Water Sampling Report
Sauk River at St. Cloud, 2003-2004

INTRODUCTION

The Sauk River meanders 120 miles from the eastern portions of Douglas County within 3 miles of Alexandria into the Mississippi River near St. Cloud. The watershed, like the Sauk River, extends in a northwest to southeast direction. The overall watershed is about 75 miles in length with some areas being up to 20 to 30 in width.

According to data from the Minnesota Land Management Information Center (LMIC), the Sauk River watershed covers over 667,000 acres of approximately 1,007 square miles across portions of five counties. The portions of counties with the watershed include southeastern Douglas County, northeastern Pope County, southwestern Todd County, north central Meeker County, and the center third of Stearns County. (A very small portion of the watershed, 6 acres, overlaps into Morrison County). The table below provides the area distribution of the watershed by county.

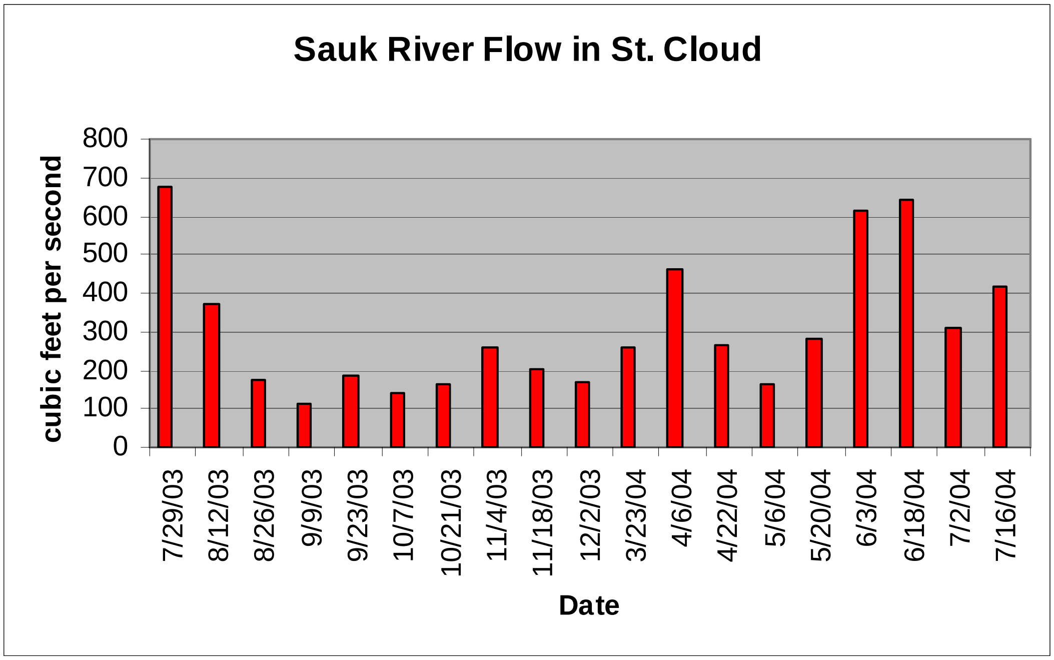
Distribution of Watershed Area by County

	Douglas	**Pope**	**Meeker**	**Stearns**	**Todd**	**Total**
Area (acres)	58,171	30,328	9,883	431,409	137,392	667,183
Area (sq. mi.)	90	47	15	674	215	1,041
Watershed (percent)	8.9	4.4	1.5	63.6	21.6	100.0

From July 2003 to July 2004, a study was conducted by volunteer researchers, Sarah Sewell and Mitch Bender, from the Department of Environmental and Technological Studies at St. Cloud State University. The study examined nitrogen and phosphorus loading of the Sauk River as it flowed through urban and residential areas of the St. Cloud metro area.

When weather permitted, biweekly grab samples were taken from two sites along a 10 km portion of the Sauk River, which runs through the St. Cloud metro area. Measurements of water quality included phosphate-phosphorus, nitrate-nitrogen, total suspended solids, total solids, dissolved oxygen, temperature, pH, and conductivity. Measurement of river flow was gathered from USGS data (gauge 05270500 near St. Cloud) and displayed in figure 1.

Figure 1: Sauk River flow data from USGS gauge 05270500 for each sampling date.



MONITORING

The St. Cloud portion of the Sauk River has not frequently been monitored by the Sauk River Watershed District. However, monitoring is a critical part of successfully improving our rivers because it gives us a quantitative and qualitative outlook on the river system before, during, and after land use changes.

Water conditions were monitored at two locations along the Sauk River by either Sarah Sewell or Mitch Bender. Site 1 was located at Miller Landing near Highway 75, where the Sauk River enters the St. Cloud area. Site 2 was located at Heims Mill Canoe Access, where the Sauk River enters the Mississippi River. When weather permitted, sampling was conducted biweekly at the same locations at each site. In total, there were 19 sampling dates between July 2003 and July 2004.

