Snake River Watershed – St. Croix River Basin

Water Assessment and Trends Update

Why is it important?

Water monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. While local partners and state agencies monitor water quality on an ongoing basis, the Minnesota Pollution Control Agency (MPCA) and local partners conduct an intensive exam of major lakes and streams in each of the state's 80 watersheds every 10 years to detect any changes in water quality. This intensive monitoring looks at fish and bug communities as well as water chemistry to gauge water quality. The partners use the data to see which waters are healthy and need protection and which are impaired and need restoration. Waters are considered impaired if they fail to meet water quality standards.

The Snake River Watershed-St. Croix River Basin, north of the Twin Cities, encompasses 1,006 square miles in six counties, including Aitkin, Kanabec, Mille Lacs, Pine, Chisago and Isanti. The Snake River Watershed has many opportunities for recreation such as fishing, canoeing and camping. The river begins in the wetland areas of the Solana State Forest before flowing to the St. Croix National Scenic Riverway. Identifying impairments to implement best management practices (BMPs) and protecting healthy systems will help to preserve them for future generations. Generally, the watershed is in good health and efforts should be made to protect the Snake River Watershed.

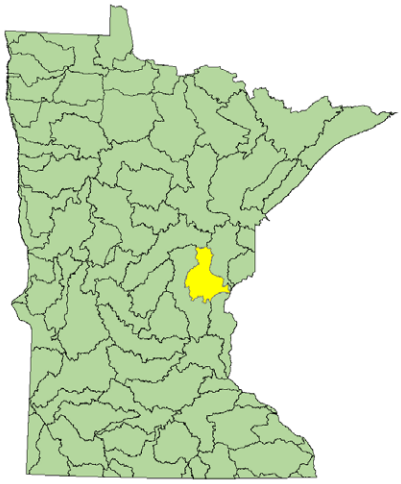
Is the water quality improving?

The MPCA first studied the Snake River Watershed in 2006 and did a second cycle of intensive water monitoring in 2017-18. This second cycle of monitoring found that generally lakes and streams in this watershed remain in good condition, though there is some room for improvement.

The Snake River Watershed has streams and lakes with healthy fish and bug communities, though recreation use is generally impaired for lakes and streams. Excess bacteria in streams and high levels of algae in lakes can limit recreational opportunities.

Overall, scientists observed little change in the water quality in the watershed over the past decade. It is important to protect the forests, wetlands and other natural features of this watershed while working to reduce pollutants like bacteria that can make water unsafe for swimming and nutrients that can cause algae.

The Snake River Watershed is located north of the Twin Cities.



Scientists use a tool called the Index of Biological Integrity to assess the biological conditions of water resources. The higher the score, the healthier the community of fish and macroinvertebrates, commonly call bugs. Macroinvertebrates are animals lacking a backbone such as mayflies, crayfish and snails. There was not a significant change in the Index of Biotic Integrity (IBI) values for fish or macroinvertebrates (bugs). The average fish IBI scores went down by 2.4 points, while the average macroinvertebrate IBI score decreased by 1 point. Bacteria concentrations were elevated in portions of the watershed, while sediment and nitrogen levels were generally low. The lakes generally had elevated levels of nutrients, which can cause algal blooms.

The headwaters of the watershed are dominated by mixed forest and wetlands. Moving further downstream there is more agriculture, pastureland, and urban development. Landowners have implemented hundreds of BMPs across the watershed to help improve and protect water quality, but more projects are needed to continue the work of removing impairments to lakes and streams.

The second cycle of intensive water monitoring found some good and bad news:

- Scientists identified three new macroinvertebrate and six new bacteria impairments. The watershed has several impairments for aquatic life and recreation (fish and swimming) from previous assessments.
- Pomroy Lake in Kanabec County has improving water clarity.
- The first assessment of fish in the lakes by the Minnesota Department of Natural Resources (DNR) showed that of the five lakes assessed; only Pokegama Lake, in Pine County, was impaired.

Highlights of monitoring

- The MPCA monitoring crew captured a lake sturgeon, a species of concern in Minnesota. Sturgeon often have healthy populations only in areas with good water quality. Finding a young lake sturgeon is a good indication that the population is reproducing and established in the river. Sturgeon are a sensitive species, meaning they are quick to react to stressors. A variety of sensitive species were found while sampling throughout the watershed, including northern hogsuckers and southern brook lamprey.

MPCA monitoring crews found northern hogsucker, a species sensitive to pollution, while sampling the Snake River.

