

2016 Annual Water Quality Report



Prepared for:
Shingle Creek and West Mississippi
Watershed Management Commissions

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(Appendices are available at <http://www.shinglecreek.org/water-quality.html>.)

Executive Summary

The Shingle Creek and West Mississippi Watershed Management Commissions annually monitor water quality in the lakes, streams and outfalls of the watersheds. The Commissions' technical staff obtains the stream and some lake water quality data while volunteers collect most lake water quality and stream and wetland macroinvertebrate and vegetation data.

Water quality in a given year is influenced by the amount of precipitation and the type of precipitation events. Overall, 2016 was an above average precipitation year. The first half of the year was below normal, while the second half was 13.5 inches above normal. This annual variability is why ongoing, long-term monitoring is necessary to determine potential trends in the data and what may be considered natural variability.

Water quality in Shingle Creek and Bass Creek and in the outfalls of the West Mississippi watershed is typical of an urban stream in the Twin Cities metropolitan area, and is dominated by watershed runoff. Both streams are listed as Impaired Waters for chloride, bacteria, biota, and dissolved oxygen. The lakes in Shingle Creek are typical of urban lakes. Thirteen of the 16 lakes are listed as Impaired Waters due to excess nutrients. TMDLs and Implementation Plans have been approved for all the Impaired Waters, and the Commissions and the member cities have been actively implementing improvements.

Trends in water quality are mostly stable, but there are encouraging signs. Three of the lakes are proposed for delisting on the pending 303(d) list of Impaired Waters – Lower Twin Lake, Ryan Lake, and Schmidt Lake – due to improvements to water quality. And water quality in Shingle Creek at the outlet monitoring site in Minneapolis shows an *improvement* – a decreasing trend in total phosphorus (TP) and total suspended solids (TSS). This improvement is likely the result of several factors, including improved erosion control and street sweeping in the watershed; the ban on phosphorus in fertilizer; retrofitting Best Management Practices in the watershed, both as part of redevelopment and as stand-alone projects; and stream stabilization projects reducing bank erosion.

The Shingle Creek Commission recently completed the identification of Directly Connected Untreated Areas that discharge directly to Shingle Creek without any water quality treatment or an intervening lake or wetland. These areas can be targeted for focused BMPs to further reduce pollutants to the stream. Similar areas will be identified tributary to the lakes and to the Mississippi River.

1.0 Introduction

BACKGROUND

Minnesota Administrative Rule 8410.0100 Subp.5 requires watershed management organizations to conduct monitoring programs “capable of producing accurate data to the extent necessary to determine whether the water quality and quantity goals of the organization are being achieved.”

The Shingle Creek and West Mississippi Watershed Management Commissions (WMC) began monitoring water quality and streamflow in 1990. In Shingle Creek, 12 sites were monitored from 1990-1992, however monitoring was discontinued from 1992 – 1995. Shingle Creek has since resumed on an annual basis at two long-term monitoring sites (SC-0 and SC-3) (Figure 1.1). In 2013, a third stream monitoring site was added near the outlet of Bass Creek (BCP). The West Mississippi WMC monitored water quality and streamflow from 1990-1992 at two outfall sites in the Oxbow Creek and Mattson Brook watersheds (Figure 1.1). Results indicated very little flow in these tributaries and no water quality or quantity problems or concerns. Thus, the Commission chose to discontinue monitoring after the 1992 monitoring season. In 2010, the Commission elected to once again monitor water quality and flow at 2-3 outfall monitoring sites per year in the West Mississippi watershed.

Thirteen of the sixteen lakes in Shingle Creek are periodically monitored for water quality by volunteers through the Citizen Assisted Monitoring program (CAMP) (Figure 1.1). Additionally, Wenck staff conducted intensive monitoring on two lakes per year as part of the 5-year TMDL review for these lakes. High school volunteers coordinated by Hennepin County Environmental Services (HCES) performed macroinvertebrate monitoring at various locations in the watersheds (Figure 1.1). HCES also coordinates wetland monitoring by adult volunteers (Figure 1.1).

OBJECTIVES

The Shingle Creek and West Mississippi WMCs have established monitoring objectives to guide their monitoring programs. The following objectives have been established for stream, outfall and lake monitoring in both watersheds:

- ▲ To quantify the current status of streams/outfalls and lakes (Shingle Creek only) throughout the watershed in comparison to state water quality standards established for nutrients, turbidity, chloride, bacteria, and other parameters currently regulated by the State.
- ▲ To quantify changes over time, or trends, in stream and lake water quality in the Shingle Creek and West Mississippi watersheds.
- ▲ To quantify the effectiveness of implemented BMPs throughout the watershed for the protection of water quality.

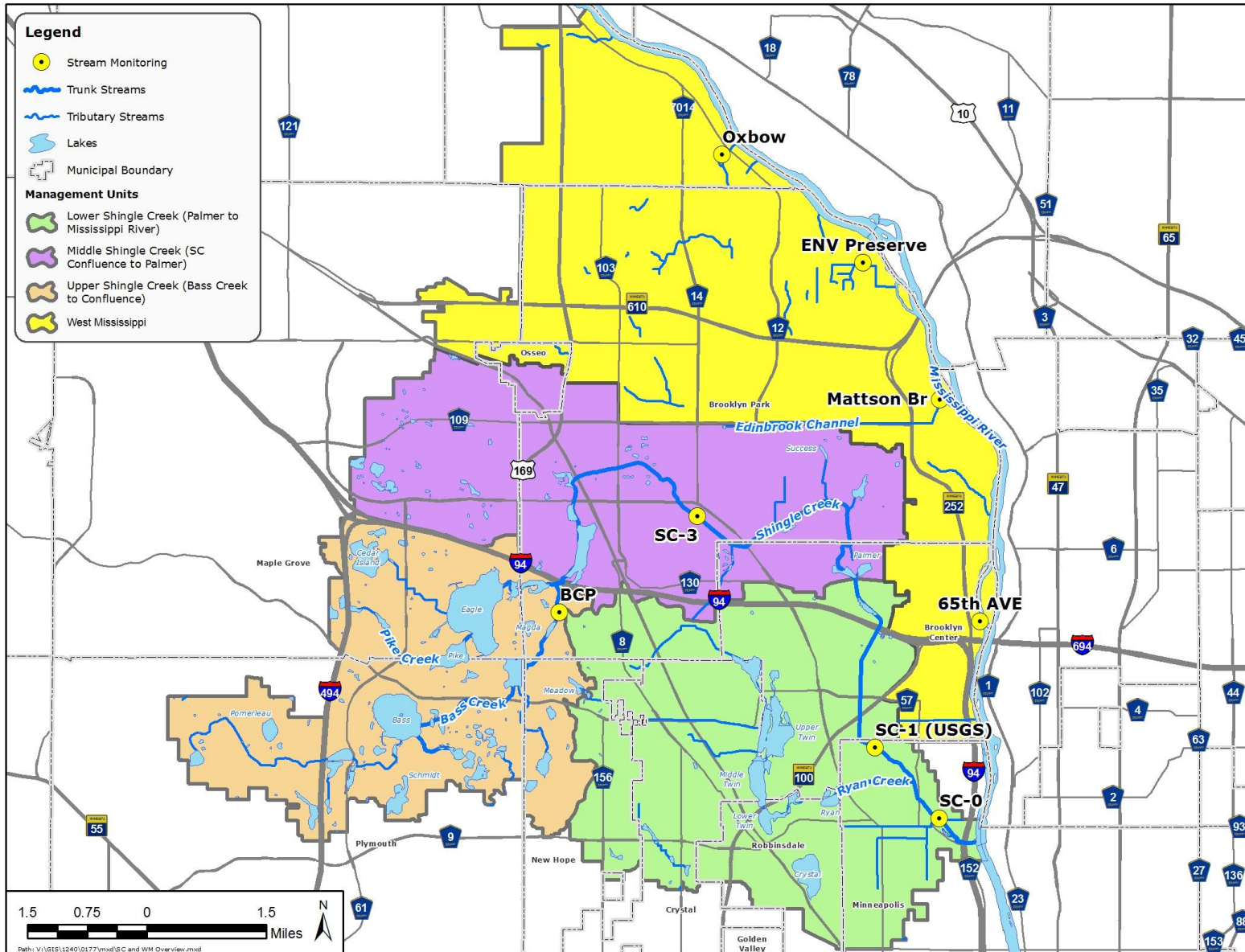


Figure 1-1. Shingle Creek and West Mississippi management units, streams, lakes, and monitoring sites.

TMDLS AND IMPLEMENTATION PLANS

Most of the lakes in the Shingle Creek watershed do not meet state standards for water quality, and are included on the Minnesota Pollution Control Agency (MPCA) 303(d) List of Impaired Waters. The 303(d) list is named after the section of the federal Clean Water Act that requires states to set water quality standards and to assess conditions in lakes, rivers, and streams to determine if those standards are being met. If the standards are not met, a Total Maximum Daily Load (TMDL) study must be completed to identify the course of action needed to restore the resource to meet state standards. Table 1.1 below shows the Impaired Waters in the Shingle Creek watershed. Regional or statewide impairments that affect the watershed are also noted in Table 1.1 and are being sponsored by the MPCA. The Commission has completed TMDLs for the balance of the impairments.

Each TMDL establishes a water quality goal and a pollutant load reduction to achieve that goal. A separate TMDL Implementation Plan sets forth actions that will be undertaken by various stakeholders. Those actions include the continuation and expansion of lake and stream monitoring to assess progress toward the load reductions and water quality goals.

Table 1-1. Impaired Waters in the Shingle Creek watershed.

Water Resource	Impairment	Date TMDL Approved	5-year Review
Bass Lake	Nutrients	9/25/09	2016-2017
Cedar Island Lake	Nutrients	4/14/10	2017-2018
Crystal Lake	Nutrients	3/25/09	Completed 2016
Eagle Lake	Nutrients	4/14/10	2017-2018
Lake Magda	Nutrients	9/30/10	2018
Meadow Lake	Nutrients	3/23/10	2018
Pike Lake	Nutrients	4/14/10	2017-2018
Pomerleau Lake	Nutrients	9/25/09	2016-2017
Ryan Lake	Nutrients	11/9/07	Completed 2014
Schmidt Lake	Nutrients	9/25/09	2016-2017
Upper, Middle, and Lower Twin Lake	Nutrients Mercury in fish PFOS, PCB in fish	11/9/07 3/27/07 (MPCA) Not yet begun (MPCA)	Completed 2014
Shingle Creek	Chloride	2/14/07	Completed 2014
Shingle Creek	Dissolved oxygen	11/4/11	2018-19
Shingle Creek	Biota-macroinvertebrates	11/4/11	2018-19
Shingle Creek	<i>E. coli</i>	11/20/14 (MPCA)	2018-19
Bass Creek	Biota-fish	11/4/11	2018-19
Bass Creek	Chloride	Metro wide TMDL (MPCA)	2018-19

2.0 Overview of 2016 Monitoring Efforts

2016 monitoring activities in the Shingle Creek and West Mississippi Watersheds included stream and outfall monitoring, lake monitoring, macroinvertebrate monitoring, and wetland monitoring. Each of these efforts are described below in more detail.

STREAM AND OUTFALL MONITORING

Continuous flow measurements and water quality samples were collected by the Commissions at six locations in the Shingle Creek and West Mississippi watersheds in 2016. Two of the stations, Environmental Preserve (ENVP) and Mattson Brook (MB), are located in the West Mississippi Management Unit (Figure 1-1). The other stations include Bass Creek Park (BCP), SC-3, and SC-0 and are located in the Upper, Middle, and Lower Shingle Creek Management Units, respectively (Figure 1-1). Additionally, the USGS, in partnership with the Shingle Creek WMC, monitored continuous flow at station SC-1 in the Lower Shingle Creek Management near the outlet of Shingle Creek in 2016. Each monitoring station is described in more detail in Sections 3.0 through 6.0.

Stream stage (water level) was continuously recorded from April through October at all monitoring station in 2016. Stage was converted to flow using site-specific stage-discharge relationships (Appendix B). Routine water quality grab samples were collected one time per month at the West Mississippi sites and two times per month at the Shingle Creek sites. In addition to the water quality grab samples, at least five storm composite samples were collected at each monitoring station in 2016 using automated sampling equipment. Routine and storm samples at each site were analyzed for total suspended solids (TSS), total phosphorus (TP), ortho-P, total Kjeldahl nitrogen (TKN), and chloride. Field parameters including dissolved oxygen (DO), temperature, pH, and conductivity were also recorded during each routine sample site visit.

Overall, rainfall in the Shingle Creek and West Mississippi Watersheds was approximately 10.4 inches above normal in 2016 (Appendix A). During the first half of 2016 (January to June), precipitation was 3.1 inches below normal, while the second half of 2016 (July through December) was 13.5 inches above normal. This pattern resulted in low-flow conditions throughout the watersheds during spring and early summer and then extremely high flow conditions during late summer. In a normal year, we typically see higher flow conditions during spring and early summer followed by low-flow conditions in the late summer and early fall.

As expected, the above average precipitation resulted in above average runoff/flow volumes at all Shingle Creek and West Mississippi monitoring sites in 2016. Despite the high flow conditions, stream pollutant concentrations (TS, TP, ortho-P, TKN, chloride) for all parameters were within the range of the average concentrations measured in previous years. In fact, TP concentrations measured at the SC-0 and SC-3 monitoring stations were the third lowest on record since routine monitoring began in the early 2000's. More detailed results of the 2016 stream and outfall flow and water quality sampling are presented in Appendices A-C. Sections 3.0 through 6.0 of this report provide more in-depth analysis of the impairment status within each management unit along with long-term trend analysis.

