11.67	---	2.082	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/12/2011 - 11/9/2011	130	0	130	143.5	258.2	185.8	183.7	39.31	144.8	147.1	199.6	257.6
Magnesium	mg/l	4/12/2011 - 10/5/2011	3	0	3	6.08	10	7.693	---	2.05	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	243	693.5	442.6	---	160	---	---	---	---



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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_11

Station Name: Pool #4 on Lake St. Croix near Prescott, WI

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
pH_HL_MS5.0	None	4/12/2011 - 11/9/2011	130	0	130	6.92	7.7	7.361	7.36	0.1602	7.191	7.258	7.43	7.676
converted pH	None					6.92	7.7	7.333	7.36	0.0171	7.191	7.257	5.139	5.143
H+ computed from pH	µeq/l					0.02	0.1202	0.0464	0.0437	0.0171	0.0211	0.0372	0.0553	0.0644
Potassium	mg/l	4/12/2011 - 10/5/2011	3	0	3	0.85	1.61	1.2	---	0.3835	---	---	---	---
Secchi Depth	m	5/10/2011 - 11/9/2011	7	0	7	1.525	2.025	1.793	---	0.183	---	---	---	---
Silicate	mg/l	4/12/2011 - 10/5/2011	3	0	3	9.86	13.3	11.29	---	1.793	---	---	---	---
Sodium	mg/l	4/12/2011 - 10/5/2011	3	0	3	3.5	4.51	3.92	---	0.526	---	---	---	---
Sulfate_Filtered	mg/l	4/12/2011 - 10/5/2011	3	0	3	4.25	5.67	4.77	---	0.7826	---	---	---	---
Temp_HL_MS5.0	°C	4/12/2011 - 11/9/2011	130	0	130	4.82	25.98	15.9	16.96	7.059	4.881	9.875	22.79	25.02
Total Nitrogen VANDORN_SCRS	µg/l	7/12/2011 - 7/12/2011	1	0	1	1220	1220	1220	---	---	---	---	---	---
Total Nitrogen_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	913.3	1318	1118	---	148.3	---	---	---	---
Total Phosphorus VANDORN_SCRS	µg/l	7/12/2011 - 7/12/2011	1	0	1	49.03	49.03	49.03	---	---	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/12/2011 - 11/9/2011	8	0	8	34.24	65.32	42.94	---	9.798	---	---	---	---
Total Suspended Solids	mg/l	4/12/2011 - 11/9/2011	8	0	8	1	3	2.5	---	0.7559	---	---	---	---
Transparency Tube	cm	4/12/2011 - 11/9/2011	8	6	8	91.65	132	124.4	---	15	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_A

Station Name: Upper St. Croix River at CCC Bridge

Analysis for 2011

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	4/11/2011 - 10/3/2011	3	1	3	25	52	40.33	---	13.87	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2011 - 11/7/2011	8	3	8	1.5	19.22	9.55	---	6.684	---	---	---	---
Calcium	mg/l	4/11/2011 - 10/3/2011	3	0	3	5.96	14.1	10.75	---	4.258	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2011 - 11/7/2011	7	2	7	0.22	2.07	1.017	---	0.6497	---	---	---	---
Chloride_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	1.4	2.6	2.1	---	0.6245	---	---	---	---
DO%_HL_MS5.0	%	4/11/2011 - 11/7/2011	14	0	14	87.7	101.9	97.4	99.15	4.574	89.4	93.85	101.3	101.7
DO_HL_MS5.0	mg/l	4/11/2011 - 11/7/2011	14	0	14	7.22	12.56	9.288	9.385	1.477	7.38	8.048	10.1	11.64
DOC	mg/l	4/11/2011 - 10/3/2011	3	0	3	5.8	12	9.033	---	3.109	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2011 - 11/7/2011	14	0	14	46	119.5	93.64	100.3	24.45	46.8	76.7	114.9	117.4