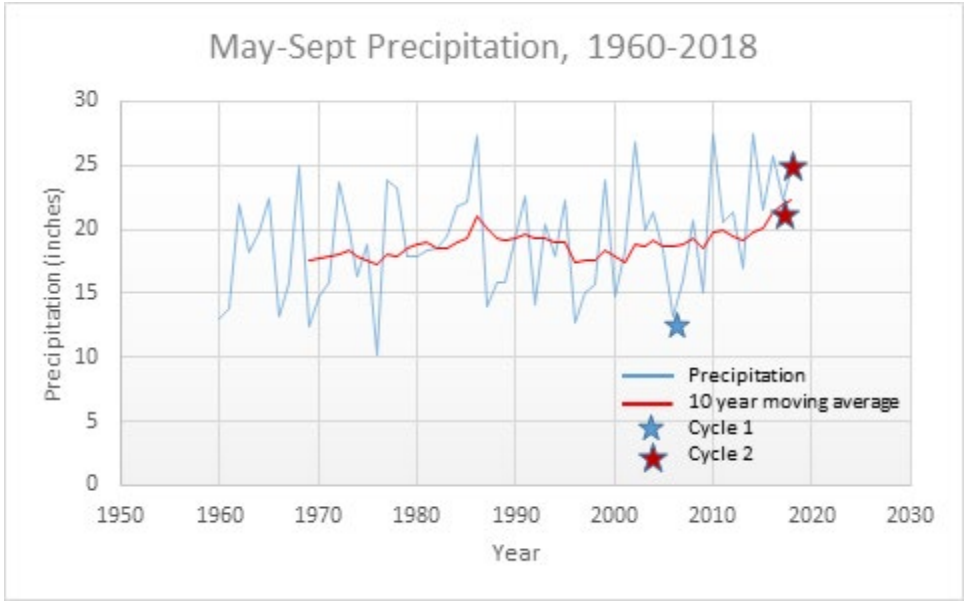
- While conducting watershed sampling, scientists note any presence of aquatic exotic species. In recent years, the presence of curly-leaf pondweed in streams throughout Minnesota has become much more common. This is also true of streams in the Snake River Watershed. All the large lakes in the watershed (Pokegama, Cross, Mud, Fish, Knife, Ann and Bear) are known to have curly-leaf pondweed, so it is to be expected that connected tributaries would also have curly-leaf. As curly-leaf spreads throughout the watershed, it can decrease available habitat for communities of fish and bugs.

Success story: Natural areas provide built-in resiliency

High water overtakes a road in the Snake River Watershed on July 12, 2006.

This watershed is better able than many areas to absorb intense storm events, and the resulting high runoff and stream flows, because scientists consider it to still be "intact," meaning many natural areas have remained untouched, including wetlands and floodplains. In 2017 and 2018, the Snake River Watershed saw multiple high intensity rain events, which led to noticeable flooding. High intensity rain events can lead to increased erosion and runoff in streams, which can cause impairments to the watershed. Intact wetlands, access to floodplains, low erosion rates, and intact riparian land all help preserve the watershed during the prolonged periods of high flow. While the watershed has experienced changes in land use and increased urbanization, many natural areas have remained untouched, helping to prevent additional impairments. In spite of all these possible stressors, the watershed has remained relatively stable, with few new impairments. The new lake assessments support the low impairment rate of biological communities in the Snake River Watershed. In cycle one, there was no fish IBI available to assess the lake fish communities. In cycle two, the DNR assessed the fish in lakes for the first time. Knife Lake, Fish Lake, Ann Lake, Cross Lake and Pokegama were all assessed. Only Pokegama was found to be impaired for aquatic life due to fish IBI. The few impairments are evidence that the watershed is intact and it is important to protect those features.

Precipitation in the Snake River watershed observed in Mora between 1960 and 2019. Precipitation during cycle two was much higher than it was in cycle one, due to the high density rain events.

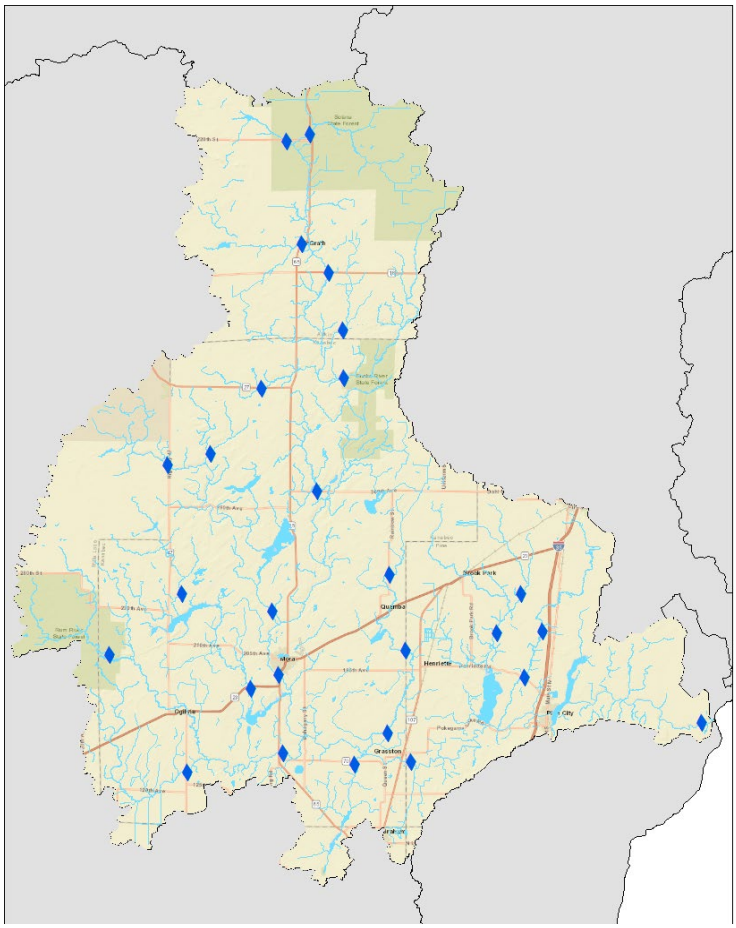


About this study

The Snake River Watershed was the first where the MPCA conducted intensive water monitoring as part of Minnesota's approach to gauging the health of major watersheds. The MPCA established a network of biological monitoring stations for streams, as listed in the table below. Fish and macroinvertebrates were sampled at these stations in 2006 and again during 2017-2018 while the DNR sampled fish communities at lakes across the watershed. The MPCA also established water chemistry stations, and collected data in 2006 and 2017-'18, with local partners collecting data in between. All this data was used to assess if waterbodies are meeting aquatic life, aquatic recreation, and aquatic consumption standards. Streams that do not meet these standards are listed as impaired and a plan is developed to identify and fix the cause of the impairment. The development of a protection strategy is recommended for streams the MPCA identifies as nearly impaired.