Temperature and dissolved oxygen were measured at each site using a dissolved oxygen meter. Three grab samples were collected at each location using a bailer on a sampling line. This device gathered a composite sample of water from the center portion of the river. Analysis of samples for phosphate-phosphorus, nitrate-nitrogen, total solids, suspended solids, pH and conductivity were conducted by Sarah Sewell and Mitch Bender in the Environmental Instrumentation Laboratory in the Department of Environmental and Technological Studies at St. Cloud State University. Note: The analysis results of the three grab samples from each site were average to give the values for each site on each sampling date.

Figure 2: Miller Landing (site 1) and Heims Mill Canoe Access (site 2), respectively.

Photo credit: Sarah Sewell

Photo credit: Sarah Sewell

SAMPLING RESULTS AND DATA INTERPRETATION

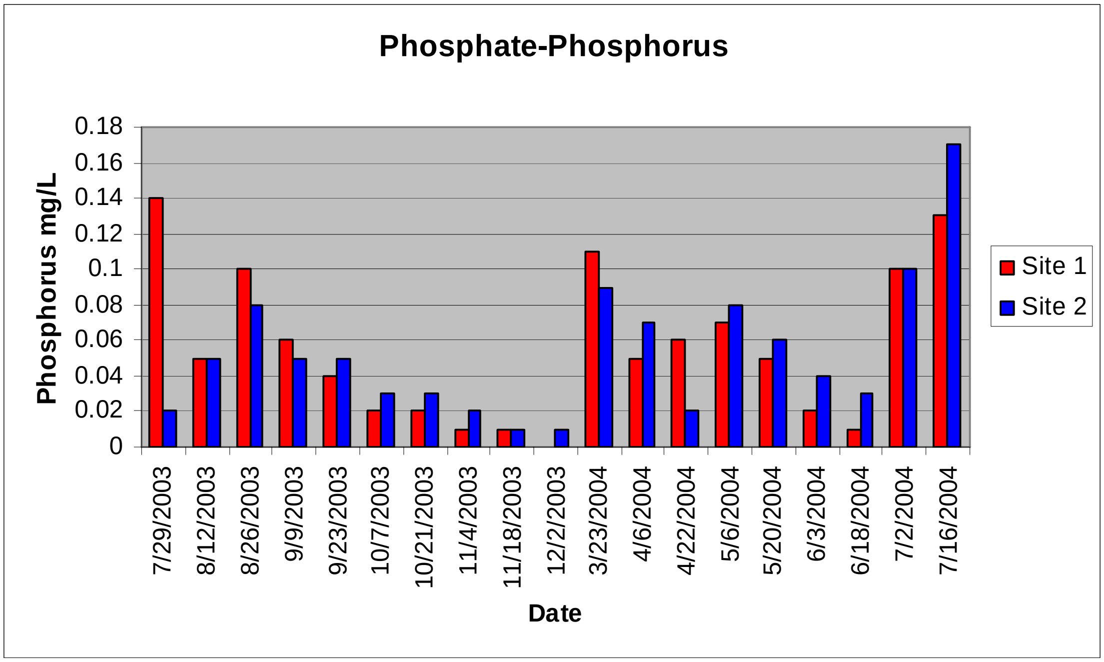
Phosphate-Phosphorus

Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphate (PO4), formed from elemental phosphorus, was sampled due to its importance in “fertilizing” water bodies. Phosphate will stimulate the growth of plankton and aquatic plants, which provide food for fish. However, increasing inputs of phosphates in lakes, streams and rivers have been associated with water quality issues, such as eutrophication and hypoxia. Eutrophication and hypoxia can ultimately degrade water quality, cause loss of biodiversity, fish kills, and loss of recreational value.

When averaged over the duration of the study, no statistical differences were found between the concentrations of phosphate-phosphorus from sites 1 and 2. However, as seen in figure 3, slightly higher phosphate-phosphorus concentrations were more commonly observed from site 2 than from site 1. During those sampling dates when phosphate-phosphorus concentrations were higher from site 2 than site 1, it may be concluded that phosphorus is being introduced to the river as it flows through the St. Cloud metro area.

Low concentrations of phosphate-phosphorus found for both sites in late September through December correlate somewhat with low flow conditions found during those times (please refer to figure 1 for flow conditions).

Figure 3: Phosphate-phosphorus averages for sites 1 and 2 for each sampling date.



