
**ANNUAL MONITORING REPORT
FOR LAKE-WIDE MANAGEMENT OF INVASIVE AQUATIC PLANTS**

Submitted to:

*Invasive Species Program
Division of Ecological and Water Resources
Minnesota Department of Natural Resources*

Lake: Lake Sarah

County: Hennepin

DOW Number: 27019100

Lake Acres: 561

Littoral Acres: 373

Date(s) of Most Recent Point-Intercept Survey(s): 08/20/2018

Other Optional Survey(s) or Monitoring Efforts (e.g. Post-Treatment Survey, Delineations, Biomass, etc.):

CLP pre and post inspection, EWM pre and post inspections, CLP Turion Surveys

Surveyors: Three Rivers Park District, AIS Consulting Services LLC

Date: December 29, 2018

Author(s) of Report: Eric Fieldseth, AIS Consulting Services LLC

Lake Representative or Permittee: Lake Sarah Improvement Association

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Summary of Results

In this report we summarize aquatic submersed plant data collected during years 2011-2018 from Lake Sarah. This report fulfills the monitoring requirements outlined in the Lake Vegetation Management Plan.

Summary Tables. Summary of aquatic submersed plants in Lake Sarah, Hennepin County, Minnesota (DOW# 27019100) as indicated by results of point-Intercept surveys. Values were calculated from littoral depth range (0-15 feet).

Lake Sarah East Basin

YEAR	Treatment Date	CLP* Acres Treated	PI Survey Date	Max Depth of Growth in feet [95%] [†]	% Points w/ Native Submersed Taxa	Mean Native Submersed Taxa/ Point	# Submersed Native Taxa	AVG Secchi Depth [m]
2011	-	-	6/9/2011	12	54	0.7	6	
2012	4/29/2012	23	6/7/2012	10	64	0.9	5	
2013	5/15/2013	95.5	6/6/2013	8	58	0.7	4	
2014	5/17/2014	95.5	6/20/2017	9	58	0.7	6	
2015	5/2/2015	95.5	6/10/2015	9	63	0.8	6	
2016	5/6/2016	95.5	6/7/2016	8	64	0.7	6	
2017	5/5/2017	95.5	6/1/2017	10	78	1	8	
2018	5/21/2018	31.3	6/13/2018	9	65	0.65	4	

Lake Sarah West Basin

YEAR	Treatment Date	CLP* Acres Treated	PI Survey Date	Max Depth of Growth in feet [95%] [†]	% Points w/ Native Submersed Taxa	Mean Native Submersed Taxa/ Point	# Submersed Native Taxa	AVG Secchi Depth [m]
2011		-	6/9/2011	13	20	0.2	4	1.5
2012	4/29/2012	26	6/7/2012	13	44	0.5	7	1.5
2013	5/15/2013	164.5	6/6/2013	9	34	0.4	5	1.6
2014	5/17/2014	164.5	6/20/2017	14	48	0.6	5	1.5
2015	5/2/2015	164.5	6/10/2015	10	37	0.5	5	1.9
2016	5/6/2016	164.5	6/7/2016	12	56	1	6	1.9
2017	5/5/2017	164.5	6/1/2017	14	66	0.83	7	1.4
2018	5/21/2018	83.2	6/13/2018	14	53	0.5	8	2.04

*CLP is short for Curly-leaf pondweed

[†]95th percentile calculated based on all vegetated sampling points

Taxa refers to groups of submersed aquatic plant species or genera

AVG- average secchi depth (water clarity measurement) from May-September

Table 1-Invasive Plant Management Summary. Characteristics and history of herbicide treatment for Lake Sarah (DOW# 27019100, Total acres: 561, Littoral acres: 373, 15% Littoral acres: 56).

