

2015 Biotic Index Evaluation of Plymouth Creek and Bassett Creek

Prepared by
Bassett Creek Watershed Management Commission



April 2016



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Acronyms

Acronym	Description
MPCA	Minnesota Pollution Control Agency
HBI	Hilsenhoff Biotic Index
ICI	Invertebrate Community Index
BCWMC	Bassett Creek Watershed Management Commission
M-IBI	Macroinvertebrate Biotic Index
ClimberCh	Taxa richness of climbers (number of climbers' taxa)
ClingerChTxPct	Relative percentage of taxa adapted to cling to substrate in swift flowing water
DomFiveChPct	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
InsectTxPct	Relative percentage of insect taxa
Odonata	Taxa richness of Odonata (number of Odonata taxa)
Plecoptera	Taxa richness of Plecoptera (number of Plecoptera taxa)
Predator	Taxa richness of Predators (number of predators' taxa)
Tolerant2ChTxPct	Relative percentage of taxa with tolerance values equal to or greater than 6, using Minnesota tolerance values (TVs)
Trichoptera	Taxa richness of Trichoptera (number of Trichoptera taxa)

1.0 Executive Summary

During 2015, the Bassett Creek Watershed Management Commission (BCWMC) monitored Plymouth Creek, North Branch Bassett Creek, Sweeney Lake Branch Bassett Creek, and Main Stem Bassett Creek to evaluate the macroinvertebrate community, water quality, and habitat. Macroinvertebrates are organisms without backbones which are visible to the eye without the aid of a microscope. The BCWMC began periodic monitoring of the macroinvertebrate communities in these creeks in 1980 and has monitored every three years since 2000. In 2015, monitoring occurred on the following streams: one location each on Plymouth Creek, North Branch Bassett Creek, and Sweeney Branch Bassett Creek, and three locations on Main Stem Bassett Creek. Macroinvertebrate monitoring locations are shown in Figures 3-1 through 3-7.

The BCWMC has used biotic indices to evaluate the water quality of Plymouth Creek, North Branch Bassett Creek, Sweeney Lake Branch Bassett Creek, and Main Stem Bassett Creek since 1980. From 1980 through 2015, the Hilsenhoff Biotic Index (HBI) was used to assess the long-term oxygen content of the streams. HBI assesses stream oxygen content by determining the average tolerance of the macroinvertebrate community to low oxygen conditions. A second index, the Invertebrate Community Index (ICI), was added in 1995 to provide a second assessment of long-term water quality. The ICI provides a broader view of the streams' water quality than the HBI, determining the average tolerance of the macroinvertebrate community to a wide range of pollutants.

Trend analyses were completed on HBI and ICI values for the period of record at individual sample locations using Water Quality Statistics (WQ Stat) software. The trend analyses document statistically significant changes over time.

In 2015, a third biotic index was added to the biological assessment of Plymouth Creek, North Branch Bassett Creek, Sweeney Lake Branch Bassett Creek, and Main Stem Bassett Creek: the Macroinvertebrate Index of Biotic Integrity (M-IBI). The M-IBI was developed by the Minnesota Pollution Control Agency (MPCA) to help identify biologically impaired rivers and streams by assessing the health of their macroinvertebrate communities. In this case, it was used to assess whether Plymouth Creek, North Branch Bassett Creek, Sweeney Lake Branch Bassett Creek, and Main Stem Bassett Creek met the MPCA standard for macroinvertebrates. For these creeks, the MPCA standard is an M-IBI value of at least 37. Figure 8-1 and Table 8-1 summarize the M-IBI results for the six monitoring stations. The streams have not yet been assessed by the MPCA for macroinvertebrates and, hence, none of the streams are impaired for macroinvertebrates. Currently, the sole biological impairment is the Main Stem of Bassett Creek for "fish bioassessments."

The BCWMC also added water quality and habitat monitoring to its program in 2015. Good water quality and good habitat support a high-quality macroinvertebrate community, while poor habitat and water quality limit the macroinvertebrate community to species tolerant of those conditions. The water quality and habitat data provide insight into the factors that influence the quality of the biological community. Water quality parameters measured in 2015 include temperature, dissolved oxygen, specific conductance, pH, and turbidity.

A summary of the results of the (1) water quality, (2) habitat monitoring, (3) HBI and ICI trend analyses, and (4) M-IBI assessment at the individual monitoring stations is presented in Sections 1.1 through 1.6. Recommendations are presented in Section 1.7. The 2015 macroinvertebrate data were submitted to the MPCA per Policy 10 in the BCWMC 2015-2025 Watershed Management Plan.

1.1 Plymouth Creek at Industrial Boulevard

Water Quality. The measured specific conductance value exceeded the MPCA standard, which indicates the macroinvertebrate community may be stressed by excess ions in the stream. Chlorides, a dissolved compound added to lakes, streams, and groundwater from road and parking lot runoff during snowmelt, increases specific conductance levels. Hence, specific conductance can be used as a surrogate for chlorides and high specific conductance levels may indicate high levels of chlorides. Plymouth Creek is currently impaired for chlorides.

All other water quality parameters met the MPCA standard.

Habitat. Streambank erosion and embeddedness were prevalent and habitat diversity was limited; these factors may contribute to the biological impairment of Plymouth Creek. (Embeddedness is the extent to which large particles, such as gravel or rocks, are covered by small particles, such as sand or silt.) Tables 5-1 and 5-2 summarize the results of the habitat survey.

HBI. 2015 data show fair oxygen conditions. A trend analysis of historical HBI data indicates improving water quality, but the changes are not significant. The trend analysis also indicates that the HBI values have been relatively stable over time.

ICI. 2015 data show better than average water quality. A trend analysis of historical ICI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. With an M-IBI score of 18 (compared to the MPCA standard of 37), Plymouth Creek at Industrial Boulevard does not meet the State standard for macroinvertebrates. Section 8.0 and Appendix B provide more information about the M-IBI and the individual biological metrics used to generate the M-IBI scores.

1.2 Sweeney Lake Branch of Bassett Creek at Woodstock Avenue

Water Quality. The measured specific conductance value exceeded the MPCA standard, which indicates the macroinvertebrate community may be stressed by excess ions in the stream. Specific conductance can be used as a surrogate for chlorides and high specific conductance levels may indicate high levels of chlorides.

All other water quality parameters met the MPCA standard.

Habitat. Streambank erosion, embeddedness, and depth of fine sediment were prevalent. Although these factors may cause stress on the macroinvertebrate community, the excellent habitat diversity in the Sweeney Lake Branch of Bassett Creek supported a healthy and diverse macroinvertebrate community.

HBI. 2015 data show fairly poor oxygen conditions. A trend analysis of historical HBI data indicates degrading water quality, and the changes are significant. The degrading water quality is correlated with increased precipitation (Appendix A).

ICI. 2015 data show average water quality. A trend analysis of historical ICI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. With an M-IBI score of 39 (compared to the MPCA standard of 37), the Sweeney Lake Branch of Bassett Creek meets the MPCA standard for macroinvertebrates.

1.3 North Branch of Bassett Creek at 34th Avenue

Water Quality. All water quality parameters met the MPCA standards.

Habitat. Embeddedness was prevalent in the North Branch of Bassett Creek and may stress the macroinvertebrates. Algae attached to the stream substrate and boulders were prevalent and provided good habitat for macroinvertebrates.

HBI. 2015 data showed good oxygen conditions. A trend analysis of historical HBI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the HBI values have been relatively stable over time.

ICI. 2015 data show better than average water quality. A trend analysis of historical ICI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. With an M-IBI score of 30 (compared to the MPCA standard of 37), the North Branch of Bassett Creek does not meet the State standard for macroinvertebrates.

1.4 Main Stem of Bassett Creek at Rhode Island Avenue

Water Quality. The measured specific conductance value exceeded the MPCA standard, which indicates the macroinvertebrate community may be stressed by excess ions in the stream. Specific conductance can be used as a surrogate for chlorides and high specific conductance levels may indicate high levels of chlorides. The Main Stem of Bassett Creek is impaired for chlorides.

All other water quality parameters met the MPCA standard.

Habitat. Streambank erosion and embeddedness were prevalent and habitat diversity was very limited; these factors may contribute to the biological impairment of the Main Stem of Bassett Creek at Rhode Island Avenue.

HBI. 2015 data showed good oxygen conditions. A trend analysis of historical HBI data indicates improving water quality, but the changes are not significant. The trend analysis also indicates that the HBI values have been relatively stable over time.

ICI. 2015 data show better than average water quality. A trend analysis of historical ICI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. The M-IBI score of the Main Stem of Bassett Creek at Rhode Island Avenue is 13—well beneath the MPCA standard of 37.

1.5 Main Stem of Bassett Creek East of Brookridge Avenue

Water Quality. The measured specific conductance value exceeded the MPCA standard, which indicates the macroinvertebrate community may be stressed by excess ions in the stream. Specific conductance can be used as a surrogate for chlorides and high specific conductance levels may indicate high levels of chlorides. The Main Stem of Bassett Creek is impaired for chlorides.

All other water quality parameters met the MPCA standard.

Habitat. Streambank erosion and embeddedness were prevalent and habitat diversity was limited; these factors may contribute to the biological impairment of the Main Stem of Bassett Creek east of Brookridge Avenue.

HBI. 2015 data showed good oxygen conditions. A trend analysis of historical HBI data indicates improving water quality, and the changes are significant.

ICI. 2015 data show better than average water quality. A trend analysis of historical ICI data indicates degrading water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. The M-IBI score of the Main Stem of Bassett Creek east of Brookridge Avenue is 17—well beneath the MPCA standard of 37.

1.6 Main Stem of Bassett Creek at Irving Avenue

Water Quality. All water quality parameters met the MPCA standards.

Habitat. Streambank erosion and embeddedness were prevalent and habitat diversity was limited; these factors may contribute to the biological impairment of the Main Stem of Bassett Creek at Irving Avenue.

HBI. 2015 data show fair oxygen conditions. A trend analysis of historical HBI data indicates improving water quality, but the changes are not significant. The trend analysis also indicates that the HBI values have been relatively stable over time.

ICI. 2015 data show better than average water quality. A trend analysis of historical ICI data indicates improving water quality, but the changes are not significant. Because the changes are not significant, the trend analysis indicates that the ICI values have been relatively stable over time.

M-IBI. The M-IBI score of the Main Stem of Bassett Creek at Irving Avenue is 19—well beneath the MPCA standard of 37.

1.7 Recommendations

Recommendations include:

- Monitoring chloride concentrations in Plymouth Creek and the Main Stem of Bassett Creek to determine how frequently chloride concentrations fail to meet MPCA chloride standards and the contribution of ionic stress toward the impairment of the macroinvertebrate communities. Plymouth Creek and the Main Stem of Bassett Creek are currently impaired for chlorides.
- Monitoring chloride concentrations in the North Branch of Bassett Creek and the Sweeney Lake Branch of Bassett Creek to determine whether chloride concentrations meet MPCA chloride standards and the contribution of ionic stress toward the impairment of the macroinvertebrate communities. The North Branch of Bassett Creek and the Sweeney Lake Branch of Bassett Creek are not currently impaired for chlorides. However, a high specific conductance measurement was observed in the Sweeney Lake Branch of Bassett Creek during October of 2015, indicating chloride concentrations were high.
- Implementing habitat improvement projects for specific reaches of Plymouth and Bassett Creeks. Assessing Plymouth and Bassett Creeks to identify additional feasible opportunities for habitat improvement to improve the quality of the macroinvertebrate community.
- Monitoring the biota of Plymouth and Bassett Creeks at a three year frequency is recommended to periodically assess the biological community. Using the M-IBI to assess the macroinvertebrate data is recommended to determine whether or not the macroinvertebrate community meets the State standard. Using the HBI and ICI, including trend analyses, is recommended to identify significant changes in oxygen conditions and/or water quality over time. These recommendations are consistent with the monitoring recommendations in Appendix A of the BCWMC 2015-2025 Watershed Management Plan

http://www.bassettcreekwmo.org/application/files/3114/4676/8825/BCWMC_2015_Watershed_Management_Plan_Appendices.pdf.

- Monitoring habitat and water quality when biological samples are collected is recommended to determine whether changes have occurred since 2015 and to identify stressors to the biological

communities These recommendations are consistent with the monitoring recommendations in Appendix A of the BCWMC 2015-2025 Watershed Management Plan (http://www.bassettcreekwmo.org/application/files/3114/4676/8825/BCWMC_2015_Watershed_Mgmt_Plan_Appendices.pdf).

2.0 Introduction

In 10 of the last 36 years (1980, 1983, 1991, 1995, 2000, 2003, 2006, 2009, 2012, and 2015), the BCWMC has collected benthic macroinvertebrates (bottom-dwelling organisms) from Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek to evaluate water quality and detect changes in water quality over time. Samples from the Sweeney Lake Branch of Bassett Creek and the Main Stem of Bassett Creek east of Zane Avenue were also collected by BCWMC in 1996. This report presents the results of benthic macroinvertebrate monitoring completed in 2015.

Evaluating benthic macroinvertebrates in a stream determines the health of the macroinvertebrate community and also provides a long-term assessment of its water quality. Benthic macroinvertebrates are exposed to all of the temporal variations in stream water quality and reflect the quality of the passing water. The presence of pollution-tolerant organisms and/or the absence of pollution-sensitive organisms demonstrate the adverse water-quality impacts of urban runoff.

The BCWMC has used biotic indices to evaluate the water quality of Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek since 1980. From 1980 through 2015, the Hilsenhoff Biotic Index (HBI) was used to assess the long-term oxygen content of the stream. HBI assesses stream oxygen content by determining the average tolerance of the macroinvertebrate community to low oxygen conditions. A second index, the Invertebrate Community Index (ICI), was added in 1995 to provide a second assessment of long-term water quality. The ICI provides a broader view of the stream's water quality than the HBI, determining the average tolerance of the macroinvertebrate community to a wide range of pollutants.

In 2015, a third biotic index was added to the biological assessment of Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek: the Macroinvertebrate Index of Biotic Integrity (M-IBI). The M-IBI was developed by the Minnesota Pollution Control Agency (MPCA) to help identify biologically impaired rivers and streams by assessing the health of their macroinvertebrate communities. In this case, it was used to assess whether Plymouth and Bassett Creeks met the MPCA standard for macroinvertebrates.

This report uses the three biotic indices (M-IBI, HBI, and ICI) to assess the macroinvertebrate data collected from Plymouth and Bassett Creeks. The M-IBI was used to determine whether these streams met the MPCA impairment standard. Trend analyses of HBI and ICI data collected between 1980 and 2015 (the period of record) were completed to assess the significance of changes. Both HBI and ICI data were compared to precipitation data to assess the impact of precipitation changes and associated changes in flow and runoff on HBI and ICI.

The BCWMC also added water quality and habitat monitoring to its program in 2015. Good water quality and good habitat support a high-quality macroinvertebrate community, while poor habitat and poor water quality limit the macroinvertebrate community to species tolerant of those conditions. The water

quality and habitat data provide insight into the factors that influence the quality of the biological community.

This report discusses the results of the (1) water quality monitoring, (2) habitat monitoring (3) HBI and ICI trend analyses, and (4) M-IBI assessment.

3.0 Methods

3.1 Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate samples were collected from Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek in early October of 2015. The sampling locations and dates are identified below:

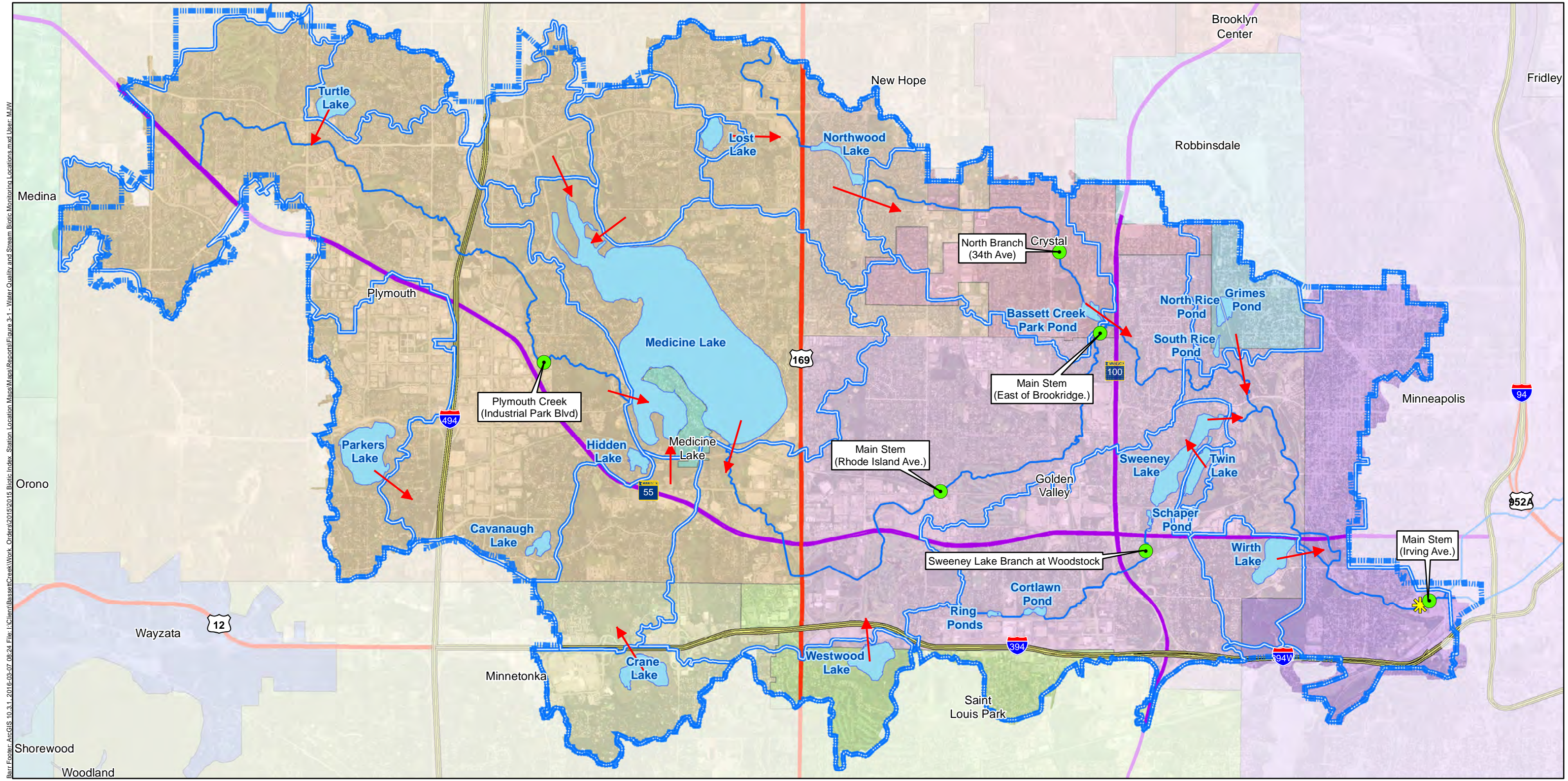
- Plymouth Creek at Industrial Boulevard in Plymouth (October 7)
- North Branch of Bassett Creek at 34th Avenue North in Crystal (October 3)
- Sweeney Lake Branch of Bassett Creek at Woodstock Avenue (East) in Golden Valley (October 3)
- Main Stem of Bassett Creek at Rhode Island Avenue in Golden Valley (October 3)
- Main Stem of Bassett Creek east of Brookridge Avenue/South of 29th Avenue North in Golden Valley (October 7)
- Main Stem of Bassett Creek at Irving Avenue in Minneapolis (October 2)

Maps of station locations are found in Figure 3-1, Figure 3-2, Figure 3-3, Figure 3-4, Figure 3-5, Figure 3-6, and Figure 3-7.





The locations have been regularly monitored since 1980 with the following exceptions:



- In 1995 the North Branch site was moved slightly upstream (to 32nd Avenue) because the former location had silted in and was no longer a representative habitat. Samples were collected at the 32nd Avenue location until 2015, when MPCA sampling methodology dictated a longer sample reach (150 meters). The new location, slightly upstream, is between 32nd and 34th Avenue.
- In 2003 access problems at Dupont Avenue required the Main Stem's most downstream station to move to Irving Avenue, slightly upstream.
- The Sweeney Lake Branch location at Turner's Crossroad was moved downstream to Woodstock Avenue in 2015 because MPCA sampling methodology required a longer sample reach (150 meters).
- The Main Stem site at Dresden was added by the MPCA in 2008 because the fish index of biotic integrity (F-IBI) indicated this reach was impaired. The site was monitored by BCWMC in 2012, but not in 2015.

The name of one of the sampling stations on the Main Stem of Bassett Creek was changed in 2015 from "Main Stem of Bassett Creek east of Zane Avenue" to "Main Stem of Bassett Creek east of Brookridge Avenue." This more accurately reflects its location.