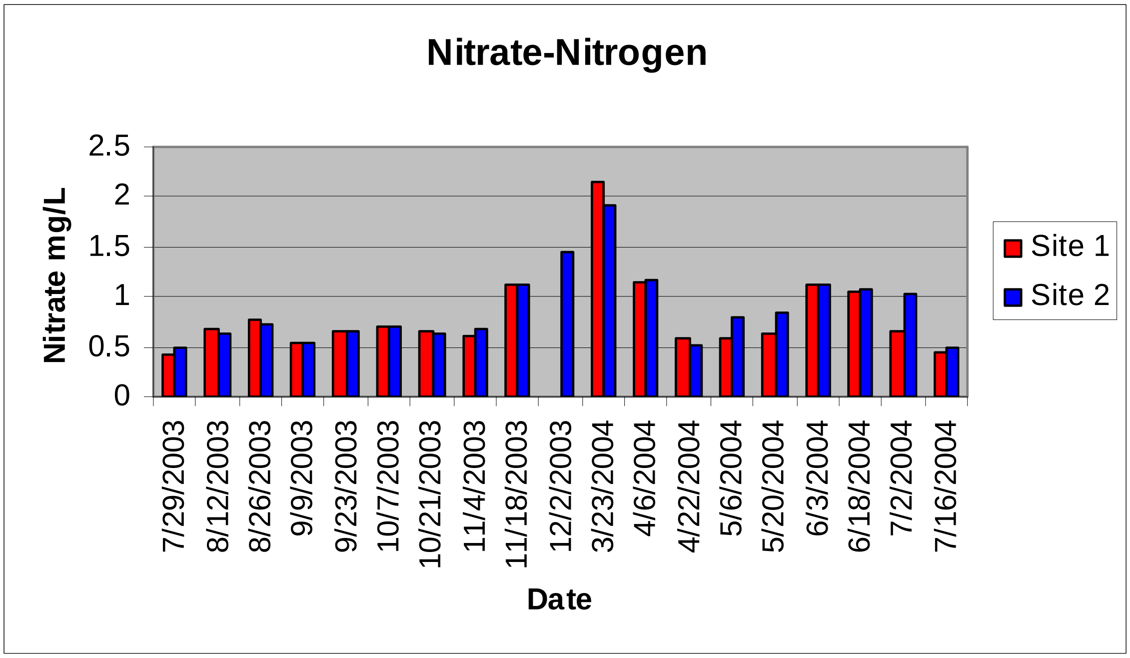
Nitrate-Nitrogen

Nitrogen is one of the most abundant elements. About 80 percent of the air we breathe is nitrogen. It is found in the cells of all living things and is a major component of proteins. Inorganic nitrogen may exist in the Free State as a gas N2, or as nitrate (NO3-), nitrite (NO2-) or ammonia (NH3+). Organic nitrogen is found in proteins and is continually recycled by plants and animals.

Nitrogen-containing compounds act as nutrients in streams and rivers. Nitrate reactions in fresh water can cause oxygen depletion. Thus, aquatic organisms depending on the supply of oxygen in the stream will die. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes (including birds and fish) and discharges from car exhausts. Bacteria in water quickly convert nitrites [NO2-] to nitrates [NO3-].

When averaged over the duration of the study, no statistical differences were found between the concentrations of nitrate-nitrogen from sites 1 and 2. There was also very little observed difference among sites for each of the sampling dates. Unlike with the phosphate-phosphorus data, nitrate-nitrogen concentrations do not appear to be strongly correlated with flow. The highest concentrations of nitrate-nitrogen were found just before ice-in and just after ice-out conditions.

Figure 4: Nitrate-nitrogen averages for sites 1 and 2 for each sampling date.



