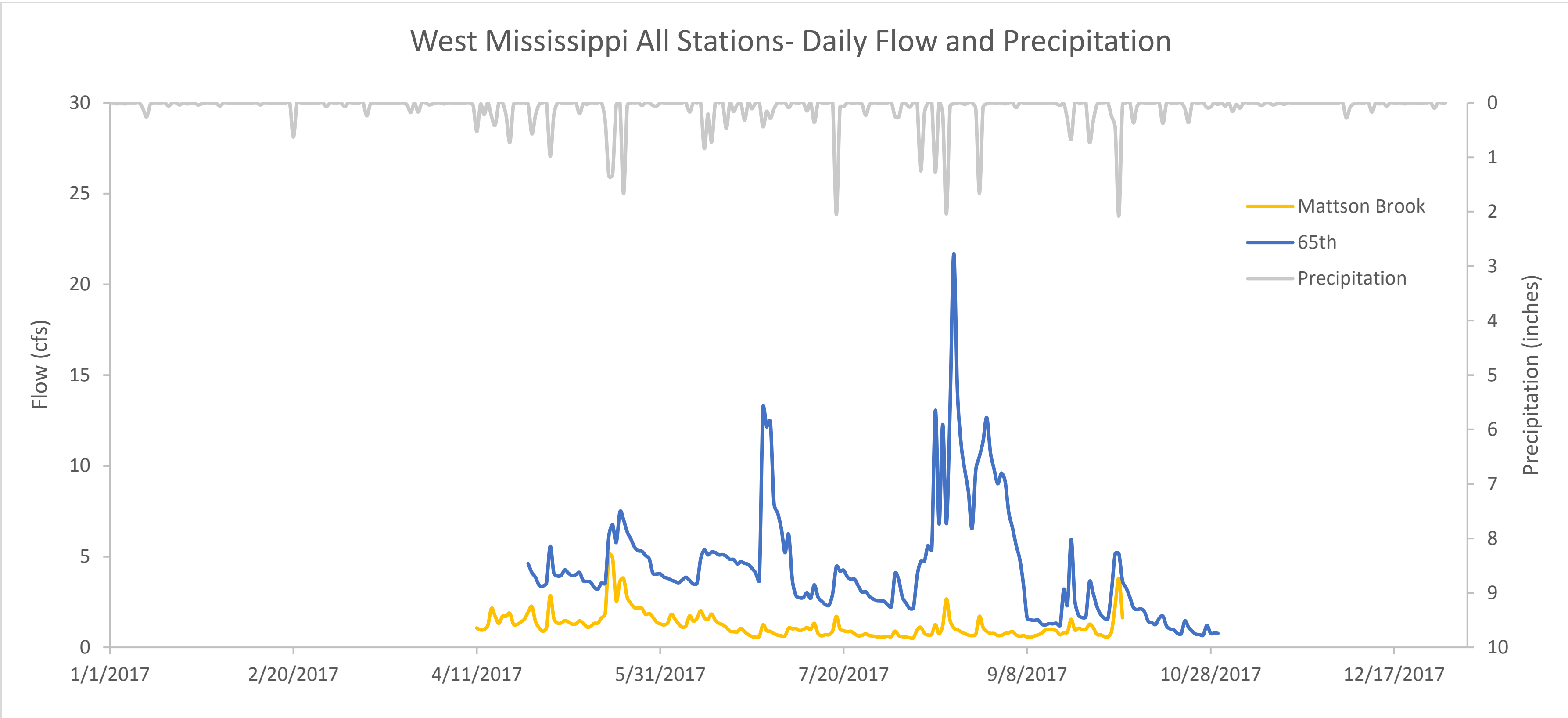
Appendix A: 2017 West Mississippi Outfall Monitoring Data

2017 precipitation measured at the New Hope weather station

Month	2017 Precipitation (inches)	1992-2017 Monthly Average Precipitation (inches)	Departure from Long-Term Average (inches)
January	0.77	0.96	-0.19
February	0.78	0.93	-0.15
March	0.85	1.80	-0.95
April	4.37	3.40	0.97
May	6.45	4.26	2.19
June	3.33	4.85	-1.52
July	3.72	4.51	-0.79
August	6.88	4.11	2.77
September	1.89	3.17	-1.28
October	5.75	2.88	2.87
November	0.51	1.76	-1.25
December	0.77	1.41	-0.64
TOTAL	36.07	33.97	2.10


West Mississippi All Stations- Daily Flow and Precipitation
Flow (cfs)
Precipitation (inches)
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
1/1/2017
2/20/2017
4/11/2017
5/31/2017
7/20/2017
9/8/2017
10/28/2017
12/17/2017
Mattson Brook
65th
Precipitation

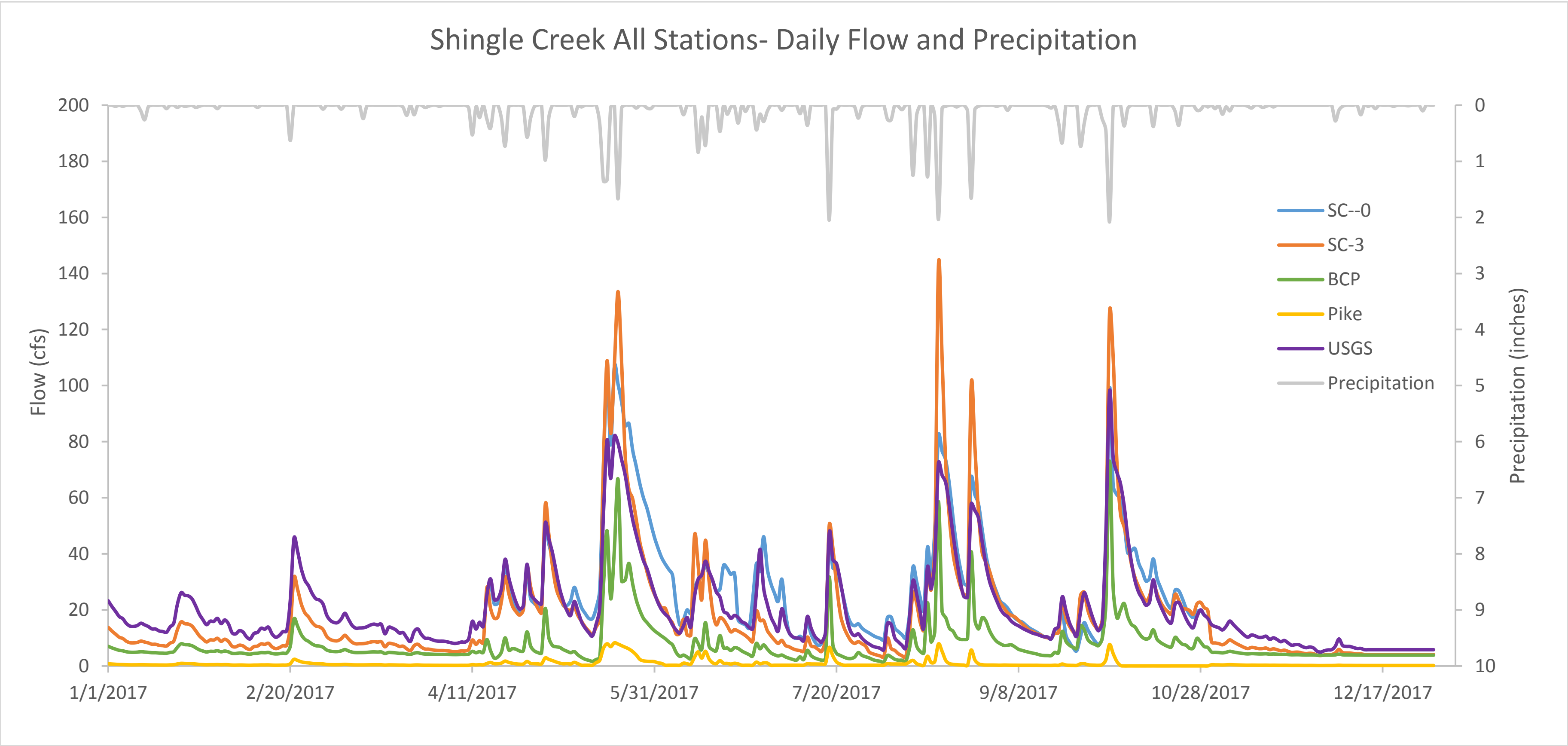
65^{th} Avenue Outfall Monitoring 2017

Date	Time	Temp [C]	DO [mg/L]	pH	Sp. Cond	TP [mg/L]	Ortho-P [mg/L]	TSS [mg/L]
4/25/2017	19:45					0.087	0.05	26.8
5/11/2017	14:40	14	9.67	8.04	1258	0.052	0.023	5
5/17/2017	13:50					0.113	0.038	35.6
6/6/2017	11:30	17.14		7.58	1130.9	0.075	0.038	5.2
6/28/2017	16:34					0.083	0.046	31.2
7/6/2017	12:40	21.92	7.54	7.53	963.6	0.081	0.062	2
8/10/2017	13:15	19.14	7.33	7.85	465.4	0.096	0.07	5.6
9/7/2017	13:40	14.9	9.25	7.84	1087.6	0.051	0.041	3.6
10/9/2017	13:05	13.58	10.21	8.17	505	0.065	0.046	5.3
10/30/2017	13:15	8.58	10.32	7.66	1230.9	0.061	0.045	7

Mattson Brook Outfall Monitoring 2017

Date	Time	Temp [C]	DO [mg/L]	pH	Sp. Cond	TP [mg/L]	Ortho-P [mg/L]	TSS [mg/L]
4/25/2017	17:48					0.192	0.032	48.2
5/11/2017	15:55	15.72	8.40	7.89	1303	0.055	0.03	2.6
5/17/2017	2:14					0.238	0.038	0.6
6/6/2017	12:45	18.25	7.85	7.77	1162.8	0.061	0.038	4
7/6/2017	13:20	22.35	6.47	7.57	1143.8	0.077	0.06	3.2
8/3/2017	2:40					0.165	0.107	44.8
8/10/2017	13:50	19.46	7.83	7.88	786.8	0.102	0.051	4
9/7/2017	14:25	15.6	8.24	8.01	1365.3	0.051	0.041	<1.00
10/9/2017	14:15	12.62	9.59	8.09	1001	0.051	0.037	<1.00
10/30/2017	14:30	6.06	10.71	7.65	1217.3	0.065	0.023	2.3
10/30/2017	14:30	6.06	10.71	7.65	1217.3	0.057	0.023	2.3

Appendix B: 2017 Shingle Creek Stream Monitoring Data



Shingle Creek SC-0 Monitoring 2017

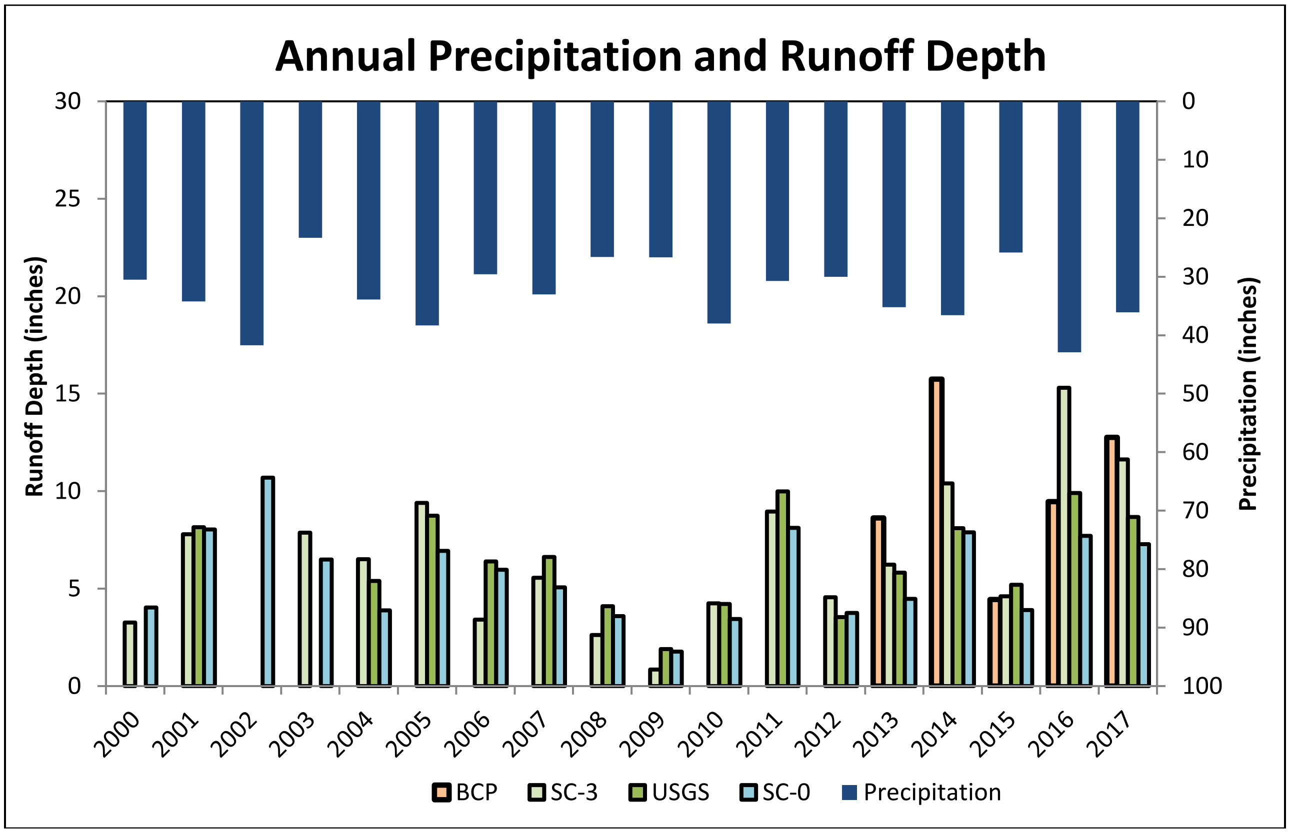
Date	Time	Temp [C]	DO [mg/l]	pH	Sp. Cond	TP [mg/l]	Ortho-P [mg/l]	TKN [mg/l]	Nitrate [mg/l]	TSS [mg/l]	Chloride [mg/l]
2/15/2017	11:05	1.24	11.89		1342.0						271
3/28/2017	9:35	4.82	12.14	7.40	1366						231
4/14/2017						0.072	0.024	0.761	0.499	5.2	202
4/27/2017	13:00	7.63	10.27	7.77	699	0.071	0.021	1.68		8.0	
5/7/2017	14:45										
5/11/2017	13:45	16.65	10.08	7.89	940	0.048	0.018	0.608	0.165	4.6	150
5/18/2017	14:45					0.140	0.071	0.929	0.144	4.0	39.7
5/23/2017	13:15	13.93	7.64	7.77	554.3	0.069	0.027	0.663	0.140	9.6	82.7
6/6/2017	10:55	19.94	6.13	7.66	912.1	0.062	0.028	<0.500	0.203	3.6	136.0
6/14/2017	0:51					0.120	0.065	0.979	0.326	13.2	
6/22/2017	12:05	21.24	4.91	7.46	719.8	0.071	0.036	0.616	0.206	11.6	
6/28/2017	5:21					0.109	0.037	0.978	0.278	24.4	
7/6/2017	11:20	24.09	4.1	7.34	821.9	0.056	0.045	<0.500	0.274	5.2	122.0
7/17/2017	14:15	25.04	5.85	7.52	1030	0.065	0.044	<0.500	0.283	2.8	141.0
8/10/2017	12:25	19.77	5.08	8.05	482.7	0.081	0.051	<0.500	0.222	11.6	74.7
8/25/2017	11:40	19.05	5.95	7.38	612	0.090	0.054	0.644	0.180	6.6	98.8
9/7/2017	12:40	16.61	7.12	7.77	816.9	0.041	0.024	<0.500	0.296	2.8	134.0
9/20/2017	12:50	19.94	5.6	7.38	669	0.069	0.035	0.600	0.348	10.0	93.2
10/2/2017	2:11					0.081	0.067	0.898	0.318	38.4	94.1
10/9/2017	11:30	13.29	7.77	8.30	579	0.072	0.043	<0.500	0.276	7.2	89.4
########	11:30	5.33	9.37	7.36	859.3	0.062	0.04	<0.500	0.583	2.7	129

Shingle Creek SC-3 Monitoring 2017

Date	Time	Temp [C]	DO [mg/l]	pH	Sp. Cond	TP [mg/l]	Ortho-P [mg/l]	TKN [mg/l]	Nitrate [mg/l]	TSS [mg/l]	Chloride [mg/l]
2/15/2017	10:35	0.60	10.24		1570.0						376
3/28/2017	9:10	4.77	10.77	7.00	1378						279
4/14/2017						0.074	0.019	0.663	0.175	3.8	250
4/25/2017	18:28					0.073	0.023	1.21		6.4	
4/27/2017	10:45	6.913	4.51	7.52	816	0.049	0.011	0.925		2.8	
5/11/2017	9:55	13.914	7.61	7.56	827	0.047	0.02	0.585	<0.030	2.6	145
5/17/2017	1:50					0.168	0.027	1.37	0.153	58.4	87.5
5/23/2017	12:38	13.07	6.48	7.80	589.7	0.050	0.026	0.585	0.068	6.40	107.0
6/6/2017	8:00	18.5	5.41	7.53	810.3	0.092	0.066	0.647	0.035	3.60	140.0
6/14/2017	0:23					0.094	0.062	1.020	0.366	36.40	
6/22/2017	11:15	19.78	4.86	7.18	706.2	0.080	0.073	0.628	0.099	7.60	
7/6/2017	9:00	22.06	3.72	7.28	773.1	0.071	0.065	0.644	0.104	5.2	127.0
7/17/2017	12:50	22.33		7.3	908.1	0.086	0.076	0.655	0.099	6.8	145.0
8/10/2017	11:25	19.37	4.93	8.31	310.9	0.116	0.069	0.686	<0.030	16	56.0
8/25/2017	10:45	18.37	5.89	7.34	599	0.098	0.078	0.517	<0.030	9.6	108.0
9/7/2017	10:55	15.01	7.43	7.79	685.7	0.045	0.035	0.533	0.035	5.6	125.0
9/20/2017	11:05	19.297	5.93	7.56	388.1	0.080	0.072	0.820	0.215	5	65.4
10/1/2017	4:36					0.069	0.037	0.697	0.124	18.2	84.8
10/9/2017	10:50	12.07	7.39	8.38	560	0.061	0.037	<0.500	0.148	5.2	94.1
10/30/2017	9:30	4.21	9.40	7.57	697	0.035	0.019	0.638	0.215	1.7	115

Shingle Creek BCP (Bass Creek Outlet) Monitoring 2017

Date	Time	Temp [C]	DO [mg/l]	pH	Sp. Cond	TP [mg/l]	Ortho-P [mg/l]	TKN [mg/l]	Nitrate [mg/l]	TSS [mg/l]	Chloride [mg/l]
2/15/2017	10:20	0	8.61		1328.5						319
3/28/2017	9:00	2.88	10.18	6.80	1791.5						439
4/14/2017						0.057	0.027	0.750	0.094	4.8	217
4/15/2017	14:30										
4/25/2017	19:48					0.109	0.062	0.695		12	
4/27/2017	9:30	6.55	9.26	7.50	853	0.053	0.026	<.500		1.8	
5/11/2017	8:25	12.7	5.83	7.46	775	0.056	0.035	0.574	0.054	2.4	140
5/17/2017	1:51					0.116	0.045	2.2	0.177	124	82.7
5/23/2017	11:30	13.84	7.88	7.74	625.2	0.049	0.026	0.663	0.075	4.40	111.0
6/6/2017	8:30	16.68	3.69	7.43	766.8	0.088	0.065	0.585	0.062	3.20	145.0
6/22/2017	10:15	19.78	3.83	7.18	774.1	0.107	0.092	0.752	0.088	3.20	
7/6/2017	8:30	22.84	2.78	7.44	897.4	0.088	0.070	1.100	0.135	2.4	172.0
7/17/2017	12:00	22.88	3.07	7.39	938.4	0.101	0.078	1.330	0.380	4.4	182.0
7/25/2017	22:06					0.130	0.088	1.840	0.241	10	112.0
8/10/2017	8:10	18	3.94	7.95	462.3	0.134	0.105	<0.500	0.094	3.2	93.3
8/25/2017	9:55	18.12	7.17	7.26	574	0.098	0.062	<0.500	0.057	4	108.0
9/7/2017	10:10	14.67	7.09	7.71	583.9	0.063	0.051	0.580	0.065	2.4	111.0
9/20/2017	9:50	19.14	4.55	7.52	348.5	0.138	0.108	0.809	0.303	13.7	60.7
10/2/2017	16:32					0.298	0.181	1.12	0.205	107	56.8
10/9/2017	9:45	12.74	7.77	8.46	549	0.091	0.063	0.591	0.153	12	98.8
10/30/2017	8:30	4.16	8.85	7.67	710.9	0.069	0.054	<0.500	0.290	3.3	134



Annual Precipitation and Runoff Depth
Runoff Depth (inches)
Precipitation (inches)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
BCP
SC-3
USGS
SC-0
Precipitation

Stream Site Trend analysis

Intercept, slope and p-value for Mann Kendall trend analysis performed on each parameter at each stream site over the last 18 years, 10 years and 5 years. P-values ≤0.05 were considered significant trends with the ± notation of the slope indicating trend directions. The green cells convey an improving condition while the red cells convey a deteriorating condition. NA = not applicable (i.e., not enough samples for a trend analysis).

18-year

	TP			TSS			SRP			TKN			Chloride			DO		
	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	intercept	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value
SC-3	2.8	-0.001	0.07	400.1	-0.199	0.012	-0.9	0.0004	0.26	42.5	-0.021	0.002	-6989	3.480	0.0002	173.5	-0.086	0.03
BCP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC-0	6.9	-0.003	<0.0001	1115.2	-0.555	<0.0001	-1.0	0.0005	0.05	96.2	-0.048	<0.0001	-2200	1.096	0.10	-31.9	0.016	0.71

10-year

	TP			TSS			SRP			TKN			Chloride			DO		
	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value
SC-3	8.8	-0.004	0.01	1140.3	-0.566	0.001	-2.8	0.001	0.18	50.5	-0.025	0.01	-3050	1.509	0.64	257.5	-0.128	0.07
BCP*	16.7	-0.008	0.09	1830.2	-0.909	0.1551131	-15	0.008	0.05	174.3	-0.086	0.01	NA	NA	NA	720.6	-0.357	0.12
SC-0	10.4	-0.005	0.0001	1241.7	-0.616	0.001	-4.8	0.002	0.0002	120.9	-0.060	<0.0001	4217	-2.094	0.32	-22.1	0.011	0.91

