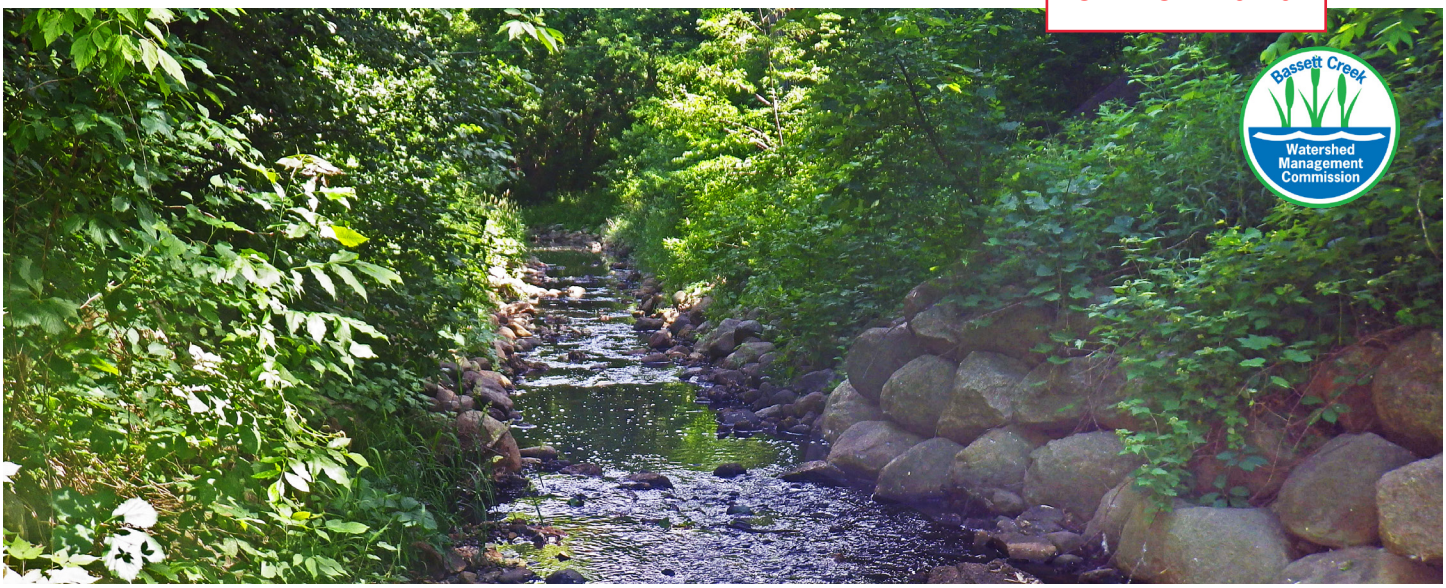
Item 5B.
BCWMC 7-16-20



2018–2019 Stream Monitoring and 2018 Biotic Index Evaluation of the North Branch of Bassett Creek

Summary

In 2018 and 2019, the BCWMC collected flow and water quality data from the North Branch of Bassett Creek. The purpose of the stream monitoring program is to evaluate flow and water quality, detect changes over time, determine whether the Minnesota Pollution Control Agency (MPCA) water quality standards are met, and identify stressors to the biological community.

Results of the North Branch stream monitoring program show the stream met MPCA standards for temperature, metals (total cadmium, chromium, copper, nickel, lead, and zinc), and stream eutrophication (i.e., total phosphorus in combination with chlorophyll *a*), but failed to meet standards for chlorides and total suspended solids. While the stream also failed to meet the MPCA standard for E. coli bacteria in 2018 and 2019, the MPCA requires collection of a minimum number of samples within a 10-year period before determining impairment. The number of samples collected in 2018 and 2019 was less than the required minimum. Therefore, the stream is not, yet, considered impaired for E. coli.

Between 1980 and 2018, the BCWMC collected benthic macroinvertebrates (bottom-dwelling organisms) from the North Branch of Bassett Creek on 11 occasions. The purpose of the sampling was to evaluate water quality and detect changes over time. The 2018 monitoring program sampled for macroinvertebrates and assessed habitat.

Three biotic indices were used to assess the macroinvertebrate data:

- **Hilsenhoff Biotic Index (HBI)—**Assesses long-term oxygen content of the stream.
- **Invertebrate Community Index (ICI)—**Measures the average tolerance of the macroinvertebrate community to a wide range of pollutants.
- **Macroinvertebrate Index of Biotic Integrity (M-IBI)—**Assesses the health of the macroinvertebrate communities. The MPCA developed the M-IBI and added it to Minnesota's water quality standards to help identify biologically impaired rivers and streams.

2018 Hilsenhoff Biotic Index (HBI) and Invertebrate Community Index (ICI) scores were consistent with past values.

None of the locations monitored from 2006 through 2018 met the MPCA M-IBI impairment standard and poorer M-IBI scores were documented at the North Branch in 2018. Thus, the North Branch of Bassett Creek would be considered biologically impaired. The 2018 decrease in score may be due to the negative impacts of increased flow and increased pollutant loading during a major precipitation event that occurred 2 weeks prior to collection of the 2018 macroinvertebrate samples.

Poorer M-IBI scores in 2018 reflected:

- Decreased numbers of taxa (a scientifically classified group or entity) known as climbers (i.e., taxa requiring habitat such as overhanging vegetation and algae that provide opportunities to climb); this is an indication of poorer habitat.
- An increased percentage of tolerant taxa in the stream.
- A lower HBI_MN score, resulting from a higher percentage of tolerant taxa in the stream.
- Lower numbers of Odonata taxa (i.e., dragonflies and damselflies).
- Lower numbers of taxa known as predators (i.e., taxa that feed on other organisms in the stream).
- Lower numbers of Trichoptera taxa (i.e., caddisflies).

Recommendations

Because the North Branch of Bassett Creek is biologically impaired and failed to meet MPCA standards for total suspended solids, chlorides, and E. coli bacteria from 2018 through 2019, it is recommended that BCWMC continue to:

- Assess the North Branch of Bassett Creek to identify the cause of high concentrations of total suspended solids and E. coli bacteria and implement management measures to reduce concentrations and meet MPCA water quality standards for the stream.
- Continue education efforts to reduce chloride use in the watershed (e.g., Smart Salting Certification training) with a goal of meeting the MPCA chloride standard for the stream.
- Assess the North Branch of Bassett Creek to identify and implement additional habitat and/or water quality improvement projects to improve the macroinvertebrate community with a goal of meeting the M-IBI impairment threshold for the stream.
- Monitor stream habitat, flow, and water quality to determine if the stream meets MPCA water quality standards, identify changes over time, and identify stressors to the macroinvertebrate community.
- Monitor habitat, flow, and water quality when biological samples are collected to identify changes over time and stressors to the macroinvertebrate community.

Stream monitoring

The North Branch of Bassett Creek was monitored from 2018 through 2019 at a station immediately downstream of 34th Avenue and upstream of the biological monitoring location. Figure 1 shows the location of the monitoring station. Table 1 describes the stream restoration project completed in this area.

Water depth, flow, specific conductance, and temperature were measured continuously during the monitoring period. Water quality samples were collected manually on 14 occasions to monitor base-flow conditions and with an automatic sampler on 16 occasions to monitor storm events.

Because ice conditions in the channel during winter months prevent accurate measurements, the monitoring period was limited to spring through early winter (May through December of 2018 and April 2019 through January 3, 2020). All storm and base-flow samples were analyzed for nutrients (total phosphorus, dissolved phosphorus, nitrate/nitrite, and total Kjeldahl nitrogen), solids (total suspended solids and volatile suspended solids), chlorides, hardness, sulfate, alkalinity, and total organic carbon. Quarterly samples were analyzed for metals (chromium, cadmium, copper, lead, nickel, and zinc). In addition, grab samples were analyzed for ortho phosphorus, chlorophyll *a*, and E. coli bacteria. The following equipment was used for the monitoring program:

- **Radar water-level sensor:** A radar water-level sensor (Figure 2) measured water levels at 15-minute intervals and a data logger (Figure 3 and Figure 4) recorded the measurements. A data logger is an electronic device that records data over time. Flow was measured at a range of depths using a flow meter, and a stage-rating curve was developed to estimate flow from the measured water depths. The stage-rating curve equation was added to the data logger program, which allowed the automatic computation of flow from water depth for the duration of the monitoring period.
- **Cellular modem (Figure 3):** Enabled staff to control equipment and download data from their offices.
- **SunSaver regulator (Figure 3):** This instrument controls the current flowing from the solar panel to the battery and prevents the current from flowing in reverse (i.e., battery to solar panel).

