2019 ANNUAL WATER QUALITY REPORT

APRIL 2020

Technical Appendices

Shingle Creek

West Mississippi
Watershed Management Commission

Appendix A: Precipitation Data

Table A1. Summary of 2019 and long-term precipitation data measured at the New Hope weather station.

Month	2019 Precipitation (inches)	1992-2018 Monthly Average Precipitation (inches)	Departure from Historical Average (inches)
January	0.46	0.99	-0.51
February	2.39	0.89	1.44
March	2.42	1.81	0.59
April	3.23	3.21	0.02
May	7.59	4.19	3.27
June	2.71	4.56	-1.78
July	6.18	4.36	1.75
August	6.48	3.79	2.59
September	4.39	2.97	1.37
October	5.61	2.68	2.82
November	2.31	1.69	0.60
December	2.01	1.34	0.65
TOTAL	45.78	32.47	12.82

Figure B1. Flow at the Mattson Brook sampling station. The blue line represents flow in cubic feet per second (cfs). Daily precipitation totals in inches are represented in gray on the secondary axis.

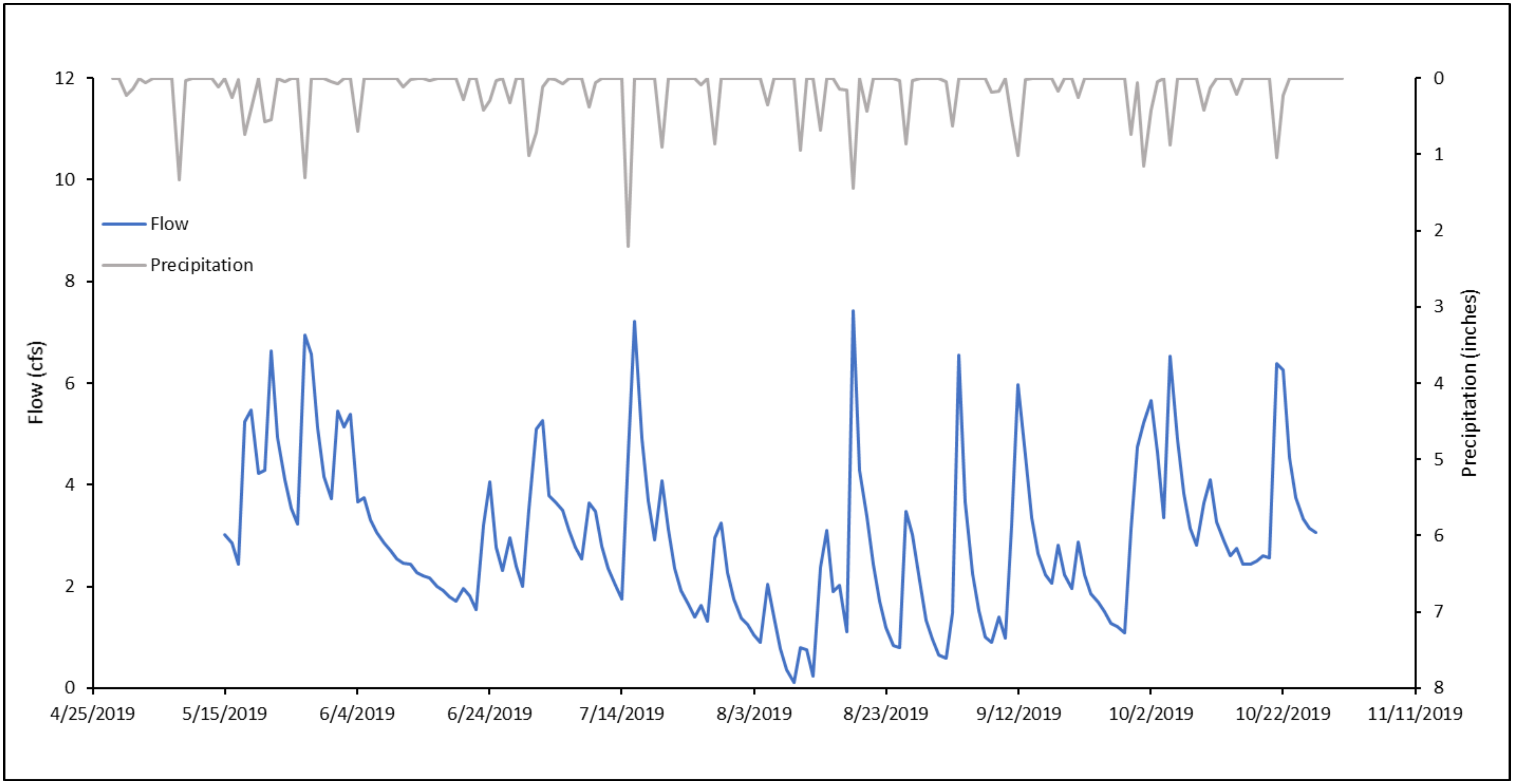


Figure B2. Flow at the Environmental Preserve sampling station. The blue line represents flow in cubic feet per second (cfs). Daily precipitation totals in inches are represented in gray on the secondary axis. Stage height was not recorded from 5/23/19 to 6/4/19 due to instrumental error, so data is missing during this window.

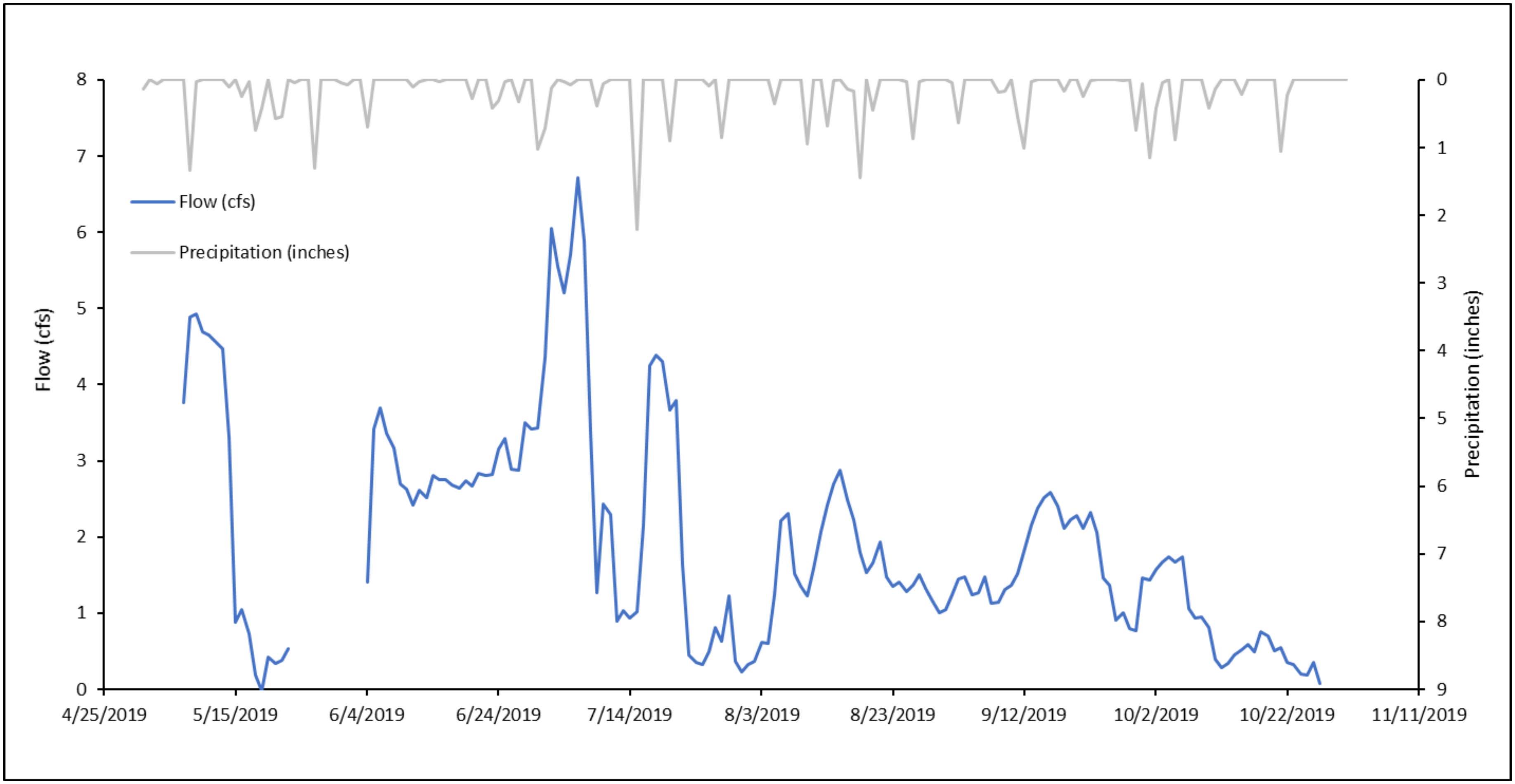


Table B1. Water quality data from the Mattson Brook site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), oxidation reduction potential (ORP), total phosphorus (TP), orthophosphate (orthoP), total suspended solids (TSS), chloride and Escherichia coli (E. coli).

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. Cond. [μS/cm]	ORP [mV]	TP [mg/L]	OrthoP [mg/L]	TSS [mg/L]	Chloride [mg/L]	E. coli [MPN/100mL]
4/29/2019	17:00	10.6	12.72	113.0	8.09	1,751	209	0.060	0.008	5.8	327.0	—
5/14/2019	14:30	15.6	11.93	124.0	8.73	1,481	329	0.059	0.008	23.5	51.5	32.3
6/4/2019	14:30	18.4	7.21	80.7	7.62	1,231	179	0.083	0.048	1.9	193.0	209.8
7/8/2019	12:30	20.9	7.06	79.1	7.45	1,142	158	0.150	0.085	2.8	163.0	206.4
8/5/2019	10:30	21.4	7.19	84.4	7.84	1,221	475	0.102	0.087	1.6	182.0	186.0
9/16/2019	8:15	16.6	8.19	88.2	7.97	904	430	0.073	0.057	1.0	—	67.0
10/27/2019	12:00	7.4	10.55	90.9	7.73	1,012	414	0.041	0.015	1.4	107.0	82.0

Table B2. Storm water quality data from the Mattson Brook site measured in 2019. Parameters measured include total phosphorus (TP), orthophosphate (orthoP), total suspended solids (TSS) and Escherichia coli (E. coli).

Start Date	Time	End Date	Time	TP [mg/L]	OrthoP [mg/L]	TSS [mg/L]	E. coli [MPN/100mL]
7/15/2019	17:18	7/15/2019	23:03	0.443	0.015	130.0	2,419.6
8/5/2019	12:58	8/5/2019	18:29	0.242	0.061	30.2	>2,419.6
9/9/2019	14:05	9/9/2019	18:59	0.106	0.044	23.2	>2,419.6
9/11/2019	4:31	9/11/2019	5:32	0.276	0.051	57.1	>2,419.6

Table B3. Water quality data from the Environmental Preserve stream site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), total phosphorus (TP), orthophosphate (orthoP), total suspended solids (TSS) chloride and Escherichia coli (E. coli).

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. Cond. [µS/cm]	ORP [mV]	TP [mg/L]	OrthoP [mg/L]	TSS [mg/L]	Chloride [mg/L]	E. coli [MPN/100mL]
5/14/2019	15:15	19.4	10.48	118.4	8.74	871.2	325	0.064	0.007	5.7	176.0	5.1
6/4/2019	15:30	24.3	8.77	104.9	7.98	821.0	173	0.074	0.011	19.8	82.5	21.1
7/8/2019	11:00	23.9	8.16	97.0	7.56	784.0	164	0.115	0.032	23.6	73.3	157.6
8/5/2019	10:00	21.1	7.42	86.7	7.81	862.0	488	0.064	0.028	7.0	79.3	290.9
9/16/2019	9:00	16.6	8.13	—	7.87	802.0	449	0.054	0.038	5.4	—	54.8
10/27/2019	13:00	8.6	11.37	100.9	7.88	836.8	399	0.080	0.009	8.2	62.7	19.3

Table B4. Storm water quality data from the Environmental Preserve stream site measured in 2019. Parameters measured include total phosphorus (TP), orthophosphate (orthoP), total suspended solids (TSS) and Escherichia coli (E. coli).

Start Date	Time	End Date	Time	TP [mg/L]	OrthoP [mg/L]	TSS [mg/L]	E. coli [MPN/100mL]
5/20/2019	12:45	5/20/2019	14:30	0.097	0.006	24.1	150.0
7/16/2019	8:58	7/16/2019	9:16	0.126	0.022	28.7	2,419.6
8/6/2019	9:38	8/6/2019	11:08	0.106	0.016	16.5	528.0
9/11/2019	9:37	----	----	0.102	0.035	27.8	613.1

Appendix C: 2018 Shingle Creek Stream Data

Figure C1. Daily flow in cubic feet per second (cfs) for all monitored Shingle Creek locations, including SC-3, SC-0 and BCP. Daily precipitation totals (inches) are represented in gray on the secondary axis.

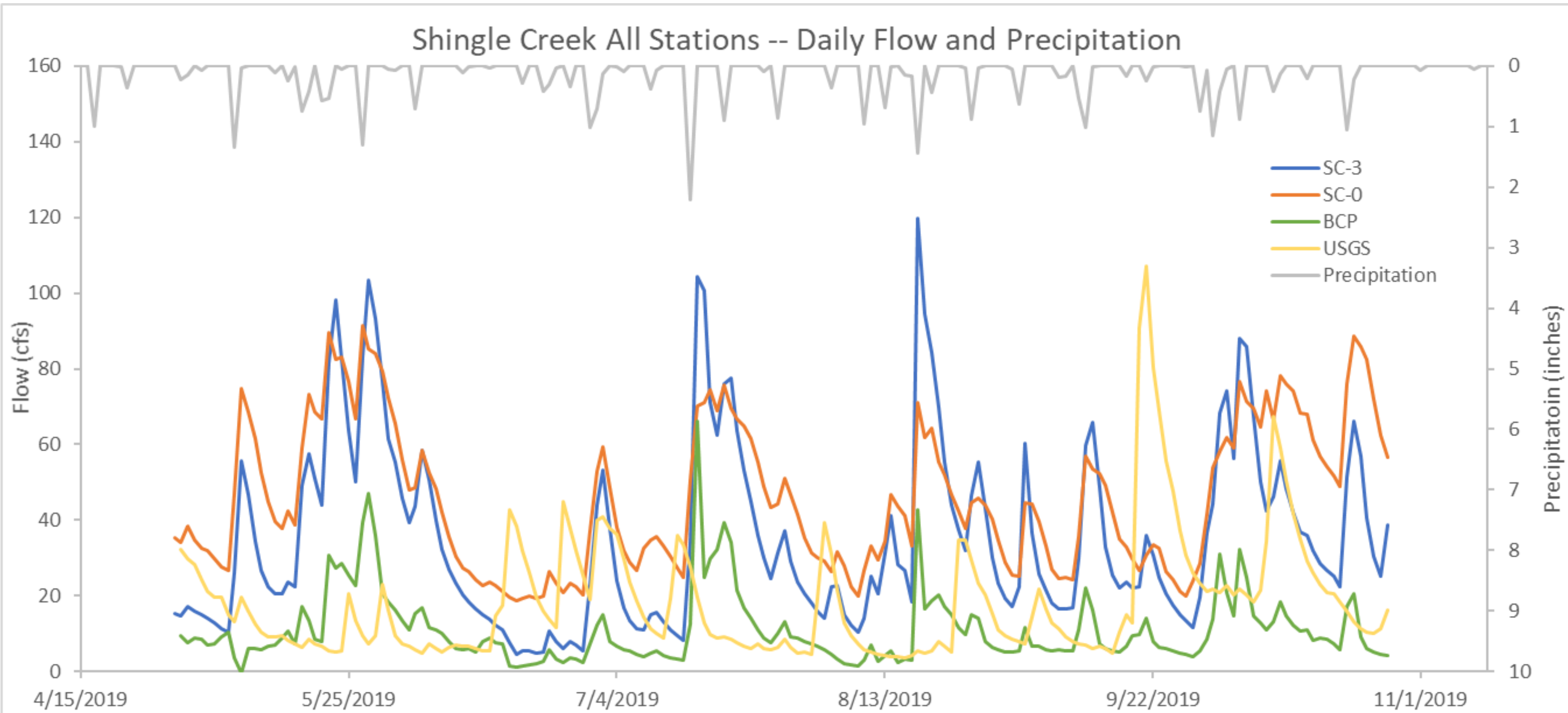


Figure C2. Annual precipitation and runoff depth for Shingle Creek stream sites.

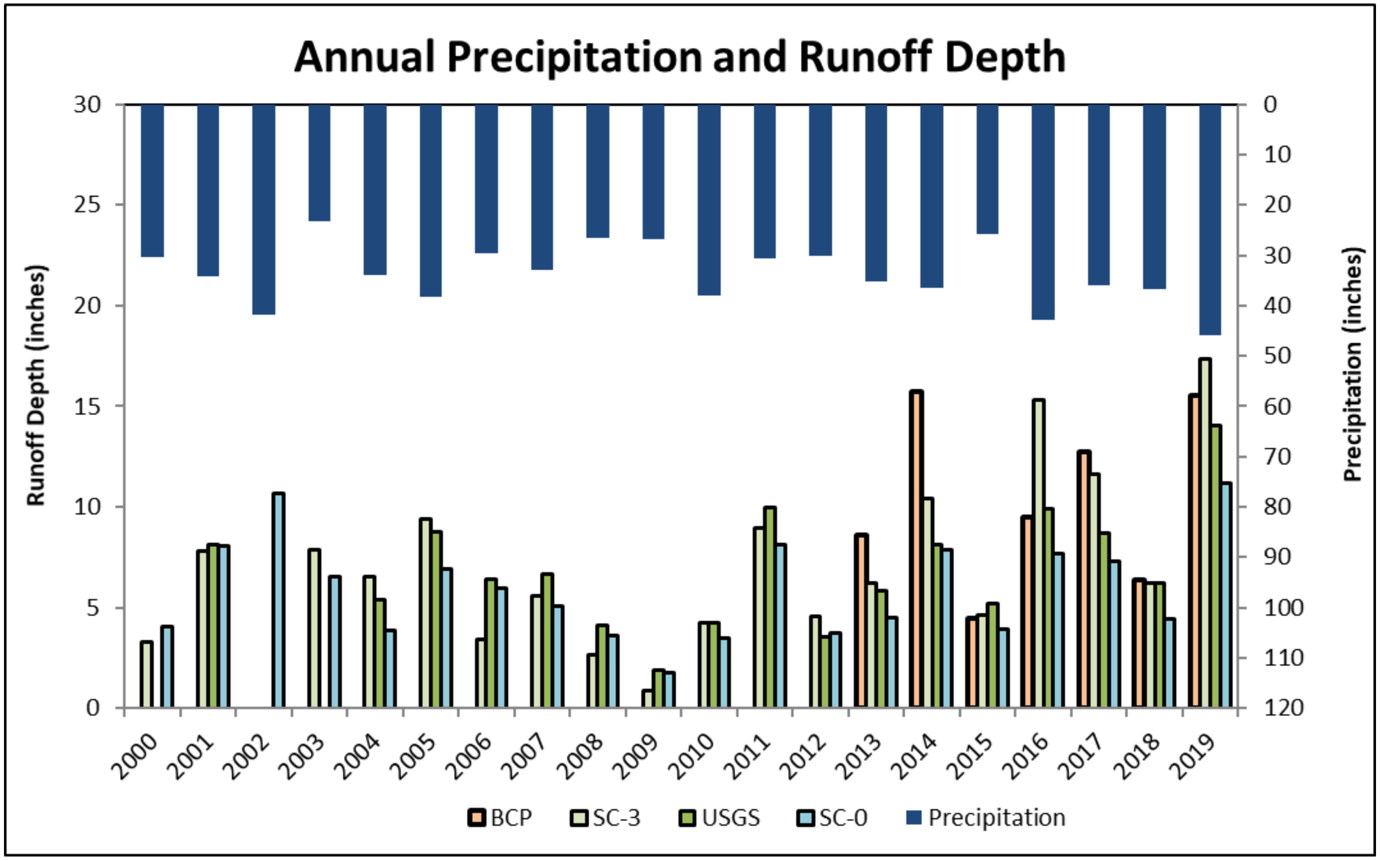


Table C1. Water quality data from the Shingle Creek SC-0 stream site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), oxidation reduction potential (ORP), total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS), chloride and Escherichia coli (E. coli).

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. cond. [µS/cm]	ORP [mV]	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	Chloride [mg/L]	E. coli [MPN/100mL]
1/23/2019	13:30	—	11.14	76.2	6.94	1,537.0	132	—	—	—	—	248	—
2/21/2019	14:00	0.1	11.14	76.8	7.49	1,683.0	152	—	—	—	—	287	—
3/14/2019	13:45	—	—	—	—	—	—	—	—	—	—	378	—
4/29/2019	14:45	11.2	14.23	130.0	8.25	1,015.0	301	0.062	0.003	0.016	6.5	196	—
5/14/2019	13:30	15.1	10.53	108.2	8.46	960.2	339	0.073	0.008	0.030	6.4	131	21.6
5/23/2019	12:00	12.1	7.51	72.1	8.42	598.5	289	0.091	0.018	0.036	16.9	119	275.5
6/4/2019	14:00	19.8	7.95	87.4	7.49	912.0	177	0.079	0.015	0.041	7.7	154	45.2
6/18/2019	14:30	19.3	6.50	72.9	7.57	1,090.2	450	0.065	0.020	0.037	4.3	188	292.4
7/8/2019	14:00	24.0	5.44	64.8	7.20	889.0	154	0.113	0.048	0.086	4.2	152	298.7
7/23/2019	12:15	21.8	4.74	55.2	7.27	659.1	445	0.138	0.073	0.100	7.9	—	53.7
8/5/2019	11:15	23.8	4.97	61.1	7.57	868.4	471	0.067	0.036	0.040	3.3	151	151.0
8/20/2019	12:30	20.7	5.08	58.3	7.37	378.3	438	0.131	0.047	0.056	21.9	—	>2,419.6
9/16/2019	7:15	18.5	6.56	72.2	7.67	631.9	459	0.065	0.027	0.028	7.4	—	261.3
9/25/2019	10:30	17.8	6.43	70.6	7.73	811.6	440	0.048	0.022	0.021	4.0	—	98.5
10/9/2019	7:45	12.3	7.61	72.4	7.02	607.7	467	0.057	0.022	0.029	6.5	—	78.5
10/27/2019	10:30	7.1	8.83	75.7	7.44	793.3	413	0.056	0.013	0.022	3.9	106	37.3
11/20/2019	9:00	4.7	9.25	74.3	7.38	991.1	491	—	—	—	—	140	—
12/17/2019	10:30	0.18	11.56	82.1	7.39	1,165.4	355	—	—	—	—	171	—

Table C2. Storm water quality data from the Shingle Creek SC-0 stream site measured in 2019. Parameters measured include total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS) and Escherichia coli (E. coli).

Start Date	Start Time	End Date	End Time	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	E. coli [MPN/100mL]
5/8/2019	13:12	5/8/2019	18:57	0.286	0.003	0.051	64	307.6
7/15/2019	17:09	7/15/2019	23:17	0.281	0.004	0.033	89	>2,419.6
8/5/2019	13:16	8/5/2019	15:31	0.116	0.010	0.022	15	9,804.0
8/26/2019	13:17	8/26/2019	16:17	0.106	0.007	0.021	35	17,329.0
9/9/2019	15:46	9/9/2019	20:36	0.066	0.015	—	8	>2,419.6
9/11/2019	4:31	9/11/2019	5:32	0.112	0.029	0.033	27	>2,419.6

Table C3. Water quality data from the Shingle Creek SC-3 stream site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), oxidation reduction potential (ORP), total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS), chloride (mg/L) and Escherichia coli (E. coli). Note that there is no data from January and February because water was frozen at this site during sampling events.

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. cond. [µS/cm]	ORP [mV]	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	Chloride [mg/L]	E. coli [MPN/100mL]
3/14/2019	13:00	—	—	—	—	—	—	—	—	—	—	577	—
4/29/2019	12:30	9.3	11.16	97.4	7.77	909.0	311	0.037	0.008	0.020	2.8	194	—
5/14/2019	12:30	14.2	9.12	92.3	8.25	872.8	339	0.048	0.015	0.031	1.5	102	77.1
5/23/2019	11:00	11.7	6.24	59.4	8.22	609.0	275	0.062	0.018	0.033	12.7	130	193.5
6/4/2019	13:00	19.6	7.26	78.3	7.26	799.0	185	0.094	0.035	0.053	4.2	149	74.9
6/18/2019	13:45	18.9	5.29	59.0	7.27	1,039.5	455	0.100	0.029	0.050	4.6	195	149.7
7/8/2019	10:00	21.4	4.85	55.1	7.02	817.0	178	0.164	0.076	0.113	8.4	158	920.8
7/23/2019	10:30	21.4	4.21	48.9	7.06	607.5	440	0.144	0.062	0.090	5.6	—	185
8/5/2019	9:15	22.4	5.16	61.9	7.50	809.3	511	0.099	0.041	0.057	5.2	155	172
8/20/2019	12:00	20.3	5.27	60.5	7.22	331.6	436	0.118	0.012	0.029	27.2	—	>2,419.6
9/16/2019	9:45	17.2	6.13	65.8	7.46	629.1	461	0.062	0.024	0.030	7.2	—	248.1
9/25/2019	9:30	17.0	5.87	63.3	7.54	702.3	445	0.070	0.030	0.040	6.2	—	209.8
10/9/2019	8:30	12.1	7.19	69.5	7.31	569.4	466	0.037	0.012	0.021	2.6	—	115.3
10/27/2019	9:45	6.4	8.81	73.9	7.37	682.8	392	0.037	0.010	0.018	2.7	105	27.5
11/20/2019	8:30	3.4	9.97	77.4	7.20	866.7	492	—	—	—	—	146	—
12/17/2019	10:00	0.1	10.49	74.3	7.24	1,036	355	—	—	—	—	189	—

Table C4. Storm water quality data from the Shingle Creek SC-3 stream site measured in 2019. Parameters measured include total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS) and Escherichia coli (E. coli).

Start Date	Start Time	End Date	End Time	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	E. coli [MPN/100mL]
5/8/2019	12:23	5/8/2019	18:08	0.321	0.123	0.203	34.8	980.4
7/15/2019	13:04	7/15/2019	22:54	0.313	0.030	0.057	68.6	>2,419.6
8/5/2019	12:52	8/5/2019	18:22	0.222	0.057	0.071	23.4	>24,196.0
8/26/2019	12:56	8/26/2019	18:26	0.122	0.022	0.034	25.6	3,076.0
9/9/2019	17:12	9/9/2019	18:12	0.068	0.012	—	12.5	547.5
9/11/2019	4:12	9/11/2019	8:32	0.086	0.027	0.040	10.3	>2,419.6

Table C5. Water quality data from the Bass Creek Park (BCP) stream site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), oxidation reduction potential (ORP), total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS), chloride and Escherichia coli (E. coli). Note that there is no data from January and February because water was frozen at this site during sampling events.