In addition to data collected for assessment, there are four Watershed Pollutant Load Monitoring Network (WPLMN) stations that operate every year on a long-term basis. The stations measure stream discharge and several water chemistry parameters. The sample location furthest downstream is near Pine City; the others are located at upstream locations, including in Mora. The long-term data collected at these stations is used for watershed modeling, determining pollutant source contributions, developing reports, and measuring water quality restoration efforts.

Biological monitoring stations in the Snake River Watershed sampled for fish and/or macroinvertebrates during cycle 2 monitoring.



Biological Monitoring Site Location Information

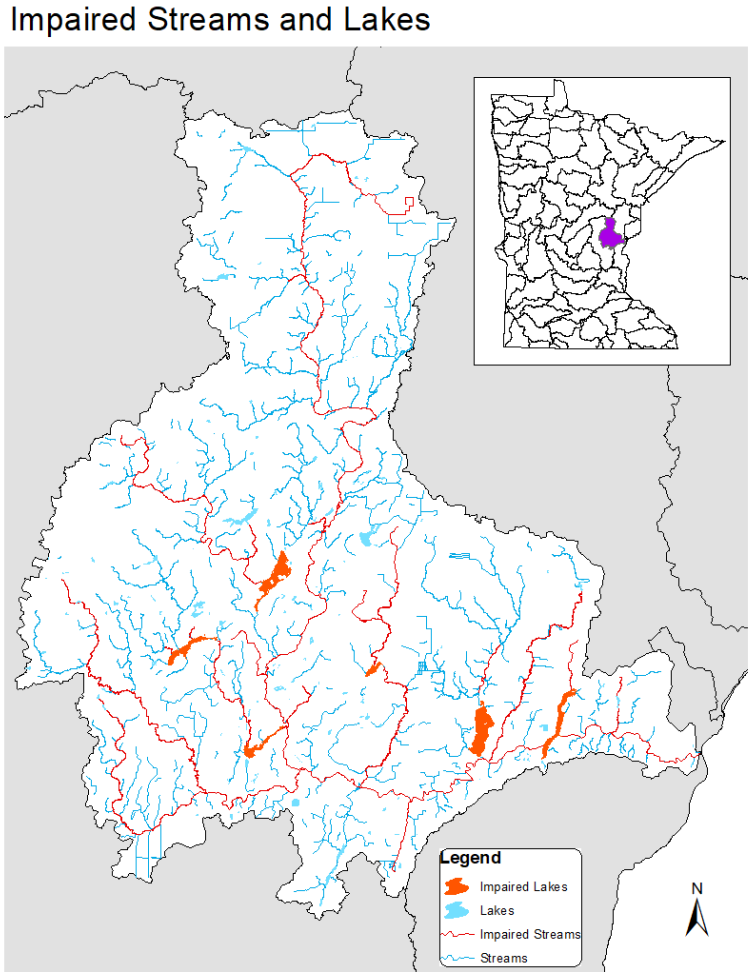
Field Number	Waterbody Name	Location
06SC007	Snake River	Downstream of CR 9, 9 mi. E of Pine City
06SC042	Pokegama Creek	Downstream of CR 14, 6 mi. NW of Pine City
06SC054	Snake River	Downstream of Hwy 107, 0.5 mi. E of Grasston
06SC107	Mud Creek	Upstream of CR 5, 1 mi. NW of Grasston
06SC109	Mud Creek	Upstream of CR 120, 1 mi. NW of Henriette
06SC110	Mud Creek	Downstream of CR 5, 4 mi. W of Brook Park
06SC111	Rice Creek	Upstream of Hwy 70, 3 mi. W of Grasston
06SC115	Snake River	Upstream of Hwy 65, in Mora
06SC117	Snowshoe Brook	Adjacent to CSAH 3, 3 mi. SE of Warman
06SC123	Snake River	Downstream of Olympic St, 3 mi. NE of Woodland
06SC125	Knife River	Downstream of CR 88, 6 mi. N of Mora
06SC127	Trib. to Knife River	Upstream of CR 15, 5 mi. W of Warman
06SC128	Knife River	Upstream of Hwy 47, 7 mi. W of Warman
06SC131	Cowan's Brook	Downstream of CR 61, 5 mi. NE of Woodland
06SC133	Bear Creek	Upstream of CR 9, in McGrath
06SC138	Little Ann River	Upstream of CR 26, 3 mi. N of Ann Lake
07SC009	Mission Creek	Upstream of Hwy 11, 3 mi. NW of Pine City
17SC102	Trib. to Snake River	Upstream of CR 2, 1 mi. W of Pliny
17SC105	Chelsey Brook	Adjacent to FR 38-1, 5 mi. SW of Giese

Fish and Macroinvertebrate Assessment

Fish communities are generally healthy in the Snake River Watershed, and have not changed much since sampling in cycle one (2006). During assessment, the MPCA and partners reviewed the fish data for 24 stream sections. They decided not to assess two sections for meeting standards. Of the 22 remaining sections, only two are impaired for fish. Mission Creek and the headwaters of the Snake River had existing impairments and will remain listed as impaired. Both streams have a lack of fish cover and in-stream habitat at stations where fish scored below the impairment standard. Insignificant changes were observed in IBI scores between cycle one and two, and none resulted in an impairment status change. Samples should occur at normal (base) flow. In 2006, the watershed experienced periods of drought, which can impact fish movement throughout the summer. Both 2017 and 2018 experienced periods of high water which can also impact fish communities. The lack of new fish impairments despite significant fluctuations in flow demonstrate the stability of the Snake River Watershed.