Table 1: Capital improvement project (stream restoration) along the North Branch of Bassett Creek

Project	Status	Location
North Branch Bassett Creek Restoration Project: 200 feet upstream of Douglas Drive to 32nd Avenue North	Construction began fall 2012; completed in fall 2013	Crystal

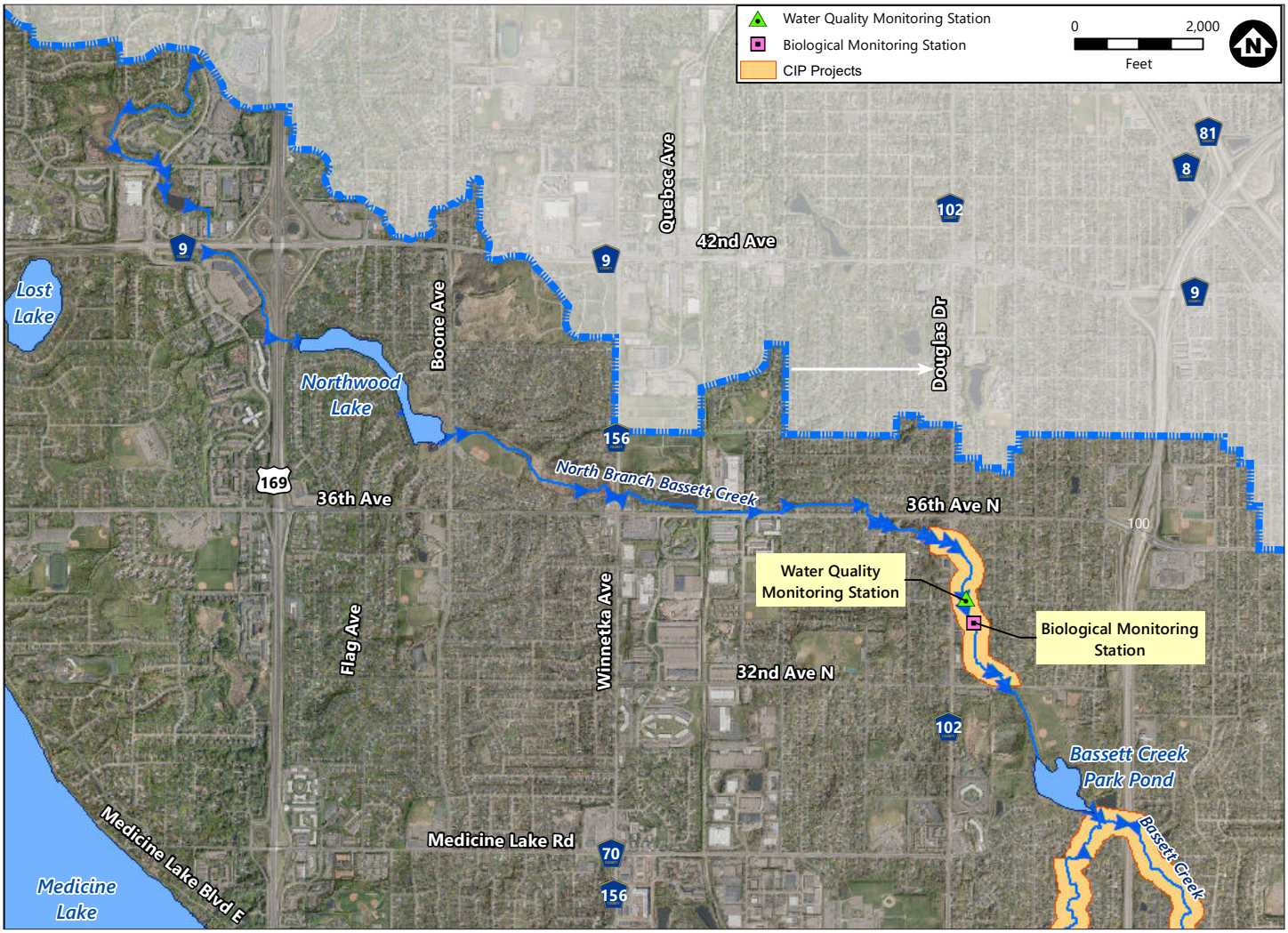


Figure 1: North Branch Water Quality and Biological monitoring locations at 34th Avenue

- **Temperature probe and data logger (Figure 3):** The probe measured water temperature and the data logger recorded the measurements.
- **Specific conductance probe and data logger (Figure 3):** The probe measured specific conductance and the data logger recorded the measurements.
- **Solar panel (Figure 4):** Charged the battery used to operate the equipment.
- **Automatic sampler (Figure 5) and sampler intake:** Collected storm samples.

Figure 2: Radar water level sensor

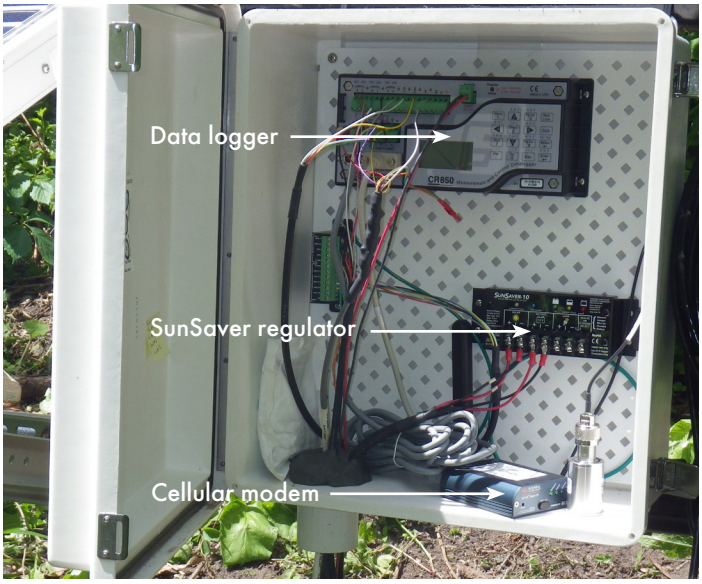


Figure 3: Data logger, cellular modem, and SunSaver regulator

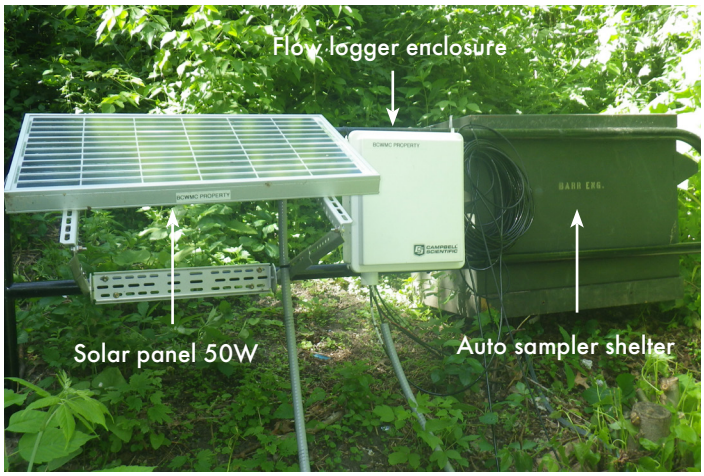


Figure 4: Solar panel, flow logger enclosure, and auto sampler shelter

Figure 5: Automatic sampler and external battery

Results of 2018–2019 stream monitoring program

Water depth and flow

Water depth and flow were measured at 15-minute intervals throughout the monitoring period. The results are shown in Table 2 and Figures 6 and 7.

The highest flows during 2018 and 2019 are more uncertain and considered provisional due to the lack of depth and flow data at the high levels during development of the stage-rating curve. It is difficult to capture these high measurements due to the flashiness of the stream (rapid increases and decreases in depth and flow after a storm).

Temperature

Temperature was measured at 15-minute intervals throughout the monitoring period. During the 2018 monitoring period, the average daily temperature ranged from 32° F to 80 °F; the overall average was 59° F (Figure 8). During the 2019 monitoring period, average daily temperature ranged from 32 °F to 79 °F; the overall average was 59 °F (Figure 8). All measurements met the MPCA standard of less than or equal to 86°F. The MPCA is not currently using the standard to assess warm-water streams such as the North Branch of Bassett Creek. Instead, it is evaluating mostly cold-water fisheries for temperature-caused impairment because of the special sensitivity of cold-water fish to temperature elevations.