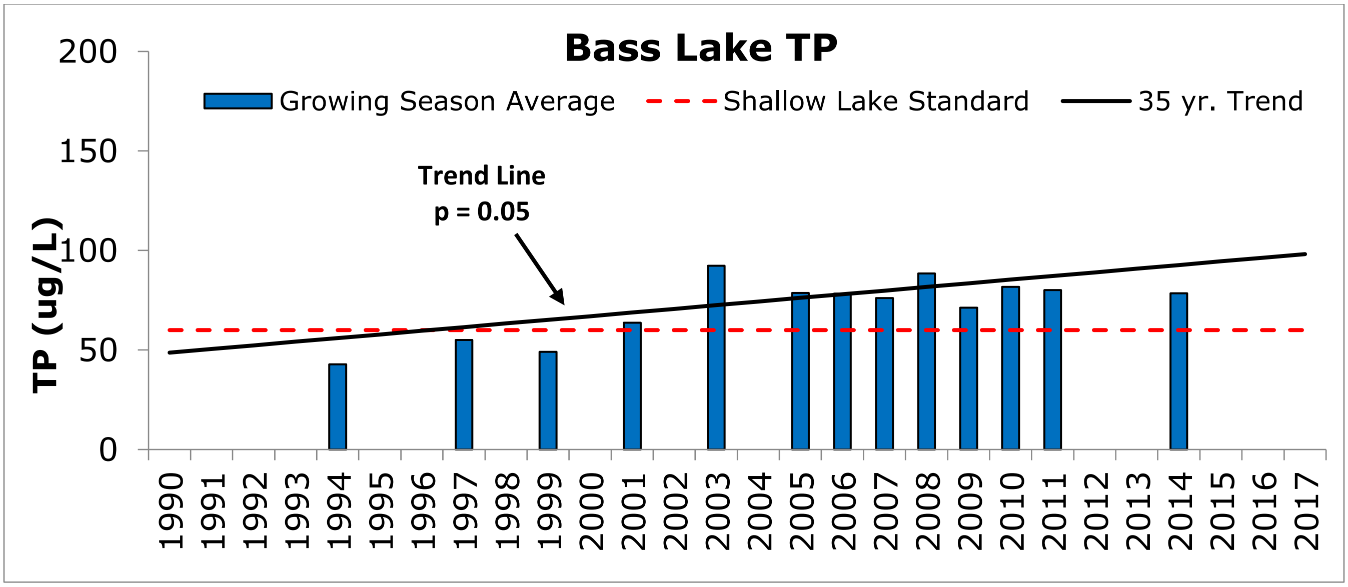
*BCP is 8-year trend

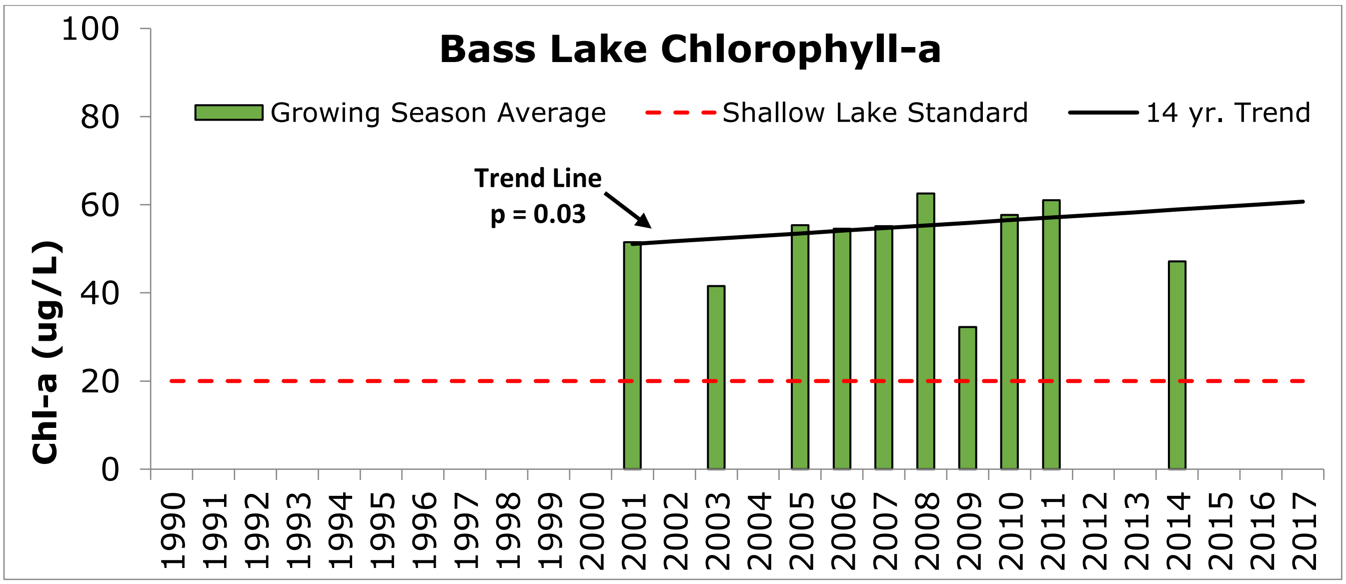
5-year

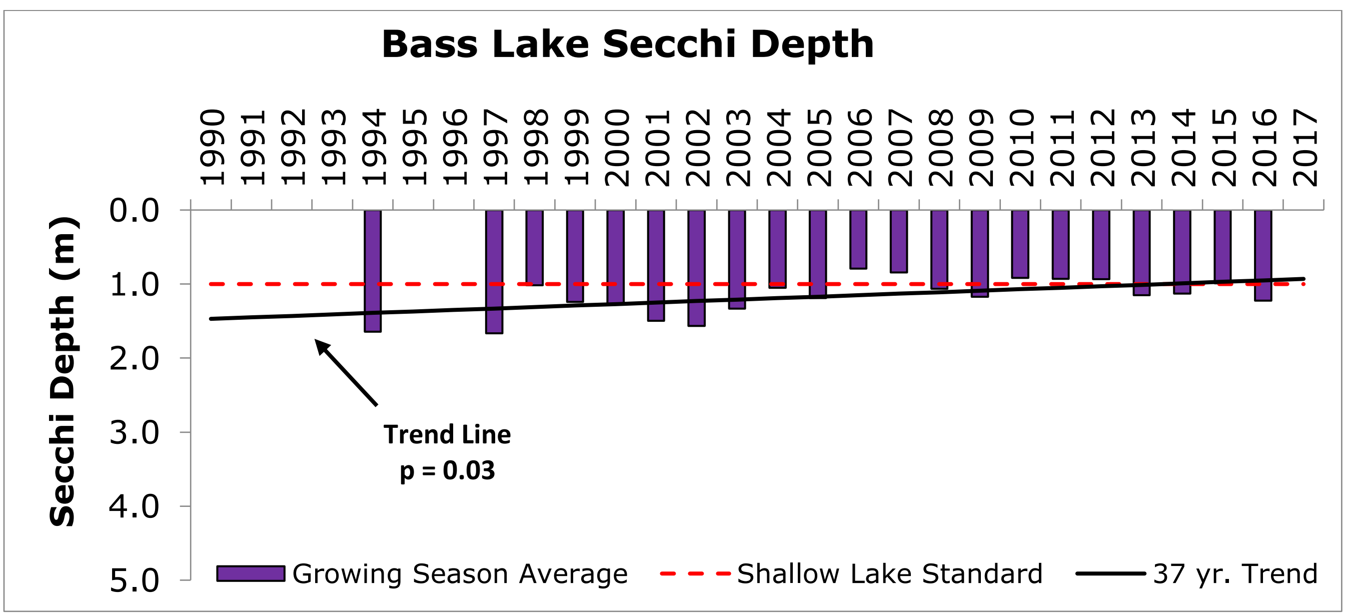
	TP			TSS			SRP			TKN			Chloride			DO		
	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value	y - int.	slope	p-value
SC-3	33.1	-0.016	0.0001	1656.6	-0.822	0.05	-0.2	0.0001	0.96	202.6	-0.100	0.0002	71566	-35.515	0.0001	609.5	-0.303	0.11
BCP	16.7	-0.008	0.09	1830.239	-0.909	0.1551131	-15	0.008	0.05	174.3	-0.086	0.01	NA	NA	NA	720.6	-0.357	0.12
SC-0	14.7	-0.007	0.002	1480.5	-0.735	0.08	-11	0.006	0.001	188.3	-0.093	0.0001	36594	-18.156	0.0001	281.7	-0.140	0.38

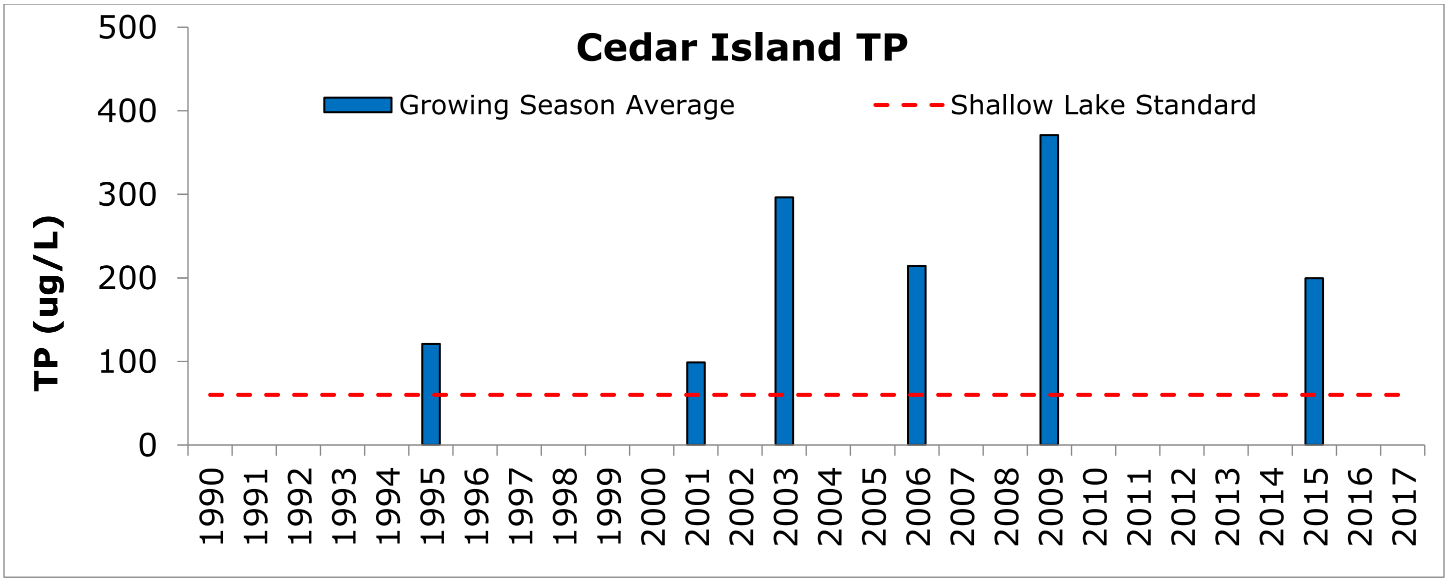
Appendix D: Shingle Creek Lake Trend Analysis

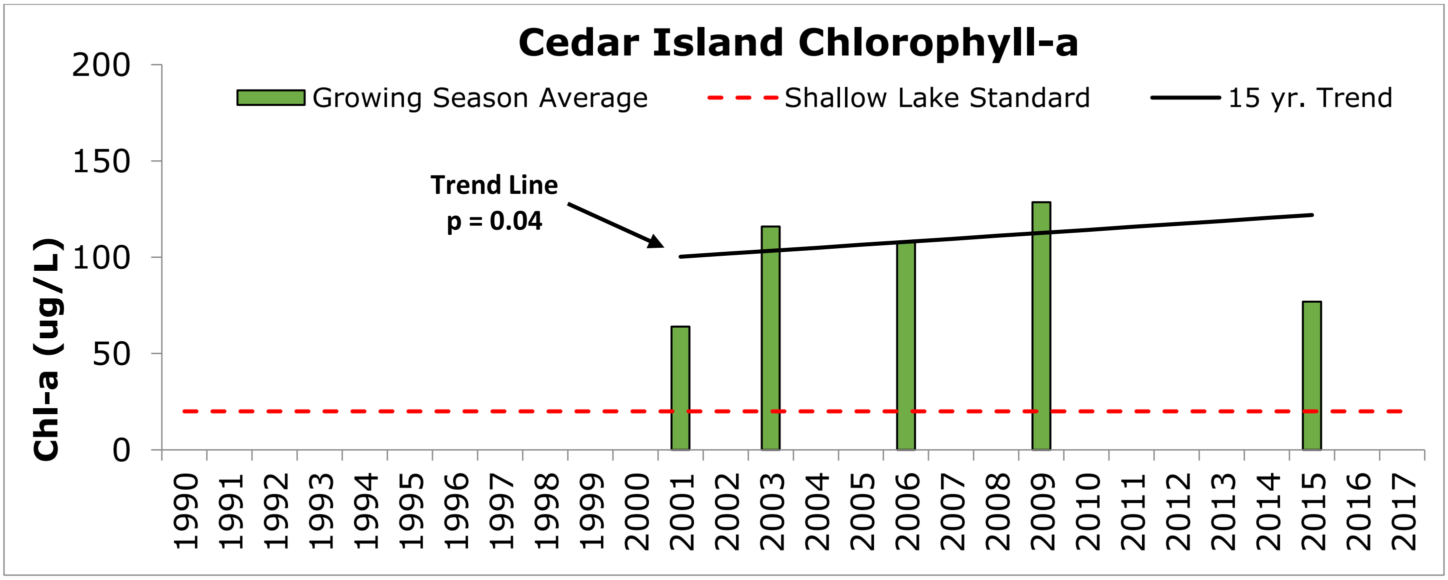
The graphs in this section show total phosphorus (TP), chlorophyll-a, and Secchi depth for each lake in the watershed and compare these values to MPCA standards (dotted red line). A Mann Kendal trend analysis was run on all years of available data for each parameter. If the trend was statistically significant (defined here as $p < 0.05$), the trend line and p-value are displayed on the graph. Years of available data used to create the trendline is also displayed in the legend.

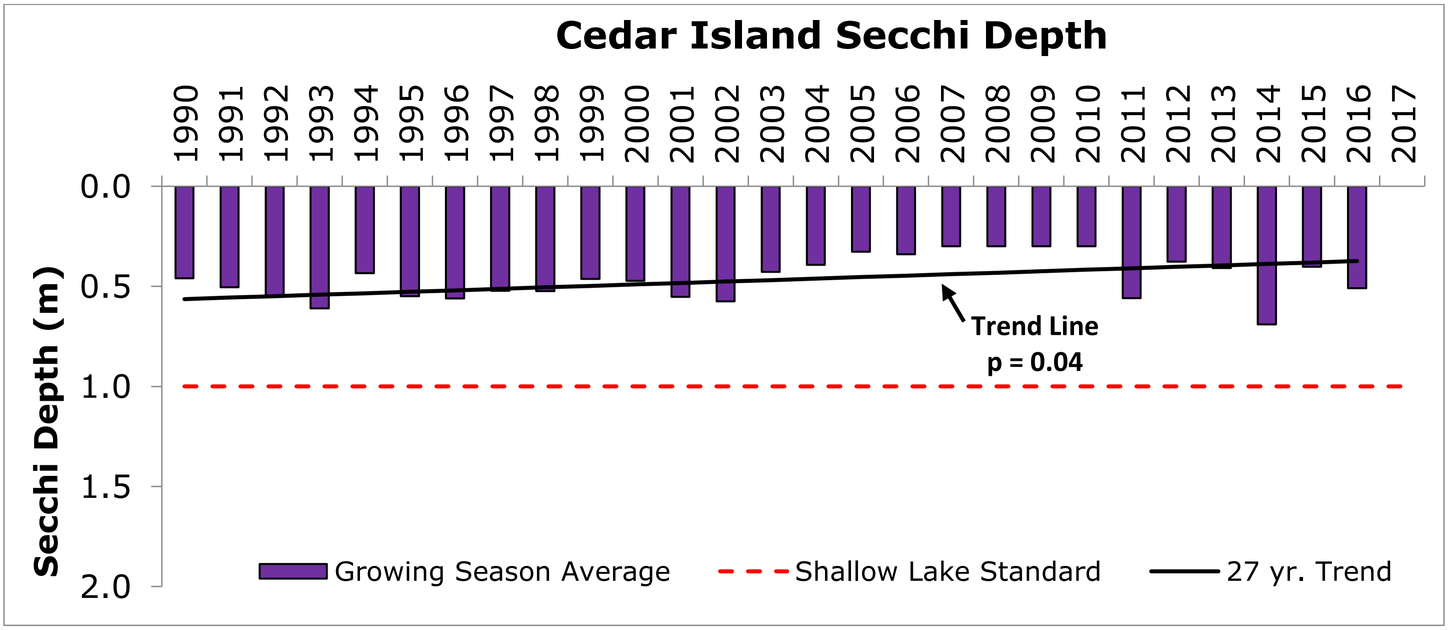

Bass Lake TP
Growing Season Average
Shallow Lake Standard
35 yr. Trend
Trend Line
p = 0.05
TP (ug/L)
200
150
100
50
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

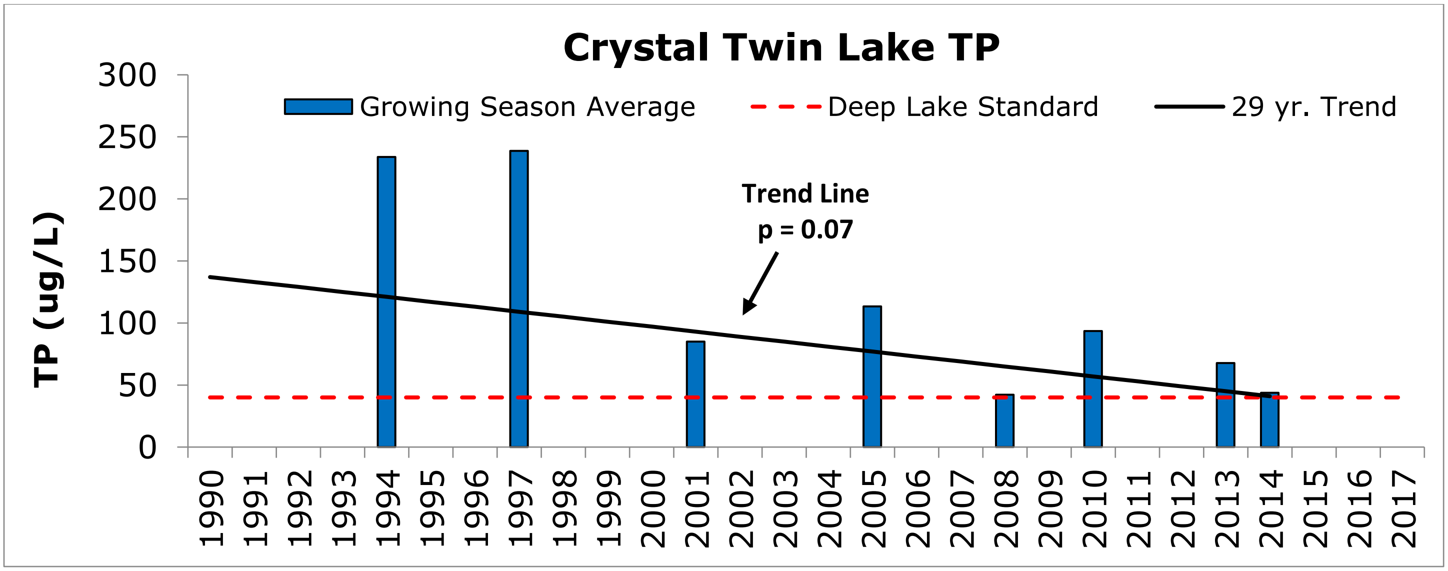

Bass Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
14 yr. Trend
Trend Line
p = 0.03
Chl-a (ug/L)
100
80
60
40
20
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

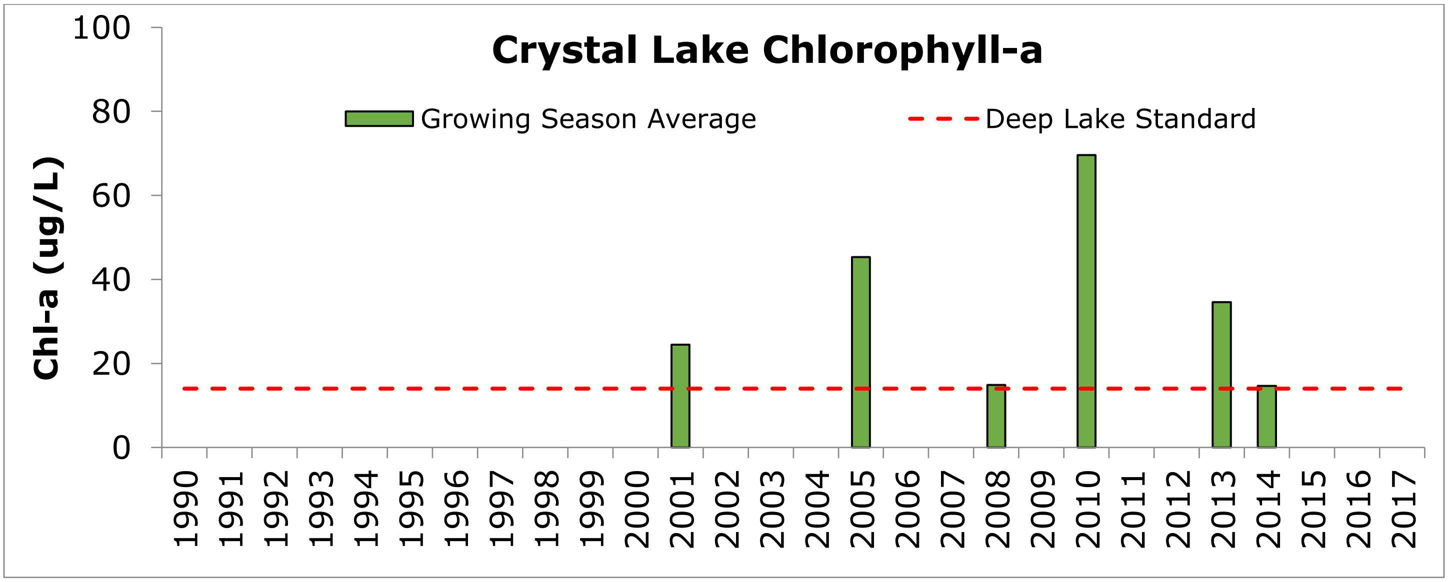

Bass Lake Secchi Depth
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Trend Line
p = 0.03
Growing Season Average
Shallow Lake Standard
37 yr. Trend

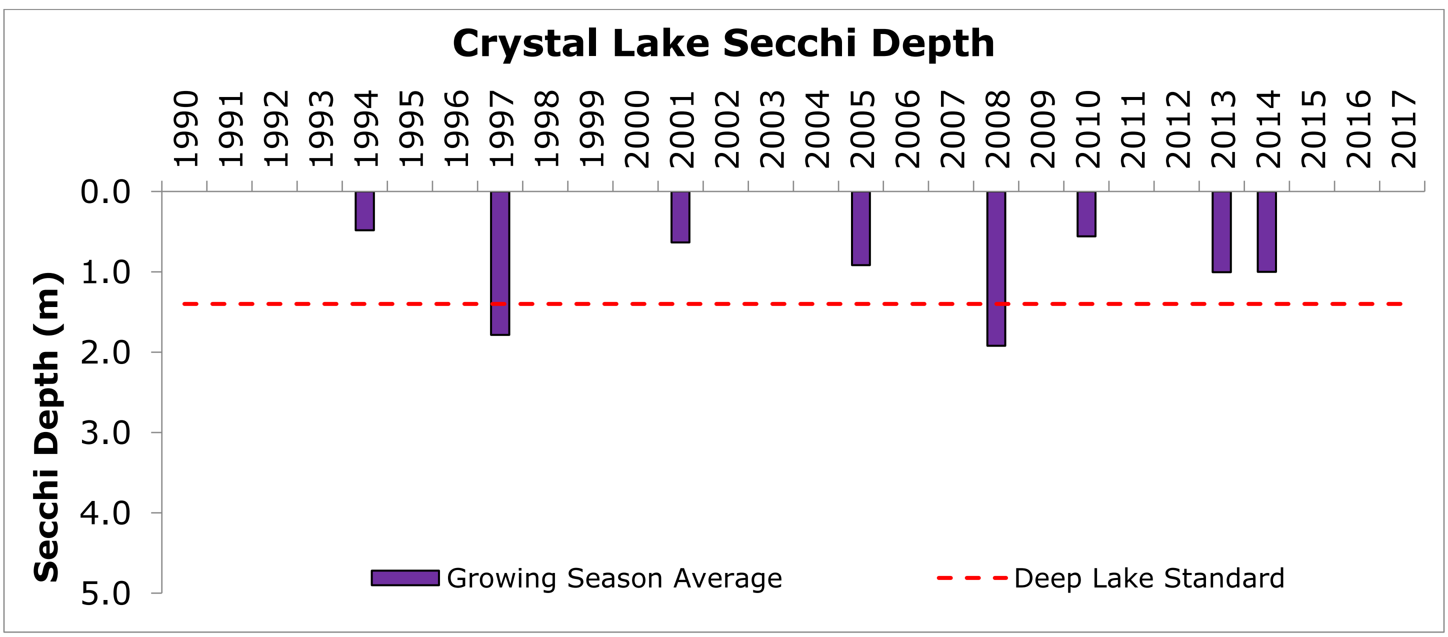

Cedar Island TP
Growing Season Average
Shallow Lake Standard
TP (ug/L)
500
400
300
200
100
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

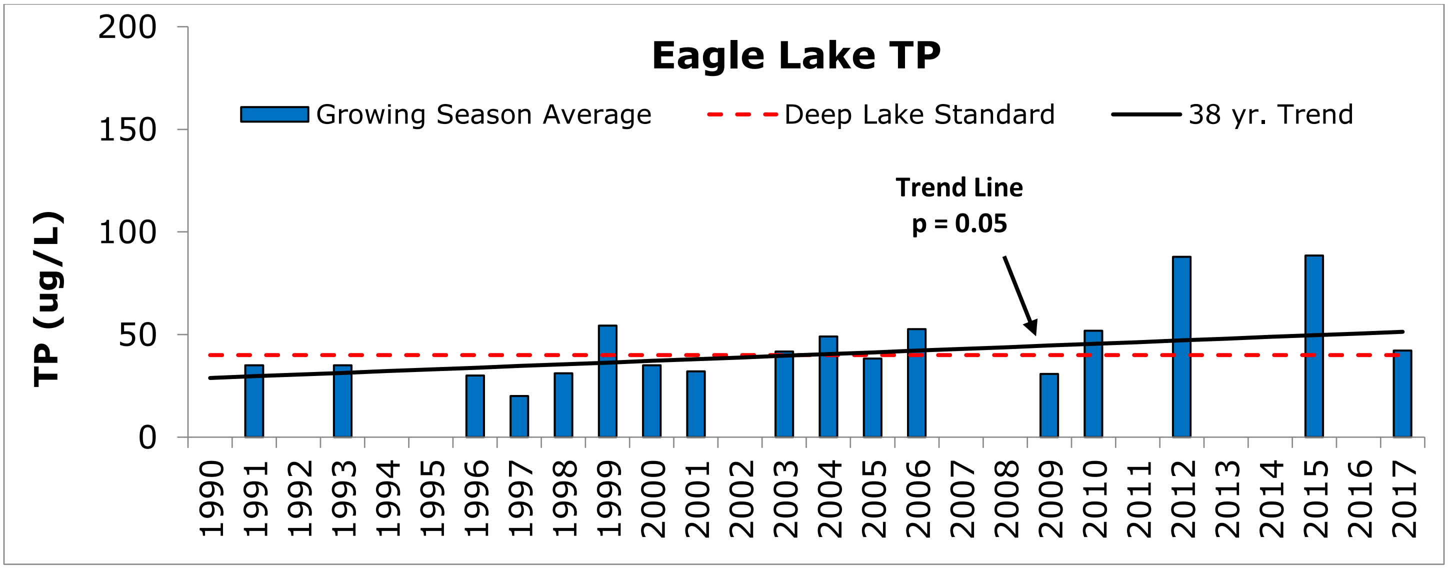

Cedar Island Chlorophyll-a
Growing Season Average
Shallow Lake Standard
15 yr. Trend
Trend Line
p = 0.04
Chl-a (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