Barr, Feather, ArcGIS 10.3.1, 2015-03-07 08:24, File: L:\Client\BassettCreek\Work_Orders\2015\2015 Biotic Index - Station Location Maps\Reports\Figure 3-1 - Water Quality and Stream Biotic Monitoring Locations.mxd User: MJW

-  BCWMC Jurisdictional Boundary
-  Major Subwatersheds
-  Flow Directions
-  Creeks

-  Watershed Outlet Monitoring Program (WOMP) Station
-  2015 Biotic Monitoring Locations (BCWMC)

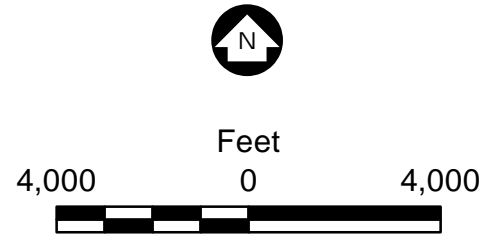


Figure 3-1
PLYMOUTH AND BASSETT CREEK
2015 BIOTIC MONITORING LOCATIONS
 Bassett Creek Watershed
 Management Commission

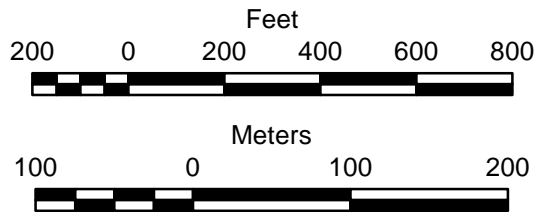


Aerial Imagery: MN DNR Color Twin Cities 2012

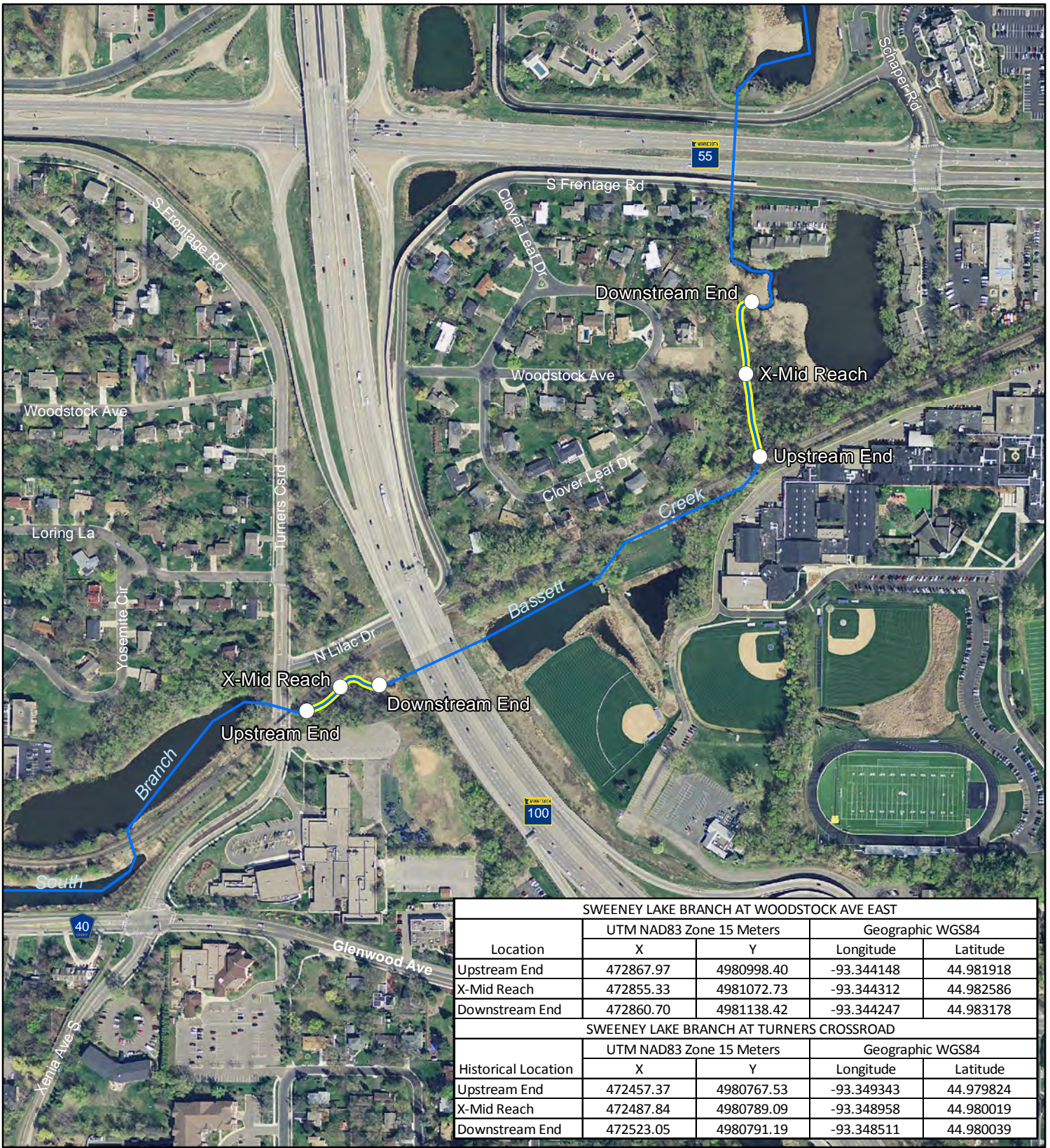


Figure 3-2

- Stream Monitoring Location
- Creek
- Stream Monitoring Segment (150 meters)

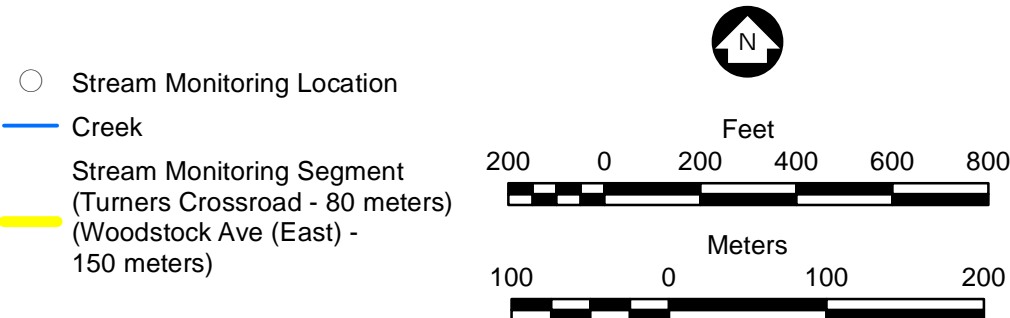


PLYMOUTH CREEK AT INDUSTRIAL BOULEVARD SAMPLE LOCATION
 (Water Quality, Habitat, and Macroinvertebrates)
 Hennepin County, Minnesota

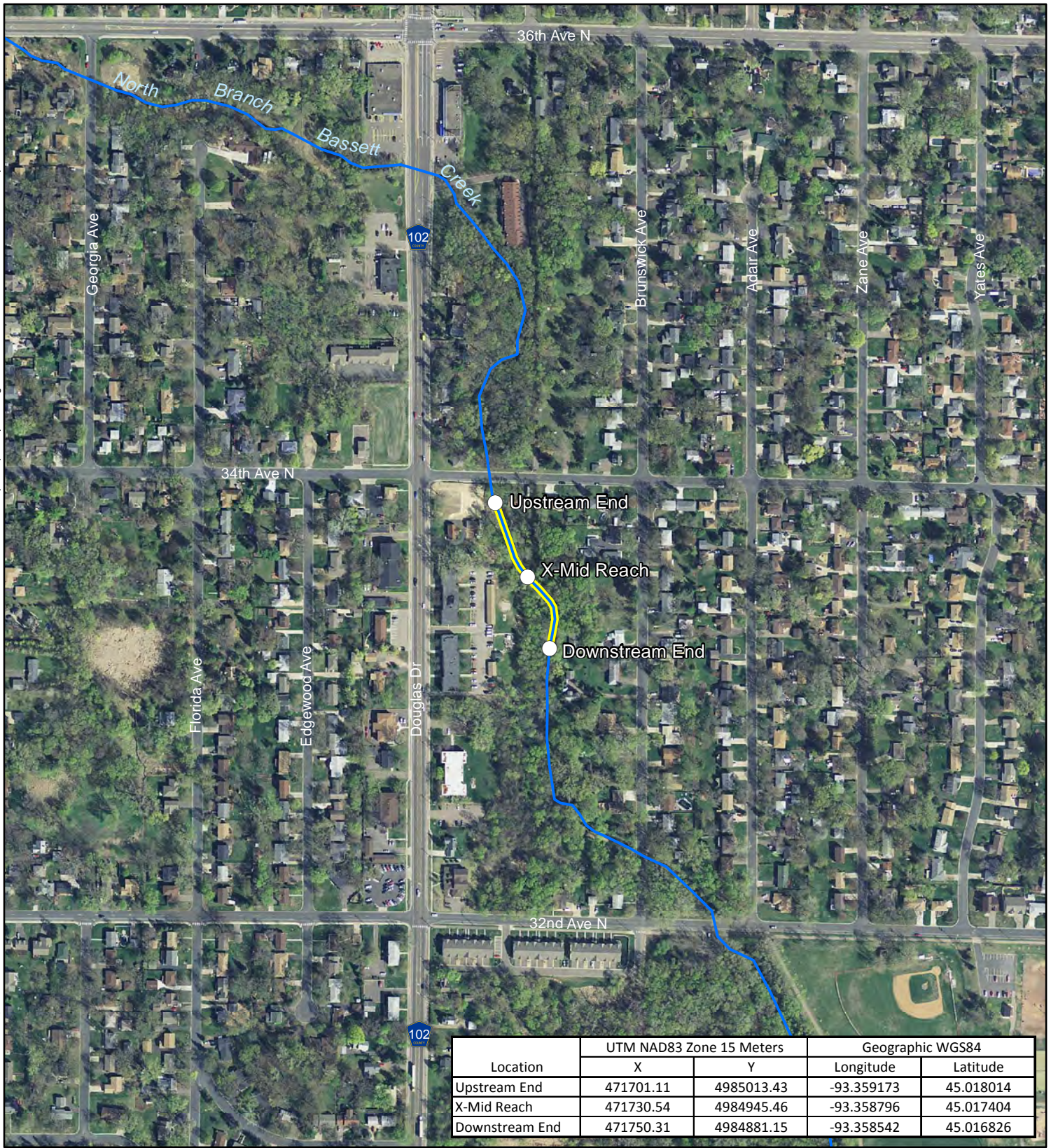


SWEENEY LAKE BRANCH AT WOODSTOCK AVE EAST				
Location	UTM NAD83 Zone 15 Meters		Geographic WGS84	
	X	Y	Longitude	Latitude
Upstream End	472867.97	4980998.40	-93.344148	44.981918
X-Mid Reach	472855.33	4981072.73	-93.344312	44.982586
Downstream End	472860.70	4981138.42	-93.344247	44.983178
SWEENEY LAKE BRANCH AT TURNERS CROSSROAD				
Historical Location	UTM NAD83 Zone 15 Meters		Geographic WGS84	
	X	Y	Longitude	Latitude
Upstream End	472457.37	4980767.53	-93.349343	44.979824
X-Mid Reach	472487.84	4980789.09	-93.348958	44.980019
Downstream End	472523.05	4980791.19	-93.348511	44.980039

Aerial Imagery: MN DNR Color Twin Cities 2012



BARR Figure 3-3
SWEENEY LAKE BRANCH AT WOODSTOCK AVENUE (EAST) AND TURNER'S CROSSROAD SAMPLE LOCATION
 (Water Quality, Habitat, and Macroinvertebrates)
 Hennepin County, Minnesota



Aerial Imagery: MN DNR Color Twin Cities 2012

- Stream Monitoring Location
- Creek
- Stream Monitoring Segment (150 meters)

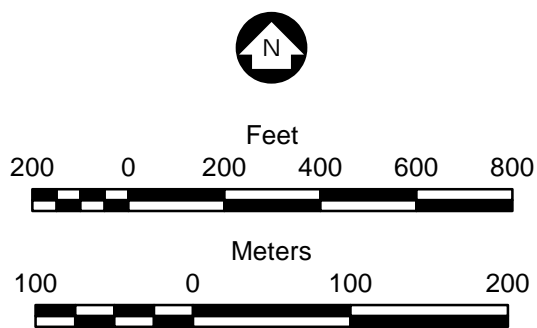


Figure 3-4

**NORTH BRANCH AT
34TH AVENUE SAMPLE
LOCATION**
(Water Quality, Habitat, and
Macroinvertebrates)
Hennepin County, Minnesota



Location	UTM NAD83 Zone 15 Meters		Geographic WGS84	
	X	Y	Longitude	Latitude
Upstream End	470223.40	4981862.07	-93.377741	44.989586
X-Mid Reach	470311.23	4981917.75	-93.376631	44.990091
Downstream End	470387.67	4981977.70	-93.375665	44.990634

Aerial Imagery: MN DNR Color Twin Cities 2012

- Stream Monitoring Location
- Creek
- Stream Monitoring Segment (210 meters)

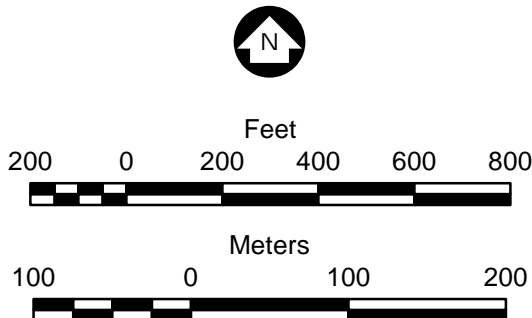
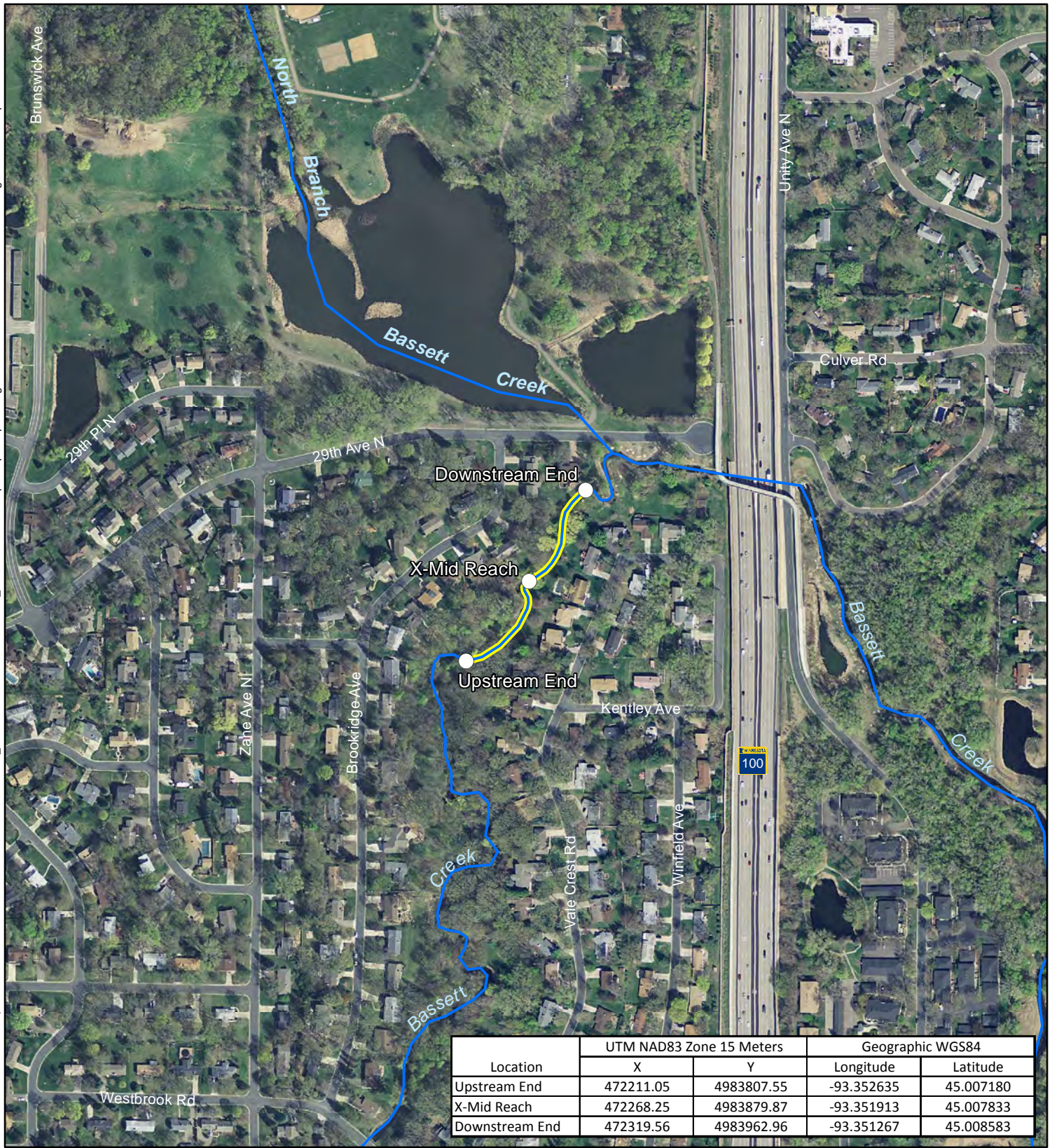


Figure 3-5

BASSETT CREEK AT RHODE ISLAND AVENUE SAMPLE LOCATION
(Water Quality, Habitat, and Macroinvertebrates)
Hennepin County, Minnesota

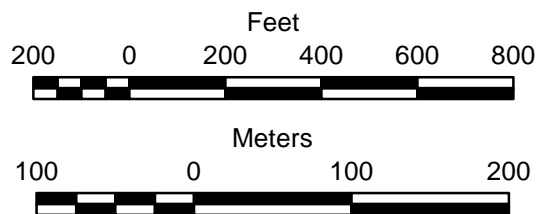


Aerial Imagery: MN DNR Color Twin Cities 2012

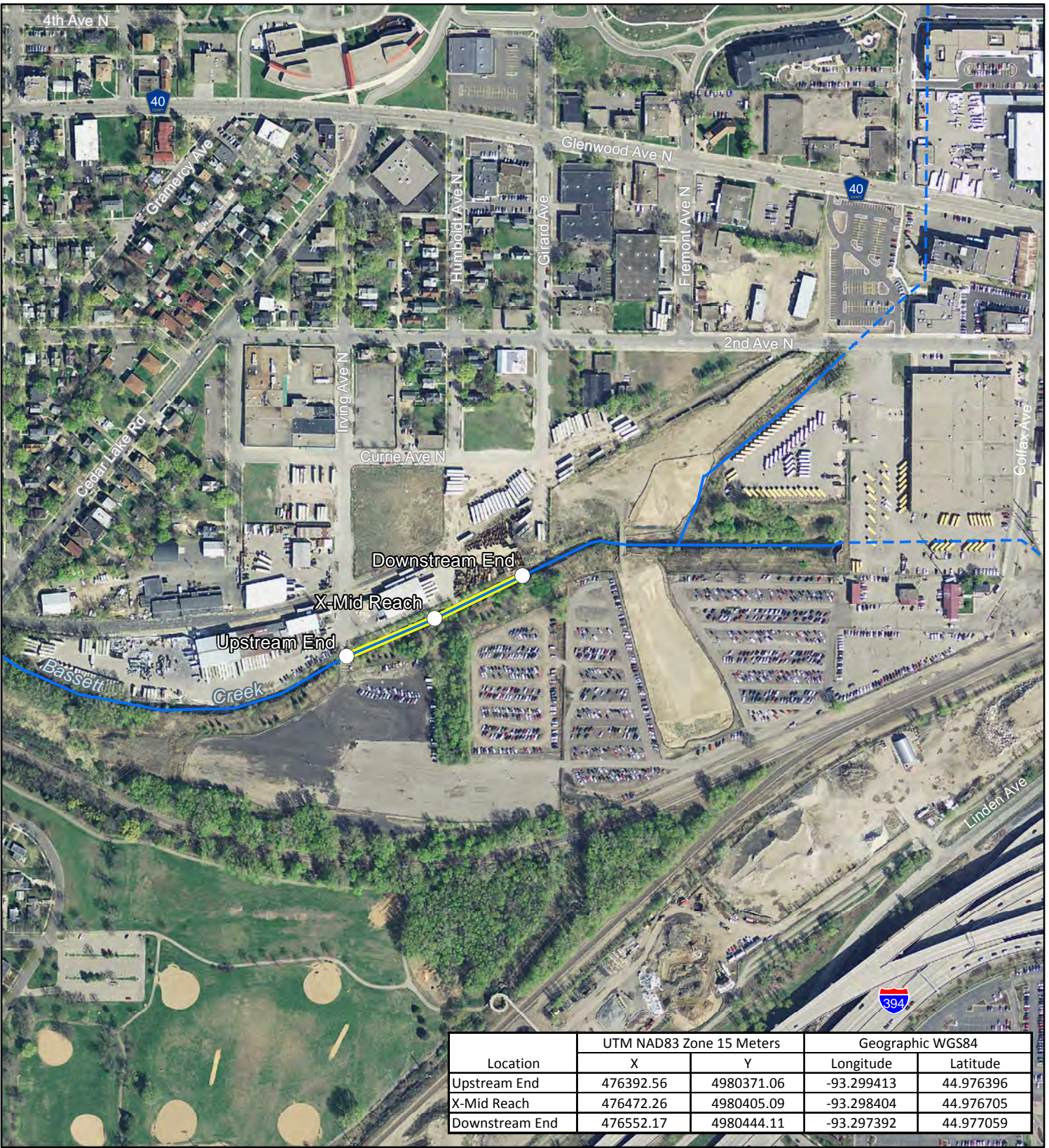


Figure 3-6

- Stream Monitoring Location
- Creek
- Stream Monitoring Segment (211 meters)



**BASSETT CREEK EAST OF BROOKRIDGE AVENUE
SAMPLE LOCATION**
(Water Quality, Habitat, and Macroinvertebrates)
Hennepin County, Minnesota



Aerial Imagery: MN DNR Color Twin Cities 2012

- Stream Monitoring Location
- Creek
- - - Creek in Tunnel
- Stream Monitoring Segment (180 meters)

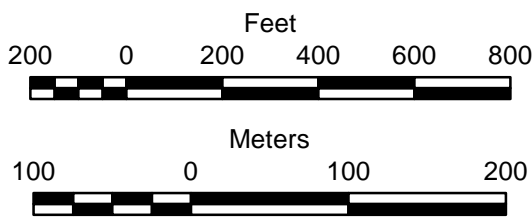


Figure 3-7

BASSETT CREEK AT IRVING AVENUE SAMPLE LOCATION
 (Water Quality, Habitat, and Macroinvertebrates)
 Hennepin County, Minnesota

Stream reaches for sampling were verified and/or finalized during a field reconnaissance in the spring and macroinvertebrate samples were collected in October. As required by MPCA methodology, each sample location was a minimum of 150 meters long; the exact length of each location was determined by multiplying the average stream width by 35. The lengths of the six sampling locations ranged from 150 to 211 meters (Figure 3-2, Figure 3-3, Figure 3-4, Figure 3-5, Figure 3-6 and Figure 3-7).

Macroinvertebrate samples were collected from primary habitats at each location (riffle-runs, undercut banks, aquatic macrophytes, and woody debris). A total of 20 samples were taken—divided among the primary habitats present in each reach.

The habitats sampled at the Plymouth Creek and Bassett Creek locations are as follows:

- Plymouth Creek at Industrial Boulevard, the North Branch of Bassett Creek at 34th Avenue, and the Main Stem of Bassett Creek at Rhode Island Avenue, east of Brookridge Avenue, and at Irving Avenue—all samples (20 at each location) taken from riffle habitat
- Sweeney Lake Branch of Bassett Creek at Woodstock Avenue—three primary habitats present; six samples taken from riffle habitat, seven from overhanging vegetation, and seven from woody debris

As required by MPCA methodology (MPCA 2014), samples were collected using a D-frame dip net. Each of the 20 samples was taken in two D-frame net sweeps. A D-frame net sweep was taken by placing the net on the substrate and disturbing the area directly in front of the net. The water current conveyed the macroinvertebrates into the net. The total area covered for all 20 samples was 3.6 m².