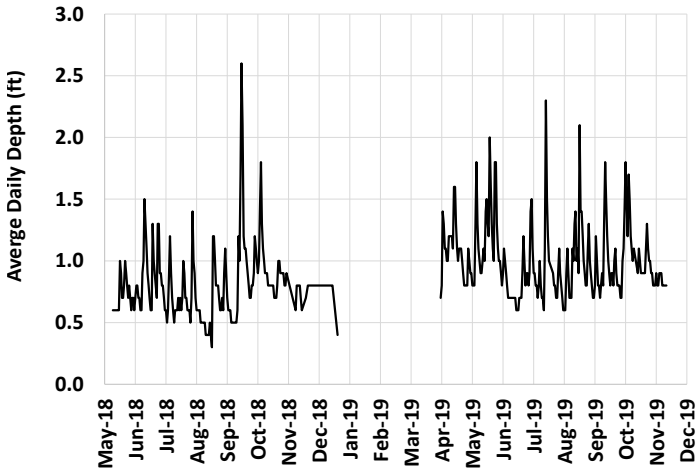


Figure 6: Average daily depth of the North Branch of Bassett Creek at 34th Avenue

Table 2: 2018–2019 water depth and flow

Parameter	2018			2019		
	Low	High	Average	Low	High	Average
Average daily water depth	0.3 feet 8/23/18	2.6 feet 9/21/18	0.8 feet	0.6 feet 6/19/19	3.5 feet 7/16/19	1.0 foot
Average daily flow	0.01 cfs 8/23/18	74.9 cfs 9/21/18	2.9 cfs	0.3 cfs 7/14/19	53.4 cfs 7/16/19	5.4 cfs

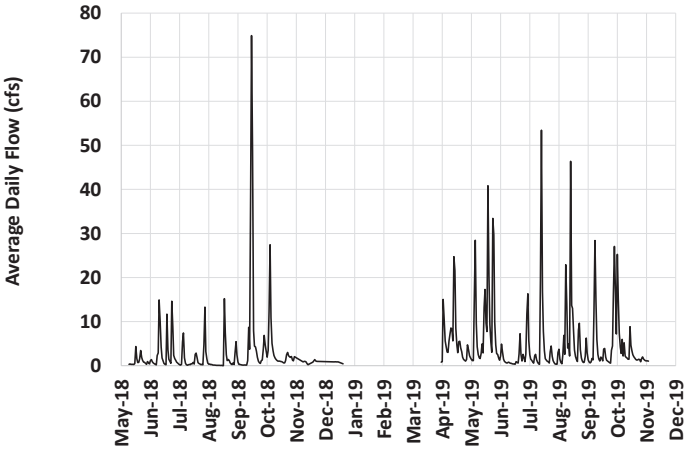


Figure 7: Average daily flow of the North Branch of Bassett Creek at 34th Avenue

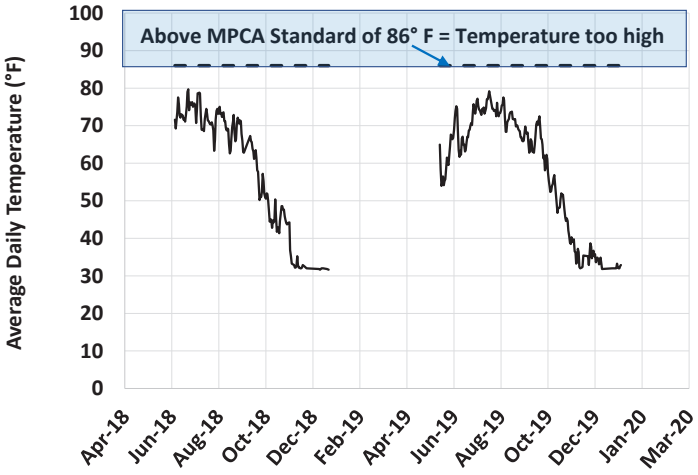


Figure 8: Average daily temperature of the North Branch of Bassett Creek at 34th Avenue

Chlorides

Chloride concentrations in area streams have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the water, there is no way to remove chloride.

Because high concentrations of chloride can harm fish and plant life, the MPCA has established a chronic chloride exposure standard of 230 mg/L or less.

Based on samples collected in 2018 and 2019, chloride concentrations in the North Branch of Bassett Creek ranged from a low of 10 mg/L, measured September 28, 2018, to a high of 437 mg/L, measured December 28, 2019 (Figure 9). Two of the 30 samples (7 percent) exceeded the MPCA standard; both were collected in December of 2019 (Figure 9).

Additional information about chloride concentrations was captured by doing a specific-conductance analysis. Specific conductance measures how well water can conduct electricity. It provides an indication of what is dissolved in the water and increases with larger numbers of ions, including chloride ions. A linear regression analysis of specific conductance and chloride measurements from the North Branch of Bassett Creek indicated that 87 percent of the specific-conductance value was due to chloride ions in the stream. The outcome of the linear regression analysis was a regression equation, which is a statistical model of the relationship between specific conductance and chloride. The model was used to estimate average daily chloride values from the average daily specific-conductance values measured in the stream. In 2018, the estimated chloride concentrations in the stream ranged from 0 mg/L to 374 mg/L, with an average of 134 mg/L. The estimated number of days that chloride concentrations exceeded the MPCA standard was 32 of the 223 days of specific-conductance measurements

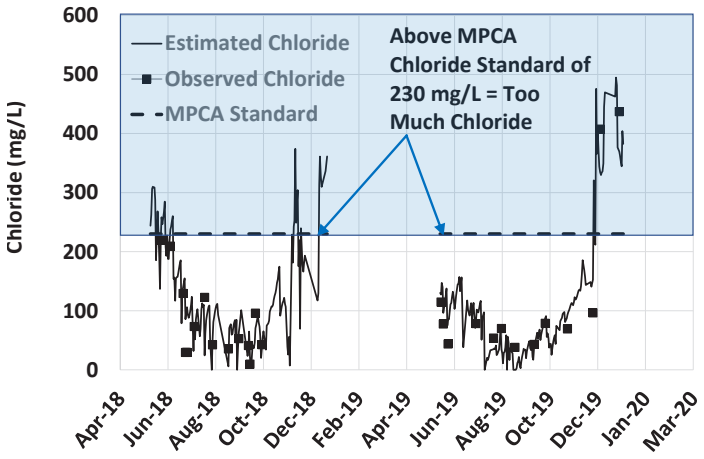


Figure 9: Chloride concentrations: Observed and estimated from average daily specific-conductance measurements of the North Branch of Bassett Creek at 34th Avenue

(14 percent). In 2019, the estimated chloride concentrations in the stream ranged from 0 mg/L to 495 mg/L, with an average of 114 mg/L. The estimated number of days that chloride concentrations exceeded the MPCA standard was 23 of the 232 days of specific-conductance measurements (10 percent) (Figure 9).

E. coli bacteria

The Environmental Protection Agency (EPA) determined that E. coli is the preferred indicator of the potential presence of waterborne pathogens. The MPCA standard for E. coli protects streams used for two types of recreation: primary body contact (e.g., swimming, where inadvertent ingestion of water is likely) and secondary body contact (e.g., wading, where the likelihood of ingesting water is much smaller). The MPCA uses average and maximum E. coli values to determine impairment. E. coli standards are applicable only during the warmer months of April through October since swimming or wading in Minnesota streams during the November through March period is not expected.

Average E. coli is assessed by a standard based on a geometric mean EPA criterion of 126 E. coli colony-forming units (cfu) per 100 mL. Data are aggregated by individual month (e.g., all April values, all May values, etc.) for up to 10 years to determine impairment due to high average monthly E. coli values. (Figure 10). At least three months of data must be collected, preferably between June and September, and at least 5 values must be collected per month for those three months (15 samples) to determine impairment due to high average E. coli.

Maximum E. coli is assessed by a criterion of a maximum of 1,260 cfu that is not to be exceeded by 10 percent of all samples taken over the 10-year assessment period—independent of month (Figure 11).

If the geometric mean of the aggregated monthly values for one or more months exceeds 126 cfu per 100 mL, that reach is considered to be impaired. Also, a waterbody is considered to be impaired if more than 10 percent of individual values over the 10-year assessment period (independent of month) exceed 1,260 cfu per 100 mL.