Treatment Date	Target Species	Total Acres Treated	% Littoral Treated	Herbicide	Target Concentration	Average Depth Treated [feet]	Amount Applied [gallons]	Estimated Whole Lake Concentration	Licensed Commercial Applicator
4/29/2012	CLP	49	13.4	Endothall (Aquathol K)	1 ppm	5.67	180.64	.075 ppm	Aquatic Solutions of MN
5/20/2012	EWM	16	4.3	2,4-D (DMA-4)	2 ppm	3	70	-	Aquatic Solutions of MN
6/6/2012	EWM	10	2.7	2,4-D (DMA-4)	2 ppm	3.92	65	-	Aquatic Solutions of MN
5/15/2013	CLP	260	69.7	Endothall (Aquathol K)	0.75 ppm	5	624	0.13 ppm	Lake Sarah Improvement Association (LSIA)
5/17/2014	CLP	260	69.7	Endothall (Aquathol K)	0.75 ppm	5	624	0.13 ppm	LSIA
8/12/2014	EWM	12.9	3.5	2,4-D (DMA-4)	4 ppm	3	110	-	LSIA
5/2/2015	CLP	260	69.7	Endothall (Aquathol K)	0.75 ppm (East) & 0.57 ppm (West)	4 (East) & 4.8 (West)	471	0.1 ppm	LSIA
6/25/2015	EWM	47.54	12.7	2,4-D (DMA-4)	4 ppm	2 to 5	417.08	-	Lake Restoration
5/6/2016	CLP	260	69.7	Endothall (Aquathol K)	0.75 ppm (East) & 0.57 ppm (West)	4.4 (East) & 5.4 (West)	492.89	0.1 ppm	Lake Restoration
6/29/2016	EWM	31	8.3	2,4-D	4 ppm	1.6 to 5.6	251.29	-	Lake Restoration
5/5/2017	CLP	260	69.7	Endothall (Aquathol K)	0.75 ppm (East) & 0.57 ppm (West)	4.8 (East) & 4.8 (West)	495	0.1 ppm	Aquatic Solutions of MN
7/12/2017	EWM	20.5	3.6	Diquat	0.5 gal/acre/ft	2.75 - 5	38	-	Aquatic Solutions of MN
5/21/2018	CLP	114.5	30.7	Endothall (Aquathol K)	0.75 ppm (West) & 1 ppm (East)	6 (west) & (5) East	342	.08 ppm (west) & .05 (east)	Aquatic Solutions of MN

CLP is an abbreviation for curly-leaf pondweed. EWM is an abbreviation for Eurasian watermilfoil

Table 2- Early Summer Point Intercept Metrics (East Basin). Summary of early summer point intercept metrics for Lake Sarah (East Basin), Hennepin County (DOW # 27019100). Shaded values were calculated from littoral depth range. (0 to 15 ft.)

	June 2011	June 2012	June 2013	June 2014	June 2015	June 2016	June 2017	June 2018
Surveyor	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District
Total # Points Sampled	76	76	76	76	76	76	76	76
Max Depth of Growth (95%)†	12 ft	10 ft	8 ft	9 ft	9 ft	8 ft	10 ft	9 ft.
# Point in Max Depth Range	68	63	60	52	63	59	65	64
# Points in Littoral (0-15 feet)	70	73	74	71	73	70	74	74
% Points w/ Submersed Native Taxa	54%	64%	58%	58%	63%	64%	78%	65%
Mean Submersed Native Taxa/ Point	0.7	0.9	0.7	0.7	0.8	0.7	1	0.65
# Submersed Native Taxa	6	5	4	6	6	6	8	4
# Submersed Non-Native Taxa	2	2	1	2	1	2	2	2

†95th percentile calculated based on all vegetated sampling points

Taxa refers to groups of submersed aquatic plant species or genera

Table 3- Early Summer Point Intercept Metrics (West Basin). Summary of early summer point intercept metrics for Lake Sarah (West Basin), Hennepin County (DOW # 27019100). Shaded values were calculated from littoral depth range (0 to 15 ft.).

	June 2011	June 2012	June 2013	June 2014	June 2015	June 2016	June 2017	June 2018
Surveyor	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District
Total # Points Sampled	121	121	121	121	121	121	121	121
Max Depth of Growth (95%)†	13 ft	13 ft	9 ft	14	10 ft	12 ft	14 ft.	14 ft.
# Point in Max Depth Range	98	97	88	97	93	95	104	113
# Points in Littoral (0-15 feet)	104	107	111	106	111	107	109	116
% Points w/ Submersed Native Taxa	20%	44%	34%	48%	37%	56%	66%	53%
Mean Submersed Native Taxa/ Point	0.2	0.5	0.4	0.6	0.5	1	0.83	0.53
# Submersed Native Taxa	4	7	5	5	5	6	7	8
# Submersed Non-Native Taxa	2	2	2	2	2	2	2	2

†95th percentile calculated based on all vegetated sampling points
 Taxa refers to groups of submersed aquatic plant species or genera

Table 4- Late Summer Point Intercept Metrics (East Basin). Summary of late summer point intercept metrics for Lake Sarah (East Basin), Hennepin County (DOW # 27019100). Shaded values were calculated from littoral depth range (0 to 15 ft.).