Samples were preserved in alcohol and later processed in the laboratory. In a process known as “picking,” the macroinvertebrate material was then removed from larger vegetation, debris, and gravel in the samples and evenly distributed in a divided tray to allow for subsampling. The sample was picked until at least 200 organisms were found. Then, the remainder of the sample, including gravel, was examined for larger taxa (species). Because the samples collected from Plymouth and Bassett Creeks contained more than 200 organisms and only about 200 organisms were analyzed for each sample, the analyses were performed on a portion of the sample, termed a subsample. In 2015, subsamples from Plymouth and Bassett Creeks consisted of from one sixteenth to one half of the sample. All macroinvertebrates in each subsample were identified to the lowest practicable taxonomic level under the microscope. Once all of the identifications had been completed, the number of each taxon (genus or species) in the sample was multiplied by a factor to account for subsampling. For example, if the subsample analyzed was one-eighth of the sample, then the number counted represented one-eighth of the sample and that number was multiplied by 8 to estimate the total number present in the sample.

Following identification and summarization of the data, biotic index computations were completed for the HBI and ICI using the methodology of previous years (BCWMC 2012). The 2015 data were submitted to the MPCA for computation of the Macroinvertebrate Index of Biotic Integrity (M-IBI). Because the MPCA’s M-IBI computation methodology has not, yet, been released for public use, all M-IBI computations must be completed by the MPCA.

3.2 Habitat Monitoring

Habitat monitoring of each sample location was completed shortly after collection of macroinvertebrate samples. Sample locations are shown in Figures 3-1 to 3-7. Habitat within each station was quantified using a transect-point method (modified from Simonson, et al., 1994). Thirteen transects were established within the sampling reach of each station and four equally spaced sampling points plus the thalweg (deepest point in the transect) were established along each transect. Measurements or visual estimates were made to characterize key components of the physical habitat structure important in influencing stream ecology and the benthic macroinvertebrate community. Habitat parameters included:

Morphology – Morphology features measured included (1) the length of each major morphological feature within a sampling station, including riffles, runs, and pools, (2) the distance between bends, and (3) stream width

Transect Point Measurements – At five points along each transect, water depth, depth of fine sediment, depth of water, embeddedness, substrate, percent algae, and percent macrophytes

Cover for Fish - the amount of cover or shelter available for fish such as undercut banks, overhanging vegetation, woody debris, boulders, submergent or emergent macrophytes (plants) and other debris

Bank Erosion – The amount of the stream bank that is actively eroding

Riparian Land Use – The predominant land use within the riparian zone (e.g., developed, woodland, wetland).

Riparian Buffer Width – the amount of contiguous undisturbed land use within a 10 meter buffer zone. If no undisturbed land uses are directly adjacent to the stream, the riparian buffer width is 0 meters.

Canopy/Shading – A measure of overhead canopy cover that is shading the stream.

3.3 Water Quality Monitoring

Flow and water quality (temperature, dissolved oxygen, specific conductance, pH, and turbidity) were measured at each monitoring station (Figures 3-1 to 3-7) prior to collection of macroinvertebrate samples.

4.0 2015 Water Quality and Flow

Water quality (temperature, dissolved oxygen, specific conductance, and pH) and flow were measured in Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek in October after collection of macroinvertebrate samples. The data were compared to MPCA water quality standards shown in Table 4-1. Both Plymouth and Bassett Creeks are classified as Class 2B streams and are required to meet the standards listed in Minnesota Administrative Rules 7050.022 Specific Water Quality Standards for Class 2 Waters of the State; Aquatic Life and Recreation; Subpart 4 Class 2B Waters. All measurements of temperature, pH, turbidity, and dissolved oxygen met the MPCA water quality standards. However, specific conductance measurements failed to meet the MPCA standard for water quality at four of the six monitoring stations.

October data collected from Plymouth Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek locations at Rhode Island Avenue and east of Brookridge Avenue failed to meet the MPCA standard for specific conductance. Specific conductance is a measure of water's ability to conduct an electric current and serves as a quantitative measure of ionic strength. While specific conductance is a measure of all ionic species, in many streams it is highly correlated with chloride concentrations. The presence of excessive ions, such as chloride, can cause sustained osmotic stress—causing water to leave macroinvertebrate cells and inhibiting the transport of necessary materials to the cells. Some macroinvertebrates, such as mayflies, are unable to survive sustained osmotic stress. The subsequent reduction of the macroinvertebrate community can cause biological impairment to a stream.

Because Plymouth Creek and the Main Stem of Bassett Creek are considered impaired for chlorides, the excess ions causing the high specific conductance measurements at these locations in October are likely chloride ions. 2015 chloride data collected by Three Rivers Park District from Plymouth Creek show high chloride concentrations in excess of the MPCA standard were observed in the stream on multiple occasions during 2015. Samples were collected from Plymouth Creek at the Industrial Park sampling location during April through October of 2015, including a sample collected on October 8, one day after BCWMC measured specific conductance. Chloride concentrations failed to meet the MPCA chronic chloride standard of 230 mg/L on April 27, May 7, May 26, and August 17 (Three Rivers Park District, 2016). The October 8 chloride concentration was 214.9 mg/L (Three Rivers Park District, 2016) which was near the MPCA impairment threshold and indicates the high specific conductance measured by BCWMC on October 7 was caused by chloride ions.

Although the Sweeney Lake of Bassett Creek is not impaired for chlorides, the high specific conductance measurement in October indicates chloride concentrations were high.

In Table 4-1, values meeting MPCA standards are shown in black; values that do not meet the standards are shown in red.

Table 4-1 2015 Plymouth Creek and Bassett Creek Water Quality and Flow Data Compared with MPCA Standards

Sample Location	Sample Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (Standard Units)	Specific Conductance (µmhos/cm @25 °C)	Turbidity (NTU)	Flow (cfs)
Minnesota Class 2B Standard Minn. R. Pt. 7050.0222, subpart 4		Maximum of 30 °C (86 °F)	Minimum of 5 mg/L	6.5–9.0 Standard Units	Not to Exceed 1,000 µmhos/cm @ 25 °C	Maximum of 25 NTU	No Standard
Plymouth Creek at Industrial Blvd.	10/7/2015	13.1	12.4	8.0	1,553	2.1	0.2
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	10/2/2015	13.5	10.2	8.0	1,578	8.9	1.87
North Branch of Bassett Creek at 34 th Ave.	10/3/2015	13.0	11.2	7.9	685	1.7	0.03
Main Stem of Bassett Creek at Rhode Island Ave.	10/3/2015	11.7	7.3	7.3	1,021	3.1	4.3
Main Stem of Bassett Creek East of Brookridge Ave.	10/7/2015	12.0	9.7	7.3	1,155	2.2	3.4
Main Stem of Bassett Creek at Irving Ave.	10/2/1015	12.8	8.9	7.0	913	4.0	8.9

5.0 Habitat

Using MPCA methodology, habitat data were collected from Plymouth Creek, the Sweeney Lake Branch of Bassett Creek, the North Branch of Bassett Creek, and the Main Stem of Bassett Creek shortly after macroinvertebrate samples were collected. Habitat data included documentation of the percent of sample transects with bank erosion and the average length of the erosion per transect. A lack of bank stability results in eroded banks and indicates a problem of sediment movement and deposition. Also documented was the embeddedness of coarse substrate such as gravel, rubble, cobble, and boulders (i.e., the extent to which large particles are surrounded by small particles such as silt or sand). Generally, as rocks become embedded, fewer living spaces are available to macroinvertebrates, resulting in reduced numbers of macroinvertebrate taxa. As shown in Table 5-1, bank erosion and embeddedness of coarse substrate was prevalent at all sample locations.

The depth of fine sediment at sample locations was also measured. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms. Sediment deposited on the substrate makes it difficult for organisms to attach firmly and avoid being carried downstream by the current, thereby reducing macroinvertebrate numbers.

Fine sediment was observed at all locations except the Main Stem of Bassett Creek east of Brookridge Avenue. However, fine sediment depths were very low at all locations except the Sweeney Lake Branch of Bassett Creek at Woodstock Avenue.



Bank erosion was prevalent in Bassett and Plymouth Creeks, including the Main Stem of Bassett Creek at Irving Avenue, pictured above, and the Main Stem of Bassett Creek at Rhode Island Avenue, pictured below.



Table 5-1 Plymouth Creek and Bassett Creek Habitat Survey: Bank Erosion, Embeddedness, and Fine Sediment

Sample Location	% of Transects with Left-Bank Erosion	% of Transects with Right-Bank Erosion	Average Length of Left-Bank Erosion per Transect (m)	Average Length of Right-Bank Erosion per Transect (m)	Average % Embeddedness of Coarse Substrate Per Transect	Average Depth of Fine Sediment (cm)
Plymouth Creek at Industrial Blvd.	38	8	0.2	0	52	1
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	69	85	0.4	0.9	67	15
North Branch of Bassett Creek at 34 th Ave.	15	0	0.3	0	51	1
Main Stem of Bassett Creek at Rhode Island Ave.	92	77	1.1	0.6	50	2
Main Stem of Bassett Creek East of Brookridge Ave.	54	62	0.5	0.6	50	0
Main Stem of Bassett Creek at Irving Ave.	69	69	1.0	1.1	69	2

Algae attached to the stream substrate, submerged macrophytes, overhanging vegetation, woody debris, and boulders provide valuable habitat for the macroinvertebrate community. Hence, these attributes were assessed in Plymouth Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and the Main Stem of Bassett Creek. As shown in Table 5-2 all reaches had one or more of the habitat attributes. However, the percentage of each stream that contained algae, submerged macrophytes, overhanging vegetation, woody debris, and/or boulders was generally small. The data indicate lack of favorable habitat is a likely stressor to the macroinvertebrate community at most stream locations.

A moderate growth of algae attached to the stream substrate (rocks or stream bottom) is



The Sweeney Lake Branch of Bassett Creek, pictured above, was the only location with overhanging vegetation. It provided valuable habitat for the macroinvertebrate community.

desirable for habitat. This type of algae termed periphyton, or attached algae, is used for food by macroinvertebrates and has been associated with increases in both diversity and abundance of macroinvertebrates (Shilling, 2005). While a moderate growth of periphyton is desirable, excessive growth of any type of algae, whether attached to the substrate or suspended in the water column, is undesirable because it is an indication of water quality degradation. Water resource managers generally work to limit phosphorus concentrations in water bodies to minimize the growth of algae that is suspended in the water column, termed planktonic algae, to optimize water clarity and protect water quality from degradation. Water resource managers also work to limit phosphorus concentrations to limit periphyton growth to a moderate level. Because periphyton provide food and valuable habitat for macroinvertebrates, a moderate growth is desirable for Bassett and Plymouth Creeks.

Table 5-2 Plymouth Creek and Bassett Creek Habitat Survey: Algae, Overhanging Vegetation, Submergent Macrophytes, Woody Debris, and Boulders

Sample Location	Average Amount of Algae Observed Per Quadrate ¹ (%)	Average % Length of Transect With Overhanging Vegetation ²	Average % Length of Transect with Submergent Macrophytes ²	Average % Length of Transect with Woody Debris ²	Average % Length of Transect with Boulders ²
Plymouth Creek at Industrial Blvd.	12	0	0	0	8
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	2	5	0	12	0
North Branch of Bassett Creek at 34 th Ave.	31	0	0	0	14
Main Stem of Bassett Creek at Rhode Island Ave.	0	0	0	3	0
Main Stem of Bassett Creek East of Brookridge Ave.	8	0	0	0	7
Main Stem of Bassett Creek at Irving Ave.	9	0	0.4	0	0

¹ Each sample transect was divided into four equal parts and each part is a quadrate. The average percent of each quadrate that was covered by algae and/or macrophytes is shown in the table.

² Only the portion of the transect with a water depth of at least 10 centimeters was included in this assessment.



Main Stem of Bassett Creek at Rhode Island Avenue, pictured above, had very poor habitat for macroinvertebrates.

6.0 The Use of Precipitation Data to Assess Flow Changes and Associated Impacts on HBI/ICI

Average daily flow during the period of August through October from 2000 to 2015 was compared with precipitation over the same period of time to verify that precipitation is a valid indicator of flow changes in streams. Precipitation data from 1980 through 1999 were collected at the Minneapolis-St. Paul International Airport. Precipitation data from 2000 through 2015 were collected from the Watershed Outlet Monitoring Program (WOMP) monitoring station at Dupont Avenue. As shown in Figure 6-1, precipitation and flow were consistently correlated between 2000 and 2015: increases in precipitation were associated with increases in stream flow, while precipitation decreases were associated with decreases in stream flow. The data validate the use of precipitation to assess flow changes and their associated impacts on HBI/ICI.

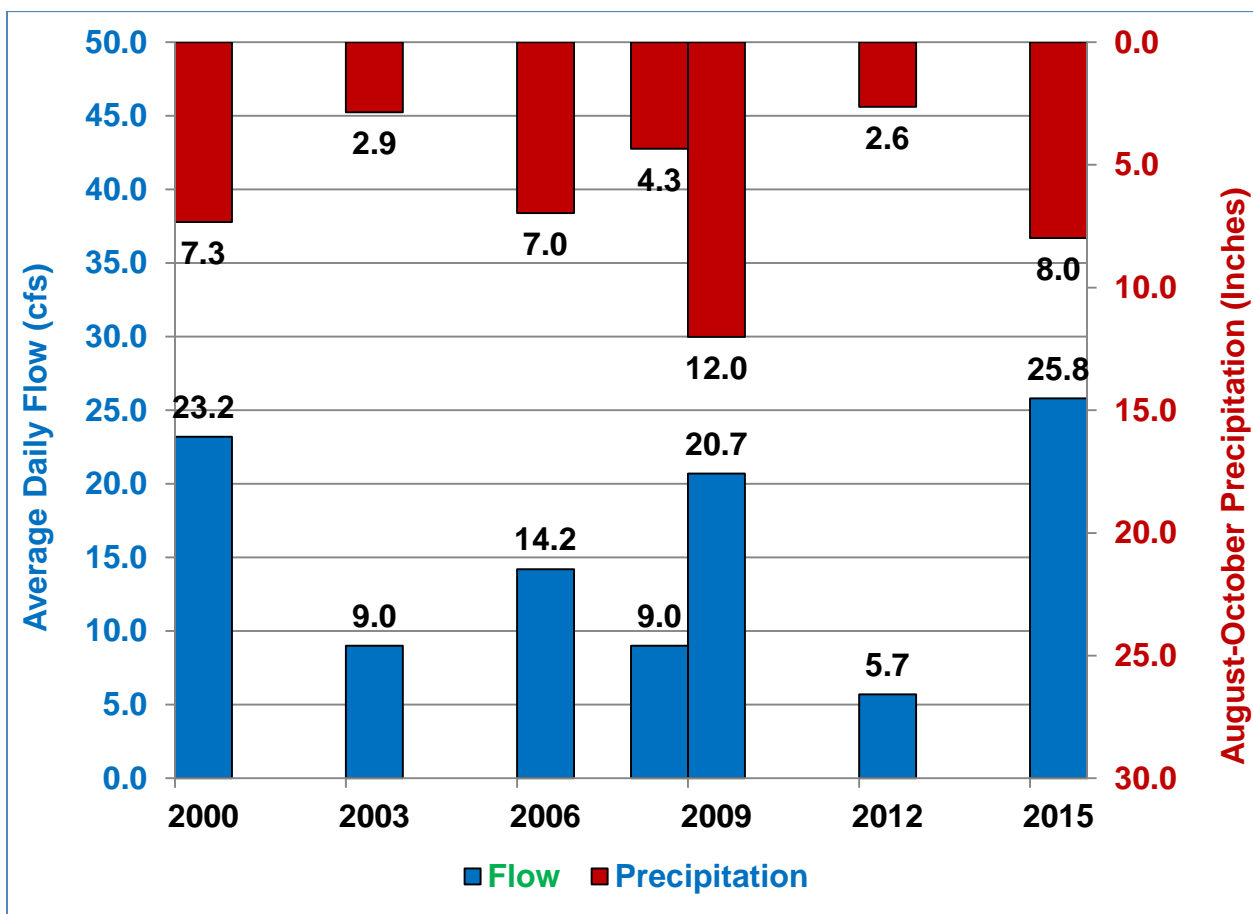


Figure 6-1 2000–2015 Main Stem of Bassett Creek Average Daily Flow and Total Precipitation from August through October at WOMP Station near Dupont/Irving Avenue Sample Location

7.0 HBI and ICI Trend Analyses

The HBI and ICI have been used to evaluate biological data from Plymouth Creek, the Sweeney Lake Branch of Bassett Creek, the North Branch of Bassett Creek, and the Main Stem of Bassett Creek since 1980 and 1995, respectively.

The HBI assesses oxygen content of the stream by assessing the average tolerance of the macroinvertebrate community to low oxygen conditions. The average tolerance level is computed from HBI tolerance values (from 0–10) assigned to each taxa (species) weighted by the number of individuals. A value of 0 indicates the lowest tolerance to low dissolved-oxygen conditions and corresponds with the highest water quality and low levels of organic pollution. A value of 10 indicates the highest tolerance to low dissolved oxygen conditions and indicates the poorest water quality. The average HBI value for a community also indicates the amount of organic pollution the stream has received. When organic materials are added to streams via stormwater runoff, oxygen depletion occurs as bacteria use oxygen to break down the materials. Average HBI values in Plymouth and Bassett Creeks during the period of record have ranged from 4.2 to 7.2, reflecting the runoff they receive from urban areas. An average HBI value of 4.2 indicates very good water quality and possible slight organic pollution. An average HBI value of 7.2 indicates fairly poor water quality and significant organic pollution. Table 7-1 summarizes the water quality and degree of organic pollution indicated by HBI values.

Table 7-1 Water Quality and Degree of Pollution Indicated by HBI Values

HBI Value	Water Quality	Degree of Organic Pollution
0.00–3.50	Excellent	No apparent organic pollution
3.51–4.50	Very Good	Possible slight organic pollution
4.51–5.50	Good	Some organic pollution
5.51–6.50	Fair	Fairly significant organic pollution
6.51–7.50	Fairly Poor	Significant organic pollution
7.51–8.51	Poor	Very significant organic pollution
8.51–10.0	Very Poor	Severe organic pollution

Expected HBI response with increased organic pollution = Increase

ICI tolerance values (DeShon 1995) indicate impacts from a wider range of pollutants and provide a broader view of water quality than the HBI. The scale for the ICI ranges from 0 to 60. A score of 60 indicates the highest water quality and a score of 0 indicates the lowest water quality.

Trend analyses for the period of record were completed using HBI and ICI values at individual sample locations. The trend analyses document statistically significant changes over time. A change in HBI or ICI was considered significant if there was less than a 5 percent probability that the change was due to chance (i.e., 95 percent confidence level).

Results of the trend analyses for the six individual sample locations are summarized in Section 7-1 through 7-6. The HBI and ICI trend graphs show the individual HBI and ICI values as green diamonds. The rate of change over time is shown by the blue trend line and summarized in blue text.

HBI and ICI values were compared with precipitation to determine whether or not changes in precipitation were correlated with changes in HBI and ICI values. With few exceptions, changes in precipitation were not correlated with changes in HBI and ICI values. The exceptions include:

Plymouth Creek - Increased precipitation has generally been correlated with increased ICI (improved quality of the invertebrate community/improved water quality). The data indicate increased precipitation was correlated with improved water quality, possibly due to dilution of chlorides added to the stream from groundwater by increased runoff. It has been hypothesized that chlorides added to surficial groundwater during snowmelt runoff increase groundwater chloride concentrations. Consequently, groundwater added to streams increases stream chloride concentrations, especially during periods of low flow when groundwater impacts on stream water quality are greatest. Increased runoff to Plymouth Creek during summer may dilute chlorides added to the stream from groundwater, thereby improving stream water quality during periods of increased precipitation.

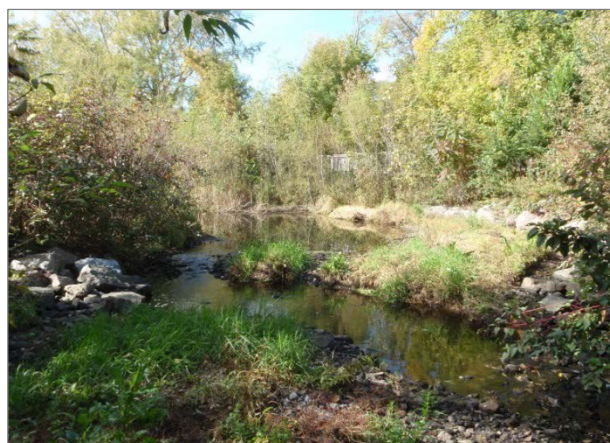
Sweeney Lake Branch of Bassett Creek – HBI and precipitation have generally been correlated since 2003. During this period of time, precipitation and HBI have generally increased, indicating increased precipitation has been correlated with reduced oxygen. When precipitation declined in 2012, HBI also declined, indicating reduced precipitation was correlated with increased oxygen.

Additional details regarding the comparisons between HBI and ICI and precipitation changes are found in Appendix A.

7.1 Plymouth Creek

As shown in Figure 7-1, HBI values for Plymouth Creek have been relatively stable over time, ranging from a high of 6.5 in 2003 to a low of 4.3 in 2012. The 2015 value of 5.8 was within the historical range and indicates the average oxygen conditions at this location are fair. The trend line over the period of record indicates the overall change is a decrease of 0.06 HBI units per year. A decrease indicates increased oxygen concentrations. These changes in HBI over time are not significant because there is more than a 5 percent probability that they were due to chance.

Figure 7-2 shows that ICI values have generally been greater than 30 throughout the period of record, indicating water quality has generally been better than average. The 2015 value of 36.6 was within the historical range of 16.7 (2012) to 41.2 (2003). The trend line



The HBI and ICI values during the period of record indicate the water quality of Plymouth Creek, pictured above, has been stable over time.

shows an overall decrease in ICI of 0.5 ICI units per year. A decrease indicates water quality degradation; however, the changes in ICI were not considered significant because there is more than a 5 percent probability that they are due to chance.

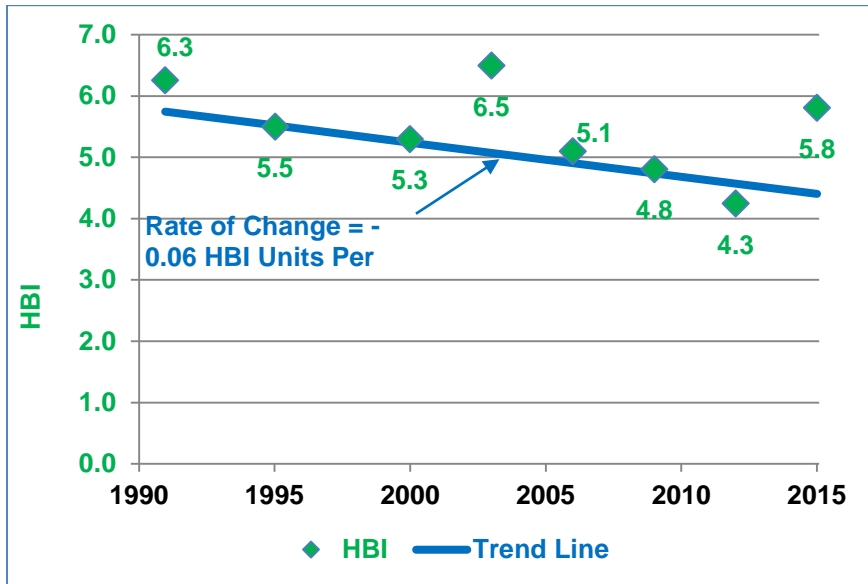


Figure 7-1 1991-2015 Plymouth Creek at Industrial Boulevard HBI Trend Analysis shows increasing oxygen, but not statistically significant.