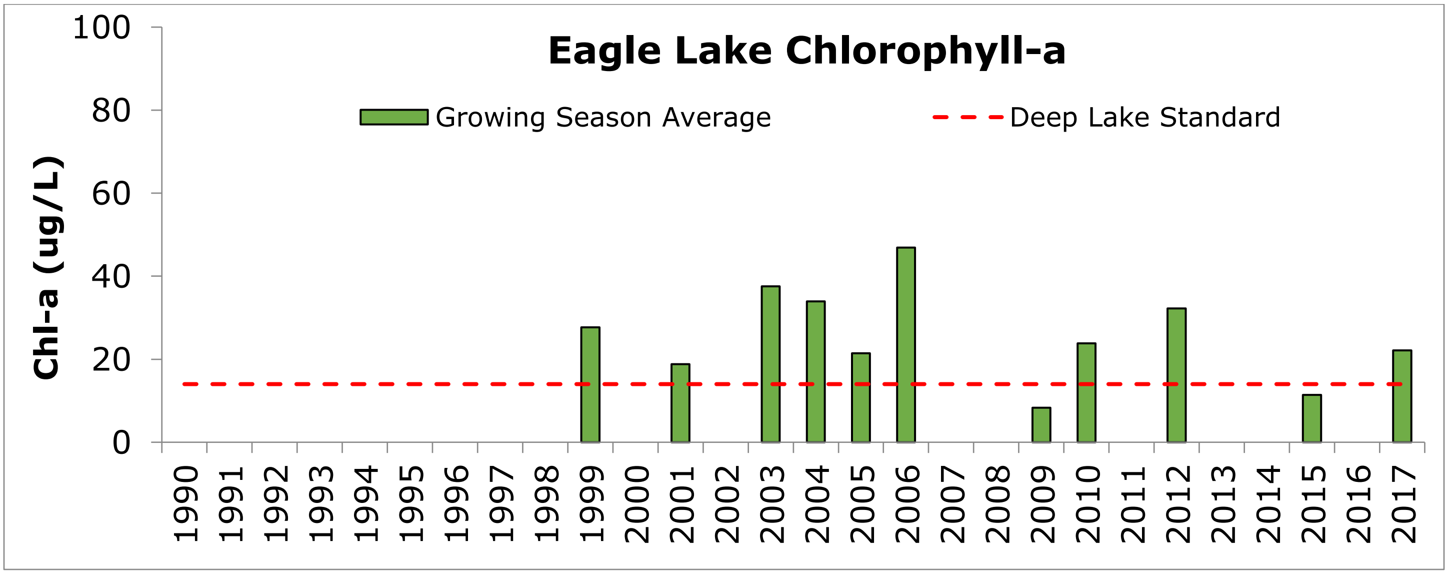

Cedar Island Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
0.5
1.0
1.5
2.0
Trend Line
p = 0.04
Growing Season Average
Shallow Lake Standard
27 yr. Trend

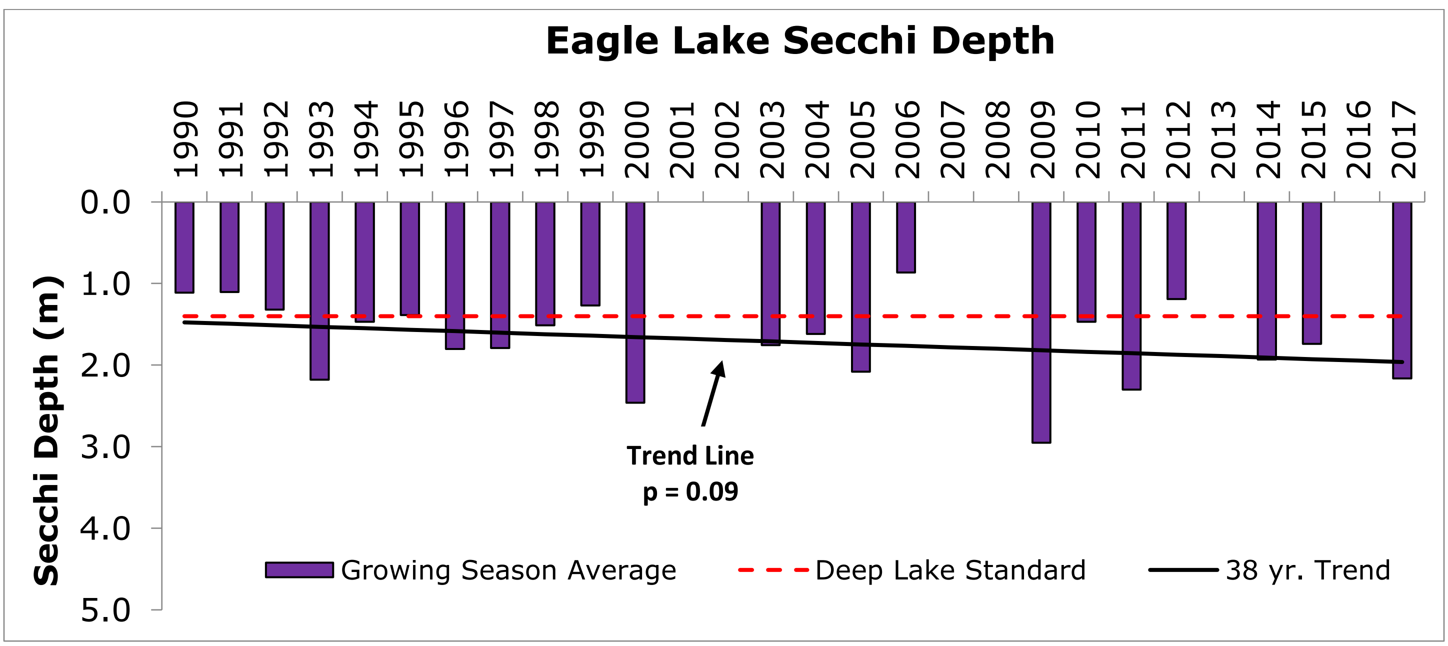

Crystal Twin Lake TP
Growing Season Average
Deep Lake Standard
29 yr. Trend
Trend Line
p = 0.07
TP (ug/L)
0
50
100
150
200
250
300
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

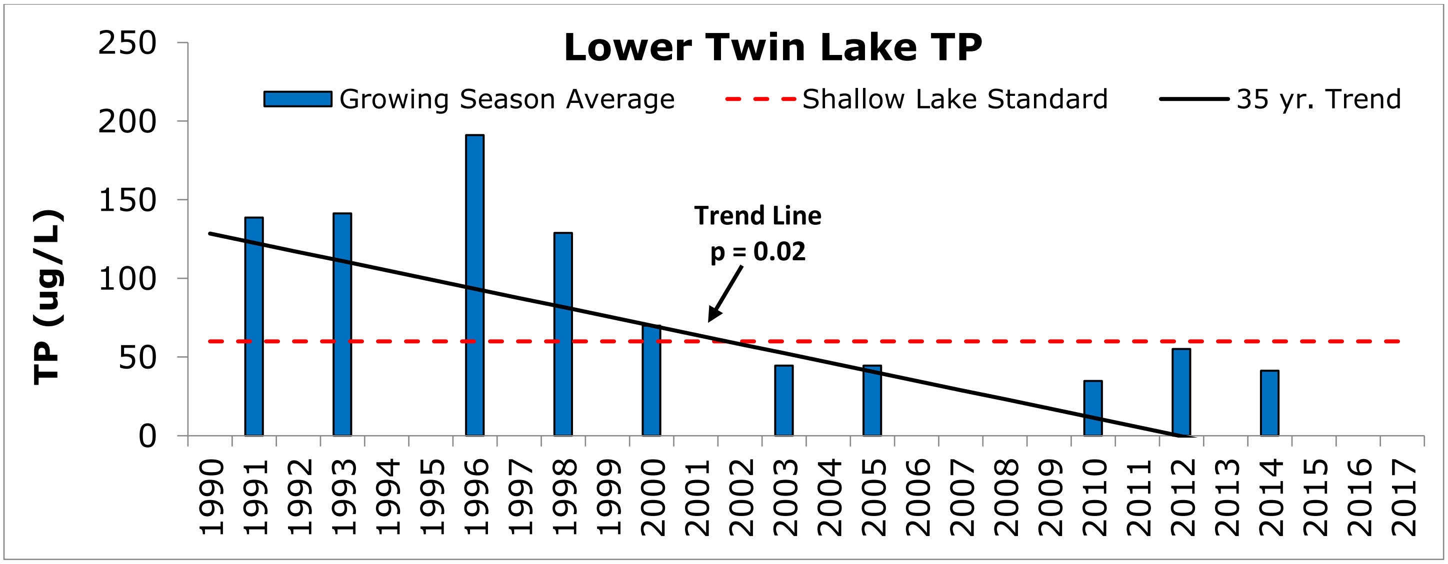

Crystal Lake Chlorophyll-a
Growing Season Average
Deep Lake Standard
Chl-a (ug/L)
0
20
40
60
80
100
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

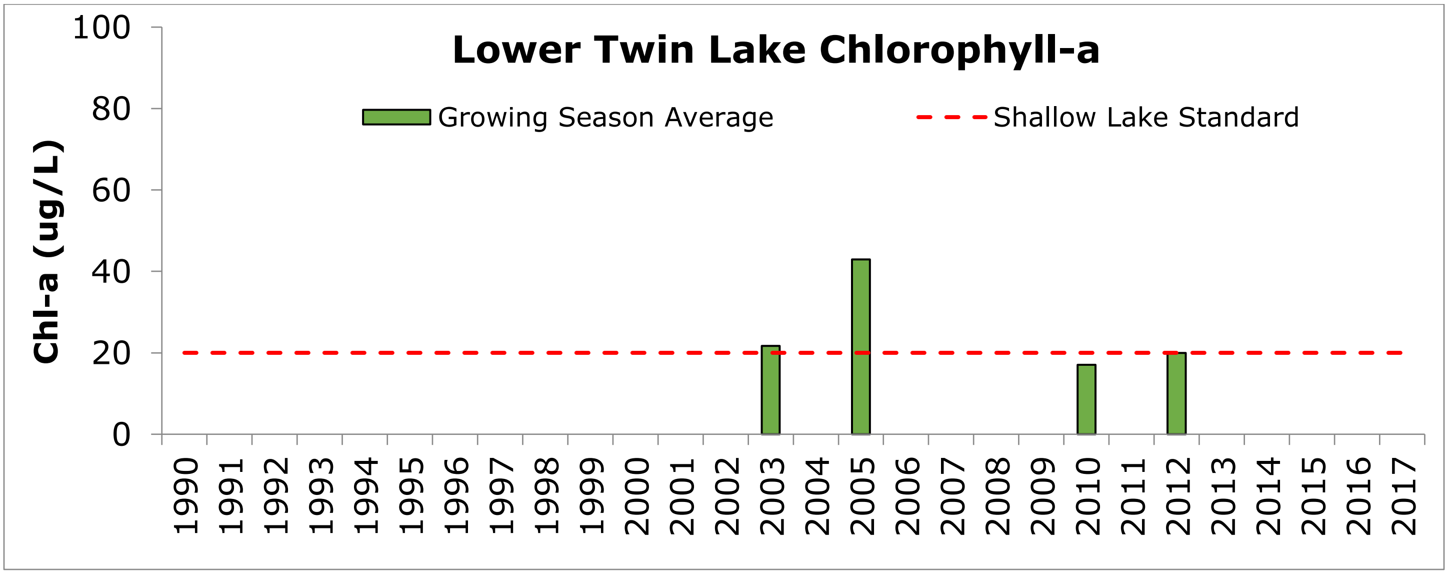

Crystal Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Growing Season Average
Deep Lake Standard

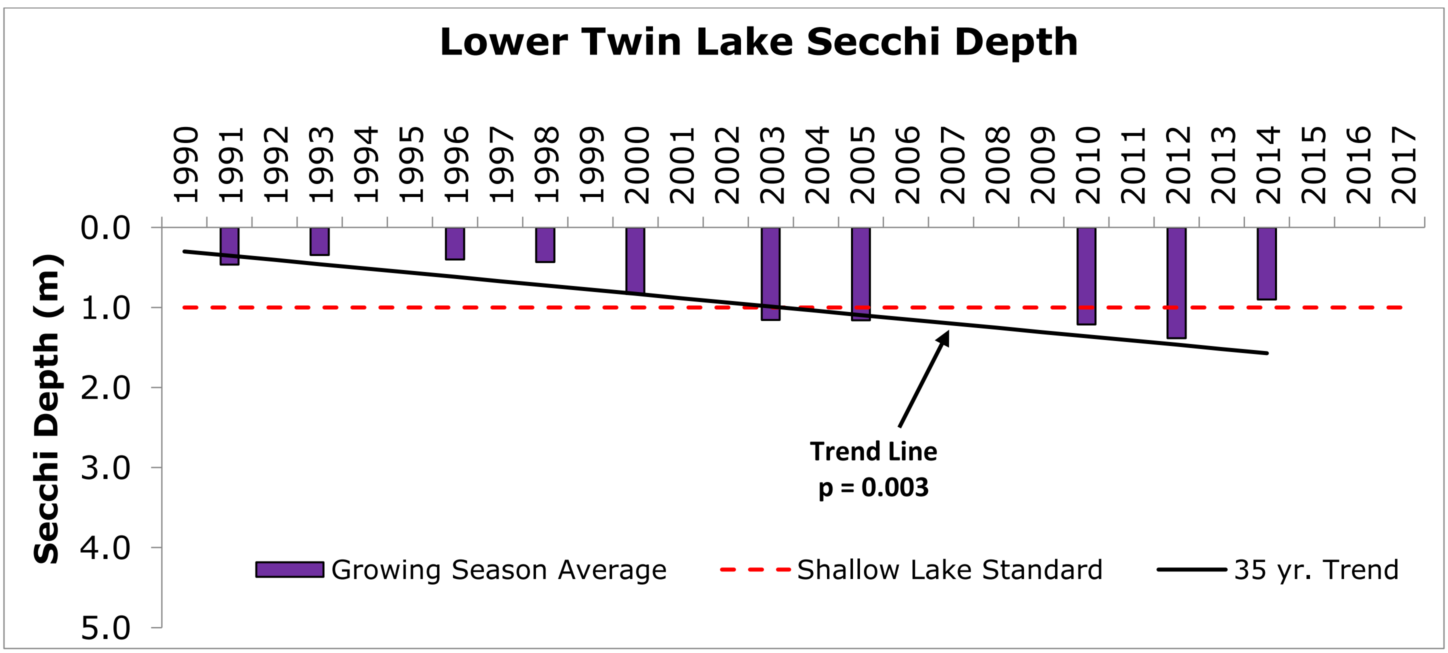

Eagle Lake TP
Growing Season Average
Deep Lake Standard
38 yr. Trend
Trend Line
p = 0.05
TP (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

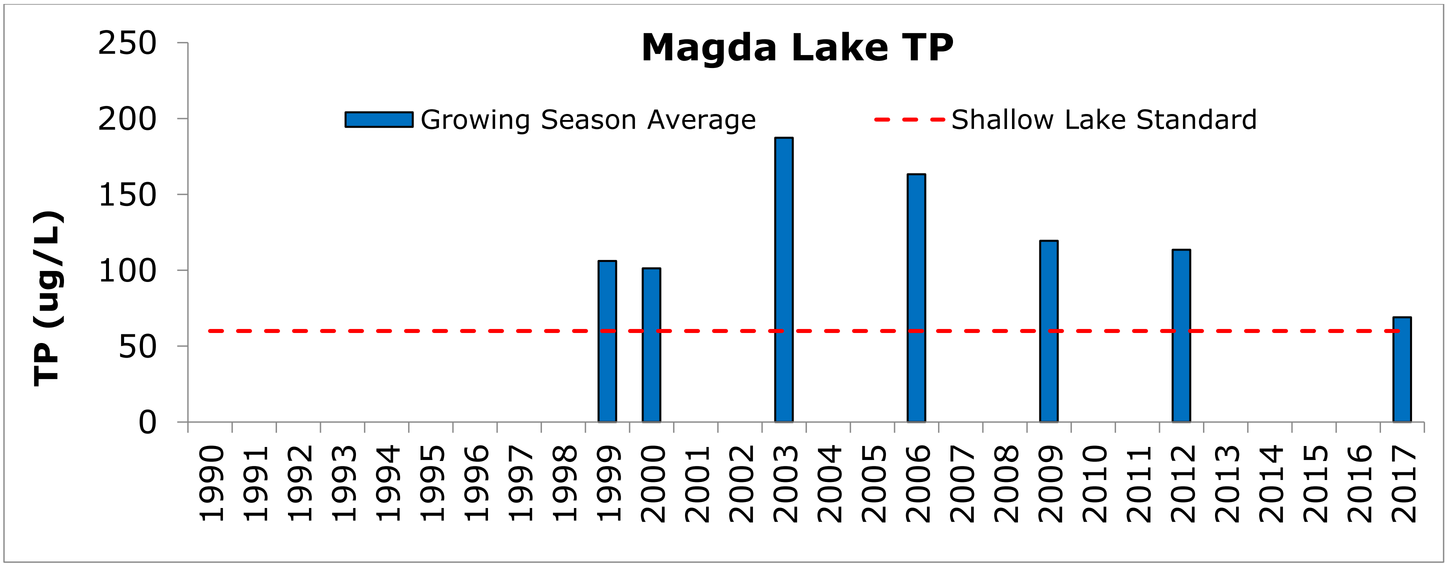

Eagle Lake Chlorophyll-a
Growing Season Average
Deep Lake Standard
Chl-a (ug/L)
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

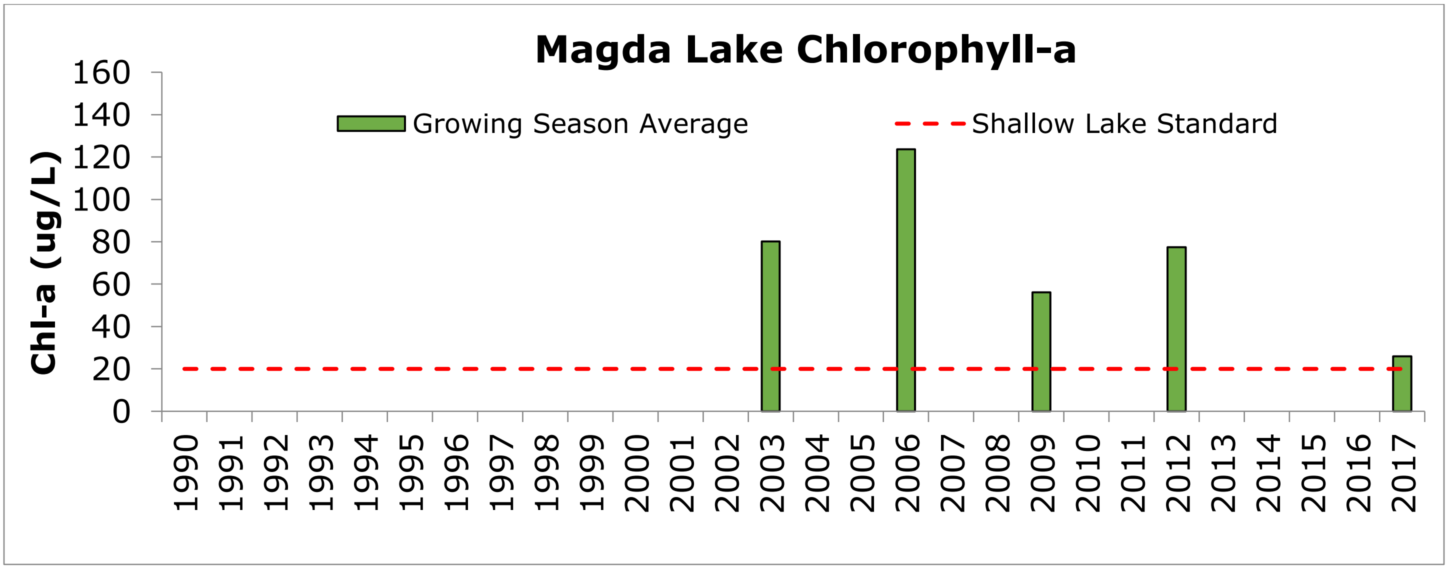

Eagle Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Trend Line
p = 0.09
Growing Season Average
Deep Lake Standard
38 yr. Trend

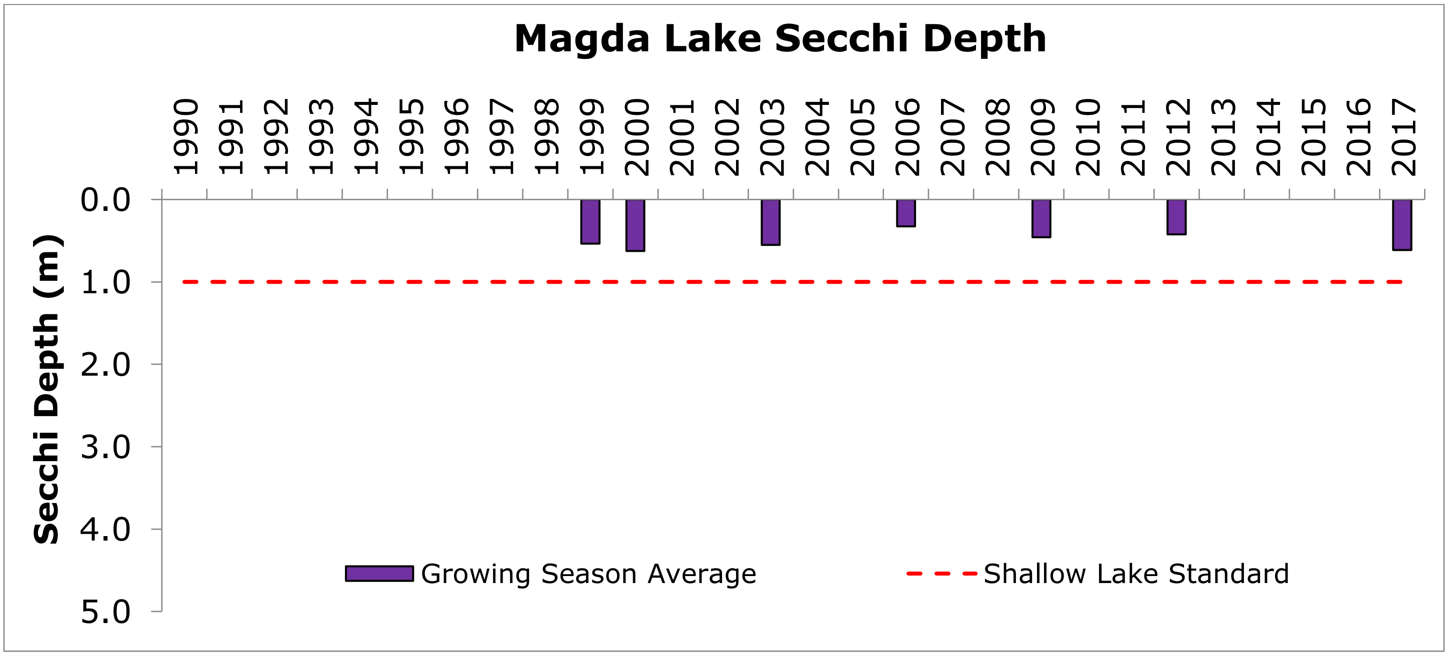

Lower Twin Lake TP
Growing Season Average
Shallow Lake Standard
35 yr. Trend
Trend Line
p = 0.02
TP (ug/L)
250
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

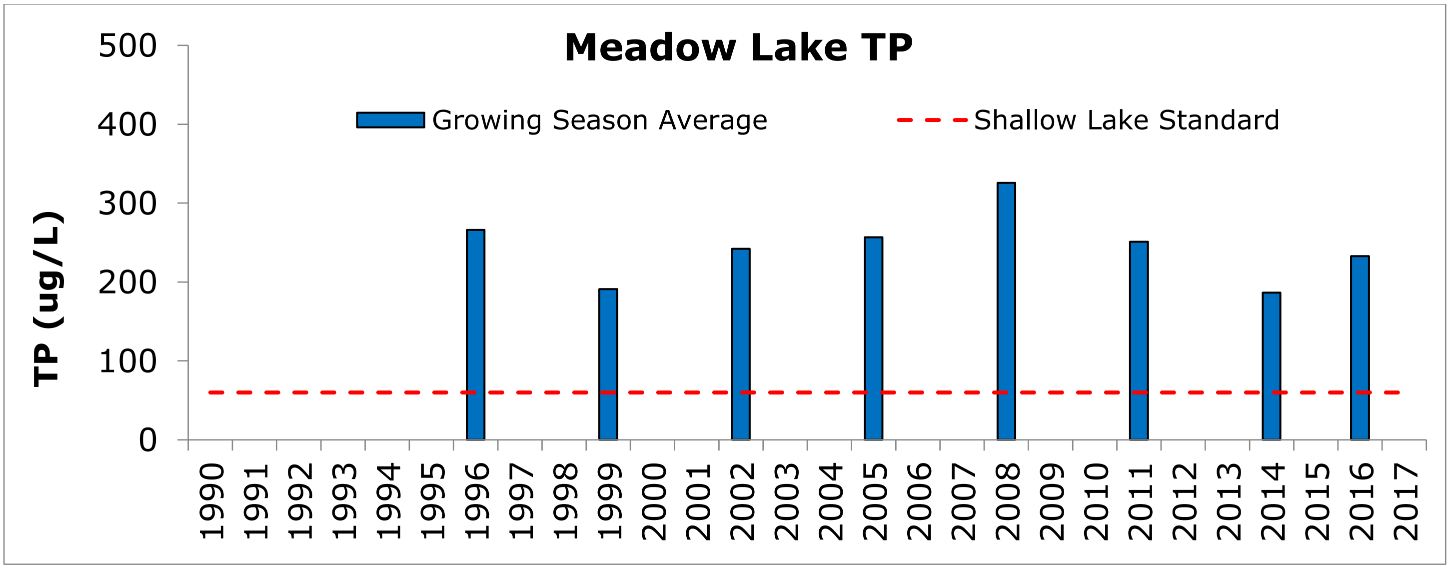

Lower Twin Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
Chl-a (ug/L)
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