Historical monitoring data have generally pointed to high levels of bacteria on the North Branch of Bassett

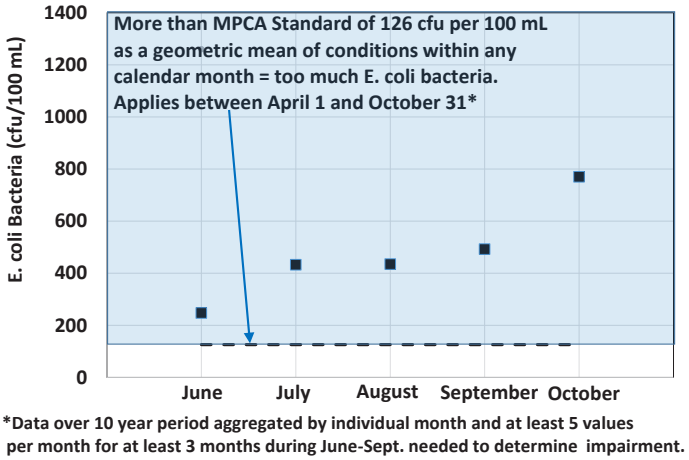


Figure 10: 2018–2019 monthly geometric means of E. coli bacteria from the North Branch of Bassett Creek at 34th Avenue

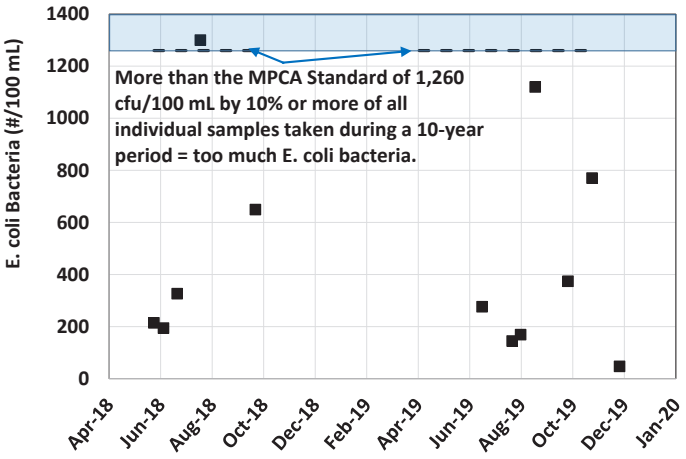


Figure 11: 2018–2019 E. coli bacteria from the North Branch of Bassett Creek at 34th Avenue

Creek. Fecal coliform bacteria data collected from 1975 through 1985 documented consistently high bacteria levels in the stream. During that period, fecal coliform bacteria was the preferred indicator of the potential presence of waterborne pathogens.

Monitoring from 2008 through 2010 again identified high bacteria levels in the stream. E. coli samples were collected between 32nd and 34th Avenue from July through September of 2008, June through September of 2009, and June of 2010. Individual E. coli values ranged from a low of 250 cfu per 100 mL to a high of 2,400 cfu per 100 mL.

Consistent with past data, high bacteria levels were found in the stream in 2018 and 2019. The April through October monthly geometric means from the aggregated 2018 through 2019 values ranged from a low of 247 cfu per 100 mL in June to a high of 770 cfu per 100 mL in October (Figure 10). All monthly geometric means failed to meet the MPCA standard of 126 cfu per 100 mL (Figure 10). However, fewer than five individual values were used to compute the monthly averages. At least three months of data must be collected, preferably between June and September, and at least five values must be collected per month for those three months (15 samples) to determine impairment due to high average E. coli. The 2018 through 2019 aggregated data consisted of from two to four samples per month. Hence, the monthly averages did not meet the MPCA criteria for determining impairment. Data collected from the North Branch in the future could be aggregated with 2018 and 2019 data to attain the MPCA minimum data requirement for determining impairment from monthly averages.

According to the standard, a water body is also considered impaired if more than 10 percent of individual samples taken from April 1 through October 31 over a 10-year period (independent of month) exceed 1,260 cfu per 100 mL. In 2018 and 2019 a single sample value of 1,300 cfu/100 mL, measured on July 25, 2018, exceeded the impairment threshold (Figure 11). Because this was one sample out of 11 (9 percent) samples collected during the April through October period, the MPCA standard was met.

Total phosphorus and chlorophyll *a*

While phosphorus is necessary for plant and algae growth, too much phosphorus leads to excessive algae, decreased water clarity, and water quality impairment. Some common sources of phosphorus are fertilizers, leaves and grass clippings from streets, atmospheric deposition, eroded soil, and material from plant die-off. The quantity of algae in water is measured by chlorophyll *a,* a pigment in algae. The MPCA standard for total phosphorus and chlorophyll *a* is the river eutrophication standard (RES). RES is a two-part standard, requiring an exceedance of the "causative variable," total phosphorus, and a "response variable," which indicates the presence of eutrophication (excessive nutrients). Total phosphorus and chlorophyll *a* are used in combination and not independently. To determine whether a stream is impaired, data must be collected during at least 2 different years during a 10-year period and a minimum of 12 measurements per parameter (from June to September) must be used to determine the seasonal average. The seasonal average is then compared with the MPCA standard for each parameter: a maximum of 100 micrograms per liter (µg/L) for total phosphorus and a maximum of 18 µg/L for chlorophyll *a*. Both must be exceeded for the stream to be impaired.

The 2018 through 2019 seasonal average (June through September) for the causative variable, total phosphorus, was 235 µg/L, which exceeded the MPCA standard (Figure 12). The 2018 through 2019 seasonal average response variable, chlorophyll a, was 17.6 µg/L, which was within the MPCA standard (Figure 13). Even though the causative variable (total phosphorus) failed to meet the MPCA standard, the stream was not impaired since the response variable (chlorophyll *a*) met the MPCA standard.

Total suspended solids

Total suspended solids consist of soil particles, algae, and other materials that are suspended in water and cause a lack of clarity. Excessive total suspended solids can harm aquatic life and degrade aesthetic and recreational qualities. A stream is considered to exceed the standard for total suspended solids (30 mg/L) if (1) the standard is exceeded more than 10 percent of the days of the assessment season (April through September) and (2) there are at least three such measurements exceeding the standard.

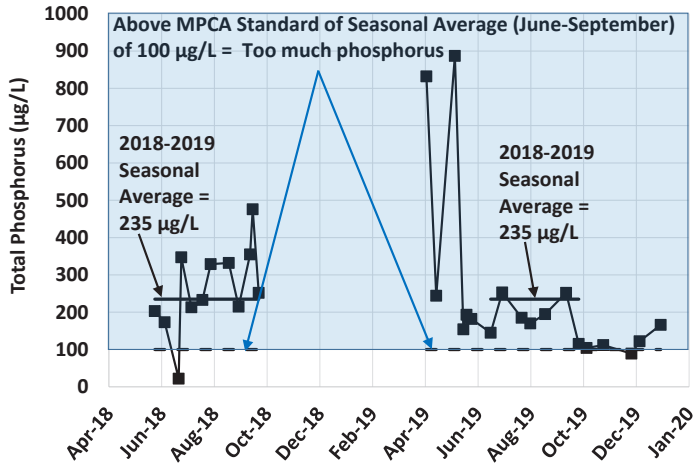


Figure 12: 2018–2019 total phosphorus from the North Branch of Bassett Creek at 34th Avenue

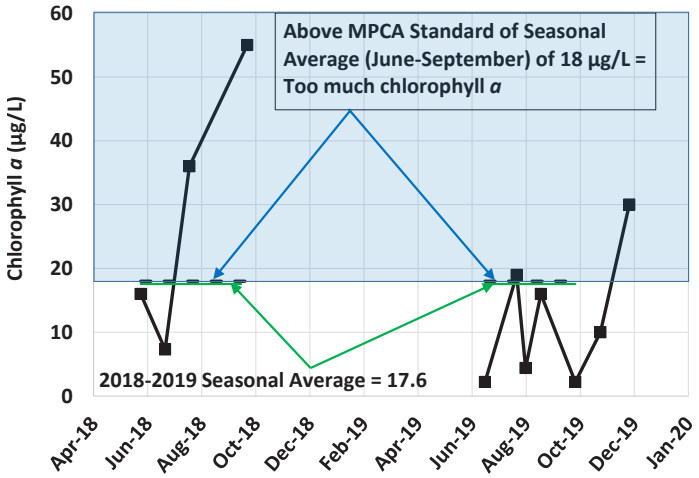


Figure 13: 2018–2019 chlorophyll *a* from the North Branch of Bassett Creek at 34th Avenue