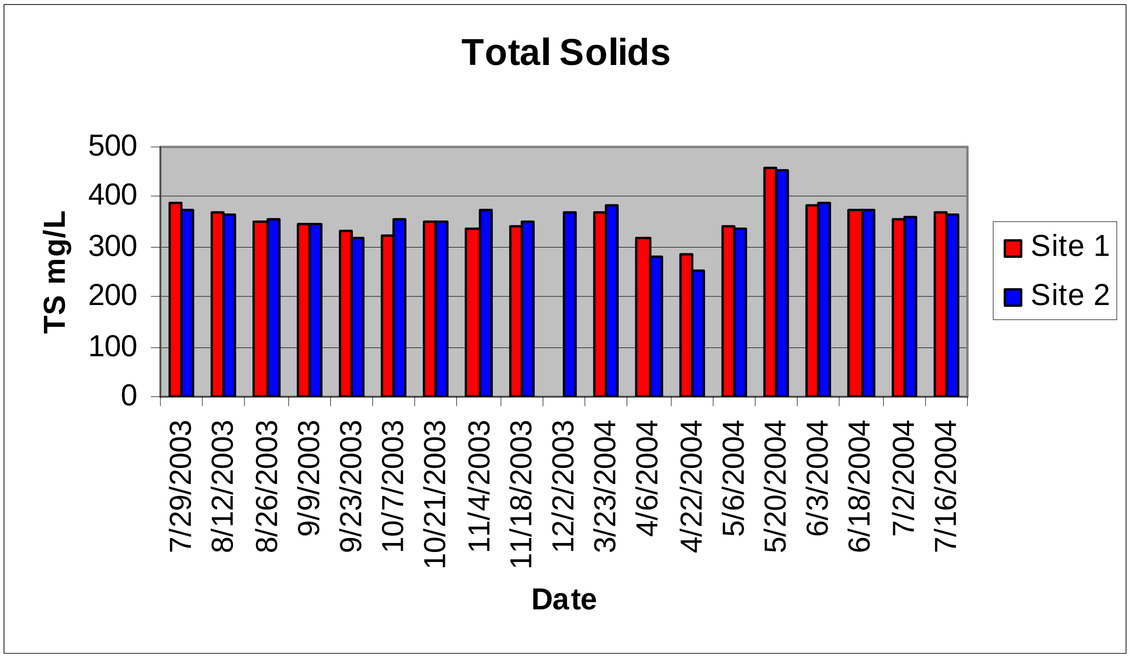
Total Solids

Total solids (TS) refers to all materials suspended and dissolved in water. Suspended solids include materials such as plankton, small invertebrates, silt and clay. Dissolved solids include materials such as minerals, road salt, nutrients and metals. Suspended solids can be filtered out, while dissolved solids cannot. To gain an estimate of the amount of dissolved solids, the amount of total suspended solids can be subtracted from the amount of total solids. High levels of total solids can contribute to turbidity of a water body and may also be an indicator of eutrophic conditions.

During this study, there was little difference observed in total solids from sites 1 and 2 for any of the sampling dates. Likewise there was little difference observed between sampling dates. Most measurement ranges between 300 and 400 mg/L. There was no correlation between flow conditions and total solid values. Please refer to figure 1 for flow conditions during this study.

By subtracting the total suspended solids (as found in figure 6) from the total solids, it can be concluded that most solids were in dissolved form.

Figure 5: Total solid averages for sites 1 and 2 for each sampling date.



Total Suspended Solids (TSS)

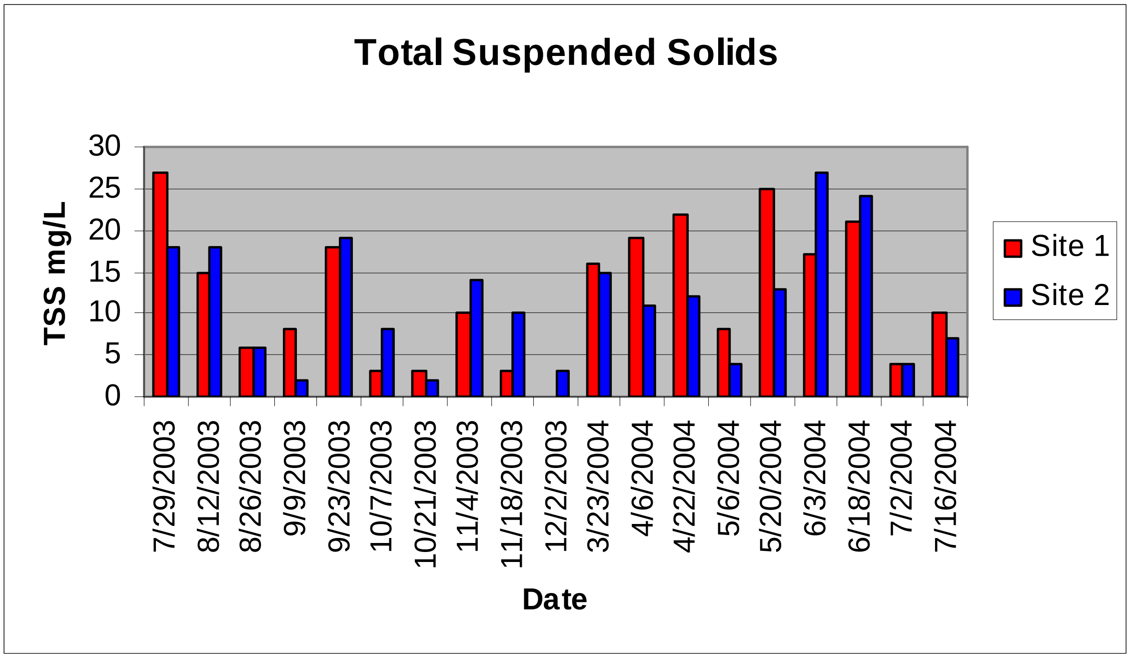
Total suspended solids refers to the material suspended within the water column. It can be both organic (plankton, sewage) and inorganic (silt, clay). The suspended material will scatter and absorb light passing through the water. Developing areas where a great deal of construction and land disturbance is occurring will elevate TSS numbers.

High TSS readings can indicate erosion and sedimentation problems. Rainfall and runoff can increase the suspended solid load in a river and make the river appear cloudy or muddy. High biological productivity related to increases in nutrients and temperature can result in increase of diatoms and other algae that contribute to matter suspended in the water column.

Elevated TSS can cause an increase in temperature since suspended particles absorb heat. Reduction of light penetrating the water column due to this material can decrease the rate of photosynthesis. This, in turn, can decrease the amount of dissolved oxygen in the water. As suspended particles settle, they can impair the habitat needed for fish spawning and aquatic macro invertebrates. They can also clog the gills of fish and the breathing apparatus of invertebrates. Particles serve as places of attachment for harmful microorganisms and toxic materials.