Tuesday, September 04, 2012

Percentiles Calculated Using NIST Method

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Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_A

Station Name: Upper St. Croix River at CCC Bridge

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
Magnesium	mg/l	4/11/2011 - 10/3/2011	3	0	3	1.86	4.24	3.243	---	1.236	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2011 - 11/7/2011	8	4	8	1	33.88	14.89	---	13.56	---	---	---	---
pH_HL_MS5.0	None	4/11/2011 - 11/7/2011	14	0	14	6.84	7.91	7.589	7.685	0.3325	6.925	7.482	7.84	7.905
converted pH	None					6.84	7.91	7.44	7.684	0.039	6.917	7.452	5.128	5.16
H+ computed from pH	µeq/l					0.0123	0.1445	0.0363	0.0207	0.039	0.0124	0.0145	0.0353	0.1211
Potassium	mg/l	4/11/2011 - 10/3/2011	3	1	3	0.2	0.62	0.3933	---	0.212	---	---	---	---
Silicate	mg/l	4/11/2011 - 10/3/2011	3	0	3	6.93	8.86	7.987	---	0.978	---	---	---	---
Sodium	mg/l	4/11/2011 - 10/3/2011	3	0	3	1.38	2.68	2.067	---	0.6531	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.3	3.88	3.217	---	0.8199	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2011 - 11/7/2011	14	0	14	5.35	27.94	16.96	16.62	7.412	6.505	11.49	23.29	27.94
Total Nitrogen_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	259.7	1073	515.7	---	250.1	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	14.14	51.14	23.5	---	11.9	---	---	---	---
Total Suspended Solids	mg/l	4/11/2011 - 11/7/2011	8	0	8	1	8	3.375	---	2.56	---	---	---	---
Transparency Tube	cm	4/11/2011 - 11/7/2011	8	6	8	82	132	122.2	---	18.99	---	---	---	---

Organization: St. Croix National Scenic Riverway

Station ID: SACN_B

Station Name: Namekagon River at Phipps Landing

Analysis for 2011

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	4/11/2011 - 10/3/2011	3	0	3	40	72	60.67	---	17.93	---	---	---	---
Ammonium_SCRS	µg/l	4/11/2011 - 11/7/2011	8	3	8	1.5	27.82	11.68	---	10.2	---	---	---	---
Calcium	mg/l	4/11/2011 - 10/3/2011	3	0	3	11.7	20.3	16.93	---	4.594	---	---	---	---
chl_a(fluor)_SCRS	µg/l	4/11/2011 - 11/7/2011	8	1	8	0.22	4.66	1.775	---	1.48	---	---	---	---
Chloride_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	2.4	3.2	2.933	---	0.4619	---	---	---	---
DO%_HL_MS5.0	%	4/11/2011 - 11/7/2011	13	0	13	86.1	106.4	95.95	95.4	7.47	86.22	87.5	102.2	106
DO_HL_MS5.0	mg/l	4/11/2011 - 11/7/2011	13	0	13	8.37	12.69	9.525	9.15	1.171	8.37	8.88	9.98	11.91
DOC	mg/l	4/11/2011 - 10/3/2011	3	0	3	5.2	10	6.833	---	2.743	---	---	---	---
EC25_HL_MS5.0	µS/cm	4/11/2011 - 11/7/2011	13	0	13	89.6	162.2	134.9	135.6	24.3	89.68	124.8	157.4	160.5
Magnesium	mg/l	4/11/2011 - 10/3/2011	3	0	3	3.24	5.79	4.82	---	1.38	---	---	---	---
Nitrate+Nitrite_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	24.92	175	76.19	---	49.12	---	---	---	---



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Organization: St. Croix National Scenic Riverway