Macroinvertebrate communities are also generally healthy in the Snake River Watershed. Macroinvertebrate assessments took place on 29 stream sections where only three new impairments were identified. The northern and western half of the watershed, which is dominated by forested areas and wetlands, supports a pattern of healthy stream macroinvertebrate communities based on 2017-2018 monitoring. The data collected in cycle one (2006) was collected during a significant drought, and showed variable results throughout the watershed. Higher scores were generally associated with streams able to support more stable base flows during the stressed condition. Lower scores in the southern and eastern half of the watershed follow a pattern of agricultural development, including cropland and grazing.

Impaired streams and lakes in the Snake River watershed.



Fish communities are a reflection of the cumulative effects of natural and human-caused influences in lakes. An IBI measures a lake's health and identifies lakes that may be impacted by watershed disturbance, shoreline degradation, or other environmental stressors. Five lakes were assessed for aquatic life using a fish-based IBI, developed for Minnesota lakes. Overall fish diversity was fairly high due to connections with the Knife, Ann, and Snake rivers. However, relatively few species of fish intolerant to stressors were sampled within lakes in the watershed. Four of the lakes within the Snake River Watershed fish communities met standards, although the fish community data collected suggested some impacts from watershed land use and water quality. Pokegama Lake was assessed as impaired for fish; a relatively high biomass of tolerant species of fish were sampled in Pokegama Lake. The fish community in Pokegama Lake appears to be impacted by the large watershed area draining to Pokegama Lake, poor water quality, and areas of intensive shoreline development.

The Groundhouse River, Ann River, Mission Creek, South Fork Groundhouse River, Knife River, Mud Creek and Bear Creek were listed as impaired for biology during the initial assessment of this watershed, using initial IBI methods. A reevaluation of these results using updated indicators, along with an evaluation of subsequently collected samples; suggest that these streams should no longer be listed as impaired. Fish impairment corrections will be made to Bear Creek, Ann River, Groundhouse River and South Fork.

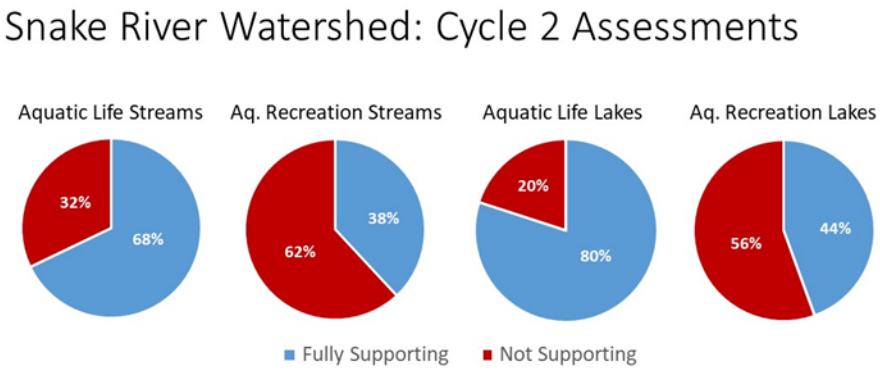
Macroinvertebrate corrections will be made to Groundhouse River, Ann River, Mission Creek, South Fork Groundhouse River, Mud Creek and Knife River. While these streams have had corrections made due to improved standards, improvements have been made based on recommendations outlined in the Watershed Restoration and Protection Strategies (WRAPS) report. The MPCA has developed Stressor Identification for the Ann River and Mud Creek, and the Groundhouse River and Ann River have completed or in-process Total Maximum Daily Load plans.

Spring Brook was managed as a trout stream by DNR until 1967. Management ended due to beaver activity and poor habitat. An evaluation of the macroinvertebrates and temperature resulted in Spring Brook being reclassified as a cold-water stream. The stream is an isolated cold-water system that is unable to support a healthy cold-water fish community so no fish assessments occurred. If the DNR resumes managing Spring Brook as a trout stream it may be possible to assess future fish samples.

Water Chemistry Assessment

In the Snake River Watershed, low dissolved oxygen and elevated bacteria levels were the primary chemical impairments found throughout the watershed. The majority of these impairments are found in the southern, downstream half of the watershed. The land use consists of mixed forest and wetlands in the headwaters, but moving downstream, it transitions to being dominated by row crop, pasture, and developed lands, which could be driving some of the impairments.

While most streams are supporting the standard for aquatic life (fish and bugs), many are not supporting the standard for aquatic recreation (wading and swimming) because of high bacteria levels at times. Most lakes are supporting the standard for aquatic life, but most are not supporting aquatic recreation because of high nutrient levels at times.



Most of the 13 publicly accessible lakes are found in the lower half of the watershed. Six of the lakes have excess nutrients, all of which were found to be impaired in previous assessments. Characteristics among these lakes are similar, with all being flow-through lakes, where agriculture comprises much of their watersheds, and many are shallow (less than 15 feet deep). These characteristics result in high nutrient loads and warm, shallow waters which grow algae. Based on the most recent assessment, Mora Lake is near the impairment threshold. In addition, Pomroy, Devils and Pennington lakes were identified as priorities for phosphorus reduction. Work to reduce phosphorus levels will be important to protect these lakes from becoming impaired.