	Aug 2011	Aug 2012	Aug 2013	Aug 2014	Aug 2015	Sept 2016	Aug 2017	August 2018
Surveyor	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District
Total # Points Sampled	76	76	76	76	76	76	76	76
Max Depth of Growth (95%) [†]	8 ft	7 ft	8 ft	7 ft	7 ft	7 ft	8.5 ft	8.2 ft.
# Point in Max Depth Range	52	52	61	53	55	55	63	60
# Points in Littoral (0-15 feet)	69	73	74	73	72	74	75	74
% Points w/ Submersed Native Taxa	56%	55%	69%	51%	53%	61%	72%	73%
Mean Submersed Native Taxa/ Point	0.6	0.8	0.7	0.7	0.6	0.7	1.1	0.73
# Submersed Native Taxa	5	4	2	7	5	7	6	6
# Submersed Non-Native Taxa	2	2	2	2	2	1	1	1

[†]95th percentile calculated based on all vegetated sampling points

Taxa refers to groups of submersed aquatic plant species or genera

Table 5- Late Summer Point Intercept Metrics (West Basin). Summary of late summer point intercepts metrics for Lake Sarah (West Basin), Hennepin County (DOW # 27019100). Shaded values were calculated from littoral depth range (0 to 15 ft.).

	Aug 2011	Aug 2012	Aug 2013	Aug 2014	Aug 2015	Sept 2016	August 2017	August 2018
Surveyor	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District	Three Rivers Park District
Total # Points Sampled	121	121	121	121	121	121	121	121
Max Depth of Growth (95%) [†]	7 ft	8 ft	8 ft	6 ft	5 ft	8 ft	9 ft	12 ft.
# Point in Max Depth Range	72	78	79	67	70	82	87	100
# Points in Littoral (0-15 feet)	102	109	109	110	111	114	111	114
% Points w/ Submersed Native Taxa	46%	44%	41%	44%	41%	54%	60%	62%
Mean Submersed Native Taxa/ Point	0.5	0.6	0.5	0.6	0.6	0.8	0.96	0.62
# Submersed Native Taxa	4	5	5	5	5	8	10	10
# Submersed Non-Native Taxa	2	2	1	2	2	1	1	1

[†]95th percentile calculated based on all vegetated sampling points

Taxa refers to groups of submersed aquatic plant species or genera

Tables 6 & 7 - Early Summer Plant Frequency Occurrence. Historic early summer percent frequency of occurrence for submersed vegetation within the littoral zone (0-15 feet) in Lake Sarah (East and West Basin), Hennepin County (DOW # 27019100).

Table 6. Lake Sarah East Basin

Taxonomic Name	Common Name	June 2011	June 2012	June 2013	June 2014	June 2015	June 2016	June 2017	June 2018
SUBMERSED PLANTS									
<i>Myriophyllum spicatum</i> *	Eurasian watermilfoil*	43	21		3	44	34	15	23
<i>Potamogeton crispus</i> *	Curlyleaf Pondweed*	73	48	32	3		4	14	7**
<i>Chara sp.</i>	Muskgrass	< 1	< 1			< 1	4	8	
<i>Ceratophyllum demersum</i>	Coontail	46	58	57	58	53	56	57	59
<i>Elodea canadensis</i>	Canadian waterweed	7	5	4		4	11	18	11
<i>Myriophyllum sibiricum</i>	Northern watermilfoil		12		4	19			
<i>Potamogeton foliosus</i>	Leafy pondweed	9		4	1			3	4
<i>Tolypella intricata</i>	Bird's Nest Stonewort							7	
<i>Potamogeton pusillus</i>	Small pondweed		8		3	1	1	4	
<i>Stuckenia pectinata</i>	Sago pondweed	1		3	7		3		
Floating, Free-floating & Emergent plants observed: <i>Lemna minor</i> (Common duckweed), <i>Lemna trisulca</i> (Star duckweed), <i>Nuphar variegata</i> (Bullhead pond lily), <i>Nymphaea odorata</i> (White water lily), <i>Spirodela polyrhiza</i> (Greater duckweed), and <i>Wolffia</i> spp. (Watermeal)									
Less common (< 5% frequency) submersed vegetation observed: <i>Najas flexilis</i> (Slender maid) in 2015, <i>Potamogeton zosteriformis</i> (Flat stem pondweed) in 2011, <i>Vallisneria americana</i> (Water celery) in 2014, 2016 and 2017, <i>Zannichellia palustris</i> (Horned Pondweed) in 2017, <i>Heteranthera dubia</i> (Water Stargrass) in 2018									
* denotes invasive aquatic plant									
** observed as dead CLP									