Station ID: SACN_B

Station Name: Namekagon River at Phipps Landing

Analysis for 2011

Local Name	Units	Period of Record	Count	Cens.	Incl.	Min.	Max.	Mean	Median	Std Dev	10th per.	25th per.	75th per.	90th per.
pH_HL_MS5.0	None	4/11/2011 - 11/7/2011	13	0	13	7.43	8.12	7.762	7.71	0.2251	7.462	7.57	7.94	8.112
converted pH	None					7.43	8.12	7.712	7.71	0.0094	7.46	7.565	5.121	5.127
H+ computed from pH	µeq/l					0.0076	0.0372	0.0194	0.0195	0.0094	0.0077	0.0115	0.0272	0.0347
Potassium	mg/l	4/11/2011 - 10/3/2011	3	0	3	0.53	0.78	0.63	---	0.1323	---	---	---	---
Silicate	mg/l	4/11/2011 - 10/3/2011	3	0	3	8.93	13.8	11.78	---	2.537	---	---	---	---
Sodium	mg/l	4/11/2011 - 10/3/2011	3	0	3	1.92	2.76	2.423	---	0.4441	---	---	---	---
Sulfate_Filtered	mg/l	4/11/2011 - 10/3/2011	3	0	3	3.5	5.27	4.54	---	0.9248	---	---	---	---
Temp_HL_MS5.0	°C	4/11/2011 - 11/7/2011	13	0	13	4	20.6	13.95	12.33	5.617	5.66	8.81	18.75	20.59
Total Nitrogen_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	235.4	810.7	458.5	---	190.6	---	---	---	---
Total Phosphorus_SCRS	µg/l	4/11/2011 - 11/7/2011	8	0	8	16.3	40.04	24.11	---	8.155	---	---	---	---
Total Suspended Solids	mg/l	4/11/2011 - 11/7/2011	8	1	8	0.5	11	3.688	---	3.432	---	---	---	---
Transparency Tube	cm	4/11/2011 - 11/7/2011	8	7	8	85.3	132	126.2	---	16.51	---	---	---	---

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		
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		
Secchi Depth	Depth, Secchi Disk Depth	Water		



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Filtered Results, Grouped by Organization, Station

Silicate	Silicate	Water
Sodium	Sodium	Water
Sulfate_Filtered	Sulfur, sulfate (SO4) as SO4	Water
Temp_HL_MS5.0	Temperature, water	Water
Total Nitrogen VANDORN_SCRS	Nitrogen	Water
Total Nitrogen_SCRS	Nitrogen	Water
Total Phosphorus VANDORN_SCRS	Phosphorus	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 = SACN: St. Croix National Scenic Riverway

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 Secchi Depth

or Silicate

or Sodium

or Sulfate_Filtered

or Temp_HL_MS5.0

or Total Nitrogen VANDORN_SCRS

or Total Nitrogen_SCRS

or Total Phosphorus VANDORN_SCRS

or Total Phosphorus_SCRS

or Total Suspended Solids

or Transparency Tube

Only display results that meet characteristic criteria



NPSTORET Descriptive Statistics - Annual



Filtered Results, Grouped by Organization, Station

Include Only Samples Not Checked as QC

Date ($\geq 3/1/2011$ and $\leq 12/30/2011$)

Censored Data Substitutions: *Non-detect= $0.5 \times \text{DetectionLimit}$, *Present $> \text{QL} = 1.1 \times \text{UpperQuantificationLimit}$, *Present $< \text{QL} = 0.5 \times \text{LowerQuantificationLimit}$

Missing Statistic Codes:

--- Computation requires 9 observations

... Computation requires more than 1 observation

Appendix B: Annual mean values of field and laboratory variables measured at six mainstem sites on the St. Croix River in April, July, and October for 2007–2011.

Table B1. Mean values (N=3) of field and laboratory variables measured at six mainstem sites on the St. Croix River in April, July, and October for 2007-2011. Near-surface values were used for pH, specific conductance, DO, and temperature. Dash (-) = not measured, calculated, or available. * = includes censored data. ** = Mean values are not shown due to a high number of censored values.