LAKE MONITORING

There are 16 lakes in the Shingle Creek watershed, and none in the West Mississippi watershed. The Shingle Creek WMC has monitored 14 of the lakes routinely since 1996 through the Citizen Assisted Lake Monitoring Program (CAMP) and the Commission's Intensive Lake Monitoring Program (Palmer and Curtis Lakes are wetlands and are not monitored). The CAMP was initiated by the Met Council to supplement the water quality monitoring performed by Met Council staff and to increase knowledge of water quality of Metro area lakes. Volunteers in the program monitor their lake every other week from mid-April to mid-October. They measure surface water temperature, Secchi depth, and collect surface water samples that are analyzed by the Met Council for TP, TKN, and chlorophyll-a. Two lakes were monitored in 2016 through CAMP: Middle Twin and Crystal. Monitoring results indicate water quality was similar to the historic data/trends and both lakes still exceed state water quality standards. The 2016 data is presented in Appendix D and the long-term trends for both lakes are discussed in Section 6.0.

The Commission's Intensive Lake Monitoring Program was established in 2012. Through this program, each lake in the watershed is monitored once every five years to evaluate protection efforts for lakes that are not impaired, and to assess progress toward achieving the TMDLs and state water quality standards for the impaired lakes. Monitoring activities included in the program include early and late season vegetation surveys, sediment core collection, and bi-weekly water quality sampling. Two lakes were monitored in 2016: Lake Success, and Meadow Lake. Monitoring results indicate water quality in 2016 was similar to the historic data/trends. A detailed review of the 2016 data is presented in Appendix D and the long-term trends for both lakes are discussed in Sections 4.0 and 5.0. The data collected for Meadow Lake will be used in the upcoming five year review of TMDL progress which will be started in 2017 and completed in 2018. The data collected for Success Lake will be used to support development of protection strategies to ensure the lake remains below state water quality standards and off the 303(d) list of impaired waters.

WETLAND MONITORING

Both Commissions have participated in the Hennepin County Department of Environment and Energy Wetland Health Evaluation Program (WHEP) since 2006. The WHEP program uses trained adult volunteers to monitor and assess wetland plant and animal communities in order to score monitored wetlands on an Index of Biological Integrity for macroinvertebrates and for vegetation. Two wetlands in each watershed were assessed in 2016. All scored Moderate on vegetative quality and three were Poor for invertebrates. Invertebrate health is related to the amount of water they hold, and many urban wetlands get reduced inputs from groundwater as hard cover reduces infiltration in the watershed.

BIOTIC MONITORING

Stream macroinvertebrate monitoring in both watersheds is conducted by volunteers through Hennepin County's River Watch program. Hennepin County coordinates student and adult volunteers who use the River Watch protocols to collect physical, chemical, and biological data to help determine the health of streams in the watershed. Two sites on Shingle Creek were monitored in 2016: in Lions Park in Brooklyn Center and at the Connections site in Brooklyn Park. Lions Park scored Fairly Poor while the Connections site, which was disturbed by construction, scored Very Poor.

3.0 West Mississippi Management Unit

WEST MISSISSIPPI MANAGEMENT UNIT OVERVIEW

The West Mississippi Management Unit encompasses the entire West Mississippi Watershed Management Commission jurisdictional boundary. This management unit covers 16,000 acres across five municipalities in Hennepin County. Brooklyn Park (64%) covers a majority of the management unit, with Champlin (20%), Brooklyn Center (11%), Maple Grove (5%), and Osseo (1%) making up the rest (Figure 3-1 and Table 3-1).

The West Mississippi Management Unit is highly developed, however there is still approximately 1,000 acres (7% of management unit) agricultural land still in production within the City of Brooklyn Park in the western portion of the watershed. Most of the developed land in the watershed is single family residential and therefore the most common land use classification is low-moderate impervious development (38%). Due to soil conditions within the watershed, there are no lakes and very few wetlands. Land use for the West Mississippi Management Unit is summarized in Table 3-1 and presented on a map in Appendix G.

One of the defining characteristics of the West Mississippi Management Unit is its sandy, well-draining soils. Much of the watershed is located within the Anoka Sand Plain and therefore approximately 88% of the management unit contains type A, A/D, or B soils (Table 3-1). Soil type for the West Mississippi Management Unit is summarized in Table 3-1 and presented on a map in Appendix G.

There are four major outfalls in West Mississippi: Oxbow, Environmental Preserve, Mattson Brook, and 65th Avenue outfalls. Located in Champlin, the Oxbow storm sewer outfall consists of a series of storm sewer pipes that drain approximately 1,167 acres of land in Champlin and Maple Grove. The Environmental Preserve is a small stream located in Brooklyn Park. This stream drains approximately 2,160 acres upstream of Brooklyn Park's Environmental Preserve and outlets to a small wetland in the Coon Rapids Dam Regional Park. Mattson Brook is another small surface channel/stream that drains most of central Brooklyn Park (approximately 3,500 acres) and includes a tributary, Edinbrook/Century Channel. The 65th Avenue outfall is located in Brooklyn Center at the northeast corner of the Highway 252 and Interstate 694 interchange. This outfall drains approximately 590 acres of land in Brooklyn Center, which includes runoff from the Regal Cinema and other commercial and industrial land west of Highway 252. The remainder of the West Mississippi Management Unit is made up of a series of small outfalls with relatively small drainage areas that discharge directly to the Mississippi River.

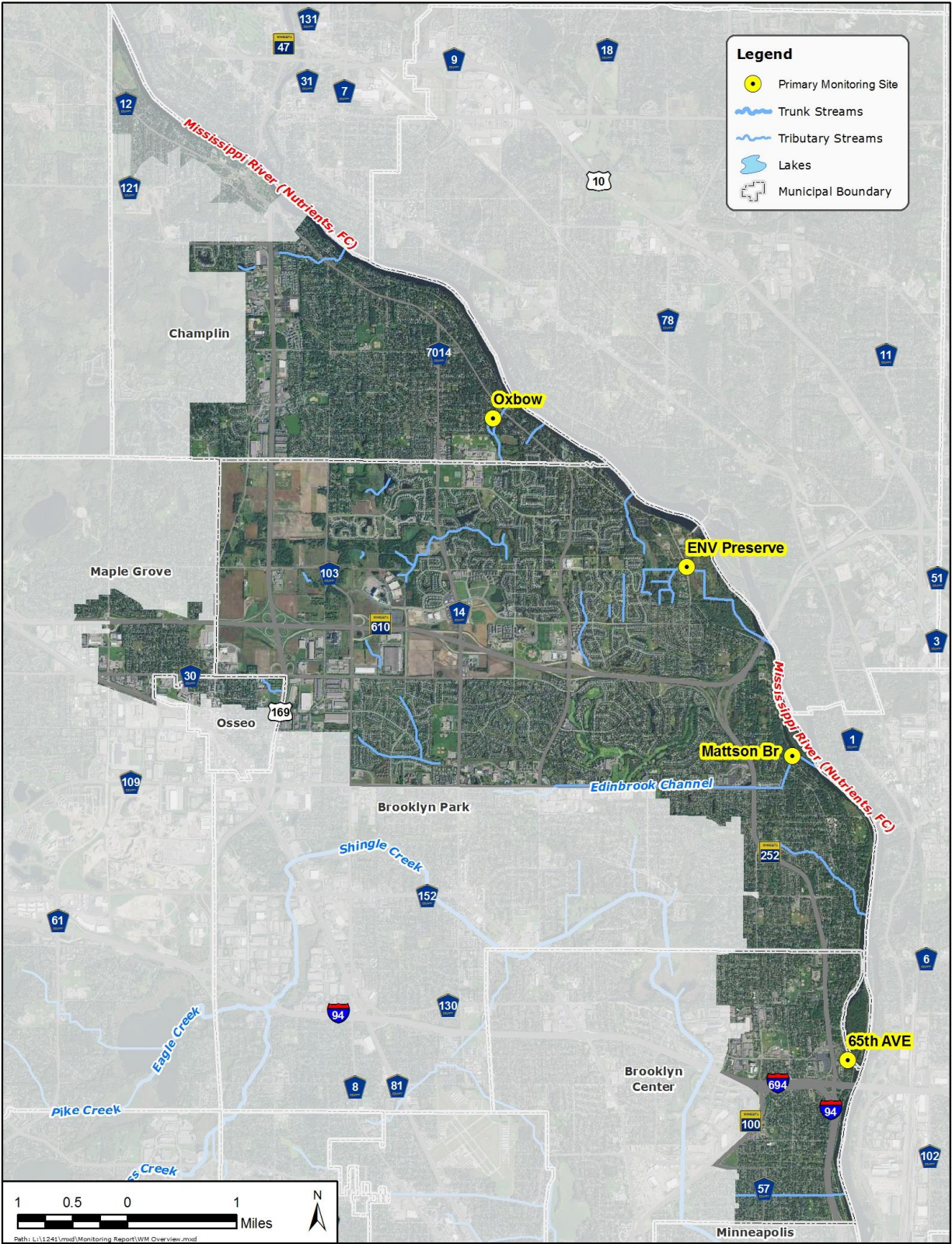


Figure 3-1. West Mississippi Management Unit Overview

Table 3-1. West Mississippi Management Unit water resources and land features.

Streams/Outfalls	Type	Impairment Status
65 th Ave Outfall	Storm sewer/Intermittent	Not Assessed
Mattson Brook	Storm sewer/Intermittent	Not Assessed
Environmental Preserve	Storm sewer/Intermittent	Not Assessed
Oxbow Creek	Storm sewer/Intermittent	Not Assessed

Lakes	Type	Impairment Status
None		

Cities	Acres	Percent
Brooklyn Park	9,920	64%
Champlin	3,123	20%
Brooklyn Center	1,693	11%
Maple Grove	559	5%
Osseo	190	1%

Landuse	Acres	Percent
Low-Moderate Impervious (5-50%)	6,062	38%
Highly Impervious (51-100%)	4,078	25%
Grassland/Shrubland	2,679	17%
Agriculture	1,105	7%
Wetland	850	5%
Forest	669	4%
Open Water	618	4%

Soil Type	Acres	Percent
A	7,910	51%
A/D	4,419	29%
B	1,221	8%
B/D	320	2%
C	30	<1%
C/D	58	<1%
Not Assessed (Heavily Disturbed)	1,032	7%

Untreated Area	Acres
Not Yet Estimated	

OUTFALL MONITORING CURRENT CONDITIONS AND TRENDS

The West Mississippi WMC monitored water quality and streamflow from 1990-1992 at two of the four major outfalls (Oxbow Creek and Mattson Brook). Results indicated very little flow in these tributaries and no water quality or quantity problems or concerns. Thus, the Commission chose to discontinue monitoring after the 1992 monitoring season. In 2010, the Commission elected to once again monitor water quality and flow at two outfall monitoring sites per year in the West Mississippi watershed.

Due to the extensive storm sewer infrastructure and other drainage alterations, the four major outfalls in West Mississippi are likely considered Class 7 waters. By definition, Class 7 waters are "limited resource value waters and are typically not protected for aquatic life and recreation due to lack of water, lack of habitat, or extensive physical alteration." While these outfalls are not subject to water quality standards/assessments, they all discharge to the Mississippi River, which is a Class 2B water that is currently impaired for bacteria and

nutrients (TP). Thus, the Class 2B water quality standards developed by the State of Minnesota provide a good benchmark to evaluate water quality of the four major outfalls.

Four main water quality parameters have been sampled at each of the outfall monitoring stations since 2010: TSS, TP, bacteria (*E. coli*), and chloride. Figures 3-2 through 3-5 contain a series of bar figures that summarize current water quality conditions at each station. Each bar figure depicts the current condition, parameter units, parameter, and the Class 2B water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is for a given site. The Class 2B standards provide reasonable benchmarks to evaluate water quality of each outfall and how it may be affecting water quality in the Mississippi River and other downstream waterbodies.

Below is a general summary and description of current water quality conditions of each outfall based on recent monitoring data (2010 through 2016). At this time, we were not able to calculate long-term data trends due to the limited amount of data for each site.

Oxbow Outfall

- ▲ TSS and TP concentrations currently exceed Class 2B standards. Almost all of the TSS and TP measurements that exceeded the Class 2B were collected during storm events.
- ▲ Ortho-phosphorus (not shown on figures) concentrations measured at this station were relatively high (approximately 50% of TP) indicating phosphorus loads are coming from both dissolved and particulate sources.
- ▲ Bacteria and chloride levels at this outfall location were consistently low and well below Class 2B standards.

Environmental Preserve Outfall

- ▲ TSS concentrations currently exceed Class 2B standards. All of the high TSS values were measured during storm events.
- ▲ TP, bacteria, and chloride concentrations are at or below Class 2B standards.

Mattson Brook Outfall

- ▲ TSS and TP concentrations currently exceed Class 2B standards. Most of the high TSS and TP measurements were collected during storm events.
- ▲ Ortho-phosphorus (not shown on figures) concentrations measured at this station were relatively high (approximately 50% of TP) indicating phosphorus loads are coming from both dissolved and particulate sources.
- ▲ Bacteria levels were very high and routinely exceed Class 2B standards during all flow conditions.
- ▲ Chloride concentrations are low and rarely exceed the Class 2B standard.

65th Ave Outfall

- ▲ TSS, TP, and bacteria concentrations are generally at or below Class 2B standards.
- ▲ Chloride levels at this site are high and often exceed the Class 2B standard particularly during low flow conditions in the spring and fall.