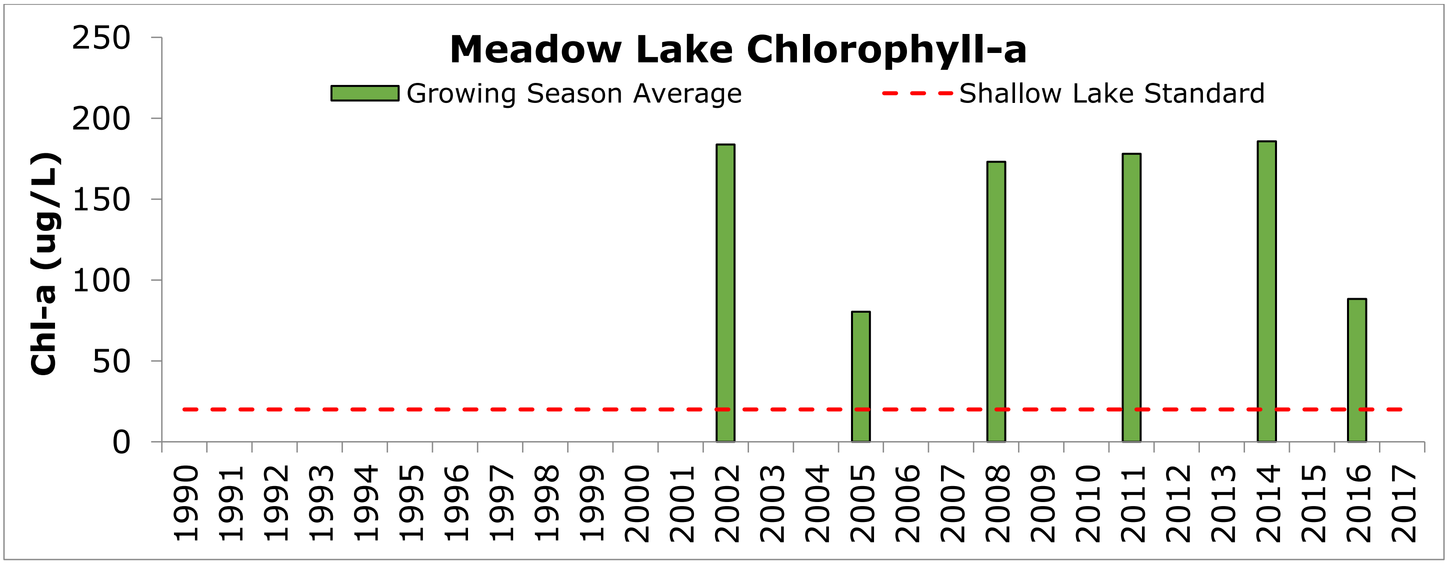

Lower Twin Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Trend Line
p = 0.003
Growing Season Average
Shallow Lake Standard
35 yr. Trend

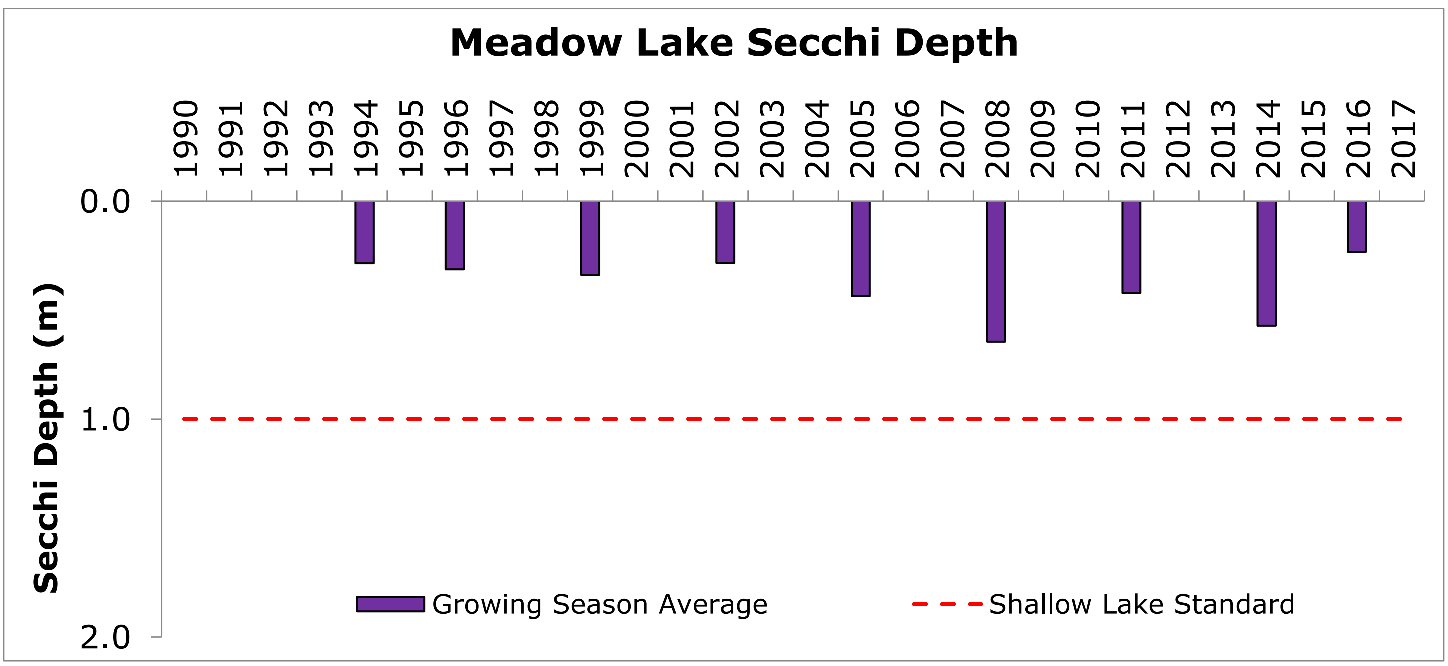

Magda Lake TP
TP (ug/L)
250
200
150
100
50
0
Growing Season Average
Shallow Lake Standard
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

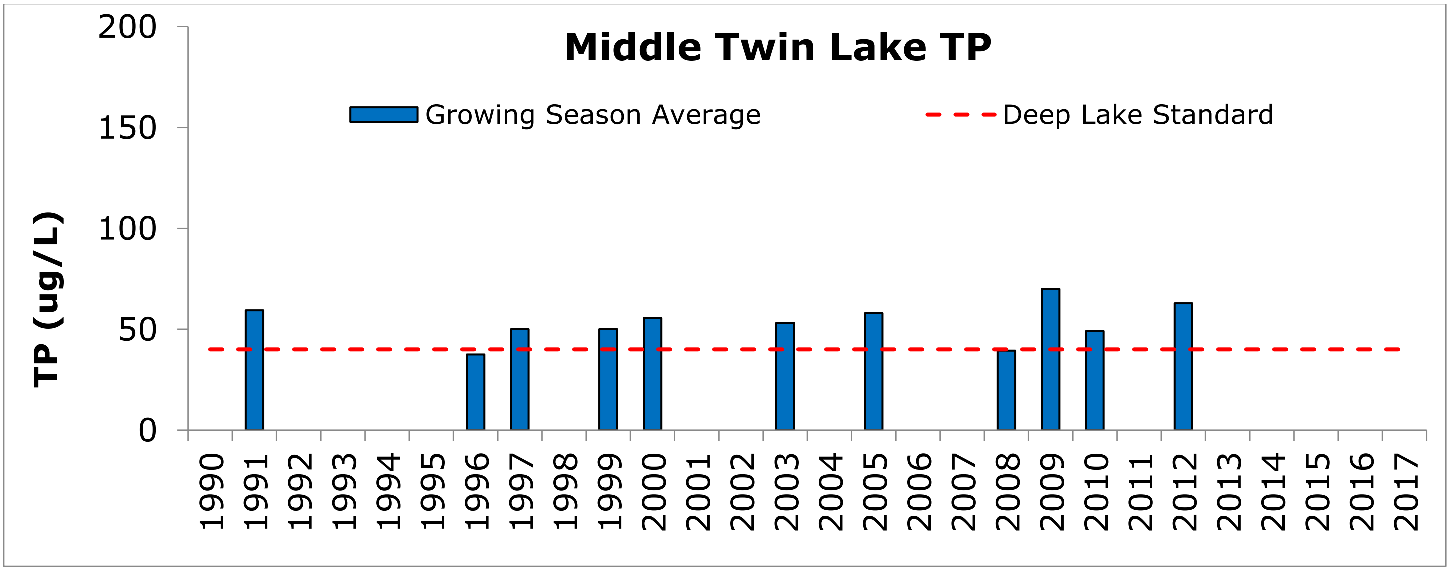

Magda Lake Chlorophyll-a
Chl-a (ug/L)
160
140
120
100
80
60
40
20
0
Growing Season Average
Shallow Lake Standard
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

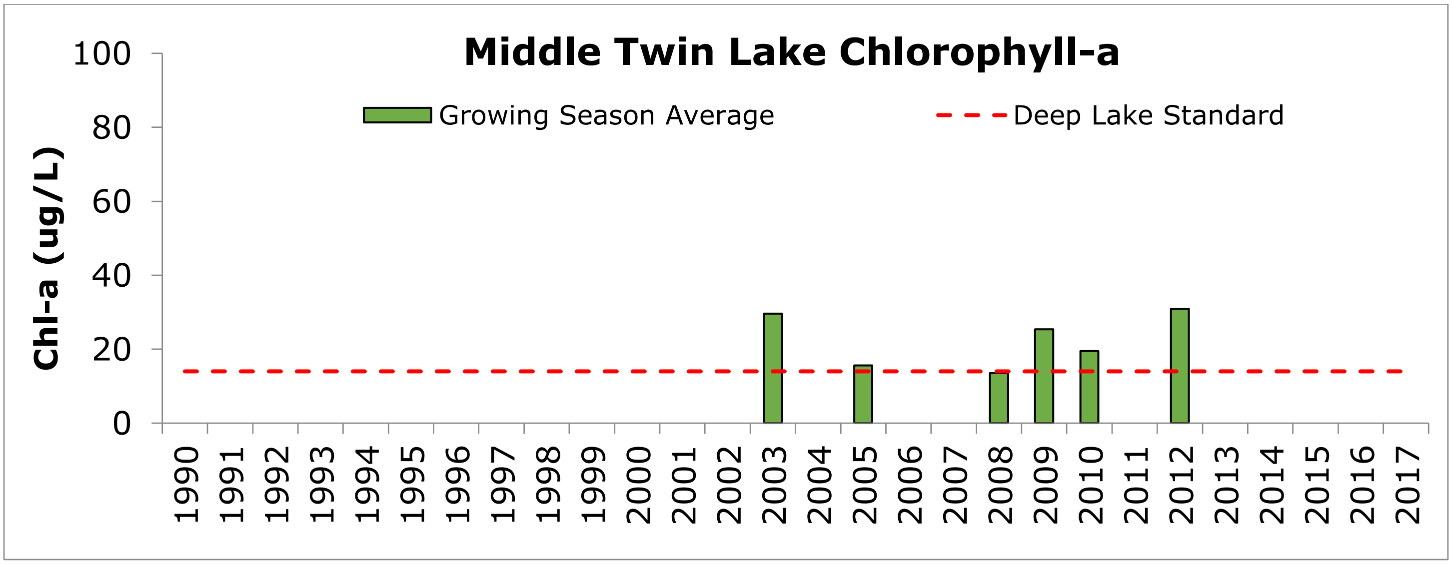

Magda Lake Secchi Depth
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Growing Season Average
Shallow Lake Standard
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

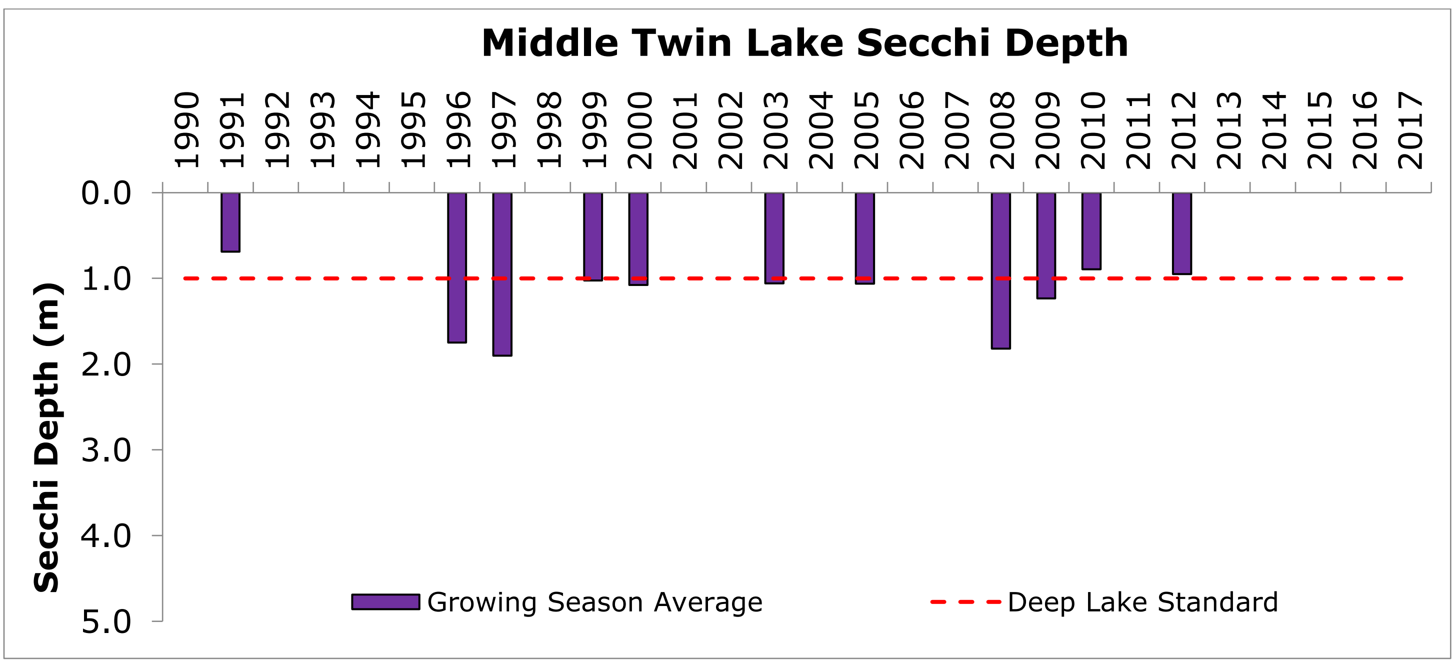

Meadow Lake TP
Growing Season Average
Shallow Lake Standard
TP (ug/L)
500
400
300
200
100
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

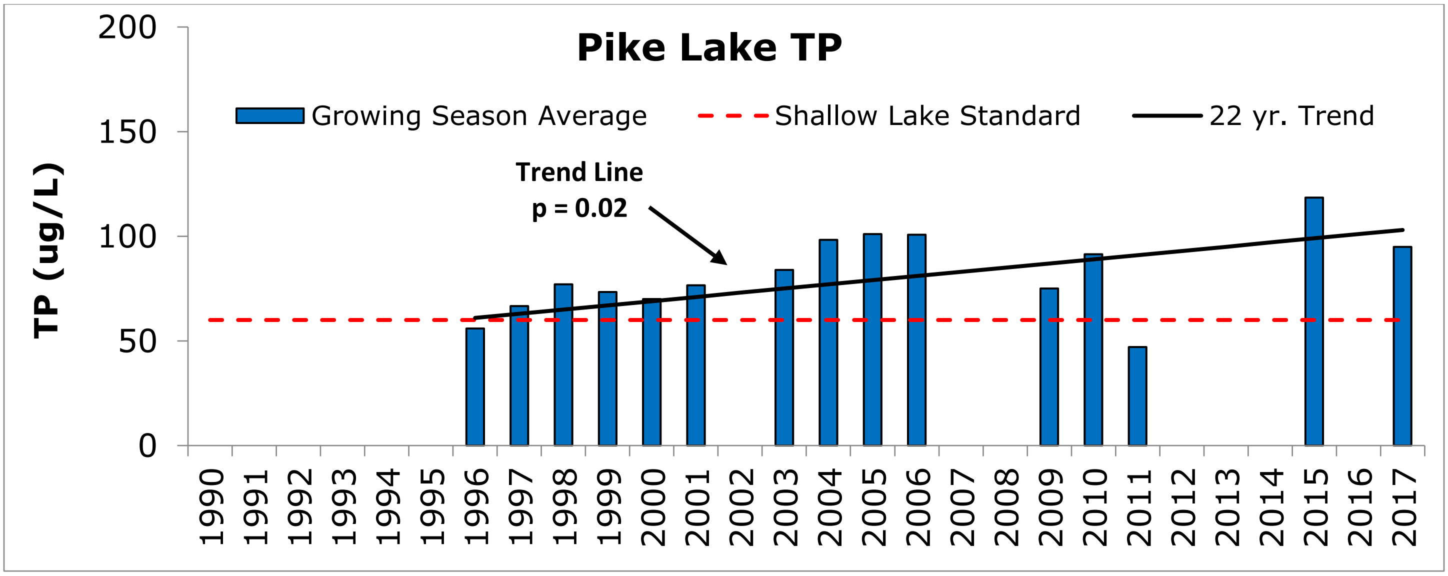

Meadow Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
Chl-a (ug/L)
250
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

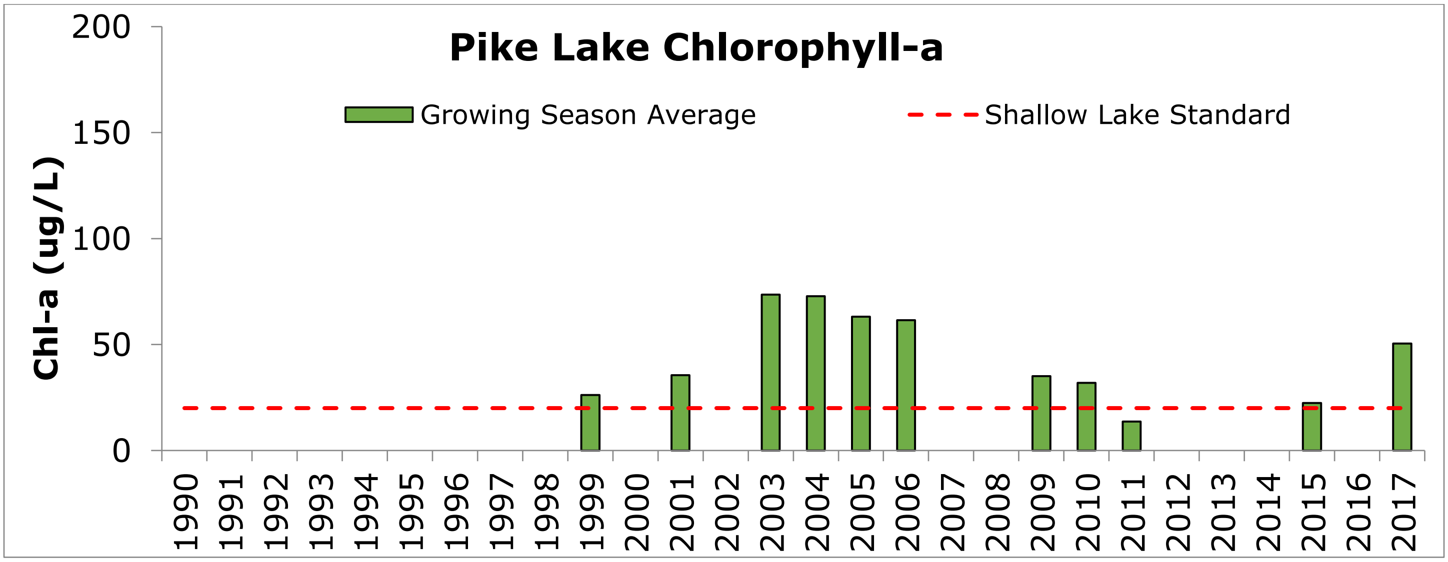

Meadow Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
Growing Season Average
Shallow Lake Standard

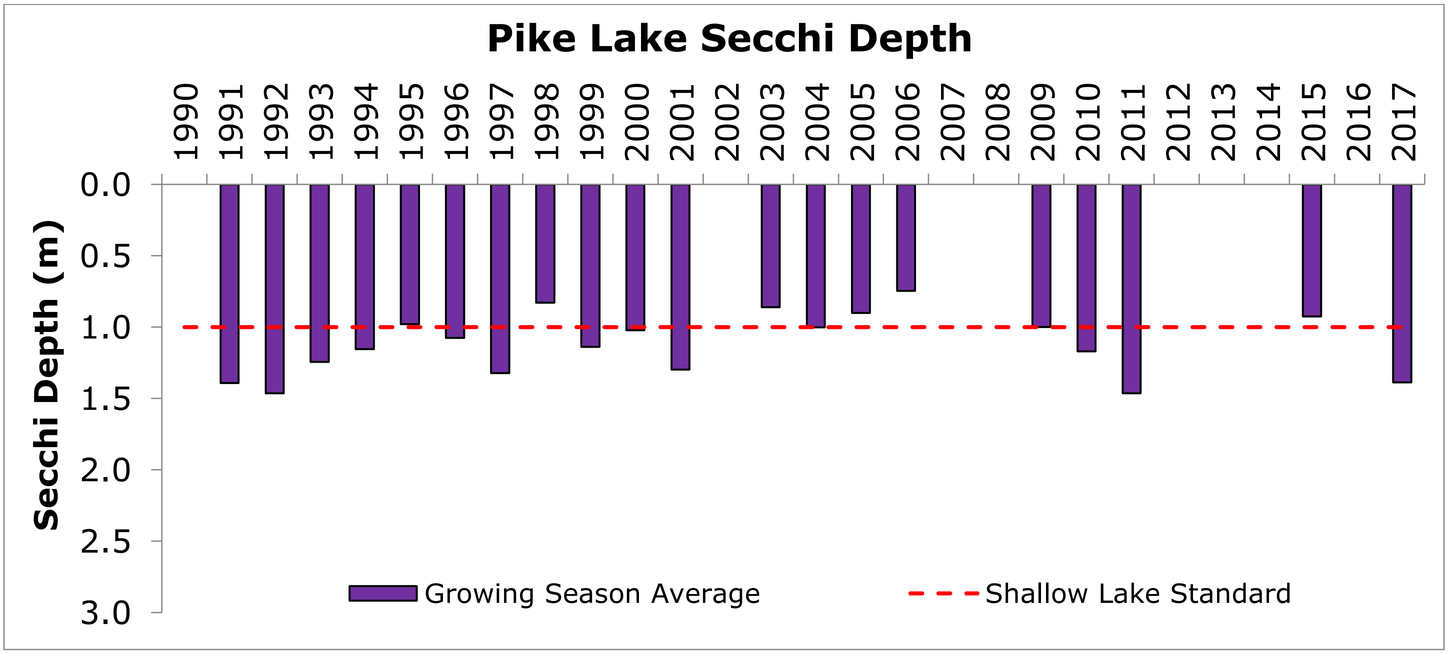

Middle Twin Lake TP
Growing Season Average
Deep Lake Standard
TP (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

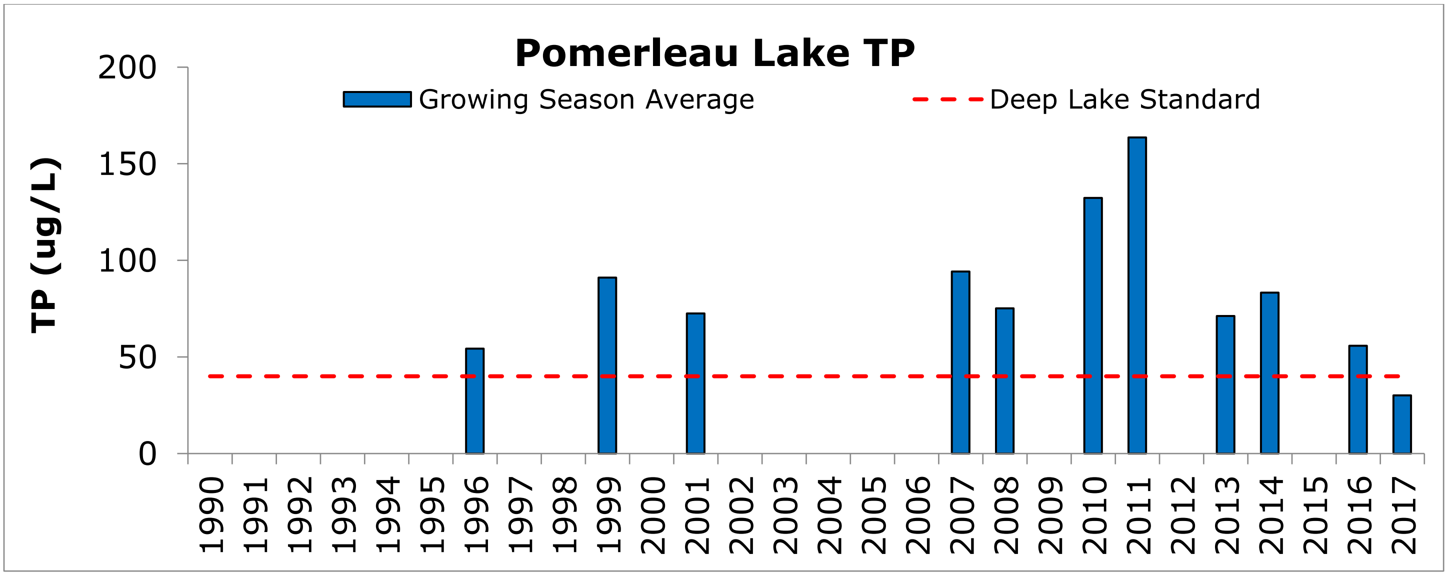

Middle Twin Lake Chlorophyll-a
Growing Season Average
Deep Lake Standard
Chl-a (ug/L)
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