Table 7. Lake Sarah West Basin

Taxonomic Name	Common Name	June 2011	June 2012	June 2013	June 2014	June 2015	June 2016	June 2017	June 2018
SUBMERSED PLANTS									
<i>Myriophyllum spicatum</i> *	Eurasian watermilfoil*	19	28	6	17	17	20	15	18
<i>Potamogeton crispus</i> *	Curlyleaf pondweed*	74	37	24		1	1	16	3**
<i>Ceratophyllum demersum</i>	Coontail	18	37	32	44	28	36	39	38
<i>Macroalgae</i>	Muskgrass and Stonewort			1		2	12	4	7
<i>Elodea canadensis</i>	Canadian waterweed	2	5	1	4	11	14	30	14
<i>Potamogeton foliosus</i>	Leafy pondweed	2			1	7		2	10
<i>Tolypella intricata</i>	Bird's Nest Stonewort							6	3
<i>Potamogeton pusillus</i>	Small pondweed		6			3		2	
<i>Stuckenia pectinata</i>	Sago pondweed	2		5	8		4	1	1
Floating, Free-floating & Emergent plants observed: <i>Lemna minor</i> (Common duckweed), <i>Lemna trisulca</i> (Star duckweed), <i>Nuphar variegata</i> (Bullhead pond lily), <i>Nymphaea odorata</i> (White water lily), <i>Spirodela polyrhiza</i> (Greater duckweed), <i>Wolffia columbiana</i> (Watermeal)									
Less common (< 5% frequency) submersed vegetation observed: <i>Heteranthera dubia</i> (Water stargrass) in 2012, <i>Myriophyllum sibiricum</i> (Northern watermilfoil) in 2012-13, 2016, <i>Najas flexilis</i> (Slender naiad) in 2012 and 2018, <i>Vallisneria americana</i> (Water celery) in 2014, 2016, 2018									
* denotes invasive aquatic plant									
** observed as dead CLP									

Tables 8 & 9- Late Summer Plant Frequency Occurrence. Historic late summer percent frequency of occurrence for submersed vegetation within the littoral zone (0-15 feet) in Lake Sarah (East and West Basin), Hennepin County (DOW # 27019100).

Table 8. Lake Sarah East Basin

Taxonomic Name	Common Name	Aug 2011	Aug 2012	Aug 2013	Aug 2014	Aug 2015	Sept 2016	August 2017	August 2018
SUBMERSED PLANTS									
<i>Myriophyllum spicatum</i> *	Eurasian watermilfoil*	19	4	5	22	4	8	17	7
<i>Potamogeton crispus</i> *	Curlyleaf pondweed*	7	8	5	4	3			
<i>Najas flexilis</i>	Bushy Pondweed				1	< 1	1	8	4
<i>Ceratophyllum demersum</i>	Coontail	55	55	68	49	47	55	65	70
<i>Elodea canadensis</i>	Canadian waterweed	4	4		1	3	7	25	3
<i>Myriophyllum sibiricum</i>	Northern watermilfoil		15		3				
<i>Heteranthera dubia</i>	Water Stargrass						4	8	5
<i>Stuckenia pectinata</i>	Sago pondweed	1		4	7	1	3	3	3
<i>Vallisneria americana</i>	Water celery	3	7		3	6		11	16
Floating, Free-floating & Emergent plants observed: <i>Lemna minor</i> (Common duckweed), <i>Lemna trisulca</i> (Star duckweed), <i>Nuphar variegata</i> (Bullhead pond lily), <i>Nymphaea odorata</i> (White water lily), <i>Spirodela polyrhiza</i> (Greater duckweed), <i>Wolffia columbiana</i> (Watermeal)									
Less common (< 5% frequency) submersed vegetation observed: <i>Macroalgae</i> (Muskgrass) in 2016, <i>Potamogeton foliosus</i> (Leafy pondweed) in 2011, 2016, <i>Potamogeton zosteriformis</i> (Flat stem pondweed) in 2014									