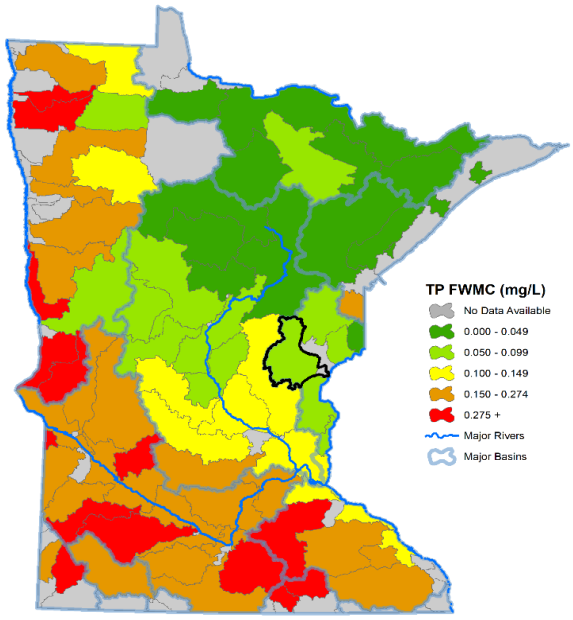
The pollutants: suspended solids, phosphorus, and nitrate

In addition to the Watershed Pollutant Load WPLMN site downstream near Pine City that has been operating every year since 2007, there are three subwatershed-scale sites that have been operating since 2015. These sites monitor for:

- Total suspended solids – soil, sediment and other particles - in the water that can make it hard for fish to breathe, find food, escape predators and reproduce.
- Phosphorus that can grow algae.
- Nitrogen that can contribute to algal growth and be toxic to fish.

The Snake River has overall low levels of total suspended solids (sediment) and nitrogen at all four monitoring locations. Phosphorus concentrations remain low in the Snake River watershed. Both suspended solids and phosphorus concentrations in the upper watershed may become elevated immediately

2007-2016 average total phosphorus (TP) flow weighted mean concentrations by major watershed. The Snake River watershed is outlined in black.



following heavy rain, but these conditions are short-lived. Nitrate concentrations are typically higher during low flow periods and winter months.

Snake River total load contributions to the St. Croix and Mississippi rivers

Pollutant	St. Croix before confluence with Mississippi	Mississippi before it reaches Iowa
Suspended Solids	8%	<1%
Phosphorus	22%	2%
Nitrate	6%	<1%

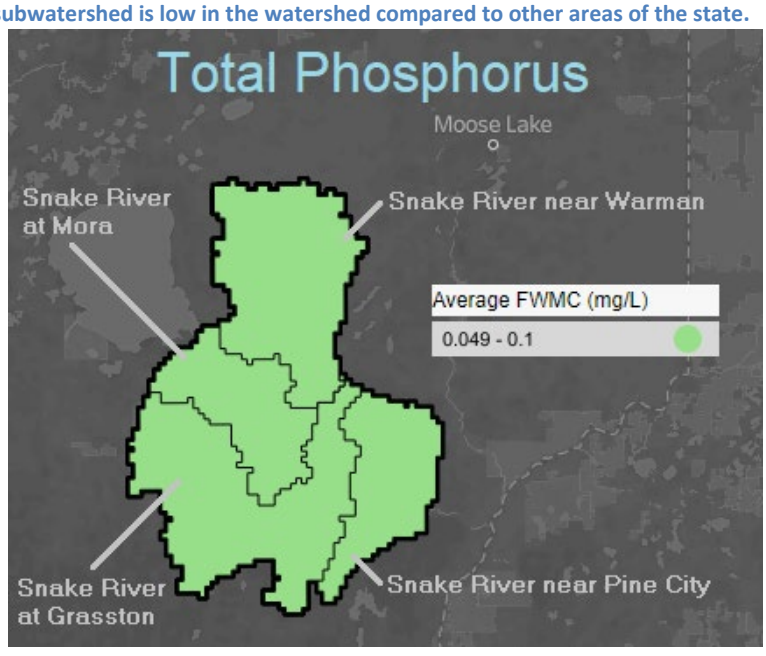
Water quality impacts of the Snake River on the St. Croix River is greatest for phosphorus. The average phosphorus load from the Snake River is the equivalent of 22% of the average load measured at Stillwater (monitored by Metropolitan Council Environmental Services). Suspended solids and nitrate inputs from the watershed have a lesser impact, with the Snake River contributing the equivalent of 8% of the average suspended solids load measured at Stillwater and 6% of the average nitrate load measured at Lock and Dam 3.

Water quality impacts of the Snake River on the upper Mississippi River basin is greatest for total phosphorus. The average phosphorus load from the Snake River is the equivalent of 2% of the average load measured at Lock and Dam 3. Lock and Dam 3 is the furthest downstream monitoring site on the Mississippi River above Lake Pepin (monitored by Metropolitan Council Environmental Services). The average load from the Snake River is the equivalent of <1% of the average load measured at Lock and Dam 3 for both suspended solids and nitrate.

Seasonal trend analysis on sediment, phosphorus, and nitrate concentrations in the Snake River near Pine City was used to determine if changes over time are statistically significant. Only phosphorus showed a statistically significant change from 2008 to 2017, decreasing about 3.5% each year. This trend is promising because phosphorus is the only parameter of the three considered that might be seen as slightly elevated. No trend was detected for suspended solids or nitrate.