During this study, total suspended solid values were quite varied between sampling sites and samplings dates. There also did not appear to be a strong correlation between flow conditions and total suspended solid values. Please refer to figure 1 for flow conditions during this study.

Figure 6: Total suspended solid averages for site 1 and 2 for each sampling date.



Dissolved Oxygen

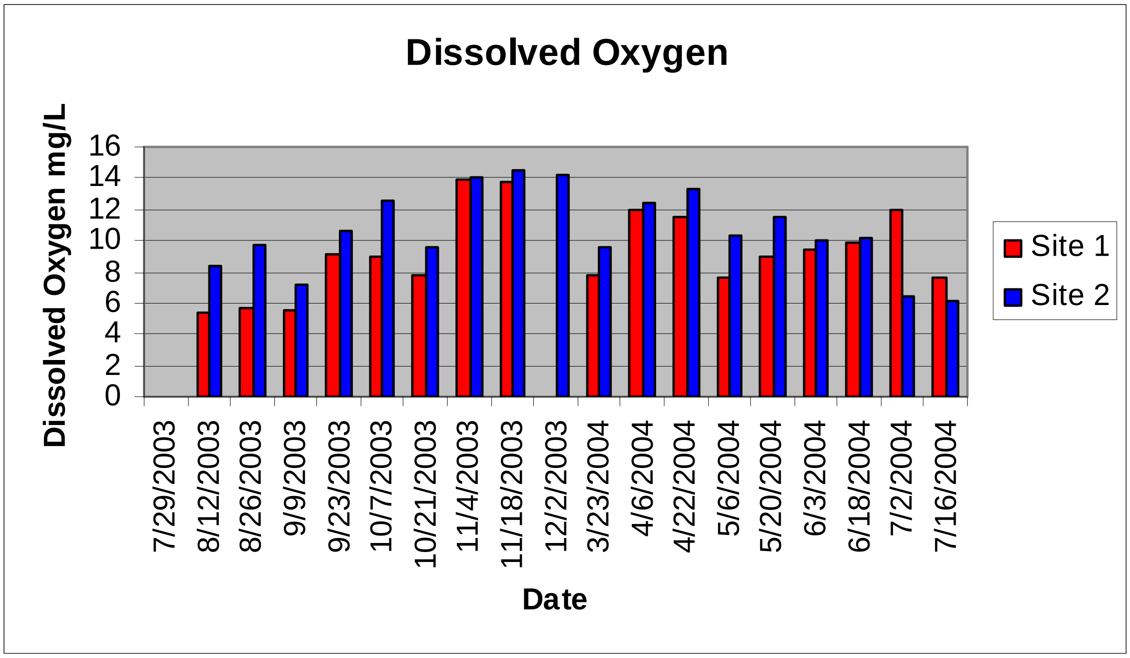
Dissolved oxygen and temperature measurements are taken to characterize the presence or absence of oxygen available for aquatic life in the stream. The major sources of dissolved oxygen in water are the atmosphere and photosynthesis by aquatic vegetation (macrophytes and algae).

Generally, dissolved oxygen concentrations are in a constant state of flux on a daily basis (consumption/production biotic responses) and seasonal basis (climatic and flow responses). In the same regard, oxygen concentrations cannot fall too low. Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to animals. Natural lake and stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/L, aquatic life is put under stress, the lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in fish kills.

During this study, dissolve oxygen levels remained above the critical 5.0 mg/L level. Dissolved oxygen levels may be less of an issue for rivers than it is for lakes, as water is sufficiently moving and can capture oxygen from the atmosphere.

For most sampling dates, site 2 had greater dissolved oxygen levels than site 1. This may be due to the faster, churning movement of water at site 2. Please compare photographs of the sites in figure 2. The portion of the river at site 2 is also exposed to more sunlight, and therefore, may have higher levels of photosynthesis than site 1. If more photosynthesis is present, more oxygen would be released to the water by plants and algae.

Figure 7: Dissolved oxygen averages for sites 1 and 2 for sampling date.



<u>If dissolved oxygen levels are low, the levels may be a result of:</u>

- Atmosphere: The air we breathe contains approximately 21% oxygen which equates to 210,000 ppm oxygen. Most surface waters contain between 5 and 15 ppm dissolved oxygen. Waves and tumbling water act to mix atmospheric oxygen with water.

- Temperature: Gases, like oxygen, are more easily dissolved in cooler water than in warmer water.

- Dissolved or suspended solids: Oxygen dissolves more readily in water that does not contain a high concentration of salts, minerals, or other solids.

- Aquatic plants: During the day, when the sun is shining, dissolved oxygen levels rise due to photosynthesis. As the sun sets, photosynthesis stops, but plant and animal respiration continues to consume oxygen. Just before dawn, dissolved oxygen levels fall to their lowest level. Large fluctuations in oxygen from late afternoon to early morning are characteristics of waterways with extensive plant growth.