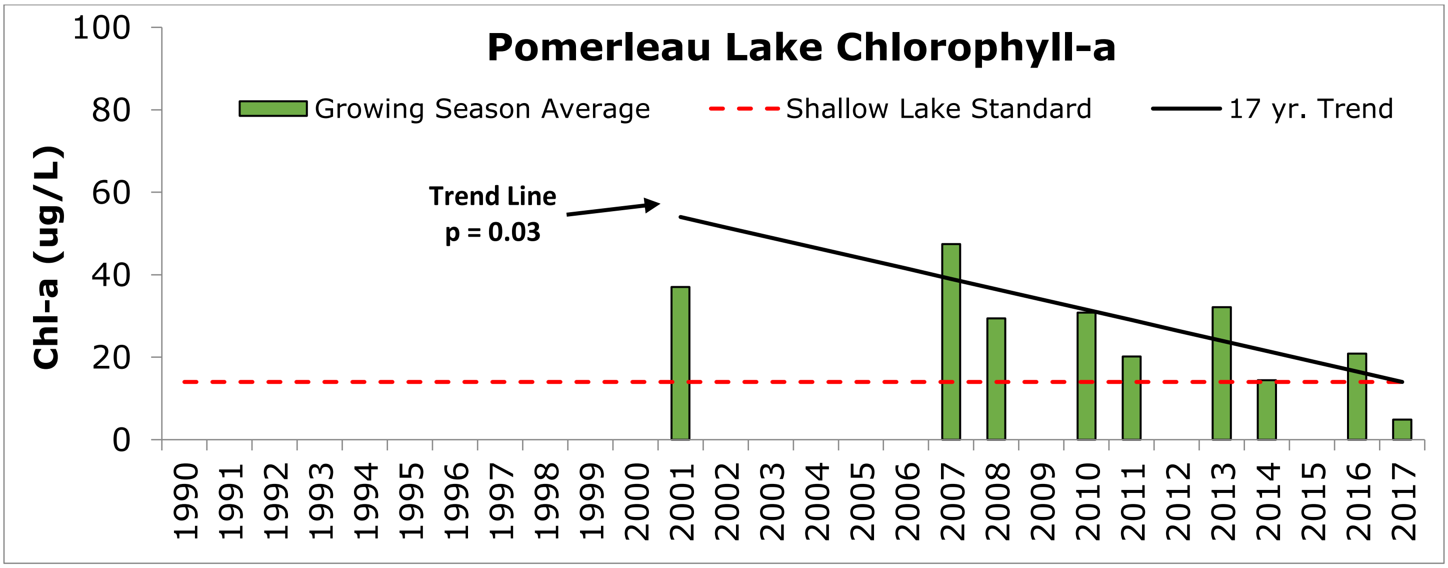

Middle Twin Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Growing Season Average
Deep Lake Standard

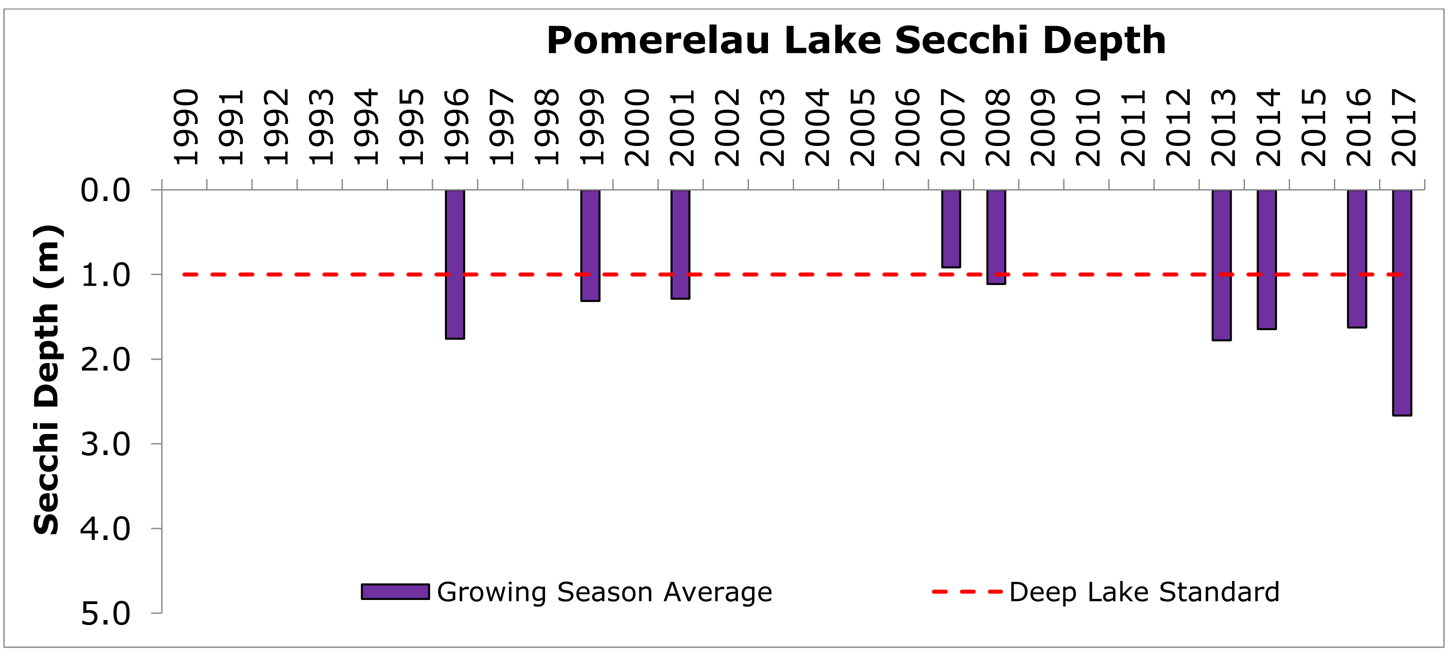

Pike Lake TP
Growing Season Average
Shallow Lake Standard
22 yr. Trend
Trend Line
p = 0.02
TP (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

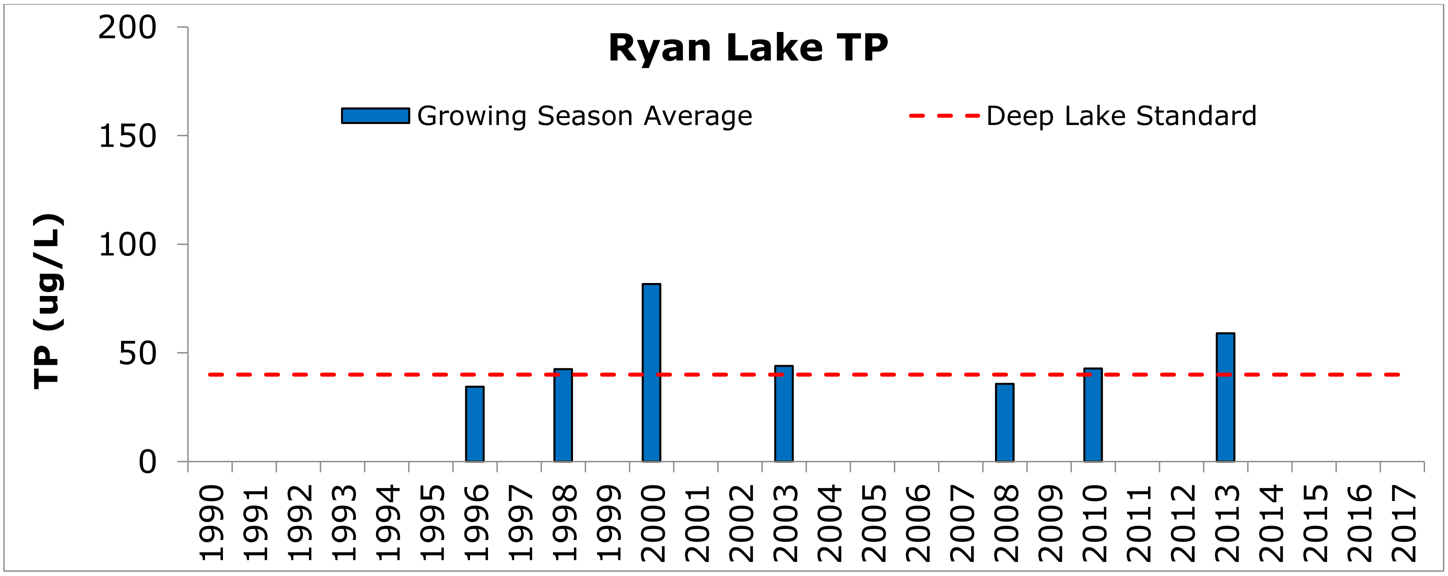

Pike Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
Chl-a (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

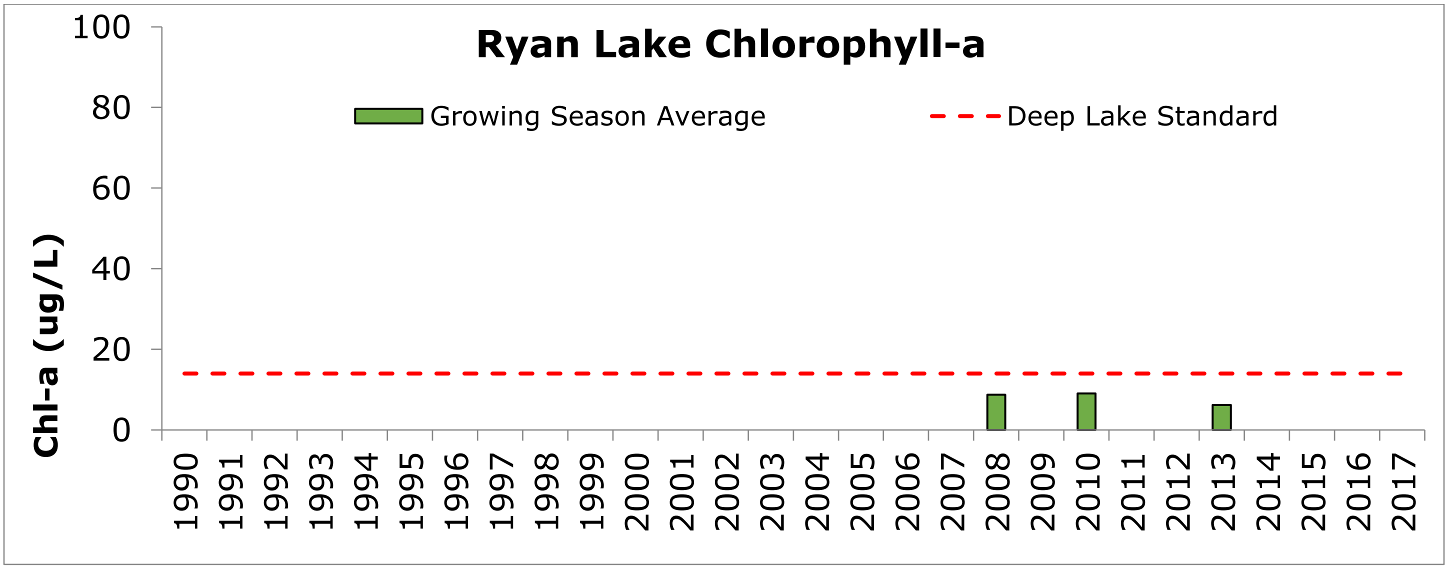

Pike Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Growing Season Average
Shallow Lake Standard

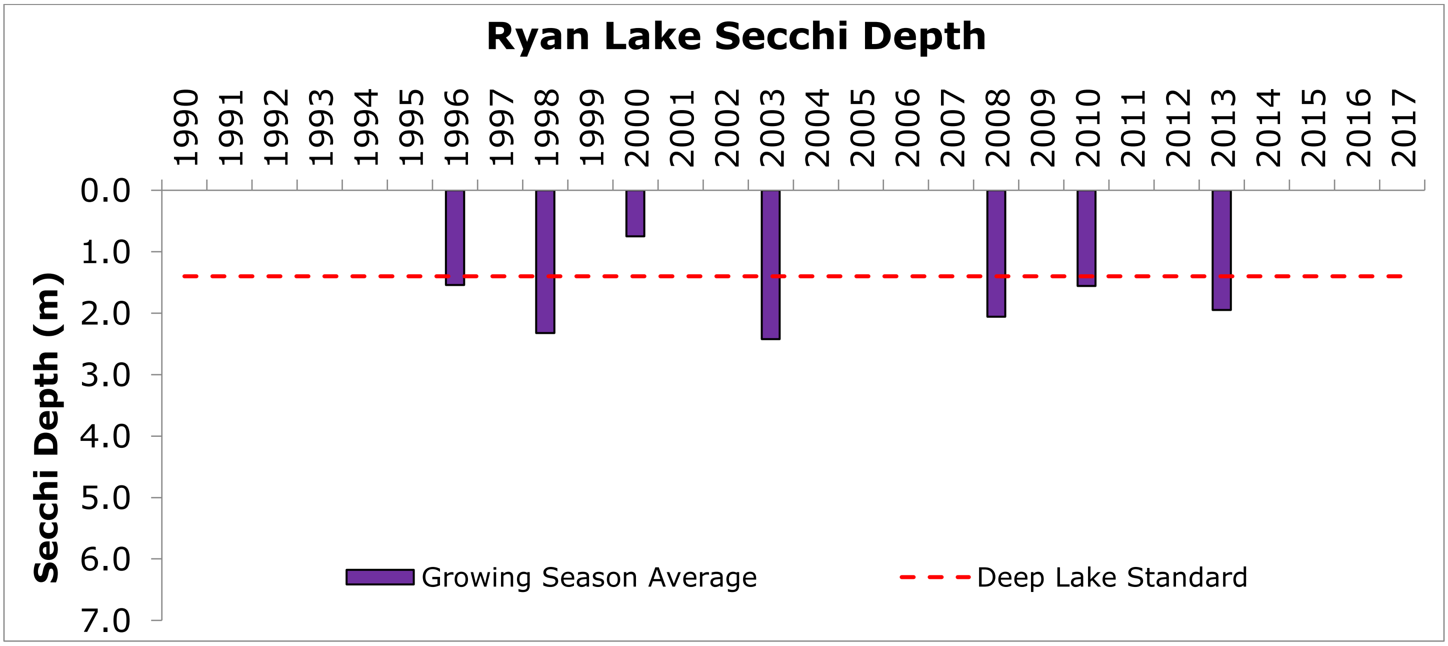

Pomerleau Lake TP
Growing Season Average
Deep Lake Standard
TP (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

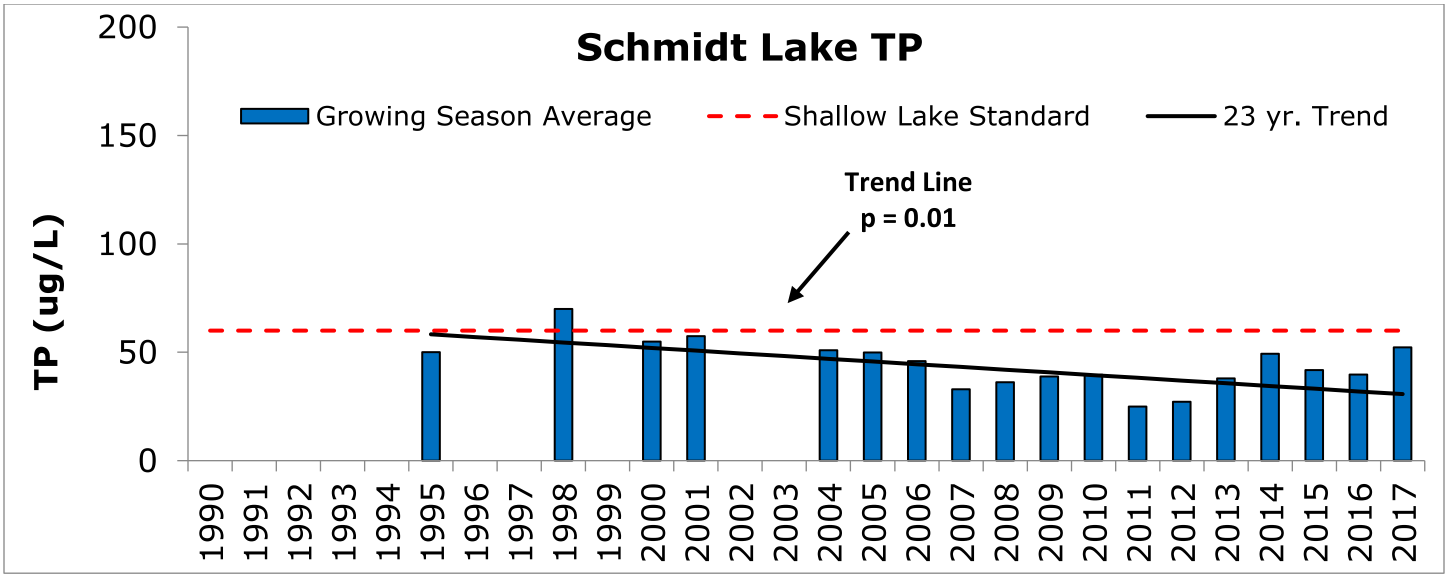

Pomerleau Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
17 yr. Trend
Trend Line
p = 0.03
Chl-a (ug/L)
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

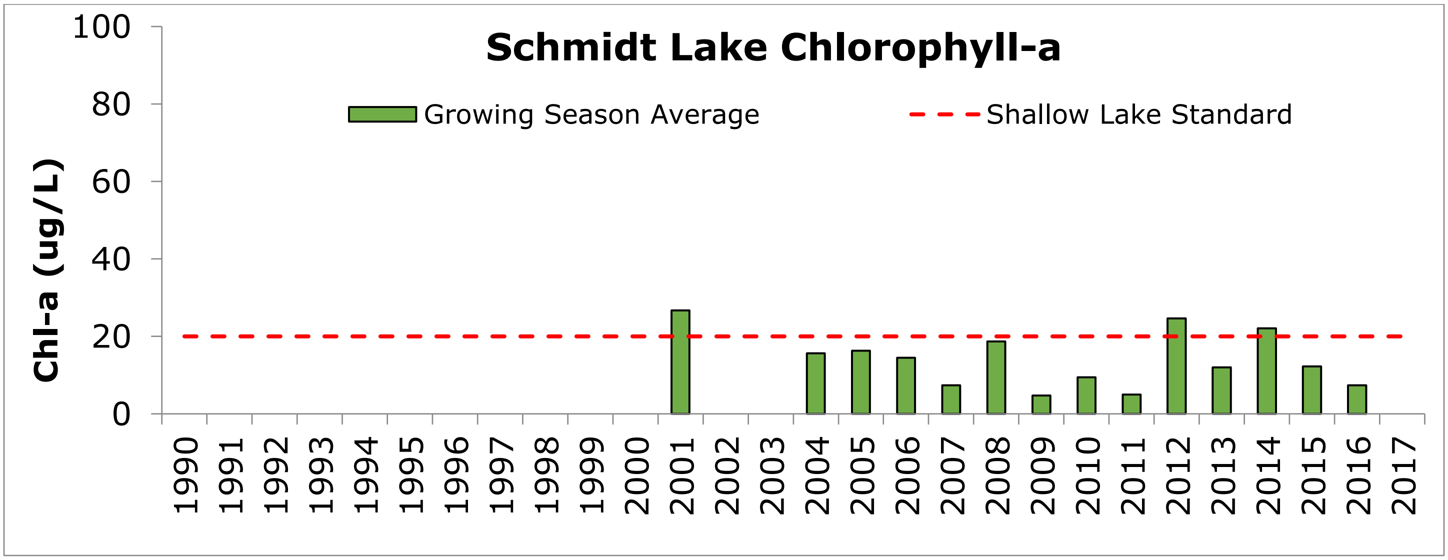

Pomerelau Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Growing Season Average
Deep Lake Standard

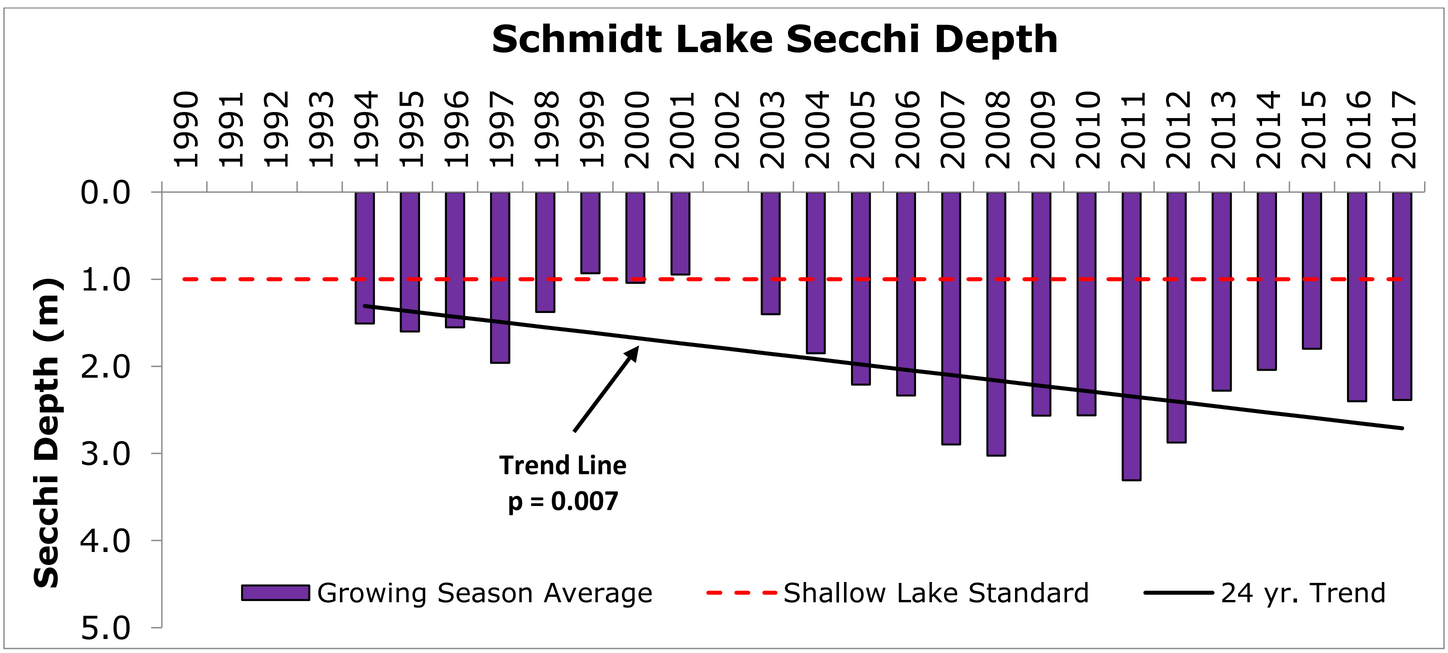

Ryan Lake TP
Growing Season Average
Deep Lake Standard
TP (ug/L)
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

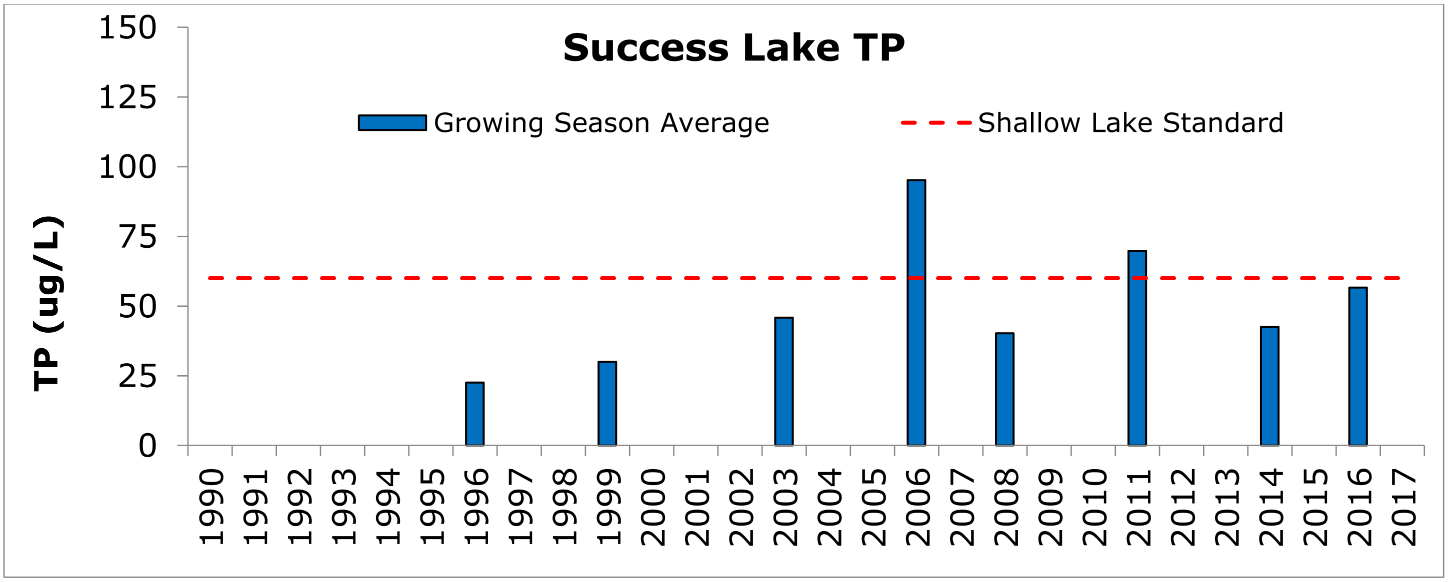

Ryan Lake Chlorophyll-a
Growing Season Average
Deep Lake Standard
Chl-a (ug/L)
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