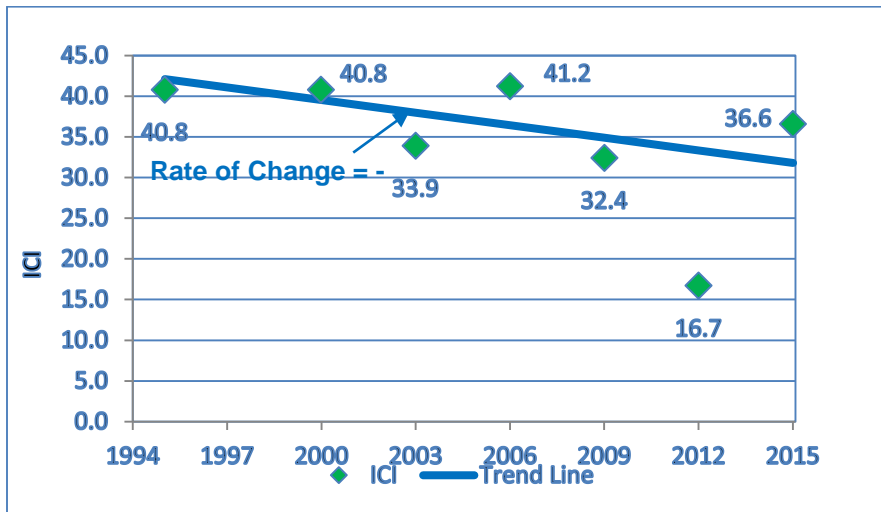


Figure 7-2 1995-2015 Plymouth Creek at Industrial Boulevard ICI Trend Analysis shows degrading water quality, but not statistically significant

7.2 Sweeney Lake Branch of Bassett Creek

As shown in Figure 7-3, HBI values for the Sweeney Lake Branch of Bassett Creek have consistently increased over time—from 4.2 in 1980 to 6.6 in 2015. The 2015 value of 6.6 was within the historical range of 4.3 (1980) to 7.2 (1995) and indicates the average oxygen concentrations at this location are fairly poor. The trend line shows an overall increase of 0.05 HBI units per year. These changes in HBI over time are significant because there is less than a 5 percent probability that they were due to chance. The trend toward increasing HBI indicates oxygen levels in the Sweeney Lake Branch of Bassett Creek have significantly declined over time.



A significant increase in HBI over time was observed at the Sweeney Lake Branch of Bassett Creek, pictured above, indicating oxygen concentrations in the stream have declined over time.

Figure 7-4 shows that ICI values have ranged from a low of 24.8 in 2012 to a high of 38.5 in 1996. The ICI value of 31.8 in 2015 was within the historical range and indicates water quality was average. The trend line over the period of record shows an overall decrease of 0.4 ICI units per year, indicating water quality degradation. However, these changes were not considered significant because there is more than a 5 percent probability that they are due to chance.

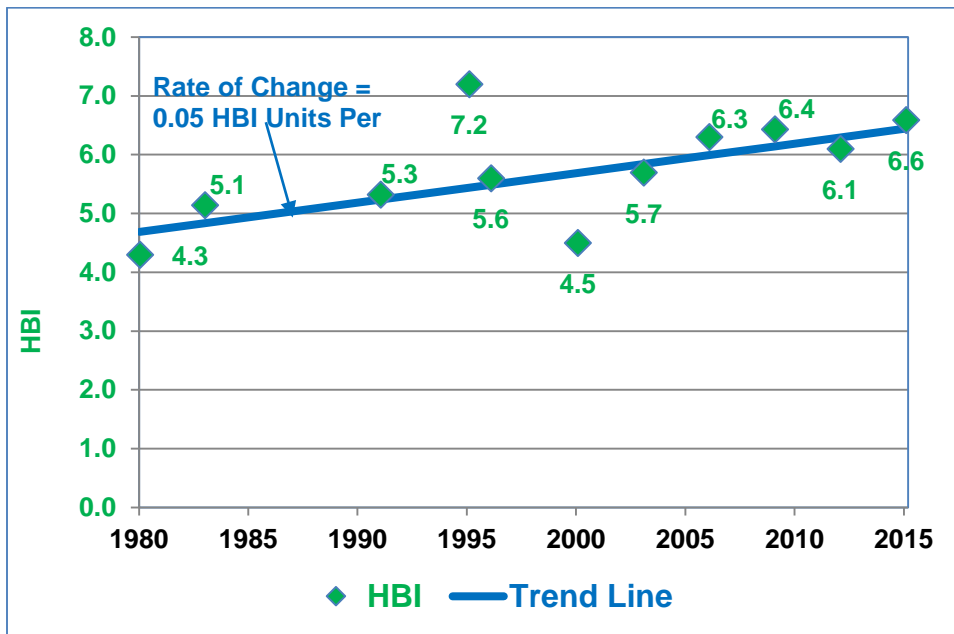


Figure 7-3 1980-2015 Sweeney Lake Branch of Bassett Creek at Turner’s Crossroad/Woodstock Avenue HBI Trend Analysis shows statistically significant declines in oxygen

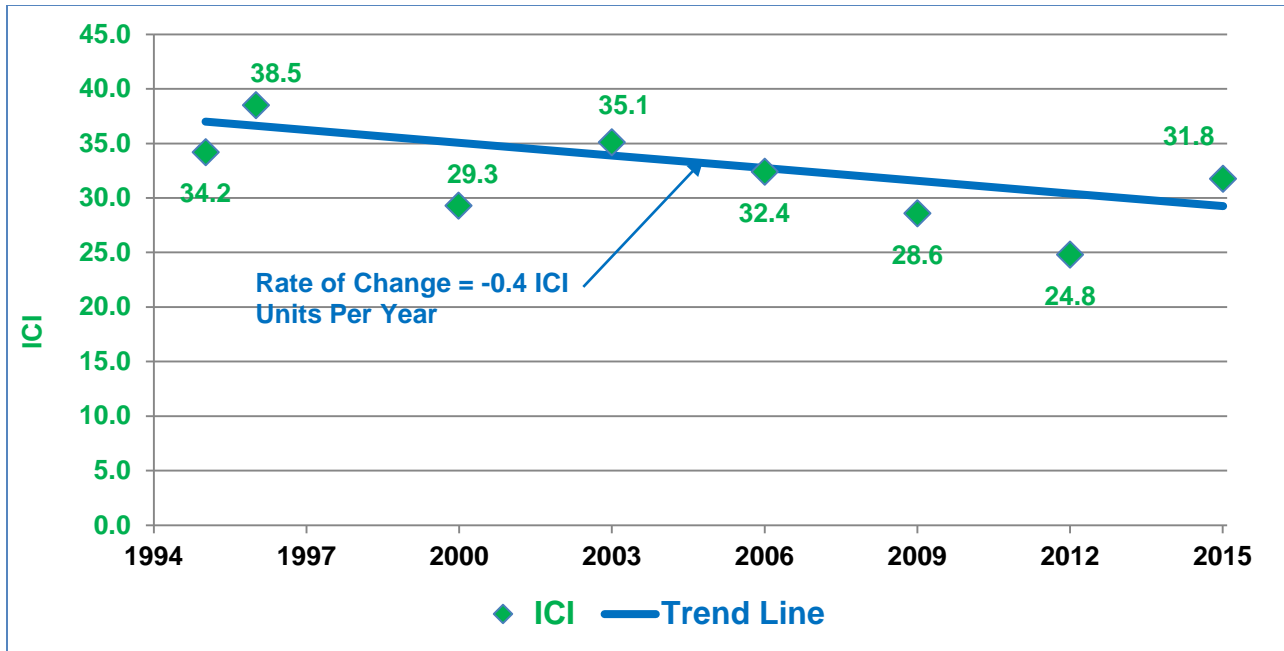


Figure 7-4 1995-2015 Sweeney Lake Branch of Bassett Creek at Turner’s Crossroad/Woodstock Avenue ICI Trend Analysis shows degrading water quality, but not statistically significant

7.3 North Branch of Bassett Creek

As shown in Figure 7-5, HBI values from the North Branch of Bassett Creek have been relatively stable over time, ranging from a high of 7.6 in 2009 to a low of 4.6 in 2000. The 2015 value of 5.3 was within the historical range and indicates the average oxygen conditions at this location are good. The trend line shows an overall increase of 0.02 HBI units per year. Although the rate of increase is very small, an increase indicates reduced oxygen conditions and is unfavorable for the stream. These changes in HBI over time are not significant because there is more than a 5 percent probability that the changes were due to chance.

Figure 7-6 shows that ICI values have generally been greater than 30 throughout the period of record, indicating water quality has generally been better than average. The 2015 value of 40.2 was the highest value observed to date. The trend line over the period of record shows a slight overall decrease in ICI of 0.01 units per year, generally indicating water quality degradation. However, these changes are not considered significant because there is more than a 5 percent probability that they are due to chance.



The HBI and ICI values during the period of record verify that the water quality of the North Branch of Bassett Creek, pictured above, has been relatively stable over time.

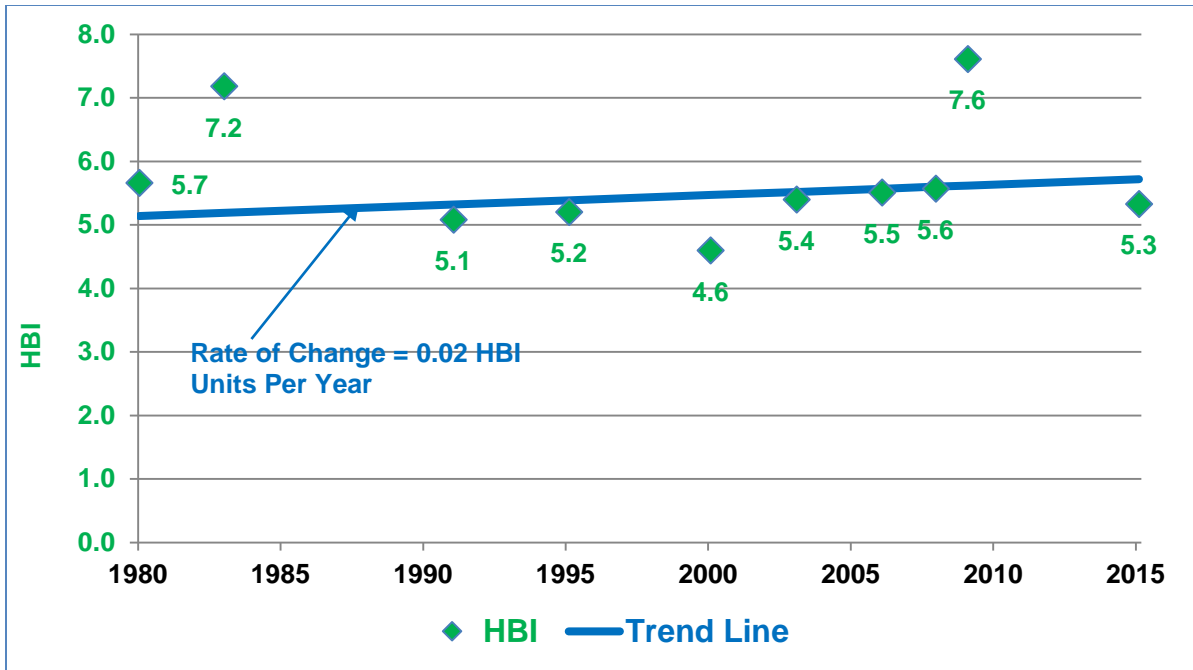


Figure 7-5 1980-2015 North Branch of Bassett Creek HBI Trend Analysis shows declining oxygen, but not statistically significant

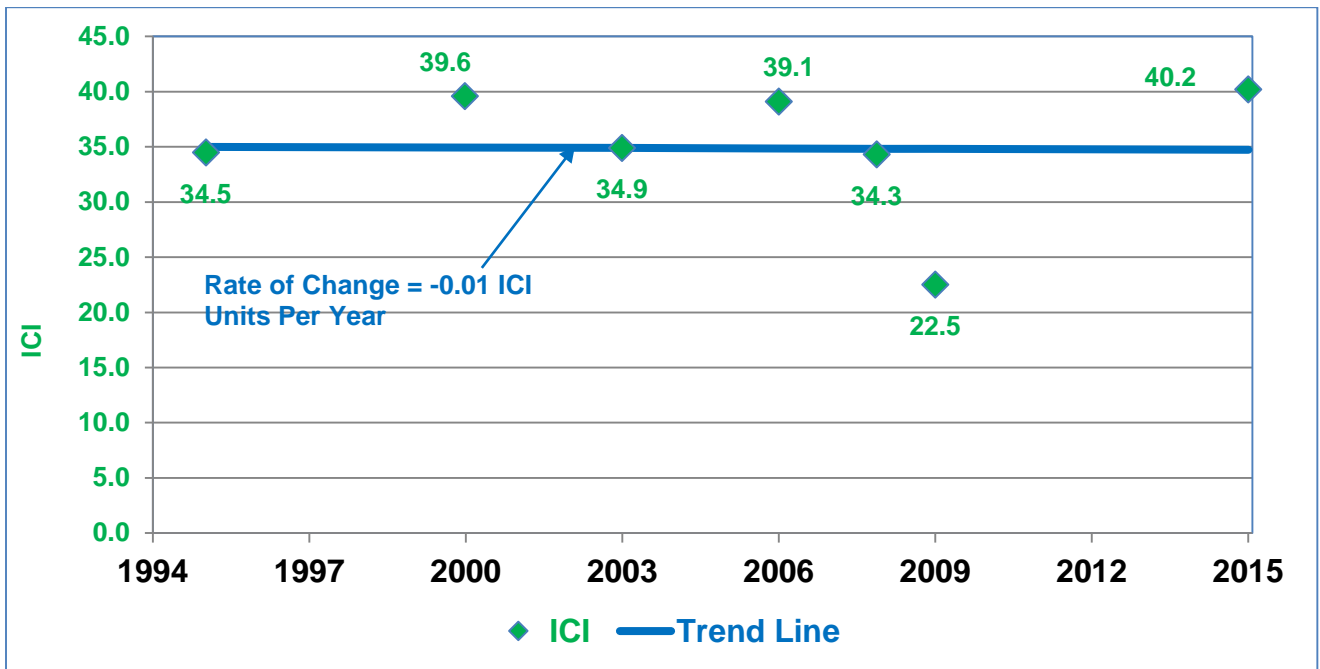


Figure 7-6 1995-2015 North Branch of Bassett Creek ICI Trend Analysis shows degrading water quality, but not statistically significant

7.4 Main Stem of Bassett Creek at Rhode Island Avenue

As shown in Figure 7-7, HBI values from Bassett Creek at Rhode Island Avenue have been relatively stable over time, ranging from a high of 6.1 in 1983 to a low of 4.2 in 2012. The 2015 value of 5.1 was within the historical range and indicates the average oxygen conditions at this location are good. The trend line shows an overall decrease of 0.03 HBI units per year, indicating that oxygen concentrations may have been increasing, which is favorable for the stream. However, these changes are not considered significant because there is more than a 5 percent probability that they are due to chance.



The HBI and ICI values verify that the water quality of Bassett Creek at Rhode Island Avenue, pictured above, has remained relatively stable over time.

Figure 7-8 shows that ICI values have generally been greater than 30 throughout the period of record, indicating water quality has generally been better than average. Values have ranged from a low of 19.7 in 2012 to a high of 40.4 in 2000. The 2015 value of 38.9 was within the historical range. The trend line over the period of record shows an overall decrease of 0.4 ICI units per year, indicating water quality degradation. However, the changes in ICI are not considered significant because there is more than a 5 percent probability that they are due to chance. Because the changes are not significant, the ICI trend analysis verifies that the water quality of Bassett Creek at Rhode Island Avenue has been relatively stable over time.

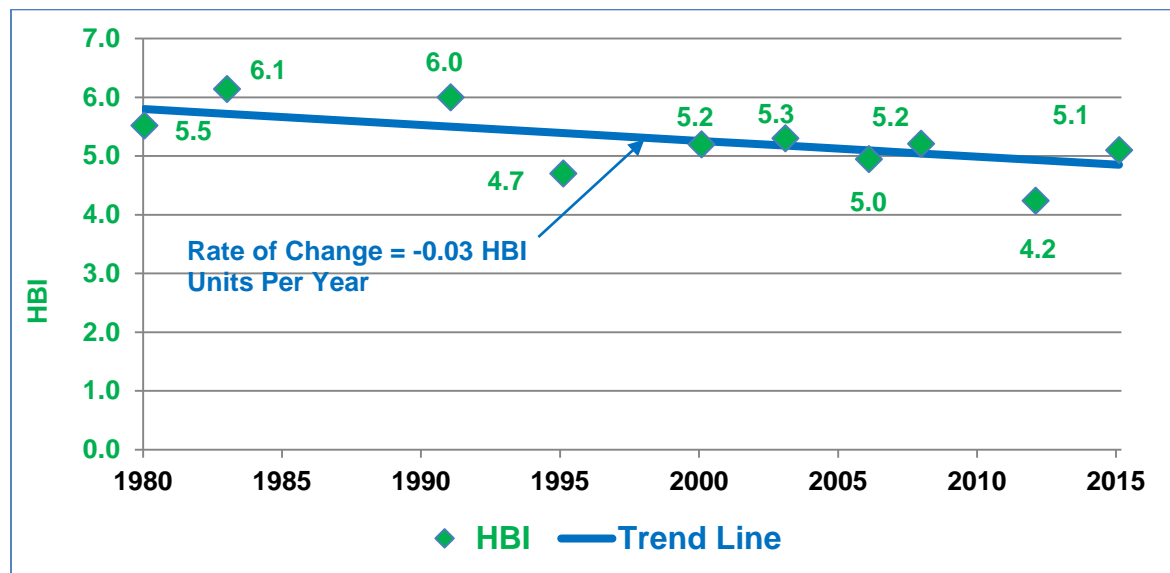


Figure 7-7 1980-2015 Main Stem of Bassett Creek at Rhode Island Avenue HBI Trend Analysis shows increasing oxygen, but not statistically significant

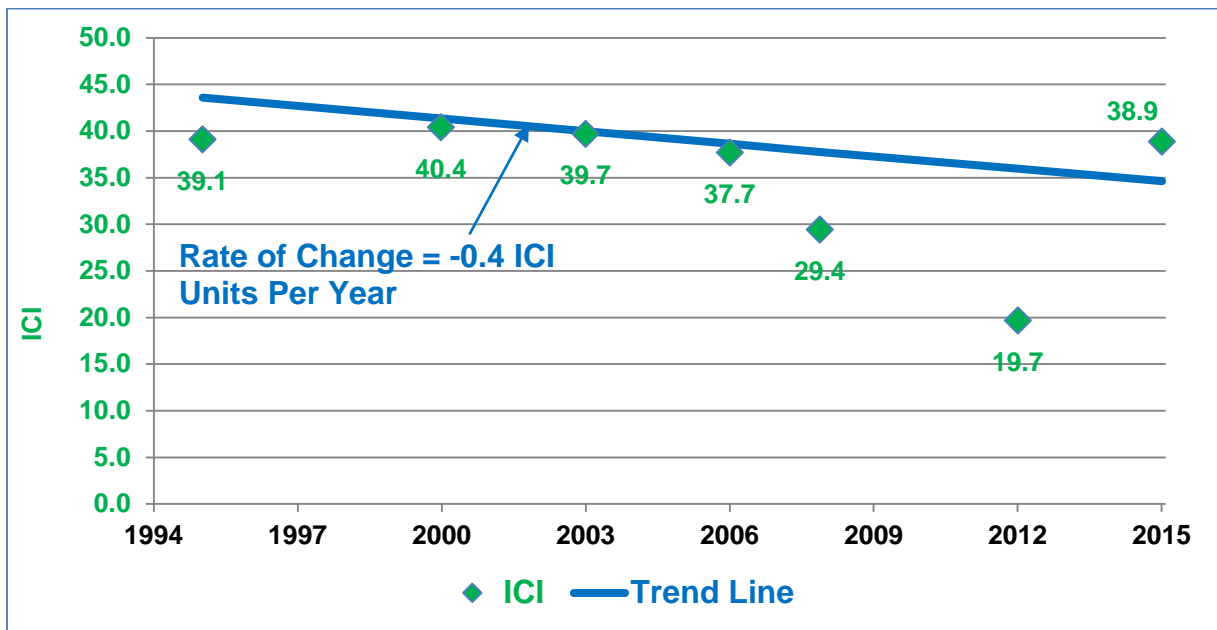
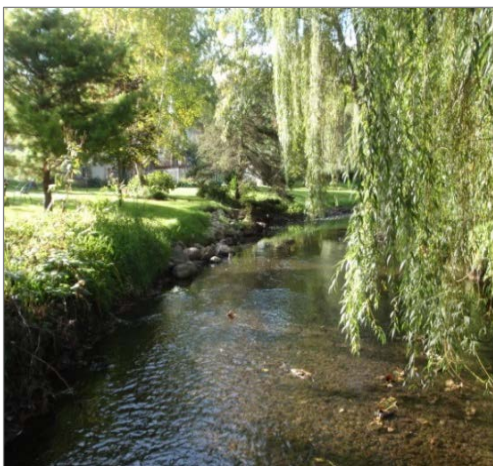


Figure 7-8 Main Stem of Bassett Creek at Rhode Island Avenue ICI Trend Analysis: 1995–2015 shows degrading water quality, but not statistically significant

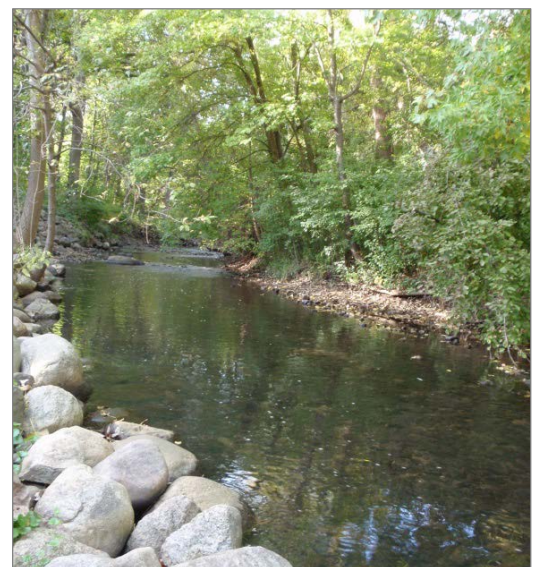
7.5 Main Stem of Bassett Creek East of Brookridge Avenue

As shown in Figure 7-9, HBI values for the Main Stem of Bassett Creek east of Brookridge Avenue have significantly decreased over time, ranging from a high of 6.0 in 1983 to a low of 4.6 in 2012. The 2015 value of 5.2 was within the



A significant decline in HBI values in the Main Stem of Bassett Creek east of Brookridge Avenue, pictured above, indicates oxygen levels have increased over time.

historical range and indicates the average oxygen conditions at this location are good. The trend line over the period of record shows an overall decrease of 0.03 HBI units per year, indicating oxygen



The 2015 ICI values in the Main Stem of Bassett Creek east of Brookridge Avenue, pictured above, indicated water quality was better than average.

concentrations may be increasing. These changes in HBI over time are considered significant because there is less than a 5 percent probability that they are due to chance.