Another way to look at trends in sediment, phosphorus, and nitrogen is through flow weighted mean concentrations. These are the total yearly mass (loads) of sediment, phosphorus, and nitrate coming out of the Snake River at its mouth divided by the total yearly flow. Intensive water sampling combined with accurate streamflow data is necessary to calculate loads, so they are only available from 2007 for the Snake River. This time period is too short to make definitive statements about trends over time; however, sediment, phosphorus and nitrate flow weighted mean concentrations appear to be relatively low and relatively stable.

The average phosphorus flow weighted mean concentration by Snake River subwatershed is low in the watershed compared to other areas of the state.



The Snake River has overall low levels of sediment and nitrogen. Phosphorus levels are slightly elevated but remain fairly low when compared to many other watersheds throughout the state. Overall, water quality in the Snake River is similar to nearby watersheds in northern Minnesota. The map above shows statewide monitoring results for phosphorus. Similar maps for other pollutants and supporting data can be found at https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

Trends

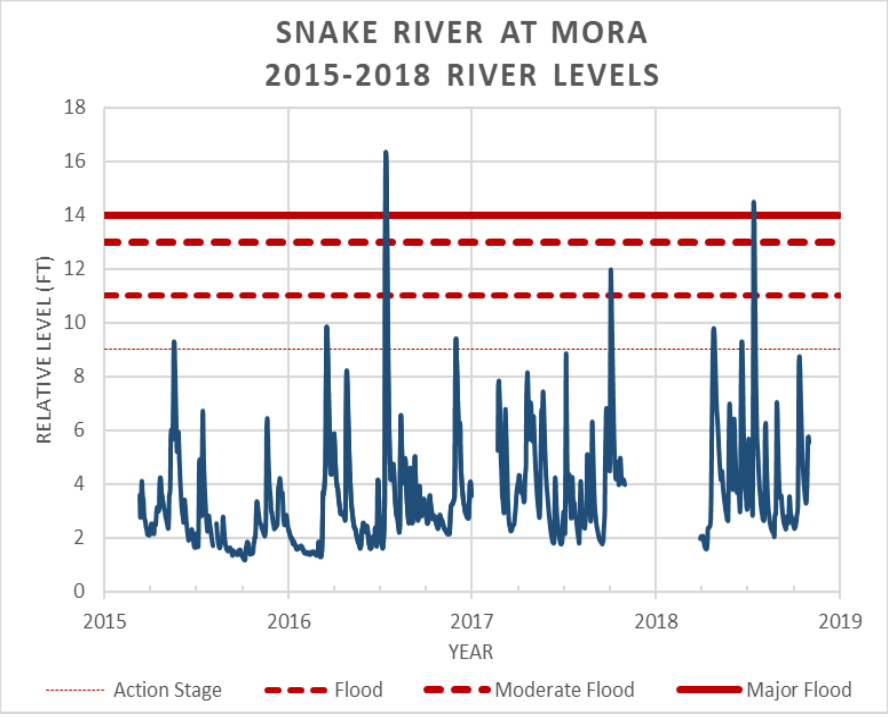
A key objective of the 2017 monitoring effort was to evaluate if and how water quality has changed since 2006. If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation, based on the initial work and combined with actions that were already underway, may be responsible. It is equally important to understand if water quality does not appear to be changing, or is declining. Either way, the knowledge will help inform future activities.

Trends in four different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Snake River Watershed:

1. Streamflow, sediment (total suspended solids), total phosphorus, and nitrogen (nitrate)
2. Biological communities (fish and bugs)
3. Clarity of lakes
4. Climate

Streamflow and water levels

The Snake River Watershed has recorded several flood events in recent years.

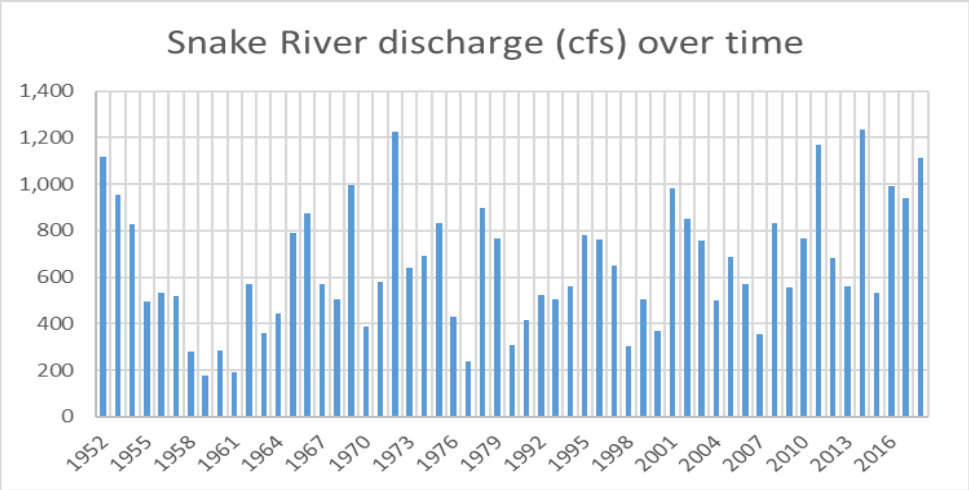


The upper Snake River has risen above flood stage on multiple occasions in recent years. Widespread rainfall of 5-6 inches was recorded across nearly all of the upper Snake River Watershed on July 12, 2016. The Snake River responded by exceeding major flood stage by more than 2 feet, submerging roads and causing widespread flooding. Two years later to the day, widespread rainfall of 3-5 inches was recorded across much of the upper Snake River Watershed, once again prompting the Snake River to exceed major flood stage. In both cases, river levels had attenuated below flood stage by the time the crest had reached the U.S. Geological Survey river gaging station near Pine City.