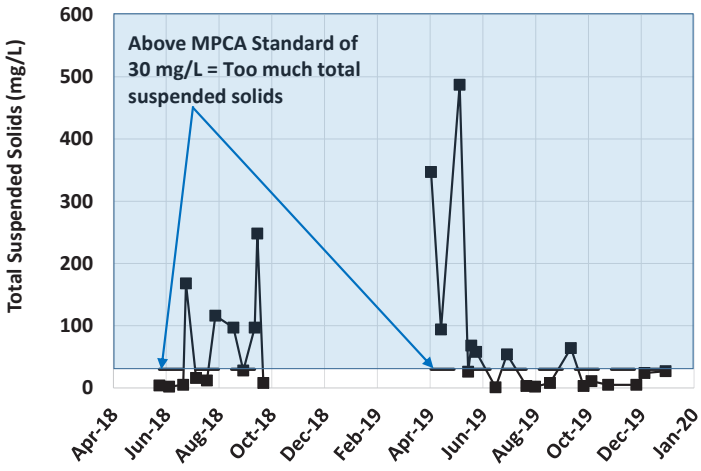


Figure 14: 2018–2019 total suspended solids from the North Branch of Bassett Creek at 34th Avenue

In 2018, total suspended solids concentrations in the North Branch of Bassett Creek ranged from a low of 2 mg/L on June 12 to a high of 248 mg/L on September 20 (Figure 14); the average was 67 mg/L. Five of the 12 samples collected from April through September (42 percent) exceeded the MPCA standard of 30 mg/L. In 2019, total suspended solids concentrations ranged from a low of 1 mg/L on June 18 to a high of 487 mg/L on May 9 (Figure 14); the average was 72 mg/L. Seven of the 13 samples collected from April through September (54 percent) exceeded the MPCA standard of a maximum of 30 mg/L. As such, the stream would be considered imparied; however, it is not, yet, listed on the MPCA's impaired waters list.

Metals

Metals are naturally occurring elements found throughout the earth's crust. Their multiple industrial, domestic, agricultural, medical, and technological applications have led to their widespread distribution in the environment. Because heavy metal-induced toxicity can harm aquatic life, the MPCA has established three standards for Class 2B waters like Bassett Creek—chronic, maximum, and final acute values (FAVs)—for each metals species. The chronic standard (CS) is the highest concentration of a toxicant that aquatic organisms can be indefinitely exposed to with no harmful effects. The maximum standard (MS) is a concentration that protects aquatic organisms from potential lethal effects of a short-term "spike" in toxicant concentrations. The MS is always equal to one-half of the FAV. The FAV is the concentration that would kill about one-half of the exposed individuals of a very sensitive species. The FAV is most often used as an "end-of-pipe" effluent limit to prevent an acutely toxic condition in the effluent or the mixing zone. Because increases in water hardness decrease toxicity of metals, the MPCA metals standards vary with water hardness. To show this variation, metals concentrations are plotted on the y-axis and hardness on the x-axis on Figures 15 through 20.

Quarterly samples were collected from the North Branch of Bassett Creek and analyzed for total cadmium, total chromium, total copper, total nickel, total lead, and total zinc during the 2018 and 2019 monitoring period. All samples met the MPCA standards (Figures 15 through 20), indicating metals are not causing heavy metal-induced toxicity to aquatic organisms in the stream.

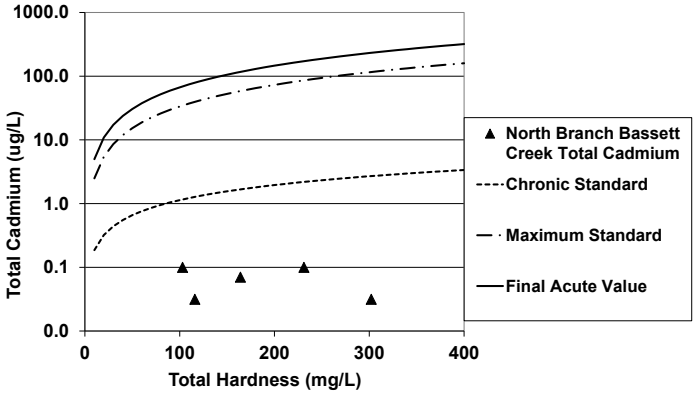


Figure 15: 2018–2019 total cadmium from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

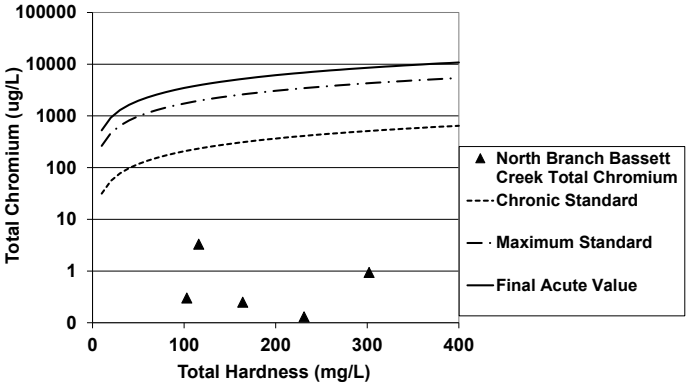


Figure 16: 2018–2019 total chromium from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

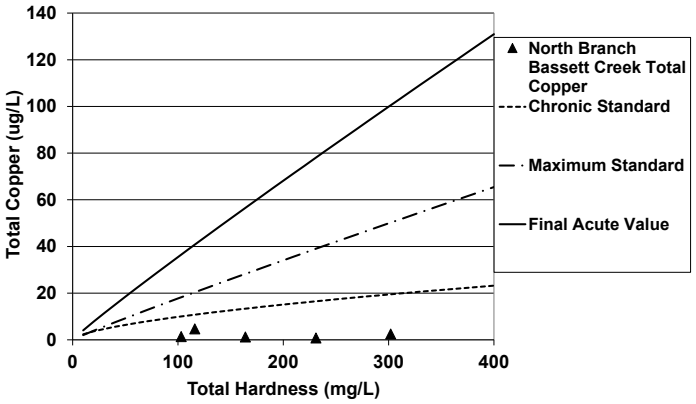


Figure 17: 2018–2019 total copper from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

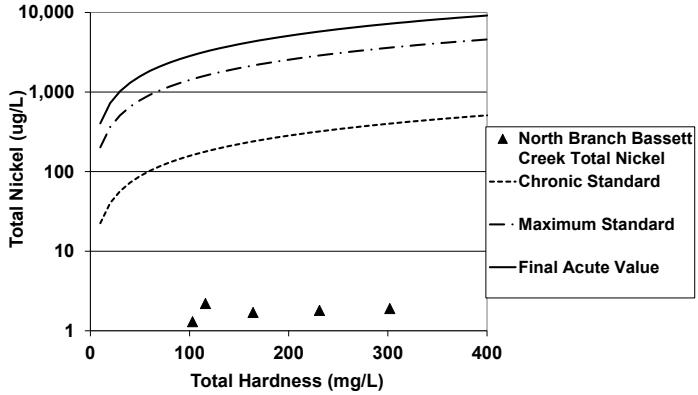


Figure 18: 2018–2019 total nickel from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

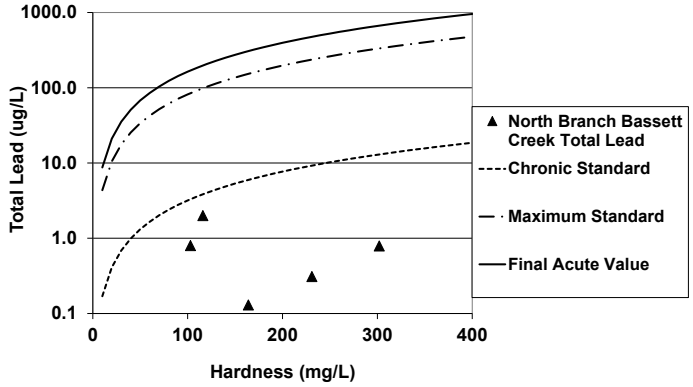


Figure 19: 2018–2019 total lead from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

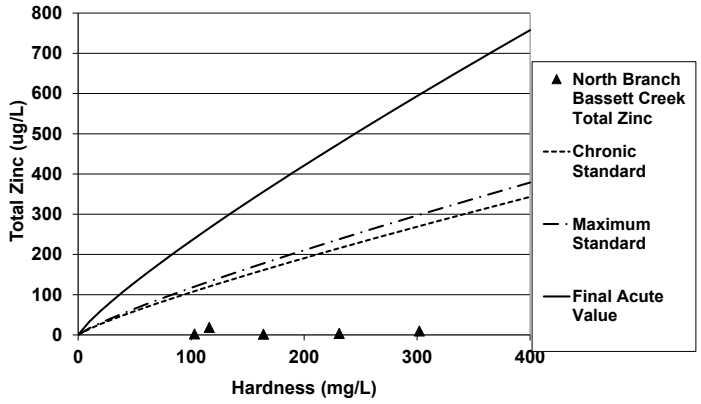


Figure 20: 2018–2019 total zinc from the North Branch of Bassett Creek at 34th Avenue compared to MPCA standards

Biotic index evaluation

Between 1980 and 2018, the Bassett Creek Watershed Management Commission (BCWMC) collected benthic macroinvertebrates (bottom-dwelling organisms) from the North Branch of Bassett Creek on 11 occasions (see Figure 1 for the sampling location). The purpose of the sampling is to evaluate water quality and detect changes over time.