Figure 7-10 shows that ICI values have generally been greater than 30 throughout the period of record, indicating water quality has generally been better than average. Values have ranged from a low of 27.4 in 2012 to a high of 42.0 in 2006. The 2015 value of 41.8 was within the historical range. The trend line over the period of record shows an overall decrease of 0.03 ICI units per year, indicating water quality degradation. However, these changes in ICI are not considered significant because there is more than a 5 percent probability that they are due to chance.

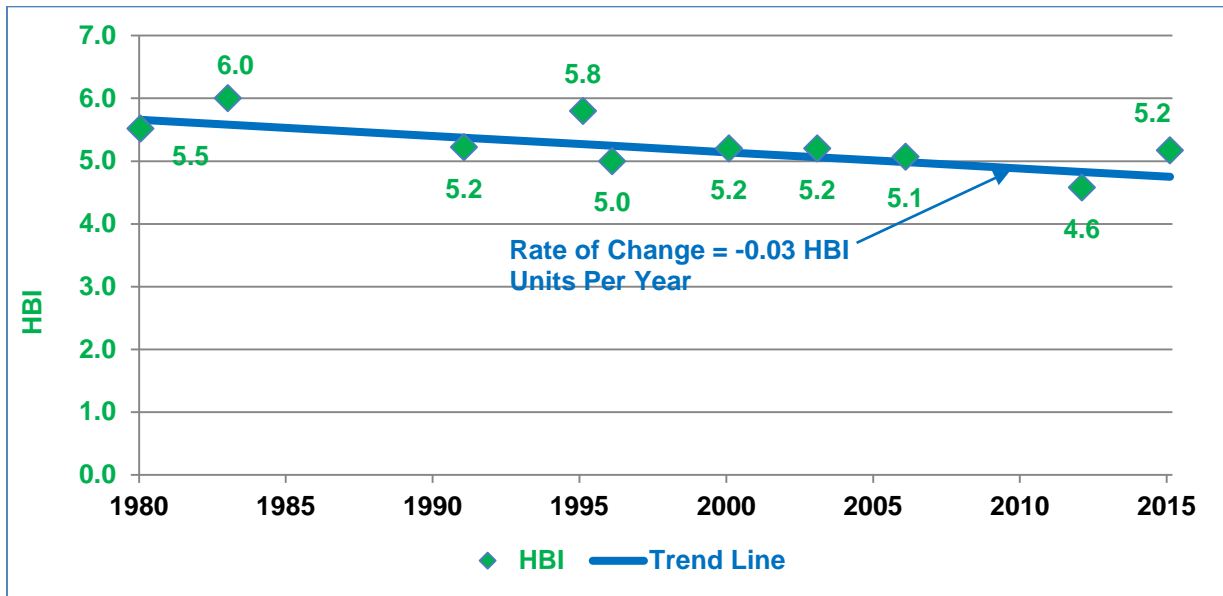


Figure 7-9 1980-2015 Main Stem of Bassett Creek East of Brookridge HBI Trend Analysis shows statistically significant increases in oxygen

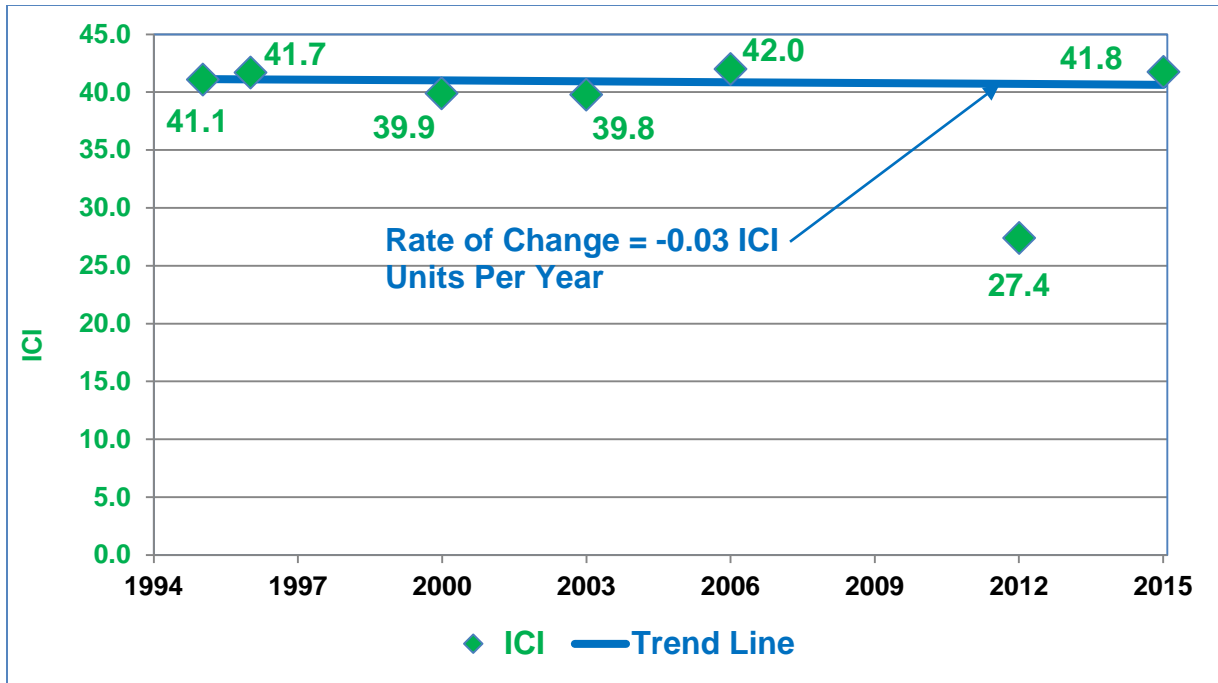


Figure 7-10 1995-2015 Main Stem of Bassett Creek East of Brookridge Avenue ICI Trend Analysis shows degrading water quality, but not statistically significant

7.6 Main Stem of Bassett Creek at Dupont/Irving Avenue

As shown in Figure 7-11 HBI values from the Main Stem of Bassett Creek at Dupont/Irving Avenue have remained stable over time, ranging from a high of 6.5 in 1983 to a low of 4.9 in 2008. The 2015 value of 5.2 was within the historical range and indicates the average oxygen conditions at this location are good. The trend line over the period of record shows an overall decrease of 0.03 HBI units per year, indicating that oxygen concentrations may have been increasing. However, these changes are not considered significant because there is more than a 5 percent probability that they were due to chance.



The HBI values show that the water quality of Bassett Creek at Dupont/Irving Avenue has remained relatively stable over time. The Irving Avenue monitoring station is pictured above.

Figure 7-12 shows that ICI values have generally been greater than 30 throughout the period of record, indicating water quality has generally been better than average. Values have consistently increased from a low of 35.1 in 1995 to a high of 41.3 in 2015, the highest value and best water quality observed to date. The trend line over the period of record shows an overall increase of 0.3 ICI units per year, suggesting an increase in

water quality. However, these changes are not considered significant because there is more than a 5 percent probability that they are due to chance.

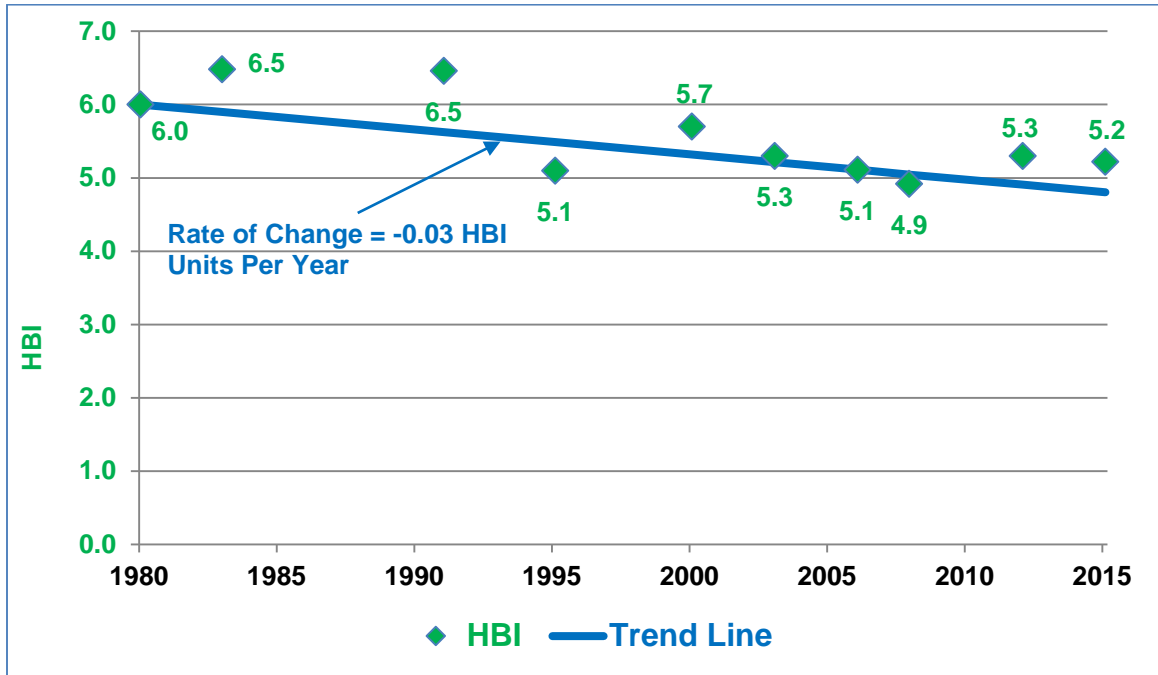


Figure 7-11 1980-2015 Main Stem of Bassett Creek at Dupont/Irving Avenue: HBI Trend Analysis shows increasing oxygen, but not statistically significant

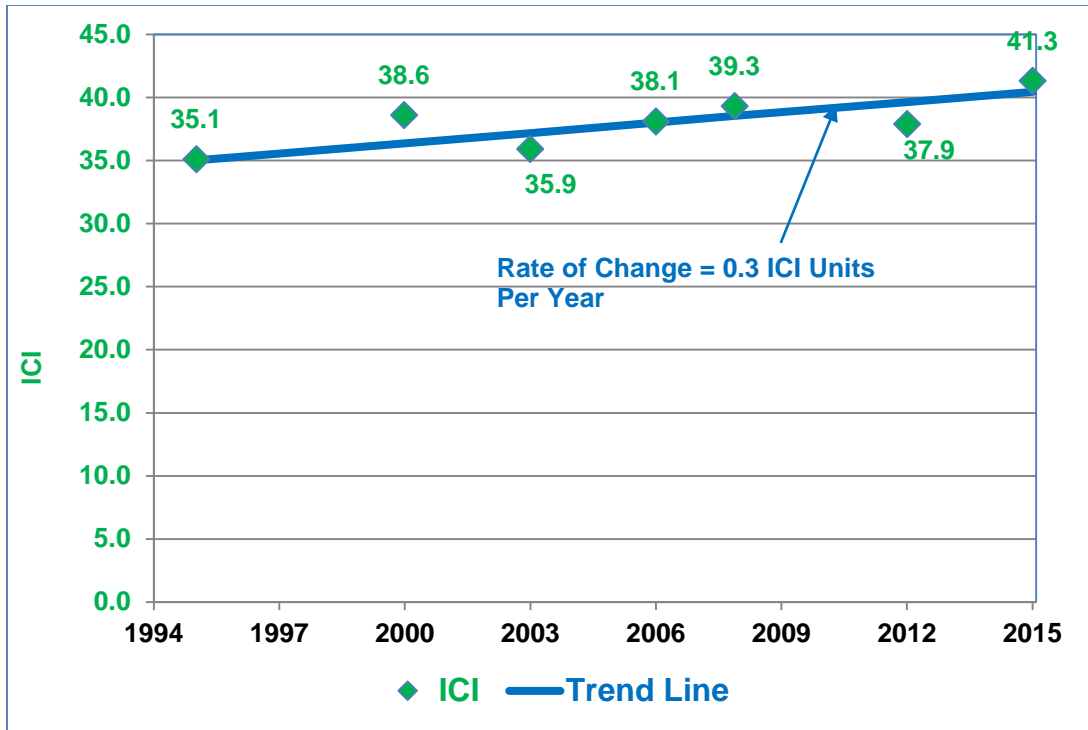


Figure 7-12 1995-2015 Main Stem of Bassett Creek at Dupont/Irving Avenue ICI Trend Analysis shows improving water quality, but not statistically significant

8.0 M-IBI

Minnesota’s water quality standards call for the maintenance of a healthy community of aquatic life. The Macroinvertebrate Index of Biotic Integrity (M-IBI) is used to assess the health of the aquatic communities. The MPCA identifies biological impairments in Minnesota streams by using the M-IBI to assess aquatic macroinvertebrate communities and comparing those scores to their regional impairment threshold. Scores below the impairment threshold indicate that a stream reach does not support aquatic life and does not meet the state standard.

The MPCA partitioned Minnesota streams into five distinct classes and developed a unique M-IBI for each class. The class selected by the MPCA to describe Bassett and Plymouth Creek locations (with corresponding M-IBI thresholds) is *Southern Forest Streams (Riffle/Run Habitats)*. This *Southern Forest Streams* class applies to streams with a drainage area less than 500 square miles and is based on stream morphology—fast-moving/turbulent water.

The MPCA standard for Plymouth and Bassett Creeks is an M-IBI value of at least 37. Figure 8-1 compares the 2015 M-IBI values for Plymouth and Bassett Creeks with the MPCA standard and Table 8-1 shows stream reaches meeting the MPCA standard. Only the Sweeney Lake Branch of Bassett Creek met the MPCA standard for macroinvertebrates (Table 8-1 and Figure 8-1).

Table 8-1 Plymouth Creek and Bassett Creek Reaches Meeting State Standards for Macroinvertebrates

Stream Name	Reach Description	Met State Standard for Macroinvertebrates
Plymouth Creek	Plymouth Creek at Industrial Blvd.	No
Bassett Creek	North Branch of Bassett Creek at 34 th Ave.	No
	Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	Yes
	Main Stem of Bassett Creek at Rhode Island Ave., East of Brookridge Ave., and Irving Ave.	No

Additional details about the M-IBI scores are found in Appendix B.

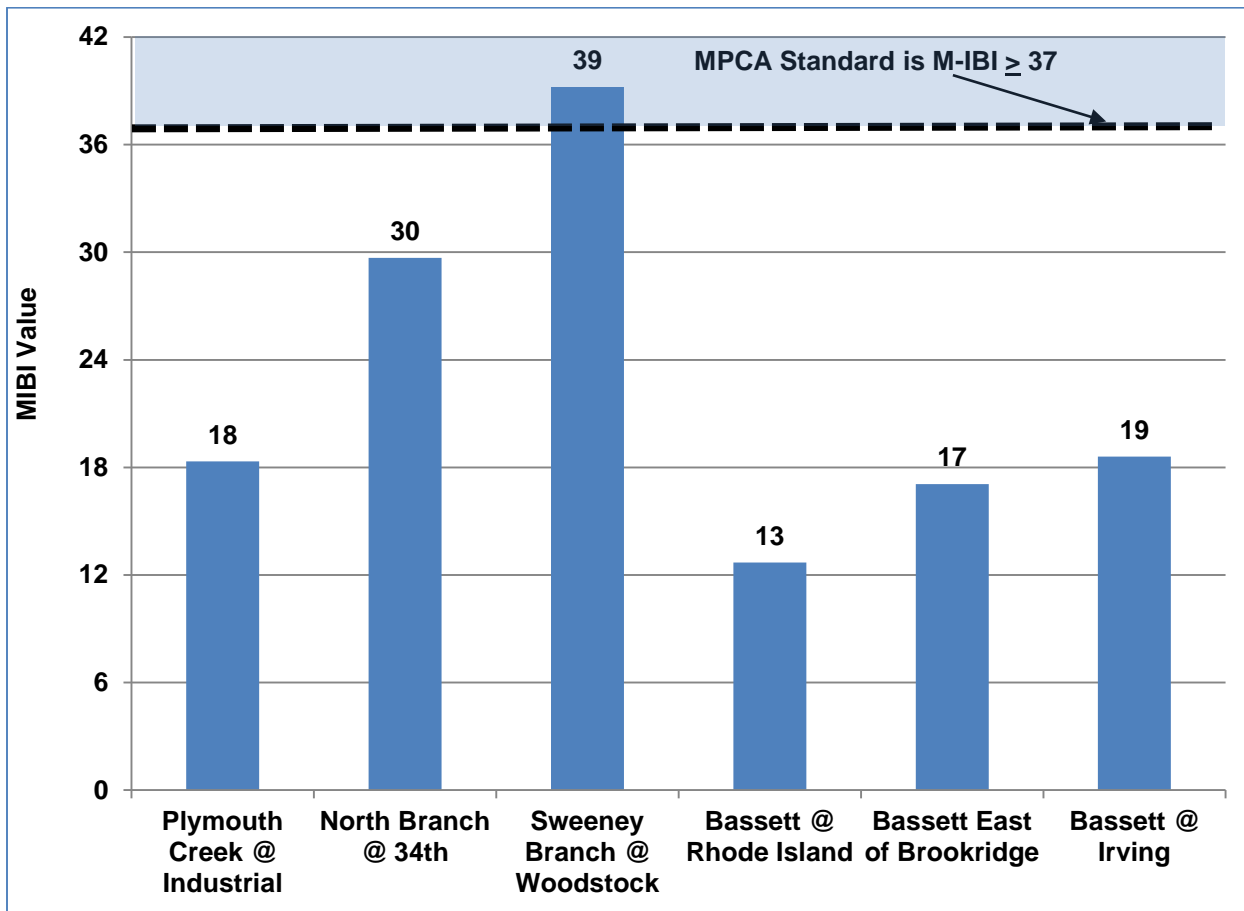


Figure 8-1 2015 M-IBI Values from Plymouth and Bassett Creeks Compared to MPCA Standard (M-IBI \geq 37): Above the Line is Meeting the Standard

9.0 Summary of Results

The following conclusions for individual sampling locations summarize the results of the *2015 Biotic Index Evaluation of Plymouth Creek and Bassett Creek*.

9.1 Plymouth Creek at Industrial Boulevard

9.1.1 M-IBI

The total M-IBI score for Plymouth Creek (18) failed to meet the State standard of at least 37. Assessing the individual scores of the 10 metrics that comprise the M-IBI (Appendix B) provides insight into the strengths and weaknesses of the macroinvertebrate community at this location (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate oxygen (HBI_MN) adequate number of Odonata taxa, and a suitably low percentage of tolerant macroinvertebrates.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include inadequate habitat for climber and clinger taxa, uneven distribution between taxa indicated by a high percentage of the dominant five taxa, inadequate relative percentage of insect taxa, lack of Plecoptera and predator taxa, and an insufficient number of Trichoptera taxa.

9.1.2 HBI and ICI

The HBI trend analysis verifies that the oxygen content of Plymouth Creek has been relatively stable over time. The ICI trend analysis verifies that the pollutant load to Plymouth Creek has been relatively stable over time. However, increased precipitation has generally been correlated with increased ICI (better water quality) while decreased precipitation has generally been associated with decreased ICI (poorer water quality). The data indicate wetter climatic conditions have a more favorable impact on the macroinvertebrate community. Increased runoff to Plymouth Creek during summer may dilute chlorides added to the stream from groundwater, thereby improving stream water quality during periods of increased precipitation.

9.1.3 Water Quality

The specific conductance value of 1,553 μ mhos per centimeter at 25 °C exceeded the MPCA standard of 1,000 μ mhos per centimeter. Specific conductance can be used as a surrogate for chlorides. The high specific conductance value suggests high chloride concentrations were present in the stream, causing sustained osmotic stress that may stress the macroinvertebrate community and contribute to Plymouth Creek's biological impairment. All other water quality parameters met the MPCA standard.

9.1.4 Habitat

Streambank erosion and embeddedness were high and may contribute to Plymouth Creek's biological impairment.

Fine sediment was observed in Plymouth Creek, but the depth was low (on average, 1 centimeter).

Habitat diversity in Plymouth Creek was limited. Overhanging vegetation, submerged macrophytes (aquatic plants), and woody debris were not observed. On average, algal growth was found in about 12 percent of each sample transect and boulders were found along about 8 percent of the length of each transect.

9.2 Sweeney Lake Branch of Bassett Creek at Woodstock Avenue

9.2.1 M-IBI

The Sweeney Lake Branch at Woodstock Avenue met the State standard for macroinvertebrates; its total M-IBI score of 39 met the MPCA M-IBI standard of at least 37. Assessing the individual scores of the 10 metrics that comprise the M-IBI provides insight into the strengths and weaknesses of the macroinvertebrate community at this location (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate habitat for climber taxa, an even distribution of taxa (dominant five taxa), adequate Odonata and predators, and a sufficiently low percentage of tolerant macroinvertebrates.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include inadequate habitat for clinger taxa, inadequate levels of oxygen to support more sensitive species, inadequate relative percentage of insect taxa, lack of Plecoptera, and an insufficient number of Trichoptera taxa.

9.2.2 HBI and ICI

A trend analysis shows a significant increase in HBI over time, indicating that oxygen levels in the Sweeney Lake Branch have declined significantly. A correlation between increasing precipitation and increasing HBI was observed.

ICI did not change significantly over time, indicating that the pollutant load to the Sweeney Lake branch has been relatively stable.

9.2.3 Water Quality

The specific conductance value of 1,578 μmhos per centimeter at 25 °C exceeded the MPCA standard of 1,000 μmhos per centimeter. Specific conductance can be used as a surrogate for chlorides. The high specific conductance value suggests high chloride concentrations were present in the stream, causing sustained osmotic stress that may stress the macroinvertebrate community. However, other positive characteristics, such as habitat diversity, have mitigated the impacts of sustained osmotic stress, enabling the creek to meet the State standard.

9.2.4 Habitat

Streambank erosion, embeddedness, and depth of fine sediment were high and may stress the macroinvertebrate community.