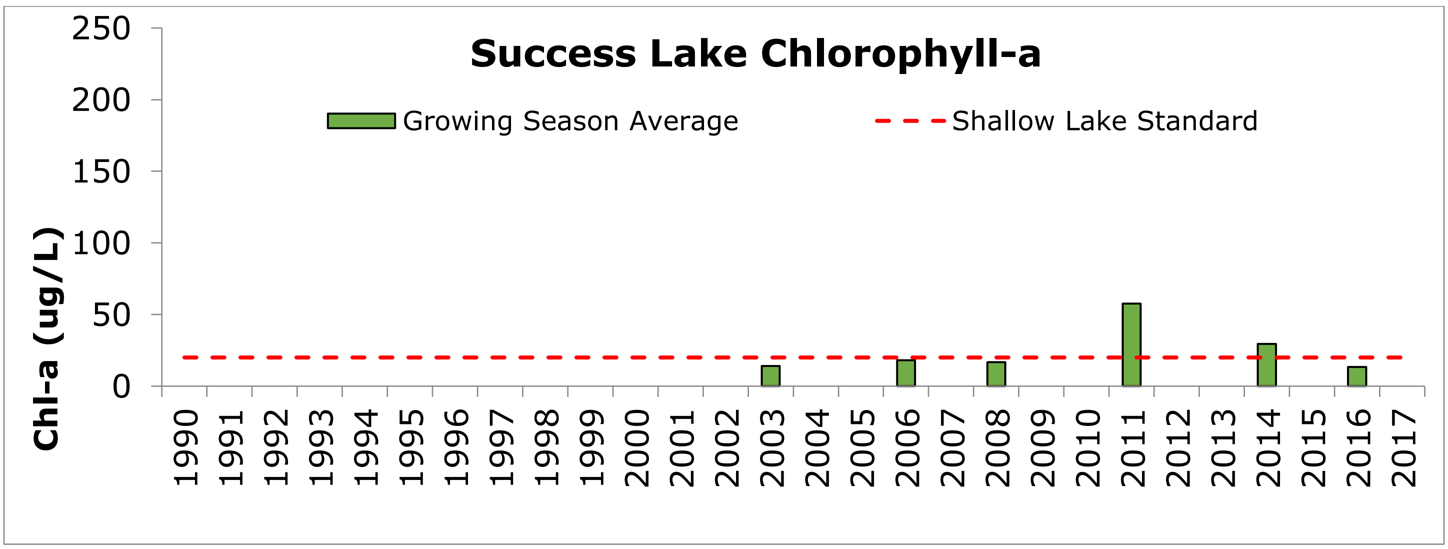

Ryan Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Growing Season Average
Deep Lake Standard

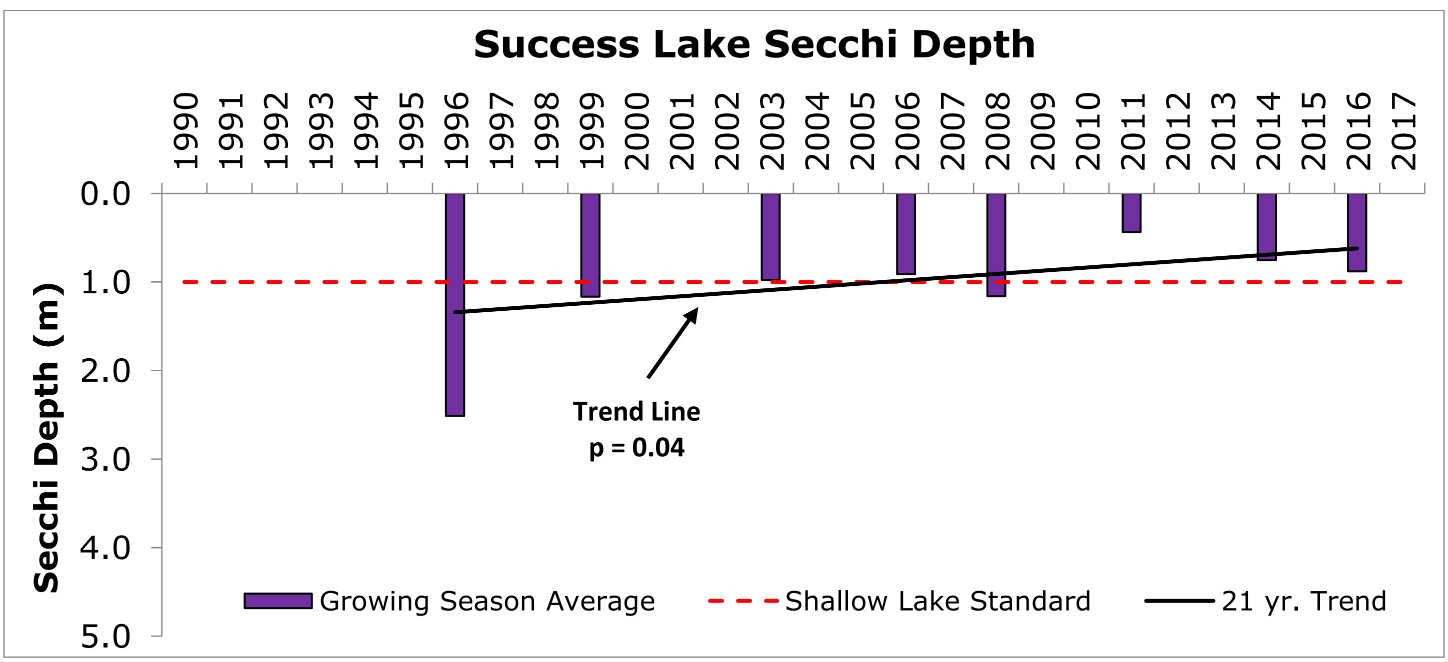

Schmidt Lake TP
Growing Season Average
Shallow Lake Standard
23 yr. Trend
Trend Line
p = 0.01
TP (ug/L)
0
50
100
150
200
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

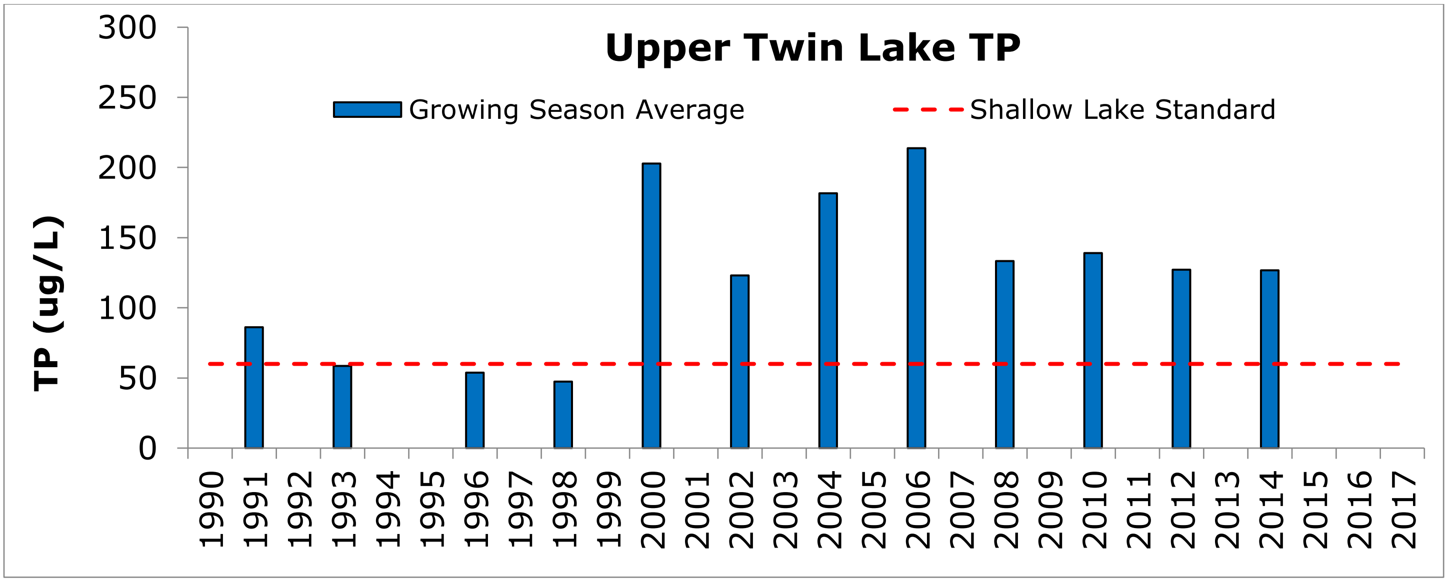

Schmidt Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
Chl-a (ug/L)
0
20
40
60
80
100
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

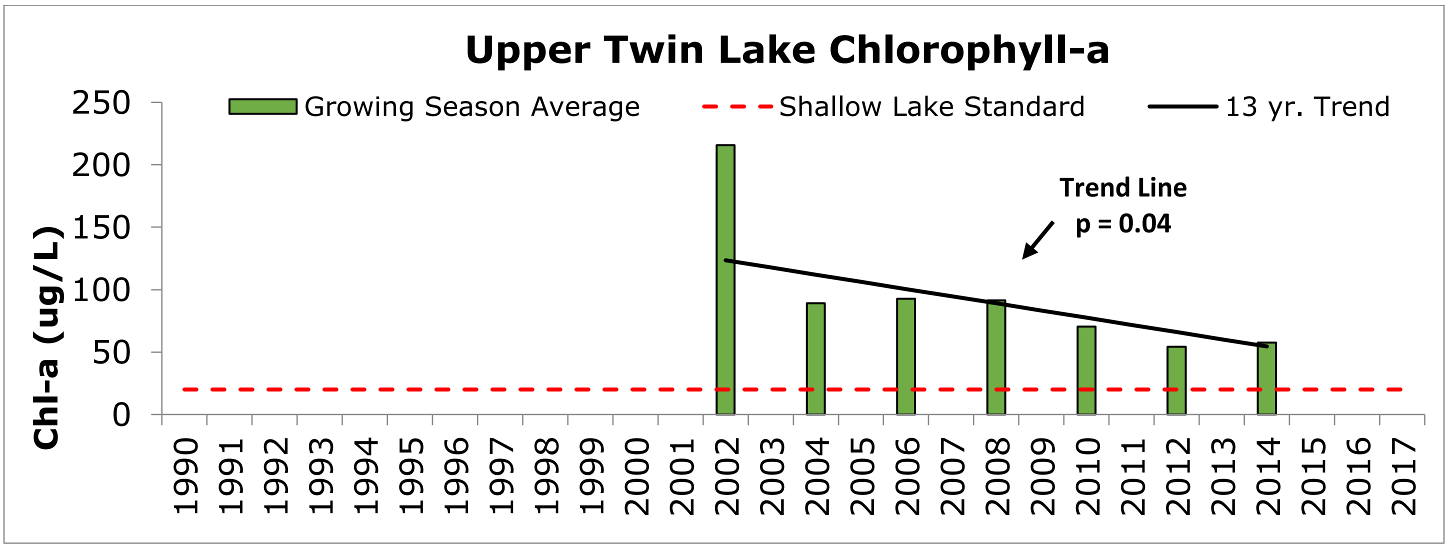

Schmidt Lake Secchi Depth
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Trend Line
p = 0.007
Growing Season Average
Shallow Lake Standard
24 yr. Trend

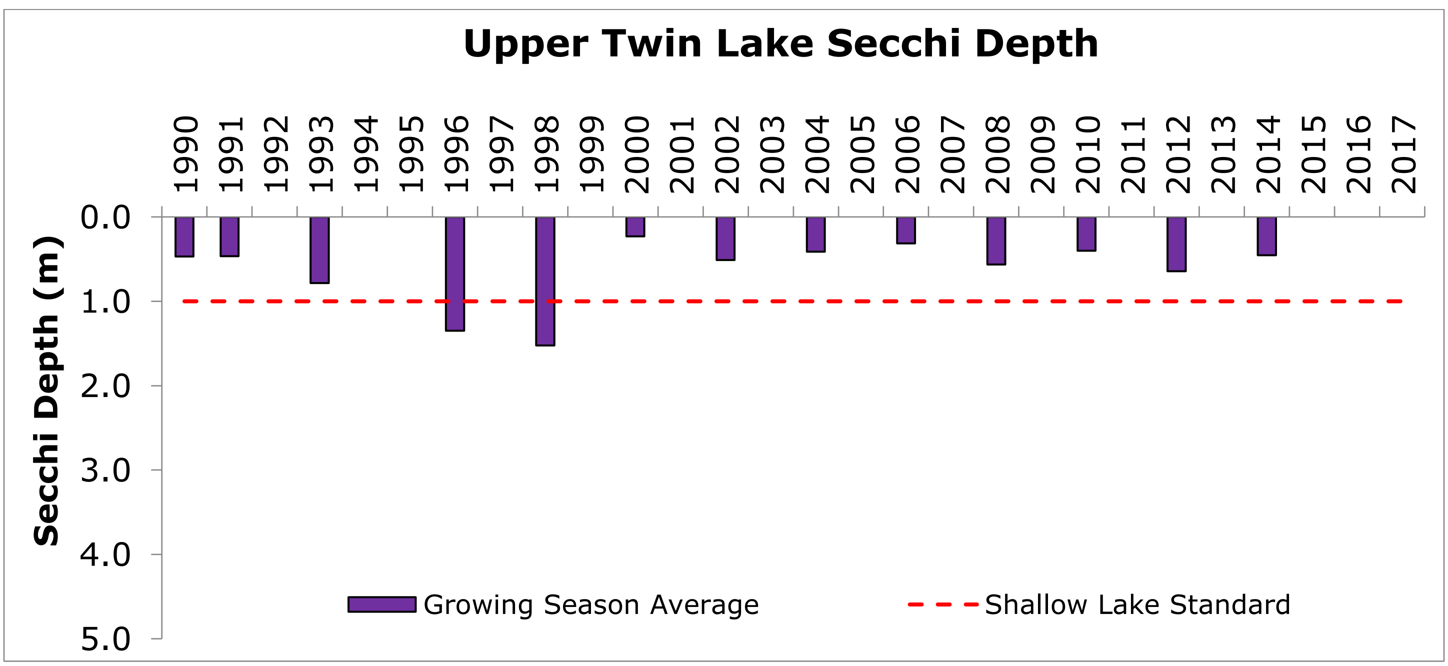

Success Lake TP
Growing Season Average
Shallow Lake Standard
TP (ug/L)
150
125
100
75
50
25
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


Success Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
Chl-a (ug/L)
250
200
150
100
50
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


Success Lake Secchi Depth
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Trend Line
p = 0.04
Growing Season Average
Shallow Lake Standard
21 yr. Trend


Upper Twin Lake TP
Growing Season Average
Shallow Lake Standard
TP (ug/L)
300
250
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017


Upper Twin Lake Chlorophyll-a
Growing Season Average
Shallow Lake Standard
13 yr. Trend
Trend Line
p = 0.04
Chl-a (ug/L)
250
200
150
100
50
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017


Upper Twin Lake Secchi Depth
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Secchi Depth (m)
0.0
1.0
2.0
3.0
4.0
5.0
Growing Season Average
Shallow Lake Standard

Appendix E: 2017 5-Year TMDL Review Lake Monitoring

OVERVIEW

The Shingle Creek Third Generation Watershed Management Plan recommends 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 Department of Natural Resources (DNR).

LAKE DESCRIPTIONS

Magda Lake is approximately 10.2 acres in size with no depths greater than 10 feet. Thus, 100% of the lake area is littoral and, therefore, fish, sediment and aquatic vegetation have an impact on the water quality in this shallow. The residence time indicates that runoff from the watershed displaces the lake volume approximately once every 0.12 years (approximately 1.5 months).

Pomerleau Lake is approximately 25.7 acres in size and 77% littoral area. The residence time indicates that runoff from the watershed displaces the lake volume approximately once every 0.12 years (approximately 1.5 months).

WATER QUALITY MONITORING

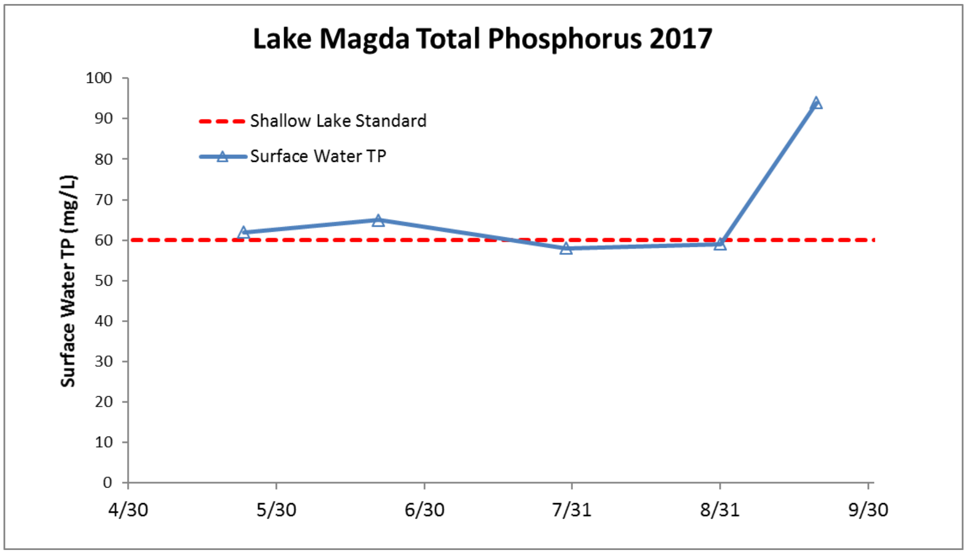
Water quality sampling was conducted by Wenck staff at the long-term monitoring sites on Magda and Pomerleau in 2017. Water depth at the Magda and Pomerleau monitoring sites is approximately 6 and 22 feet deep, respectively. For each lake, surface samples were collected bi-weekly from late May to late September and analyzed for TP, Secchi depth, and chlorophyll-a.

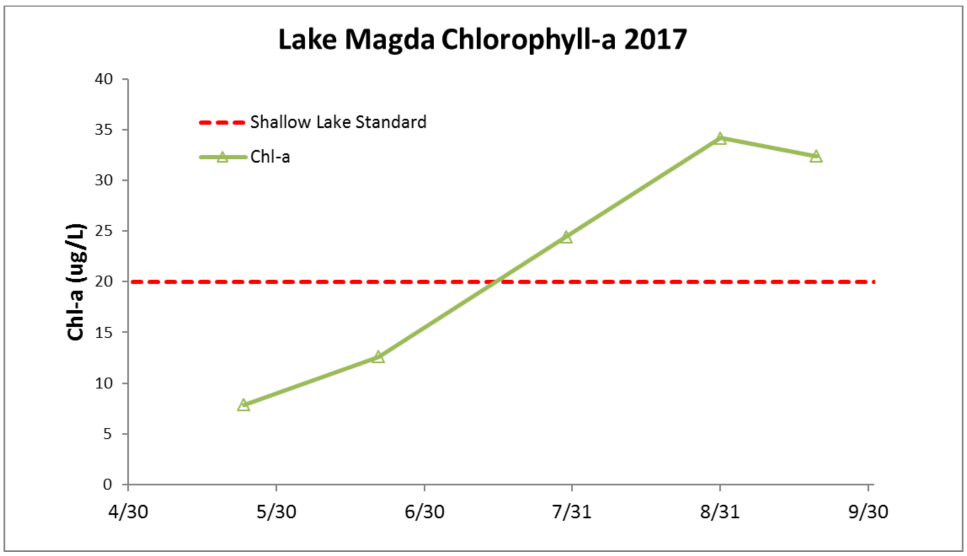
Lake Magda Water Quality

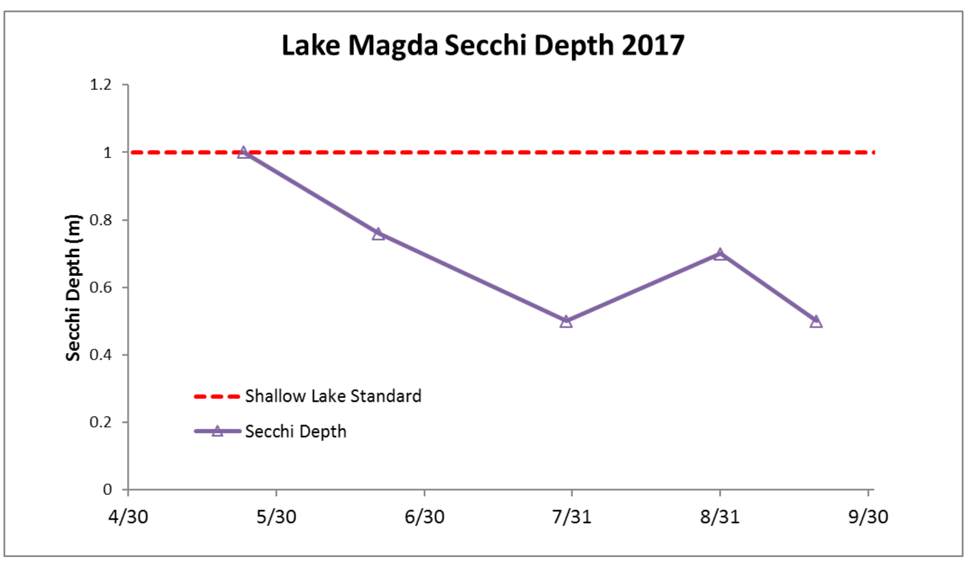
Surface TP concentrations in 2017 were at or slightly above the 60 µg/L standard until the beginning of September when concentrations increased well above the State standard until the end of the sampling season. Chlorophyll-a concentrations started below the State standard until early July where they surpassed standard values for the remainder of the sampling season. Transparency (Secchi depth) did not meet state water quality standards during any of the sampling events in 2017 (see figures below). Historic data (see Appendix D) indicates growing season average TP, chlorophyll-a, have never met state water quality standards since monitoring began in 1999.

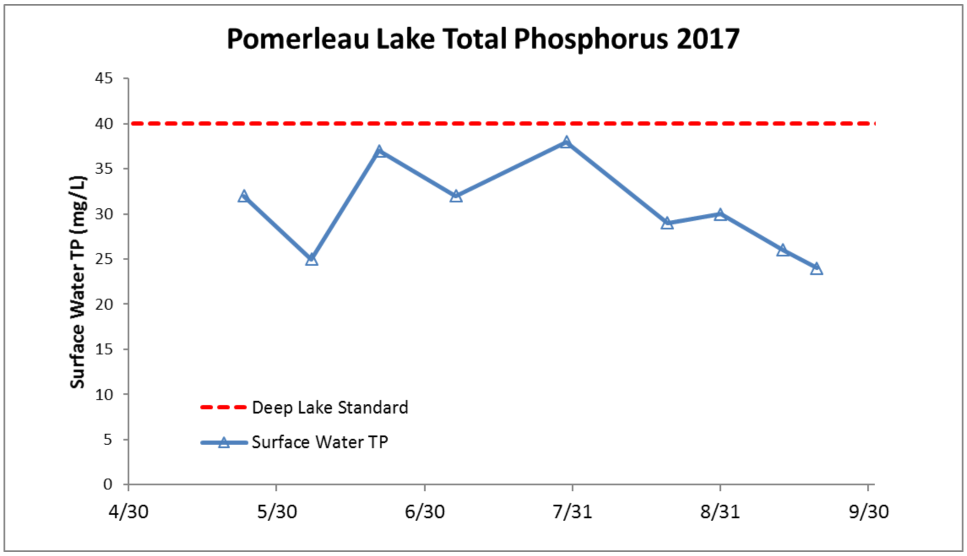
Pomerleau Lake Water Quality

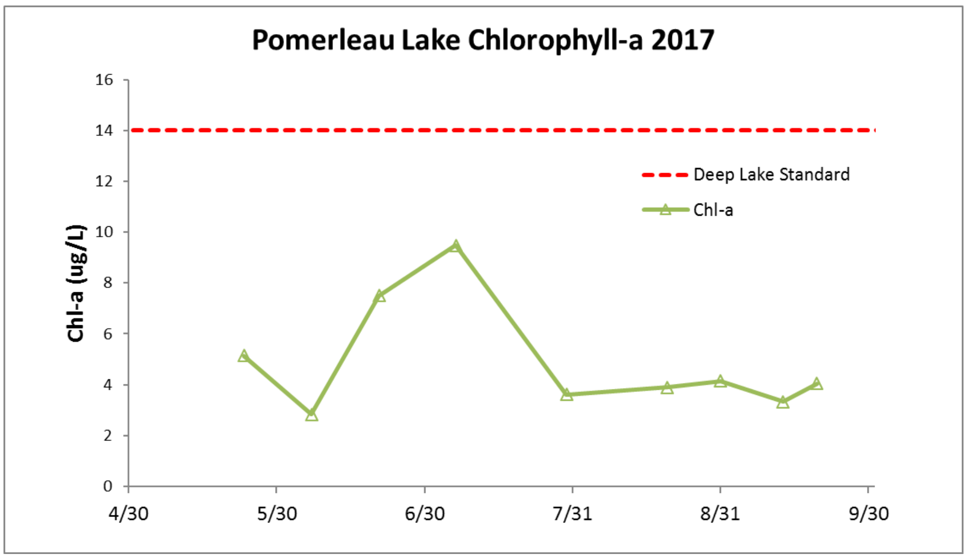
Surface TP concentrations in 2017 met the 40 µg/L for the entire sampling season. Chlorophyll-a concentrations experienced a slight increase over the month of June but was below the State standard the entire sampling season. Transparency (Secchi depth), had an inverse relationship to Chlorophyll-a concentrations experiencing and was well below the State standard the entire sampling season (see figures below). Historic data suggests Pomerleau Lake (see Appendix D) has not met state standards for TP in, has occasionally met Secchi depth and has only hit Chlorophyll-a concentrations once since 1996.