In 2018, the BCWMC monitored the North Branch of Bassett Creek for:

- Macroinvertebrates
- Habitat

Three biotic indices were used to assess the macroinvertebrate data:

- **Hilsenhoff Biotic Index (HBI)—**Assesses long-term oxygen content of the stream.
- **Invertebrate Community Index (ICI)—** Determines the average tolerance of the macroinvertebrate community to a wide range of pollutants.
- **Macroinvertebrate Index of Biotic Integrity (M-IBI)—**Assesses the health of the macroinvertebrate communities. The Minnesota Pollution Control Agency (MPCA) developed the M-IBI and added it to Minnesota's water quality standards to help identify biologically impaired rivers and streams.

North Branch Bassett Creek habitat

Habitat is a key factor in determining the presence and distribution of macroinvertebrates in streams. Stream macroinvertebrates are influenced by such habitat factors as substrate size and composition, quantity of fine sediment deposited on the substrate, and presence of vegetation. The substrate provides places for food and refuge for macroinvertebrates. Aquatic vegetation provides shelter against predation by small fish. Adverse changes in habitat can result in adverse changes to the macroinvertebrate community.

Habitat surveys of the North Branch at 34th Avenue were completed during 2015 and 2018 using the MPCA quantitative habitat survey method. The survey results are summarized in Table 3. Habitat changes documented by the 2018 survey include:

- An increase in flows and water depths (Figure 21 and 22).
- An increase in depth of fine sediments.
- A decrease in the average embeddedness of coarse sediment.
- A decrease (to none) in percent of transects with left-bank erosion.
- A decrease (to none) in the average length of left-bank erosion; right bank erosion was not observed during either 2015 or 2018.
- A decrease (to none) in the average amount of algae.
- An increase in boulders (as represented by the "percent of transect over at least 10 cm of water with boulders" metric) due to an increased area of the sample reach with water deeper than 10 cm.

Figure 21 and 22: North Branch of Bassett Creek at 34th Avenue in 2015 (top) and 2018 (bottom)

Table 3: 2015 and 2018 North Branch Bassett Creek habitat comparison at 34th Avenue

Parameter	North Branch	
	2015	2018
Discharge (flow) (cfs)	0.03	8.2
Average depth of water (cm)	6	25
Average depth of fine sediment (cm)	0.6	0.7
Average embeddedness of coarse sediment (%)	51	38
Percent of transects with left-bank erosion	15	0
Percent of transects with right-bank erosion	0	0
Average length of bank erosion per transect: left bank (m)	0.3	0
Average length of bank erosion per transect: right bank (m)	0	0
Average amount of algae (filamentous or attached) observed on quadrate (%)	31	0
Average number of macrophytes observed on quadrate (%)	0	0
Percent length of transect over at least 10 cm of water depth with overhanding vegetation	0	0
Percent length of transect over at least 10 cm of water depth with submergent vegetation	0	0
Percent length of transect over at least 10 cm of water depth with emergent vegetation	0	0
Percent length of transect over at least 10 cm of water depth with woody debris	0	0
Percent length of transect over at least 10 cm of water depth with boulders	13.8	19.2

HBI and ICI

From 1980 through 2018, the BCWMC assessed macroinvertebrates using biotic indices to evaluate the water quality of the North Branch of Bassett Creek. The Hilsenhoff Biotic Index (HBI) was used to assess the long-term oxygen content of the stream from 1980 through 2018. Sediment added to streams by stormwater runoff or streambank erosion contains organic matter that consumes oxygen during degradation, lowering oxygen levels in the stream. The HBI assesses stream oxygen by determining the average tolerance of the macroinvertebrate community to low oxygen conditions.

A second index, the Invertebrate Community Index (ICI), provides a broader view of the stream's water quality from 1995 through 2018 by determining the average tolerance of the macroinvertebrate community to a wide range of pollutants.

To determine whether any trends could be detected, HBI scores from 2018 were compared to scores from 1980 through 2015, and ICI scores from 2018 were compared to scores from 1995 through 2015. The 2018 HBI and ICI scores were consistent with past scores. The results of the trend analyses indicate there were no statistically significant changes (i.e., there is more than a 5 percent probability that changes were due to chance).

M-IBI biological metrics

The MPCA has established biological water quality standards for all Minnesota streams and rivers, including Bassett Creek. A macroinvertebrate index of biotic integrity (M-IBI) and a fish index of biotic integrity (F-IBI) were added to Minnesota standards and approved by the United States Environmental Protection Agency on June 26, 2018.

The M-IBI helps identify biologically impaired rivers and streams by assessing the health of their macroinvertebrate communities. The BCWMC used the M-IBI to assess the North Branch of Bassett Creek from 2006 through 2018 to determine whether it met the MPCA standard for macroinvertebrates (Figure 24).

The M-IBI score is the sum of the scores from 10 individual metrics (Table 4). Each metric assesses an attribute of the macroinvertebrate community; collectively, the metrics assess the overall health of the community.

Each M-IBI metric has a scale of 0 to 10, the lowest possible score is 0 and the highest is 10. Increasing scores indicate improving conditions. Because 10 metrics are summed to attain the M-IBI score and each metric has a maximum score of 10, the maximum possible score is 100. To meet the MPCA

macroinvertebrate standard, the sum of the scores from the 10 individual metrics must equal or exceed the impairment threshold—a score of at least 37 for the North Branch of Bassett Creek. On average, a score of at least 3.7 for each metric would be needed to meet the impairment threshold.

As shown in Figure 23, none of the monitoring from 2006 through 2018 met the MPCA M-IBI impairment standard. Thus, the North Branch of Bassett Creek would be considered biologically impaired. M-IBI scores improved slightly from 2006 through 2009 (i.e., 1 percent to 6 percent). After BCWMC completed a stream restoration project on the North Branch in 2013 (Figure 1 and Table 1), the M-IBI score improved by 55 percent in 2015. However, the score worsened in 2018 to the lowest score to date (Figure 23).

The worsened score in 2018 may be due to the negative impacts of increased flow and increased pollutant loading during a major precipitation event 2 weeks prior to collection of the 2018 macroinvertebrate samples. The Minneapolis-St. Paul International Airport weather station documented 3.28 inches of precipitation on September 20, 2018, which increased flow in the North Branch from 4 cubic feet per second (cfs) on September 19, to 40 cfs on September 20, and 75 cfs on September 21 (Figure 7). Flow then rapidly declined to 4 cfs by September 24 (Figure 7). Total suspended solids concentrations in the stream increased to 248 mg/L on September 20 and declined to 8 mg/L by September 27 (Figure 14). It appears the high flows and high concentrations of total suspended solids may have adversely impacted the macroinvertebrate community, resulting in a lower M-IBI score.

The 10 individual metrics of the M-IBI were assessed to determine changes since 2006. The scores were also compared to the individual metric score required to attain the impairment threshold score of 37 (an average of 3.7). Poorer scores for six of the 10 metrics were documented in the North Branch of Bassett Creek during 2018. The worsening scores are discussed in the following paragraphs. The monitoring location is pictured in Figure 22.