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. Cond. [µS/cm]	ORP [mV]	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	Chloride [mg/L]	E. coli [MPN/100mL]
3/14/2019	12:30	—	—	—	—	—	—	—	—	—	—	682	—
4/29/2019	10:00	9.5	10.39	91.2	7.81	854.0	340	0.040	0.010	0.021	3.0	184	—
5/14/2019	11:30	16.0	10.04	105.5	8.35	805.0	327	0.050	0.020	0.038	1.3	122	75.9
5/23/2019	9:30	11.5	6.97	66.2	8.32	634.8	295	0.048	0.027	0.042	2.5	126	248.9
6/4/2019	9:30	19.0	7.28	78.6	7.37	747.0	200	0.073	0.036	0.055	2.8	143	159.7
6/18/2019	11:00	16.1	4.46	47.0	7.36	1,038.2	468	0.108	0.027	0.055	3.2	212	517.2
7/8/2019	8:30	20.5	3.54	39.5	7.02	795.0	190	0.196	0.091	0.157	2.2	158	172.0
7/23/2019	9:00	21.5	4.49	52.4	7.24	604.2	395	0.107	0.062	0.085	2.7	—	62.4
8/5/2019	8:30	22.0	3.78	21.79	7.43	676.1	520	0.107	0.055	0.067	2.4	134	114.5
8/20/2019	11:20	20.5	5.32	61.70	7.39	409.9	445	0.154	0.063	0.078	20.7		>2,419.6
9/16/2019	10:15	17.5	5.93	64.10	7.69	618.6	445	0.112	0.046	0.052	10.5	—	307.6
9/25/2019	8:30	17.0	5.41	58.40	7.54	642.3	437	0.119	0.058	0.068	6.3	—	410.6
10/9/2019	9:00	12.1	7.55	72.9	7.44	553.60	456	0.046	0.020	0.026	2.2	—	48.7
10/27/2019	9:00	5.4	8.50	69.7	7.23	728.6	461	0.058	0.015	0.022	3.5	114	32.7
11/20/2019	8:15	2.8	10.08	77.2	7.27	842.4	501	—	—	—	—	139	—
12/17/2019	9:15	-.1	10.00	70.6	7.11	1,165.4	420	—	—	—	—	152	—

Table C6. Storm water quality data from the Bass Creek Park (BCP) stream site measured in 2019. Parameters measured include total phosphorus (TP), orthophosphate (orthoP), total dissolved phosphorus (TDP), total suspended solids (TSS) and Escherichia coli (E. coli).

Start Date	Time	End Date	End Time	TP [mg/L]	OrthoP [mg/L]	TDP [mg/L]	TSS [mg/L]	E. coli [MPN/100mL]
7/16/2019*	8:00	—	—	0.195	0.088	0.119	13.6	>2,419.6
5/8/2019	13:12	5/8/2019	18:57	0.249	0.087	0.136	34.5	2,419.6
8/5/2019	12:55	8/5/2019	19:47	0.184	0.039	0.068	18.8	19,863.0
9/11/2019*	10:36	—	—	0.166	0.064	0.068	19.8	>2,419.6

*Storm samples from 7/16/19 and 9/11/19 are grab samples, i.e, unlike other storm samples, they were not composite samples and were not taken during the course of the storm, but were taken soon after.

Table C7. Water quality data from the United States Geological Survey (USGS) stream site measured in 2019. Parameters measured include temperature (temp.), dissolved oxygen (DO), percent saturated dissolved oxygen (DO_{sat}), pH, specific conductivity (sp. cond.), oxidation reduction potential (ORP) and chloride.

Date	Time	Temp. [°C]	DO [mg/L]	DO_{sat} [%]	pH	Sp. cond. [µS/cm]	ORP [mV]	Chloride [mg/L]
1/23/2019	13:15	1.3	10.01	71.0	6.93	1,527.0	115	258
2/21/2019	14:45	1.8	10.52	76.29	7.45	1,548.0	125	261
3/14/2019	13:30	—	—	—	—	—	—	499
11/20/2019	9:15	2.8	7.90	63.8	7.25	1036.8	446	139
12/17/2019	10:45	1.3	9.64	70.6	7.25	1,230.0	356	190

Appendix D: 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.

In 2019 volunteers assessed 31 sites across Hennepin County. On a scale of 1 to 30, the macroinvertebrate IBI scores ranged from a low of 5 (poor) to a high of 19 (excellent), with most of the sites in the 7-11 (poor) range. On a scale of 1 to 35, the vegetation IBI scores ranged from 7 (poor) to 27 (excellent). This is unsurprising as most urban wetlands exhibit variable macroinvertebrate and vegetative diversity due to their altered hydrology and pollutant and sediment conveyed by storm sewers. It is not uncommon for a site to score well on one metric and poorly on the other, illustrating the difficulty of "rating" wetlands.

1.1.1 2019 Monitoring

Four sites were monitored in 2019: two in West Mississippi (both in Brooklyn Park) and two in Shingle Creek (one in Brooklyn Park, one in Crystal).

West Mississippi

Zane Sports Park (Figure D -1), riparian to Century Channel in Brooklyn Park. It scores poorly for macroinvertebrates (Table D-1), likely because the water levels in the wetland fluctuate. Because it receives runoff through Century Channel that is likely high in sediment and nutrients, plant diversity is moderate.

Table D-1. WHEP site BP-7, Zane Sports Park, Brooklyn Park.

Year	2015	2016	2019
Invertebrate	8 (poor)	8 (poor)	6 (poor)
Vegetation	17 (moderate)	19 (moderate)	17 (moderate)

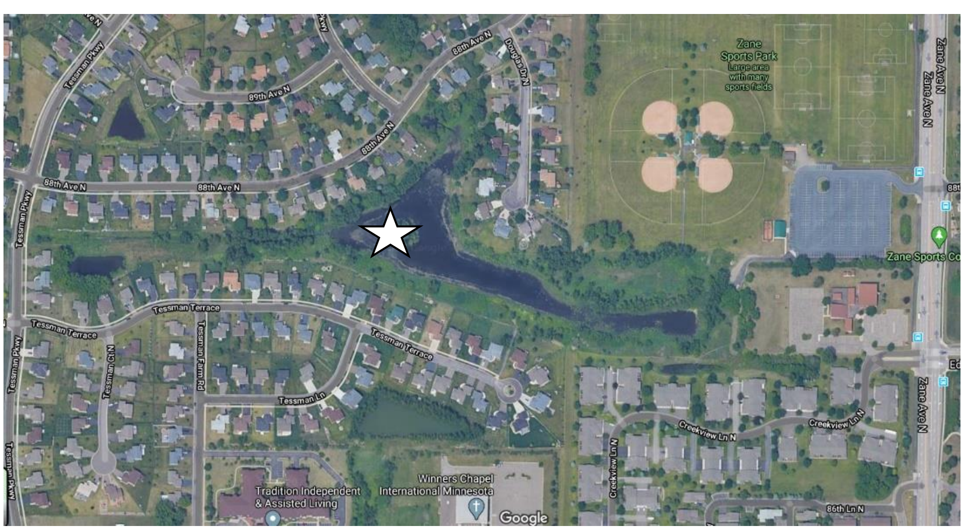


Figure D-1. Zane Sports Park wetland (BP-7) in Brooklyn Park.

A wetland in Brooklyn Park's Environmental Preserve (Figure D-2) has been monitored frequently, and serves as a reference and training site. This higher-quality wetland receives stormwater from a large area to the west that has developed in the last 10-15 years. This area is served by several detention ponds to treat runoff, and the health of BP-1 is one indicator of the effectiveness of that treatment in protecting downstream resources. Invertebrate health appears to be degrading. However, 2019 is the first year in the long history of monitoring that we have seen a slight improvement in the Invertebrate IBI score. (Table D-2).

Table D-2. WHEP site BP-1, Environmental Preserve, Brooklyn Park.

Year	2006	2007	2008	2009	2010	2011	2015	2016	2019
Invertebrate	28 (ex)	22 (mod)	21 (mod)	20 (mod)	20 (mod)	18 (mod)	18/20 (mod)	7 (poor)	8 (poor)
Vegetation	13 (poor)	19 (mod)	22 (mod)	19 (mod)	19 (mod)	20 (mod)	23/27 (mod/ex)	17 (mod)	23 (mod)

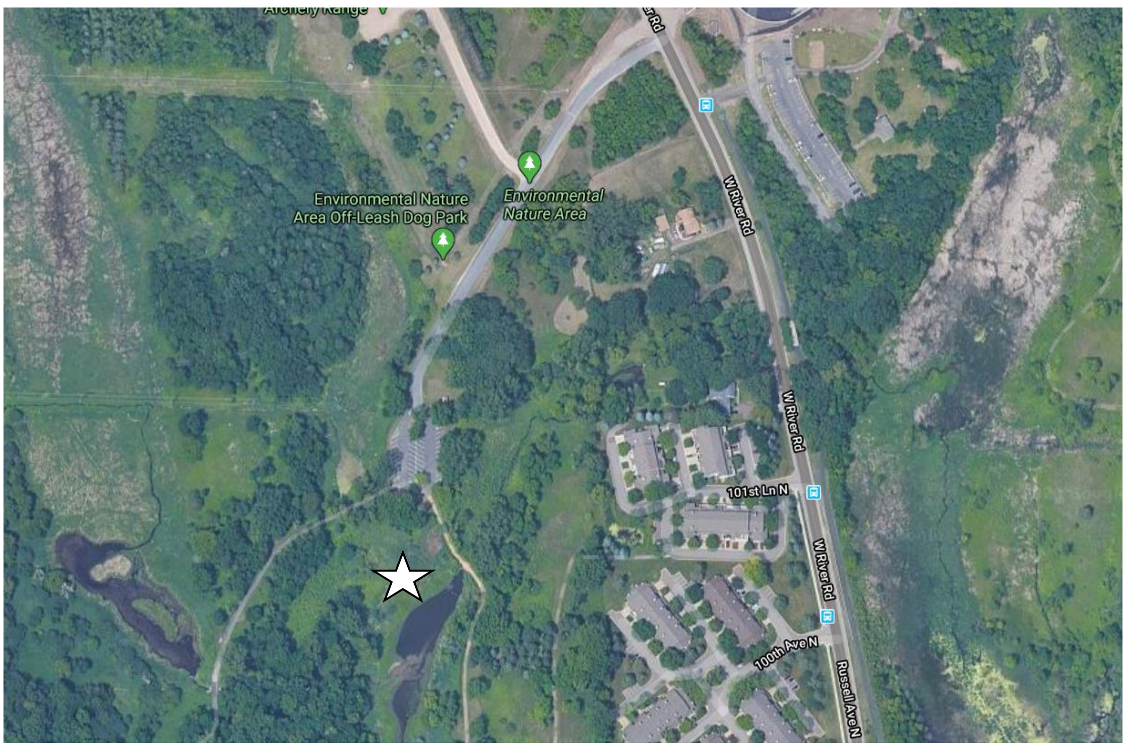


Figure D-2. Environmental Preserve wetland (BP-1) in Brooklyn Park.

Shingle Creek

Site BP-5 is in Brookdale Park, in a series of wetlands just south of Shingle Creek, downstream of Noble Avenue and "monkey falls." Old records show that before the Creek was straightened and channelized through the park, it meandered through these wetlands. (Table D-3 and Figure D-3). This wetland had some of the better scores of the WHEP wetlands in the watersheds until 2018 when both metrics were poor. In 2019 the invertebrate IBI score got worse, but the vegetation IBI score improved back into the moderate category.

Table G-3. WHEP site BP-5, Brookdale Park, Brooklyn Park.

Year	2014	2015	2018	2019
Invertebrate	24 (excellent)	16 (moderate)	8 (poor)	6 (poor)
Vegetation	15 (moderate)	25 (moderate)	13 (poor)	23 (moderate)

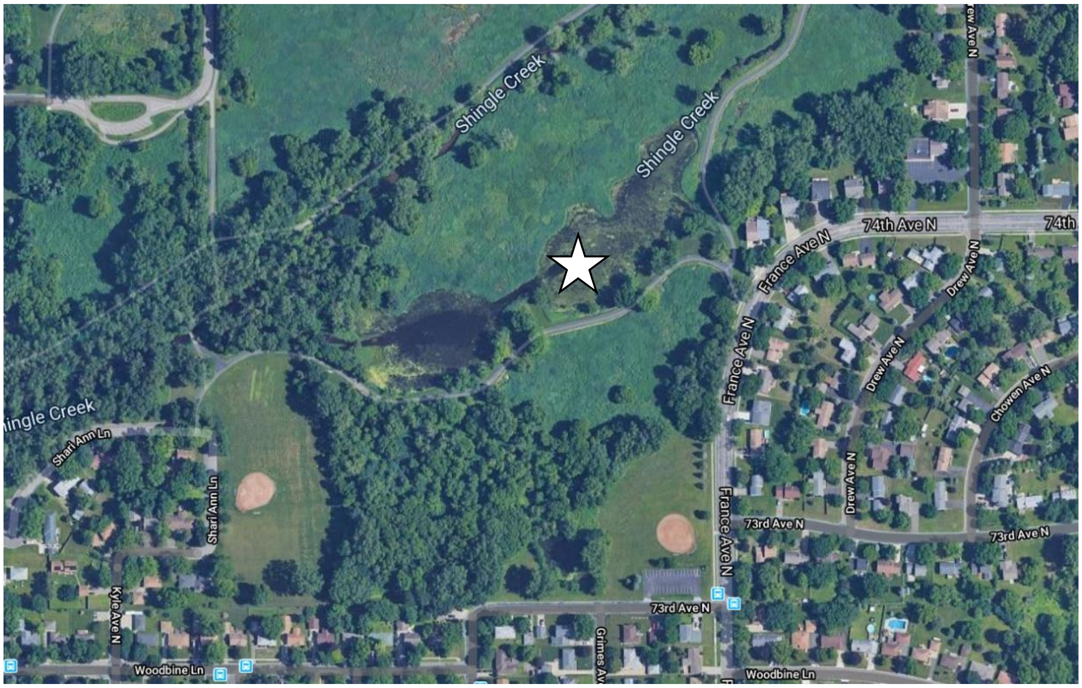


Figure D-3. Wetlands in Brookdale Park (BP-5), Brooklyn Park.

Site CR-1 is in Wetland 639W in Crystal (Figure D-4), just East of the Crystal Airport and North of 60th Ave N. Both scores for this wetland got worse from 2014 to 2019. The wetland scored moderate for macroinvertebrates and poor for vegetation in 2019 (Table D-4).

Table D-4. WHEP site CR-1, Wetland 639W, Crystal.

Year	2012	2013	2014	2019
Invertebrate	16 (moderate)	16 (moderate)	22 (moderate)	14 (moderate)
Vegetation	13 (poor)	17 (moderate)	19 (moderate)	11 (poor)

Figure D-4. Wetland in Wetland 639W (CR-1), Crystal.

Wetlands previously monitored but not in 2019 include:

West Mississippi

In 2008 and 2009 a wetland in Brooklyn Park's Jewel Park was monitored (Table D-5). Typical of small remnant wetlands in the watershed, this site is dominated by cattails and this monoculture greatly reduces both invertebrate and plant diversity.

Table D-5 WHEP site BP-3, Jewel Park, Brooklyn Park.

Year	2008	2009
Invertebrate	10 (poor)	20 (moderate)
Vegetation	7 (poor)	10 (poor)

The Oxbow Ponds site is in a series of ponds and remnant wetlands north of "Oxbow Lake" near Regent and 101st Avenues North (Figure D-2) related to the 2002 development of Oxbow Commons. This area has rapidly developed in the past ten years, contains protected and mitigation wetlands, and is in an area where other wetlands have lost their hydrology. This site scored moderately well on both metrics in previous years but in 2017 and 2018 was rated Poor (Table D-2).

Table D-6. WHEP site BP-4, Oxbow Ponds, Brooklyn Park.

Year	2012	2013	2014	2017	2018
Invertebrate	16 (moderate)	16 (moderate)	24 (excellent)	9 (poor)	9 (poor)
Vegetation	16 (moderate)	21 (moderate)	21 (moderate)	11 (poor)	11 (poor)

Table D-7. WHEP site CH-1, Mitigation Wetland, Champlin.

Year	2010	2011	2012	2013
Invertebrate	8 (poor)	16 (moderate)	18 (moderate)	18 (moderate)
Vegetation	11 (poor)	15 (poor)	7 (poor)	15 (poor)

Bartusch Park in Champlin (Figure D -1), in the northwest quadrant of 109th and Maryland Avenues N. This is a deeper wetland, so it is able to support more organisms (Table D-1).

Table D-8. WHEP site CH-3, Bartusch Park, Champlin.

Year	2015	2017	2018
Invertebrate	20 (moderate)	15 (moderate)	15 (moderate)
Vegetation	21 (moderate)	15 (poor)	15 (poor)

Shingle Creek

A wetland in Brooklyn Park just north of Palmer Lake was monitored in 2007-2009. The results (Table D-9) illustrate how variable biotic health can be based on precipitation.

Table D-9. WHEP site BP-2, Brookdale Drive Wetland, Brooklyn Park.

	2007	2008	2009
Invertebrate	16 (moderate)	20 (moderate)	13 (poor)
Vegetation	15 (poor)	7 (poor)	10 (poor)

A mitigation wetland in Palmer Lake Park just south of Palmer Lake was monitored for four years (Table D-10). Biotic quality varied, likely due to variations in precipitation.

Table D-10. WHEP site BC-1, South Palmer Lake, Brooklyn Center.

Year	2010	2011	2012	2013
Invertebrate	24 (excellent)	18 (moderate)	22 (moderate)	22 (moderate)
Vegetation	17 (moderate)	11 (poor)	19 (moderate)	17 (moderate)

Site BC-2 is a stormwater pond constructed in an upland area of the west side of the Palmer Lake Basin. This pond receives runoff from a large neighborhood to the west that had previously flowed untreated in the basin (Table D-11.)

Table D-11. WHEP site BC-2, West Palmer Lake, Brooklyn Center.

Year	2012	2013	2014
Invertebrate	14 (poor)	14 (poor)	16 (moderate)
Vegetation	17 (moderate)	19 (moderate)	19 (moderate)

Wetland 639W in Crystal has in the past been monitored. This site showed moderate invertebrate and vegetative diversity (Table D-12).

Table D-12. WHEP site CR-1, Wetland 639W, Crystal.

Year	2012	2013	2014
Invertebrate	16 (moderate)	16 (moderate)	22 (moderate)
Vegetation	13 (poor)	17 (moderate)	19 (moderate)

The site BP-6 is in Greenhaven Park in Brooklyn Park. This wetland is riparian to Shingle Creek, which flows north, turns almost 90 degrees to the east and flows under Bottineau Boulevard and past Wal-Mart (Table D-13).

Table D-13. WHEP site BP-6, Greenhaven Park, Brooklyn Park.

Year	2014
Invertebrate	22 (moderate)
Vegetation	25 (moderate)

One of the first sites monitored through this program was in Plymouth in Timber Shores Park in the wetland complex at the outlet of Bass Lake (Table D-14.).

Table D-14. WHEP site PL-6, Timber Shores, Plymouth.

Year	2005	2006	2008	2009	2010	2015	2016
Invertebrate	10 (poor)	16 (mode)	22 (mod)	24 (ex)	18/22 (mod)	22 (mod)	13 (mod)
Vegetation	15 (poor)	15 (poor)	17 (mod)	15 (poor)	25/15 (mod/poor)	13(poor)	21 (mod)

Site PL-7 is in Three Ponds Park in Plymouth (Figure D-4), south of Bass Lake Road and east of Zachary Lane. This wetland scored very low for both macroinvertebrates and vegetation in both 2017 and 2018 (Table D-4).

Table D-15. WHEP site PL-7, Three Ponds Park, Plymouth.

Year	2017	2018
Invertebrate	8 (poor)	8 (poor)
Vegetation	13 (poor)	13 (poor)

Appendix E: 2019 Lake Monitoring

OVERVIEW

The Shingle Creek Third Generation Watershed Management Plan includes a rotating schedule of intensive monitoring on all lakes in the Shingle Creek Watershed. The primary purpose of the intensive lake monitoring program is to evaluate protection efforts for lakes that are not impaired, and to assess progress toward achieving the TMDLs and state water quality standards for all impaired lakes throughout the watershed. Activities included in the intensive lake monitoring program include water quality monitoring, aquatic vegetation surveys, and fish sampling coordinated with the Minnesota Department of Natural Resources (DNR).

In Section 1.0, we provide an overview of the various sampling methodologies (Section 1.0) used to collect water quality (Section 1.1), submersed aquatic vegetation (Section 1.2), and fisheries (Section 1.3) data on the lakes within Shingle Creek watershed. In Sections 2.0 and beyond we summarize the most recent assessments in each lake (water quality, aquatic vegetation, fisheries), providing results and discussions for each lake as a new section.

Results and discussions can be found in the following order:

- Section 2.0 – Bass Lake
- Section 3.0 – Pomerleau Lake
- Section 4.0 – Schmidt Lake
- Section 5.0 – Upper Twin Lake
- Section 6.0 – Middle Twin Lake
- Section 7.0 – Lower Twin Lake

1.0 Sampling Methods

1.1 WATER QUALITY

Lakes are central to Minnesota's economy and our way of life, making it imperative that we protect our high-quality lakes and work to restore those with poor water quality. The Minnesota Pollution Control Agency (MPCA) monitors and assesses lakes around the state to determine if they meet water quality standards. The agency relies on local partners, including soil and water conservation districts, watershed districts, tribal entities, nonprofit groups, and citizens to help monitor the more than 10,000 lakes in the state. Shingle Creek Watershed Management Commission (Commission) is an active participant in aiding the MPCA in sampling and collecting information on the state of water quality of its lakes. The Commission is focused on sampling total phosphorus (nutrient), chlorophyll-a (pigment in algae), and Secchi depth (a measure of water clarity). In addition to these parameters for water quality standard comparison, the Commission collects certain chemical and physical parameters on its lakes.

Routine lake sampling occurs on a rotating basis. For a lake that is selected for sampling in a given year, water samples are typically collected twice per month starting in May and ending in September. For all lakes, surface water samples are collected and assessed for total phosphorus (TP), soluble reactive phosphorus (ortho-P), total suspended solids (TSS), and chlorophyll-a (chl-a). In some of the deeper lakes, a hypolimnetic (deep) water sample is collected and tested for TP and ortho-P. In addition to these chemical parameters, a physical profile of the lake is assessed in the deepest part of the lake. A profile typically consists of measurements at the water's surface and at each meter below the surface throughout the entire water column. A YSI or similar multimeter probe is used to collect these measurements. Parameters measured include dissolved oxygen (DO), dissolved oxygen percent saturation, temperature, pH, oxidation reduction potential (ORP) and specific conductivity. Additionally, a Secchi disk reading is taken during every assessment to record the relative level of water transparency.

Lake profiles are used to better understand the chemical and nutrient cycling processes occurring within the lake, in addition to the stressors that may be contributing to biological impairments. The surface water chemical information is used for multiple reasons, one of which is to compare to the North Central Hardwood Forest (NCHF) ecoregions water quality standards established by the MPCA (Table 1.1).

Table 1.1. MPCA water quality standards for the NCHF ecoregion by lake type.

Lake Type	TP (ug/L)	Chl-a (ug/L)	Secchi (m)
Deep	40	14	>1.4
Shallow	60	20	>1.0

1.2 SUBMERSED AQUATIC VEGETATION

In healthy lake ecosystems aquatic vegetation will grow throughout the littoral area (< or = 15 feet depth) and consist of a diverse native community (Figure 1.1). A well vegetated littoral area promotes and facilitates the health of a lake's ecosystem by providing critical spawning, foraging and nursery habitat for aquatic insects, amphibians, birds and fishes. The littoral area is also important for human recreation and aesthetic enjoyment.

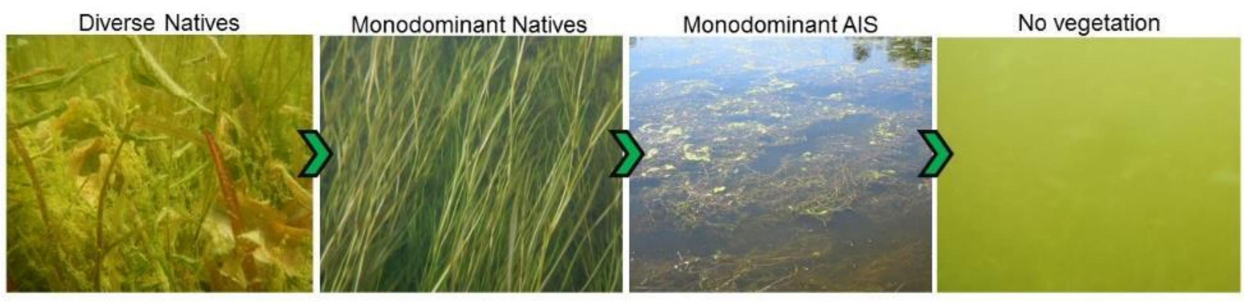


Figure 1.1. Biotic community health continuum portrayed using submersed aquatic vegetation.

The relative health of the SAV community can be assessed with the DNR's Floristic Quality Index (FQI). The FQI is an assessment tool used to determine the biological health of the SAV community. The FQI utilizes species richness and the habitat specificity (C-score) of each species identified to score community health (Equation 1.1). C-score is an index of how desirable or tolerant a group of species is, and DNR standard C-Scores range from 1 to 10 (with 1 being the worst and 10 being the best). FQI scores are compared to a threshold for context and classification of biological impairment status. Lakes with greater FQI scores and taxa richness are typically comprised of diverse native communities with abundant plant growth across the entire littoral area. As health begins to deteriorate within the lake, we typically see a reduced diversity, introduction of invasive species, increasing monodominant communities, and decreased growth across the entire littoral area. Extremely degraded lakes become void of plant growth and become dominated by phytoplankton and/or harmful algae blooms. The biological thresholds for deep lakes in the Central Hardwood Forest ecoregion are a FQI score of 18.6 and 12 taxa. The biological thresholds for shallow lakes in this ecoregion are 17.8 and 11, respectively.

Equation 1.1. Definition of the DNR's Floristic Quality Index (FQI).

$$FQI = \overline{C_{Score}} * \sqrt{No. of\ Species}$$

To assess the presence, abundance and health of the submersed aquatic vegetation (SAV) community, two point-intercept surveys are typically conducted: late spring (typically May or June) and late summer survey (typically July or August). Late spring surveys are primarily conducted to understand the presence and distribution of *Potamogeton crispus* (curly-leaf pondweed, CLP), a plant with high spring growth and early growing season senescence. Late summer surveys provide the greatest assessment of SAV community, abundance, and spatial distribution. Therefore, if a single survey is conducted on a lake, targeting the late summer survey timeframe is recommended.

To sample the SAV community, computer software is used to overlay a grid of points (distance between points is lake specific) across the entire lake. The resulting points serve as predetermined sampling locations. To limit sampling of vegetation where it is not expected to grow, all deep lakes within Shingle Creek are capped to a maximum sampling depth of 20 feet or more (lake specific), therefore, all sampling points in depths beyond the designated cap are removed from the sampling grid. This results in a lake specific number of sampling locations, however, the sampling protocol and reporting of each lake is similar and allows comparisons to be made across systems.

At each survey location a double sided weighted 14-tine rake is thrown from the boat, allowed to sink, and pulled across the lake bottom to represent approximately 1 m^2 of lake area. We refer to this process as a rake toss. For each rake toss, vegetation is removed from the rake, identified to the species level, placed in a perforated bucket, weighed and assigned a proportion of the total biomass based on visual approximation (i.e. 80% of total weight was curly-leaf pondweed and 20% of total weight was coontail). All biomass values are reported in wet weights (kg).