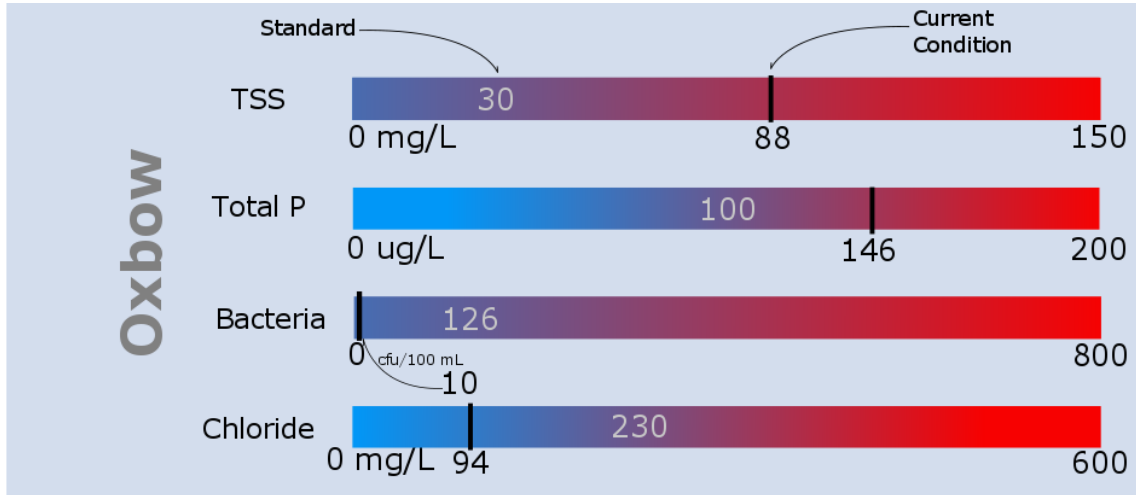


Figure 3-2. Oxbow Outfall water quality summary (2010-2016).

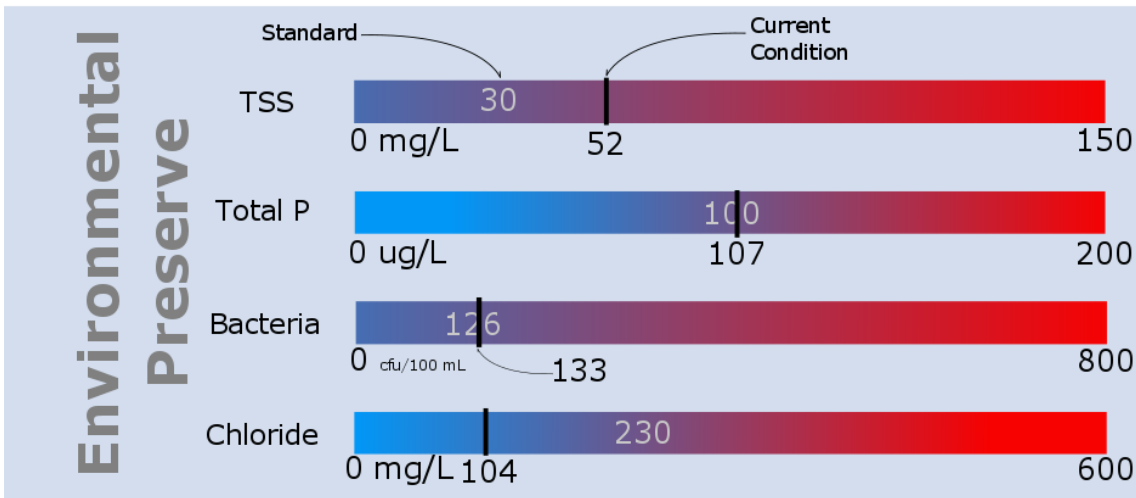


Figure 3-3. Environmental Preserve Outfall water quality summary (2010-2016).

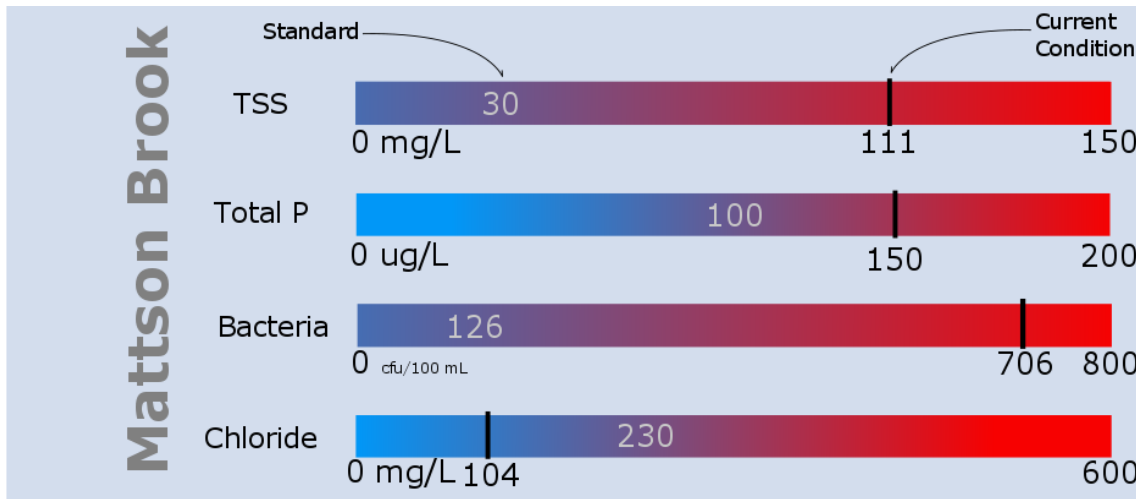


Figure 3-4. Mattson Brook Outfall water quality summary (2010-2016).

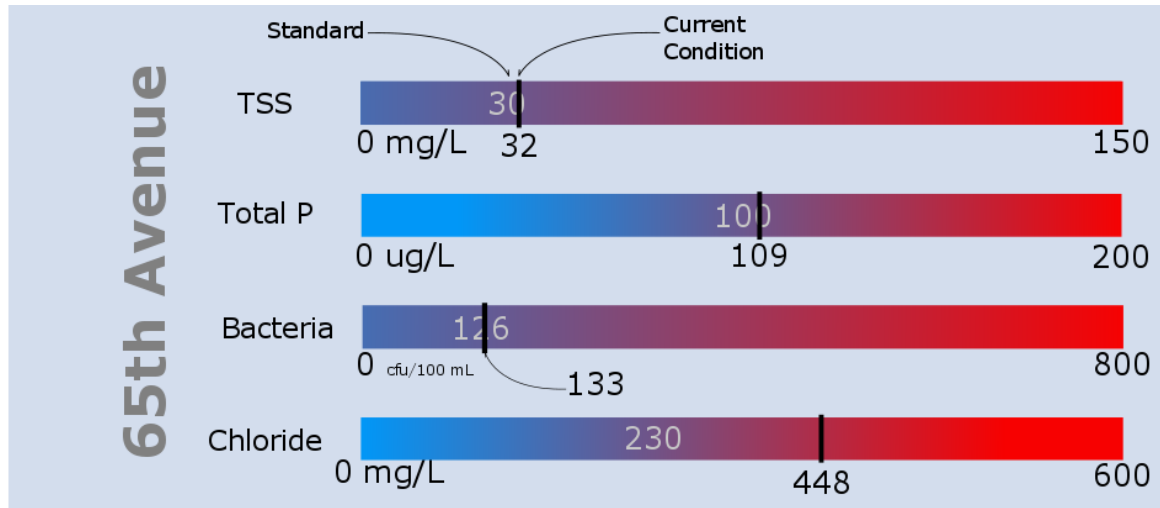


Figure 3-5. 65th Ave Outfall water quality summary (2010-2016).

4.0 Upper Shingle Creek Management Unit

UPPER SHINGLE CREEK MANAGEMENT UNIT OVERVIEW

The Upper Shingle Creek Management Unit is the headwaters of the Shingle Creek watershed and covers approximately 8,300 acres across four municipalities in Hennepin County. Plymouth (53%) and Maple Grove (30%) make up a majority of this management unit, with New Hope (12%) and Brooklyn Park (5%) also having small portions (Figure 4-1 and Table 4-1).

Lakes and wetlands are a common feature in the Upper Shingle Creek Management Unit. The Bass Chain of Lakes is located in the City of Plymouth and includes Bass, Schmidt and Pomerleau Lakes. Bass and Schmidt are considered shallow lakes, while Pomerleau Lake is considered a deep lake. The major inflow to Bass Lake and out of the lake is Bass Creek. Bass Creek starts as a series of wetlands west of Vicksburg Lane in Plymouth and flows east into New Hope and then north to where it meets Eagle Creek just south of Interstate 694 in Brooklyn Park.

The other major lake chain in the Upper Shingle Creek Management Unit is the Eagle Chain of Lakes. This chain includes Eagle, Cedar Island, and Pike Lakes. The Eagle Chain of Lakes is located primarily in the City of Maple Grove, however portions of Pike Lake and the watershed draining to Pike Lake are located in Plymouth. Eagle Lake outlets to Eagle Creek which flows a short distance through a series of wetlands prior to its confluence with Bass Creek just south of Interstate 694 in Brooklyn Park.

Lake Magda and Meadow Lake are the two other lakes in the Upper Shingle Creek Management Unit. Lake Magda is a small (10 acre) lake located Brooklyn Park. Meadow Lake is also a very small lake (12 acres) located in New Hope. Both lakes are considered shallow lakes and have relatively small contributing areas.

The Upper Shingle Creek Management Unit is almost fully developed, however it was one of the last areas in the Shingle Creek watershed to develop. Thus, much of this management unit was developed under stormwater management rules and therefore has some level of water quality treatment. Most of the water quality treatment throughout the watershed consists of stormwater ponds and wetlands. A recent desktop analysis determined that approximately 66 acres of the watershed flows directly to Bass Creek with no water quality treatment (see Table 4-1 and map in Appendix G). By comparison, the Middle and Lower Shingle Creek Management Units have approximately 1,700 and 2,000 acres of untreated area, respectively, that discharge directly to Shingle Creek.

Land use within the Upper Shingle Creek Management Unit is predominantly high impervious urban development (28%) and low-moderate impervious urban development (26%). While this management unit is almost fully developed, it has significantly less impervious coverage (54%) compared to the Middle (73%) and Lower (84%) Shingle Creek Management Units. The Upper Shingle Creek Management Unit also has the highest percentage of wetlands and open water (lake) features compared to the other Shingle Creek management units.

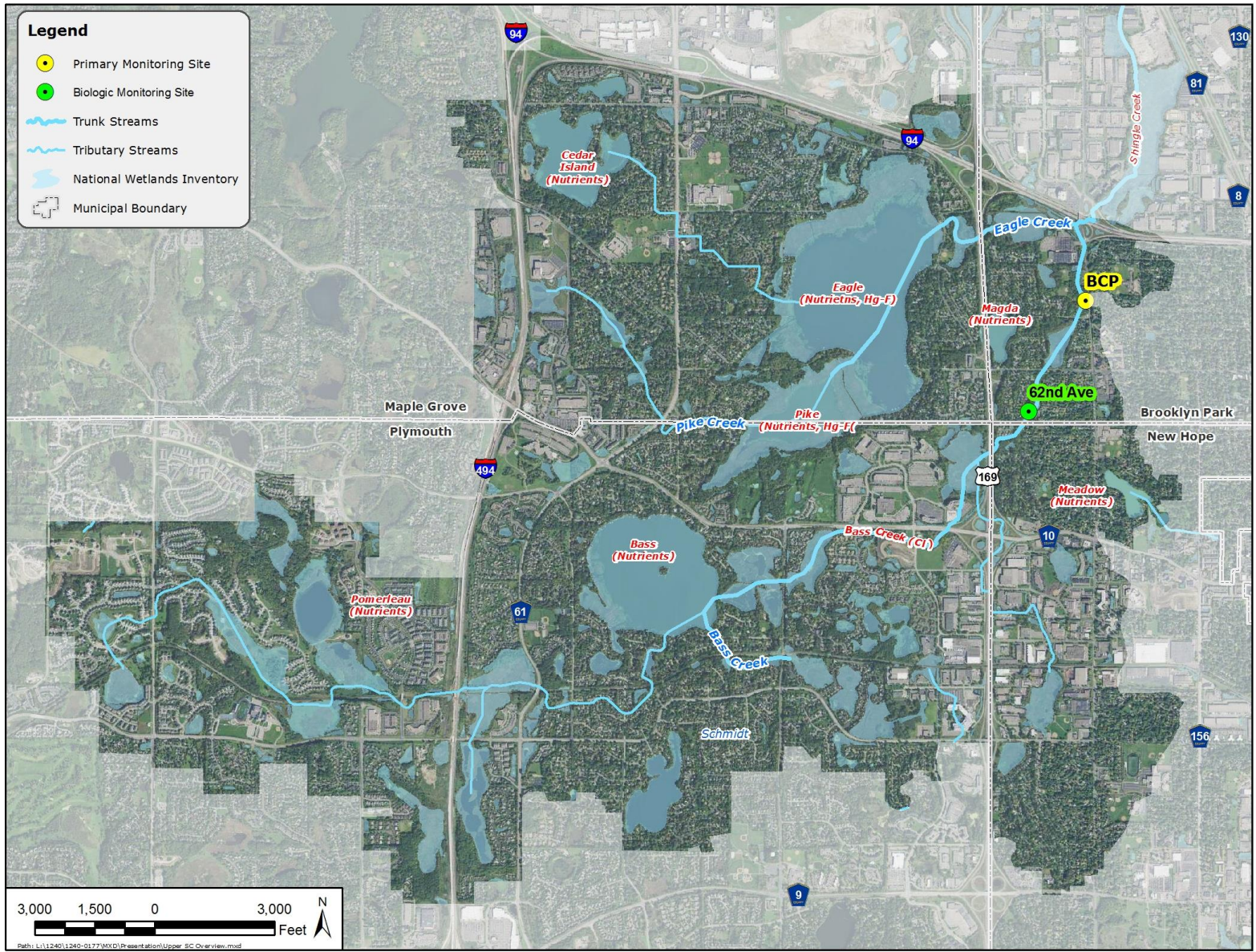


Figure 4-1. Upper Shingle Creek Management Unit Overview.