- Organic wastes: These wastes include the bodies of once-living plants and animals, the feces of living animals, and the effluent form industries that process organic materials. Organic wastes take the form of sewage and runoff from cropland, septic systems, and animal operations (feedlots, zoos, etc.), golf courses, lawns, and gardens. Organic wastes act as fertilizers to stimulate aquatic plant growth. As these plants die, they too become organic waste. Aerobic bacteria (bacteria that need oxygen) consume dissolved oxygen in the process of decomposing organic matter that is in water.

- Urban Runoff: Rain carries salt, sediment and other pollutants off of impervious surfaces (streets, roofs, parking lots) into streams. This raises the total solids in the water and reduces the amount of dissolved oxygen it can hold.

- Removal of vegetation in riparian corridor: Lack of shade, which causes increase water temperature, and lack of protection from erosion, which cause increased solids, can work together to reduce oxygen levels.

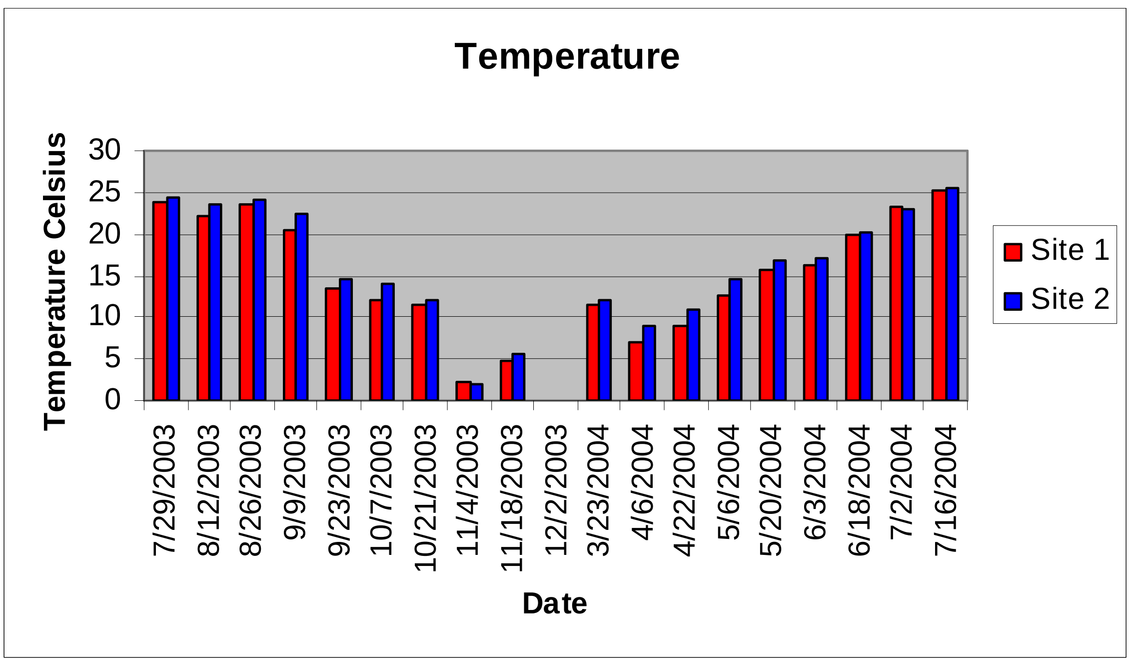
Temperature

Temperature influences a river's fundamental processes: the depletion of dissolved oxygen, nutrient release and algae growth. Changing water temperature beyond natural season fluctuations disrupts aquatic ecosystems.

The temperature readings also give an indication of whether conditions are favorable for cold water fish. The rate of metabolism of cold-blooded animals as well as rates of photosynthesis is temperature sensitive. The migration of fish and spawning behavior are associated with temperature changes. This is why it is important to document the temperatures of the waters coming into and out of the river.

During this study, thermal pollution did not appear to be an issue at either site. Temperature measurements were slightly higher at site 2 than those from site 1. The portion of the river on site 2 is also exposed to more sunlight, and therefore, would have higher water temperatures.

Figure 8: Temperature averages for sites 1 and 2 for each sampling date.



If temperature levels are changing, the levels may be a result of:

- Thermal pollution is water entering the stream or lake via a tributary or pipe that is warmer than the water already present. One source is industries which discharge cooling water. Another source is stormwater runoff from heated surfaces such as parking lots.

- Riparian cover removal impacts water temperature by eliminating shade. The rate of photosynthesis and plant growth increase with warmer temperatures. When plants die, they are decomposed by bacteria that need oxygen. Oxygen levels in the water are lowered by this process. The metabolic rate of organisms increases. This results in a higher oxygen demand for fish, aquatic insects and aerobic bacteria.