**Note: Lily species, duckweed species, and filamentous algae are not included in any biomass measurements due to difficulty in collecting a representative sample with the sample rake, however, their locations and C-Score values are recorded and factored into the lake FQI score.*

We developed a model to estimate the total SAV biomass within the lake. Depth was stratified into four intervals (0-5, 5-10, 10-15, >15 feet) to more accurately account for spatial variation in vegetation growth and improve model accuracy. For each species we calculate a depth interval specific frequency of occurrence, an average rake toss biomass, and a depth interval lake area. Multiplying these three parameters results in a species-specific total biomass/depth interval. All species-specific depth interval biomasses are then summed within each depth interval to calculate depth specific biomasses and all depth intervals are summed to calculate a total lake biomass (Equation 1.2). The total lake biomass estimation uses the individual surveyed data point information to extrapolate coverage estimates across the entire basin. This is not meant to serve as an exact biomass calculation, rather, this estimate is useful to 1) make relative comparisons to other observed species, 2) be used to compare to future sampling efforts, and 3) provide general information to assist aquatic vegetation management planning.

Continuous sonar readings were also collected during each survey trip using a Lowrance HDS Sonar/GPS unit. This data was processed using CiBioBase software (https://www.cibiobase.com/) to map water depth and vegetation biovolume. Biovolume differs from biomass in that it provides context to vegetation water column saturation. The higher the biovolume the more saturated the water column is with vegetation. Sonar readings in depths <2 feet are subject to extreme 'sonar noise' and therefore are not always accurate. Additionally, sonar readings do not detect surface floating vegetation (i.e. pad part of Lily species, duckweed).

Equation 1.2. Definition of total in-lake submersed aquatic vegetation biomass.

$$Total\ Lake\ Biomass = \sum ([Depth\ Interval]\ (\overline{Species\ Biomass} * Species\ \%\ Occurence * Basin\ Area))$$

1.3 FISHERIES SURVEYS

Fish communities are sampled using various techniques and equipment to target specific aspects of the fish community or due to the type of system being sampled. We outline five survey technique/ assessment methods that were implemented on Shingle Creek lakes in 2017.

1.3.1 Trap and Gill Net Surveys (Lakes)

DNR survey game fish populations using standardized trap and gill net survey methods to assess gamefish populations within lakes. DNR standard trap and gill net surveys consist of setting trap and gill nets at predetermined locations based on lake size (Schlagenhaft 1993). The trap and gill nets are meant to tangle or entrap fish over a 12 to 24-hour period. Trap nets contain a lead net perpendicular to shore with a series of hoops and funnels at the end of the net that direct and entrap fish. The gill nets catch fish via gill entanglement and consist of multi-sized mesh panels. The gill nets are typically set in deeper (~8-12 feet), open water habitats. Fish captured from trap and gill net assessments are identified, total length measured and weighed.

1.3.2 Nearshore Surveys (Lakes)

The DNR developed protocols and has begun implementing nearshore surveys to capture and identify more non-game type species (i.e. darter species, shiner species) using beach seines and backpack electroshocking equipment (hereafter referred to as nearshore surveys). Nearshore sampling is an active method of fishing that targets all fish within shoreline habitats. Nearshore survey points are relatively equidistant from each other across the shoreline with the number of sampling locations determined by lake size (Bacigalupi et al. 2015). Beach seine tows consist of pulling a net throughout the water column to entrap fish. Electrofishing uses electrical charges that temporarily stun fish so they can be netted. Fish from nearshore assessments are identified and summed.

1.3.3 IBI Assessment (Select Deep Lakes)

Lake classes were developed by the DNR to characterize and group lakes based on physical and chemical differences (Schupp 1992). Historically, the classification system provided a systematic approach to manage fisheries (i.e. game fish populations) within Minnesota. Since that time the DNR has been developing specific tools that utilize fish community information to relate the health of a given lake. Minnesota lakes that fall within lake classes 22–25, 27-39 and 41-43 can be partitioned into one of four distinct IBIs.

Known as Indices of Biotic Integrity (IBIs), these tools are comprised of multiple metrics that score a lake's health based on the fish species captured. Fish species vary in their ability to tolerate various kinds, magnitudes and frequency of disturbance, therefore, the species present and their abundances can be used to infer the amount of disturbance a given lake is/has experienced. Primary disturbances used during IBI development were shoreline degradation, urbanization, agriculture land use and nutrient loading. IBI tools attempt to account for the expected variability of a fish community due to natural phenomenon (i.e. habitat complexity, system productivity), yet are coarse enough to encompass multiple lake classes. They are comprised of multiple metrics that integrate aspects of species richness, community assemblage and trophic composition that have been correlated to changes in disturbance levels. The IBI tools vary in the number of metrics (8 – 15 metrics) with some metrics becoming gear type specific or lake size adjusted within a given IBI. Combining all individual metrics within a given IBI tool results in a single score that relates the relative health of the lake. IBI scores range from 0 – 100, with 100 being the highest score possible reflecting the most pristine and natural community for a given lake class.

Fisheries survey information from trap and gill net surveys are combined with nearshore survey results in certain situations to rate conduct the IBI health assessment.

1.3.4 Common Carp Population Evaluation (Lakes of Water Quality Concern)

The common carp (*Cyprinus carpio*) is a widespread aquatic invasive species that can have deleterious effects on lake ecosystems. Common carp uproot aquatic vegetation, resuspend lake bottom sediments and increase available nutrients that can fuel algal growth leading to ecosystem degradation. Significant water quality degradation has been shown to begin at common carp densities of 100 kg/hectare (89 lbs./ acre) (Bajer 2012). Efforts aimed at restoring water quality that do not reduce the presence of common carp have limited success in long term restoration, therefore, survey efforts are used to determine common carp densities and whether there is a need for carp management. Common carp population assessments implement boat electrofishing techniques that target the carp population within a lake. Carp are targeted along shoreline habitats with captured carp total length measured, weighed and tallied. A regression model is then used to extrapolate the abundance and density of common carp with the lake. Inputs into the regression model include the amount of time fished (shocking time), the total number of fish captured, and total biomass captured.

2.0 Bass Lake

2.1 INTRODUCTION & SAMPLING OVERVIEW

Bass Lake is located in the city of Plymouth within Hennepin County, MN. Bass Lake is classified as a shallow lake and has an approximate surface area of 176 acres, 148 acres of littoral area (i.e., area less than 15 feet deep), 3.2 miles of shoreline, and a maximum depth of 31 feet. The list below summarizes the year in which each type of sampling was most recently performed on Bass Lake:

- Water Quality - 2019
- SAV – 2019
- Fisheries - 2017
- Carp – 2017

Bass Lake received an alum treatment on May 15, 2019 to mitigate internal phosphorus loading (Figures 2.1.1 and 2.1.2). Alum was applied to a 35-acre area of the lake that consisted of all parts of the lake 14 feet and deeper. Alum was applied at 789 gallons/acre.

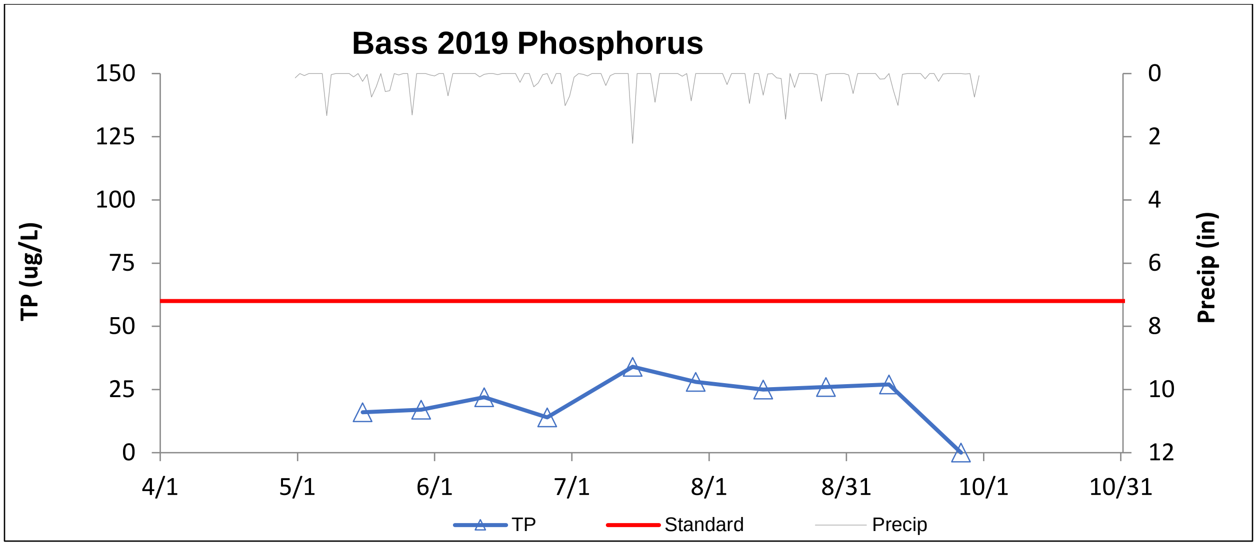
Figure 2.1.1. A barge applies alum to Bass Lake.

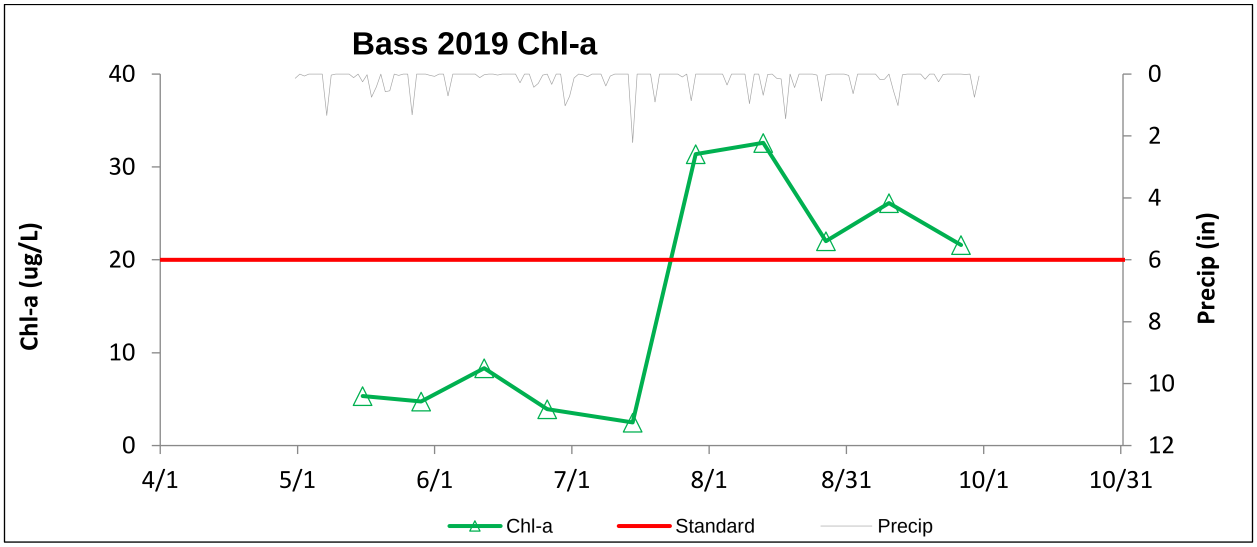
Figure 2.1.2. The alum application barge.

2.2 WATER QUALITY

Water was collected twice per month May through September 2019 for a total of 10 sampling events. Likely as a result of the May 2019 alum treatment, water quality was substantially improved compared to past summers. All three eutrophication standards (total phosphorus, chlorophyll-a, and Secchi depth) were met throughout the growing season, except chlorophyll, which exceeded the shallow lake standard of 20 ug/L from the end of July to the end of September (Figure 2.2.1) following a significant rain event. Peak chlorophyll concentration in 2019 was 32.6 ug/L (Figure 2.2.1), which is less than peak chlorophyll concentration for the three previous seasons monitored, which ranged from 69 to 130 ug/L (three previous monitoring years were 2011, 2014, 2018).

Water quality data on Bass Lake has been collected since 1994 (Figure 2.2.2). Since at least 2000, eutrophication standards have generally not been met, so 2019 water quality showed great improvement (Figure 2.2.2). In typical years, deep water phosphorus concentrations increase over the course of the growing season, suggesting phosphorus release from anoxic sediments (i.e., internal loading). Due to the 2019 alum treatment, deep water phosphorus concentrations remained low for the entire growing season (Figure 2.2.3). The alum treatment will prevent excessive phosphorus release from sediments in the future; however, the lake continues to receive substantial phosphorus loads from the watershed (Figure 2.2.4), so future phosphorus management will likely be needed.





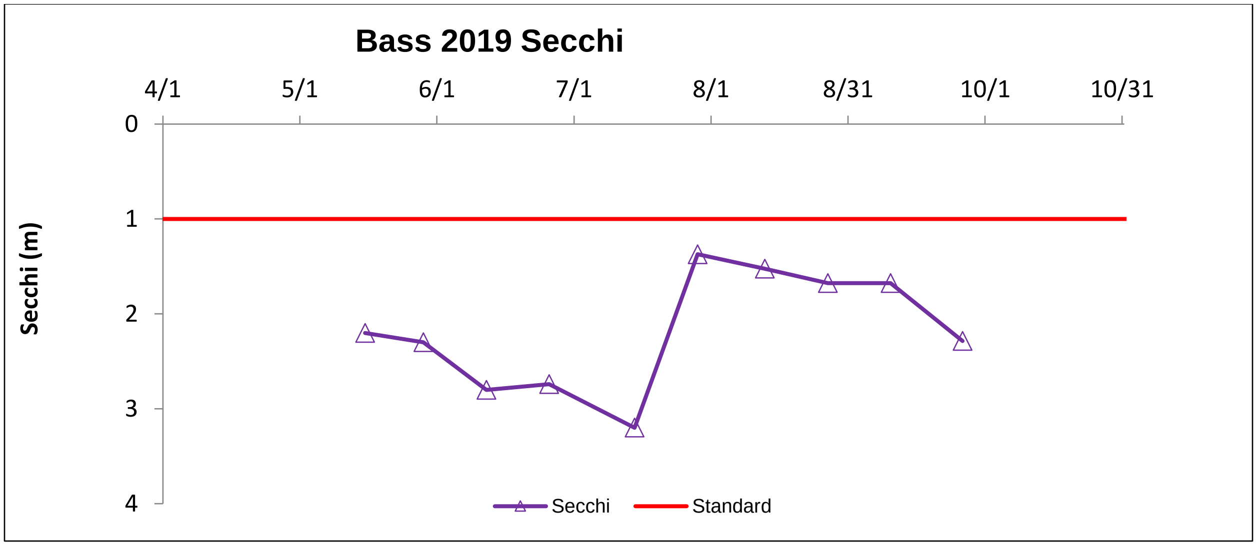


Figure 2.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.

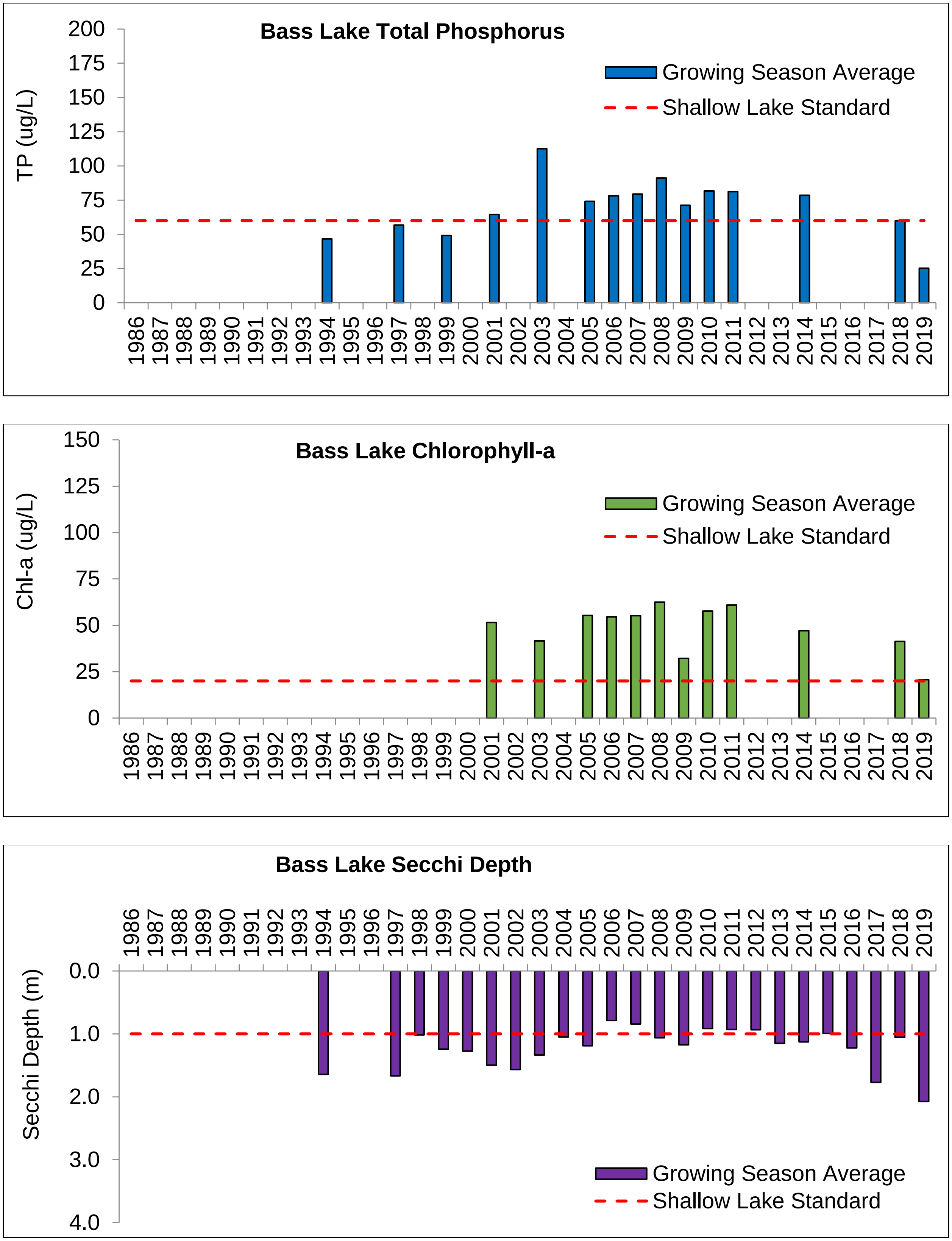


Figure 2.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

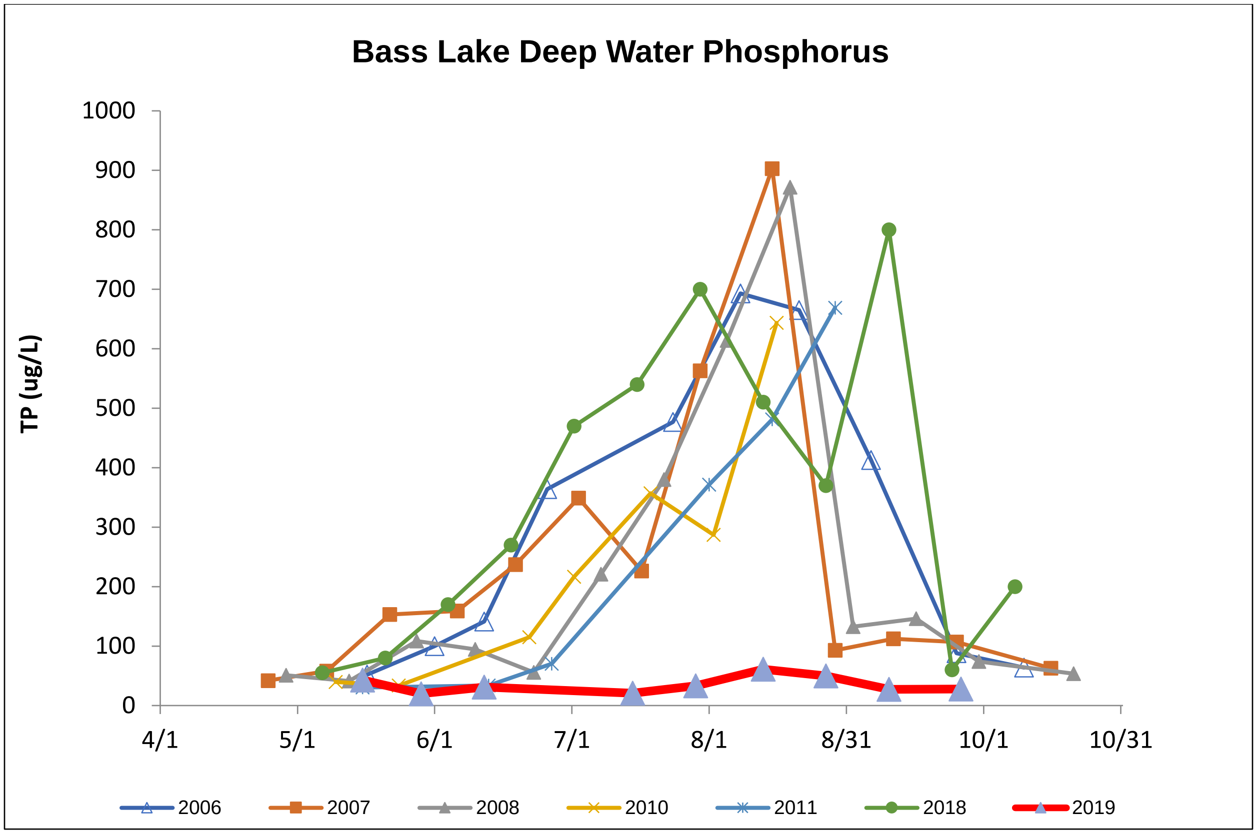


Figure 2.2.3. Hypolimnetic (deep) total phosphorus (TP) throughout the summer in several years from 2006 to 2019. Due to alum inactivation of sediment, in 2019, phosphorus does not appear to accumulate in the hypolimnion over the summer.

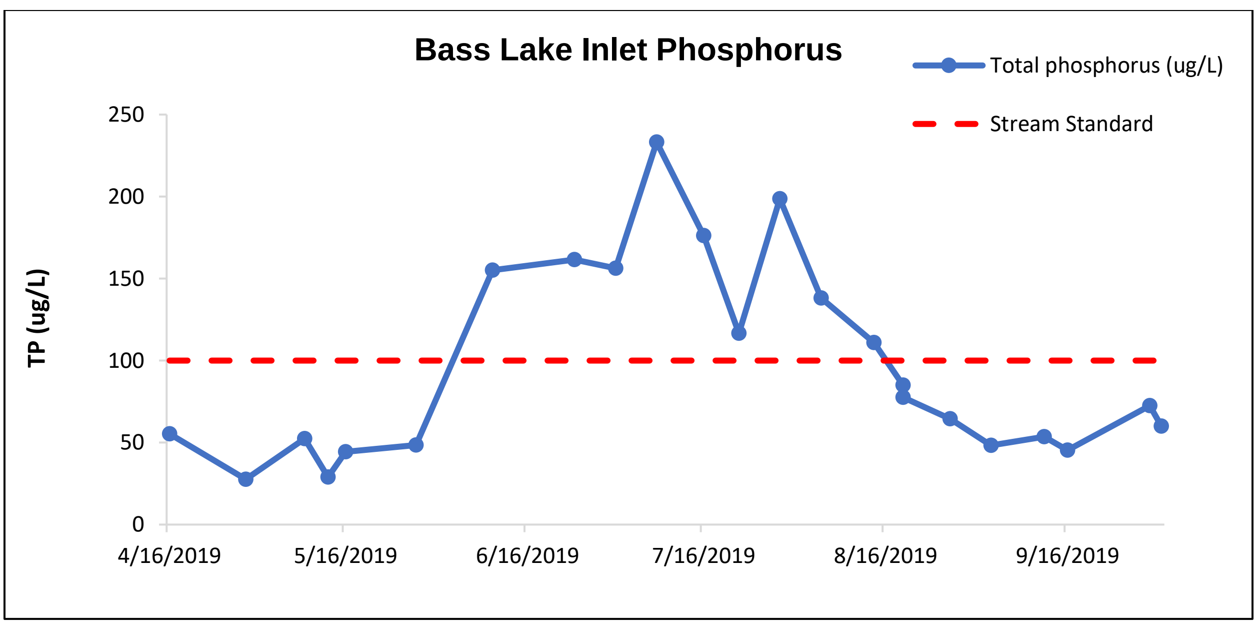


Figure 2.2.4. Total phosphorus (TP) throughout the summer at sampling station BL3, an inlet to Bass Lake (data was collected by Three Rivers Park District).

2.3 SUBMERSED AQUATIC VEGETATION

A point-intercept aquatic vegetation survey was conducted on July 29, 2019 to document the late summer submersed aquatic vegetation in Bass Lake. Vegetation covered over half the lake; a total of 111 survey points were assessed, and 65 of these points were vegetated (Table 2.3.1). Bass Lake is classified as a shallow lake and is mostly littoral, with 148 of its 176 acres in the littoral zone (i.e., water less than 15 feet deep). All 65 points occurred in the littoral zone, and the littoral zone was 64% covered in vegetation.

Table 2.3.1. Survey statistics.

Index	Result	Index	Result
Total Points	111	Vegetated Points	65
Littoral Points	101	Littoral Points with Vegetation	64%

Biovolume, or the volume of water occupied by vegetation, was highest in shallow areas near shore or near the island (Figure 2.3.1). Biomass and species richness showed the same trend (Table 2.3.2). For instance, areas with depth between 0 and 5 feet had more biomass than areas at 5 to 10 feet by an order of magnitude (approximately 116,000 kg versus 11,500 kg; Table 2.3.2), and eight species were observed in 0 to 5 feet versus only five species in 5 to 10 feet (Table 2.3.2). No vegetation was observed in water depths greater than 9 feet due to lack of available light.

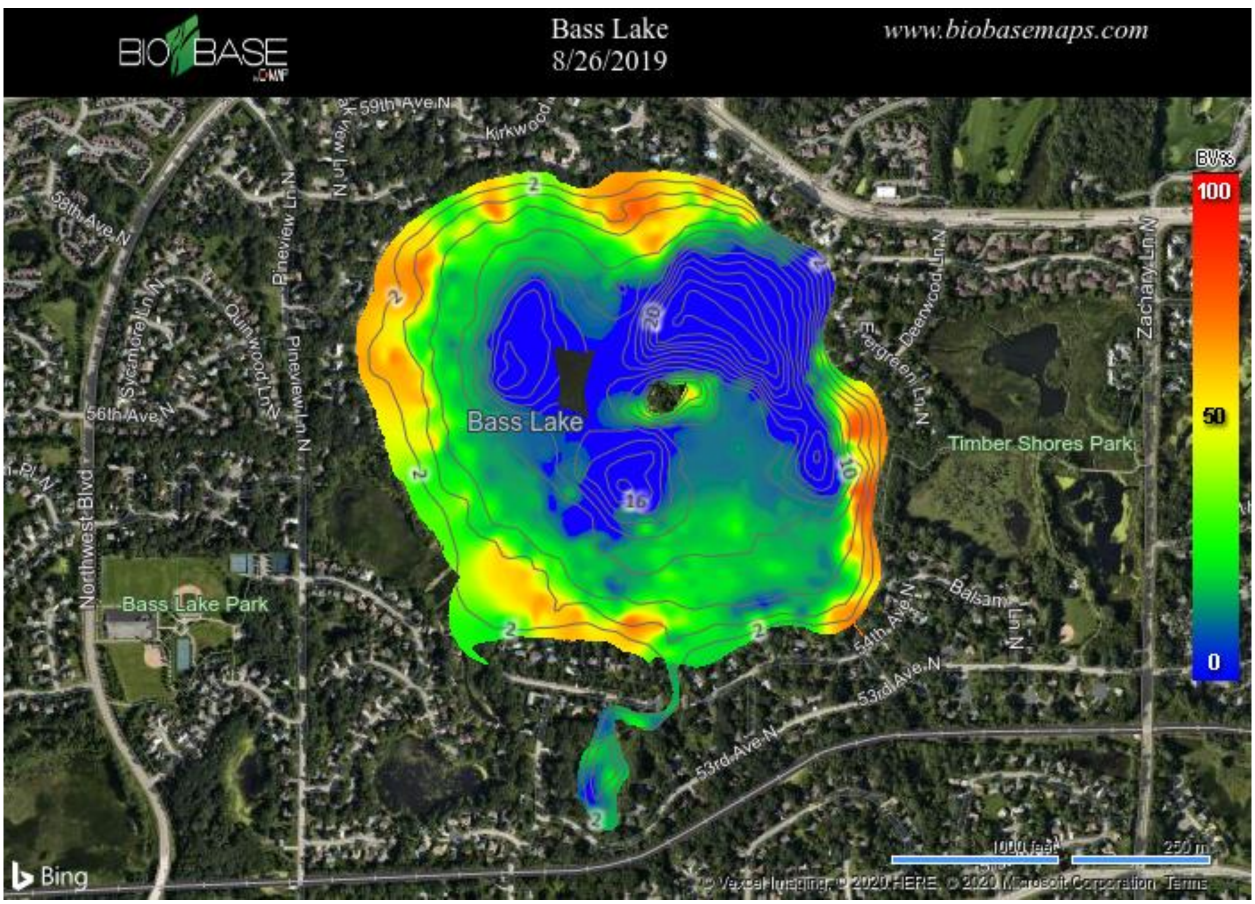


Figure 2.3.1. Biovolume heat map of Bass Lake. In the heatmap, red indicates 100% biovolume and blue indicates 0% biovolume. Biovolume refers to the percentage of the water column taken up by vegetation (Date of map is the date of BioBase processing, not the date of sampling).