April 2017

Table 4-1. Upper Shingle Creek Management Unit water resources and land features.

Streams	Type	Impairment Status
Bass Creek (07010206-784)	Class 2B	Impaired (CI, Biota – Fish)
Eagle Creek (07010206-671)	Class 2B	Not Assessed
Pike Creek (07010206-667)	Class 2B	Not Assessed

Lakes	Type	Impairment Status
Pomerleau	Deep Lake	Impaired (nutrients)
Schmidt	Shallow Lake	Not Impaired (de-listed in 2016)
Bass	Shallow Lake	Impaired (nutrients)
Meadow	Shallow Lake	Impaired (nutrients)
Magda	Shallow Lake	Impaired (nutrients)
Cedar Island	Shallow Lake	Impaired (nutrients)
Pike	Shallow Lake	Impaired (nutrients)
Eagle	Deep Lake	Impaired (nutrients)

Cities	Acres	Percent
Plymouth	4,417	53%
Maple Grove	2,477	30%
New Hope	965	12%
Brooklyn Park	463	6%

Landuse	Acres	Percent
Highly Impervious (51-100%)	2,367	28%
Low-Moderate Impervious (5-50%)	2,165	26%
Wetlands	1,250	15%
Grassland and Shrubland	1,104	13%
Open Water	665	8%
Forest	617	7%
Agriculture	154	2%

Soil Type	Acres	Percent
A	2,346	28%
A/D	2	<1%
B	1,892	23%
B/D	1,006	12%
C	89	1%
C/D	1,003	12%
Water	736	9%
Not Assessed (Heavily Disturbed)	1,249	15%

Untreated Area (Creek Corridor)	Acres
Maple Grove	48
Plymouth	18

STREAM MONITORING CURRENT CONDITIONS AND TRENDS

Stream flow and water quality have been monitored at one location, BCP, in the Upper Shingle Creek Management Unit. This station is located in Bass Creek Park in Brooklyn Park and drains approximately 65% of the Upper Shingle Creek Management Unit. This station was monitored briefly in 2000 by the MPCA as part of a water quality assessment project. This assessment determined that Bass Creek was impaired for chloride and fish IBI scores. TMDL studies were completed by the Commission and the MPCA in 2007 to address the chloride impairment and in 2011 to address the Fish IBI impairment. The Commission began monitoring the BCP site in 2013 to continually assess water quality conditions in Bass Creek and measure progress toward achieving the TMDLs. Bass Creek is considered a Class 2B water and is therefore subject to the North Central Hardwood Forest Class 2B water quality standards for streams.

Four main water quality parameters of concern have been sampled at the BCP monitoring station since 2013: TSS, TP, dissolved oxygen (DO), and chloride. Figure 4-2 contains a series of bar figures that summarize current water quality conditions at the BCP site for each of the aforementioned parameters. Each bar figure depicts the current condition, parameter units, parameter, and associated Class 2B water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is compared to the Class 2B standard. Monitoring results for other water quality parameters not covered in this section (ortho-P, TKN and nitrate) are presented in Appendices B and C. Also included in Figure 4-2 is the fish and macroinvertebrate IBI monitoring results for the BCP and 62nd Ave stations (Figure 4-1) that were collected in 2000 and 2010, respectively. We are currently unable to calculate long-term data trends for the BCP monitoring site due to a limited amount of data.

Below is a general summary of the current conditions of the four main water quality parameters of concern and IBI monitoring results in the Upper Shingle Creek Management Unit.

TSS

- ▲ TSS concentrations at BCP are currently very close to meeting the 30 mg/L Class 2B standard.
- ▲ TSS concentrations measured at BCP were significantly lower than the concentrations measured in the Middle (SC-3) and Lower (SC-0) Shingle Creek Management Units
- ▲ The relatively low TSS concentrations are likely due to settling in the lakes, wetlands, and stormwater ponds located throughout the Upper Shingle Creek Management Unit.

TP

- ▲ TP concentrations at BCP currently exceed the Class 2B standard. The high TP concentrations occurred during both high and low flow conditions.
- ▲ Ortho-phosphorus (not shown on figures) concentrations measured at this station were very high (70% of TP). This suggests that the phosphorus loads in the Upper Shingle Creek Management Unit are primarily coming from dissolved sources such as release from sediment and the breakdown of organic matter. A large flow-through wetland is just upstream of Bass Creek Park.
- ▲ TP levels measured at BCP were similar to the TP concentrations measured in the Middle (SC-3) and Lower (SC-0) Shingle Creek Management Units. However, ortho-P concentrations at BCP were significantly higher than the other management units.

DO

- ▲ DO at BCP does not currently meet the 5.0 mg/L Class 2B standard as DO levels consistently drop below 5.0 mg/L during the summer months.
- ▲ Longitudinal DO surveys performed along Bass Creek in recent years indicate DO levels drop dramatically beginning at the downstream end of the Cherokee Wetland which is just upstream of the BCP monitoring site.

Chloride

- ▲ Chloride levels the BCP site are high and often exceed the Class 2B standard particularly during low flow conditions in the winter and spring.
- ▲ Chloride concentrations measured at BCP are similar to the concentrations measured in the Middle (SC-3) and Lower (SC-0) Shingle Creek Management Units

Fish and Invertebrate IBI Scores

- ▲ Fish IBI scores at the 62nd Ave (4) and BCP sites (0) were well below the IBI standard threshold of 46, likely due to low DO levels in Bass Creek.
- ▲ The invertebrate IBI score measured at the 62nd Ave (22) site in 2010 was well below the IBI threshold of 43.
- ▲ The invertebrate IBI score measured at the BCP site in 2000 exceeded the IBI threshold of 43.

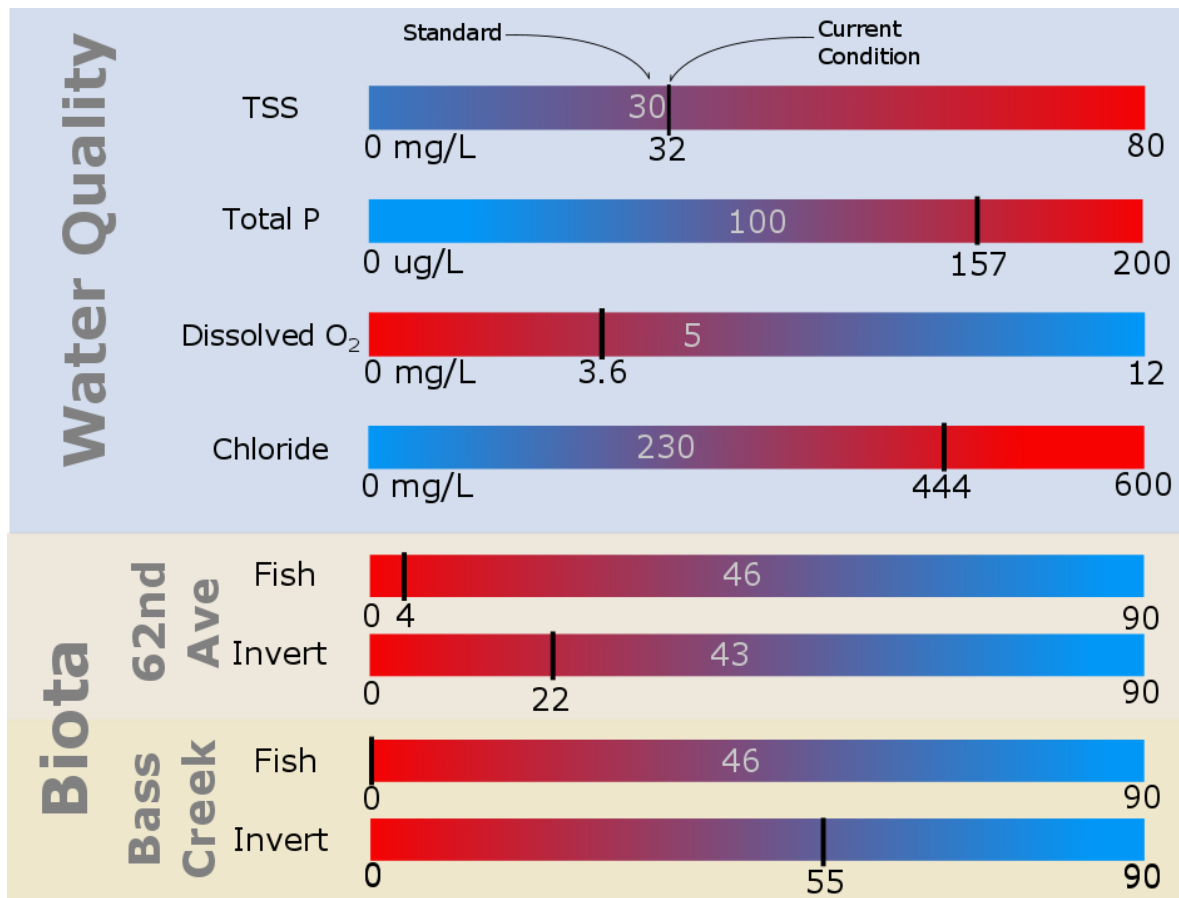


Figure 4-2. BCP water quality and IBI summary (2013-2016).

LAKE MONITORING CURRENT CONDITIONS AND TRENDS

Lake water quality has been monitored for all eight lakes in the Upper Shingle Creek Management Unit since at least the mid-1990s. All of the lakes in the Upper Management Unit were assessed as impaired for nutrients (TP) in the early 2000s. TMDL studies for each lake were completed by the Commission and the MPCA through four different TMDL studies:

- ▲ Schmidt, Pomerleau and Bass Lakes Nutrient TMDL (2009)
- ▲ Cedar Island, Pike, and Eagle Lakes Nutrient TMDL (2010)
- ▲ Lake Magda Nutrient TMDL (2010)
- ▲ Meadow Lake Nutrient TMDL (2010)

Historic water quality sampling on each lake has focused on three main parameters: TP, chlorophyll-a, and Secchi depth (transparency). Figures 4-3 through 4-5 contain a series of bar figures that summarize the three water quality parameters for each lake. Each bar figure depicts the current condition, parameter units, parameter, and associated lake water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is compared to the standard. Long-term data trends for each lake are presented in Appendix D. While no formal trend analysis has been performed on these data, visual inspection of the figures in Appendix D does not indicate any increasing or decreasing data trends for the eight lakes in the Upper Shingle Creek Management Unit over the past 10 years.

Below is a general summary of water quality conditions for each lake in the Upper Shingle Creek Management Unit over the most recent 10-year period.

Bass Lake Chain

- ▲ Pomerleau and Bass Lake have exceeded water quality standards over the past 10 years
- ▲ There does not appear to be any positive or negative trends in water quality for Pomerleau and Bass Lakes and both lakes are still considered impaired
- ▲ Schmidt Lake has met State standards for all three parameters over the past 10 years. Schmidt Lake was removed from the State's 303(d) list of impaired waters in 2016.
- ▲ Schmidt Lake was listed as impaired in 2002 and this listing was based on limited data at that time from the 1990s. The lake was recently removed from the State's 303(d) list of impaired waters in 2016. There does not appear to be any clear trends in the water quality data for Schmidt Lake over the past 10 years and the lake has consistently met water quality standards since the early 2000s.

Eagle Lake Chain

- ▲ Cedar Island and Pike Lakes have consistently exceeded water quality standards over the past 10 years. Cedar Island has some of the highest TP and chlorophyll-a concentrations of any lake monitored in the Shingle Creek watershed over the past 10 years.
- ▲ There does not appear to be any positive or negative trends in water quality for Cedar Island and Pike Lakes and both lakes are still considered impaired.
- ▲ Eagle Lake has met standards in 2 of the past 4 years in which it has been monitored (See Appendix D), however the 10-year average still exceeds State standards. Monitoring on Eagle Lake should continue to track the recent improvements in water quality

Lake Magda and Meadow Lake

- ▲ Meadow Lake and Lake Magda have consistently exceeded water quality standards over the past 10 years.
- ▲ There do not appear to be any positive or negative trends in water quality for Meadow Lake and Lake Magda over the past 10 years (Appendix D).
- ▲ Meadow Lake has some of the highest TP and chlorophyll-a concentrations of any lake monitored in the Shingle Creek watershed over the past 10 years.