- Soil erosion increases the amount of suspended solids carried by the river. The cloudy water absorbs the sun's rays, which warms the water.

pH

pH is a measure associated with the acidity of a water body and is largely affected by the underlying geology of the area, but can be influenced by land use and runoff. pH is a measure of the acidic or basic (alkaline) nature of a solution. The concentration of the hydrogen ion [H+] activity in a solution determines the pH. Water (H2O) contains both H+ (hydrogen) ions and OH (hydroxyl) ions. pH measures the H+ ion concentration of substances and gives results on a scale from 0 to 14. Water that contains equal numbers of H+ and OH- ions is considered neutral (pH7). If a solution has more H+ than OH- ions, it is considered acidic and has a pH less than 7. If the sample contains more OH- ions than H+ ions, it is considered basic with a pH greater than 7. It is important to remember that every one unit change on the pH scale is a tenfold change in how acidic or basic the sample is.

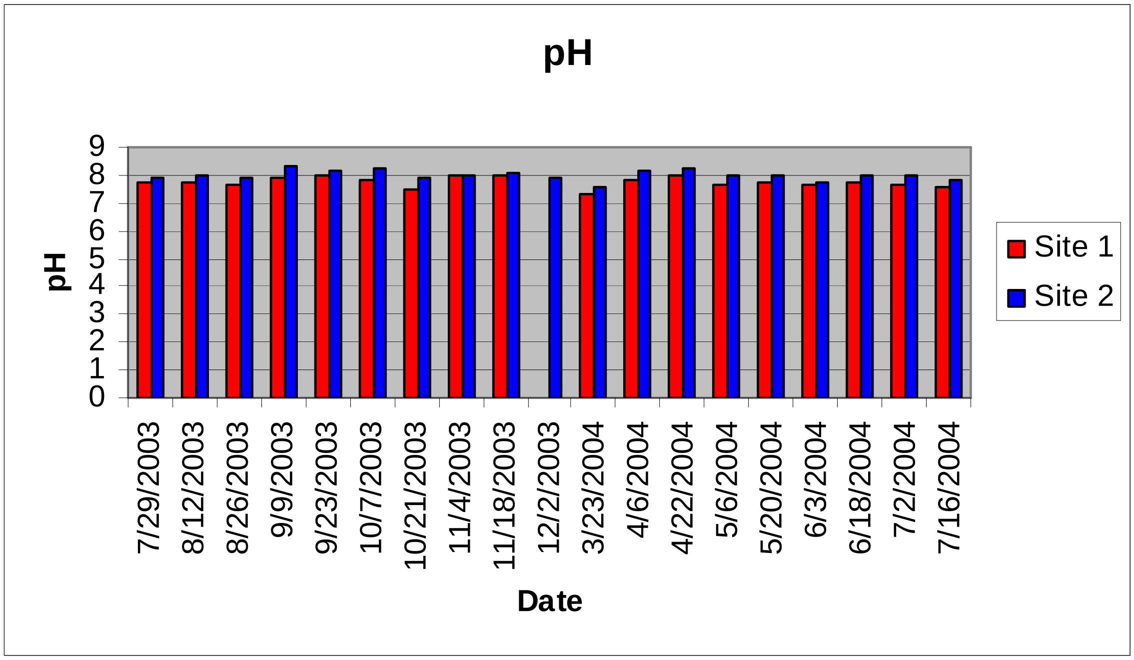
The pH of surface waters is important because runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. The pH of the water will determine the toxic effects, if any, of these substances. For example, 4 mg/L of iron would not present a toxic effect at a pH of 4.8. However, as little as 0.9 mg/L of iron at a pH of 5.5 can cause fish to die.

pH levels may affect fish in the following ways:

pH	
10.0	Fish eggs could be hatched, but deformed young are often produced
10.1	Limits for the most resistant fish species
9.5	Range tolerated by trout
4.3	Carp die in five days
9.0	Trout eggs and larvae develop normally
9.5	Limits for perch
5.0	Limits for stickleback fish
9.0	Tolerable range for most fish
8.7	Upper limit for good fishing waters
11.4	Fish avoid waters beyond these limits
7.2	Optimum (best) range for fish eggs
1.0	Mosquito larvae are destroyed at this pH value
4.7	Mosquito larvae live within this range
8.4	Best range for the growth of algae

During this study, pH values, which ranged from 7.34 to 8.31, found at both sites are considered near optimal. Across all sampling dates, pH values were only slightly higher for site 2 than those from site 1. There was little difference observed between sampling dates and there was no correlation between flow conditions and pH values. Please refer to figure 1 for flow conditions during this study.

Figure 9: pH averages for sites 1 and 2 for each sampling date.

