



Natural Shoreline at High Water in Fish Lake, Scott County, MN, on June 19, 2014

Curlyleaf Pondweed Delineation and Assessment for Fish Lake, Scott County, 2014

Delineation Date: May 21, 2014
Assessment Date: June 19, 2014

Prepared for:
Prior Lake/Spring Lake
Watershed District
Prior Lake, Minnesota



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Fish Lake, Scott County, Curlyleaf Pondweed Assessment for 2014

Overview: Two curlyleaf pondweed (CLP) surveys were conducted in Fish Lake within the 15.5 acre area that was treated with an endothall herbicide from 2005-2008. A curlyleaf pondweed delineation was conducted on May 21 and a curlyleaf assessment was conducted on June 19, 2014. In the delineation on May 21, 2014 curlyleaf pondweed was found at 6 out of the 15 sites sampled. CLP growth was mostly light with potential heavy growth predicted to occur at about 2 acres (yellow shaded area in Figure S1). No treatment was conducted in 2014. For the CLP assessment on June 19, curlyleaf abundance remained about the same compared to the May delineation survey. In addition, the rest of the Fish Lake nearshore area was also assessed on June 19. No additional curlyleaf was observed at these sites (Figure S1). Overall curlyleaf growth has been mostly light to moderate in the last few years and that was also the case for 2014. No herbicides have been used in the 15.5 acre area on the west side of the lake from 2009 through 2014.