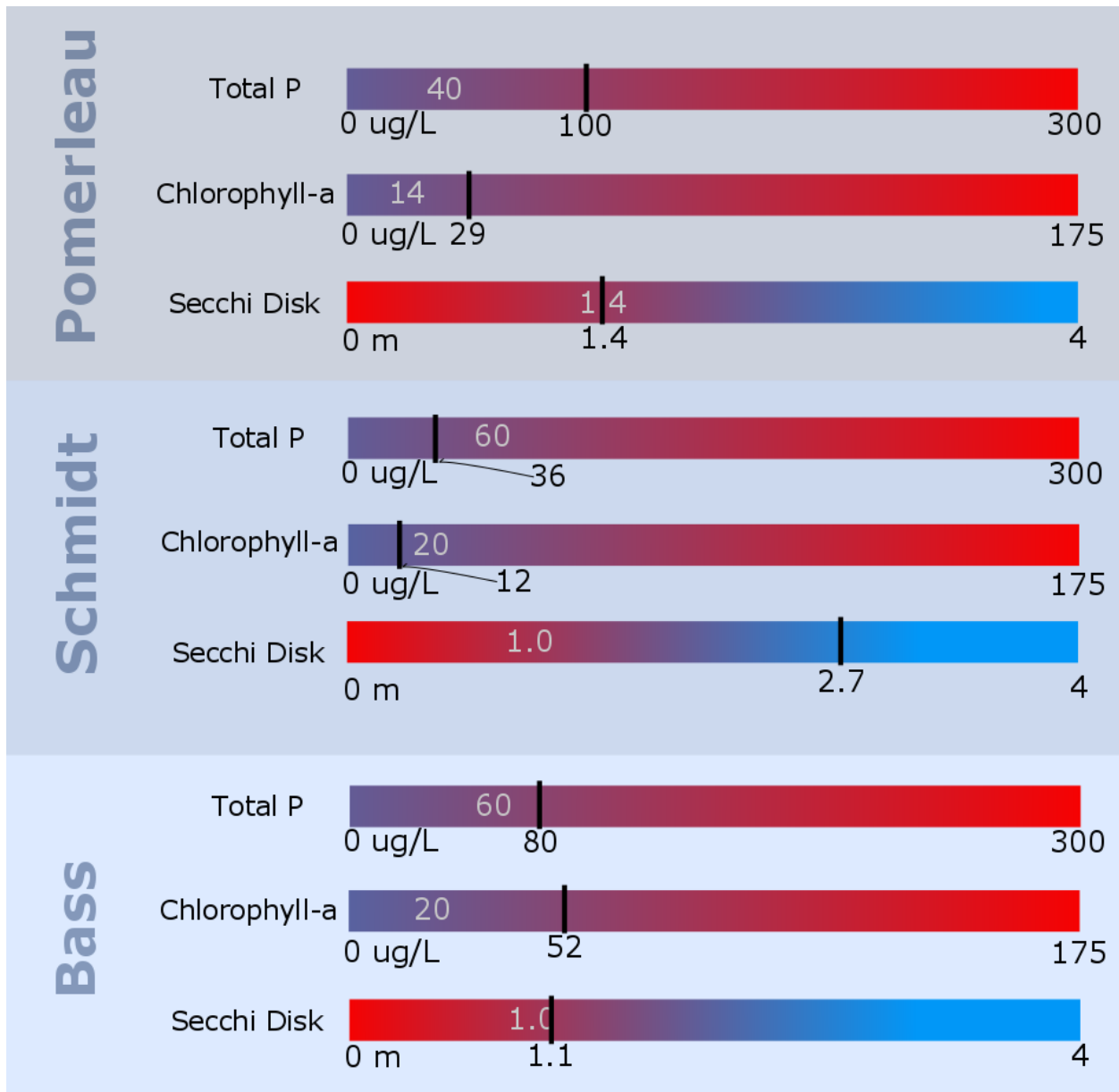


Figure 4-3. Water quality summary (recent 10 years) for Pomerleau, Schmidt and Bass Lakes.

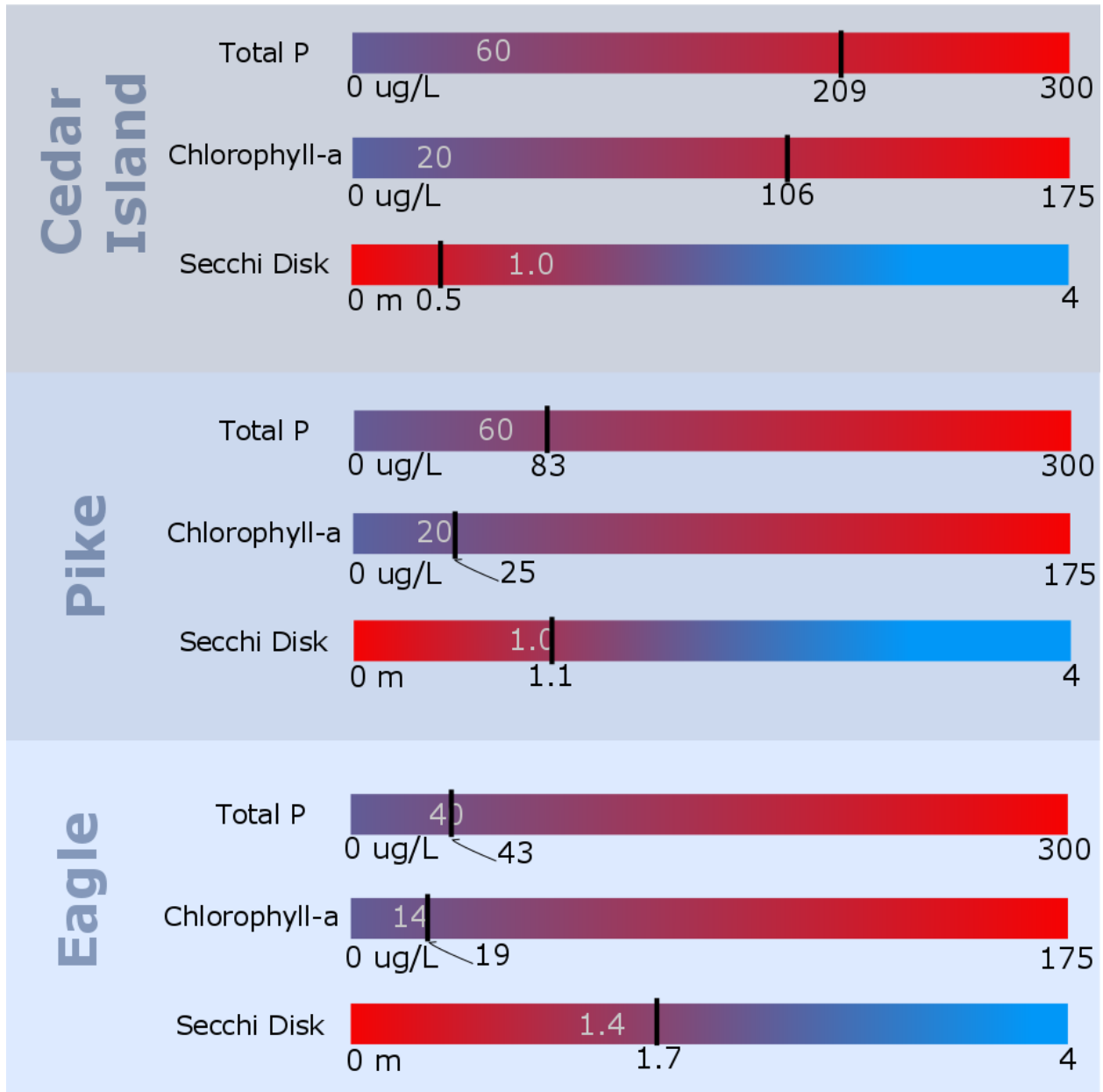


Figure 4-4. Water quality summary (recent 10 years) for Cedar Island, Pike, and Eagle Lakes.

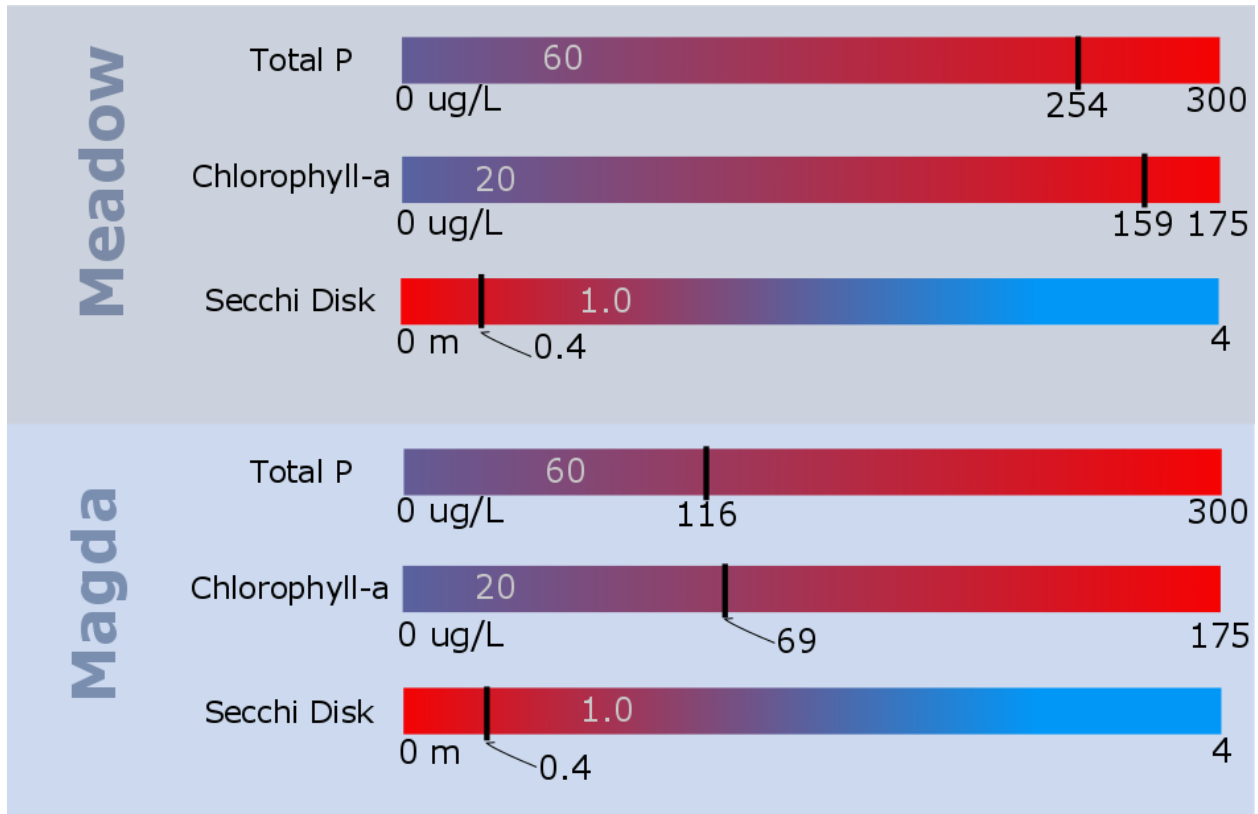


Figure 4-5. Water quality summary (recent 10 years) for Meadow Lake and Lake Magda.

5.0 Middle Shingle Creek Management Unit

MIDDLE SHINGLE CREEK MANAGEMENT UNIT OVERVIEW

The Middle Shingle Creek Management Unit covers Shingle Creek from the confluence of Eagle and Bass Creeks to Palmer Lake in Brooklyn Park. This management unit covers approximately 9,500 acres across four municipalities in Hennepin County. A majority of the management unit is located in Brooklyn Park (62%), with the rest covering portions of Maple Grove (27%), Brooklyn Center (8%), and Osseo (3%) (Figure 5-1 and Table 5-1).

The Middle Single Creek Management Unit is fully developed. Most of the eastern portion of the management unit (Brooklyn Park and Brooklyn Center) was developed in the 1960s and 1970s with minimal stormwater treatment. The western portion of the watershed, particularly Maple Grove, was developed more recently in the 1980s and 1990s and therefore much of this area has some level of stormwater quality treatment. A recent desktop analysis determined that there are approximately 1,700 acres of the watershed flowing directly to Shingle Creek with no water quality treatment, most of which is in the City of Brooklyn Park (see Table 5-1 and map in Appendix G).

Land use within the Middle Shingle Creek Management Unit is predominantly high impervious urban development (45%) and low-moderate impervious urban development (28%). In general, development through the Shingle Creek watershed occurred from east to west and therefore the Middle Shingle Creek Management Unit has the second most impervious coverage of the three management units. Lakes are a not a common feature in the Middle Shingle Creek Management Unit. Lake Success is the only lake in the watershed by DNR definition. Palmer Lake is another shallow water body located in this management unit, however it is classified as a wetland by DNR standards.

Similar to the West Mississippi Management Unit, the Middle Shingle Creek Management Unit is characterized by sandy, well-draining soils. Approximately 62% of the management unit contains type A, A/D, or B soils. Soil type for the Middle Shingle Creek Management Unit is summarized in Table 5-1 and presented on a map in Appendix G.

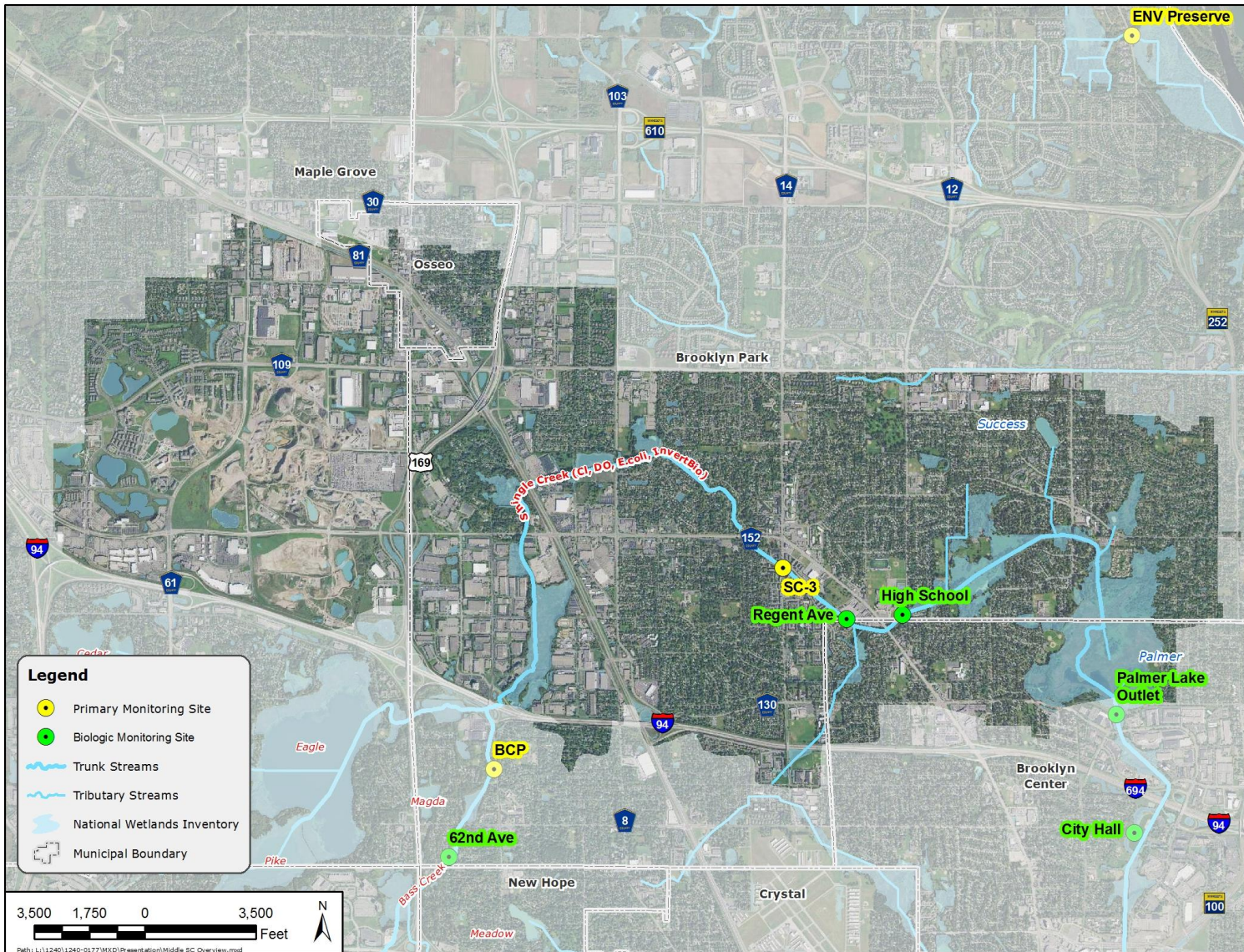


Figure 5-1. Middle Shingle Creek Management Unit Overview.