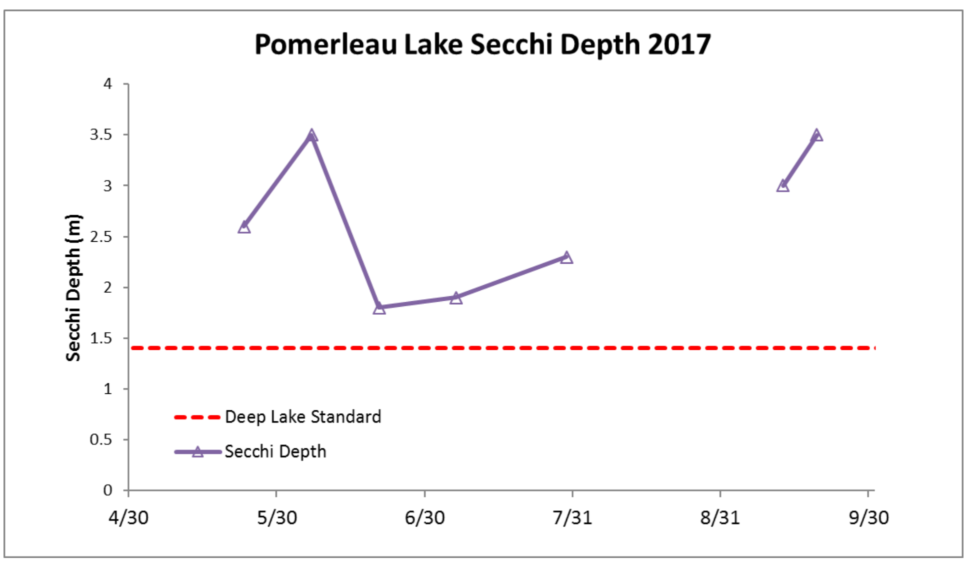

Lake Magda Total Phosphorus 2017
Shallow Lake Standard
Surface Water TP
Surface Water TP (mg/L)
100
90
80
70
60
50
40
30
20
10
0
4/30
5/30
6/30
7/31
8/31
9/30


Lake Magda Chlorophyll-a 2017
Shallow Lake Standard
Chl-a
Chl-a (ug/L)
40
35
30
25
20
15
10
5
0
4/30
5/30
6/30
7/31
8/31
9/30


Lake Magda Secchi Depth 2017
Shallow Lake Standard
Secchi Depth
Secchi Depth (m)
1.2
1
0.8
0.6
0.4
0.2
0
4/30
5/30
6/30
7/31
8/31
9/30


Pomerleau Lake Total Phosphorus 2017
Surface Water TP (mg/L)
45
40
35
30
25
20
15
10
5
0
4/30
5/30
6/30
7/31
8/31
9/30
Deep Lake Standard
Surface Water TP


Pomerleau Lake Chlorophyll-a 2017
Chl-a (ug/L)
16
14
12
10
8
6
4
2
0
4/30
5/30
6/30
7/31
8/31
9/30
Deep Lake Standard
Chl-a


Pomerleau Lake Secchi Depth 2017
Secchi Depth (m)
4
3.5
3
2.5
2
1.5
1
0.5
0
4/30
5/30
6/30
7/31
8/31
9/30
Deep Lake Standard
Secchi Depth

VEGETATION SURVEYS

Point-intercept surveys using methodology developed by the Minnesota Department of Natural Resources (DNR) were conducted on May 24, 2017 and July 28, 2017 on Lake Magda and Pomerleau Lake. Point-intercept sample points were established in GIS across each lake basin using a 50x50 meter grid file which resulted in a total of 18 sample point locations on Magda Lake and 38 locations on Pomerleau Lake. The survey grids were downloaded onto a GPS unit that was used to navigate to each sample point during the surveys. One side of the boat was designated as the sampling area. Water depth was recorded at each sample point using an electronic depth finder.

A double-sided weighted 14 tine rake was thrown from the boat and retrieved across three meters of the lake bottom to represent approximately one square meter of vegetation sampling. We refer to this as a rake toss. For each rake toss, all vegetation species collected on the rake tines were identified, 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 curlyleaf pondweed). All biomass values are reported in wet weights (kg).

The late summer surveys were conducted to assess each lake’s overall plant community and diversity during the peak of the summer growing season. The early summer surveys were conducted to target and estimate the distribution and abundance of curlyleaf pondweed, which senesces by early summer and is missed during late season vegetation surveys.

Native Submerged Vegetation

Native plant species often co-exist with each other and provide a robust and versatile community and habitat for aquatic biota. In the presence of AIS native species are often threatened and reduced to low frequency of abundance, compromising the integrity of the vegetation community. Thus, monitoring the presence of native species provides insight in to what species could be targeted to restore and/or protect the lake’s vegetation community. Native vegetation establishment is often an afterthought and typically not the primary motive for lake users, however a native dominated vegetation community should be considered a primary goal to promote water quality and the overall health of the lake’s ecosystem.

Curlyleaf Pondweed

Curlyleaf pondweed is dormant through late summer and begins growing in the fall. The plant grows under the ice and reaches its maximum growth in May and June, when most native plant growth is still hindered by cool water temperatures. Since it has little competition from native species early in the year, curlyleaf pondweed can form dense stands that incorporate nutrients from the lake sediments. When the plants begin to die back (senesces) in early summer the nutrients stored in the stems and leaves of the plants are released back into the lake. The timing of the large pulse of nutrients to the lake (typically mid-summer) can cause excess algal blooms or impact water quality negatively in other ways.

Curlyleaf pondweed spreads across the lake by forming turions at the end of each stem tip in early summer which break off and fall to the lake bottom. The turions are distributed across the lake by currents and wave action and germinate into new plants in the early fall.

Magda Lake Survey Results

Vegetation was found at 14 of 18 (78%) sampling sites during the May 24th, 2017 survey and only 10 of 18 (56%) sampling sites during the July 28th, 2017 survey. Six species of aquatic vegetation were documented during the May survey and four species were documented during the July survey (Table E-1). Secchi depth was measured at 1.0 meter in May and 0.5 meters in July. In general, vegetation occurrence and diversity decreased over the open water season.

Of the 14 vegetated locations in May the most common species observed was curlyleaf pondweed (61%). Of the 10 vegetated locations in July, Canadian waterweed was the most common species (50%). As expected, curly-leaf pondweed observation dropped from 61% occurrence to not observed by July. Frequency of occurrence of each plant species observed in Magda Lake is summarized in Table E-2.

Table E-1: Vegetation sample summary on Magda Lake.

Sample Date	5/24/2017	7/28/2017
Total Observations	18	18
% Littoral Sample Points	100	100
% of Littoral with Vegetation	77.8	55.6
Lake Taxa	6	4
Lake Taxa Status	Failing	Failing
Lake FQI	18.0	14.7
FQI Status	Meeting	Failing

Table E-2: Frequency of species occurrence during Magda Lake vegetation surveys.

Species		% Occurrence	
Scientific Name	**Common Name**	**5/24/2017**	**7/28/2017**
Potamogeton crispus	curly-leaf pondweed	61%	--
Elodea nuttallii	waterweed (slender)	39%	--
Chara sp.	muskgrass	11%	17%
Elodea canadensis	waterweed (Canadian)	11%	50%
Stuckenia pectinata	sago pondweed	11%	6%
Ceratophyllum demersum	coontail	6%	--
Myriophyllum spicatum	water milfoil (Eurasian)	--	11%

Pomerleau Lake Survey Results

Vegetation was found at 96% of the littoral sample sites during the May 24th, 2017 survey and 88% of the littoral sample sites during the July 28th, 2017 survey. Seven species of aquatic vegetation were documented during the May survey and four species were documented during the July survey (Table E-3). Secchi depth was measured at 2.6 meters in May and 2.3 meters in July. In general, vegetation occurrence and diversity decreased over the open water season.

Of the 22 vegetated locations in May the most common species observed was coontail (78%) and curlyleaf pondweed (43%). Of the 21 vegetated locations in July, Coontail remained the most common species (88%). As expected, curly-leaf pondweed observation dropped from 43% occurrence to not observed by July. Frequency of occurrence of each plant species observed in Magda Lake is summarized in Table E-4.

Table E-3: Vegetation sample summary on Pomerleau Lake.

Sample Date	5/24/2017	7/28/2017
Total Observations	37	38
% Littoral Sample Points	62.2	63.2
% of Littoral with Vegetation	95.7	87.5
Lake Taxa	7	4
Lake Taxa Status	Failing	Failing
Lake FQI	19.5	14.7
FQI Status	Meeting	Failing

Table E-4: Frequency of species occurrence during Pomerleau Lake vegetation surveys.

Species		% Occurrence	
Scientific Name	**Common Name**	**5/24/2017**	**7/28/2017**
Ceratophyllum demersum	coontail	78%	88%
Potamogeton crispus	curly-leaf pondweed	43%	0%
Nymphaea odorata	white waterlily (common)	17%	4%
Lemna minor	duckweed (lesser)	9%	0%
Lemna trisulca	duckweed (star)	9%	0%
Nuphar variegata	yellow waterlily (common)	4%	0%
Potamogeton zosteriformis	flat-stemmed pondweed	4%	0%
Najas sp.	naiad (a species)	0%	4%
Stuckenia pectinata	sago pondweed	0%	4%

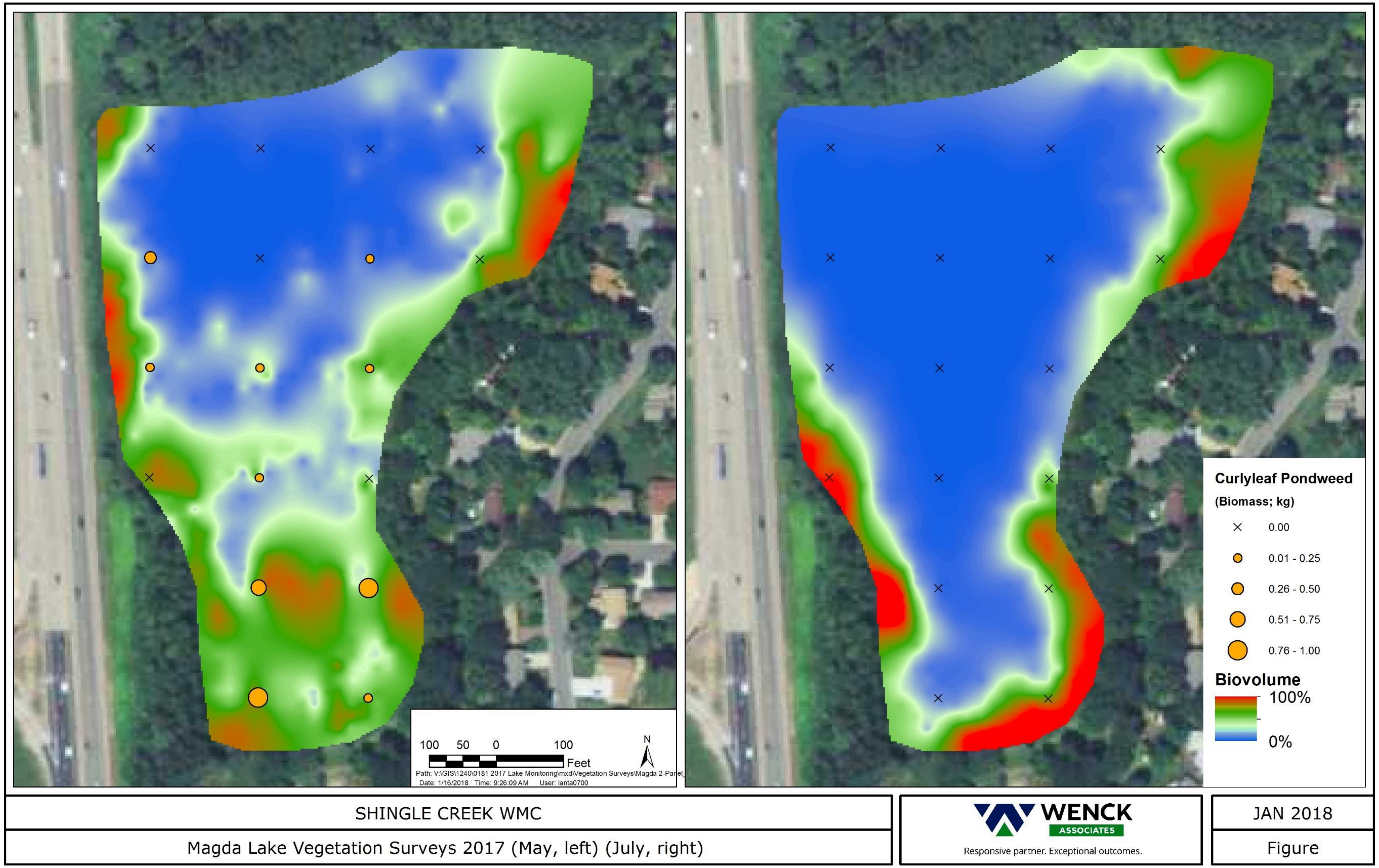
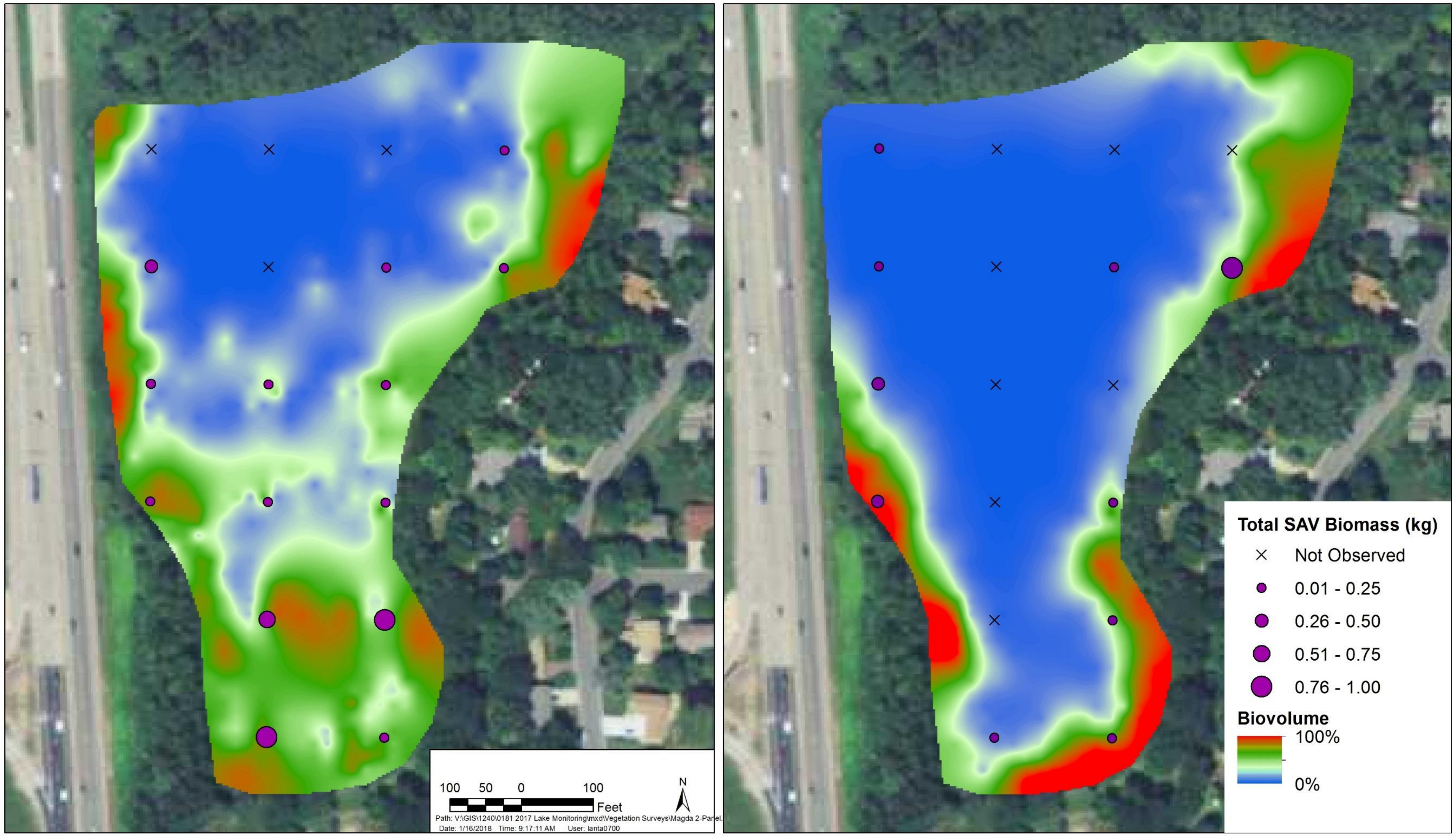


Figure E-1: Lake Magda curly-leaf pondweed observations and biomass and total vegetation biovolume.



SHINGLE CREEK WMC	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	JAN 2018
Magda Lake Vegetation Surveys 2017 (May, left) (July, right)		Figure

Figure E-2: Lake Magda total vegetation biomass and biovolume.

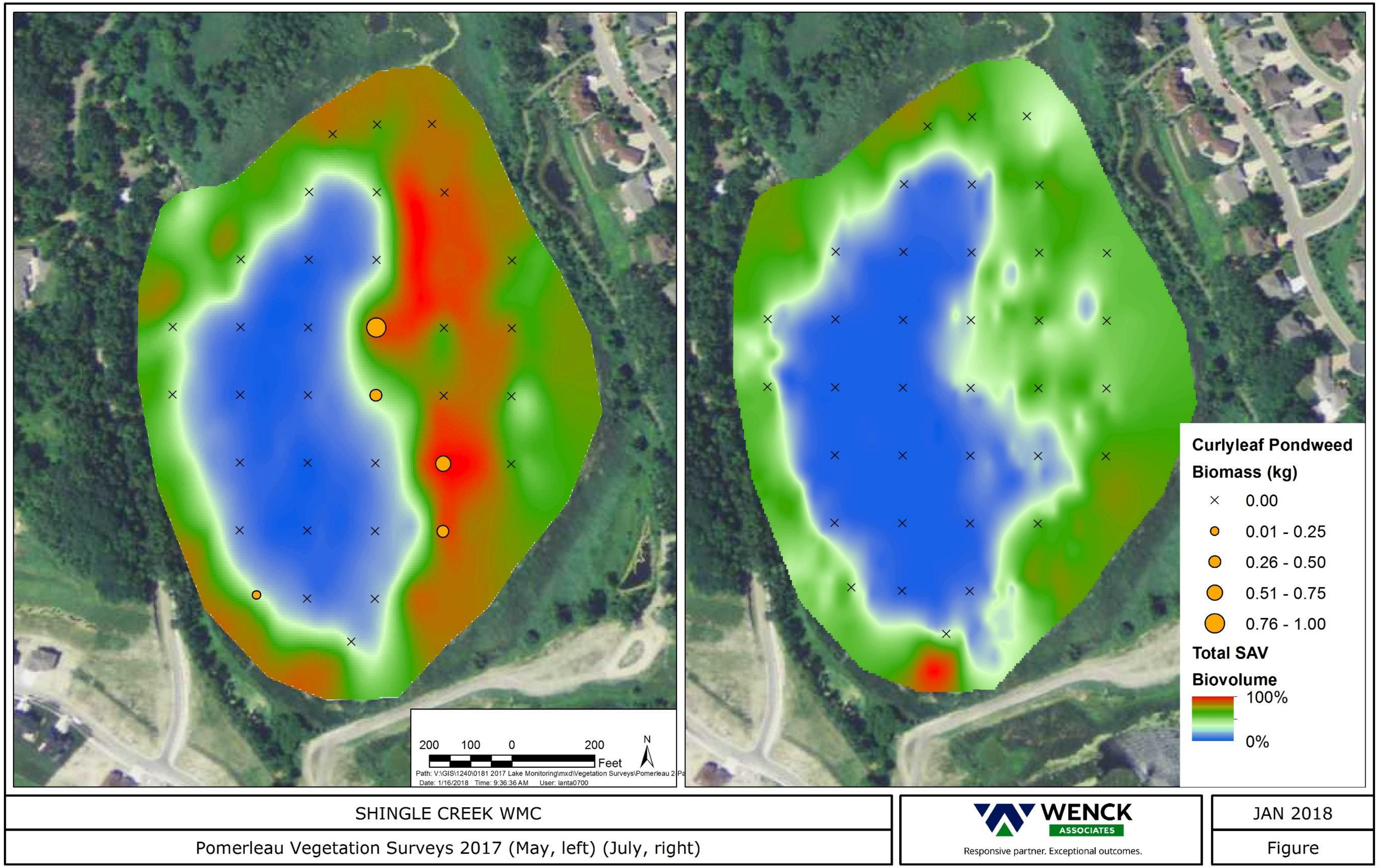
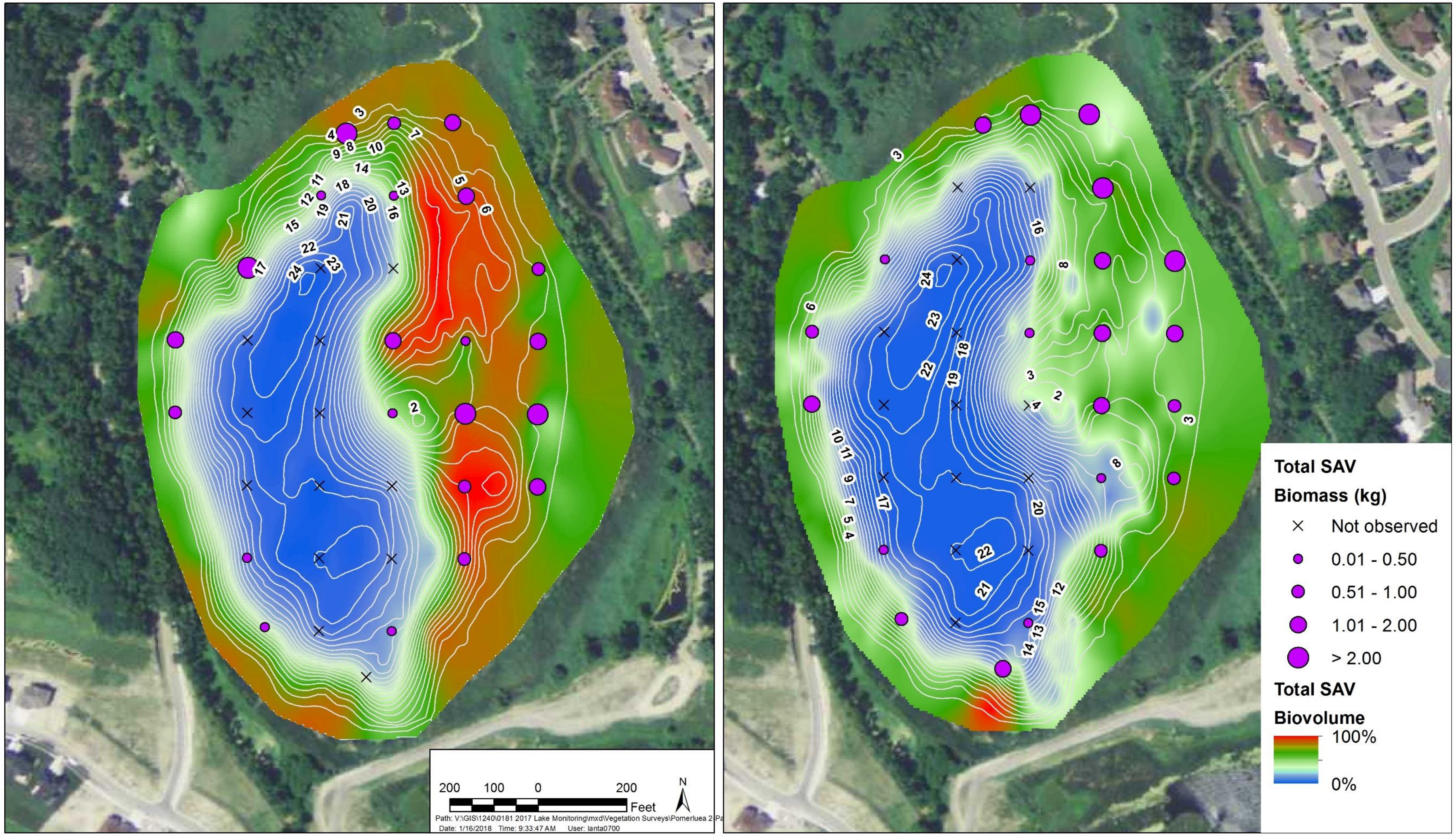


Figure E-3: Pomerleau Lake curly-leaf pondweed observations and biomass and total vegetation biovolume.



SHINGLE CREEK WMC	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	JAN 2018
Pomerleau Vegetation Surveys 2017 (May, left) (July, right)		Figure

Figure E-4: Pomerleau Lake total vegetation biomass and biovolume.

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.

Trap and Gill Net Surveys (Deep Lakes)

MnDNR survey game fish populations using standardized trap and gill net survey methods to assess gamefish populations within lakes. MnDNR 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 12-24 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.