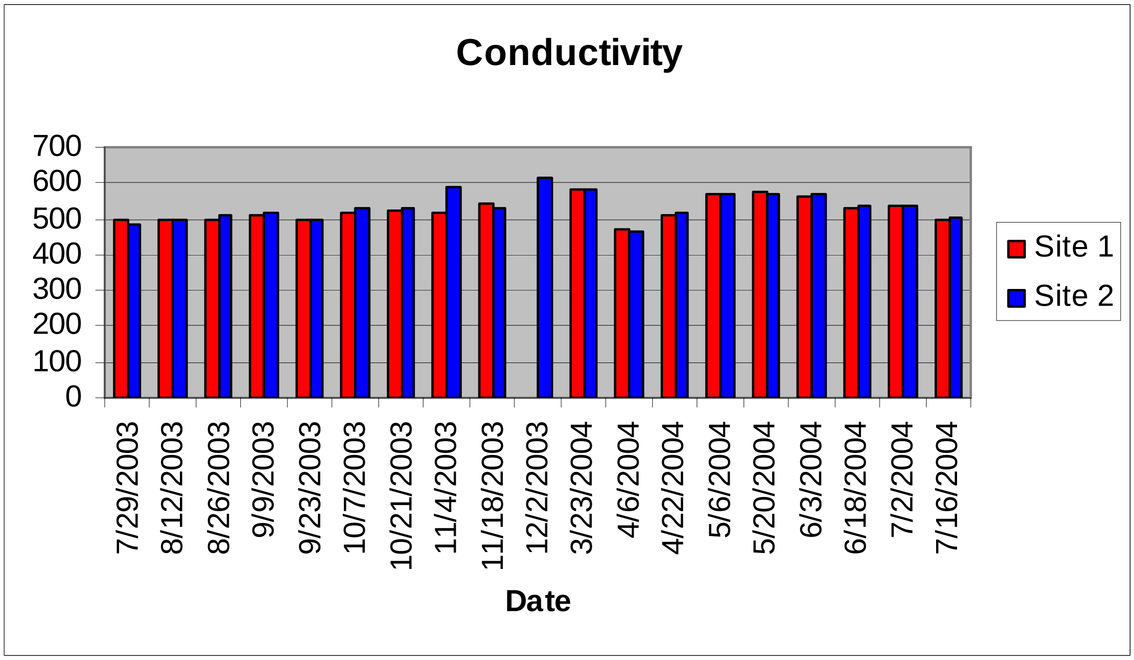


Conductivity

Conductivity is measured by passing an electrical current through water. Inorganic dissolve solids, such as dissolved minerals, road salt, nutrients and metals increase the conductivity of water.

During this study, conductivity values were slightly higher from site 2 than site 1. This may be due to some input to the river as it flowed through the St. Cloud metro area. However, changes in geology may also influence conductivity of water. When comparing sampling dates was little difference observed. There was no correlation between flow conditions and conductivity values. Please refer to figure 1 for flow conditions during this study.

Figure 10: Conductivity averages for sites 1 and 2 for each sampling date.



RECOMMENDATIONS AND SUGGESTED ACTIONS

The Sauk River Watershed District, partnering agencies and volunteers work towards maintaining and improving lakes and streams within the District. We have these partnerships with land owners, municipalities and volunteers to create successful projects and programs to reach this goal. The following recommendations are offered to support the current activities, identify opportunities, and provide ideas for future endeavors. It should be remembered that maintaining and/or improving water quality is a long-term commitment. There are no quick fixes that produce immediate and lasting improvements in water quality. Only individual behavior changes, accumulated across the watershed and continuing over time, can begin to have positive impacts upon water quality. The rewards for such actions at times can be difficult to identify and require a long time to become noticeable. Those involved in these efforts must keep in mind that their collective influence is eliciting positive change that will be realized at some future date.

- ***Continue water quality analysis.*** Documenting the values and changes of water quality on the Sauk River provides a valuable piece to the puzzle of understanding the dynamics of the watershed. If feasible, continue monitoring efforts from ice-out to ice-in on the river.

- ***Develop contingency plans for the lower Sauk River.*** Create detailed procedures for continued sampling or intensive sampling on the river if it exhibits conditions that are a cause for concern (e.g., elevated levels of phosphorus). Define a set of threshold criteria that indicate when the river may exceed acceptable conditions and necessitate the implementation of the contingency plan.

- ***Develop a long-term management plan for the lower Sauk River.*** Complete a program, perhaps using the Initiative Foundation's 'Healthy Lakes and Rivers Program' to create a long-term plan for caring for the Sauk River. Completing a plan similar to this allows many citizens to get involved and partnerships with local and state agencies to flourish. It allows goals to be clearly identified and the action plan created.

- ***Establish demonstrations highlighting best practices on rivers.*** A picture is worth a thousand words. Having a number of demonstrations highlighting river best management practices, such as stormwater education, shoreland landscaping, bank stabilization, and septic system maintenance, can get a lot of good discussion and momentum started around these topics within the river community.

- ***Do not hesitate to retell important messages.*** Even the most basic messages may find a new and receptive audience. Provide area residents with resources that help them make good decisions and become responsible stewards by partnering with municipalities, the watershed district, and county soil and water conservation districts (e.g., stormwater publications which promote proactive practices).