Variable	SACN01					SACN02					SACN04				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Temperature (°C)	14.0	11.1	11.5	14.2	15.0	13.2	11.4	12.1	15.9	16.4	13.5	12.2	11.5	16.9	16.8
DO (mg/L)	8.9	10.9	10.3	8.8	8.8	9.3	9.5	9.5	8.4	8.5	8.5	10.2	10.0	8.8	8.7
pH (std. units)	7.4	7.7	7.8	7.7	7.7	7.4	7.3	7.6	7.6	7.4	7.4	7.5	7.8	7.7	7.6
SC25 (µS/cm)	148.7	157.3	174	169	157.6	120.3	114.6	138.7	120.9	126.8	132.0	128.1	151.6	137.9	139.2
TSS (mg/L)	8.3	8.0	5.0	5.0	6.3	7.7	10.0	4.3	5.7	5.5	11.7	13.3	5.3	6.7	6.1
T-Tube (cm)	**	**	**	117.8*	**	97.08*	77.6	**	78.12	**	83.7	63.8	108.6*	84.5	92.7*
Secchi (m)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP (µg/L)	37.7	25.3	23.4	34.0	29.0	44.7	38.0	31.1	42.6	36.2	70.0	51.3	39.1	57.0	40.2
Chl a (ug/L)	-	4.4	1.4	1.8	2.2	-	4.2	3.3	4.3	3.5	-	4.2	3.9	3.5	3.2
TN (µg/L)	682	458.3	328.6	519.1	552.8	860	693.7	518.5	755.2	639.2	1027	832.3	608.2	869.2	718.8
NO ₃ +NO ₂ -N (µg/L)	148.0	166.3	115.3	119.1	118.3	157.3	146.3	52.2	53.1	56.1	169.0	190.3	75.7	106.8	88.8
NH ₄ -N (µg/L)	20.7	26.7	**	**	**	44.3	32.3	**	**	**	59.3	42.3	**	**	**
DOC (mg/L)	9.9	5.2	3.9	6.6	6.8	11.8	10.9	8.2	13.6	9.8	12.5	12.1	9.5	14.7	10.9
Alkalinity (mg/L)	64.3	70.3	76.3	78.3	56.0	53.7	51.0	58.3	59.0	47.7	54.3	55.0	66.0	69.0	50.3
Cl ⁻ (mg/L)	4.1	4.7	4.7	4.9	5.0	3.3	3.4	3.5	3.1	3.4	4.8	4.4	4.9	4.1	3.9
SO ₄ ⁻² (mg/L)	5.2	4.8	5.2	4.7	4.5	5.5	4.3	4.2	3.4	3.35	6.4	4.4	4.4	3.3	3.5
Ca ⁺² (mg/L)	19.6	20.8	24.1	22.8	19.2	15.0	15.4	18.7	16.2	14.4	16.8	16.4	19.6	17.5	15.9
Mg ⁺² (mg/L)	6.0	6.4	7.1	6.7	5.7	5.2	5.3	5.8	5.15	4.6	6.0	5.9	6.9	6.1	5.5
K ⁺ (mg/L)	0.9	0.8	0.7	0.7	0.8	1.1	0.8	0.7	0.6	0.7	1.8	1.2	1.1	1.0	0.9
Na ⁺² (mg/L)	3.2	3.5	3.6	3.38	3.4	2.7	2.8	2.9	2.3	2.5	3.5	3.2	3.6	2.8	3.0
SiO ₂ (mg/L)	10.5	10.3	12.7	15.0	11.3	7.6	8.7	9.1	10.0	9.6	7.6	8.3	7.5	9.9	10.0

Table B1. Mean values (N=3) of field and laboratory variables measured at six mainstem sites on the St. Croix River in April, July, and October for 2007-2011. Near-surface values were used for pH, specific conductance, DO, and temperature. Dash (-) = not measured, calculated, or available. * = includes censored data. ** = Mean values are not shown due to a high number of censored values (continued).