Table 2.3.2. Comparison of community composition with depth.

Depth (ft.)	Lake Area (acres)	Sample points at this depth (#/%)		Species Observed (#)	Biomass (kg)
0- 5	67	33	30	8	116,031
5- 10	61	60	54	5	11,581
10- 15	20	8	7	0	0
> 15	28	10	9	0	0

Aquatic vegetation species richness of Bass Lake was moderate but did not have high enough quantity or quality of species to meet shallow lake standards for the Central Hardwood Forest Ecoregion (Table 2.3.3). Eight species were observed in the lake, which is below the shallow lake species richness standard of 11. These observed species had an average C-score of 5.3 (Table 2.3.3). Floristic quality index (FQI), an index based on the number of species observed and quality (i.e., C-score) of each species, was 14.8, which is below the shallow lake FQI standard of 17.8 (Table 2.3.3).

Table 2.3.3. Species diversity statistics.

Index	Result*
Observed Taxa	8
Average C-score	5.3
Lake Floristic Quality Index (FQI)	14.8

*The standards for number of taxa and FQI in Bass Lake are 11 and 17.8, respectively.

Species composition did not include any non-native or dominant species (>50% occurrence) and was similar to species composition found during previous late-season surveys of Bass Lake in 2014 and 2018 (Table 2.3.4). Coontail, muskgrass, and waterweed were the most abundant species observed in the 2019 survey, but none of these species appeared to be dominant (Table 2.3.4). Lilies (white and yellow), duckweeds (star and lesser), and water celery comprised the remainder of the community, with occurrences at or less than 12% of survey locations (Table 2.3.4). Percent occurrence is defined as the number of survey points at which a plant species was observed divided by the total number of points surveyed on a lake or within a specific depth range.

Although all species found during the 2019 survey were native, past surveys performed in the spring have observed curly-leaf pondweed (CLP), an invasive plant that outcompetes many native species (Table 2.3.4). CLP grows under ice, which means populations can reach maximum growth in May and June, when growth of most native vegetation is still hindered by short day length. This attribute gives CLP an extreme competitive advantage, causing it to form dense stands that shade out other native species and prevent them from sprouting. CLP's early season grown leads to senescence in early summer. This means that as the plant senesces and is decomposed by bacteria, the nutrients stored in its stems and leaves are released into the water column and may promote algae blooms. It makes sense that CLP was not found during the July 29, 2019 survey, since CLP senesces in early summer. The DNR documented presence of CLP in May of 2019 during a CLP delineation. The Commission has received a three-year Aquatic Invasive Species (AIS) Lake Management Variance Plan from the DNR. This Plan allows the Commission to treat up to 50% of the littoral area each spring for AIS, including CLP. Each spring the Commission will work with the DNR will delineate CLP to identify areas for herbicide treatment.

Table 2.3.4. Species occurrence, or the percent of survey points containing a given species, during surveys in 2014, 2018 and 2019.

Common Name	Scientific Name	% Lake Occurrence				
		6/24/14	8/21/14	5/21/18	8/16/18	7/29/19
Curly-leaf pondweed	*Potamogeton crispus*	21	--	46	--	--
Coontail	*Ceratophyllum demersum*	22	20	39	28	41
Muskgrass	*Chara sp.*	1	2	26	1	29
Waterweed (Canadian)	*Elodea canadensis*	--	--	10	5	15
Yellow waterlily	*Nuphar variegata*	8	8	7	7	12
White waterlily	*Nymphaea odorata*	2	8	6	8	9
Very small pondweed	*Potamogeton pusillus*	--	--	5	2	--
Water milfoil (northern)	*Myriophyllum sibiricum*	--	--	2	--	--
Duckweed (star)	*Lemna trisulca*	--	--	1	--	6
Duckweed (lesser)	*Lemna minor*	--	--	1	9	4
Water celery	*Vallisneria americana*	3	9	1	8	8
Ribbon-leaved pondweed	*Potamogeton epihydrus*	--	--	--	1	--
Flat-stem pondweed	*Potamogeton zosteriformis*	2	2	--	--	--
Leafy pondweed	*Nymphaea ordornata*	--	1	--	--	--

In May 2019, Bass Lake was treated with aluminum sulfate. At least in part as a result of this alum treatment, in 2019, Bass Lake's water quality was substantially improved from previous years, including improved water clarity (Section 2.2). Clearer water can change the SAV community. For example, clearer water allows light to penetrate deeper into the water column and encourages plant growth in deeper locations in the lake. Over time, clearer water may also allow growth of new species, such as species that are less tolerant of turbid, eutrophic waters.

Results of the 2019 and 2018 SAV surveys were compared to investigate changes to the SAV community as a result of the alum treatment. Overall, slightly fewer species were observed in the 2019 survey (10 in 2018 vs. 8 in 2019), but the lake had substantially more vegetation biomass in 2019, as well as more species diversity in deeper areas. The two species that were observed in 2018 but not in 2019 are very small pondweed and ribbon leaved pondweed. It is likely that these species persisted during the 2019 survey but were simply not observed due to their limited occurrence. In fact, in the 2018 survey, very small pondweed and ribbon leaved pondweed had only 2% and 1% occurrence throughout the lake, respectively (Table 2.3.4). Biomass trends, on the other hand, appear to have shifted significantly since the alum treatment. In the 0-5 feet depth interval, biomass changed negligibly between 2018 and 2019, with about 119,000 kg in 2018 and 116,000 kg in 2019. However, in the 5-10 feet depth interval, biomass increased from 1,147 kg in 2018 to 11,581 kg in 2019 (Figure 2.3.2). In addition to increases in biomass in the 5-10 feet depth interval, there was also an increase in number of species observed at this depth interval. Muskgrass, yellow waterlily, and star duckweed, three species that were previously absent in this depth interval, were observed between 5 and 10 feet in 2019 (Table 2.3.5).

Table 2.3.5. SAV species occurrence by depth.

Common Name	% Lake Occurrence by Depth					
	8/16/2018			7/29/2019		
	0-5 ft.	5-10 ft.	10-15 ft.	0-5 ft.	5-10 ft.	10-15 ft.
Coontail	71	13	14	27	18	--
Muskgrass	4	--	--	13	19	--
Waterweed (Canadian)	11	3	--	9	8	--
Yellow waterlily	25	--	--	12	1	--
White waterlily	29	--	--	10	--	--
Very small pondweed	7	--	--	--	--	--
Duckweed (star)	--	--	--	6	1	--
Duckweed (lesser)	29	2	--	4	--	--
Water celery	29	--	--	9	--	--
Ribbon-leaved pondweed	4	--	--	--	--	--

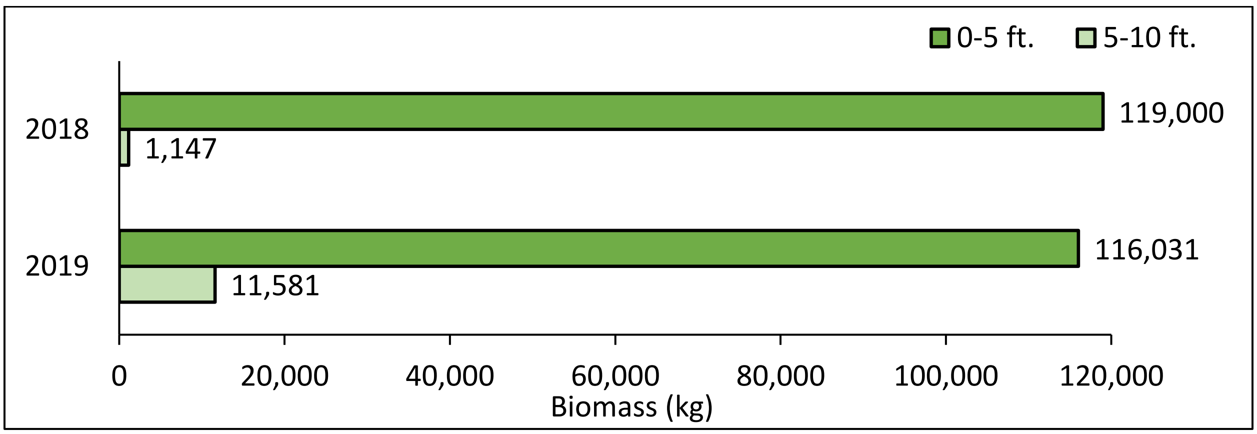


Figure 2.3.2 Biomass at 0-5 ft. and 5-10 ft. depth intervals during the 8/16/18 and 7/29/19 surveys. Biomass at 5-10 ft. increased substantially from 2018 to 2019.

Increases in SAV biomass, coverage and diversity are positive for the Bass Lake ecosystem, but may create recreational concerns, especially if vegetation begins to impede aquatic recreation (e.g., boating, fishing, swimming). If this happens, landowners can apply for a permit through the Minnesota Department of Natural Resources to remove and/or chemically treat vegetation in areas near the shore in order to facilitate recreation. However, caution must be taken to prevent removal of desirable and ecologically beneficial species.

In conclusion, the summer 2019 SAV survey showed encouraging signs for the Bass Lake SAV community, likely in part due to the alum treatment of May 2019. Only native vegetation was present during the survey (although it was documented that CLP was present earlier in the summer), and this native vegetation covered over half the lake. Species diversity, measured with the FQI, does not meet the state FQI standard, but is not much below the standard. FQI was low in part because only 8 species were observed during the 2019 survey, compared to 10 in 2018. While fewer species were observed in 2019, it is important to remember that the species that were not observed in 2019 were observed to be rare in 2018. It is likely that these rare species persisted during all surveys but were simply not observed in 2019 due to their limited occurrence. The most notable change between 2018 and 2019 was the increase of about 10,000 kg of biomass in the 5-10 feet depth interval. More species were also observed in this depth interval in 2019 compared to prior years. These changes to the vegetation community coincide with increased water clarity in the lake, which allows light to penetrate to deeper depths of the water column. Water quality is still a stressor to the aquatic vegetation community, but as water quality improves, it is expected that all species observed in the 2019 survey, as well as previously observed rare plant species, should increase in both occurrence and biomass. Perhaps new species that are less tolerant to eutrophic waters will also be detected. That said, tolerant species with lower C-Scores, such as coontail, muskgrass, and waterweed will probably persist in higher occurrences before less tolerant species with higher C-scores, such as ribbon leaved pondweed, very small pondweed, and northern water milfoil, can persist in established communities across the lake. The establishment of these less tolerant species is an essential step in achieving the FQI standard established for shallow lakes in the Central Hardwood Forest Ecoregion.

3.0 Pomerleau Lake

3.1 INTRODUCTION & SAMPLING OVERVIEW

Pomerleau Lake is located in the city of Plymouth within Hennepin County, MN. Pomerleau Lake is classified as a deep lake and has an approximate surface area of 30.5 acres, 21 acres of littoral area (i.e., area less than 15 feet deep), 0.78 miles of shoreline, and a maximum depth of 26 feet. The list below summarizes the year in which each type of sampling was most recently performed on Pomerleau Lake:

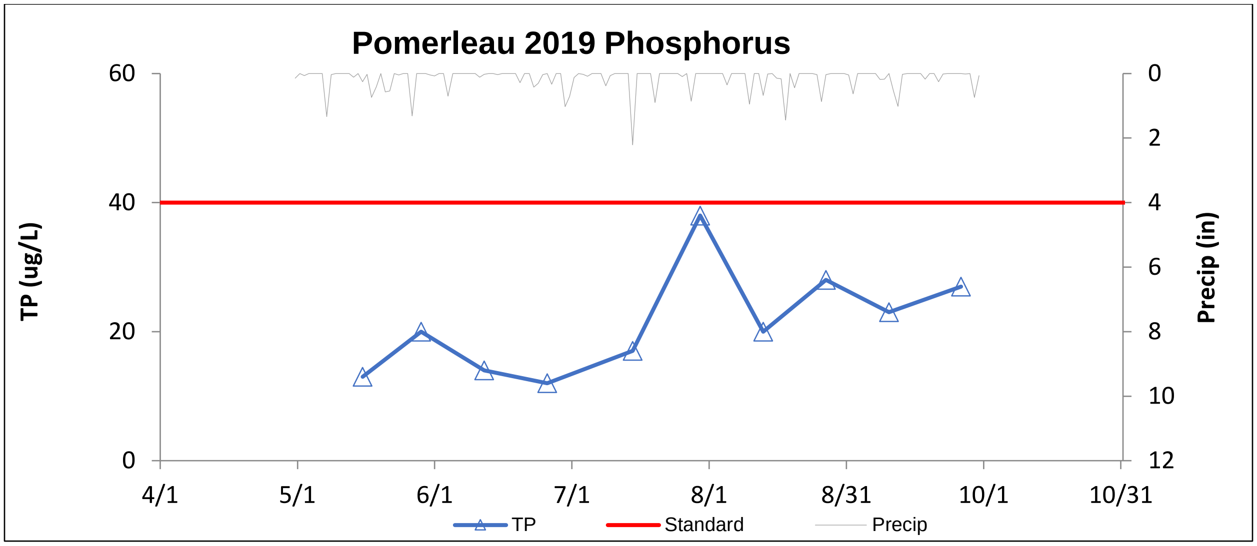
- Water Quality - 2019
- SAV – 2019
- Fisheries – 2004
- Carp – 2018

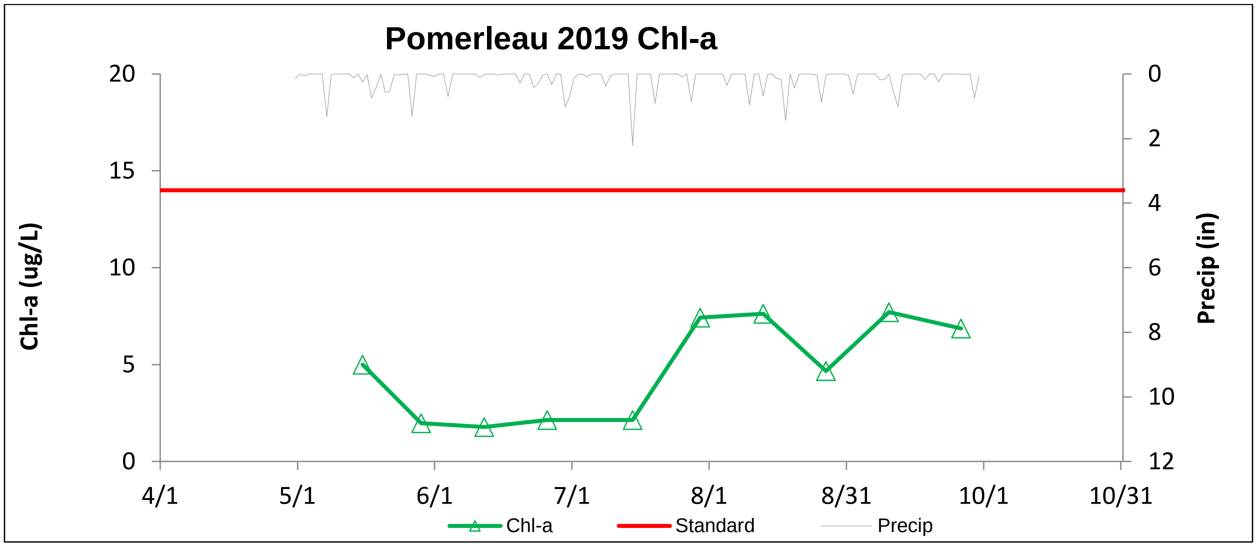
Pomerleau Lake also received an alum treatment on May 13, 2019 to mitigate internal loading (Figure 3.1.1). Alum was applied to a 14-acre area of the lake seven feet and deeper. Alum was applied at 1,374 gallons/acre.

Figure 3.1.1. Photos from the alum treatment on Pomerleau Lake in May 2019.

3.2 WATER QUALITY

Water quality was monitored twice per month May through September 2019 for a total of 10 samples. Likely as a result of the May 2019 alum treatment, water quality was substantially improved from past summers. All three eutrophication standards (total phosphorus, chlorophyll-a, and Secchi depth) were met throughout the growing season; not a single data point exceeded standards (Figure 3.2.1). Data for eutrophication metrics on Pomerleau Lake date back to 1996 (Figure 3.2.2). Since this time, eutrophication standards have generally not been met, although water quality has appeared to improve in recent years, with 2017-2019 growing season surface water averages generally meeting standards (Figure 3.2.2). Although 2017 and 2018 water quality was already improved compared to past seasons it is clear, based on hypolimnetic (deep) total phosphorus data, that the May 2019 alum treatment was the likely cause of the improved water quality in 2019. Whereas in past years, hypolimnetic total phosphorus concentrations increased throughout the season—a signature of internal loading from sediments—in 2019, hypolimnetic phosphorus concentrations did not increase (Figure 3.2.3). This is a sign that alum in fact inactivated sediment phosphorus and prevented it from getting released into the water column, where it could mix into surface waters and cause algae blooms.





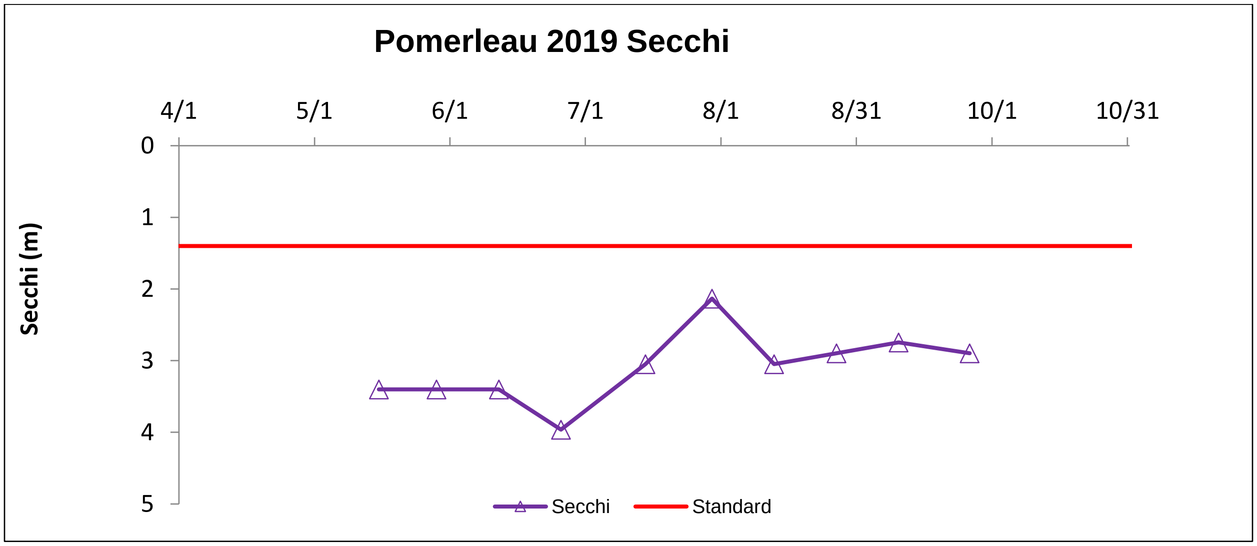


Figure 3.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.

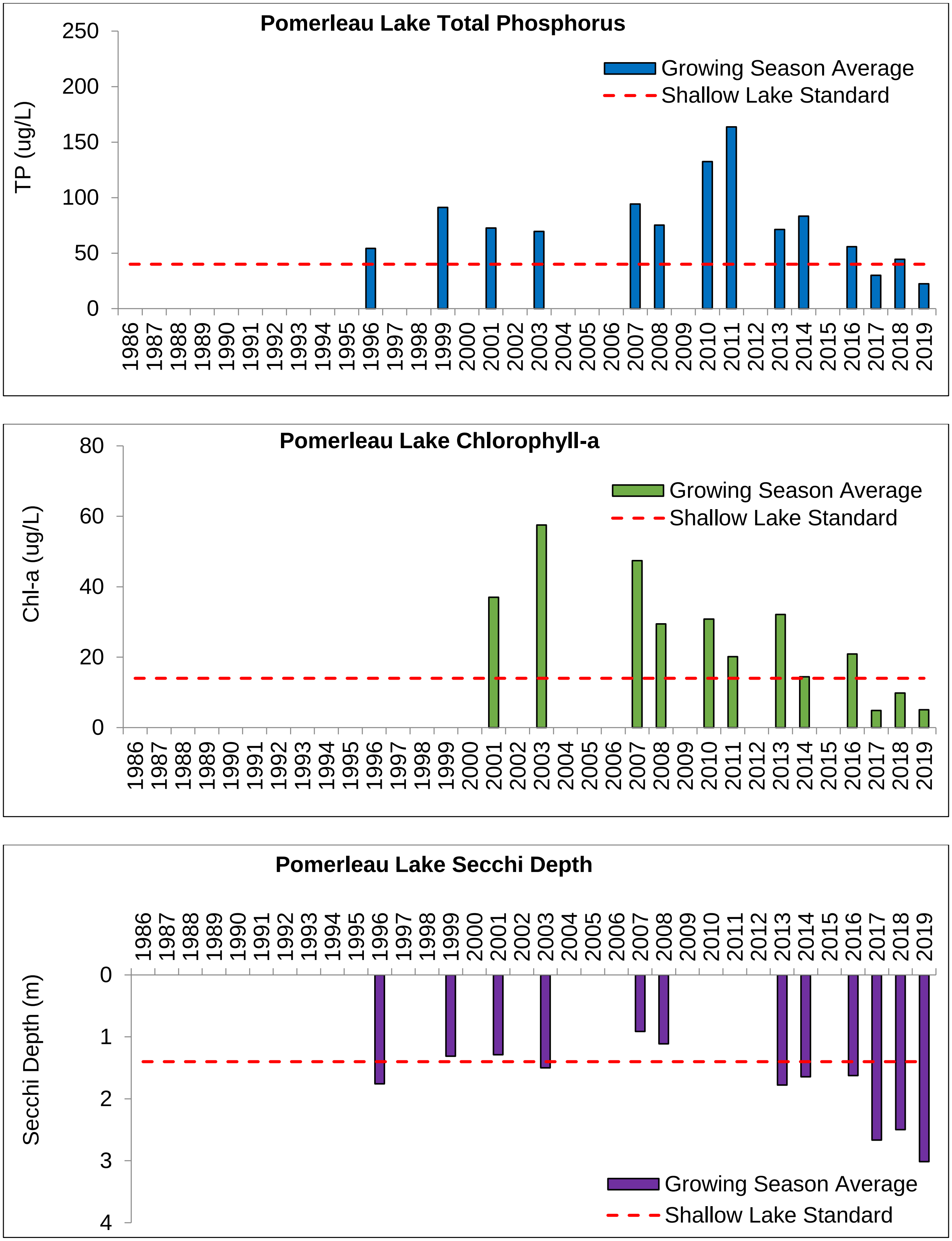


Figure 3.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

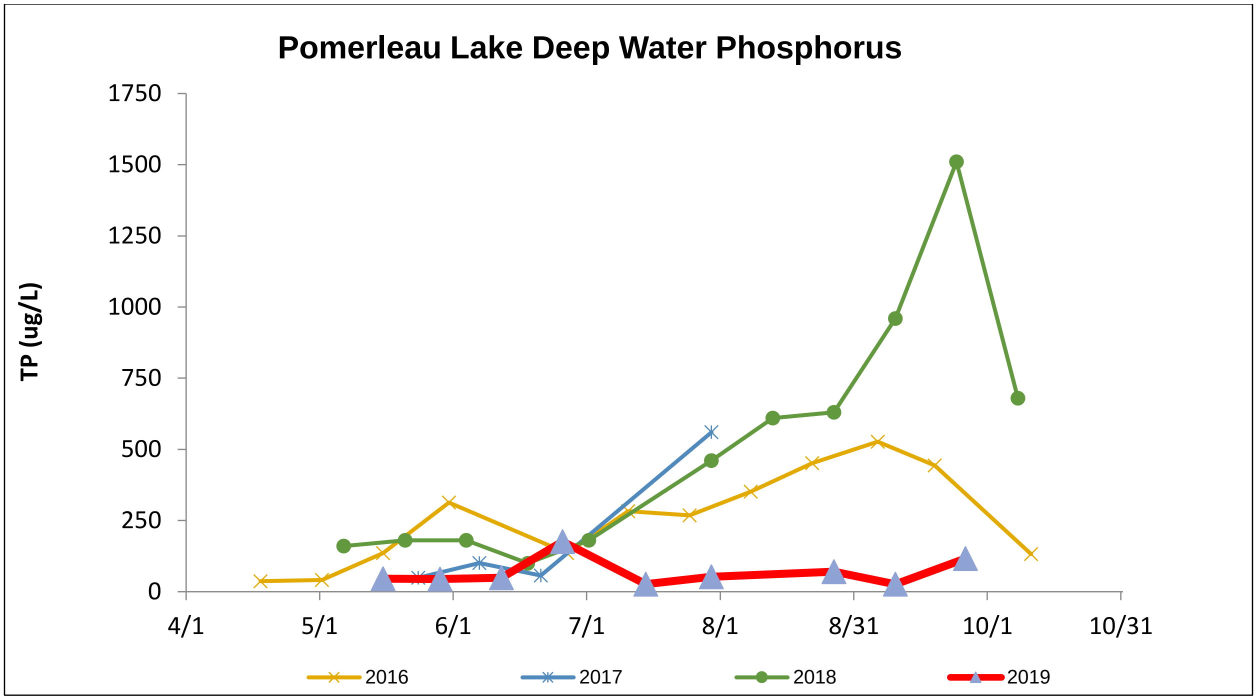


Figure 3.2.3. Hypolimnetic (deep) total phosphorus (TP) throughout the summer in 2016 through 2019. Due to alum inactivation of sediment, in 2019, phosphorus does not appear to accumulate in the hypolimnion over the summer.