* denotes invasive aquatic plant

Table 9. Lake Sarah West Basin

Taxonomic Name	Common Name	Aug 2011	Aug 2012	Aug 2013	Aug 2014	Aug 2015	Sept 2016	August 2017	August 2018
SUBMERSED PLANTS									
<i>Myriophyllum spicatum</i> *	Eurasian watermilfoil*	18	7	6	15	6	7	18	19
<i>Potamogeton crispus</i> *	Curlyleaf pondweed*	7	4		3	3			1
<i>Chara sp.</i>	Muskgrass						< 1	5	3
<i>Ceratophyllum demersum</i>	Coontail	45	41	37	42	33	42	46	43
<i>Elodea canadensis</i>	Canadian waterweed		6	3	6	9	19	32	11
<i>Najas flexilis</i>	Bushy Pondweed	1		1		5	4	3	14
<i>Stuckenia pectinata</i>	Sago pondweed		6	7	12		4	3	4
<i>Heteranthera dubia</i>	Water Stargrass						1	2	7
<i>Vallisneria americana</i>	Water celery	4			5	9	10	4	16
Floating, Free-floating & Emergent plants observed: <i>Lemna minor</i> (Common duckweed), <i>Lemna trisulca</i> (Star duckweed), <i>Nuphar variegata</i> (Bullhead pond lily), <i>Nymphaea odorata</i> (White water lily), <i>Spirodela polyrhiza</i> (Greater duckweed), <i>Wolffia columbiana</i> (Watermeal)									
Less common (< 5% frequency) submersed vegetation observed: <i>Fontinalis sp.</i> (Aquatic moss) in 2016, 2018, <i>Heteranthera dubia</i> (Water stargrass) in 2016-17, <i>Myriophyllum sibiricum</i> (Northern watermilfoil) in 2012, 2014, and 2017, <i>Potamogeton foliosus</i> (Leafy pondweed) in 2011, 2013, 2018 <i>Potamogeton pusillus</i> (Small pondweed) in 2012, 2015, <i>Nitella sp.</i> (Nitella) in 2017, <i>Tolypella intricata</i> (Bird's Nest Stonewort) in 2017, 2018									

* denotes invasive aquatic plant

Tables 10 & 11. Early Spring Point-Intercept Metrics (East Basin). Summary of aquatic submersed plants in **Lake Sarah**, Hennepin County, Minnesota (DOW# 27019100) as indicated by results of point-Intercept surveys. Values were calculated from littoral depth range (0-15 feet).

Table 10. Lake Sarah East Basin

PI Survey Date	% Frequency of CLP*	Max Depth of Growth in feet [95%] [†]	% Points w/ Native Submersed Taxa	Mean Native Submersed Taxa/ Point	# Submersed Taxa
May 2013	31	9	47	0.5	4
May 2014	26	10	47	0.4	4
April 2015**	43	7			
April 2016	30	7	30	0.29	3
April 2017	15	8	44	0.5	4
May 2018	9	9	51	0.7	4

*CLP is short for Curlyleaf Pondweed

[†]95th percentile calculated based on all vegetated sampling points

** Only CLP was surveyed in the 2015 point-intercept survey

Taxa refers to groups of submersed aquatic plant species or genera

Table 11. Lake Sarah West Basin

PI Survey Date	% Frequency of CLP*	Max Depth of Growth in feet [95%] [†]	% Points w/ Native Submersed Taxa	Mean Native Submersed Taxa/ Point	# Submersed Taxa
May 2013	41	10	23	0.2	4
May 2014	31	11	33	0.3	4
April 2015**	47				
April 2016	24	8	21	0.2	4
April 2017	27	9	34	0.4	4
May 2018	9	9	32	0.4	5

*CLP is short for Curlyleaf Pondweed

[†]95th percentile calculated based on all vegetated sampling points

Taxa refers to groups of submersed aquatic plant species or genera

** Only CLP was surveyed in the 2015 point-intercept survey

Table 11. Curlyleaf Pondweed turion surveys in Lake Sarah (East and West Basin), Hennepin County (DOW # 27019100).