Variable	SACN07					SACN09					SACN11				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Temperature (°C)	14.3	14.7	15.0	17.9	18.7	14.8	14.5	14.8	17.5	17.9	15.5	15.1	14.5	16.4	17.6
DO (mg/L)	9.6	9.4	10.4	8.6	8.9	9.7	8.5	9.4	8.9	8.5	9.3	8.0	8.9	9.1	7.8
pH (std. units)	7.6	7.6	7.9	7.6	7.6	7.7	7.6	7.9	7.8	7.5	7.9	7.6	7.7	7.7	7.4
SC25 (µS/cm)	176.9	171.9	194	168.5	164.0	185.8	179.4	198	170.9	170.5	206	194.1	190.7	175.4	188.4
TSS (mg/L)	4.7	3.0	3.3	3.7	4.5	5.3	3.3	2.3	4.0	3.4	4.0	2.3	1.8	2.7	2.5
T-Tube (cm)	74.3	65.9*	104.9*	74.7	83.0	-	99.8*	108.4*	82.3	>120*	-	**	**	100.6*	**
Secchi (m)	1.0	1.5	1.7	1.3	1.3	1.2	1.7	1.6	-	1.5	-	2.0	1.7	-	1.8
TP (µg/L)	58.0	45.0	38.8	56.2	48.8	51.0	51.7	42.7	61.6	48.8	55.0	75.3	60.2	56.5	43.6
Chl a (ug/L)	-	6.4	8.5	10.3	6.7	-	5.7	5.8	9.9	7.5	-	4.2	6.2	6.5	4.2
TN (µg/L)	1039	941	755.6	1024	900.4	1016	1067	876.2	1137	1028	1093	1107	1005.2	1290	1129
NO ₃ +NO ₂ -N (µg/L)	277.0	284.3	233.4	191.4	194.4	277.3	436.7	258.4	274.0	270.9	456.7	571.7	358.2	496.8	442.6
NH ₄ -N (µg/L)	93.0	110.0	**	12.1*	**	58.0	111.0	55.3*	14.2*	**	66.7	66.6	67.6*	**	**
DOC (mg/L)	10.7	10.9	7.1	14.3	11.2	9.4	10.2	8.6	13.3	11.1	7.7	10.9	9.4	13.0	11.7
Alkalinity (mg/L)	72.0	74.0	80.0	86.0	70.7	79.7	77.3	83.0	82.7	71.0	88.1	82.7	80.0	84.3	78.3
Cl ⁻ (mg/L)	6.6	6.5	6.7	5.5	5.7	7.0	7.3	7.3	5.8	6.3	7.0	7.5	7.1	6.0	7.1
SO ₄ ⁻² (mg/L)	6.1	5.2	5.1	4.2	4.1	6.3	5.4	5.5	4.2	4.4	6.4	5.8	5.8	4.5	4.8
Ca ⁺² (mg/L)	21.0	20.9	23.9	21.1	18.9	22.3	22.4	23.0	20.8	19.0	24.12	23.3	22.6	21.4	21.0
Mg ⁺² (mg/L)	7.9	8.0	9.2	7.5	6.7	8.7	8.7	9.3	7.8	7.1	9.9	8.7	9.0	8.1	7.7
K ⁺ (mg/L)	3.8	1.4	1.4	1.3	1.1	1.8	1.5	1.4	1.4	1.1	1.8	1.4	1.4	1.5	1.2
Na ⁺² (mg/L)	4.2	4.2	4.4	3.4	3.6	4.3	4.3	4.3	3.3	3.6	4.7	4.3	4.1	3.5	3.9
SiO ₂ (mg/L)	8.7	7.9	8.1	10.1	9.9	8.2	7.6	8.0	10.1	10.3	7.5	8.1	7.3	11.0	11.3

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 630/117111, September 2012

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

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