Habitat diversity in the Sweeney Lake Branch was high. Although submerged macrophytes and boulders were not observed, algae attached to the stream substrate (periphyton), overhanging vegetation, and woody debris were documented.

9.3 North Branch of Bassett Creek at 34th Avenue

9.3.1 M-IBI

The total M-IBI score for the North Branch of Bassett Creek (30) did not meet the State standard of at least 37. Assessing the individual scores of the 10 metrics that comprise the M-IBI provides insight into the strengths and weaknesses of the macroinvertebrate community (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate habitat for climber and clinger taxa, adequate oxygen (HBI_MN), adequate Odonata and number of predator taxa, and a sufficiently low percentage of tolerant macroinvertebrates.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include an uneven distribution of taxa (indicated by a high percentage of the dominant five taxa), inadequate relative percentage of insect taxa, lack of Plecoptera taxa, and an insufficient number of Trichoptera taxa.

9.3.2 HBI and ICI

The HBI trend analysis verifies that the oxygen content of the North Branch has been relatively stable over time. The ICI trend analysis verifies that the pollutant load to the North Branch has been relatively stable over time.

9.3.3 Water Quality

All water quality parameters met the MPCA standards.

9.3.4 Habitat

Fine sediment and stream-bank erosion were present at relatively low levels. Embeddedness was high and may stress the macroinvertebrates.

Algae and boulders provided good habitat for macroinvertebrates. On average, algal growth was found in about 31 percent of each sample transect and boulders were found along about 14 percent of the length of each transect. Overhanging vegetation, submerged macrophytes, and woody debris were not observed.

9.4 Main Stem of Bassett Creek at Rhode Island Avenue

9.4.1 M-IBI

The total M-IBI score for Bassett Creek at Rhode Island Avenue (13) did not meet the State standard of at least 37. Assessing the individual scores of the 10 metrics that comprise the M-IBI provides insight into the strengths and weaknesses of the macroinvertebrate community (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate habitat for clinger taxa and a sufficiently low percentage of tolerant macroinvertebrates.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include inadequate habitat for climber taxa, an uneven distribution of taxa (indicated by a high percentage of the dominant five taxa), inadequate oxygen levels (indicated by a low HBI_MN score), an inadequate relative percentage of insect taxa, a lack of Plecoptera and Odonata taxa, and an insufficient number of predator and Trichoptera taxa.

9.4.2 HBI and ICI

The HBI trend analysis verifies that the oxygen content of Bassett Creek at Rhode Island Avenue has been relatively stable over time. The ICI trend analysis verifies that the pollutant load to Bassett Creek at Rhode Island Avenue has also been relatively stable over time.

9.4.3 Water Quality

The specific conductance value of 1,021 μmhos per centimeter at 25 °C exceeded the MPCA standard of 1,000 μmhos per centimeter. Specific conductance can be used as a surrogate for chlorides. The high value indicates high chloride concentrations in the stream caused sustained osmotic stress that may stress the macroinvertebrate community and contribute to its biological impairment.

9.4.4 Habitat

Streambank erosion and embeddedness were high and may contribute to the biological impairment in Bassett Creek at Rhode Island Avenue.

Fine sediment was observed in Bassett Creek at Rhode Island Avenue, but depth was low (average of 2 centimeters).

Habitat diversity in Bassett Creek at Rhode Island Avenue was very limited. Overhanging vegetation, submerged macrophytes, algae, and boulders were not observed. On average, woody debris was found along about 3 percent of the length of each transect.

9.5 Main Stem of Bassett Creek East of Brookridge Avenue

9.5.1 M-IBI

The M-IBI score for the Main Stem of Bassett Creek east of Brookridge Avenue (17) failed to meet the State standard of at least 37. Assessing the individual scores of the 10 metrics that comprise the M-IBI provides insight into the strengths and weaknesses of the macroinvertebrate community (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate habitat for clinger taxa and a sufficiently low percentage of tolerant macroinvertebrates.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include inadequate habitat for climber taxa, an uneven distribution of taxa (indicated by a high percentage of the dominant five taxa), inadequate oxygen levels (indicated by a low HBI_MN score), inadequate relative percentages of insect and Odonata taxa, lack of Plecoptera taxa, and insufficient numbers of predator and Trichoptera taxa.

9.5.2 HBI and ICI

A trend analysis indicates HBI values have significantly decreased over time. This indicates that oxygen concentrations have significantly increased, creating favorable conditions for macroinvertebrates.

ICI did not change significantly over time, suggesting the pollutant load to the Main Stem of Bassett Creek east of Brookridge Avenue has been relatively stable over time.

9.5.3 Water Quality

The specific conductance value of 1,155 μ mhos per centimeter at 25 °C exceeded the MPCA standard of 1,000 μ mhos per centimeter. Specific conductance can be used as a surrogate for chlorides. The high value indicates high chloride concentrations in the stream caused sustained osmotic stress that may stress the macroinvertebrate community and contribute to its biological impairment.

9.5.4 Habitat

Streambank erosion and embeddedness were high and may contribute to biological impairment.

Habitat diversity in Bassett Creek east of Brookridge Avenue was limited. On average, algal growth was found in about 8 percent of each sample transect and boulders were found along about 7 percent of the length of each transect. Overhanging vegetation, submerged macrophytes, and woody debris were not observed.

9.6 Main Stem of Bassett Creek at Irving Avenue

9.6.1 M-IBI

The M-IBI score for the Main Stem of Bassett Creek at Irving Avenue (19) did not meet the State standard. Assessing the individual scores of the 10 metrics that comprise the M-IBI provides insight into the strengths and weaknesses of the macroinvertebrate community (Appendix B).

Strengths: Metrics Greater than the Average Score Required to Meet the State Standard (3.7)

Strengths include adequate habitat for clinger taxa and adequate Odonata.

Weaknesses: Metrics Less than the Average Score Required to Meet the State Standard (3.7)

Stream weaknesses include inadequate habitat for climber taxa, an uneven distribution of taxa (indicated by a high percentage of the dominant five taxa), inadequate oxygen levels (indicated by a low HBI_MN score), an inadequate relative percentage of insect taxa, a lack of Plecoptera and predator taxa, a low relative percentage of taxa with tolerance values equal to or greater than 6, and an insufficient number of Trichoptera taxa.

9.6.2 HBI and ICI

The HBI trend analysis verifies that the oxygen content of the Main Stem of Bassett Creek at Irving Avenue has been relatively stable over time. The ICI trend analysis verifies that the pollutant load to the Main Stem of Bassett Creek at Irving Avenue has been relatively stable over time.

9.6.3 Water Quality

All water quality parameters met the MPCA standards.

9.6.4 Habitat

Streambank erosion and embeddedness were high and may contribute toward the biological impairment observed in Bassett Creek at Irving Avenue.

Fine sediment was observed in the Main Stem of Bassett Creek at Irving Avenue, but the depth was low (average of 2 centimeters).

Habitat diversity in the Main Stem of Bassett Creek at Irving Avenue was limited. On average, algal growth was found in about 9 percent of each sample transect and submerged macrophytes (Eurasian watermilfoil) were found along about 0.4 percent of the length of each transect. Overhanging vegetation, woody debris, and boulders were not observed.

10.0 Recommendations

Recommendations include:

- **Chloride monitoring of Plymouth Creek and the Main Stem of Bassett Creek**—Because Plymouth Creek and the Main Stem Bassett Creek are considered impaired for chlorides, the high specific conductance measurements observed in these streams during October of 2015 are likely due to excess chlorides in the streams. Chloride data collected from Plymouth Creek by the Three Rivers Park District verified that the stream’s chloride concentrations exceeded the MPCA chloride standard on multiple occasions in 2015, including a relatively high concentration on the day after BCWMC observed a high specific conductance measurement (Three Rivers Park District, 2016). Chloride monitoring of Plymouth Creek and the Main Stem of Bassett Creek is recommended to determine how frequently chloride concentrations fail to meet MPCA chloride standards and to assess impacts of deicing practices within the streams’ watersheds on chloride concentrations in the streams. The data will help determine the contribution of ionic stress toward the impairment of the macroinvertebrate communities.
- **Chloride monitoring of the North Branch of Bassett Creek and the Sweeney Lake Branch of Bassett Creek**—Although the North Branch Bassett Creek and the Sweeney Branch Bassett Creek are not currently impaired for chlorides, chloride monitoring of these streams is recommended to determine whether the streams are meeting MPCA chloride standards and to assess impacts of deicing practices within the streams’ watersheds on chloride concentrations in the streams. A high specific conductance measurement was observed in Sweeney Lake Branch Bassett Creek during October 2015 suggesting chloride concentrations were relatively high.
- **Habitat improvement projects**—Habitat deficiencies in Plymouth and Bassett Creeks were prevalent in 2015 and contribute toward the impairment of the macroinvertebrate communities. BCWMC is currently considering habitat improvement projects for specific reaches of Plymouth and Bassett Creeks, which are expected to improve macroinvertebrate habitat. It is recommended that BCWMC assess Plymouth and Bassett Creeks to look for additional feasible opportunities of habitat improvement to improve the quality of the macroinvertebrate community.
- **Macroinvertebrate monitoring**—Monitoring the macroinvertebrates of Plymouth and Bassett Creeks at a three year frequency is recommended to periodically assess the biological community. Assessment of the data with the M-IBI is recommended to determine whether or not the macroinvertebrate community meets the State standard of at least 37. Use of the HBI and ICI, including trend analyses, is recommended to identify significant changes in oxygen conditions and/or water quality over time. These recommendations are consistent with the monitoring recommendations in Appendix A of the BCWMC 2015-2025 Watershed Management Plan

http://www.bassettcreekwmo.org/application/files/3114/4676/8825/BCWMC_2015_Watershed_Management_Plan_Appendices.pdf.

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- **Habitat and water quality monitoring**—Monitoring of habitat and water quality when biological samples are collected is recommended to determine whether changes have occurred since 2015 and to identify stressors to the biological community. These recommendations are consistent with the monitoring recommendations in Appendix A of the BCWMC 2015-2025 Watershed Management Plan

http://www.bassettcreekwmo.org/application/files/3114/4676/8825/BCWMC_2015_Watershed_Management_Plan_Appendices.pdf.

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Appendix A

Comparison of HBI and ICI with Precipitation Changes

Appendix A

Comparison of HBI and ICI with Precipitation Changes

A comparison of HBI and ICI with precipitation is shown in the graphs that follow. Graphs compare changes in HBI/ICI values with changes in total precipitation from August through October of each sampling year. As shown in Figure 6-1 precipitation during a couple of months prior to and during the month of macroinvertebrate sample collection provided an indication of flow conditions. Under wet climatic conditions, increased precipitation resulted in increased runoff and increased flow. Conversely, under dry climatic conditions, reduced precipitation resulted in decreased runoff and decreased flow.

As shown in Figure A-1, Plymouth Creek data indicate a poor correlation between precipitation and HBI. Increased precipitation has sometimes been correlated with decreases in HBI (2006 and 2009) and sometimes with an increase (2015). Similarly, decreased precipitation has sometimes been correlated with an increase in HBI (2003) and sometimes with decreases (1995, 2000, and 2012).

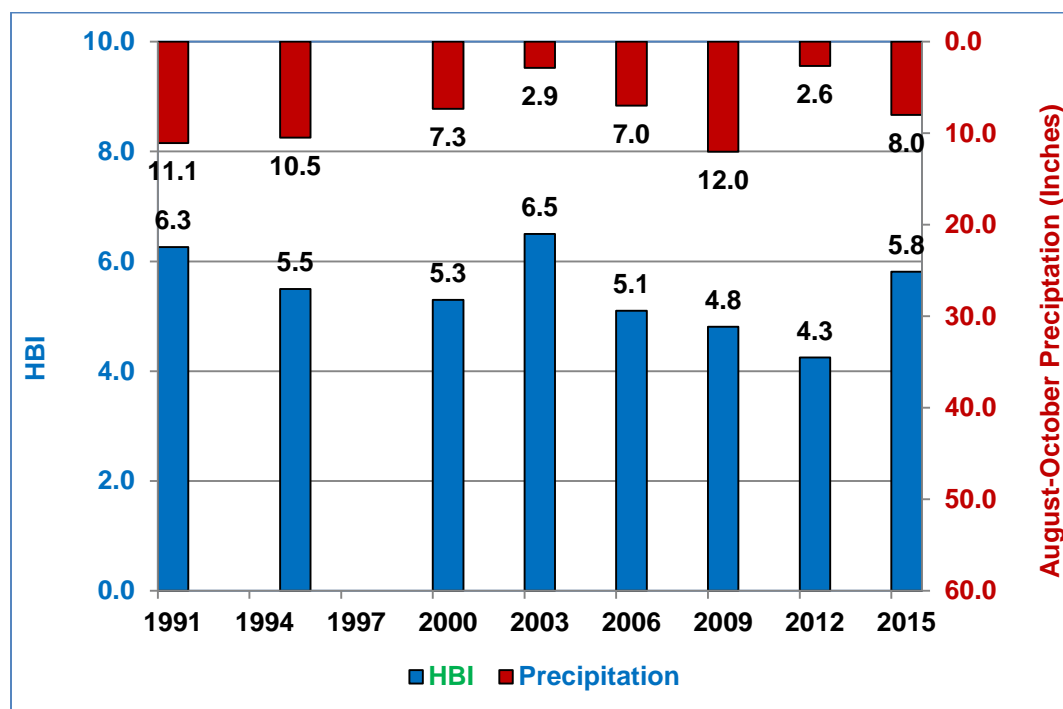


Figure A-1 Plymouth Creek at Industrial Boulevard: Comparison of HBI and Precipitation (August through October) from 1991–2015 shows poor correlation between HBI and precipitation.

As shown in Figure A-2, Plymouth Creek data indicate that increased precipitation has generally been correlated with increased ICI (better water quality), while decreased precipitation has generally been correlated with decreased ICI (poorer quality). An exception occurred in 2009 when increased precipitation resulted in a decrease in ICI. Overall, the data indicate increased precipitation has generally been correlated with improved quality of the invertebrate community at this location, indicating improved water quality. The correlation between increased precipitation and improved water quality may be related to the impact of groundwater on stream chloride concentrations. It has been hypothesized that chlorides added to surficial

groundwater during snowmelt runoff increase groundwater chloride concentrations. Consequently, groundwater added to streams increases stream chloride concentrations, especially during periods of low flow when groundwater impacts are greatest. Increased runoff to Plymouth Creek during summer may dilute chlorides added to the stream from groundwater, thereby improving stream water quality during periods of increased precipitation.

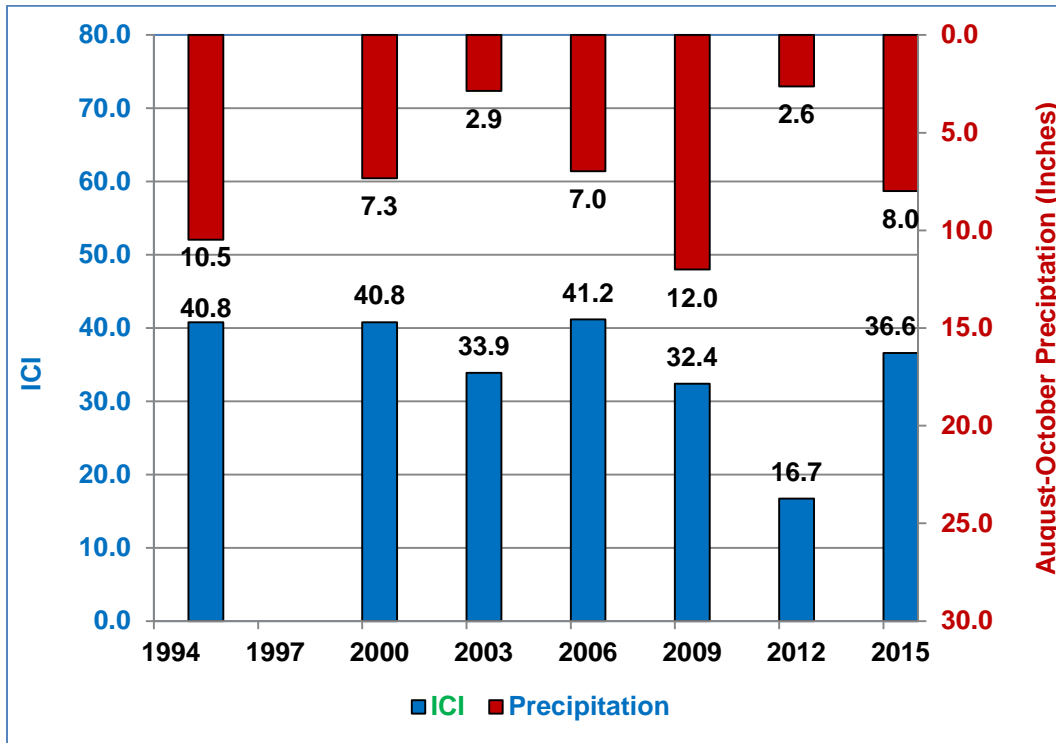


Figure A-1 Plymouth Creek at Industrial Boulevard: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows increased precipitation has generally been correlated with increased ICI (improved water quality).

Figure A-3 shows a general correlation between precipitation and HBI values from the Sweeney Lake Branch of Bassett Creek since 2003. During this period of time, precipitation has generally increased, correlating with increases in HBI values. When precipitation declined in 2012, HBI also declined.

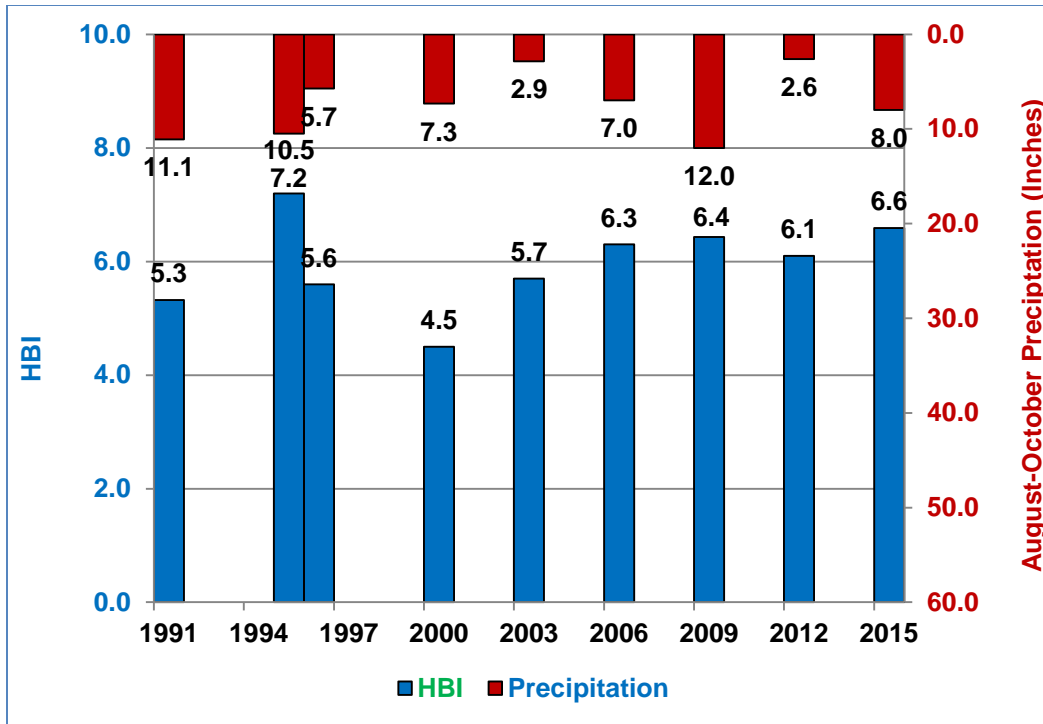


Figure A-2 Sweeney Lake Branch of Bassett Creek at Turner’s Crossroad/Woodstock Avenue: Comparison of HBI and Precipitation (August through October) from 1980–2015 shows precipitation has generally increased, correlating with increased HBI values (reduced oxygen).

Figure A-4 shows that the correlation between precipitation and ICI values from the Sweeney Lake Branch of Bassett Creek is poor. Increased precipitation was sometimes correlated with decreases in ICI (2000, 2006, and 2009) and sometimes with an increase (2015). Similarly, decreased precipitation was sometimes correlated with increases in ICI (1996 and 2003) and sometimes with a decrease (2012).

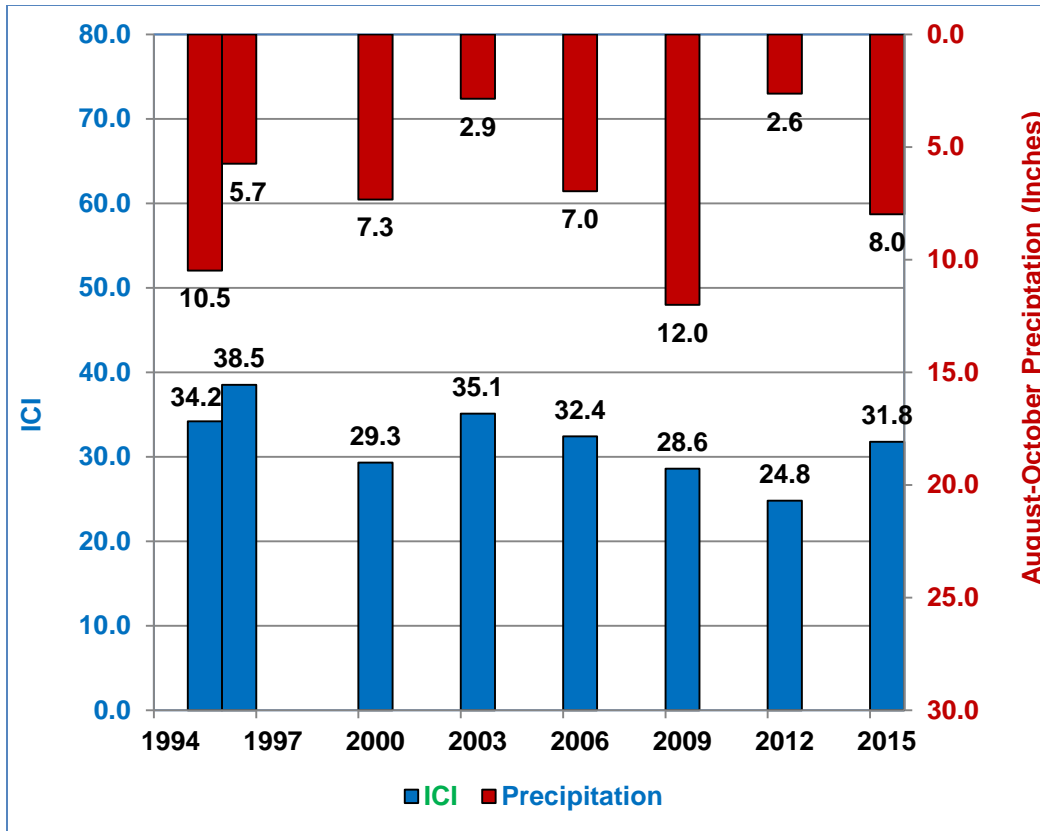


Figure A-3 Sweeney Lake Branch of Bassett Creek at Turner’s Crossroad/Woodstock Avenue: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows poor correlation between ICI and precipitation.