Mini-fyke and Gill Net Surveys (Shallow Lakes)

Mini-fyke net and gill net assessments are implemented on shallow lake ecosystems (max depth < 15 feet) and follows the sampling techniques of shallow lake researchers (Herwig *et al.* 2010). Three mini-fyke nets and one gill net are used to tangle or entrap fish over a 12-24 hour period. Mini-fyke 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 net catches fish via gill entanglement and consist of multi-sized mesh panels. The gill nets are typically set along the deepest contour within the basin. Fish captured are identified, summed and total biomass weighed.

Nearshore Surveys (Any Lake)

The MnDNR 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 (here after: 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.

IBI Assessment (Select Deep Lakes)

Lake classes were developed by the MnDNR 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 MnDNR 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 landuse 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.

Common Carp Population Evaluation (Any Lake)

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). 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) and number and total biomass.

Pomerleau Lake Results

Fisheries assessments were conducted on Pomerleau Lake from 8/23/2017 – 8/24/2017. Trap and gill net sampling methods were used to assess the population and compare to historic surveys.

A total of five species and 53 individuals during the August 2017 trap and gill net surveys (Table E-5 and E-6). Overall the number of fish captured was relatively low compared to historic survey efforts (Table E-7), however, a change in fish community composition is apparent. Many of the trap net locations were within dense lily pad and/or other submerged aquatic vegetation (SAV) stands that fish may have a difficult time swimming in.

Table E-5. 2017 trap net fish summary on Pomerleau Lake.

				Number of fish in slot (inches)								
Species	Count	% of TN catch	Total Weight (lbs)	0-5	6-7	8-9	10-11	12-14	15-19	20-24	25-29	30-34
black crappie	3	8.6	0.82	--	1	2	--	--	--	--	--	--
bluegill	29	82.9	2.31	21	7	--	--	--	--	1	--	--
largemouth bass	1	2.9	0.41	--	--	--	1	--	--	--	--	--
northern pike	2	5.7	6.13	--	--	--	--	--	--	--	2	--

Table E-6. 2017 gill net fish summary on Pomerleau Lake.

				Number of fish in slot (inches)								
Species	Count	% of GN catch	Total Weight (lbs)	0-5	6-7	8-9	10-11	12-14	15-19	20-24	25-29	30-34
black bullhead	3	16.7	0.87	--	--	3	--	--	--	--	--	--
bluegill	3	16.7	0.63	--	3	--	--	--	--	--	--	--
largemouth bass	1	5.6	2.40	--	--	--	--	--	1	--	--	--
northern pike	11	61.1	28.26	--	--	--	--	--	--	8	2	1

The MnDNR had conducted trap net assessments in 1984 and 1994 and gill net assessment in 1984. Blue Water Science conducted a trap net assessment in 2012 (Table 3). The October 2012 fish survey is difficult to compare to other survey years due to the time of year the survey was conducted. MnDNR typically samples fish communities during summer months which coincides with the growing season. Efforts conducted in October are likely past the growing season and the SAV community had likely began to senesce by the time of the survey. Additionally, October sampling would have been during a period in which water temperature and other water characteristics (lake turnover) may be drastically changing from summer conditions. These changes in habitat and water characteristics can significantly change fish behavior and their movement within a lake. We include the 2012 survey results but caution strong conclusions with the results.

Pomerleau lake appears to have shifted from a system with limited or no top carnivore species (i.e. northern pike and largemouth bass) and many green sunfish to one with top carnivore species, no/ limited green sunfish, black bullhead, bluegill and black crappie. The community also has shifted to favor fewer tolerant species (i.e. black bullhead and green sunfish) to species that are associated with improved habitat conditions within the lake.

Table E-7. Historic summary of fish summary on Pomerleau Lake.

Gear	Species	7/11/1984	7/5/1994	10/4/2012	8/23/2017
Trap Net	black bullhead	--	15	185	--
	black crappie	36	26	126	3
	bluegill	1	11	1	29
	brown bullhead	53	--	--	--
	green sunfish	1955	2884	--	--
	hybrid sunfish	36	--	--	--
	largemouth bass	--	119		1
	northern pike	--	--	5	2
Gill Net	black bullhead	10	NA	NA	3
	black crappie	1	NA	NA	--
	bluegill	--	NA	NA	3
	largemouth bass	--	NA	NA	1
	northern pike	--	NA	NA	11

Bass Lake Survey Results

Fisheries assessments were conducted on Bass Lake from 8/28/2017 – 8/30/2017. A trap and gill net survey, a nearshore survey, an IBI assessment and common carp population evaluation were conducted on Bass Lake. These efforts were conducted to evaluate the fish community, compare it to historic information, determine the overall health of the fish community and to determine if common carp population persist at ecologically detrimental densities.

Trap and Gill Net Surveys
Trap net surveying resulted in relatively low numbers of fish collected with bluegill sunfish being the most abundant species captured (Table E-8). Size distribution of capture fish is summarized in Table E-9. Many of the trap net locations were within dense lily pad and/or other submerged aquatic vegetation (SAV) stands that fish may have a difficult time swimming in.

Table E-8. 2017 trap net fish summary on Bass Lake.

Species	Count	% of GN catch	Total Weight (lbs)
black crappie	2	3.4	0.6
bluegill	48	80.0	8.0
northern pike	3	5.0	3.9
pumpkinseed	5	8.3	0.5
yellow perch	2	3.3	0.5

Table E-9. 2017 trap net size distribution summary on Bass Lake.

Species	Number of fish in slot (inches)									
	0-5	6-7	8-9	10-11	12-14	15-19	20-24	25-29	30-34	35-39
black crappie	--	--	2	--	--	--	--	--	--	--
bluegill	19	20	9	--	--	--	--	--	--	--
northern pike	--	--	1	--	--	1	--	1	--	--
pumpkinseed	4	--	1	--	--	--	--	--	--	--
yellow perch	--	1	--	1	--	--	--	--	--	--

The MnDNR conducted trap net assessments in 1981, 1986 and 1991 using the same five trap net locations as this survey. Blue Water Science conducted an assessment in 2012 setting a total of 12 trap nets in various locations with some nets reset for a second day of sampling in the same location. Blue Water Science reported two net sets malfunctioned during the 2012 survey. It is unclear why sampling did not occur in the same locations as the historical MnDNR surveys, however the same number of nets were set. To make results comparable to historic and 2017 sampling efforts we removed the catch totals from the day 2 resample, the locations that sampled on the island and the nets that malfunctioned. This resulted in five trap nets remaining in areas close to that which were historically sampled. We further caution comparison to the 2012 assessment as it was conducted after fall turnover and likely past peak vegetation growth, thus changing the behavior and location of fish within the lake.

The number of fish observed during the trap net assessment has decreased significantly since 1981 (Table E-10). It is difficult to state beyond speculation what (if any) factors resulted in significantly lower catch rates without historic vegetation and water quality information. Changes in the fish community could be associated to improvements in water quality and subsequent changes in the vegetation community. For example, black bullhead are a disturbance and poor water quality tolerant species. The abundance of black bullhead within the lake appears to have significantly declined over the years likely due to water quality improvements or increased predation by other fish. The management activities within Bass Lake ecosystem could have stimulated submerged aquatic vegetation (SAV) growth. This increased SAV growth may have resulted in select species (i.e. Coontail) that can grow very dense and inhibit catchability of fish. Therefore, the decreased numbers of bluegill may not be the result of declining populations but rather a change in capture efficiency within the lake. The timing of more recent survey efforts may also influence catch rates, the 2017 sampling efforts likely occurred shortly after peak vegetation growth, while MnDNR efforts that occurred in July may have occurred pre-peak growth limiting interference of SAV on net catch. Future trap net assessments should focus on early to mid-July sampling time frames in the event that season changes in vegetation growth have impeded catch rates.

Table E-10. Historic trap net fish summary on Bass Lake.

Species	MnDNR			McComas**	Wenck
	7/16/1981	7/14/1986	7/8/1991	10/9/2012	8/29/2017
black bullhead	39	729	241	--	--
black crappie	51	20	89	11	2
bluegill	129	739	719	178	48
brown bullhead	1	6	11	--	--
common carp	5	--	5	--	--
golden shiner	3	--	2	--	--
green sunfish	--	13	--	1	--
hybrid sunfish	36	91	2	--	--
largemouth bass	1	3	4	4	--
northern pike	--	--	2	1	3
pumpkinseed	20	--	17	22	5
yellow perch	--	--	--	2	2
white crappie	--	--	1	--	--
white sucker	--	--	1	--	--

**Adjusted results

Gill net surveying resulted in eight species being observed (Table E-11) across various sizes (Table E-12). Black crappie and sunfish species comprised the majority of the total gill net catch. Golden shiner and black bullhead were two species observed only in our gill net catch. Most fish captured were less than nine inches in length, however, numerous large northern pike were observed in the nets and ranged from 25 to 36 inches.

The MnDNR had conducted gill net assessments in 1981, 1986 and 1991 using the same two gill net locations (and those used during 2017). Blue Water Science did not conduct a gill net assessment in 2012 (Table E-13). The historic gill net survey results indicate black bullhead have steadily and significantly declined while northern pike and bluegill have increased since the 1981 survey. The community shifts appear to have shifted to favor less tolerant species and species that are associated with improved water quality and habitat conditions.

Table E-11. 2017 gill net fish summary on Bass Lake.

Species	Count	% of GN catch	Total Weight (lbs)
black bullhead	4	2.6	3.6
black crappie	57	37.7	10.6
bluegill	47	31.1	11.3
golden shiner	3	2.0	0.3
green sunfish	1	0.7	0.2
northern pike	20	13.2	97.1
pumpkinseed	8	5.3	0.9
yellow perch	11	7.3	1.2

Table E-12. 2017 gill net size distribution summary on Bass Lake.

Species	Number of fish in slot (inches)									
	0-5	6-7	8-9	10-11	12-14	15-19	20-24	25-29	30-34	35-39
black bullhead	--	--	1	2	1	--	--	--	--	--
black crappie	8	26	23	--	--	--	--	--	--	--
bluegill	7	15	25	--	--	--	--	--	--	--
golden shiner	--	3	--	--	--	--	--	--	--	--
green sunfish	--	1	--	--	--	--	--	--	--	--
northern pike	--	--	--	--	--	--	4	6	9	1
pumpkinseed	4	4	--	--	--	--	--	--	--	--
yellow perch	--	10	1	--	--	--	--	--	--	--

Table E-13. Historic gill net fish summary on Bass Lake.

Species	MnDNR			McComas**	Wenck
	7/16/1981	7/14/1986	7/8/1991	10/9/2012	8/29/2017
black bullhead	287	140	65	NA	4
black crappie	3	16	77	NA	57
bluegill	--	13	18	NA	47
brown bullhead	--	9	7	NA	--
golden shiner	--	2	55	NA	3
green sunfish	--	--	--	NA	1
largemouth bass	1	--	1	NA	--
northern pike	2	6	12	NA	20
pumpkinseed	--	--	7	NA	8
walleye	--	--	1	NA	--
Yellow perch	--	--	--	NA	11

Nearshore Survey

Select sampling locations were difficult due to dense vegetation growth (lily pads, coontail) or sudden deep water conditions (cattail fringe to unwadable waters). Efforts to sample these locations were still made with only one location being skipped with the seine sampling. IBI protocol allows for occasional missed sampling locations due to natural conditions, therefore, sampling requirements were still met and accurate metrics scoring produced. Nearshore surveying resulted in nine species being observed with bluegill dominating the catch total (Table E-14). Many of the bluegill captured were young of year individuals that were between 2.5 and 3.5 cm in length. Largemouth bass and central mudminnow were species observed only during the nearshore survey efforts. Length and weight measurements were not taken on nearshore surveyed fish.

Table E-14. 2017 nearshore survey counts by species.

Species	EFB	Seine	Total
black crappie	--	14	14
bluegill	210	4268	4478
central mudminnow	11	4	15
green sunfish	22	7	29
hybrid sunfish	2	9	11
largemouth bass	9	43	52
northern pike	1	10	11
pumpkinseed	7	47	54
yellow perch	--	5	5

IBI Assessment

Bass Lake is a small, alkaline and productive system with a relatively large littoral area (<15 depth) compared to other Minnesota lakes. Based on these characteristics the MnDNR has classified Bass Lake as a lake class 38 lake. Lake class 38 is assessed with IBI tool #7.

IBI tool #7 lakes tend to exist in southern and western Minnesota (lake classes 38, 41-43) and are generally comprised of relatively simple fish communities that may have a history of periodic winterkills, are naturally mesotrophic to eutrophic systems (moderate to high productivity), exist in relatively disturbed watersheds, and the basins are comprised of greater than 80% littoral habitat (<15 feet water depth). The three other IBI tools score lakes that have greater lake complexity, they tend to be deeper and less productive, they are often comprised of less disturbed watersheds and various levels of shoreline degradation.

IBI tool #7 is comprised of species richness, community assemblage and trophic composition (Table E-15). Metrics 1-4 are scored based on the number of species observed within each category. Metrics 2-4 are adjusted based on lake size as larger lakes are expected to contain more fish species. In general, a lake scores higher with no or few tolerant species and many insectivore, small benthic dwelling and vegetation dwelling species. Metrics 5-8 are scored based on the composition of the community. These metrics are also gear specific to account for where these species are typically observed within the lake and to make variables independent of each other. In general, a lake scores higher with higher proportions of insectivore, vegetation dwelling and top carnivore species and lower proportions of tolerant species.

Table E-15. IBI Tool #7 metrics.

Metric #	Metric
1	# of tolerant species
2	# of insectivore species *
3	# of small benthic dwelling species *
4	# of vegetation-dwelling species *
5	Pptn. of vegetation-dwelling individuals in the NS
6	Pptn. biomass of insectivores in TN
7	Pptn. biomass of tolerant species in TN
8	Pptn. biomass of habitat dependent top carnivores sampled in GN

*lake size adjusted

The IBI score can be compared to state defined impairment thresholds and to similar lakes that are scored using the same IBI tool. Viewing individual metric scores, course community differences and comparing to future datasets provides context to the Bass Lake fish community health. The IBI is intended to represent the amount of human disturbances on a lake and often correlate to water quality conditions. They do not assume a cause/effect relationship between fish and water quality, but, efforts made to improve and restore water quality and a diverse healthy vegetation community can lead to enhancements in the fish community.

The IBI assessment resulted in an overall IBI score of 56.8 which is well above the MnDNR biological impairment threshold (score = 36). The IBI scored well on metrics 6-8 due to the presence of bluegill and no observed tolerant species in the trap nets and the high biomass of northern pike and black crappie in the gill nets (Table E-16). The IBI scored less well on metrics 1-5 due to limited diversity within insectivore, small benthic dwelling and vegetation dwelling species (Table 9). The limited diversity of these species could be the result of limited habitat within the lake. The lake appears to have a high diversity of submerged aquatic vegetation, however, is also dominated by dense growth of select species (i.e. Coontail) which may be providing limited habitat for vegetation dwelling species and/or the substrate needed to support various benthic dwellers. Overall the numbers of certain species/ category (i.e. small benthic dwelling species, vegetation dwelling species) is limiting within Bass Lake, however, the proportion and abundance of the species that do occur is in good condition. Bass Lake is represented by a simple yet healthy fish community.

Table E-16. Metric, metric scores and community composition for Bass Lake IBI scoring.

Metric #	Metric	Metric Value	Metric Score
1	# of tolerant species	2	0.94
2	# of insectivore species *	6	-0.04
3	# of small benthic dwelling species *	0	-0.96
4	# of vegetation-dwelling species *	2	0.04
5	Pptn. of vegetation-dwelling individuals in the NS	0.6%	-0.38
6	Pptn. biomass of insectivores in TN	66.7%	3.48
7	Pptn. biomass of tolerant species in TN	0%	3.08
8	Pptn. biomass of habitat dependent top carnivores sampled in GN	86.0%	2.58

* Lake size adjusted

Common Carp Population Assessment

We captured one common carp during the boat electrofishing surveying. The individual weighed 0.2 pounds and measured 6.5 inches in length. Modeling suggests that approximately 647 carp exist within Bass Lake at an estimated density of 0.8 kg of carp biomass per hectare which is well below the 100 kg/ha impairment threshold. These results suggest that the presence of common carp within Bass Lake is limited and likely not a primary driver of poor water quality conditions at this time.

Meadow Lake Results

Fisheries assessments were conducted on Meadow Lake from 8/2/2017 – 8/3/2017. A mini-fyke and gill net survey was conducted on Meadow Lake. This effort was conducted to evaluate the fish community in a shallow lake community.

Two species of fish were observed during the 2017 fisheries surveys and was dominated by fathead minnow (Table E-17). Fathead minnow are a species that is very tolerant of harsh environments and can have significant water quality impacts at high densities. The abundance of fathead minnows in Meadow Lake in 2017 are likely a strong contributor to the lakes poor water quality.

Fathead minnow are very tolerant of winter kill conditions, however, the depth of Meadow Lake is likely not deep enough to support the species year-round. It is most likely that fish over winter in adjacent golf course ponds and/or recolonize the lake from Bass Creek during high water level conditions. Effort to eradicate the fish from the lake would likely have significant impacts on water quality and the vegetation community within Meadow Lake.

Table E-17. 2017 mini-fyke and gill net fish summary on Meadow Lake.

Sample Year	Fathead Minnow		Creek Chub	
	Count	Mass (g)	Count	Mass (g)
2017	4099	8782	1	10

Magda Lake Results

Fisheries assessments were conducted on Magda Lake from 8/2/2017 – 8/3/2017. A mini-fyke and gill net survey was conducted on Magda Lake. This effort was conducted to evaluate the fish community in a shallow lake community.

Three species of fish were observed during the 2017 fisheries surveys (Table E-18). The dominance of black bullhead and black crappie and not observing an abundance of other species is suggestive of a poor and imbalanced fish community. In relatively productive systems, an imbalanced fishery has the potential to reduce phytoplankton grazer (i.e. Daphnia) to the point where no significant control of the algae occurs and water quality decreases. The current state of the fishery is a likely strong contributor to the poor water quality conditions with Magda Lake.

These species likely colonized Magda Lake during ditch flooding and a period of surface connection to Eagle Lake/Creek and/or were stocked into the lake for recreational intentions by residents. Magda Lake has an area deep enough to support the fishery from winter kill which may allow the fishery to remain in an imbalanced state until management actions are taken to correct the fishery.

Table E-18. 2017 mini-fyke and gill net fish summary on Magda Lake.

Sample Year	Black Bullhead		Black Crappie		Smallmouth Buffalo	
	Count	Mass (g)	Count	Mass (g)	Count	Mass (g)
2017	64	5879	514	13158	3	516

Appendix F: Macroinvertebrate Monitoring

OVERVIEW

The Commission does not routinely undertake biological monitoring, but does obtain biological data by sponsoring volunteer monitoring through Hennepin County Department of Environment and Energy. High school students and their teachers monitor macroinvertebrates in streams through the River Watch program, and adult volunteers led by trained leaders monitor macroinvertebrates and vegetation in wetlands through the Wetland Health Evaluation Program (WHEP)

STREAM MACROINVERTEBRATE MONITORING

Routine stream macroinvertebrate monitoring in both watersheds is conducted by volunteers through Hennepin County's River Watch program. This program was initiated in 1995 to provide hands-on environmental education for high school and college students, promote river stewardship, and obtain water quality information on the streams in Hennepin County. It is a program of the River Network, a national non-profit organization that promotes community-based programs to restore and protect rivers and watersheds. Through the River Watch program, over 550,000 volunteers nationwide assist in watershed monitoring and assessment. Hennepin County coordinates student and adult volunteers who use the River Watch protocols to collect physical, chemical, and biological data to help determine the health of streams in the watershed.

One of the Commissions' goals is to track changes in streams. Examining the macroinvertebrate community provides a picture of the health of the stream. The results are qualitative and should be interpreted as one indicator of the rivers' health, not scientifically precise data. Another goal is to promote an understanding of the watershed and how water quality is related to land use. The water quality found in one short stretch of stream does not just reflect what is happening in one area. It reflects the water quality of all upstream areas draining into it.

The program began on Shingle Creek in spring 1996 and on Mattson Brook in West Mississippi in spring 1998. 2017 was the 22nd year the site at Park Center High School was monitored. Mattson Brook was in the past regularly monitored, but has been irregularly monitored since 2013. Some other sites on Shingle Creek have been monitored for a few years and then for one reason or another dropped from the program.

Retention of volunteer groups is an ongoing issue for this program. Changes in the high school graduation standards, key teaching staff retirements, and school budget reductions all make it difficult to attract and retain school groups.

2017 Monitoring

In 2017, across the county 19 stream stretches were monitored in the spring and/or fall. Overall, two sites were rated Very Good; seven sites were rated Good; four sites Fair; two sites Fairly Poor; and three sites Poor. The Commissions sponsored monitoring at two sites on Shingle Creek in 2017; no volunteer group was found for Mattson Brook in West Mississippi. The grading below shows annual variability that is likely related to precipitation and wet/dry periods. The site adjacent to Park Center High School has one of the longest data records of any of the Riverwatch sites in Hennepin County. In 2017, which is just following reconstruction of the stream as part of the Connections at Shingle Creek project, this site was rated Good. The other site, on Shingle Creek in Lions Park in Brooklyn Center just upstream of the USGS monitoring station, was rated Fair.

Riverwatch site Park Center High School, Brooklyn Park.
Monitored by Park Center High School.

Year	Grade	Year	Grade
2017	B	2006	C
2016	D	2005	C
2015	D+	2004	D
2014	D+	2003	D+
2013	D+	2002	C
2012	C-	2001	D
2011	C-	2000	D+
2010	C	1999	D+
2009	C-	1998	D+
2008	C-	1997	C+
2007	C+	1996	B-

Riverwatch site Lions Park, Brooklyn Center.
Monitored by Calvin Christian High School.

Year	Grade	Year	Grade
2017	C	2012	B-
2016	D	2011	None
2015	C-	2010	None
2014	C	2009	C+
2013	C		

Sites monitored in previous years but not in 2015:

Riverwatch site Mattson Brook, Brooklyn Park.
Monitored by Minneapolis South High School.

Year	Grade	Year	Grade
2014	C	2004	C
2013	None*	2003	C
2012	C-	2001	C
2010	C	2000	C
2009	C	1999	B
2008	C-	1998	B
2007	C-		

*Water levels too low

Riverwatch site Webber Park, Minneapolis.
Monitored by Patrick Henry High School.

Year	Grade	Year	Grade
2012	D+	2004	C
2011	D+	2003	C-
2010	C	2002	C+
2009	C+	2001	C
2008	C		

Riverwatch site North Hennepin Community College, Brooklyn Park.
Monitored by Metro Tech Academy.

Year	Grade	Year	Grade
2013	D+	2011	D+
2012	C		

Riverwatch site Boone Avenue, Brooklyn Park.

Year	Grade	Year	Grade
2010	C	2007	C-
2009	Not monitored	2002	D+
2008	C-	2001	D

Riverwatch site Brookdale Library, Brooklyn Center.

Year	Grade	Year	Grade
2009	C+		

Discussion

Based on the limited River Watch sampling, organisms found indicate average to impaired conditions for impacted urban streams. Variability is likely due to the amount of sustained flow in the streams.

Appendix G: 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 2017 volunteers assessed 33 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 27 (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 9 (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 2017 Monitoring

Four sites were monitored in 2017: two in West Mississippi (one in Brooklyn Park, one in Champlin) and two in Shingle Creek (Plymouth and Brooklyn Park).

West Mississippi

Bartusch Park in Champlin (Figure G-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 7.10).

Table G-1. WHEP site CH-3, Bartusch Park, Champlin.

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

Figure G-1. Bartusch Park wetland in Champlin.

The Oxbow Ponds site is in a series of ponds and remnant wetlands north of “Oxbow Lake” near Regent and 101st Avenues North (Figure G-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 was rated Poor (Table G-2).

Table G-2. WHEP site BP-4, Oxbow Ponds, Brooklyn Park.

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

Figure G-2. Oxbow Ponds wetland 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 G-3 and Figure G-3). This wetland has some of the better scores of the WHEP wetlands in the watersheds.

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

Year	2014	2015
Invertebrate	24 (excellent)	16 (moderate)
Vegetation	15 (moderate)	25 (moderate)

Site PL-7 is in Three Ponds Park in Plymouth (Figure G-4), south of Bass Lake Road and east of Zachary Lane. 2017 is the first year it was monitored. This wetland scored very low for both macroinvertebrates and vegetation.

Table G-4. WHEP site PL-7, Three Ponds Park, Plymouth.

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

Figure G-3. Wetlands in Brookdale Park, Brooklyn Park.

Figure G-4. Wetlands in Three Ponds Park, Plymouth.

Wetlands previously monitored by not in 2017 include:

West Mississippi

In 2008 and 2009 a wetland in Brooklyn Park's Jewel Park was monitored (Table G-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 G-5 WHEP site BP-3, Jewel Park, Brooklyn Park.

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

A mitigation wetland in Champlin was monitored for four years as site CH-1. It is a large pond/wetland east of TH 169 between 109th and 114th Avenues North. It scored poorly on vegetation (Table G-6), which is a reflection of the stormwater discharged into it.

Table G-6. 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)

A wetland in Brooklyn Park's Environmental Preserve 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 a number of 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 and should be further explored.

Table G-7. WHEP site BP-1, Environmental Preserve, Brooklyn Park.

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

Zane Sports Park, riparian to Century Channel in Brooklyn Park. It scores poorly for macroinvertebrates (Table G-8), 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 low.

Table G-8. WHEP site BP-7, Zane Sports Park, Brooklyn Park.

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

Shingle Creek

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

Table G-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 G-10). Biotic quality varied, likely due to variations in precipitation.

Table G-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 G-11.)

Table G-11. WHEP site BC-2, West Palmer Lake, Brooklyn Park.

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 G-12).

Table G-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 G-13).

Table G-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 G-14.).

Table G-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)