Table 5-1. Middle Shingle Creek Management Unit water resources and land features.

Streams	Type	Impairment Status
Shingle Creek (07010206-506)	Class 2B	Impaired (Cl, DO, <i>E. coli</i> , Biota – Invert.)

Lakes	Type	Impairment Status
Palmer	Shallow	Not Assessed
Success	Shallow	Not Impaired

Cities	Acres	Percent
Brooklyn Park	5,839	62%
Maple Grove	2,558	27%
Brooklyn Center	769	8%
Osseo	273	3%

Landuse	Acres	Percent
Highly Impervious (51-100%)	4,215	45%
Low-Moderate Impervious (5-50%)	2,645	28%
Grassland and Shrubland	1,422	15%
Wetlands	893	9%
Forest	236	3%
Agriculture	19	<1%
Open Water	10	<1%

Soil Type	Acres	Percent
A	2,943	31%
A/D	2,138	23%
B	772	8%
B/D	228	2%
C	36	<1%
C/D	39	<1%
Water	86	1%
Not Assessed (Heavily Disturbed)	3,197	34%

Untreated Area (Direct)	Acres
Brooklyn Park	1,637
Brooklyn Center	95

STREAM MONITORING CURRENT CONDITIONS AND TRENDS

Stream flow and water quality have been monitored at one location, SC-3, in the Middle Shingle Creek Management Unit. This station is located at the intersection of Shingle Creek and Brooklyn Boulevard in Brooklyn Park. This monitoring location drains approximately 54% of the Middle Shingle Creek Management Unit. The Shingle Creek WMC began monitoring this station in the early 2002. Shingle Creek was placed on the State's 303(d) list of impaired waterbodies in 1998 for chloride, in 2004 for DO, and in 2006 for macroinvertebrate IBI scores. TMDL studies were completed by the Commission and the MPCA in 2007 to address the chloride impairment and in 2011 to address the DO and macroinvertebrate IBI impairments. The Commission has continued to monitor this station every year since the completion of the TMDLs to assess water quality conditions in the Middle Shingle Creek Management Unit and measure progress toward achieving the TMDLs. Shingle Creek is considered a Class 2B water and is therefore subject to the North Central Hardwood Forest Class 2B water quality standards for streams.

Four main water quality parameters of concern have been sampled at the SC-3 monitoring station since 2002: TSS, TP, dissolved oxygen (DO), and chloride. Figure 5-2 contains a series of bar figures that summarize current water quality conditions at the SC-3 station for each of the aforementioned parameters. Each bar figure depicts the current condition, parameter units, parameter, and associated Class 2B water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is compared to the Class 2B standard. Long-term data trends for these parameters were assessed using a Mann-Kendall trend analysis corrected for flow. Parameters with long-term trends are denoted with red (declining) and blue (improving) arrows.

Monitoring results for other water quality parameters not covered in this section (ortho-P, TKN and nitrate) are presented in Appendices B and C. Also included in Figure 5-2 is the fish/macroinvertebrate IBI monitoring results for two biological monitoring stations in the Middle Shingle Creek Management Unit: Regent Avenue (10UM032) and Park Center High School (Figure 5-1). Fish and macroinvertebrate IBI assessments were performed at the Regent Ave site in 2010, and a macroinvertebrate IBI assessment was conducted at the High School site in 2015 in support of the Shingle Creek Art Aeration Project.

Below is a general summary of the current conditions of the four main water quality parameters of concern and IBI monitoring results in the Middle Shingle Creek Management Unit.

TSS

- ▲ TSS concentrations at the SC-3 monitoring site do not meet the 30 mg/L Class 2B standard.
- ▲ Most of the high TSS measurements were collected during storm events and/or high flow conditions.
- ▲ Long-term trend analysis does not suggest there are any TSS trends for this site (see Appendix C)

TP

- ▲ TP concentrations at the SC-3 site currently exceed the Class 2B standard. The high TP concentrations occurred during both high and low flow conditions.

- ▲ Ortho-phosphorus (not shown on figures) concentrations for this site were relatively low (45% of TP), particularly during low flow conditions. This suggests that phosphorus loads are likely coming from particulate sources attached to sediment.
- ▲ Long-term trend analysis does not suggest there are any TP trends for this site (see Appendix C)

DO

- ▲ DO at SC-3 does not currently meet the 5.0 mg/L Class 2B standard as DO levels consistently drop below 5.0 mg/L during the summer months.
- ▲ Longitudinal DO surveys performed along Shingle Creek throughout the Middle Management Unit indicate DO generally increases from upstream to downstream between the Northland Wetland (I-694) and Palmer Lake. However, DO at SC-3 is consistently below the standard likely due to lack of flow over-widened channels near this site.

Chloride

- ▲ Chloride levels at SC-3 are high and often exceed the Class 2B standard particularly during winter and spring snow melt events
- ▲ Long-term trend analysis suggests there is a slight increasing trend in chloride for the SC-3 site since 2002 (see Appendix C).
- ▲ The SC-3 site is located at Brooklyn Boulevard downstream of a major storm sewer outfall that drains a relatively large portion of Brooklyn Boulevard and the surrounding neighborhoods. This stretch of road is heavily trafficked and salted during the winter months.

Fish and Invertebrate IBI Scores

- ▲ Fish IBI score at the Regent Ave (0) site was well below the IBI standard threshold of 46, likely due to low DO levels in this stretch of Shingle Creek.
- ▲ The invertebrate IBI score measured at the Regent Ave (27) in 2010 and Park Center High School site (26) in 2015 was well below the IBI threshold of 43.

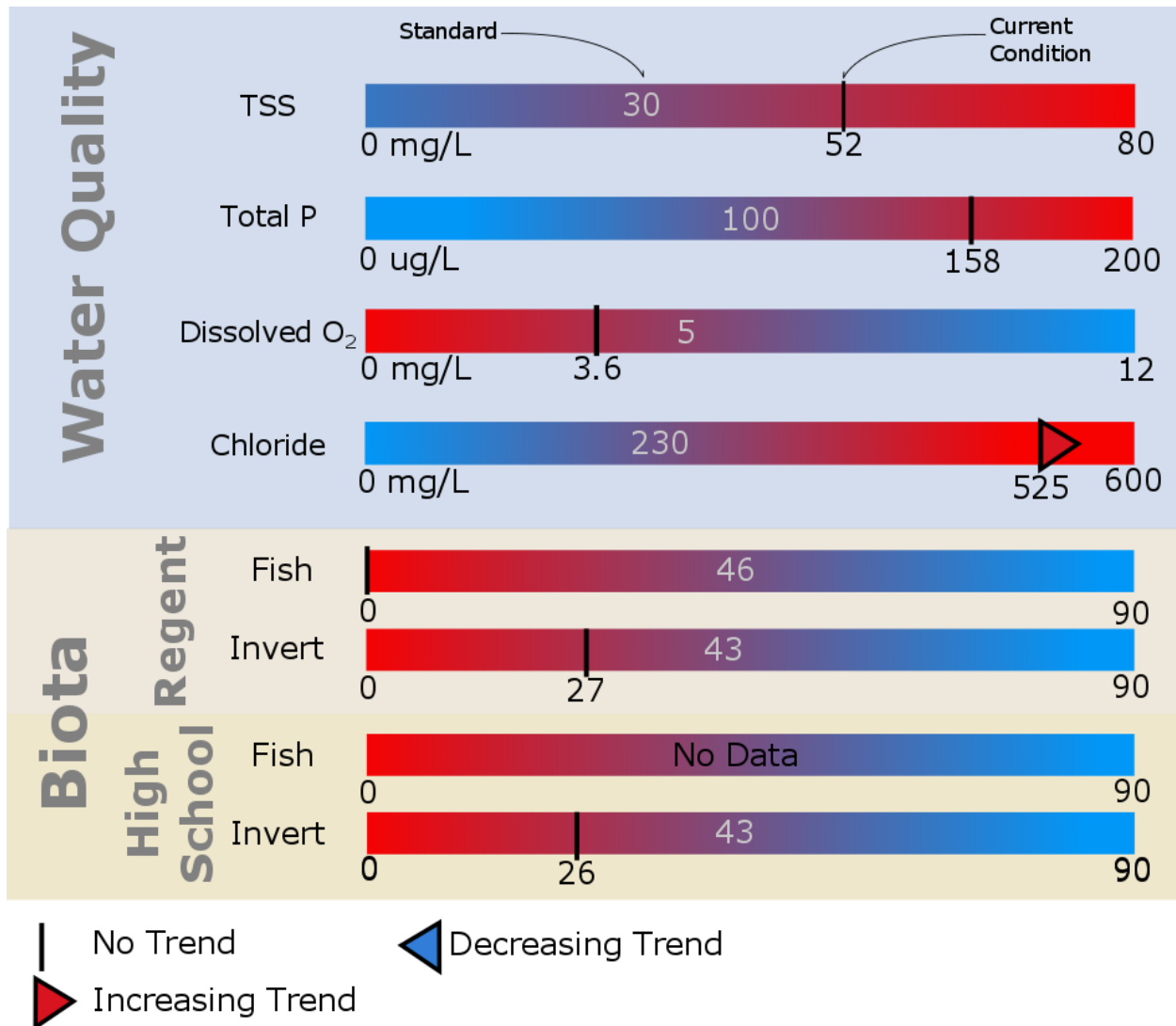


Figure 5-2. Middle Shingle Creek Management Unit stream water quality and IBI summary.

LAKE MONITORING CURRENT CONDITIONS AND TRENDS

Lake water quality has been monitored on the only lake in the Middle Shingle Creek Management Unit, Lake Success, since the 1990s. Historic monitoring for Lake Success indicates the lake is currently meeting state water quality for two of the three water quality parameters: TP and Secchi depth (Figure 5-3). Lake Success is not currently meeting state water quality standards for chlorophyll-a, however since it is meeting standards for two of the three parameters it is not considered impaired and would not be placed on the 303(d) list of impaired waters. Since the lake is very close to exceeding state water quality standards, it should be considered a high priority protection lake. Lake Success was monitored by the Commission in 2016 through the Intensive Lake Monitoring program. Detailed results of the 2016 monitoring are presented in Appendix E.

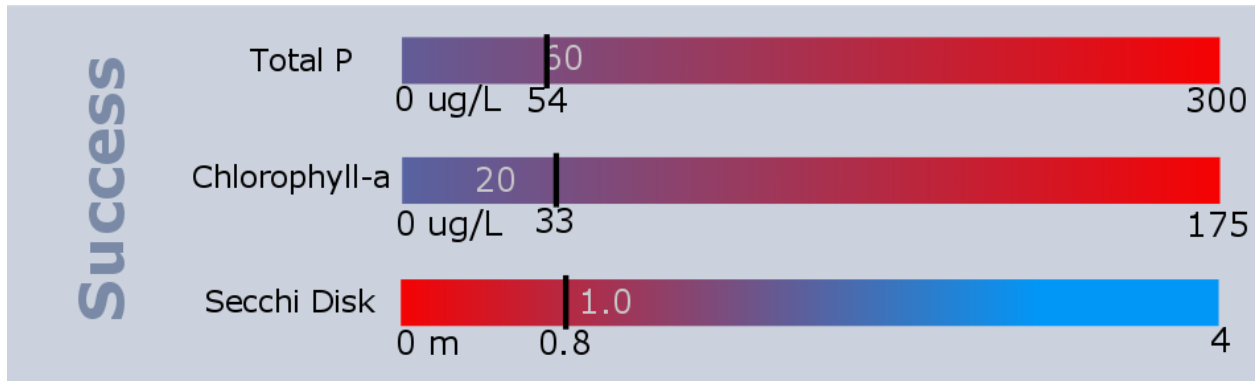


Figure 5-3. Water quality summary (recent 10 years) for Meadow Lake and Lake Magda.