The DNR began tracking river stage and flow volume in 2015. By the end of 2018, the Snake River monitoring location at Mora had recorded river levels surpassing flood stage three times, including the two instances where it surpassed major flood stage detailed above. The Snake River has exceeded action level on five other instances during this four-year period. 2019 stage data is yet to be finalized, but it is already clear that the Snake River stage was once again high on several occasions.

Continuous annual streamflow (discharge) data is available for the Snake River Watershed since 1953. In that, time period there is no clear trend, although it is important to note that three of the highest flow years have occurred since 2010, suggesting that the hydrology of the Snake River may be in a period of transition. High flow events have implications for stream channel conditions and pollutant loading, namely more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable. Because loads represent the total amount of a pollutant moving through a system, this way of measuring water quality is important for downstream resources such as Lake Saint Croix and Lake Pepin, where these pollutants may accumulate.

Flow data suggest that the Snake River is in transition to a higher flow level that can carry more pollutants to downstream to St. Croix Lake and Lake Pepin.

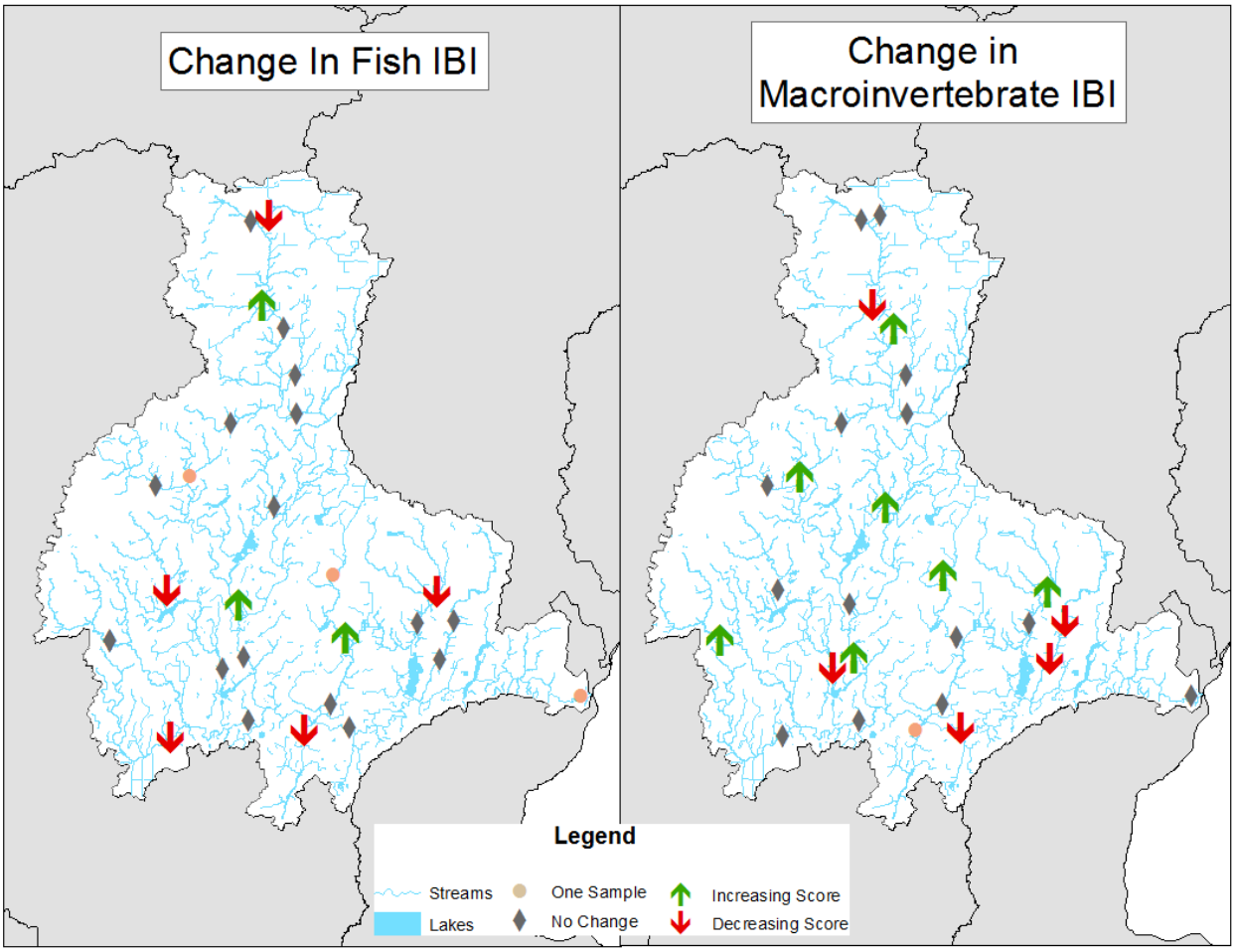


Fish and macroinvertebrate communities

Scientists used statistical testing methods, requiring site data from both cycles 1 and 2, to detect changes for fish and macroinvertebrate communities. Twenty-four sites were evaluated for macroinvertebrates and 21 for fish, with the results shown in the map below. The average macroinvertebrate IBI score for the watershed increased by 2.8 points between 2006 and 2017-18, which is not a significant change, and statistically does not indicate true change. Similarly, fish IBI scores across the Snake River Watershed decreased by 1.0 point, which was also not statistically significant. Essentially, that means there was no change to the fish and macroinvertebrate communities.