Figure A-5 shows a poor correlation between precipitation and HBI values from the North Branch of Bassett Creek. Increased precipitation has sometimes been correlated with a decrease in HBI (1991) and sometimes with increases (1983, 2006, and 2009). Similarly, decreased precipitation has sometimes been correlated with increases in HBI (1995, 2003, and 2008) and sometimes with decreases (2000 and 2015).

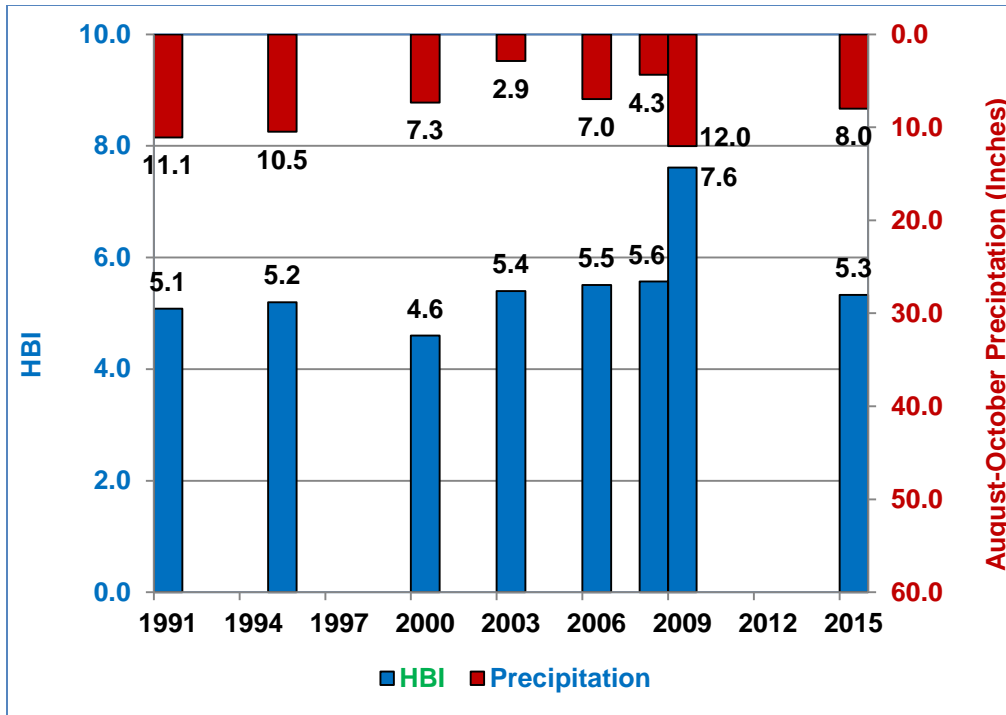


Figure A-4 North Branch of Bassett Creek: Comparison of HBI and Precipitation (August through October) from 1980–2015 shows poor correlation between HBI and precipitation.

Figure A-6 shows that the correlation between precipitation and ICI values from the North Branch of Bassett Creek is poor. Increased precipitation was sometimes correlated with decreases in ICI (1983, 2006, and 2008) and sometimes with an increase (1991). Similarly, decreased precipitation was sometimes correlated with increases in ICI (1995, 2003, and 2008) and sometimes with decreases (2000 and 2012).

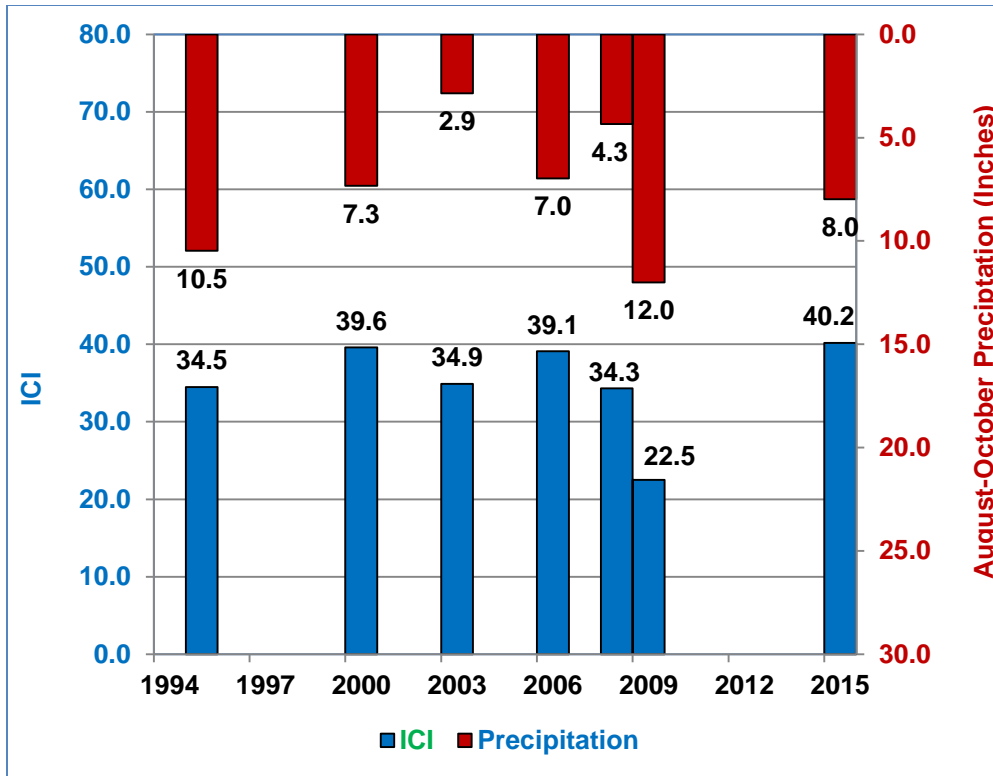


Figure A-5 North Branch of Bassett Creek: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows poor correlation between ICI and precipitation.

Figure A-7 shows a poor correlation between precipitation and HBI values from the Main Stem of Bassett Creek at Rhode Island Avenue. Increased precipitation has sometimes been correlated with decreases in HBI (1991 and 2006) and sometimes with increases (1983 and 2015). Similarly, decreased precipitation has sometimes been correlated with increases in HBI (2000, 2003, and 2008) and sometimes with a decrease (1995).

Figure A-8 shows a poor correlation between precipitation and ICI values from the Main Stem of Bassett Creek at Rhode Island Avenue. Increased precipitation was sometimes correlated with a decrease in ICI (2006) and sometimes with an increase (2015). Similarly, decreased precipitation was sometimes correlated with an increase in ICI (2000) and sometimes with decreases (2003, 2008, and 2012).

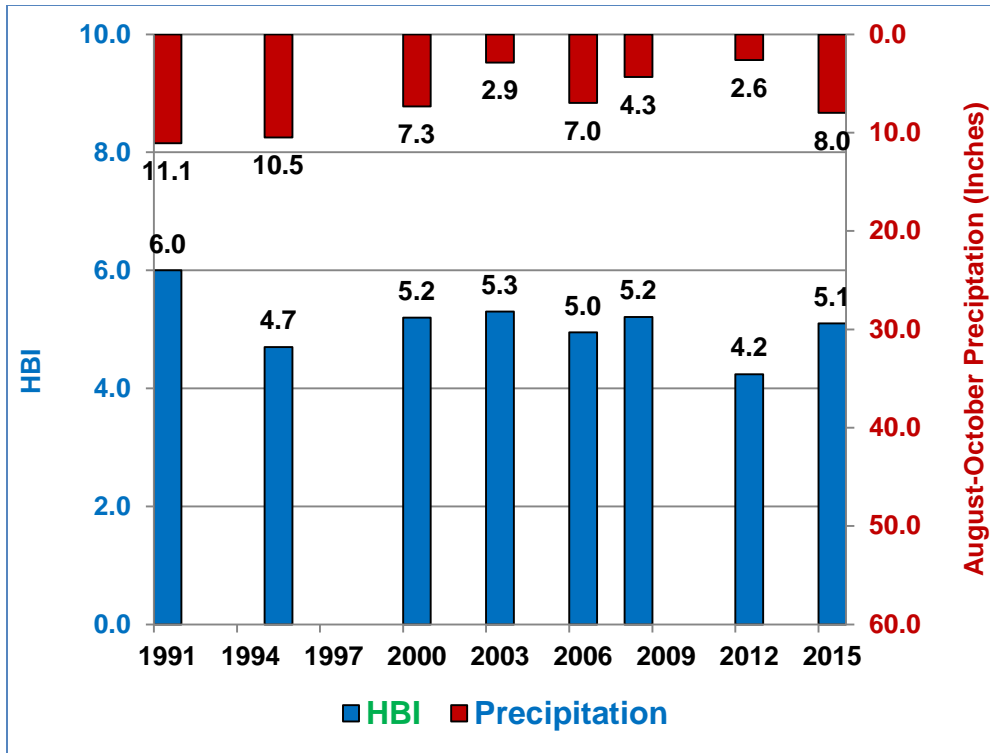


Figure A-6 Main Stem of Bassett Creek at Rhode Island Avenue: Comparison of HBI and Precipitation (August through October) from 1980–2015 shows poor correlation between HBI and precipitation.

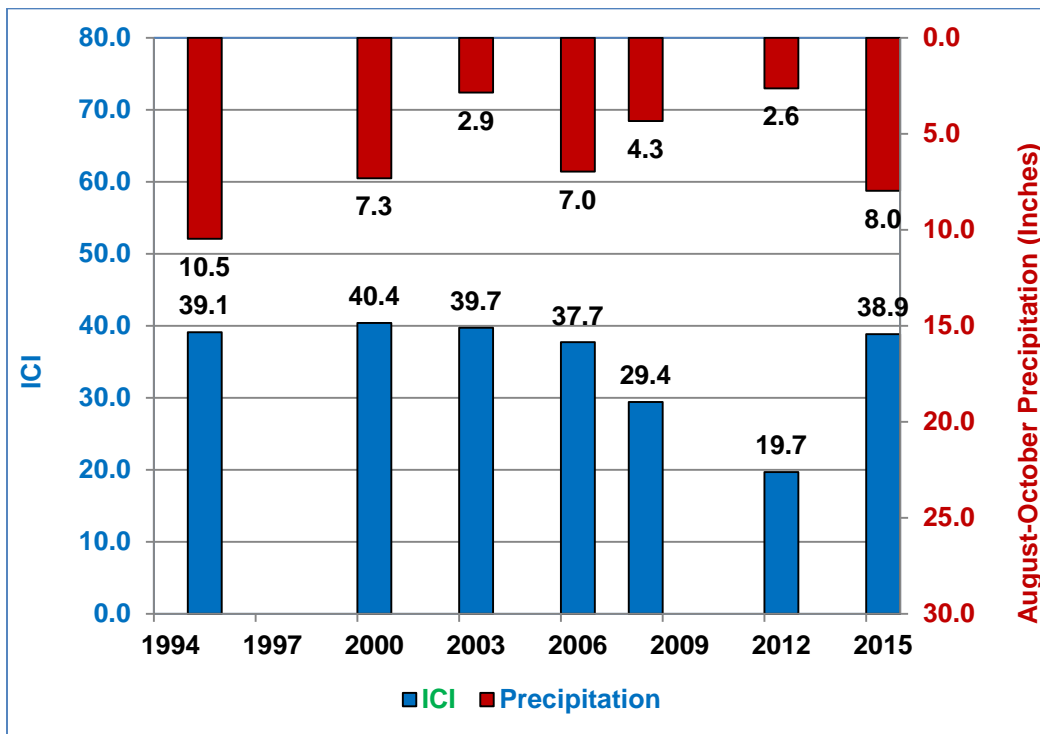


Figure A-7 Main Stem of Bassett Creek at Rhode Island Avenue: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows poor correlation between ICI and precipitation.

Figure A-9 shows a poor correlation between precipitation and HBI values from the Main Stem of Bassett Creek East of Brookridge Avenue. Increased precipitation has sometimes been correlated with decreases in HBI (1991 and 2006) and sometimes with increases (1983, 2000, and 2015). Similarly, decreased precipitation has sometimes been correlated with an increase in HBI (1995), sometimes with a decrease (1995), and sometimes with no change (2003).

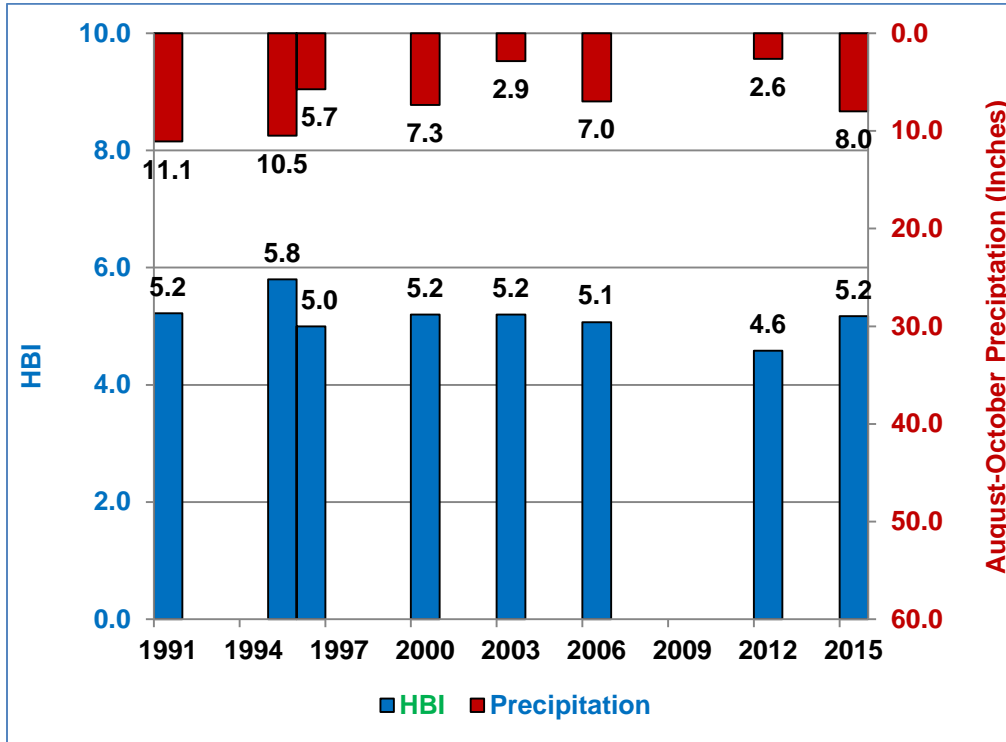


Figure A-8 Main Stem of Bassett Creek East of Brookridge Avenue: Comparison of HBI and Precipitation (August through October) from 1980–2015 shows poor correlation between HBI and precipitation.

Figure A-10 shows a poor correlation between precipitation and ICI values from the Main Stem of Bassett Creek East of Brookridge. Increased precipitation was sometimes correlated with a decrease in ICI (2000) and sometimes with increases (2006 and 2015). Similarly, decreased precipitation was sometimes correlated with an increase in ICI (1996) and sometimes with decreases (2003 and 2012).

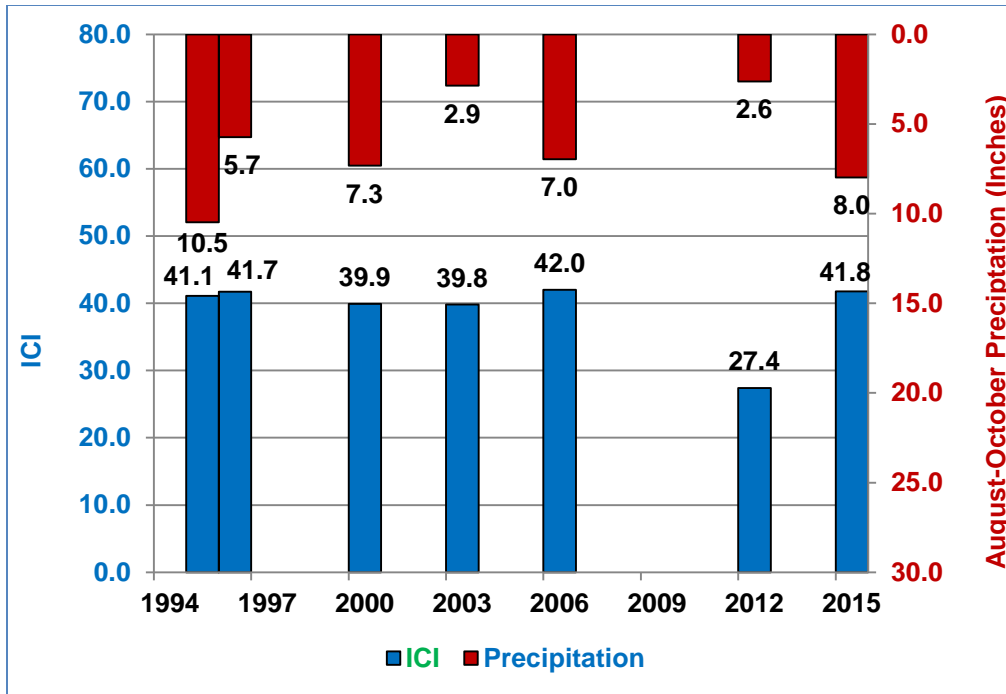


Figure A-9 Main Stem of Bassett Creek East of Brookridge Avenue: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows poor correlation between ICI and precipitation.

Figure A-11 shows a poor correlation between precipitation and HBI values from the Main Stem of Bassett Creek at Dupont/Irving Avenue. Increased precipitation has sometimes been correlated with decreases in HBI (2006 and 2015) and sometimes with an increase (1983). Similarly, decreased precipitation has sometimes been correlated with increases in HBI (2000 and 2012), sometimes with decreases (1995, 2003, and 2008), and sometimes with no change (1991).

Figure A-12 shows a poor correlation between precipitation and ICI values from the Main Stem of Bassett Creek at Dupont/Irving Avenue. Though increased precipitation has been correlated with increases in ICI (2006 and 2015), decreased precipitation has also been correlated with increases in ICI (2000 and 2008) and sometimes with decreases (2003 and 2012).

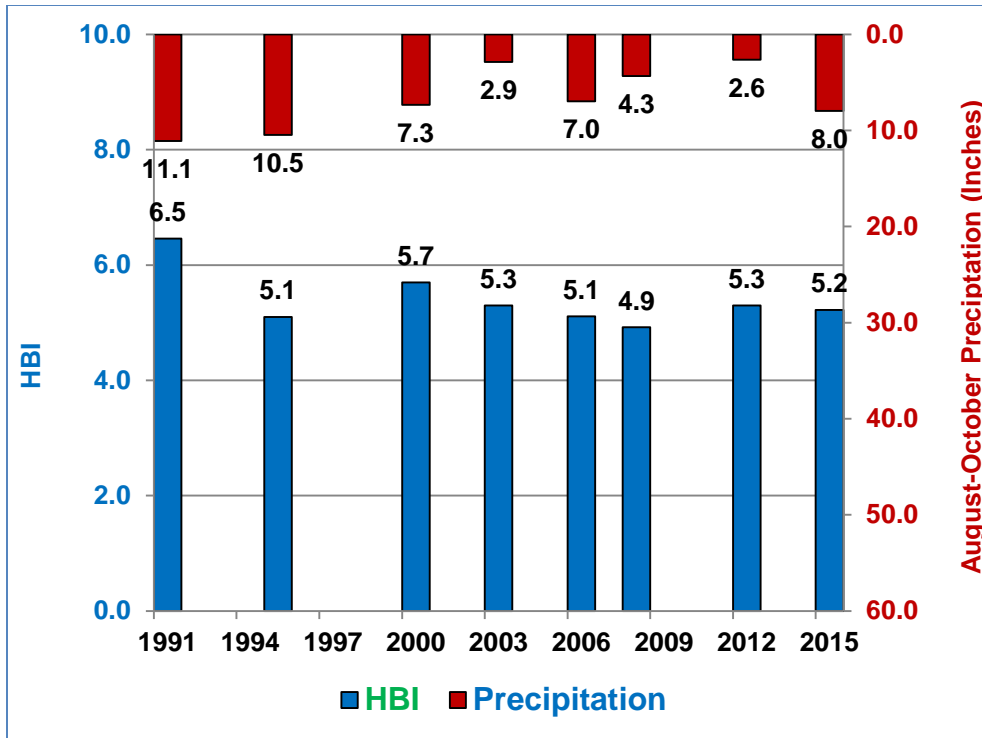


Figure A-10 Main Stem of Bassett Creek at Dupont/Irving Avenue: Comparison of HBI and Precipitation (August through October) from 1980–2015 shows poor correlation between HBI and precipitation.

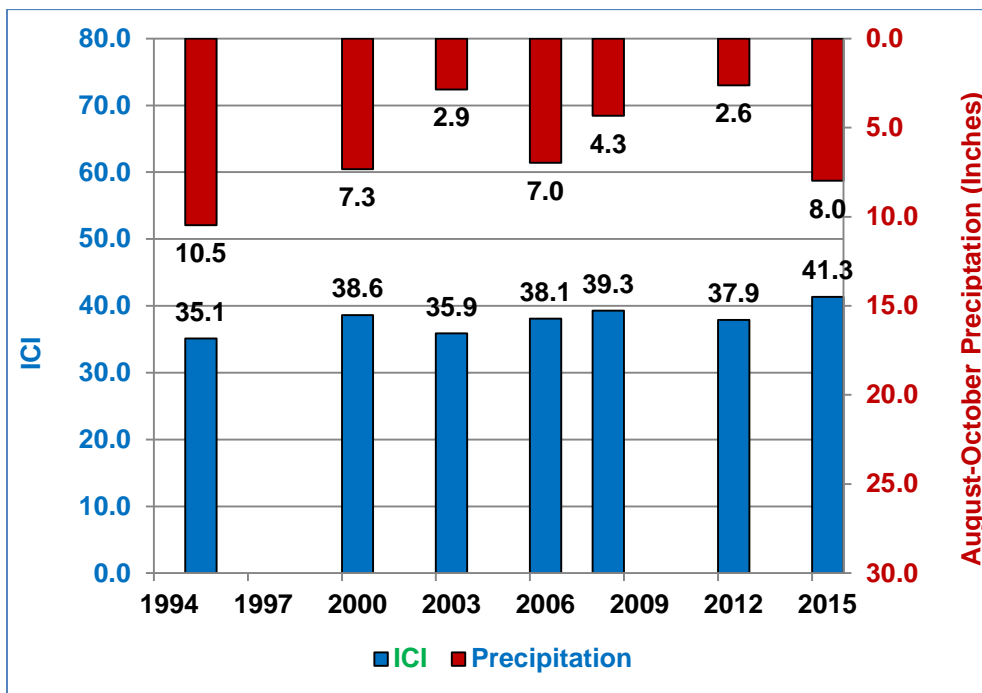


Figure A-11 Main Stem of Bassett Creek at Dupont/Irving: Comparison of ICI and Precipitation (August through October) from 1995–2015 shows poor correlation between ICI and precipitation.