6.0 Lower Shingle Creek Management Unit

LOWER SHINGLE CREEK MANAGEMENT UNIT OVERVIEW

The Lower Shingle Creek Management Unit covers Shingle Creek from the outlet of Palmer Lake in Brooklyn Park to the creek's confluence with Mississippi River in Minneapolis. This management unit covers approximately 11,000 acres across six municipalities in Hennepin County. This management unit is split up fairly evenly between Brooklyn Center (27%), Crystal (23%), Minneapolis (19%), Robbinsdale (14%), New Hope (10%), and Brooklyn Park (7%) (Figure 6-1 and Table 6-1).

Lakes are a fairly common feature in the Lower Shingle Creek Management Unit. The Twin Chain of Lakes is located in Crystal, Brooklyn Center, and Robbinsdale and includes Upper Twin, Middle Twin and Lower Twin Lakes. Upper (118 acres) and Lower Twin (30 acres) are considered shallow lakes, while Middle Twin Lake (54 acres) is considered a deep lake. Flow through the lake chain is from north to south or from Upper to Middle to Lower Twin. Lower Twin Lake outlets over a weir located at France Avenue to a small channel (Ryan Creek) that flows downstream to Ryan Lake. Ryan Lake is a small (15 acres) deep lake located in Robbinsdale, Brooklyn Center, and Minneapolis. Ryan Lake outlets to Ryan Creek which flows east to where it discharges to Shingle Creek near 49th Ave N in Minneapolis. Crystal Lake is the other lake in the Lower Shingle Creek Management Unit. Crystal Lake is a moderate sized (89 acres) deep lake located in the City of Robbinsdale.

The Lower Shingle Creek Management Unit is fully developed. Most of this management unit was developed in the 1950s and 1960s or earlier and therefore has minimal stormwater treatment. A recent desktop analysis performed by Wenck Associates, Inc. determined that there is approximately 2,000 acres of the watershed flowing directly to Shingle Creek with no water quality treatment, most of which is in Minneapolis (see Table 6-1 and map in Appendix G).

Land use within the Lower Shingle Creek Management Unit is predominantly high impervious urban development (71%). In general, development through the Shingle Creek watershed occurred from east to west and therefore the Lower Shingle Creek Management Unit has the highest impervious coverage of the three Shingle Creek Management Units. The remainder of land in the Lower Shingle Creek Management Unit is split between grassland and shrubland (13%), low-moderate impervious urban development (8%), open water (3%), wetlands (3%) and forest (2%) (see Table 6-1 and map in Appendix G).

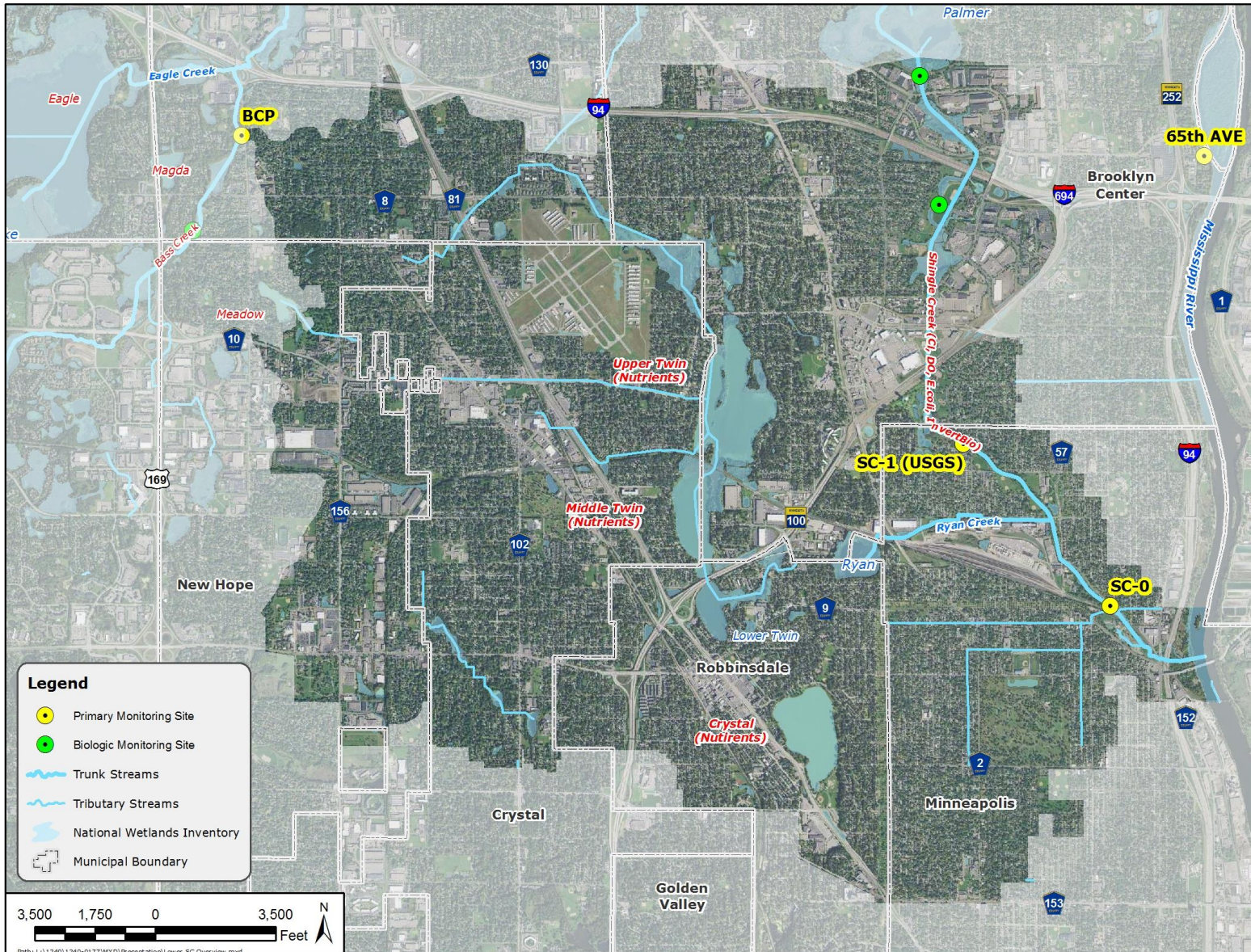


Figure 6-1. Lower Shingle Creek Management Unit Overview.

Table 6-1. Lower Shingle Creek Management Unit water resources and land features.

Streams	Type	Impairment Status
Shingle Creek (07010206-506)	Class 2B	Impaired (Cl, DO, <i>E. coli</i> , Biota - Invert.)
Ryan Creek (07010206-536)	Class 2B	Not Assessed

Lakes	Type	Impairment Status
Crystal	Deep Lake	Impaired (nutrients)
Upper Twin	Shallow Lake	Impaired (nutrients)
Middle Twin	Deep Lake	Impaired (nutrients)
Lower Twin	Shallow Lake	Not Impaired (de-listed in 2016)
Ryan	Shallow Lake	Not Impaired (de-listed in 2016)

Cities	Acres	Percent
Brooklyn Center	2,902	27%
Crystal	2,515	23%
Minneapolis	2,048	19%
Robbinsdale	1,485	14%
New Hope	1,092	10%
Brooklyn Park	810	7%

Landuse	Acres	Percent
Highly Impervious (51-100%)	7,700	71%
Grassland and Shrubland	1,425	13%
Low-Mod Impervious (5-50%)	835	8%
Open Water	370	3%
Wetlands	309	3%
Forest	196	2%
Agriculture	16	0%

Soil Type	Acres	Percent
A	2,346	28%
A/D	2	<1%
B	1,892	23%
B/D	1,006	12%
C	89	1%
C/D	1,003	12%
Water	736	9%
Not Assessed (heavily disturbed)	1,249	15%

Untreated Area (Direct to Creek)	Acres
Minneapolis	1,342
Brooklyn Center	301
Robbinsdale	295
Crystal	57

STREAM MONITORING CURRENT CONDITIONS AND TRENDS

Water quality has been monitored routinely at one location, SC-0, in the Lower Shingle Creek Management Unit. This station is located in Webber Park in Minneapolis just upstream of 45th Ave. The SC-0 monitoring station drains approximately 82% of the Lower Shingle Creek Management Unit, as well as the entire Middle and Upper Shingle Creek Management Units. The Shingle Creek WMC began monitoring this station routinely in 2002. Shingle Creek was placed on the State's 303(d) list of impaired waterbodies in 1998 for chloride, in 2004 for DO, and in 2006 for macroinvertebrate IBI scores. TMDL studies were completed by the Commission and the MPCA in 2007 to address the chloride impairment and in 2011 to address the DO and macroinvertebrate IBI impairments. The Commission has continued to monitor this station every year since the completion of the TMDLs to assess water quality conditions in the Middle Shingle Creek Management Unit and measure progress toward achieving the TMDLs. Shingle Creek is considered a Class 2B water and is therefore subject to the North Central Hardwood Forest Class 2B water quality standards for streams.

Four main water quality parameters of concern have been sampled at the SC-0 monitoring station since 2002: TSS, TP, dissolved oxygen (DO), and chloride. Figure 6-2 contains a series of bar figures that summarize current water quality conditions at the SC-0 station for each of the aforementioned parameters. Each bar figure depicts the current condition, parameter units, parameter, and associated Class 2B water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is compared to the Class 2B standard. Long-term data trends for these parameters were assessed using a Mann-Kendall trend analysis corrected for flow. Parameters with long-term trends are denoted with red (declining) and blue (improving) arrows.

Monitoring results for other water quality parameters not covered in this section (ortho-P, TKN and nitrate) are presented in Appendices B and C. Also included in Figure 6-2 is the fish/macroinvertebrate IBI monitoring results for four biological monitoring stations in the Lower Shingle Creek Management Unit: SC-0, SC-1 (USGS), City Hall, and the Palmer Lake Outlet (Figure 6-1). Fish and macroinvertebrate IBI assessments were performed by the MPCA at the USGS site in the late 1990s and at the SC-0 site in 2010. Macroinvertebrate IBI assessments were conducted at the City Hall and Palmer Lake Outlet Sites in 2015 in support of the Shingle Creek Art Aeration Project.

Below is a general summary of the current conditions of the four main water quality parameters of concern and IBI monitoring results in the Lower Shingle Creek Management Unit.

TSS

- ▲ Long-term trend analysis suggests there is a decreasing trend in TSS at site SC-0 since 2002 (see Appendix C). However, while TSS concentrations have improved, they still do not currently meet the 30 mg/L Class 2B standard. The decreasing trend is likely due to enhanced street sweeping, stream restoration, BMP retrofits and other practices implemented by the cities throughout the Lower Management Unit since the early 2000s.
- ▲ Most of the high TSS measurements were collected during storm events and/or high flow conditions.

TP

- ▲ Similar to TSS, long-term trend analysis suggests there is a decreasing trend in TP concentrations at SC-0 since 2002 (see Appendix C), however TP concentrations still do not currently meet the 100 mg/L Class 2B standard. The decreasing trend is likely due to enhanced street sweeping, ban on phosphorus fertilizer, BMP retrofits and other practices implemented by the cities.
- ▲ Ortho-phosphorus (not shown on figure) concentrations for this site were relatively low suggesting phosphorus loads at this site are likely coming from particular sources attached to sediment.
- ▲ Since ortho-phosphorus is low, the decreasing TP trend at SC-0 is likely attributed to reductions particulate phosphorus and TSS loads throughout the Lower Shingle Creek Management Unit

DO

- ▲ DO at SC-0 does not currently meet the 5.0 mg/L Class 2B standard as DO levels consistently drop below 5.0 mg/L during the summer months.
- ▲ Longitudinal DO surveys performed along Shingle Creek throughout the Lower Management Unit indicate DO generally increases from upstream to downstream between the Palmer Lake Outlet and the SC-0 site. However, DO at SC-0 is consistently below the standard likely due to extremely low DO coming out of Palmer Lake and oxygen demand in the wetlands downstream of Palmer Lake.

Chloride

- ▲ Chloride levels at SC-0 are high and often exceed the Class 2B standard particularly during winter and spring snow melt events
- ▲ Long-term trend analysis suggests there is a slight increasing trend in chloride for the SC-0 site since 2002 (see Appendix C).
- ▲ The SC-0 site is located in Minneapolis downstream of several major roads, industrial facilities, and other high impervious areas. These areas are heavily trafficked have varying levels of road salt management during the winter months.

Fish and Invertebrate IBI Scores

- ▲ Fish IBI scores at the SC-0 site (0) and the USGS site (25) were well below the IBI standard threshold of 46, likely due to low DO levels and habitat conditions in this stretch of Shingle Creek.
- ▲ The invertebrate IBI score measured at the SC-0 site (15) in 2010 and the USGS site (20) in the late 1990s were both below the IBI threshold of 43. Invertebrate IBI scores measured at the City Hall and Palmer Lake Outlet Sites in 2015 were also well below the IBI threshold.