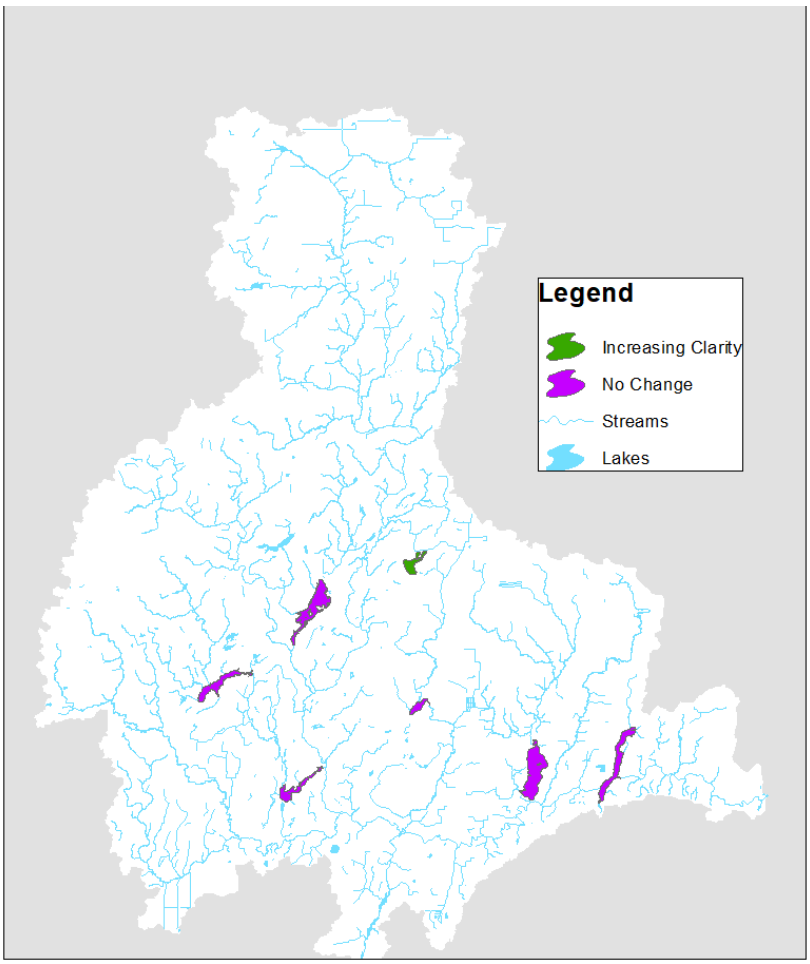
When looking at the change analysis results, it is important to consider the condition of the watershed when the sampling occurred. In 2006, the Snake River Watershed experienced a severe drought, seeing nearly 6 inches less rain than normal over the summer months and was warmer than average (+1.4 °F) during the July to September time period. The watershed had above normal rainfall and flows (+3.3/+5.7 in) in 2017 and 2018 over the May to September time period. Heavy precipitation in mid-July of 2017 and 2018 had a significant impact on fish sampling, causing delays each year. Of the 30 sites, 25 were sampled for fish – 12 in 2017 and 13 in 2018. In 2018, all sites were sampled for fish in late August into mid-September, which is nearing the end of the sampling window. Despite above average flows in 2017, all sites were able to be sampled for invertebrates. Overall, given the hot and dry conditions affecting the watershed in 2006 and the wetter than average conditions during the second cycle monitoring , there is a high likelihood that any observed changes in biological condition at either the watershed or individual site scale are at least partially due to differences in climatic conditions between the two periods.

Changes in fish and macroinvertebrate IBI scores between cycle one and cycle two. Changes indicated do not represent changes in impairment status.



Transparency of lakes

For the lakes with enough data to detect a trend, most are showing no change in clarity.



The Snake River Watershed has 13 lakes with some level of transparency data. The MPCA conducted trend analysis on eight lakes that met data requirements (25 Secchi measurements, eight years of data). Similar to statewide results, most lakes do not exhibit a significant trend and more lakes have improving clarity over declining. Pomroy Lake had improving clarity while Quamba, Cross, and Fish lakes were exhibiting no change in clarity. Many of these lakes exhibit bog staining; this results in little change in water clarity from year to year. The darker water will limit clarity more than algal growth does.

Climate

The Snake River Watershed now receives on average two additional inches of rain from the historical average (1895-2018). Furthermore, climate scientists suggest that precipitation events are becoming more intense. In addition, temperatures in the watershed have increased by a degree in spring and fall over this time period. Increased rainfall and temperature can worsen existing water quality problems. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and stream flows. Increased stream flows in turn can lead to stream channel erosion and degraded habitat for fish and other aquatic life. Longer growing seasons with higher temperatures can lead to more algal blooms. These changes will complicate efforts to protect and restore the watershed.

For more information, see the DNR climate summary for the Snake River Watershed online: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/climate_summary_major_36.pdf.

For more information

Stressor identification for new impairments and updates to the Watershed Restoration and Protection Strategy (WRAPS) follow the completion of monitoring and assessment. For more information, go to https://www.pca.state.mn.us/water/watersheds/snake-river-st-croix-basin or search for “Snake River Watershed” on the MPCA website.

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