Appendix B

M-IBI

Appendix B

M-IBI

While the composite M-IBI determines whether a stream meets the MPCA standard, it is also possible to deconstruct the index into its component metrics to determine which aspects of ecological structure and function are particularly robust or diminished (MPCA 2014). The M-IBI metrics give an indication of stressor-response relationships (the relationship between the magnitude, frequency, or duration of a stressor and the magnitude of response). These may provide information to help identify stressors that have diminished the integrity of the macroinvertebrate community in a stream. The M-IBI is comprised of 10 individual metrics. Table B-1 describes each metric and indicates whether degraded water quality and/or habitat cause an increase or decrease in the metric score. The metric names, selected by the MPCA, are abbreviations of the descriptions shown in Table B-1.

Table B-1 Descriptions of Biological Metrics used to Generate M-IBI Scores for Plymouth and Bassett Creeks

Metric Name	Category	Response to Degradation	Metric Description
ClimberCh	Habitat	Decrease	Taxa richness of climbers (number of climber taxa)
ClingerChTxPct	Habitat	Decrease	Relative percentage of taxa adapted to cling to substrate in swift-flowing water
DomFiveChPct	Composition	Increase	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
HBI_MN	Tolerance	Increase	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart
InsectTxPct	Composition	Decrease	Relative percentage of insect taxa
Odonata	Richness	Decrease	Taxa richness of Odonata (number of Odonata taxa)
Plecoptera	Richness	Decrease	Taxa richness of Plecoptera (number of Plecoptera taxa)
Predator	Trophic	Decrease	Taxa richness of predators (number of predator taxa)
Tolerant2ChTxPct	Tolerance	Increase	Relative percentage of taxa with tolerance values equal to or greater than 6, using Minnesota tolerance values (TVs)
Trichoptera	Richness	Decrease	Taxa richness of Trichoptera (number of Trichoptera taxa)

Each M-IBI metric has a scale of 0 to 10; the lowest possible score is 0 and the highest is 10. To compute the M-IBI score, the score from each of the 10 individual metrics shown in Table B-2 is summed. Because 10 metrics are used in the M-IBI, the maximum possible M-IBI 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. As indicated, the threshold for Bassett and Plymouth Creek is at least 37—an average score of 3.7 for each of the 10 metrics.

Table B-2 shows the individual biological metric scores for Plymouth and Bassett Creeks and compares them with the average metric score (3.7) required to meet the MPCA standard. Individual metric scores that are

equal to or greater than 3.7 are shown in black. Scores that are less than 3.7 are shown in red. The total M-IBI score for the Sweeney Branch at Woodstock Avenue, which exceeds the impairment threshold, is shown in black. The other total scores do not meet the impairment standard and are shown in red.

Table B-2 Individual Biological Metric Scores used to Generate M IBI Scores for Plymouth and Bassett Creeks, Compared with Average Score (3.7) required to Attain MPCA Standard of 37

Metric Name	Plymouth Creek at Industrial Blvd.	Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	North Branch of Bassett Creek at 34 th Ave.	Main Stem of Bassett Creek at Rhode Island Ave.	Main Stem of Bassett Creek East of Brookridge Ave.	Main Stem of Bassett Creek at Irving Ave.	Average Score Required to Attain MPCA Standard
<i>ClimberCh</i>	2.5	8.9	5.7	1.4	0	0	3.7
<i>ClingerChTxPct</i>	3.6	0.6	3.9	3.9	9.2	10	3.7
<i>DomFiveChPct</i>	0	6.1	0	0	0	0	3.7
<i>HBI_MN</i>	3.9	1	3.8	2.4	1.6	1.5	3.7
<i>InsectTxPct</i>	0	0	0	0	1	0	3.7
<i>Odonata</i>	3.9	9	6.1	0	0	3.9	3.7
<i>Plecoptera</i>	0	0	0	0	0	0	3.7
<i>Predator</i>	0.8	8.5	3.8	0	0	0	3.7
<i>Tolerant2ChTxPct</i>	3.7	4.3	4.4	5.1	5.3	3.2	3.7
<i>Trichoptera</i>	0	1	2	0	0	0	3.7
Total M-IBI Score	18.3	39.2	29.7	12.7	17.1	18.6	37

B.1 Number of Climber Taxa (ClimberCh)

The metric ClimberCh assesses the number of climber taxa (genus/species) in a stream. 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 found at a sample location. 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.

Table B-3 shows the number of climber taxa observed in Plymouth and Bassett Creeks during 2015, the corresponding M-IBI scores, the average score (3.7) required to meet the MPCA standard, and the types and quantity of climber habitat observed at each sample location. The number of climber taxa observed and corresponding M-IBI scores were closely associated with the quantity of climber habitat. Higher numbers of climber taxa were found in stream reaches that contained more suitable climbing habitat, such as overhanging vegetation and woody debris. The two locations with the highest scores for number of climber taxa had the highest percentages of climber-suitable habitat; the two locations with the lowest number of climber taxa had the lowest percentages of climber-suitable habitat. Of the six sample locations, two locations attained a score higher than the 3.7 average required to attain the MPCA standard—Sweeney Lake

Branch of Bassett Creek at Woodstock Avenue and the North Branch of Bassett Creek at 34th Avenue. Nearly 20 percent of the Sweeney Lake Branch of Bassett Creek contained climber habitat (filamentous or attached algae, overhanging vegetation, and/or woody debris) and 11 climber taxa were observed. More than 30 percent of the North Branch of Bassett Creek sample location contained climber habitat (filamentous or attached algae) and 8 climber taxa were observed.

Table B-3 2015 Number of Climber Taxa and Corresponding M IBI Score

Sample Location	Habitat Suitable for Climbing (% of Length of Transect)	Number of Climber Taxa (Increasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	Algae (12)	5	2.5	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	Algae (2), Overhanging Vegetation (5), Woody Debris (12)	11	8.9	3.7
North Branch of Bassett Creek at 34 th Ave.	Algae (31)	8	5.7	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	Woody Debris (3)	4	1.4	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	Algae (8)	1	0	3.7
Main Stem of Bassett Creek at Irving Ave.	Submerged Macrophytes (0.4%)	1	0	3.7

B.2 Relative Percentage of Clinger Taxa (ClingerChTxPct)

The number of macroinvertebrates in the “clinger” group can provide an indication of how flow regimes and hydrologic conditions may be impacting macroinvertebrates in a stream. The “clinger” group is best suited for high-flow or “flashy” environments, with physiological and morphological adaptations which allow them to attach to fixed, coarse substrates (gravel, cobble, or boulders) and avoid being carried downstream. Clingers maintain a relatively fixed position on firm substrates in current. The ClingerChTxPct is the relative percentage of taxa adapted to cling to substrates in swift flowing water.

Clingers need a clean substrate to hang on to. Sediment deposited on the substrate makes it difficult for them to attach firmly and avoid being carried downstream by the current. For this reason, clingers would not be expected to thrive in streams with high quantities of sediment. Hence, a relatively high percentage of clinger taxa in a stream indicate a low quantity of sediment.

Table B-4 shows the relative percentage of clinger taxa documented in Plymouth and Bassett Creeks in 2015, the corresponding M-IBI score, and the average depth of fine sediment. The ClingerChTxPct scores at four locations exceeded the average score required to meet the MPCA standard—the North Branch of Bassett Creek location and all three Main Stem of Bassett Creek locations. From 30 to 50 percent of the macroinvertebrate taxa (genus/species) were clingers at the Main Stem of Bassett Creek locations and 30

percent of the macroinvertebrate taxa were clingers at the North Branch of Bassett Creek location. M-IBI scores consistently increased from upstream to downstream locations of the Main Stem of Bassett Creek.

The relatively high clinger M-IBI scores corresponded with low quantities of fine sediment in the stream reaches. As shown in Table 8-5, the four locations with M-IBI scores greater than 3.7 had average fine-sediment depths of 0 to 2 centimeters (0 to 0.8 inches).

The Plymouth Creek score of 3.6 was very close to the average M-IBI score required to meet the M-IBI threshold (3.7). The relative percentage of clinger taxa at the Plymouth Creek sampling location was 29 percent along with very low quantities of fine sediment (1 cm depth or 0.4 inches).

The Sweeney Lake Branch had the lowest relative percentage of clinger taxa (21 percent) and a very low M-IBI score (0.6). Although some coarse substrate was observed, the primary substrates in the stream reach were sand, silt, and clay. Relatively high quantities of fine sediment were present (average depth of 16 centimeters, or 6 inches), making it difficult for clingers to attach themselves to the substrate.

Table B 4 2015 Relative Percentage of Clinger Taxa and Corresponding M IBI Score

Sample Location	Average Depth of Fine Sediment (cm)	Relative Percentage of Clinger Taxa (Increasing is Improving)	M-IBI Score (1-10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	1	29	3.6	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	15	21	0.6	3.7
North Branch of Bassett Creek at 34 th Ave.	1	30	3.9	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	2	30	3.9	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	0	44	9.2	3.7
Main Stem of Bassett Creek at Irving Ave.	2	50	10.0	3.7

B.3 Relative Abundance of Dominant Five Taxa (DomFiveChPct)

Healthy and stable streams are characterized by a greater diversity and more even distribution of organisms among taxa rather than dominance by a few taxa. The DomFiveChPct uses the percentage of the macroinvertebrate community comprised by the dominant five taxa to assess stream health. For this metric, a higher percentage indicates a less even distribution among taxa and is indicative of stream degradation. Conversely, a lower percentage indicates a more even distribution among taxa and is indicative of a healthier stream.

Table B-5 shows the percent of the macroinvertebrate community comprised by the dominant five taxa and the corresponding M-IBI score. For this metric, the Sweeney Lake Branch was the only location in which the

dominant five taxa comprised less than 60 percent of the macroinvertebrate community (54 percent) and the only location to attain an M-IBI score above 0. The M-IBI score for the Sweeney Lake Branch also surpassed the average score required to attain the MPCA standard.

Table B-5 2015 DomFiveChPct and Corresponding M IBI Score

Sample Location	Percent of Macroinvertebrate Community Comprised by Dominant Five Taxa (Decreasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 3.7
Plymouth Creek at Industrial Blvd.	95	0	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	54	6.1	3.7
North Branch of Bassett Creek at 34 th Ave.	82	0	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	79	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	87	0	3.7
Main Stem of Bassett Creek at Irving Ave.	89	0	3.7

B.4 HBI_MN

Sufficient and relatively stable dissolved-oxygen concentrations are required for aerobic life to thrive. To determine whether average long-term dissolved-oxygen concentrations fully support the aerobic biological community, the HBI_MN metric was evaluated. The HBI_MN, developed by the MPCA, is a measure of pollution, based on tolerance values assigned to each individual taxon. To produce an overall HBI_MN value for a stream reach, the average of the HBI_MN tolerance values for individual organisms are weighted by organism abundance in the stream. HBI_MN is a modification of the HBI. The HBI_MN tolerance values indicate the species' ability to survive in low-oxygen conditions. For this index, lower tolerance values indicate a lower tolerance to low dissolved-oxygen concentrations and better water quality. Conversely, higher tolerance values indicate a higher tolerance to low dissolved-oxygen values and poorer water quality.

Table B-6 shows the HBI_MN values and the corresponding M-IBI scores for Bassett and Plymouth Creek locations. The M-IBI score at Plymouth Creek (3.9) and the North Branch of Bassett Creek (3.8) exceeded the average score required to attain the MPCA standard (3.7). The HBI_MN values for these locations were 7.01 and 7.06, respectively—lower (better) than the state average of 7.5 (Table 8-7). This indicates better-than-average oxygen conditions.

The HBI_MN score for the Main Stem of Bassett Creek at Rhode Island Avenue was 7.53, very close to the state average (7.5). The remaining 3 locations had HBI_MN scores higher (poorer) than the state average (7.8 to 8), indicating below-average oxygen conditions.

The HBI_MN values for the Main Stem of Bassett Creek increased upstream to downstream—from 7.53 at Rhode Island Avenue, to 7.80 east of Brookridge Avenue, to 7.83 at Irving Avenue. This indicates that organic pollution from stormwater runoff increases going downstream, resulting in poorer oxygen conditions. Corresponding M-IBI values also declined upstream to downstream (2.4 at Rhode Island Avenue, 1.6 east of Brookridge Avenue, 1.5 at Irving Avenue).

Of the six locations sampled, the Sweeney Lake Branch had the highest HBI_MN value (8.01) and the lowest corresponding M-IBI value (1.0), indicating that oxygen conditions are poorest at this location. Another indication of poor oxygen conditions is the greater depth of fine sediment at this location (Section 8.2). This suggests greater organic pollution. Because bacteria use up oxygen as they decompose this organic material, oxygen concentrations are lowered.

Dissolved oxygen was measured when macroinvertebrate samples were collected in October. As water temperatures decrease and oxygen becomes more soluble, the concentration of oxygen in the water increases. As expected, fall water temperatures were cool (11.7 to 13.5° C) and oxygen concentrations fully supported the macroinvertebrate community (concentrations of 7.3 to 12.4 mg/L were greater than the MPCA standard of at least 5 mg/L). Plymouth Creek had the highest dissolved oxygen concentration (12.4 mg/L) and the best (lowest) HBI_MN value (7.01). The North Branch of Bassett Creek had the second-highest oxygen concentration (11.2 mg/L) and the second-best (lowest) HBI_MN value (7.06).

Table B-6 2015 HBI_MN and Corresponding M IBI Score

Sample Location	HBI-MN (1–10, Decreasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 3.7
Plymouth Creek at Industrial Blvd.	7.01	3.9	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	8.01	1.0	3.7
North Branch of Bassett Creek at 34 th Ave.	7.06	3.8	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	7.53	2.4	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	7.80	1.6	3.7
Main Stem of Bassett Creek at Irving Ave.	7.83	1.5	3.7

HBI_MN Average: All Minnesota Stations, M-IBI class: *Southern Forest Streams (Riffle/Run Habitats)* = 7.5

B.5 Relative Percentage of Insect Taxa (InsectTxPct)

Insects play an important role in the macroinvertebrate community and a healthy community is characterized by a high relative percentage of insect taxa. Table B-7 shows the relative percentage of insect taxa documented in Plymouth and Bassett Creeks in 2015 and the corresponding M-IBI score. None of the sample locations attained the average score required to attain the MPCA standard (3.7). The relative percentage of insect taxa observed at Bassett Creek east of Brookridge Avenue was 75 percent, corresponding to an M-IBI

score of 1. The relative percentage of insect taxa at the other five locations ranged from 50 to 71 percent, corresponding to an M-IBI score of 0. The data document the low percentages of insect taxa in Plymouth and Bassett Creeks.

Table B-7 2015 Relative Percentage of Insect Taxa and Corresponding M IBI Score

Sample Location	Relative Percentage of Insect Taxa (Increasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 3.7
Plymouth Creek at Industrial Blvd.	65	0	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	71	0	3.7
North Branch of Bassett Creek at 34 th Ave.	63	0	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	50	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	75	1	3.7
Main Stem of Bassett Creek at Irving Ave.	71	0	3.7

B.6 Number of Odonata (Dragonflies/Damselflies) Taxa (Odonata)

Odonata, or dragon and damselflies, are a diverse group of organisms that display a wide array of sensitivities and life histories. They exploit most aquatic microhabitats, and their diversity is considered a good indicator of aquatic health (Chirhart 2003 as cited by MPCA 2011).

Table B-8 shows the number of Odonata taxa documented in Plymouth and Bassett Creeks in 2015 and the corresponding M-IBI score. Four of the six sample locations had M-IBI scores that exceeded the average M-IBI score required to attain the MPCA standard (3.7). Sweeney Lake at Woodstock Avenue had the highest number of Odonata taxa (four) and an M-IBI score of 9.0. The North Branch of Bassett Creek had the second-highest number of Odonata taxa (two) and an M-IBI score of 6.1. Plymouth Creek and the Main Stem of Bassett Creek at Irving Avenue each had one Odonata taxon and an M-IBI score of 3.9. Odonata were not observed in the Main Stem of Bassett Creek at Rhode Island Avenue or east of Brookridge Avenue.

Table B-8 2015 Number of Odonata Taxa and Corresponding M IBI Score

Sample Location	# of Odonata Taxa (Increasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	1	3.9	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	4	9.0	3.7
North Branch of Bassett Creek at 34 th Ave.	2	6.1	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	0	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	0	0	3.7
Main Stem of Bassett Creek at Irving Ave.	1	3.9	3.7

B.7 Number of Plecoptera (Stonefly) Taxa (Plecoptera)

Plecoptera is considered to be among the most sensitive to pollution and require high dissolved-oxygen concentrations to breathe. Because they also require high-quality substrate (boulder/cobble/gravel), channel modification or high sedimentation rates can negatively impact these organisms (Harper 1979). Plecoptera were not observed in Plymouth or Bassett Creek in 2015. All locations received an M-IBI score of 0 (Table B-9).

Table B-9 2015 Taxa Richness of Plecoptera and Corresponding M IBI Score

Sample Location	# of Plecoptera Taxa (Increasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	0	0	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	0	0	3.7
North Branch of Bassett Creek at 34 th Ave.	0	0	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	0	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	0	0	3.7
Main Stem of Bassett Creek at Irving Ave.	0	0	3.7

B.8 Number of Predator Taxa (Predator)

Predators, such as dragonflies and damselflies, feed on living animals (e.g., insects). Water quality or habitat degradation reduces the number of predator taxa. Table B-10 shows the number of predator taxa (species) documented in Plymouth and Bassett Creeks in 2015 and the corresponding M-IBI score. The Sweeney Lake Branch of Bassett Creek and the North Branch of Bassett Creek exceeded the average M-IBI score required to

attain the MPCA standard (3.7). Fourteen predator taxa were found at the Sweeney Lake Branch of Bassett Creek, which had an M-IBI score of 8.5. Eight predator taxa were found in the North Branch of Bassett Creek, which had an M-IBI score of 3.8. Plymouth Creek had four taxa and an M-IBI score of 0.8. The three other Bassett Creek locations (the Main Stem of Bassett Creek at Rhode Island Avenue, east of Brookridge Avenue, and Irving Avenue) had from 0 to 3 predator taxa; all were assigned an M-IBI score of 0.

Table B-10 2015 Taxa Richness of Predators and Corresponding M IBI Score

Sample Location	# of Predator Taxa (Increasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 3.7
Plymouth Creek at Industrial Blvd.	4	0.8	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	14	8.5	3.7
North Branch of Bassett Creek at 34 th Ave.	8	3.8	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	3	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	2	0	3.7
Main Stem of Bassett Creek at Irving Ave.	0	0	3.7

B.9 Relative Percentage of Taxa with Tolerance Values Equal to or Greater Than 6 (Tolerant2ChTxPct)

The MPCA has developed tolerance values (TVs) for macroinvertebrate taxa collected in Minnesota (MN TVs). Increasing TVs indicate 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.

Table B-11 shows the relative percentage of taxa with TVs greater than or equal to 6 in Plymouth and Bassett Creeks during 2015 and the corresponding M-IBI score. For this metric, decreasing percentages of tolerant taxa indicate improvement. All locations except the Main Stem of Bassett Creek at Irving Avenue had low enough percentages of tolerant organisms to attain or exceed the MPCA standard score required to attain the MPCA standard (3.7). The relative percentage of taxa with TVs greater than or equal to 6 at the Main Stem of Bassett Creek at Irving Avenue was 79 percent and the corresponding M-IBI score was 3.2. Relative percentages of taxa with TVs greater than or equal to 6 at the other five locations ranged from 69 to 76 percent, with corresponding M-IBI scores from 3.7 (Plymouth Creek) to 5.3 (the Main Stem of Bassett Creek east of Brookridge Avenue). The data indicates stream degradation occurred between the Main Stem of Bassett Creek east of Brookridge Avenue and Irving Avenue locations. The relative percent of tolerant macroinvertebrates increases by 10 percent between these locations and the M-IBI decreases from 5.3 at the Main Stem of Bassett Creek east of Brookridge Avenue to 3.2 at the Main Stem of Bassett Creek at Irving Avenue.

Table B-11 2015 Relative Percentage of Taxa with TVs > 6 and Corresponding M IBI Score

Sample Location	Relative Percentage of Taxa with TVs ≥ 6 (Decreasing is Improving)	M-IBI Score (1–10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	76	3.7	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	74	4.3	3.7
North Branch of Bassett Creek at 34 th Ave.	73	4.4	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	70	5.1	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	69	5.3	3.7
Main Stem of Bassett Creek at Irving Ave.	79	3.2	3.7

B.10 Number of Trichoptera (Caddisfly) Taxa (Trichoptera)

In general, many families of Trichoptera are sensitive to excess nutrients and excess sedimentation. Trichoptera 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. Taxa richness of Trichoptera declines steadily as humans eliminate the variety and complexity of their stream habitat. The number of Trichoptera taxa was evaluated to determine the health of Plymouth and Bassett Creeks.

Table B-12 shows the number of Trichoptera taxa documented in Plymouth and Bassett Creeks in 2015 and the corresponding M-IBI score. None of the average scores met the M-IBI score required to attain the MPCA standard (3.7). A total of four Trichoptera taxa were observed at the North Branch of Bassett Creek, resulting in an M-IBI score of 2, and three Trichoptera taxa were observed at the Sweeney Lake Branch, resulting in an M-IBI score of 1. The other Bassett Creek locations (the Main Stem of Bassett Creek at Rhode Island Avenue, east of Brookridge Avenue, and Irving Avenue) had two Trichoptera taxa and Plymouth Creek had one; all four of these locations received an M-IBI score of 0.

Table B-12 2015 Taxa Richness of Trichoptera and Corresponding M IBI Score

Sample Location	# of Trichoptera Taxa (Increasing is Improving)	M-IBI Score (1-10, Increasing is Improving)	Average Score Required to Attain MPCA Standard of 37
Plymouth Creek at Industrial Blvd.	1	0	3.7
Sweeney Lake Branch of Bassett Creek at Woodstock Ave.	3	1.0	3.7
North Branch of Bassett Creek at 34 th Ave.	4	2.0	3.7
Main Stem of Bassett Creek at Rhode Island Ave.	2	0	3.7
Main Stem of Bassett Creek East of Brookridge Ave.	2	0	3.7
Main Stem of Bassett Creek at Irving Ave.	2	0	3.7