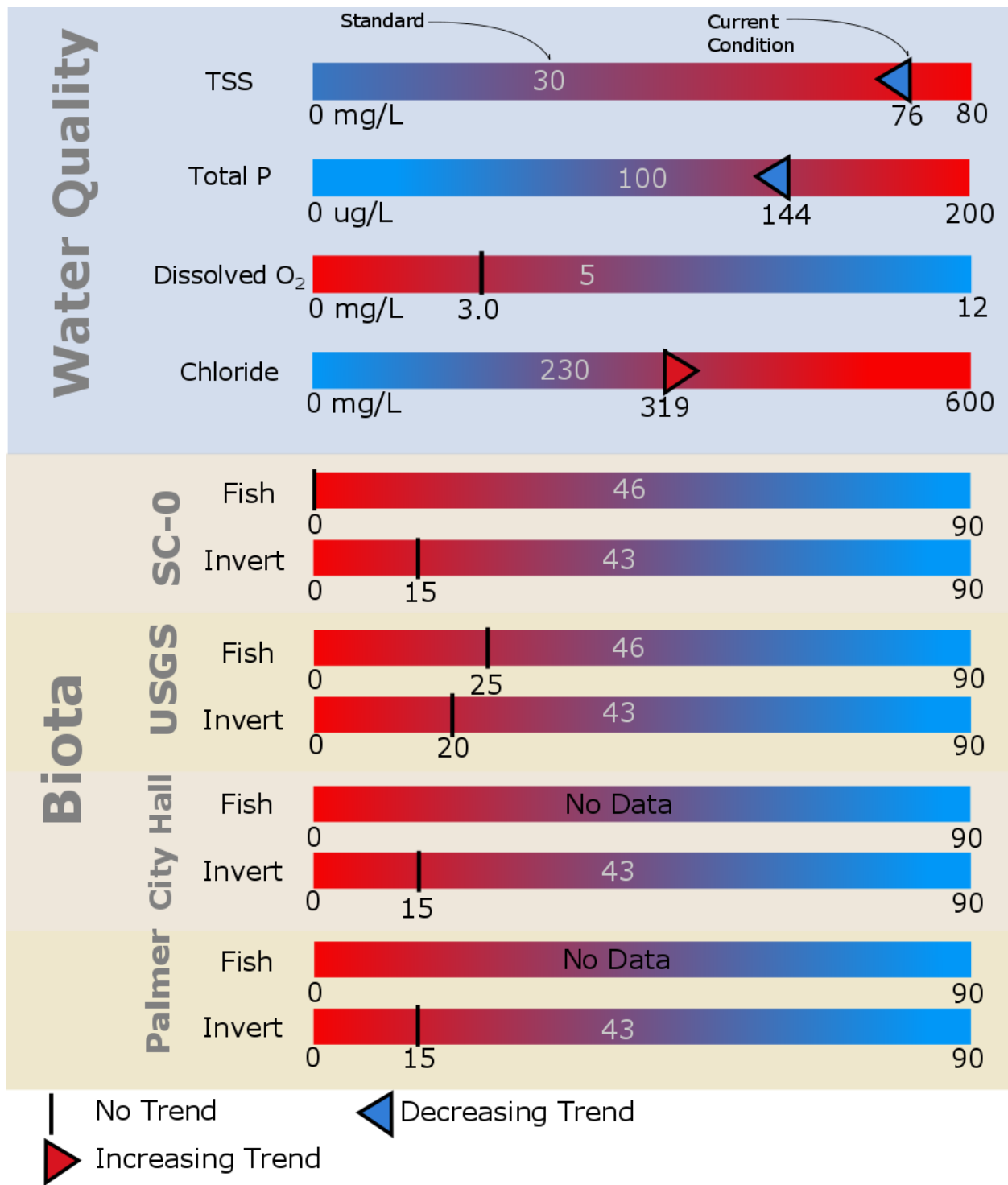


Figure 6-2. Lower Shingle Creek Management Unit stream water quality and IBI summary.

LAKE MONITORING CURRENT CONDITIONS AND TRENDS

Lake water quality has been monitored for all five lakes in the Lower Shingle Creek Management Unit since at least the mid-1990s. All of the lakes in the Lower Management Unit were assessed as impaired for nutrients (TP) in the early 2000s. TMDL studies for each lake were completed by the Commission and the MPCA through two different TMDL studies:

- ▲ The Twin and Ryan Lakes Nutrient TMDL (2007)
- ▲ The Crystal Lake Nutrient TMDL (2008)

Historic water quality sampling on each lake has focused on three main parameters: TP, chlorophyll-a, and Secchi depth (transparency). Figures 6-3 and 6-4 contain a series of bar figures that summarize the three water quality parameters for each lake. Each bar figure depicts the current condition, parameter units, parameter, and associated lake water quality standard. The color gradient on each bar depicts how far above (red) or below (blue) each parameter is compared to the standard. Long-term data trends for each lake are presented in Appendix D. While no formal trend analysis has been performed on these data, visual inspection of the figures in Appendix D does not indicate any increasing or decreasing data trends for the five lakes in the Lower Shingle Creek Management Unit over the past 10 years.

Below is a general summary of water quality conditions for each lake in the Lower Shingle Creek Management Unit over the past 10 years.

Twin Lake Chain

- ▲ Upper Twin and Middle Twin Lakes have consistently exceeded water quality standards over the past 10 years
- ▲ There does not appear to be any positive or negative trends in water quality for Upper Twin and Middle Twin and both lakes are still considered impaired
- ▲ Lower Twin has met state water quality standards over the past 10 years and was removed from the State's 303(d) list of impaired waters in 2016.

Ryan Lake

- ▲ Similar to Lower Twin, Ryan Lake has met state water quality standards over the past 10 years and was recently removed from the State's 303(d) list of impaired waters in 2016.

Crystal Lake

- ▲ Crystal Lake has not met State water quality standards over the past 10 years.

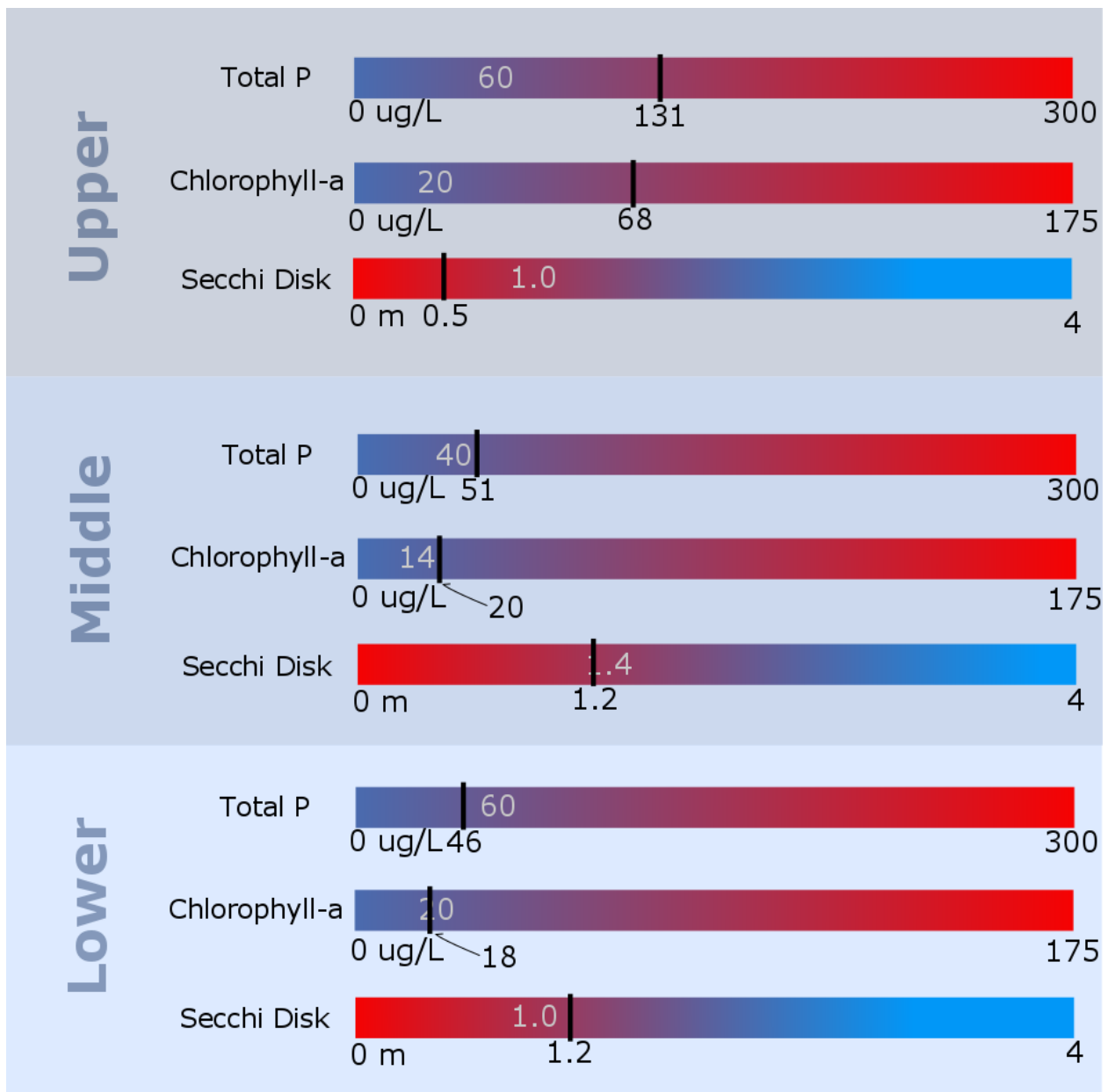


Figure 6-3. Water quality summary (recent 10 years) for Upper, Lower, and Middle Twin Lakes.

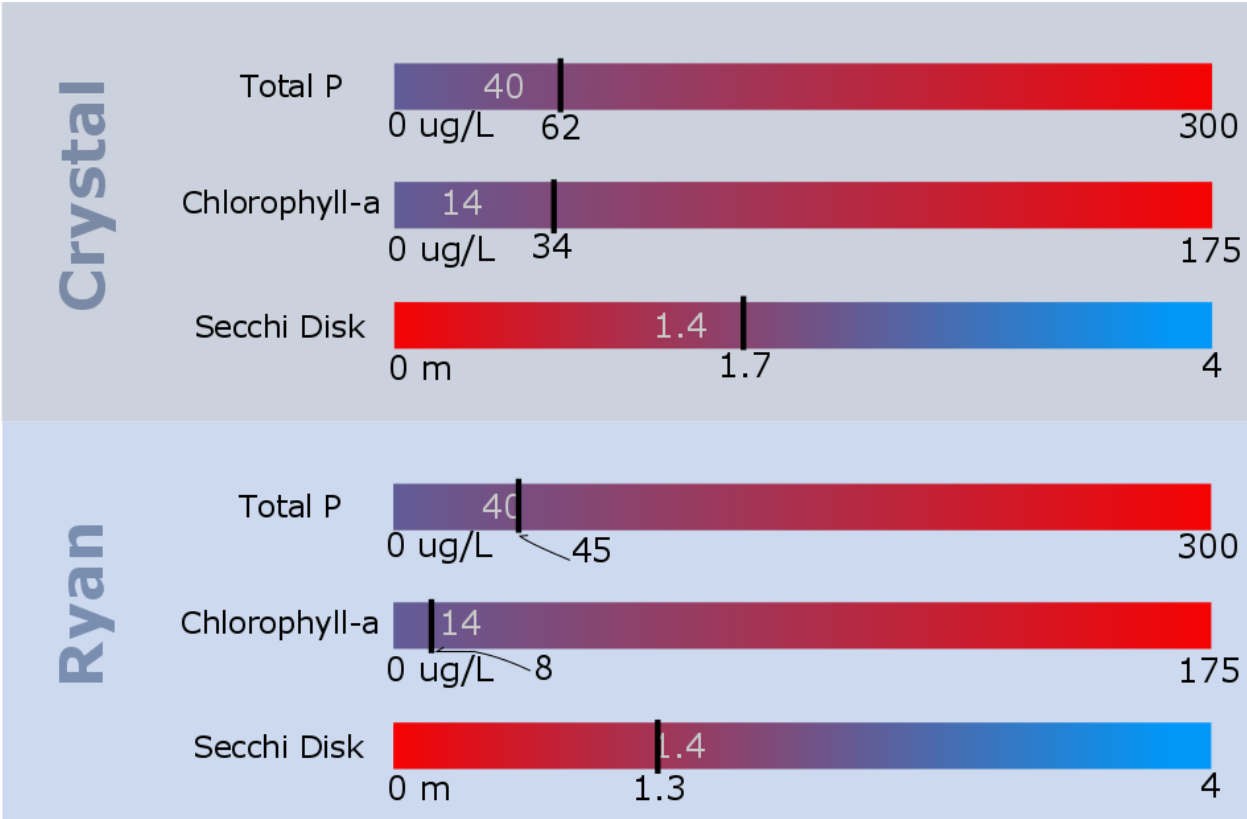


Figure 6-4. Water quality summary (recent 10 years) for Crystal and Ryan Lakes.

7.0 Recommendations

Results of the historic water quality monitoring for the four management units support the following conclusions and recommendations.

West Mississippi Management Unit

- ▲ Identify areas that currently have no water quality treatment and/or minimal treatment. Once these areas have been identified, they should be targeted for enhanced street sweeping and assessed for potential BMP retrofit opportunities.
- ▲ Identify bacteria sources and high potential loading areas.
- ▲ Salt management practices in the impervious areas upstream of the 65th Avenue outfall should be reviewed to determine potential sources of chloride at this location.

Upper Shingle Creek Management Unit

- ▲ TP concentrations currently exceed State standards near the outlet of Bass Creek, and monitoring indicates a high dissolved phosphorus component. The dissolved phosphorus is likely coming from the breakdown of organic matter and sediment release of phosphorus in the lakes, ponds and flow-through wetlands throughout the Upper Management Unit. Identify ponds and wetlands in or near the main channel (such as the Cherokee wetland) that are currently releasing phosphorus and investigate strategies to decrease these loads.

Shingle Creek Watershed-Wide

- ▲ Refine the stream Directly Connected Untreated Areas, target them for enhanced street sweeping and assess for potential BMP retrofit opportunities.
- ▲ Identify bacteria sources and high potential loading areas.
- ▲ Identify the Directly Connected Untreated Areas tributary to the lakes. Once these areas have been identified, they should be targeted for enhanced street sweeping and assessed for potential BMP retrofit opportunities.
- ▲ Evaluate opportunities for additional stream restoration and habitat enhancement.