Figure 3.2.4. Wenck staff using a Van Dorn sampler to pull a hypolimnetic (deep) water sample from Pomerleau Lake on 7/30/19.

3.3 SUBMERSED AQUATIC VEGETATION

A point-intercept aquatic vegetation survey was conducted by Wenck on July 30, 2019 to document the late summer submersed aquatic vegetation in Pomerleau Lake. Vegetation was found in more than two thirds of the monitored points; a total of 41 survey points were assessed, and 28 of these points were vegetated (Table 3.3.1). All but one of these vegetated points were in the littoral zone of the lake (i.e., the zone of the lake that is 15 feet or less), and the littoral zone was 96% covered in vegetation.

Table 3.3.1. Survey Statistics.

Index	Result	Index	Result
Total Points	41	Total Vegetated Points	28
Littoral Points	28	Littoral Points with Vegetation	96%

Biovolume, or the percentage of water occupied by vegetation, was high throughout the littoral areas of the lake (Figure 3.3.1), as was biomass (Table 3.3.2). Secchi disk data for the summer showed that light penetrated to depths of 13.0 feet, with an average Secchi depth of 9.9 feet (Section 3.2). This deep light penetration allowed for vegetation to grow and accumulate biomass at greater depths of the lake, although on the day of the vegetation survey, Secchi depth was at its lowest, at 7.0 feet (Section 3.2). Species richness was highest in the shallowest areas of the lake and decreased as depth increased (Table 3.3.2). No vegetation was observed in water depths greater than 19 feet.

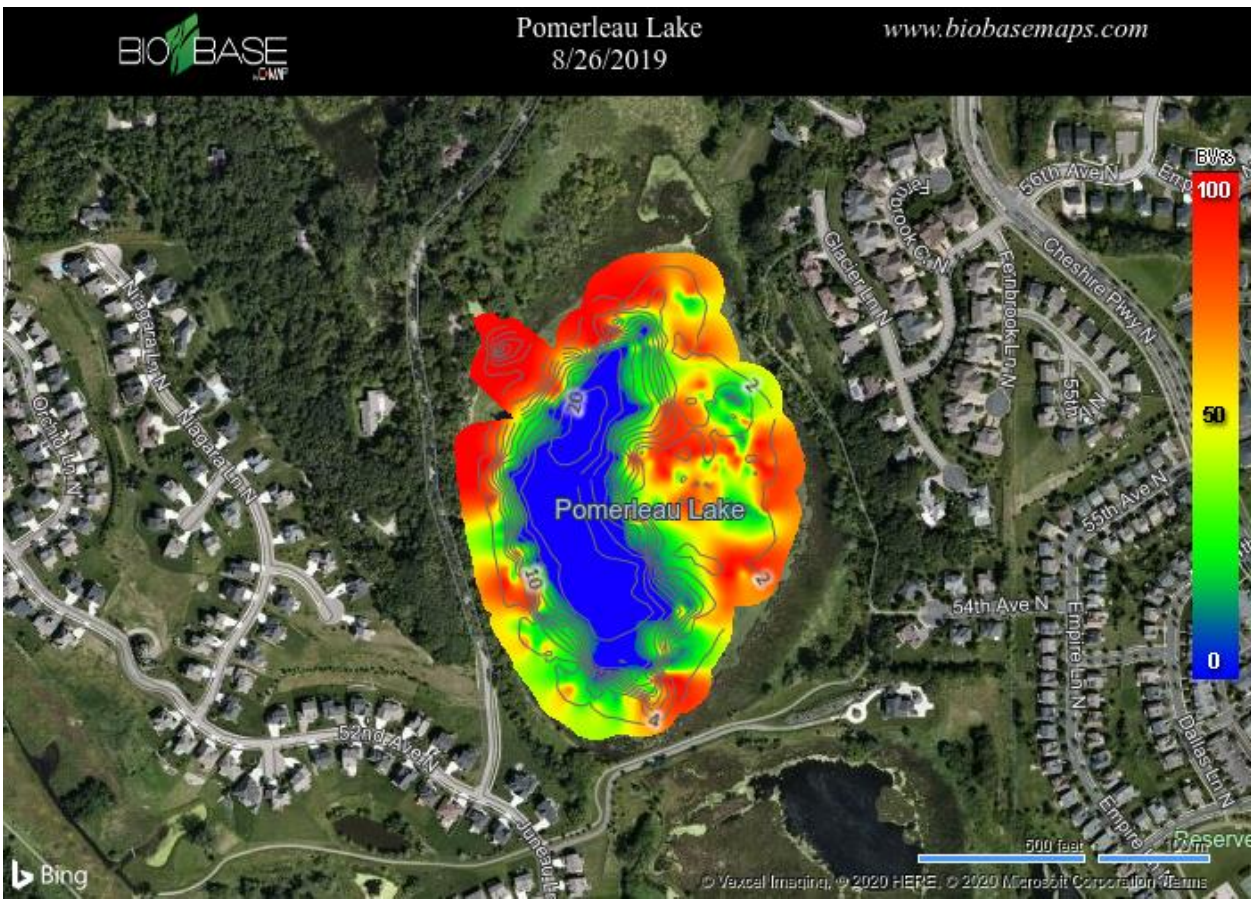


Figure 3.3.1. Biovolume heat map of Pomerleau Lake. In the heatmap, red indicates 100% biovolume and blue indicates 0% biovolume. Biovolume refers to the percentage of the water column taken up by vegetation (Date of map is the date of BioBase processing, not the date of sampling).

Table 3.3.2. Comparison of community composition with depth.

Depth (ft.)	Lake Area (acres)	Sample points at this depth (#/%)		Species Observed (#)	Biomass (kg)
0- 5	7.2	21	51	6	23,823
5- 10	3.8	4	10	4	34,296
10- 15	3.7	2	5	1	26,129
> 15	3.6	14	34	1	496

Six species were observed in Pomerleau Lake, but aquatic vegetation did not have high enough quantity or quality of species to meet deep lake standards for the Central Hardwood Forest Ecoregion (Table 3.3.3). Six species were observed in the lake, which is below the deep lake species richness standard of 12. These six observed species had an average C-score of 4.3. C-score is an index of how desirable or tolerant a group of species is (Table 3.3.3), and DNR standard C-scores range from 1 to 10. Floristic quality index (FQI), an index based on the number of species observed and quality (i.e., C-score) of each species, was 10.6, which is below the shallow lake FQI standard of 18.6 **(**Table 3.3.3**).**

Table 3.3.3. Species diversity statistics.

Index	Result*
Observed Taxa	6
Average C-score	4.3
Lake Floristic Quality Index (FQI)	10.6

*The standards for number of taxa and FQI in Pomerleau Lake are 12 and 18.6, respectively.

Species composition included one dominant species, with coontail dominating (greater than 50% occurrence), but it consisted of nearly all native species and was similar to species composition found during a late season survey performed on Pomerleau in 2017 (Table 3.3.4). Coontail was the dominant species throughout the lake, occurring at 68% of sample points, while all other observed species, such as white and yellow water lily, lesser duckweed, elodea, and curly-leaf pondweed (CLP) had occurrences at less than 25% of the sample locations (Table 3.3.4). Percent occurrence is defined as the number of survey points at which a plant species was observed divided by the total number of points surveyed on a lake or within a specific depth range. CLP was observed at a single sample location in 2019. CLP is an aquatic invasive plant that outcompetes native species and can become the dominant vegetative species found in a lake. CLP has been observed in Pomerleau before; it had 27% occurrence in the spring 2017 survey. CLP typically senesces in early summer and is therefore not usually observed in late summer surveys (Table 3.3.4).

Table 3.3.4. Species occurrence, or the percent of survey points containing a given species, during surveys in 2017 and 2019.

Common Name	Scientific Name	% Lake Occurrence		
		5/24/2017	7/28/2017	7/30/2019
Curly-leaf pondweed	*Potamogeton crispus*	27	--	2
Coontail	*Ceratophyllum demersum*	54	63	68
Waterweed (Canadian)	*Elodea canadensis*	--	--	7
Yellow waterlily	*Nuphar variegata*	3	--	5
White waterlily	*Nymphaea odorata*	11	3	22
Duckweed (star)	*Lemna trisulca*	5	--	--
Duckweed (lesser)	*Lemna minor*	5	--	7
Naiad	*Najas sp.*	--	3	--
Flat-stem pondweed	*Potamogeton zosteriformis*	3	--	--
Sago Pondweed	*Stuckenia pectinata*	--	3	--

In May 2019, Pomerleau Lake was treated with aluminum sulfate (alum). At least in part as a result of this alum treatment, in 2019, Pomerleau Lake's water quality was substantially improved from previous years, including improved water clarity measured using Secchi depth (Section 3.2). Clearer water can change the SAV community. For example, clearer water allows light to penetrate deeper into the water column and encourages plant growth in deeper locations in the lake. Over time, clearer water may also allow growth of new species, such as species that are less tolerant of turbid, eutrophic waters.

Results of the 2019 SAV survey were compared to results of the 2017 late-season survey to investigate changes to the SAV community as a result of the alum treatment. Compared to the 2017 survey, in the 2019 survey, substantially more vegetation biomass grew in the lake as a whole and at depth, more species were observed in the lake than were observed in 2017, and there was more species diversity at depth. The most notable change between 2017 and 2019 was the increase in biomass. Between 5 and 10 feet, biomass increased by about 27,000 kg; between 10 and 15 feet, biomass increased by about 26,000 kg (Figure 3.3.2). These changes to the vegetation community coincide with increased water clarity in the lake due to the alum treatment (Section 3.2). Improved water quality allows light to penetrate deeper in the water column and encourages vegetation growth at these depths.

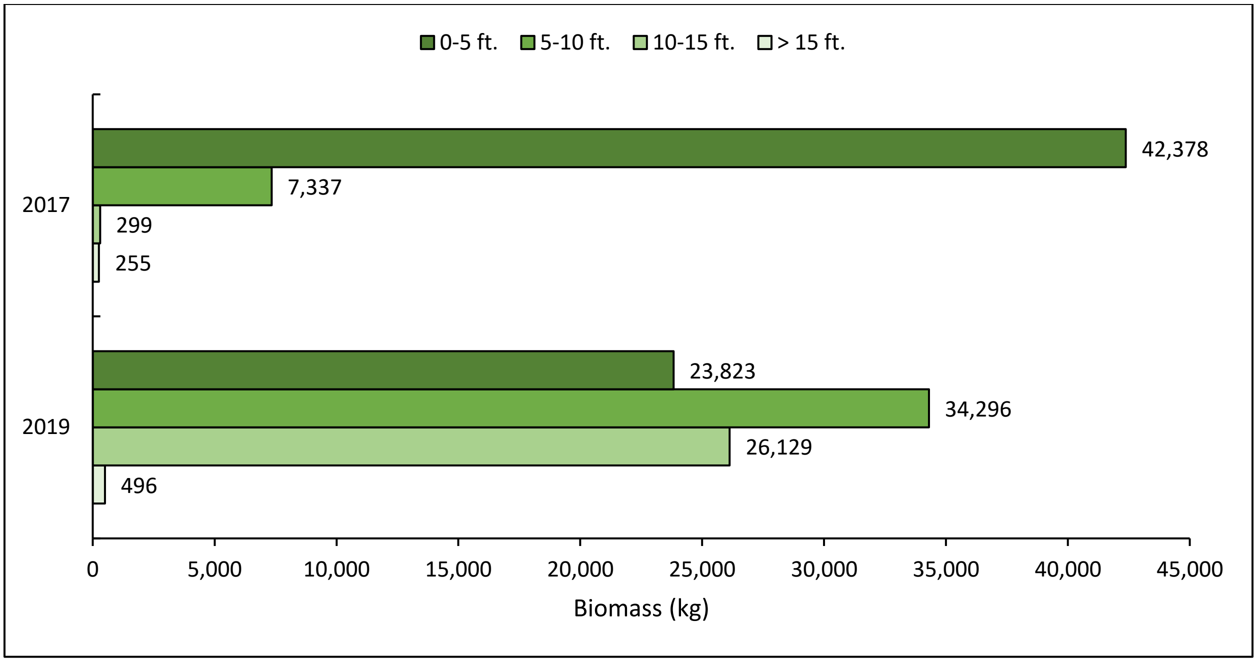


Figure 3.3.2. Biomass at various depth intervals (0-5 ft., 5-10 ft., 10-15 ft., and greater than 15 ft. during the 7/28/17 and 7/30/19 surveys.

Interestingly, between 0 and 5 feet, biomass did not increase, but rather decreased by about 18,500 kg (Figure 3.3.2). While this decrease in biomass might seem concerning, in fact it provides more habitat opportunity for previously observed rare species to establish where coontail has previously dominated. Conversely more growth was observed in deeper depth strata, primarily by coontail. Increased water clarity has likely provided habitat for increased vegetation growth in deeper areas.

In addition to changes in biomass, the vegetation community also saw an increase in the number of species observed, from 4 in 2017 to 6 in 2019 throughout the lake. Further, more species were observed at depth. At the 5-10 feet depth interval, white waterlily, yellow waterlily, and lesser duckweed were observed in 2019, whereas these species were absent in this depth interval in 2017 (Table 3.3.5). This increase in diversity in the whole lake and in deeper waters indicates increased water clarity in the lake, which allows light to penetrate to deeper depths of the water column and plants to use this light to grow at greater depths. Finally, occurrences of native, favorable species increased. The native species *elodea*, yellow water lily, and lesser duckweed had occurrences at or over 5% compared to no observations in 2017 (Table 3.3.4).

Despite the increase in species overall, two native species were observed in 2017 and not 2019: naiad and sago pondweed. It is likely that these species persisted during the 2019 survey but were simply not observed due to their limited occurrence. In fact, in the 2017 survey, naiad and sago pondweed had only 3% occurrence throughout the lake (Table 3.3.4).

Table 3.3.5. SAV species occurrence by depth.

Common Name	% Lake Occurrence by Depth							
	7/28/2017				7/30/2019			
	0-5 ft.	5-10 ft.	10-15 ft.	>15 ft.	0-5 ft.	5-10 ft.	10-15 ft.	>15 ft.
Curly-leaf pondweed	--	--	--	--	5	--	--	--
Coontail	100	50	100	21	100	100	50	14
Waterweed (Canadian)	--	--	--	--	14	--	--	--

Common Name	% Lake Occurrence by Depth							
	7/28/2017				7/30/2019			
	0-5 ft.	5-10 ft.	10-15 ft.	>15 ft.	0-5 ft.	5-10 ft.	10-15 ft.	>15 ft.
Yellow waterlily	--	--	--	--	5	25	--	--
White waterlily	6	--	--	--	38	25	--	--
Duckweed (lesser)	--	--	--	--	10	25	--	--
Naiad	6	--	--	--	--	--	--	--
Sago pondweed	6	--	--	--	--	--	--	--

In conclusion, the summer 2019 SAV survey showed encouraging signs for the SAV community of Pomerleau Lake, at least in part due to the alum treatment performed in May 2019. Nearly all observed vegetation was native during the survey (except one single CLP observation), and this native vegetation covered over two thirds of the lake. That said, species diversity measured with FQI does not meet state standards. However, species diversity improved since 2017, so the lake is trending in the right direction. The most notable change between 2017 and 2019 was the increase in thousands of kilograms of biomass between 5 and 15 feet. More species were also observed in the 5-10 feet depth interval in 2019 compared to 2017.

These changes to the vegetation community coincide with increased water clarity in the lake, which allows light to penetrate to deeper depths of the water column and encourage vegetation growth at these depths. Water quality is still a stressor to the aquatic vegetation community, but as water quality improves, it is expected that all species observed in the 2019 survey, as well as previously observed rare species, should increase in both occurrence and biomass. Perhaps new species that are less tolerant to eutrophic waters will also be detected. That said, tolerant species with lower C-scores, such as coontail will probably persist in higher occurrences before less tolerant species with higher C-scores, such as naiad and flat stem pondweed (observed spring 2017), can persist in established communities across the lake. The establishment of these less tolerant species is an essential step in achieving the FQI standard established for shallow lakes in the Central Hardwood Forest Ecoregion such as Pomerleau Lake.

4.0 Schmidt Lake

4.1 INTRODUCTION & SAMPLING OVERVIEW

Schmidt Lake is located in the city of Plymouth within Hennepin County, MN. Schmidt Lake is classified as a shallow lake and has an approximate surface area of 45 acres, 42 acres of littoral area (i.e., area less than 15 feet deep), 1.74 miles of shoreline, and a maximum depth of 27 feet. The list below summarizes the year in which each type of sampling was most recently performed on Schmidt Lake:

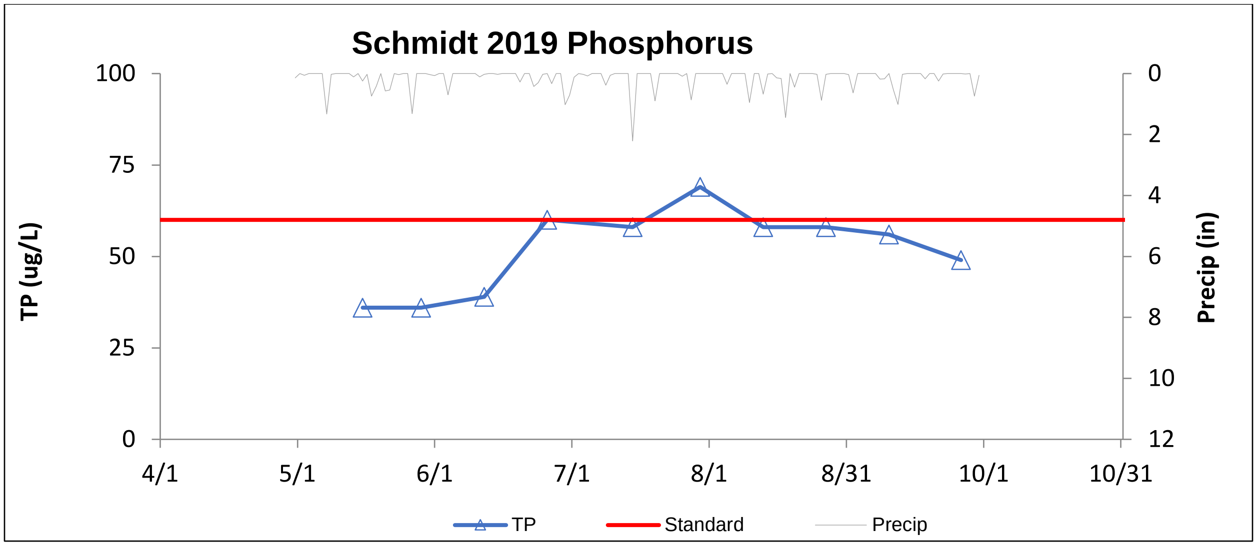
- Water Quality - 2019
- SAV – 2019
- Fisheries – 2019
- Carp – Not assessed

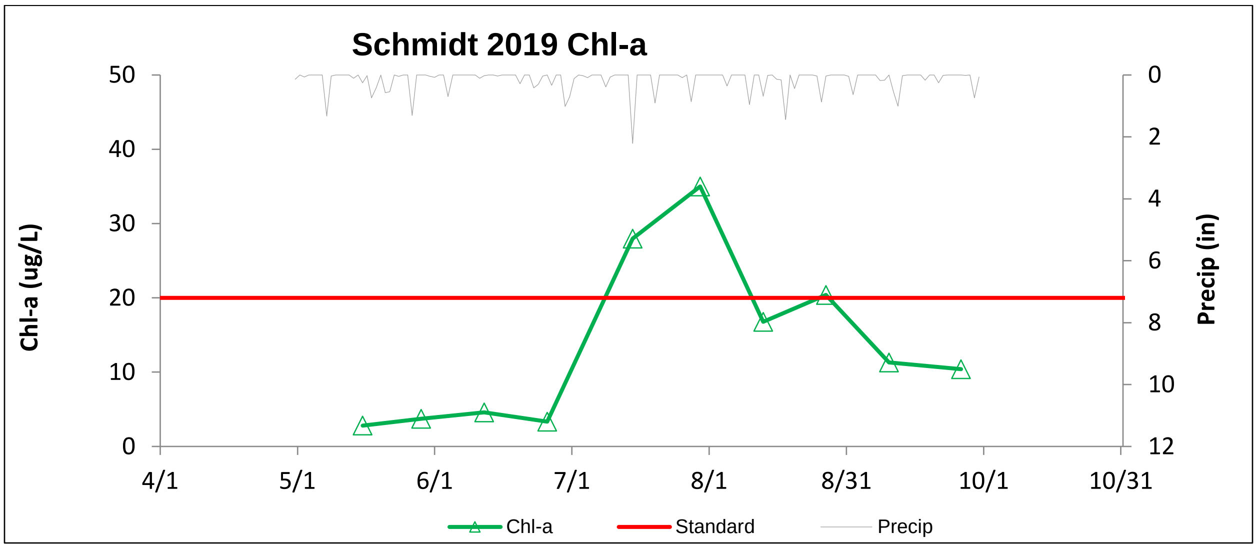
Unlike Bass and Pomerleau described above, Schmidt has not been treated with alum. However, some management does occur on Schmidt Lake (aeration).

4.2 WATER QUALITY

Water was collected twice per month May through September 2019 for a total of 10 samples. For the majority of the growing season, all three eutrophication standards were met (total phosphorus, chlorophyll-a, and Secchi depth; Figure 4.2.1). However, water quality deteriorated in mid- to late-July, at which point chlorophyll and phosphorus concentrations exceeded standards (Figure 4.2.1). The lake appears to have experienced an algae bloom at this time, likely fueled by high phosphorus levels, which could have been a result of the 2.2-inch storm on 7/15/19 (Figure 4.2.1). Still, by mid-August, the lake appears to have recovered, and annual growing season averages still met standards.

Data for eutrophication metrics on Schmidt Lake date back to 1994 and show that Schmidt Lake has generally met eutrophication standards (Figure 4.2.2). However, some data points, especially phosphorus concentrations, are close to the standard. Especially considering this is a shallow lake standard (which is less stringent than a deep lake standard), it would be ideal for values to be farther from the standards. Over the years, no water quality trend is particularly apparent.





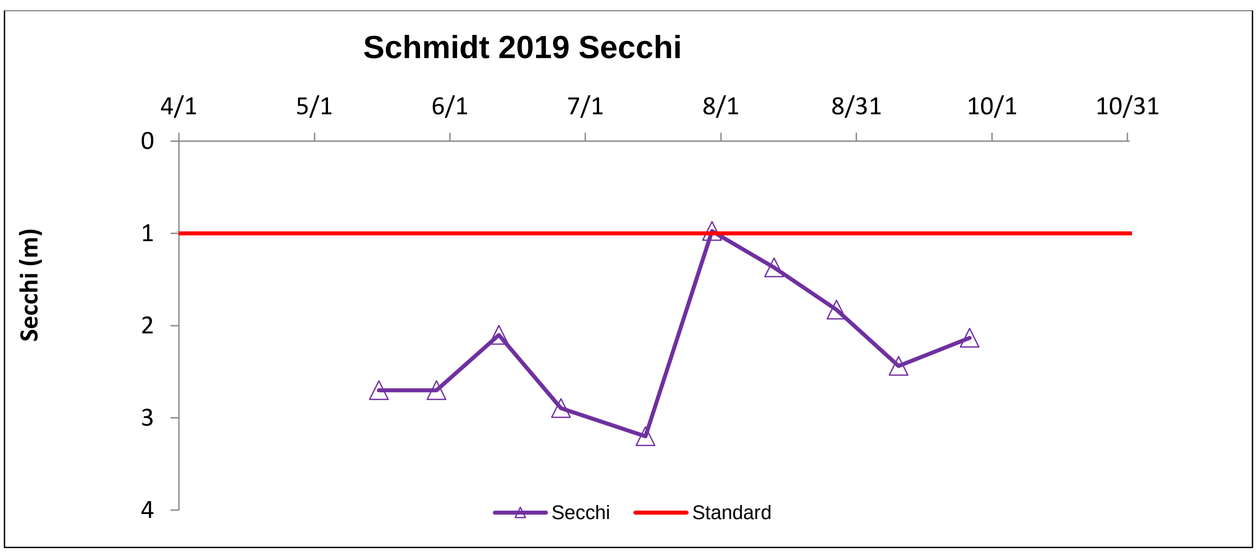
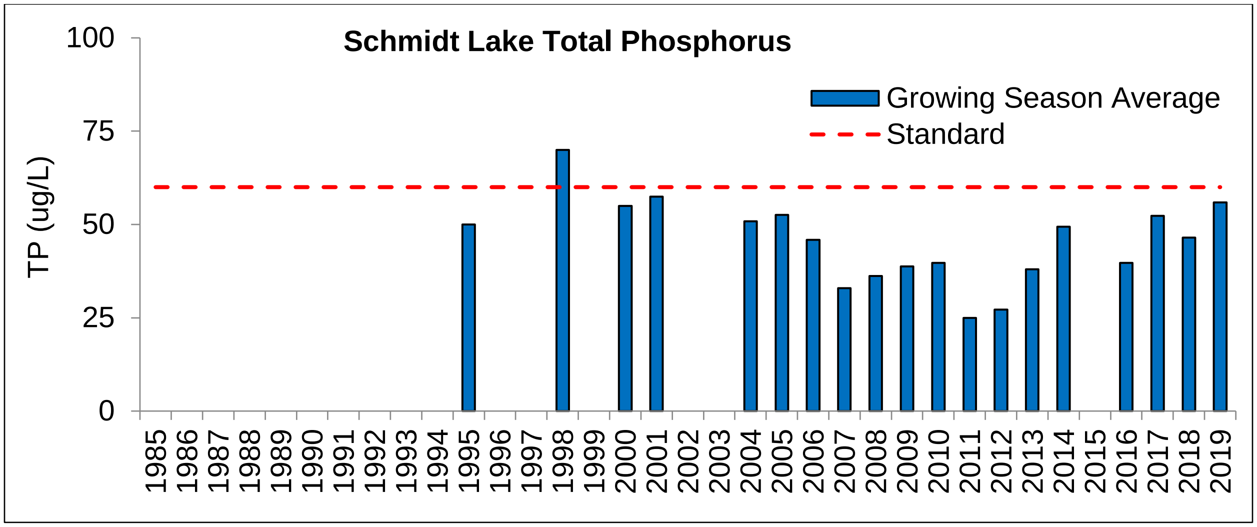
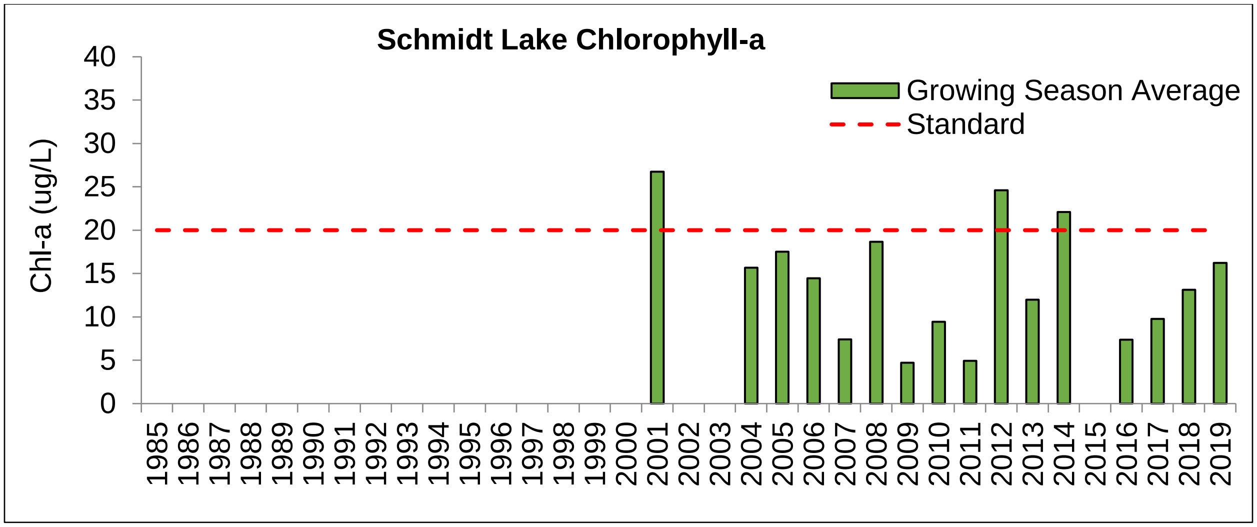


Figure 4.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.