Table 4: M-IBI metrics

Metric Name	Metric Description
ClimberCh	The number of different types of macroinvertebrates that are climbers (climb on vegetation or woody debris)
ClingerChTxPct	Relative percentage of the types of macroinvertebrates adapted to cling to a substrate, such as a rock
DomFiveChPct	The percent of the dominant five types of macroinvertebrates
HBI_MN	A measure of pollution based on tolerance values assigned to each individual type (e.g., genus or species) of macroinvertebrate. A tolerance value indicates how tolerant each type of organism is to disturbance that alters habitat and/or pollution.
InsectTxPct	The percent of macroinvertebrates collected from the stream that are insects
Odonata	The number of different types of macroinvertebrates in the Odonata group
Plecoptera	The number of different types of macroinvertebrates in the Plecoptera group
Predator	The number of different types of macroinvertebrates that are predators
Tolerant2ChTxPct	The percent of the types of macroinvertebrates that have a Minnesota tolerance value equal to or greater than 6
Trichoptera	The number of different types of macroinvertebrates in the Trichoptera group

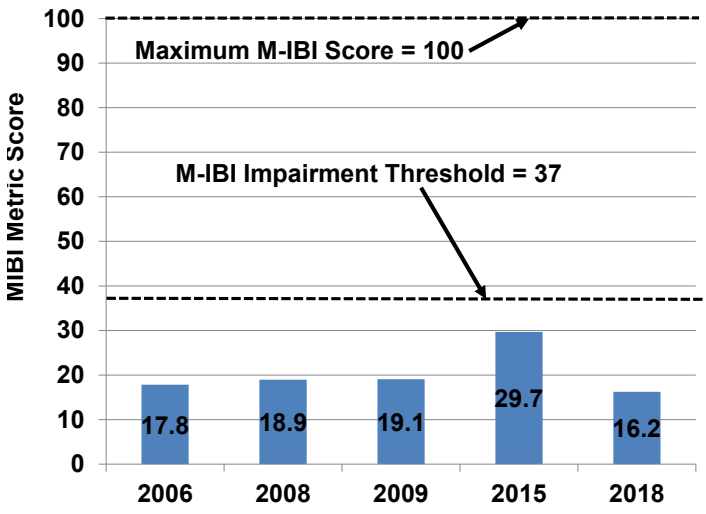


Figure 23: 2006–2018 M-IBI scores from the North Branch Bassett Creek location

ClimberCh

ClimberCh is a metric that assesses the number of different types of macroinvertebrates in a stream that are climbers. Climbers are macroinvertebrates, such as damselfly larvae, that live on plants, algae, plant debris, logs, or roots found in a stream or on vegetation overhanging the stream. The score for the metric ClimberCh is determined from the number of different climber taxa (genus/species) found at a sample location. A score of 0 is assigned when two or fewer climber taxa are found, and a score of 10 is assigned when 12 or more climber taxa are found. Scores from 1 to 9 are assigned when three to 11 climber taxa are present.

To support the presence of climbers, the stream's habitat must contain live plants, algae, plant debris, logs, or roots, or have vegetation overhanging the stream. In 2015, filamentous algae present in about a third of the sample reach supported climbers and nine climber taxa were observed. In 2018, there were no algae found during sampling. It appears that scouring, produced by the high flows from the September 20 rainstorm (Figure 7), may have removed the algae, adversely impacting climber habitat and decreasing the number of climber taxa to five. Historically, the number of climber taxa have ranged from five to nine. M-IBI metric scores during 2006, 2009, and 2015 exceeded the impairment threshold of 3.7, but were less than the impairment threshold in 2008 and 2018 (Figure 24).

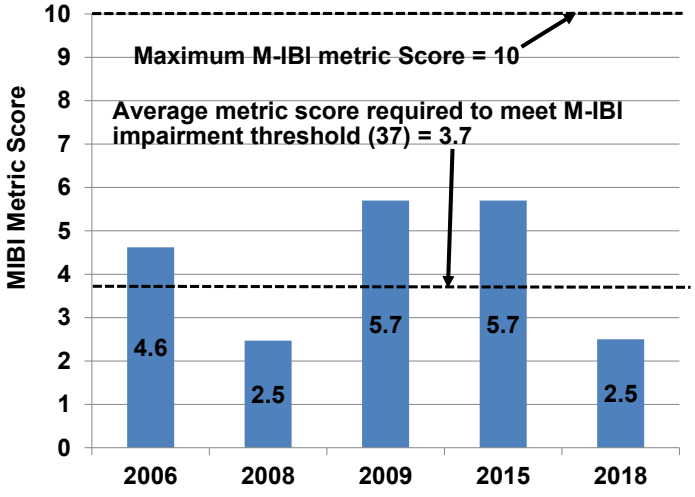


Figure 24: Above: ClimberCh scores from 2006–2018. The 2018 score failed to meet the M-IBI impairment threshold (3.7). Left: The climber Belostoma (giant waterbug)

Tolerant2ChTxPct

The MPCA has developed tolerance values (TVs) for macroinvertebrate taxa collected in Minnesota (MN TVs). Tolerance values range from 0 to 10, with increasing TVs indicating stream degradation. The Tolerant2ChTxPct metric uses the relative percentage of taxa with TVs greater than or equal to 6 to assess the percentage of taxa that are tolerant to stream degradation. A score of zero is assigned when taxa with TVs greater than or equal to 6 comprise 94 percent or more of the sample, and a score of 10 is assigned when they comprise 47 percent or less of the sample. Intermediary scores are assigned when they comprise between 47 and 94 percent of the sample.

The overall work of the BCWMC and member cities to reduce pollution and improve water quality (including the BCWMC North Branch CIP project, city projects, development requirements, education, and nonstructural BMPs) may have contributed to reductions in the percentage of taxa that are tolerant to stream degradation from 2006 through 2015 (Figure 25). Scores improved from 0 in 2006 to 4.4 in 2015—the first year the score was better than the impairment threshold (Figure 25). Although the 2018 score of 1.9 was 57 percent worse than the 2015 score, it was similar to the 2009 score and better than 2006 and 2008 scores (Figure 25). Adverse flow and water quality impacts from storms, including a storm occurring two weeks prior to sampling, may have contributed to a score decrease in 2018.

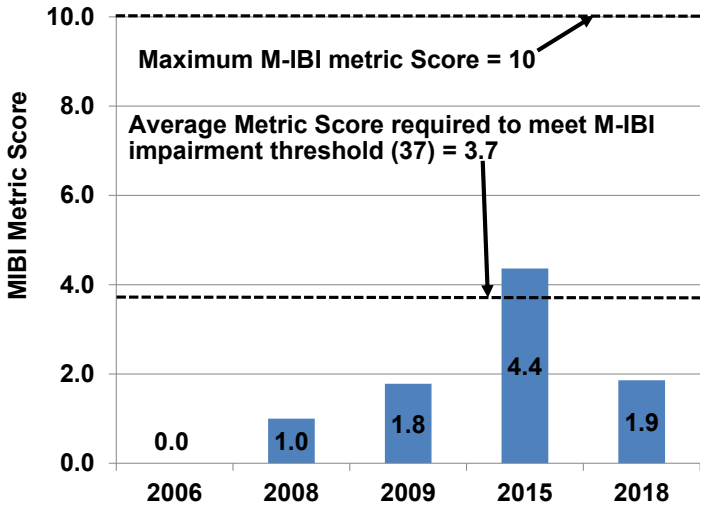


Figure 25: Above: Tolerant2ChTxPct scores from 2006–2018. The 2018 score failed to meet the M-IBI impairment threshold (3.7). Left: Simulium (blackfly larvae)

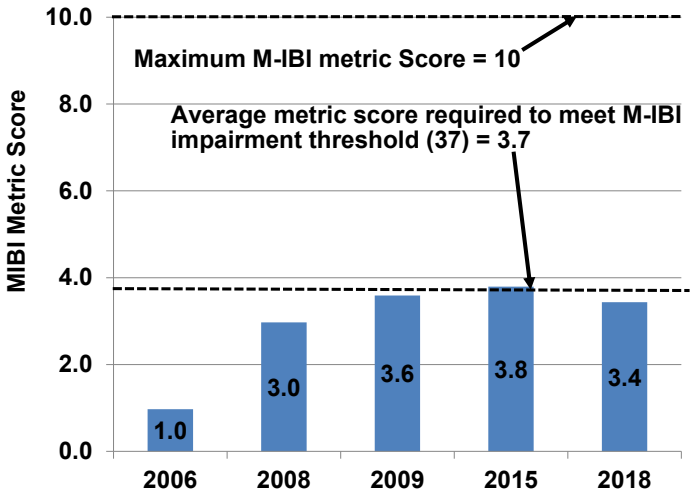


Figure 26: Above: HBI_MN scores from 2006–2018. The 2018 score failed to meet the M-IBI impairment threshold (3.7). Left: Sphaerium (fingernail clam)

HBI_MN

The HBI_MN metric, developed by the MPCA, is a measure of pollution based on tolerance values assigned to each individual taxon. The MPCA-assigned tolerance values are based on analysis of six disturbance variables: human disturbance score (a land-use-based stressor score), Minnesota stream habitat assessment score, total phosphorus, total suspended solids, ammonia, and nitrate/nitrite. Dissolved oxygen was not directly used to determine tolerance values because both very high and very low dissolved oxygen values correlate with stress on the macroinvertebrate community. However, the generalized stressors used to develop tolerance values for the HBI_MN often correlate with dissolved oxygen stress. The HBI_MN metric score is based on the average tolerance value of the sample. A score of zero is assigned when the average tolerance value is 8.3 to 10, and a value of 10 is assigned when the average is 0 to 4.9. Intermediary values are assigned when the average tolerance value is between 4.9 and 8.3.