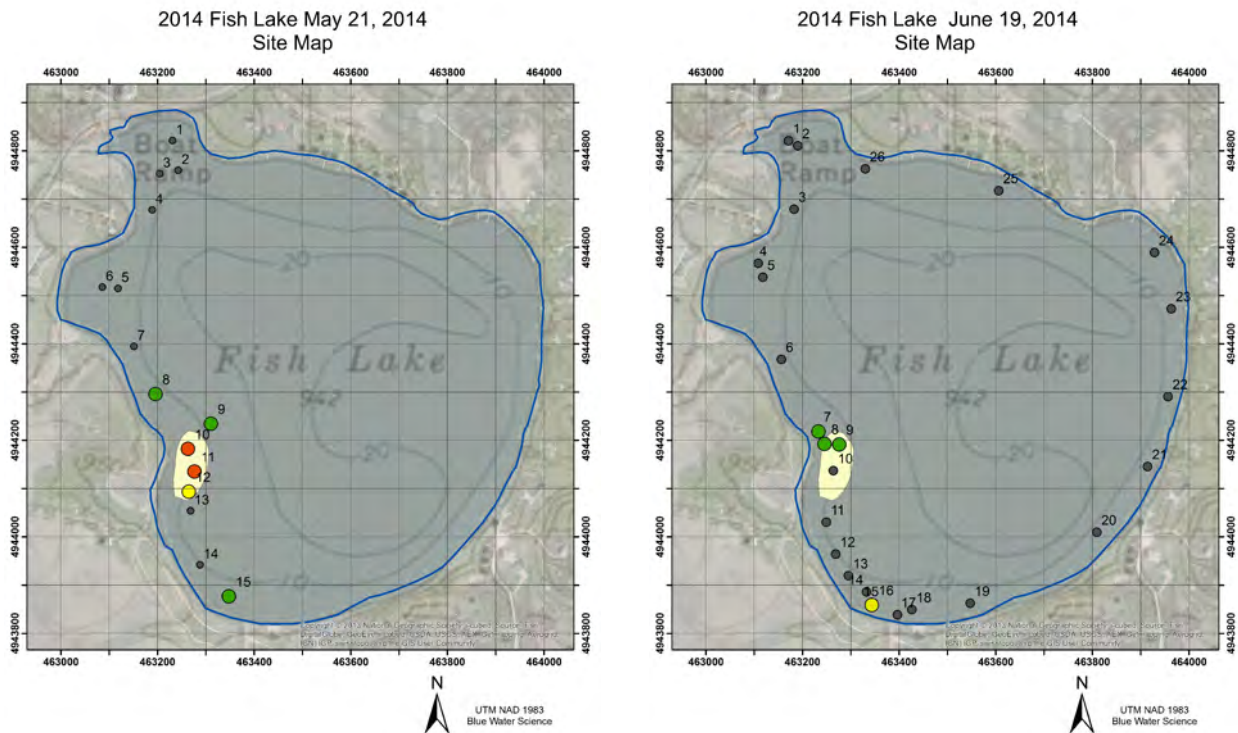


Figure S1. [left] Fifteen sites within an area that was treated from 2005-2008 were monitored on May 21, 2014. Curlyleaf was found at low densities at 6 sites and future potential growth was estimated based on stems sampled on the rake. At 3 sites future potential growth was predicted to have low densities (green dots), 1 site at moderate future potential densities (yellow dot), and 2 sites at high future potential densities (red dots). Black dots indicate no curlyleaf pondweed was observed.

[right] In June, the same areas were monitored and curlyleaf was detected at four sites. In June, actual curlyleaf densities were noted. Green dots indicates curlyleaf pondweed was observed at low densities (3 sites) and yellow dot indicates curlyleaf was observed a moderate density (1 site).

Curlyleaf Pondweed Stem Densities at Site 4 from 2005 - 2014: Curlyleaf has been monitored at the same site on early and late season dates from 2005 through 2014 (Figure S2). Curlyleaf stem densities were initially high on April 18, 2005. Curlyleaf was treated within this site for four years (2005-2008). No herbicide was used in 2009 through 2014. The early season stem density was 0 stems/m² on May 21, 2014, which was lower compared to Years 2009-2013. The next sample date on June 19, 2014, curlyleaf stem density remained at 0 stems/m² (Table S1 and Figure S3). High lake levels may have inhibited curlyleaf growth in 2014.

Table S1. Summary of curlyleaf pondweed stem densities for both pre and post herbicide conditions in Fish Lake.

	Stem Density (#/m ²)	
	Pre-Herbicide Conditions	Late Spring Conditions
2005 (treated)	379 (n=10) (April 18)	6 (n=10) (May 23)
2006 (treated)	27 (n=10) (April 25)	4 (n=10) (June 2)
2007 (treated)	22 (n=10) (April 16)	5 (n=10) (June 5)
2008 (treated)	3 (n=10) (April 29)	0 (n=10) (June 13)
2009	7 (n=10) (April 23)	130 (n=10) (June 10)
2010	32 (n=10) (April 27)	107 (n=10) (June 2)
2011	47 (n=10) (May 12)	120 (n=10) (June 13)
2012	163 (n=10) (April 17)	195 (n=10) (June 5)
2013	19 (n=10) (May 23)	62 (n=10) (June 13)
2014	0 (n=10) (May 21)	0 (n=10) (June 19)



Figure S2. Monitoring site (shown with a black dot).