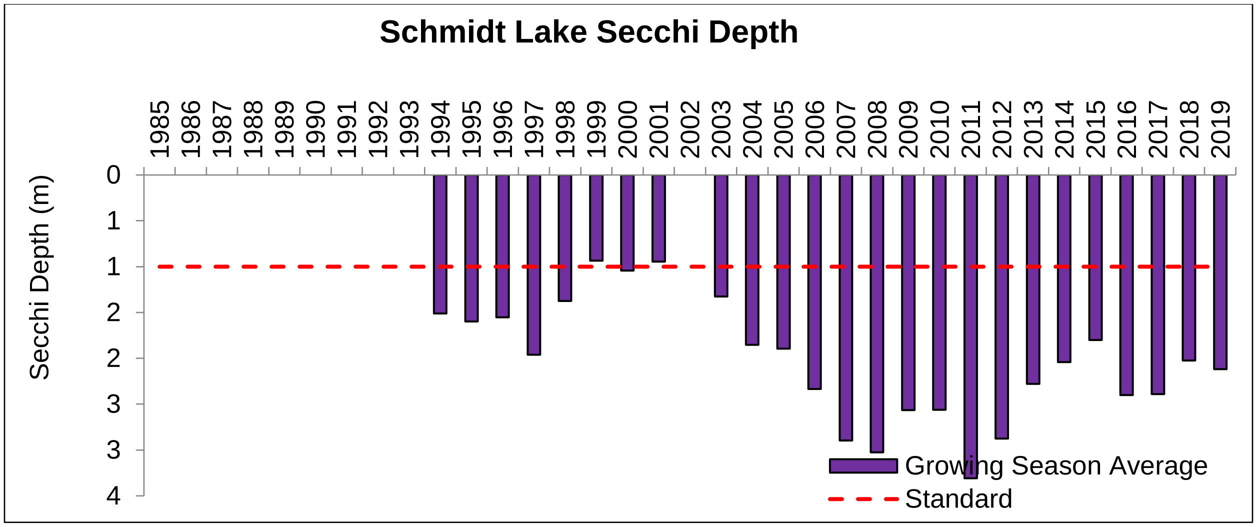


Figure 4.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

4.3 SUMERGED AQUATIC VEGETATION

Point intercept aquatic vegetation surveys were conducted on June 10, 2019 and July 30, 2019 to document the spring and summer submersed aquatic vegetation in Schmidt Lake. (These surveys will be referred to as the spring and summer surveys.) During the spring survey, the lake had 84% vegetative cover, with 64 of the 76 survey points containing vegetation. The lake had a lower vegetative cover during the summer survey, with 64% vegetative coverage, or 42 of 72 survey points covered in vegetation (Table 4.3.1). This makes sense given that Schmidt lake is classified as a shallow lake and is mostly littoral, with 42 of its 45 acres in the littoral zone (i.e., in water less than 15 feet deep).

Table 4.3.1. Survey statistics.

Index	Result	
	6/10/2019	7/30/2019
Total Points	76	72
Littoral Points	73	67
Total Vegetated Points	64	46
% Littoral Points with Vegetation	86%	69%

During both surveys, biovolume, or the volume of water occupied by vegetation, was highest in shallow areas (Figure 4.3.1). Biomass and species richness showed the same trend (Table 4.3.2). For instance, areas between 0 and 5 feet had more than three times the biomass than the areas at 5 to 10 feet (Table 4.3.2). Further, during the spring survey, ten species were observed in 0 to 5 feet versus only six species in 5 to 10 feet (Table 4.3.2), although during the summer survey, five species were observed in each of these depth intervals (Table 4.3.2). A single observation was discovered at a depth greater than 15 feet during the spring survey, while no vegetation was observed in water depths greater than 8 feet during the summer survey. This is a natural trend due to light limitation. However, in more pristine lakes with greater clarity, this transition is more gradual, with light reaching depths greater than 15 feet, and consequently vegetation growing in these greater depths.

Table 4.3.2. Comparison of community composition with depth.

Depth (ft.)	Lake Acres (acres)	6/10/2019				7/30/2019			
		Sample points at this depth (#/%)		Species Observed (#)	Biomass (kg)	Sample points at this depth (#/%)		Species Observed (#)	Biomass (kg)
0-5 ft.	30	40	53	10	68,880	34	47	5	15,538
5-10 ft.	9	29	38	6	10,682	27	38	5	4,533
10-15 ft.	3	4	5	2	337	6	8	0	0
>15 ft.	2.8	3	4	1	113	5	7	0	0

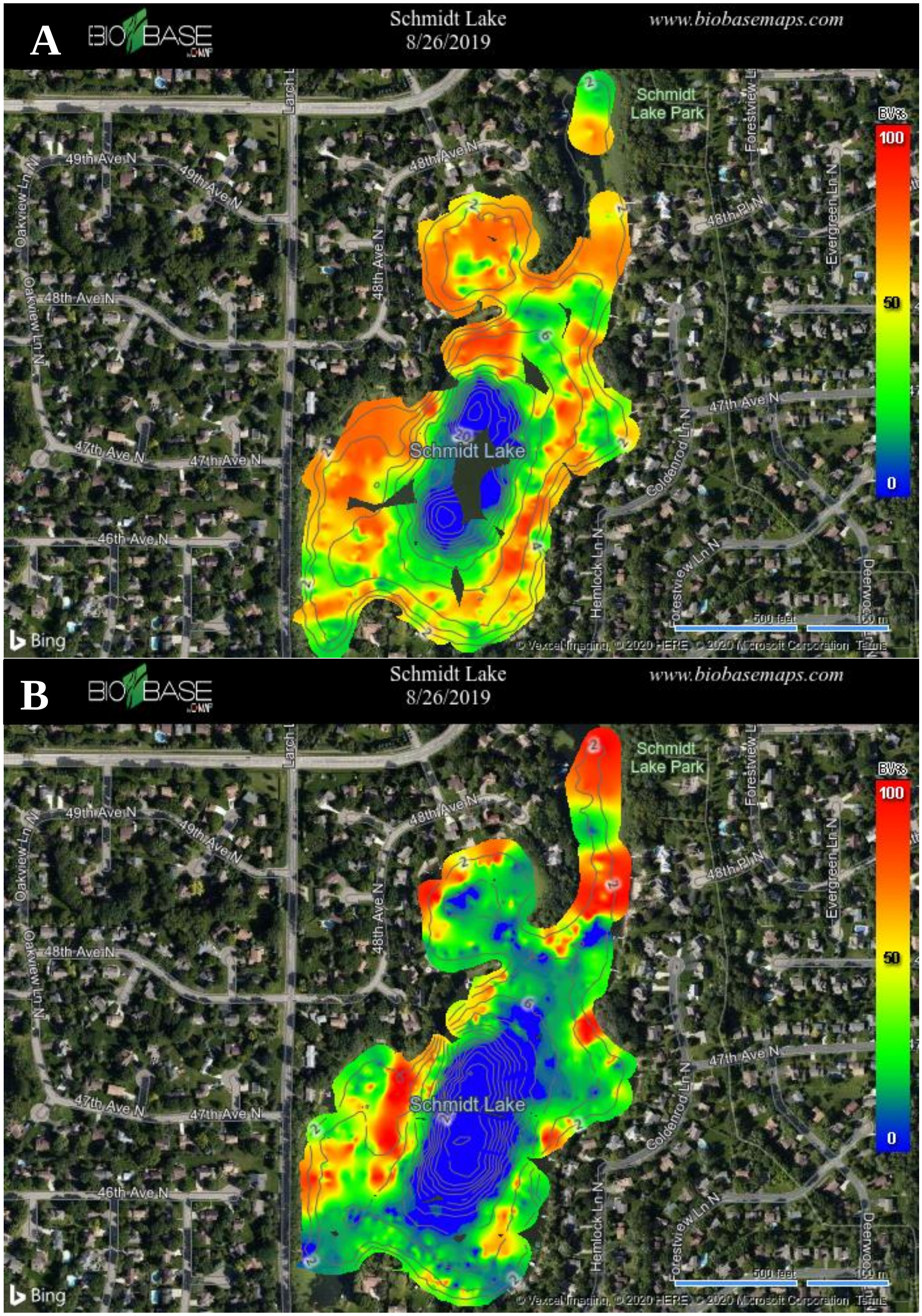


Figure 4.3.1. Biovolume heat maps for Schmidt Lake during the June (A) and July (B) 20190 surveys. In the heatmaps, red indicates 100% biovolume and blue indicates 0% biovolume. Biovolume refers to the percentage of the water column taken up by vegetation.

Schmidt Lake's June survey showed that the lake has good diversity, with 10 observed taxa, a C-score of 5.1, and an FQI of 16.1 (Table 4.3.3). However, these values still fell slightly short of the Central Hardwood Forest Ecoregion shallow lake standards, which require 11 observed taxa and an FQI of 17.8. Coontail was a dominant species during the June survey with an observed occurrence of 70% (Table 4.3.4). Coontail is native, but thrives in eutrophic waters and often grows in undesirable, monodominant stands. It was also the only species observed at depths greater than 15 feet (Table 4.3.5). The second most abundant species was curly-leaf pondweed (CLP), a non-native species that is detrimental to other vegetation and water quality. CLP had an occurrence of 43% throughout the lake and was the only invasive species observed in Schmidt Lake during either survey (Table 4.3.4). Desirable native plants were less dominant, but also established throughout the lake, such as flat stem pondweed (42% occurrence) and white water lily (18% occurrence). Muskgrass, duckweeds (star and lesser), bushy pondweed, sago pondweed, and water celery were rarely observed, with occurrences at less than 8% of the survey locations (Table 4.3.4) and in water no greater than 10 feet. (Table 4.3.5). Even though several species were observed rarely, it is encouraging to see high species diversity. With better water quality and less CLP competition, these species would persist in larger numbers.

Table 4.3.3. Species diversity statistics.

Index	Result*	
	6/10/19	7/30/19
Observed Taxa	10	6
Average C-score	5.1	5.1
Lake Floristic Quality Index (FQI)	16.1*	12.7*

*The standards for number of taxa and FQI in Schmidt Lake are 11 and 17.8, respectively.

Unlike the spring survey, the summer survey had poor diversity, with 6 observed taxa, a C-score of 5.1, and an FQI of 12.7 (Table 4.3.3). Neither species richness nor FQI came close to meeting the Central Hardwood Forest Ecoregion standards, which require 11 observed taxa and an FQI of 17.8. While fewer native species were observed in July, it is important to remember that the species that were not observed in June were observed to be rare. It is likely that these rare species persisted during both surveys but were simply not observed in July due to their limited occurrence. Interestingly, there was no single dominant species in the summer survey. Flat stem pondweed, a native favorable species, had the highest occurrence, at 38% of the lake. Other prevalent species were coontail, white water lily, and water celery, which ranged in occurrence from 19% to 33% and are all favorable (Table 4.3.4). Muskgrass and waterweed were observed to be rare during this survey. No species were observed in depths greater than 10 feet, likely because water clarity decreased in summer months (Section 4.2) and thus light limitation increased (Table 4.3.5). As expected, CLP was not observed in the summer survey, because it senesces after spring. That said, it is encouraging that in the absence of CLP, favorable native plants are able to persist in high occurrences.

Table 4.3.4. Species occurrence during 2019 surveys.

Common Name	Scientific Name	% Lake Occurrence	
		6/10/2019	7/30/2019
Curly-leaf pondweed	*Potamogeton crispus*	43	--
Coontail	*Ceratophyllum demersum*	70	33
Waterweed (Canadian)	*Elodea canadensis*	--	6
Muskgrass	*Chara sp.*	8	1
White waterlily	*Nymphaea odorata*	18	19
Duckweed (star)	*Lemna trisulca*	3	--
Duckweed (lesser)	*Lemna minor*	7	--
Bushy pondweed	*Najas flexilis*	5	--
Flat-stem pondweed	*Potamogeton zosteriformis*	42	38
Sago Pondweed	*Stuckenia pectinata*	5	--
Water celery	*Valliseria americana*	3	28

Table 4.3.5. SAV species occurrence by depth.

Common Name	% Occurrence by Depth							
	6/10/2019				7/30/2019			
	0-5	5-10	5-10	>15	0-5	5-10	10-15	>15
Curly-leaf pondweed	45	41	75	--	--	--	--	--
Coontail	73	72	50	33	38	41	--	--
Waterweed (Canadian)	--	--	--	--	6	7	--	--
Muskgrass	3	3	--	--	--	4	--	--
White waterlily	33	3	--	--	41	--	--	--
Duckweed (star)	5	--	--	--	--	--	--	--
Duckweed (lesser)	13	--	--	--	--	--	--	--
Bushy pondweed	8	3	--	--	--	--	--	--
Flat-stem pondweed	38	59	--	--	56	30	--	--
Sago pondweed	6	--	--	--	--	--	--	--
Water celery	5	--	--	--	53	7	--	--

In conclusion, species richness did not meet Central Hardwood Forest Ecoregion shallow lake standards in either the spring or summer survey, but the spring vegetation community was closer to meeting standards than the late summer survey, with 10 observed taxa compared to the standard of 11. However, healthy lake vegetation communities typically increase in species richness, vegetation abundance, and vegetation depth over the growing season, and in Schmidt, the vegetation community deteriorated over the growing season. This is likely a response to water quality, particularly water clarity, deteriorating over the growing season, which selects for growth of species that are tolerant of high nutrient conditions, such as coontail. In addition to impairing the lake ecosystem, coontail also impairs recreation because it grows thick enough to make boating and swimming difficult. Vegetation management on Schmidt Lake is not currently programmed for the Commission, but efforts to reduce, remove and replace coontail growth with other species would improve ecology and recreation in the lake.

4.4 FISHERIES

An assessment using methods comparable to DNR fisheries lake surveys was conducted in Schmidt Lake on August 11 and 12, 2019. All survey activities were permitted under DNR fisheries permit #29254. This survey effort was conducted to evaluate the status of the game fish community within Schmidt Lake in the absence of scheduled fisheries lake surveys being performed by the DNR on the lake since 1990 (Figure 4.4.1). Results from prior fish surveys were integrated with the current results to assess trends in fish abundance and community structure over time (Figure 4.4.1). This analysis suggests that game fish abundance within Schmidt lake currently falls within normal ranges for Minnesota lakes with similar characteristics. Although overall fish are not highly abundant, a high-quality Northern Pike population currently exists in Schmidt Lake. Fisheries management recommendations are provided based on available information. Additional monitoring methods necessary for assessing largemouth bass populations (electrofishing) and those needed to generate a robust fish Index of Biological Integrity score are recommended to broaden the understanding of the fish community within Schmidt Lake.

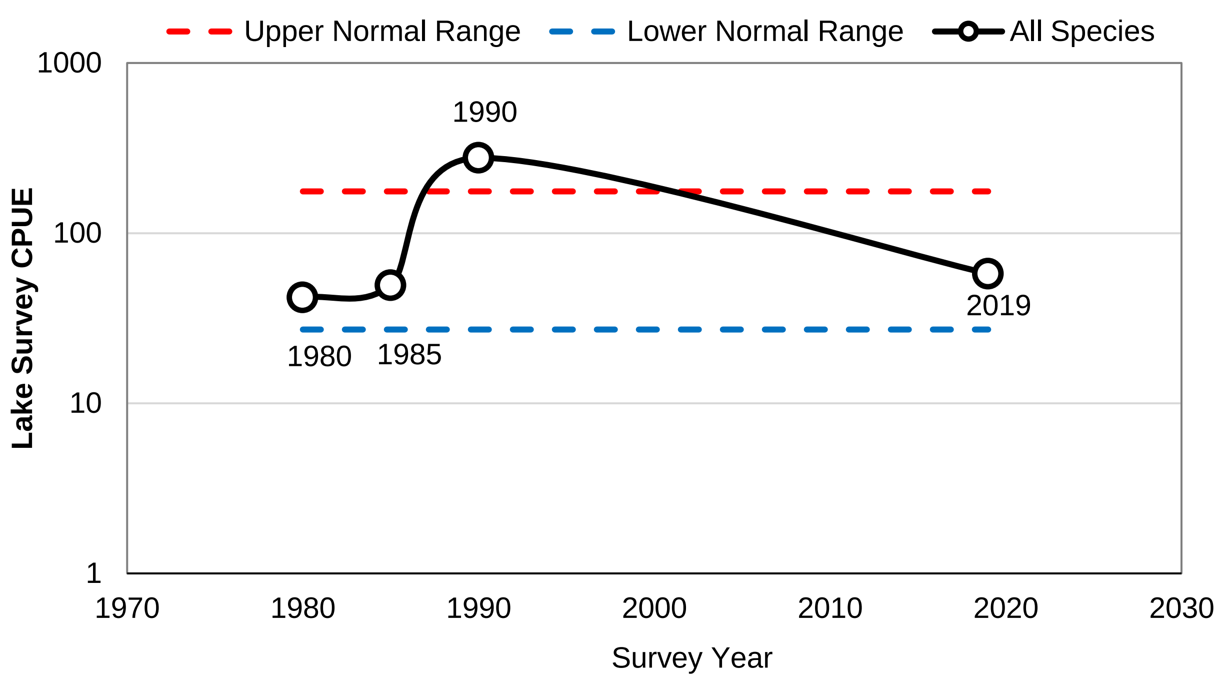


Figure 4.4.1. Catch per unit effort (CPUE) for past fisheries surveys on Schmidt Lake. Before this summer, a survey had not been conducted since 1990.

4.4.1 Methods

Four fyke nets (3/4" square mesh) and a single multi-panel DNR standard gill net were set on August 11, 2019 and left to fish overnight for 16 hours before they were pulled and their catch worked up the following morning of August 12 (Figures 4.4.2 and 4.4.3). These methods are consistent with standard fisheries lake survey methods used by the DNR, although they were employed with reduced repetition. This reduced repetition is acceptable given the small size of the lake/fishery. All survey activities were permitted under DNR fisheries permit #29254 and all best practices regarding AIS management were employed with great rigor during the course of work.

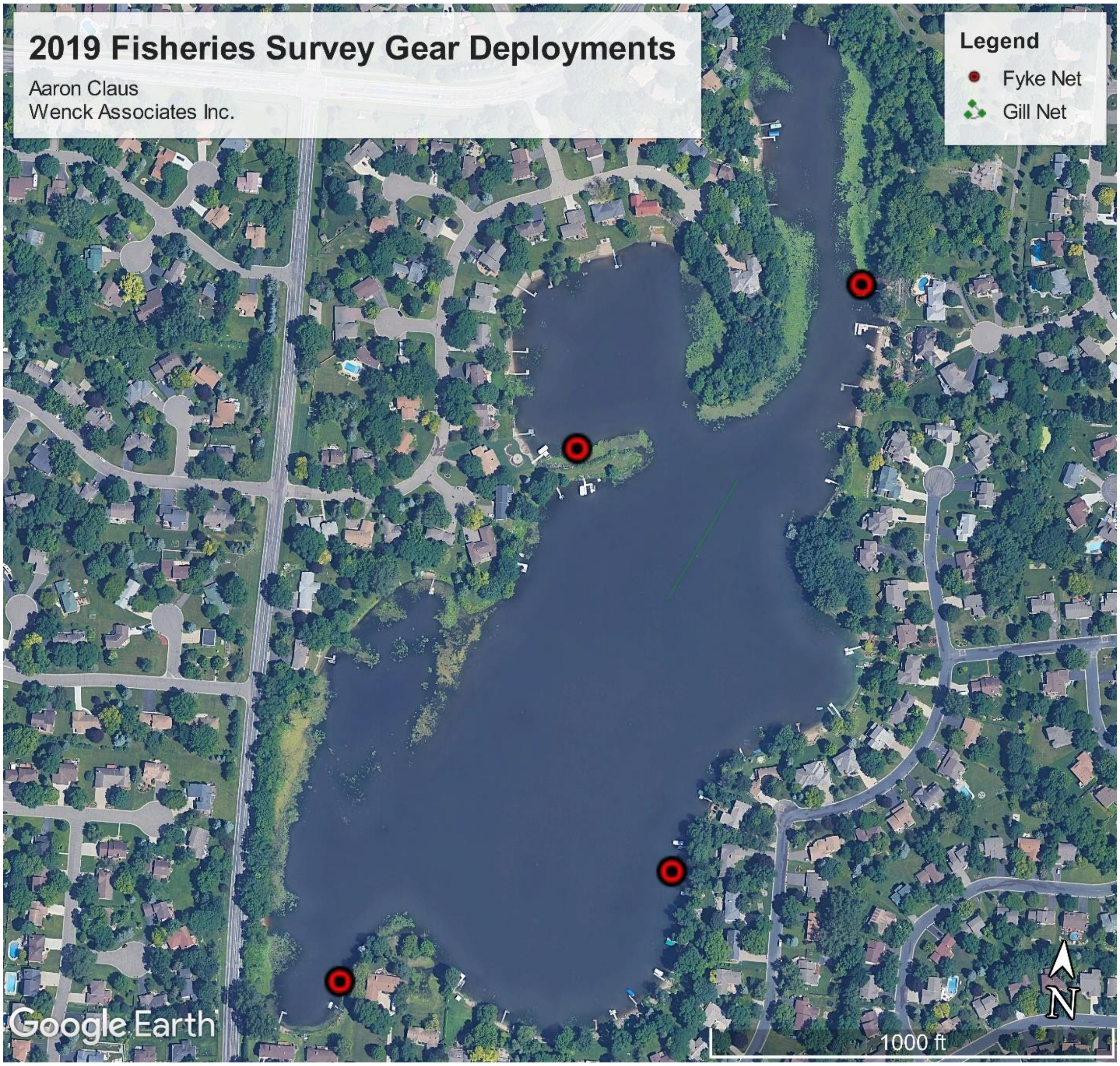


Figure 4.4.2. Fyke and gill net deployments Schmidt Lake in August 2019.


Figure 4.4.3. A fyke net set (left) and a gill net set (right) in Schmidt Lake in August 2019.

All gear deployments went smoothly and there was no indication that catches were affected by gear failure. Bycatch consisted of 10 Common Snapping Turtles (*Chelydra serpentina*) and 8 Painted Turtles (*Chrysemys picta*). Five diverse fish species were sampled, the diversity of fish species sampled is consistent with prior surveys except for the absence of Black Crappie (*Pomoxis nigromaculatus*) in the sample. Those species were the Black Bullhead (*Ameiurus melas*), Bluegill sunfish (*Lepomis macrochir*us), Pumpkinseed sunfish (*Lepomis gibbosus*), and Northern Pike (*Esox lucius*) (Table 4.4.1).

Northern Pike were the only species captured in high relative abundance and had an average weight of 3.62 lbs, and an average length of 24.4 inches (Figure 4.4.4). A 33 inch long 8.4 pound Northern Pike was captured and released alive from the gill net (Figure 4.4.5). Bluegill catch per unit effort fell within normal ranges (length frequency presented in Figure 4.4.4), however the fyke net sample did contain a large adult "bull" male individual that was 7.3" long and weighed .5 lbs (Figure 4.4.5). A hybrid complex of the *Lepomis* genus (sunfishes) was also sampled in moderate abundance alongside a low abundance of distinct Pumpkinseed sunfish. Black bullheads were sampled in low density and at low average size. Largemouth bass were not sampled in the 2019 survey effort but are likely to persist in the lake given a history of stocking. Largemouth Bass are known to be under-sampled by fyke and gill net gear types; electrofishing methods are often used to assess populations of this species because of this known ability for net avoidance.

Table 4.4.1. 2019 mini-fyke and gill net capture summary for Schmidt Lake (*denotes lack of normal range data for this species/gear type/lake class).

Species	Gear	CPUE	Normal Range	Avg Weight (lbs)	Normal Range (lbs)	Count
Black Bullhead	Fyke	0.3	1.08-25.19	0.22	0.14-0.47	1
Bluegill	Fyke	9.3	4.90-49.80	0.13	0.10-0.28	37
Hybrid Sunfish	Fyke	3.5	*	0.17	*	14
Northern Pike	Fyke	1.5	*	2.98	*	6
Pumpkinseed	Fyke	2.8	1.67-10.33	0.11	0.10-0.25	11
Black Bullhead	Gill	26.0	11.50-57.75	0.04	0.11-0.46	26
Bluegill	Gill	1.0	*	0.04	*	1
Northern Pike	Gill	15.0	4.50-11.33	3.62	1.38-2.78	15
Pumpkinseed	Gill	2.0	*	0.09	*	2

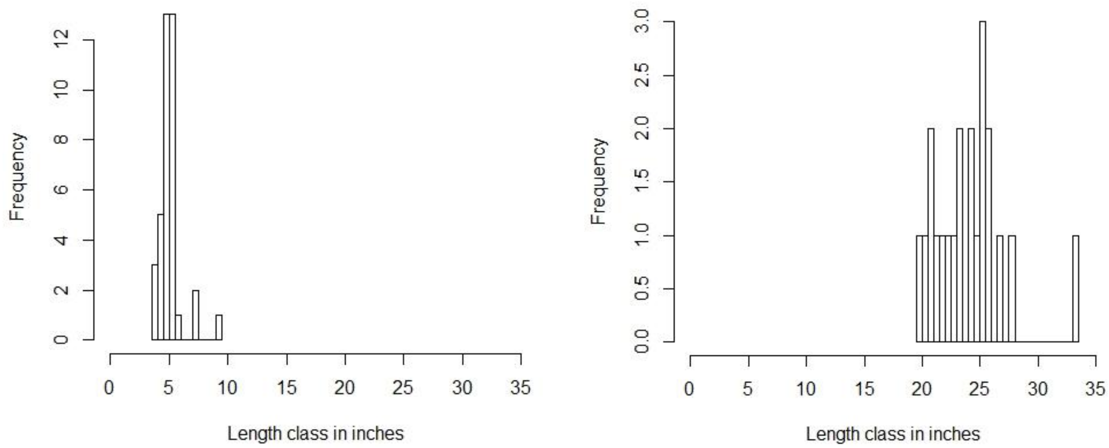


Figure 4.4.4. Length Frequency Plots of Left: Bluegill Sunfish and Right: Northern Pike sampled from gill and fyke nets set in Schmidt Lake in 2019.

Figure 4.4.5. Top: largest Northern Pike, Bottom Left: largest Bluegill, and Bottom Right: a "silver pike" sampled by Wenck in 2019.