The overall work of the BCWMC and member cities to reduce pollution and improve water quality (including the BCWMC CIP project, city projects, development requirements, education, and nonstructural BMPs) may have contributed to the improvements in HBI_MN from 2006 through 2015 (Figure 26). The 2018 score was worse than 2015. This may be due, in part, to increased pollutant loading during storms, including a major storm on September 20, 2018, when the concentration of total suspended solids increased to 248 mg/L. In 2018 42 percent of samples collected exceeded the MPCA standard of 30 mg/L, and the average total suspended solids concentration was 67 mg/L (Figure 14). Although the 2018 score was about 10 percent worse than the 2015 score, it was better than both 2006 and 2008 scores, indicating that an overall improvement in water quality has occurred since 2006 (Figure 26).

Odonata (dragonflies and damselflies)

Odonata, which include dragonflies and damselflies, are a diverse group of organisms that have a wide array of sensitivities and life histories. They exploit most aquatic microhabitats, and their diversity is considered a good indicator of aquatic health. The score for this metric is determined by the number of Odonata taxa (e.g., genus or species). A score of zero is assigned when no Odonata taxa are present, and a score of 10 is assigned when five taxa are present. Intermediary scores are assigned when one to four taxa are present.

All scores from 2006 through 2018 were better than the impairment threshold (Figure 27). Since 2006, scores have fluctuated between 3.9 (2008, 2009, and 2018) and 6.1 (2006 and 2015). It appears that a stream restoration project completed in 2013 may have improved the score for this metric in 2015 (Figure 1 and Table 1). However, adverse flow and water quality impacts from storms, including a storm two weeks prior to sampling, may have contributed to a score decrease in 2018 (Figure 27).

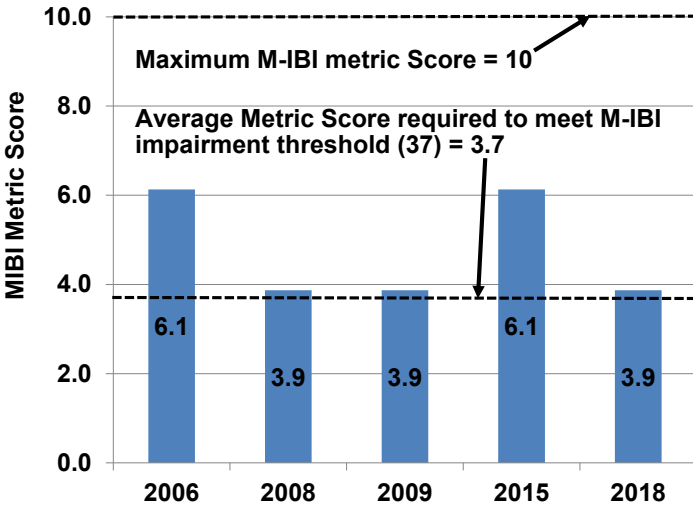


Figure 27: Above: Odonata scores from 2006–2018. The 2018 score of 3.9 met the M-IBI impairment threshold (3.7). Left: Odonata Calopteryx (damselfly larvae)

Predator

Predators, such as damselflies, beetles, water bugs, leeches, and water striders (Figure 28) feed on living animals (e.g., insects). Water quality or habitat degradation reduces the number of predator taxa. The score for this metric is determined by the number of predator taxa. A score of zero is assigned when three or fewer predator taxa are found, and a score of 10 is assigned when 16 or more are found. Intermediate values are assigned when four to 15 predator taxa are found.

Scores for the predator metric consistently improved from 2008 through 2015, and the 2015 score was better than the impairment threshold (Figure 28). However, in 2018 the score was the worst to date (Figure 28). Adverse flow and water quality impacts from storms, including a major storm occurring two weeks prior to sampling, may have contributed to the score decrease in 2018 (Figure 28).

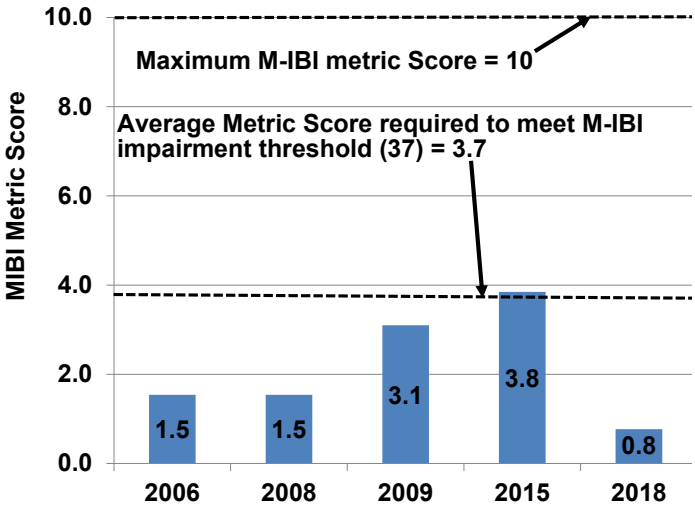


Figure 28: Above: Predator scores from 2006–2018. The 2018 score failed to meet the M-IBI impairment threshold (3.7). Left: The predator Liodessus (beetle)

Trichoptera (caddisflies)

Trichoptera (caddisflies) taxa feed in a variety of ways: some spin nets to trap food and others collect or scrape food on exposed rocks. Many caddisflies build gravel or wood cases to protect themselves from predators; others are predators themselves. In general, many families of Trichoptera are sensitive to excess nutrients and excess sedimentation. Taxa richness of Trichoptera declines steadily as humans eliminate the variety and complexity of their stream habitat. The score for this metric is determined by the number of Trichoptera taxa. A score of 0 is assigned when two or fewer Trichoptera taxa are found, and a score of 10 is assigned when 12 or more Trichoptera taxa are found. Scores from 1 to 9 are assigned when three to 11 Trichoptera taxa are found.

Improving scores from 2009 through 2015 appear to be a positive result of the overall work of the BCWMC and member cities to reduce pollution and improve water quality (including the BCWMC North Branch CIP project, city projects, development requirements, education, and nonstructural BMPs) (Figure 29). The score of zero in 2018 (Figure 29) may be due to increased pollutant loading during storms—including a major storm on September 20 which increased the concentration of total suspended solids to 248 mg/L. In 2018, 42 percent of total suspended solids samples exceeded the MPCA standard of 30 mg/L, and the average total suspended solids concentration was 67 mg/L (Figure 14). This excess sedimentation appears to have reduced the number of Trichopera taxa in the stream.

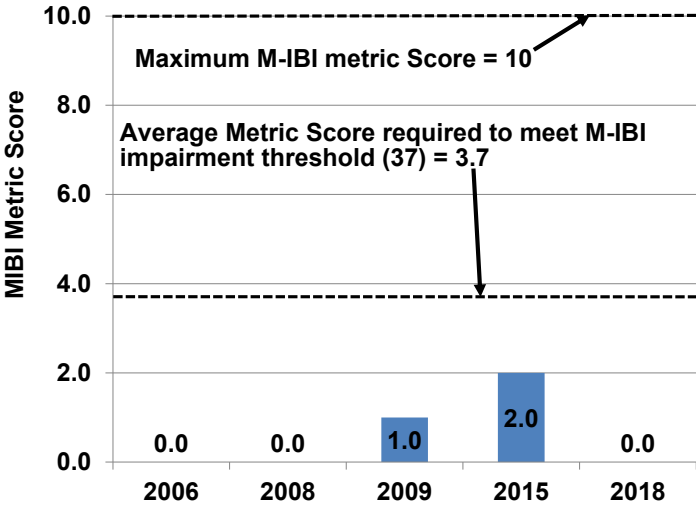


Figure 29: Above: Trichoptera scores from 2006–2018. The 2018 scores failed to meet the M-IBI impairment threshold (3.7). Left: Trichoptera Cheumatopsyche (caddisfly larvae)