Site	Number of Sample Sites	Number of Whole Turions	Number of Partial Turions	Total Turions	Average Number of Turions/Sample	Average Number of Turions/m2
2012						
East	24	391	378	769	32.04	1381.10632
West	25	207	493	700	28.00	1206.89655
2013						
East	25	131	181	312	12.48	537.931034
West	25	196	838	1034	41.36	1782.75862
2014						
East	20	104	718	822	41.10	1771.55172
West	20	78	561	639	31.95	1377.15517
2015						
East	20	93	212	305	15.25	657.327586
West	20	41	125	166	8.3	357.758621
2016						
East	20	80	28	108	5.4	232.758621
West	20	32	38	70	3.5	150.862069
2017						
East	20	60	58	118	5.9	254.310345
West	20	64	85	149	7.45	321.12069
2018						
East	20	28	109	137	6.85	295.258621
West	20	47	318	365	18.25	786.637931

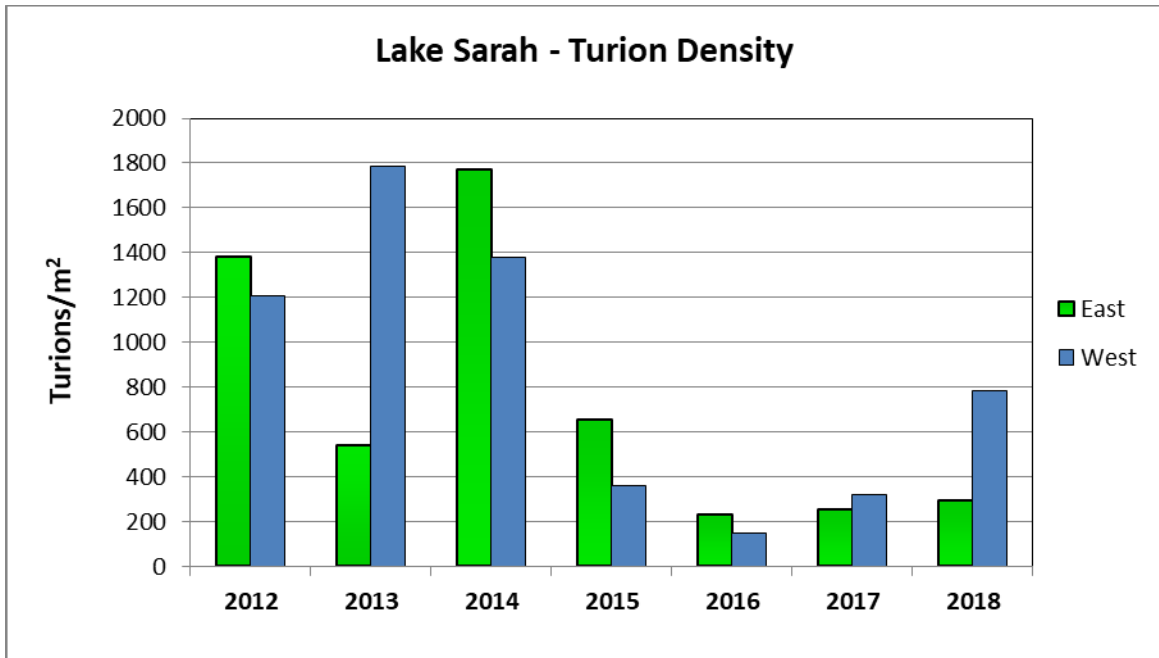


Table 4-Secchi Averages. Average Secchi disk observations in meters for Lake Sarah (West Basin) (DOW #27019100). Data gathered from Three Rivers Park District.

YEAR	MAY	JUNE	JULY	AUG	SEPT	Secchi Depth Average [May-Sept]
1990	2.2		1.4	1.6		
1992	2.9	1.7	0.8	0.8	0.9	1.4
1993		3.03	1.36	1.01	1.21	
1994		3.58	1.06	1.06	1.21	
2006	2.3	0.9	0.7	0.9	1.0	1.2
2007	2.6	1.3	0.6	0.8	0.7	1.2
2008						
2009						
2010	2.7	1.2	0.6	0.7	1.0	1.2
2011	2.1	2.2	1.2	0.9	1.3	1.5
2012	4.46	1.16	0.66	0.66	0.73	1.5
2013	2.78	2.53	0.77	0.73	1.04	1.6
2014	2.4	1.8	1.0	1.1	1.0	1.5
2015	5.05	1.53	0.9	0.75	1.05	1.9
2016	4.9	1.6	1.0	0.9	0.9	1.9
2017	2.9	1.2	1.1	0.8	0.9	1.4
2018	4.4	3.1	1.15	0.9	1.2	2.0