4.4.2 Trends in Relative Abundance of Fish

The DNR conducted lake surveys for a brief period every five years (1980, 1985, and 1990) but this was discontinued. Blue Water Science conducted a similar assessment under contract with the City of Plymouth in 2011. The 2011 survey provided a more recent snapshot of the fish community, however this survey lacked gill net sets. The 2019 Commission survey employed comparable methods to the historical DNR surveys such that their results could be integrated in a comparative manner for the purpose of assessing trends through time. This approach also leverages the statewide DNR fisheries lake survey database by facilitating comparison of the relative abundance measured in each survey to normal ranges from similar lakes in the state. Figures 4.4.6, Figure 4.4.7 and Figure 4.4.8 plot the catch per unit effort (CPUE) data from each year of comparable sampling within the normal ranges for lakes in the same ecological class. Figure 4.4.6 does this for all species sampled by the survey methods, Figure 4.4.7 considers bottom feeding (benthivorous) species only, and Figure 4.4.8 focuses on the dominant fish predator (piscivorous) species the Northern Pike.

Survey data suggest that the relative abundance of fish within Schmidt lake has varied widely through time but currently falls within normal ranges for Minnesota lakes with similar characteristics. While overall fish abundance was within normal ranges for the lake class the quantity and quality of the Northern Pike population exceeded these normal ranges in both catch per unit effort and average weight. The development of this strong population of Northern Pike requires a stable habitat that can provide conditions for consistent overwinter survival and natural reproduction. Aeration of Schmidt Lake may be partly responsible for providing the necessary habitat for Northern Pike to thrive and reach this population state. In addition to creating a recreational resource for anglers, a quality sized population of a piscivorous fish such as the Northern Pike is beneficial to lake water quality through an ecological phenomenon called trophic cascade. A robust large-bodied predator community reinforces the clear water/macrophyte dominated stable state in lakes via trophic cascade. This effect presents a dualistic purpose for positive management of game fishes in a lake such as Schmidt.

While natural reproduction of Northern Pike is occurring, the reproductive status of Bass and Sunfish populations is unclear (assuming a Bass population exists but was not sampled). Further study would be needed to ascertain whether natural reproduction is occurring within the existing populations of nest-building centrarchid fishes (Largemouth Bass and Sunfishes), or if fish sampled were remnants of prior stocking that ceased in 2015. Black bullhead were the only species of benthivorous fish sampled in the lake in 2019, but abundances were relatively lower than those sampled in 1990 and were within normal ranges for the lake class. Thus, there is little concern that benthivorous fish are significantly affecting the game fisheries and/or lake water quality at the current time.

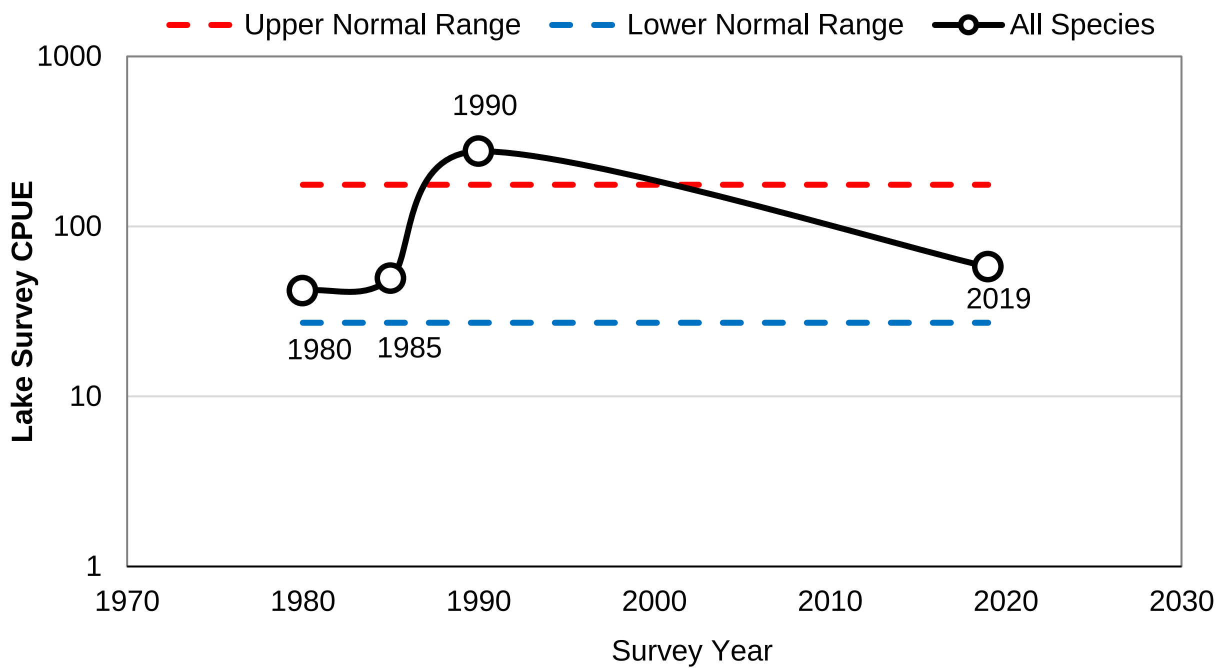


Figure 4.4.6. Relative abundance of fish through time in Schmidt Lake (all species).

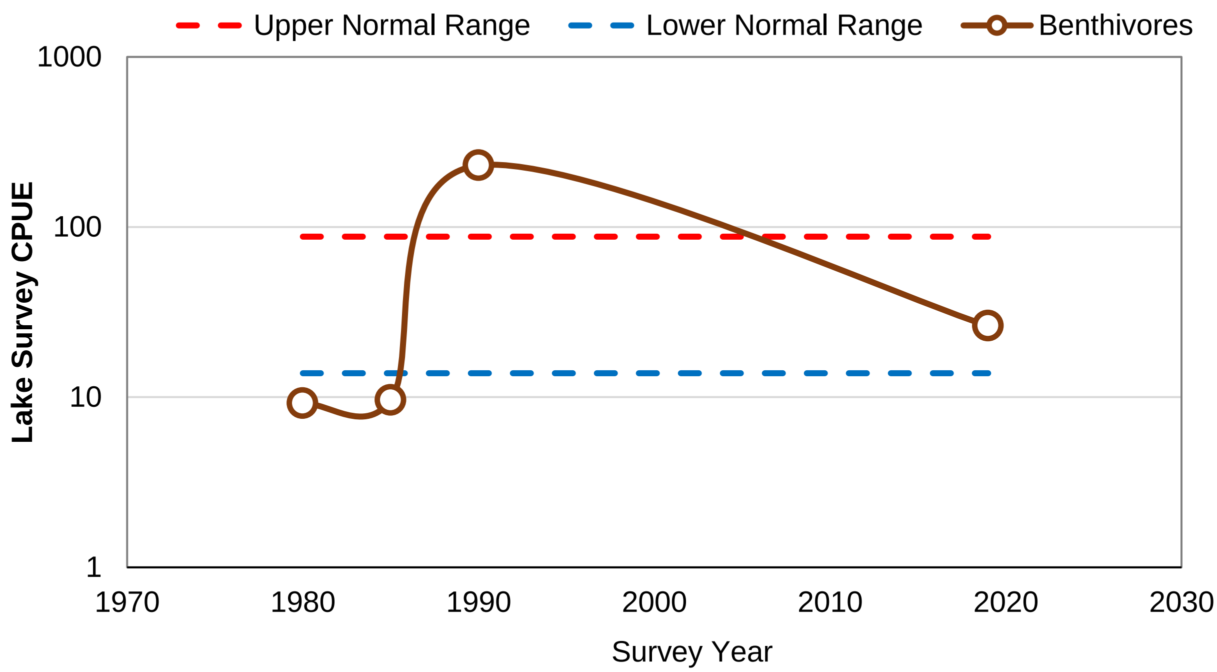


Figure 4.4.7. Relative abundance of fish through time in Schmidt Lake (benthivorous species).

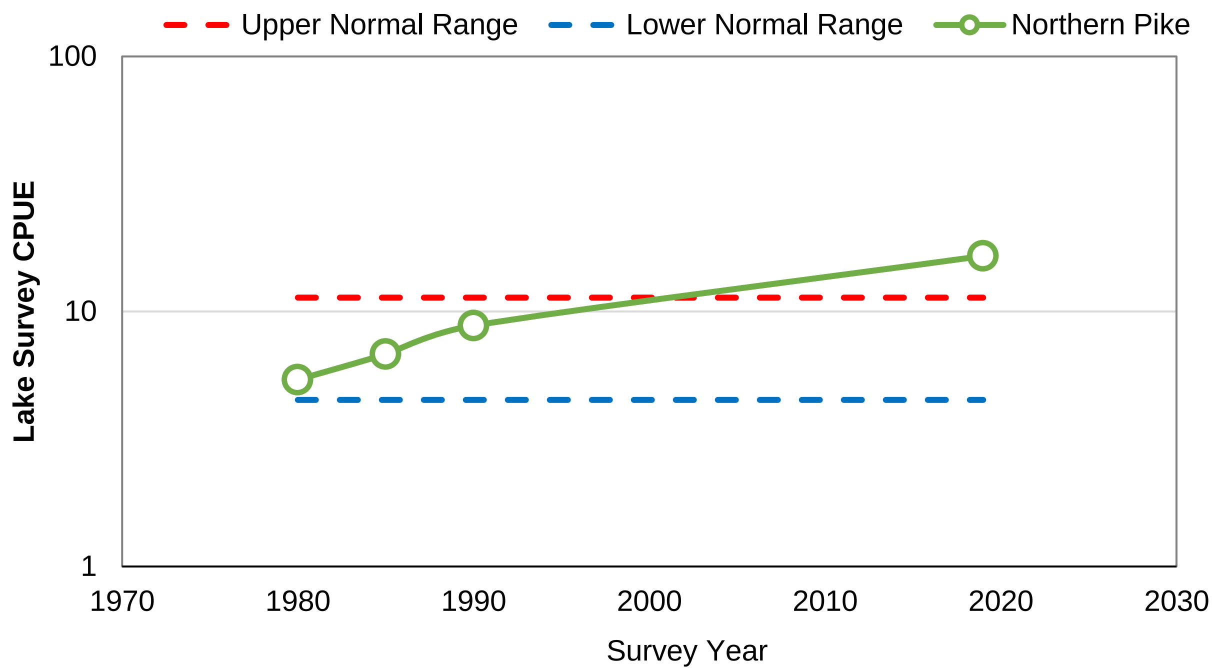


Figure 4.4.8. Relative abundance of fish through time in Schmidt Lake (Northern Pike).

4.4.3 Fisheries Management Recommendations

General aquatic habitat improvement is recommended as the primary active management activity for Schmidt Lake. The Shingle Creek Watershed Commission is already engaged in water management activities that inherently improve aquatic habitat in lakes such as a Schmidt. Beyond habitat improvement, the strategy of reducing stressors to fish survival/health and maximizing reproductive capacity is the most viable way to further augment the fisheries present. The aeration system installed in Schmidt Lake is an example of reducing oxygen stress that appears to have been effective. Routine fisheries monitoring should also continue in order to track responses to management over time, but gill net sampling should not occur in Schmidt Lake more than once every five years due to its high inherent mortality rate.

Provision of adequate spawning substrate for Bass and Sunfish is a management method that could increase natural reproduction rates and abundance of these species. Shoreland and emergent vegetated habitats around Schmidt lake would benefit from more conservative management practices, which would in parallel have a positive effect on the lake's fisheries and general ecological health. Survey methods necessary for assessing largemouth bass populations (electrofishing) are recommended if management of this species is a priority. Methods required to generate a robust fish Index of Biological Integrity score (as performed in Bass Lake) are also recommended additions to the future monitoring plan for Schmidt Lake. These surveys would broaden the ecological understanding of the fish community present beyond what is detected by standard techniques employed for surveying game fish populations.

5.0 Upper Twin Lake

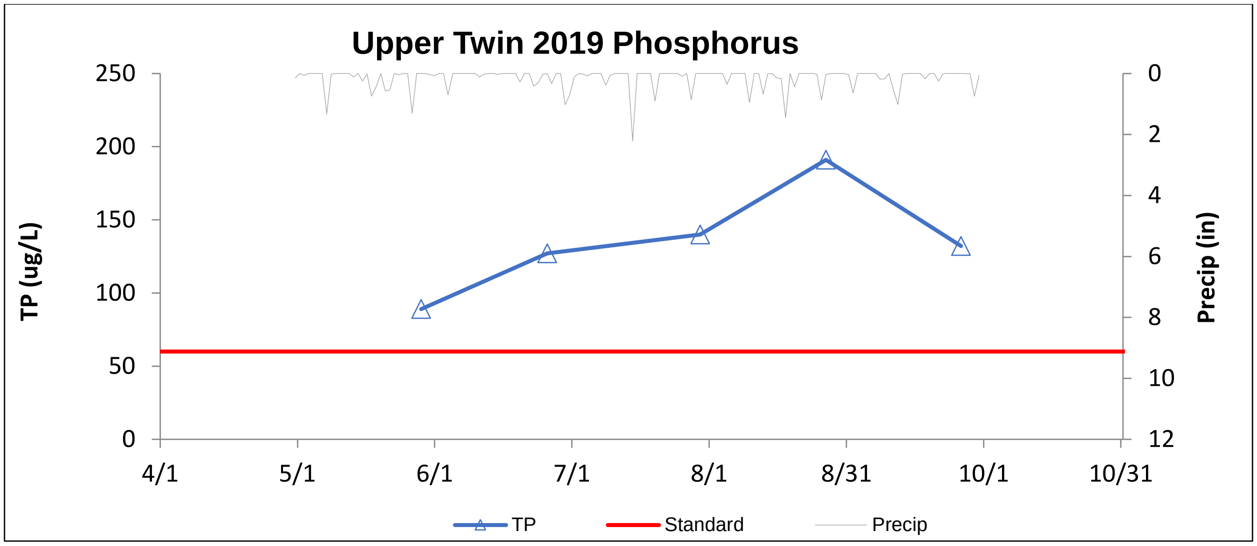
5.1 INTRODUCTION & SAMPLING OVERVIEW

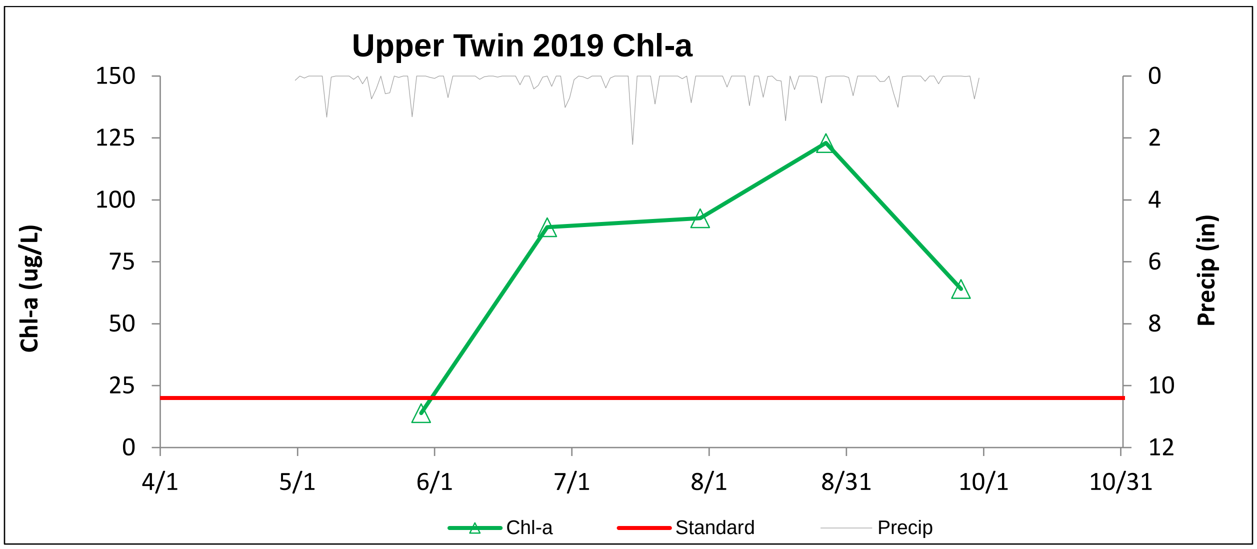
Upper Twin Lake is located in the cities of Crystal and Brooklyn Center within Hennepin County, MN. Upper Twin Lake is classified as a shallow lake and has an approximate surface area of 118 acres, all of which are littoral (i.e., area less than 15 feet deep), and a maximum depth of 10 feet. The list below summarizes the year in which each type of sampling was most recently performed on Upper Twin Lake:

- Water Quality - 2019
- SAV – 2018
- Fisheries - 2018
- Carp – 2018

5.2 WATER QUALITY

The lake was monitored once per month May through September 2019 for a total of 5 samples. Water quality was poor throughout the growing season. Eutrophication standards (measured by total phosphorus, chlorophyll-a, and Secchi depth) were almost never met, with surface chlorophyll and total phosphorus levels as high as 123 ug/L and 191 ug/L, respectively, in late August (Figure 5.2.1). Data for eutrophication metrics on Upper Twin Lake date back to 1991 and show that water quality has been poor for as long as the lake has been monitored (Figure 5.2.2).





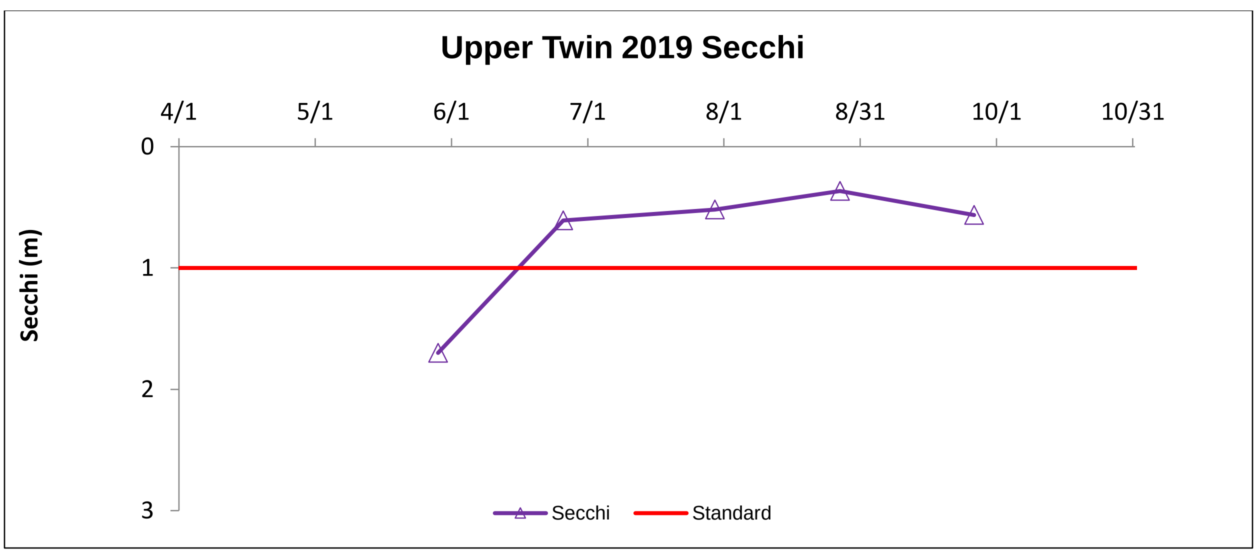
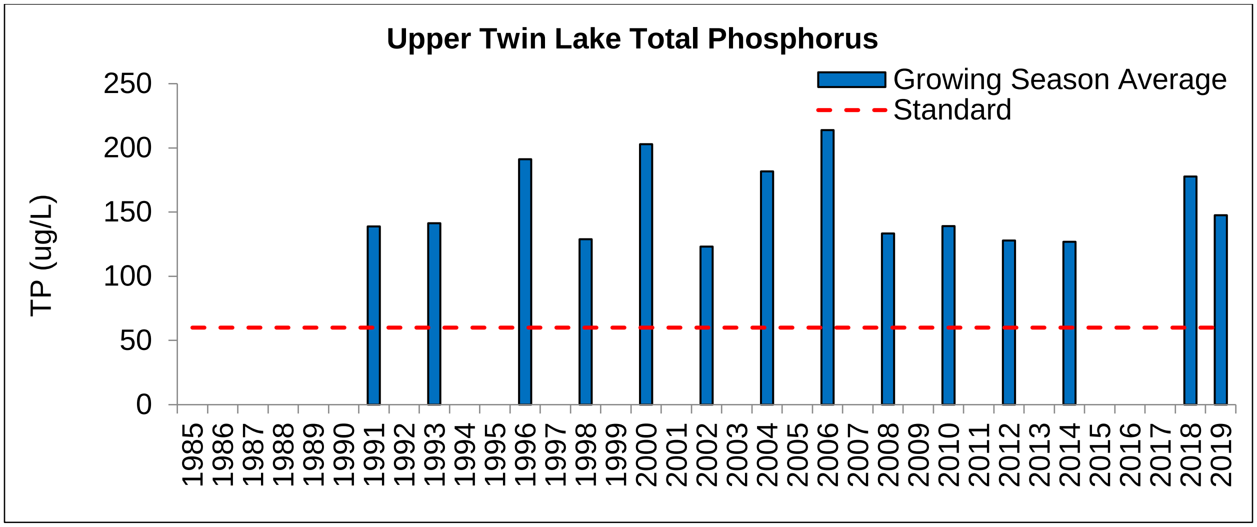
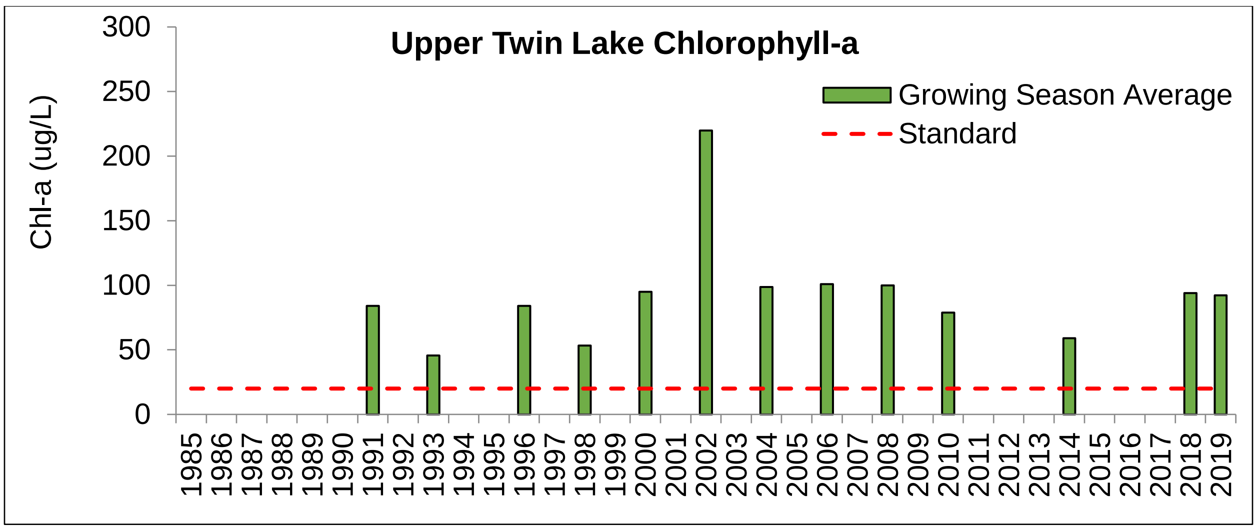


Figure 5.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.





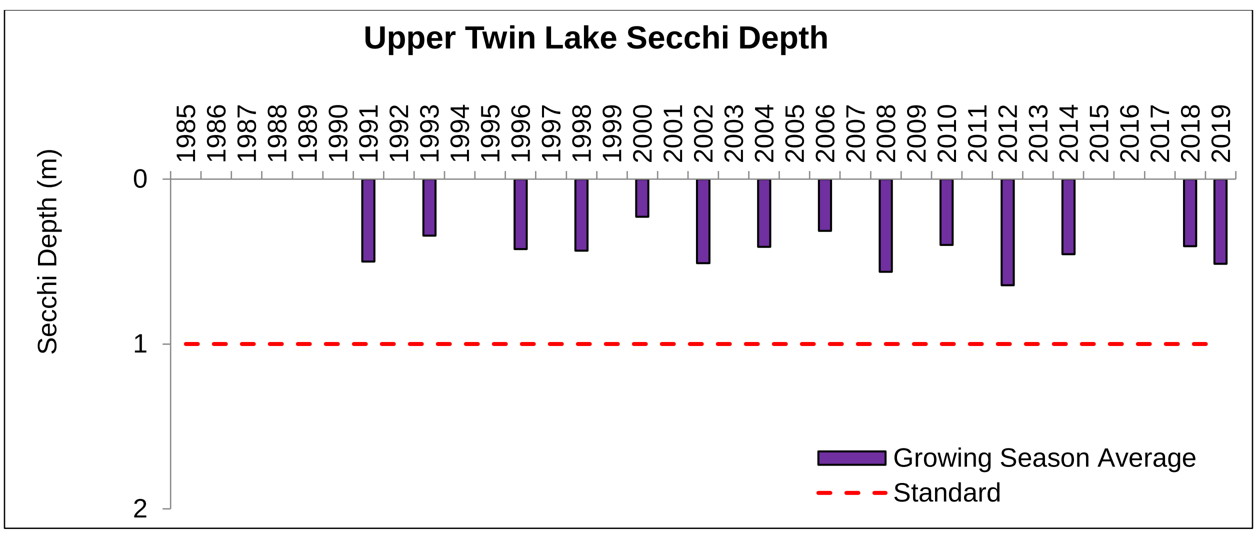


Figure 5.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

6.0 Middle Twin Lake

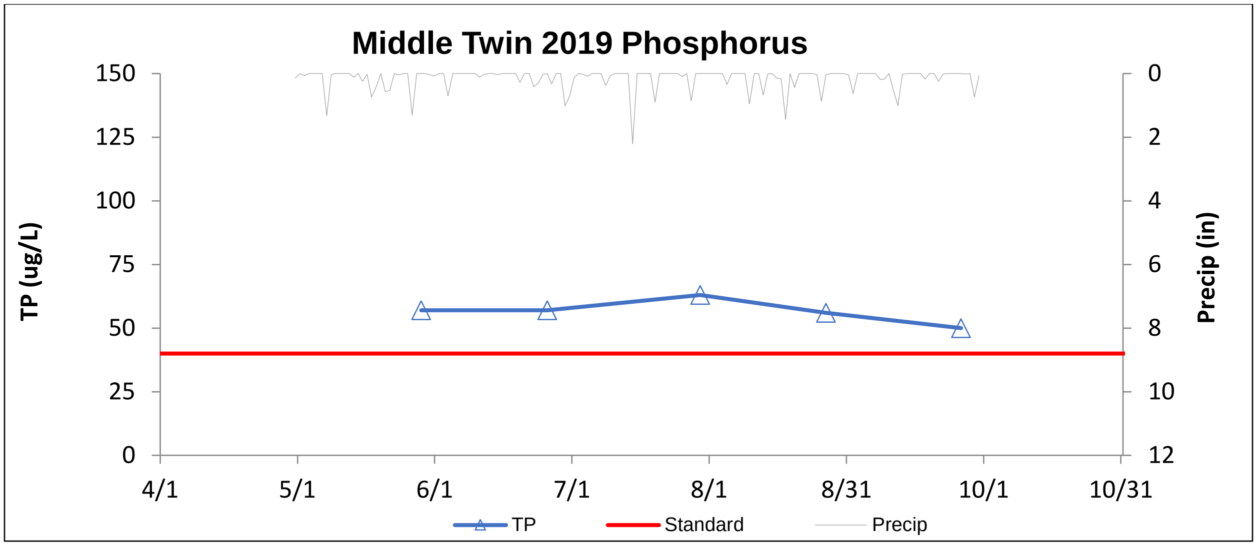
6.1 INTRODUCTION & SAMPLING OVERVIEW

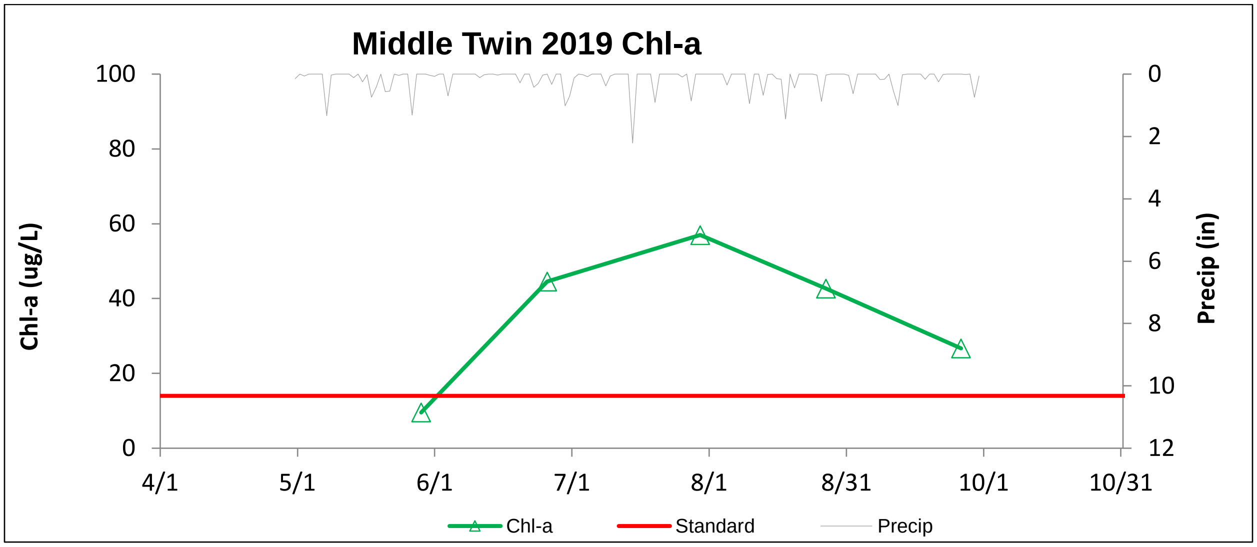
Middle Twin Lake is located in the cities of Crystal, Brooklyn Center, and of Robbinsdale within Hennepin County, MN. Middle Twin Lake is classified as a deep lake and has an approximate surface area of 54 acres, 32 acres of littoral area (i.e., area less than 15 feet deep), an average depth of 14.2 feet, and a maximum depth of 42 feet. The list below summarizes the year in which each type of sampling was most recently performed on Middle Twin Lake:

- Water Quality - 2019
- SAV – 2018
- Fisheries – 2018
- Carp – 2018

6.2 WATER QUALITY

The lake was monitored once per month May through September 2019 for a total of 5 samples. Water quality was poor throughout the growing season, though not as poor as Upper Twin Lake's water quality. Eutrophication standards (measured by total phosphorus, chlorophyll-a, and Secchi depth) were never met during the growing season (June through September), and surface chlorophyll was high, ranging from 27 to 57 ug/L (Figure 6.2.1). Data for eutrophication metrics on Middle Twin Lake date back to 1985 and show that water quality has hovered around the standard since that time (Figure 6.2.2).





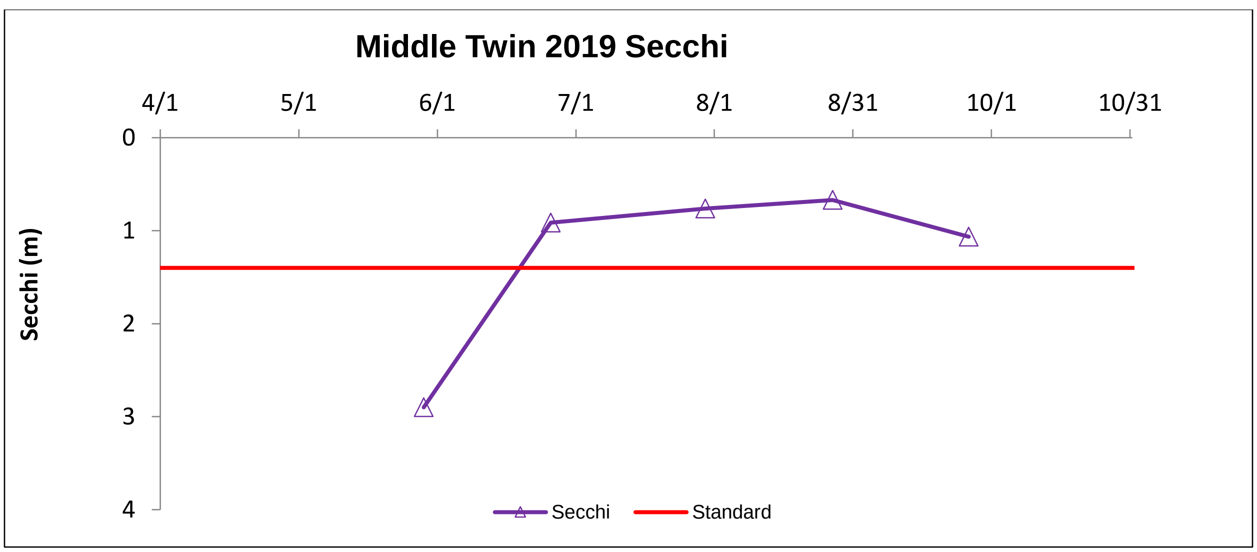


Figure 6.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.

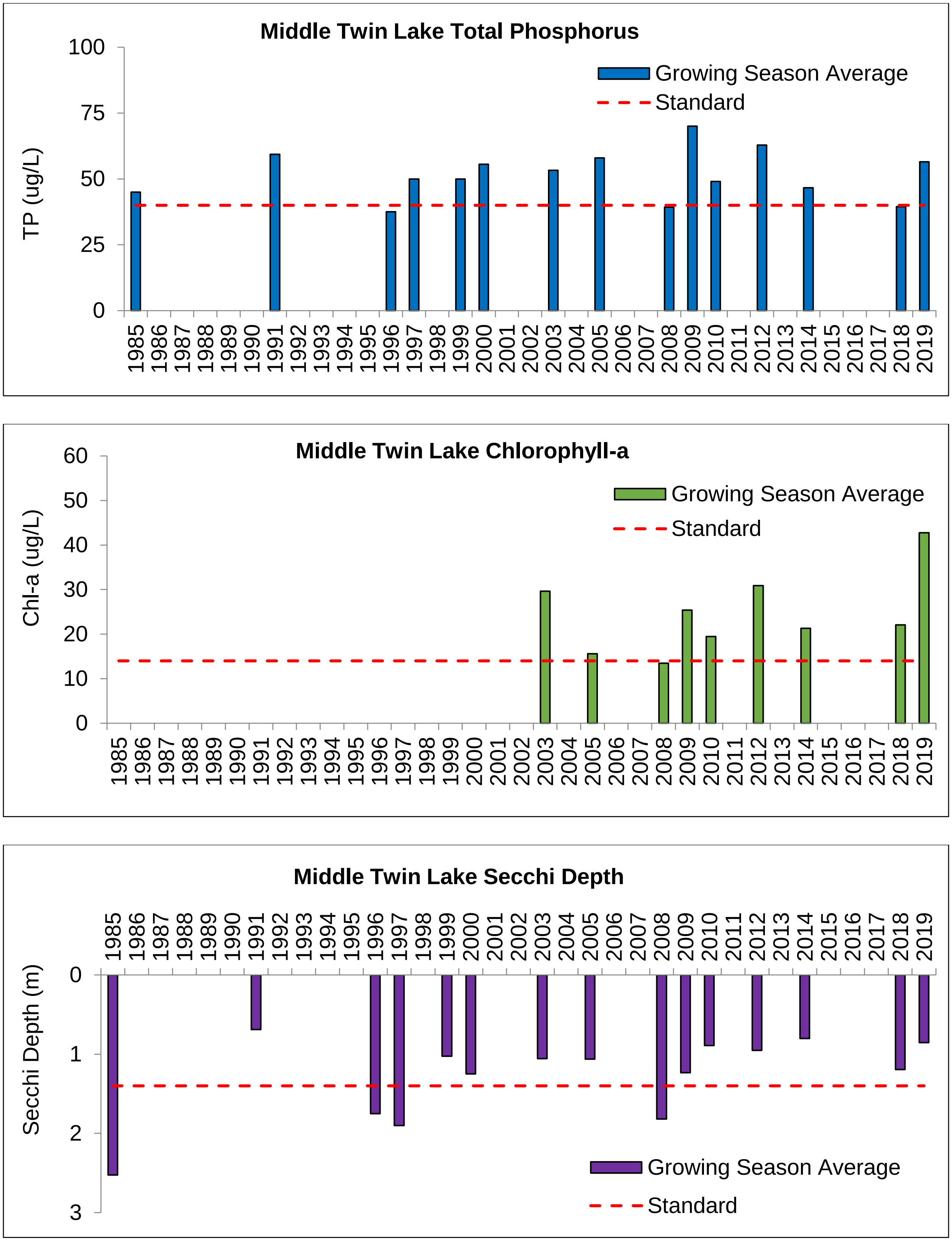


Figure 6.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

7.0 Lower Twin Lake

7.1 INTRODUCTION & SAMPLING OVERVIEW

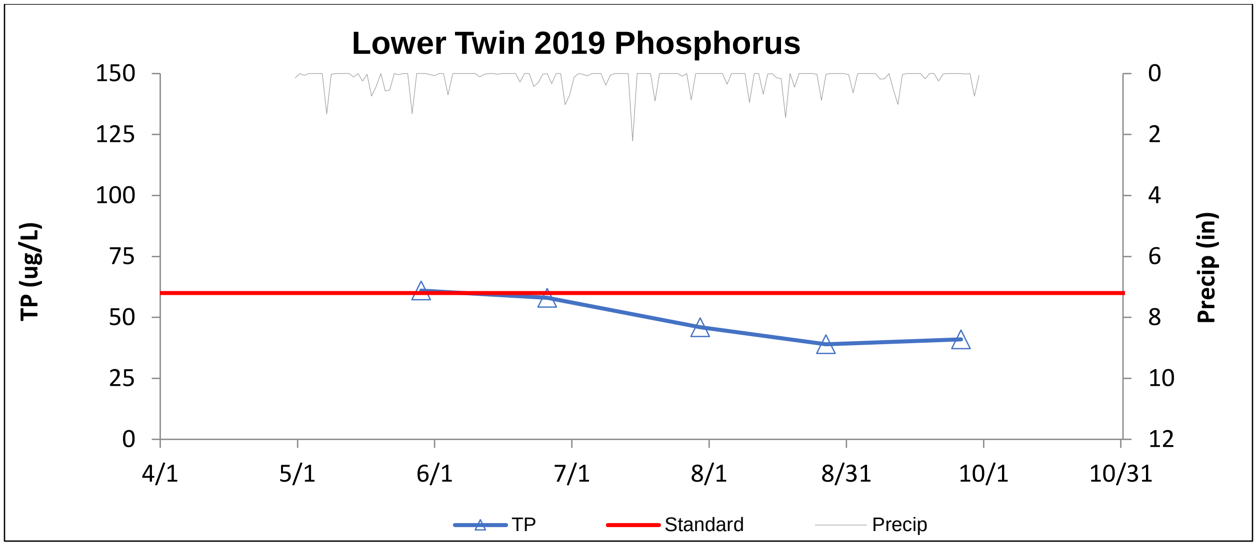
Lower Twin Lake is located in the city of Robbinsdale within Hennepin County, MN. Lower Twin Lake is classified as a shallow lake and has an approximate surface area of 30 acres, 26 acres of littoral area (i.e., area less than 15 feet deep), an average depth of 6.9 feet, and a maximum depth of 21 feet. The list below summarizes the year in which each type of sampling was most recently performed on Lower Twin Lake:

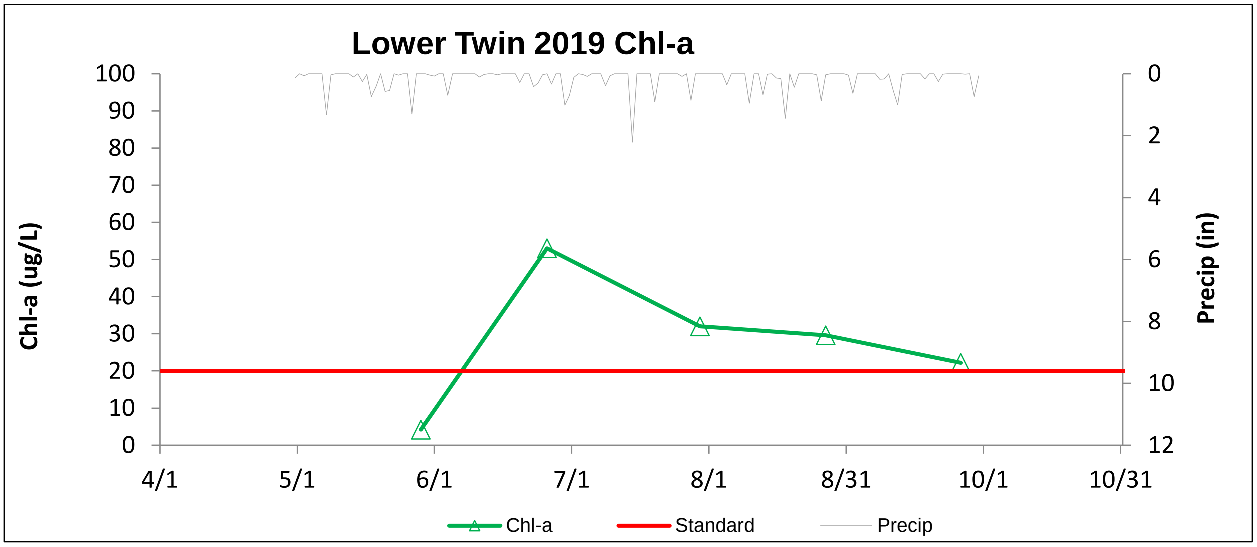
- Water Quality - 2019
- SAV – 2018
- Fisheries – 2018
- Carp – 2018

7.2 WATER QUALITY

The lake was monitored once per month May through September 2019 for a total of 5 samples. Total phosphorus and Secchi depth measurements generally met eutrophication standards throughout the growing season, although they neared the standard (Figure 7.2.1). Chlorophyll levels exceeded the standard throughout the growing season (Figure 7.2.1). Data for eutrophication metrics on Lower Twin Lake date back to 1991 and show that water quality has improved substantially since the 1990s, likely due to installation of stormwater BMPs associated with Highway 100 in about 2000. That said, this year's water quality is the worst the lake has seen in several years (Figure 7.2.2). This could have been caused at least in part by this summer's heavy precipitation (Figure 7.2.1).

In July 2019, a deep-water sample was taken from the middle of Lower Twin Lake. TP was 326 ug/L and ortho-P was 190 ug/L compared to surface water samples where average TP over the growing season was 46 ug/L and average ortho-P was 11 ug/L. The high concentrations of P in the deep-water sample suggests there could be elevated rates of internal P loading from lake sediments. More deep-water sampling and sediment collection from the lake bottom is needed to confirm this.





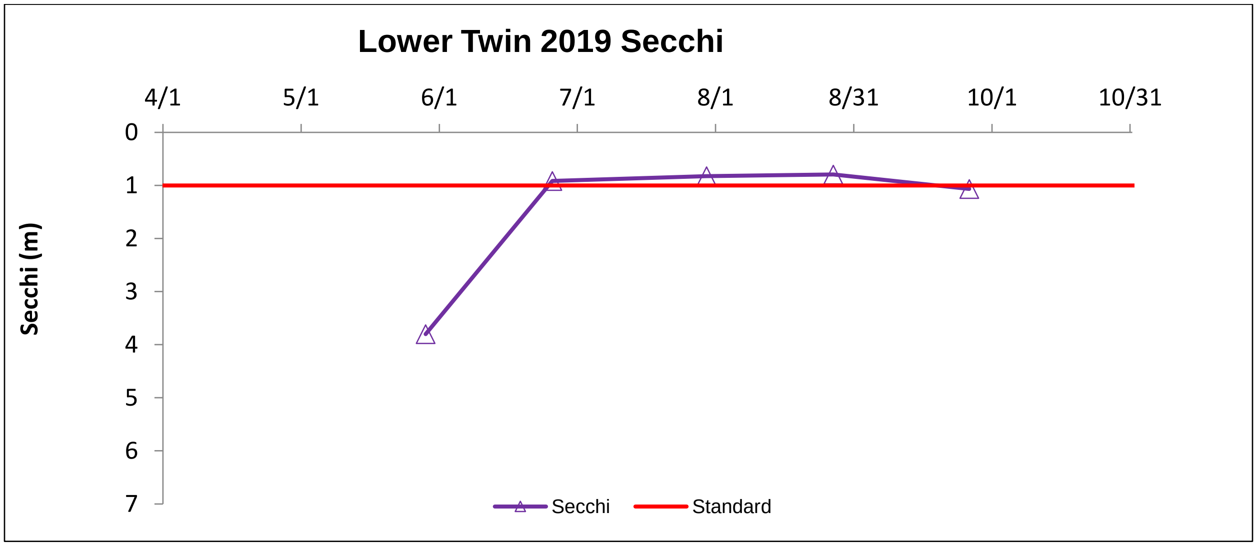
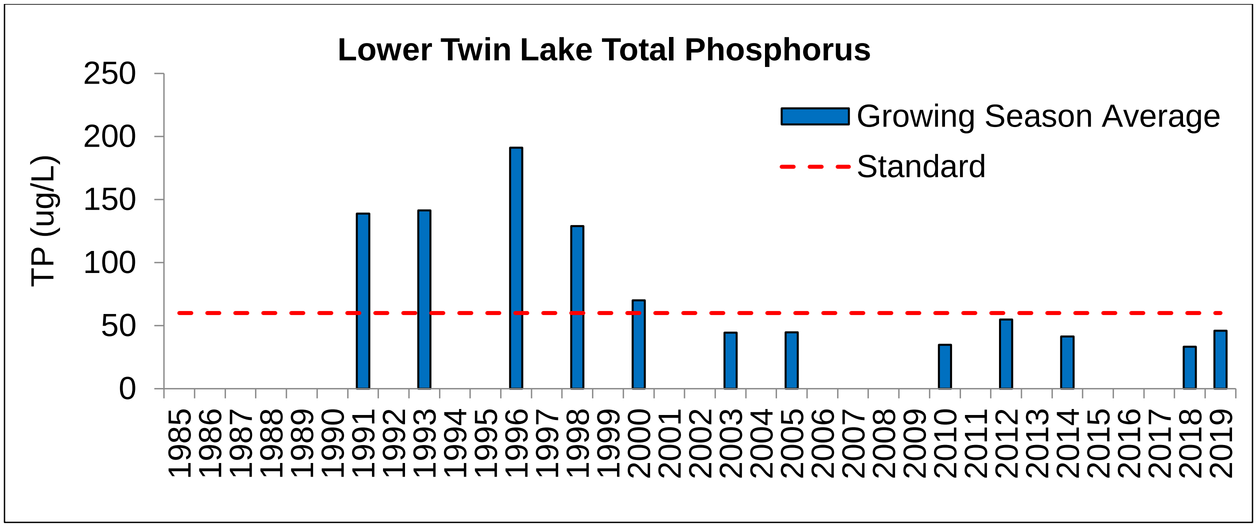
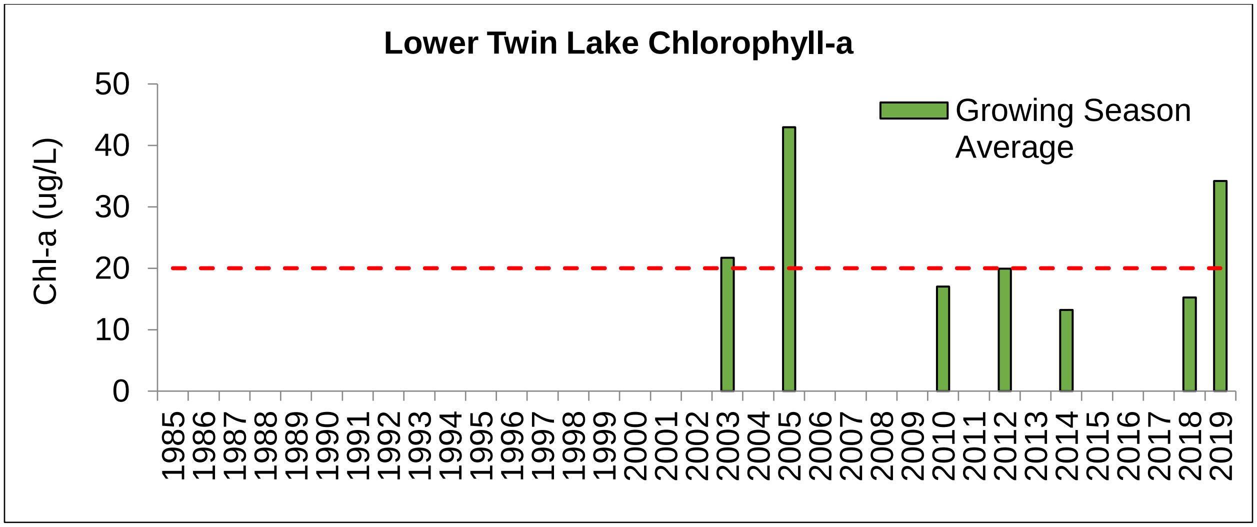


Figure 7.2.1. Seasonal TP, chl-a, and Secchi measurements and standards.





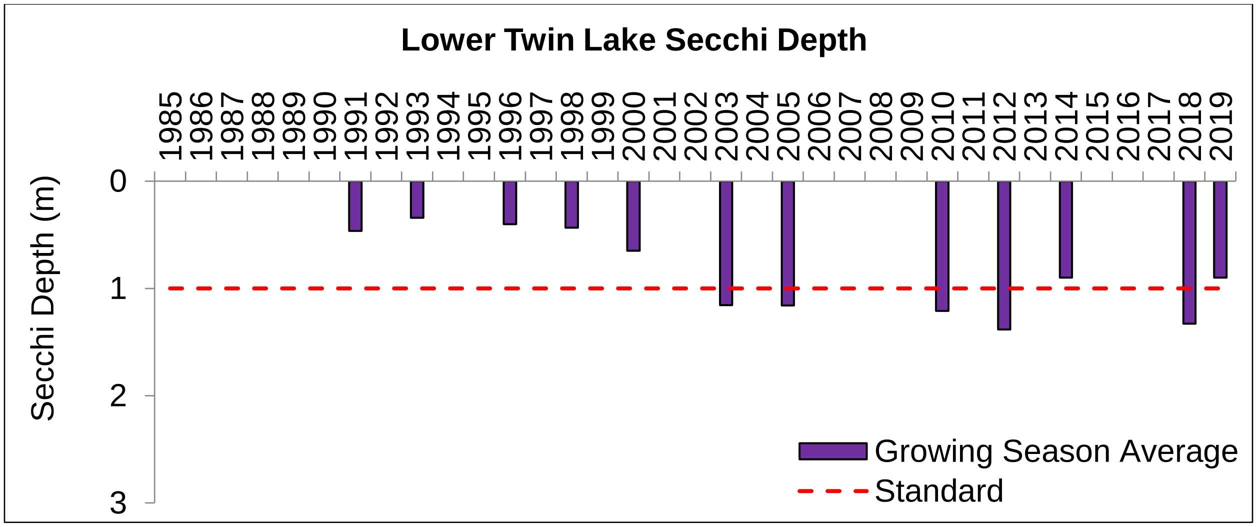


Figure 7.2.2. Annual growing season averages for total phosphorus, chlorophyll-a, and Secchi depth, with shallow lake standards in red for reference.

8.0 References

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Appendix F: Threshold Identification for Condition Classifications

Thresholds for many of the measured stream and lake parameters were developed by Wenck staff for Minnehaha Creek Watershed District's "E-grade: An Ecosystem Service Watershed Health Assessment." The following tables describe the thresholds previously identified and used to assign a classification to lakes and streams within the Shingle Creek and West Mississippi watersheds. For the most part, where the MPCA has established a threshold of impairment for a parameter, that was selected as the breakpoint between Good and Poor. If there was no state standard, then the breakpoint was the median value in the MPCA's state water quality database for similar lakes or streams. For the most part, the breakpoint between Good and Exceptional is the 90% percentile and Poor and Degraded was the 25% percentile.

Table E-1. Fish and macroinvertebrate IBI thresholds by stream and use classification.

Classification	Fish		Macroinvertebrates	
	Northern Streams	Low Gradient	Southern Stream Riffle Run	Southern Forest Glide Pool
Exceptional	>61	>70	>62	>66
Good	47-61	42-70	37-62	43-66
Poor	35-47	15-42	24-37	30-43
Degraded	≤35	≤15	≤24	≤30

Table E-2. Water quality thresholds used for streams.

Classification	TSS (mg/L)	DO Infractions	TP (ug/L)	TKN (mg/L)
Exceptional	<19	--	<30	<0.548
Good	19-30	<3	30-100	.548-1.00
Poor	30-32	≥3	100-120	1.00-1.43
Degraded	>32	--	>120	>1.43

Table E-3. Fish IBI scoring thresholds for a given assessment.

Classification	Tool 2	Tool 4	Tool 5	Tool 7
Exceptional	>64	>59	>61	NA
Good	45-64	38-59	24-61	36-54
Poor	22-44	9-38	15-24	17-36
Degraded	≤22	≤9	≤15	≤17

Table E-4. Lake plant IBI thresholds found within the NCHF (2B) Ecoregion.

Classification	FQI - Biodiversity	
	Deep	Shallow
Exceptional	>32.4	>26
Good	18.7-32.4	17.9-26
Poor	13-18.6	7.6-17.8
Degraded	≤13	≤7.5

Table E-5. Trophic grading system derived using MPCA datasets.

Classification	TP (ug/L)		Chl-a (ug/L)		Secchi Depth (m)	
	Deep	Shallow	Deep	Shallow	Deep	Shallow
Exceptional	<25	<37	<7	<9.5	>2.6	>1.6
Good	25-40	37-60	7-14	9.5-20	1.4-2.6	1-1.6
Poor	40-114	60-107	14-44	20-78	0.6-1.4	0.4-1.0
Degraded	>114	>107	>44	>78	0.6	0.4

A few important parameters that are measured through stream and lake monitoring did not already have thresholds developed. The following tables describe the thresholds developed by Wenck staff for the 2019 monitoring report.

Table E-6. Water quality breakpoints for all streams.

Classification	E. coli (CFU/100mL)*	Chloride (mg/L)**	NO3/NO2 (mg/L)***
Exceptional	--	--	--
Good	<126	<230	<4.9
Poor	126-1260	230-860	4.9 -10
Degraded	>1260	>860	>10

*monthly mean standard from MPCA is 126 CFU/100mL, 10% of samples maximum of 1260

**Chloride chronic standard from MPA is 230 mg/L, acute is 860 mg/L

***MPCA aquatic toxicity chronic standard for NO3/NO2 is 4.9 mg/L, and Minnesota's Maximum Contaminant Level for nitrate is 10 mg/L

Table E-7. Carp density thresholds for lakes.

Classification	Carp density (kg/hectare)
Exceptional	--
Good	0
Poor	1-100
Degraded	>100

For 2020, aquatic vegetation species richness was assigned the same classification as the FQI score for efficiency. In the future we should consider identifying different thresholds.