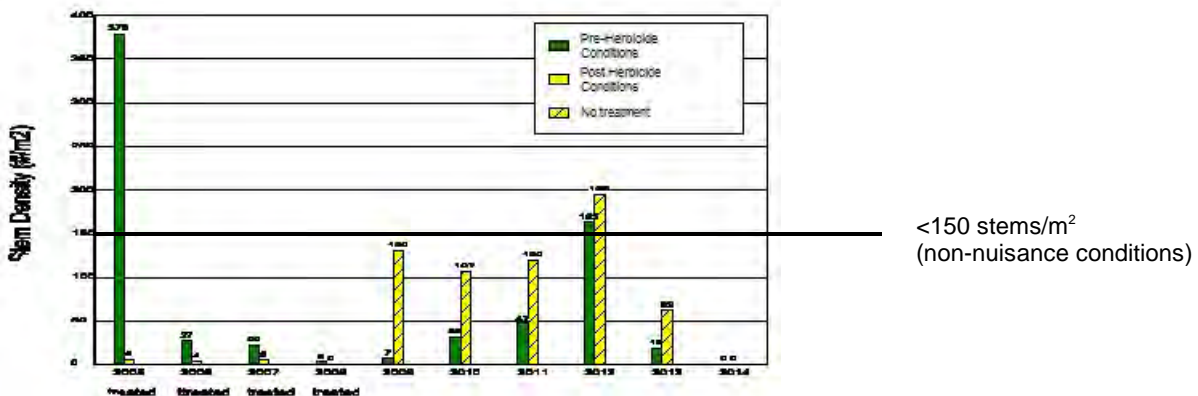


Figure S3. Average of Fish Lake curlyleaf pondweed stem densities for early season and late season conditions in 2005 through 2014 at a 6.0-foot water depth at the monitoring site shown in Figure S2.

Fish Lake Curlyleaf Pondweed Growth Potential Based on Lake

Sediment Characteristics: Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth in Fish Lake. Based on the key sediment parameters of pH, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table S2 and Figure S4.

Without herbicide applications in Fish Lake, curlyleaf pondweed growth is predicted to produce mostly light to moderate growth (where plants occasionally top out) for a number of locations around Fish Lake (Figure S4).

Table S2. Fish Lake sediment data and ratings for potential curlyleaf pondweed growth. Sediment collected in 2006.

Site	Depth (ft)	pH (su)	Organic Matter (%)	Fe:Mn Ratio	Potential for Curlyleaf Pondweed Growth
Light Growth		6.8	5	4.6	Light (green)
Moderate Growth		6.2	11	5.9	Moderate (yellow)
Heavy Growth		>7.7	>20	<1.6	Heavy (red)
1	5	7.6	3.5	2.38	Moderate
2	5	7.7	2.5	4.39	Moderate
3	5	7.7	5.1	3.12	Moderate
4	5	7.6	6.4	4.13	Light
5	5	8.1	0.9	13.33	Moderate
6	5	7.6	3.7	2.56	Moderate
7	5	7.5	2.2	3.32	Light
8	5	7.5	35.7	2.74	Moderate

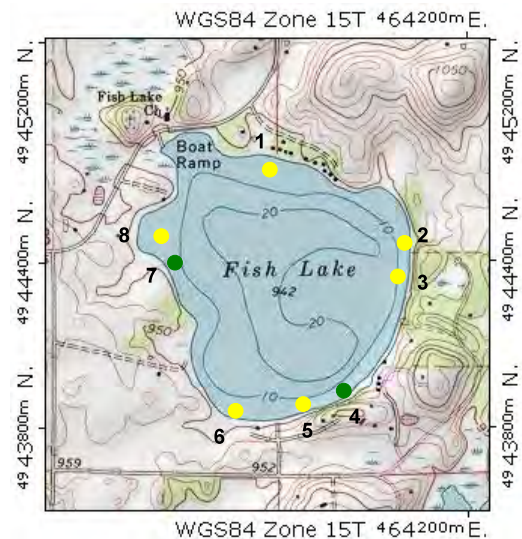


Figure S4. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = light; yellow = moderate;

Light to moderate growth typically is a non-nuisance condition. Non-nuisance growth refers to curlyleaf growth that is mostly below the surface and is not a recreational nor an ecological problem. Heavy growth refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a low iron to manganese ratio. A chart showing the three types of growth conditions is shown on the next page.

Examples of Curlyleaf Pondweed Growth Characteristics

Light Growth Conditions

Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m²

Biomass: 0 - 50 g-dry wt/m²

Estimated TP loading: <1.7 lbs/ac

MnDNR rake sample density equivalent for light growth conditions: 1, 2, or 3.



Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m²

Biomass: 50 - 85 g-dry wt/m²

Estimated TP loading: 2.2 - 3.8 lbs/ac

MnDNR rake sample density equivalent for moderate growth conditions: 2, 3 or sometimes, 4.



Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m²

Biomass: >300 g-dry wt/m²

Estimated TP loading: >6.7 lbs/ac

MnDNR rake sample density has a scale from 1 to 4. For certain growth conditions where plants top out at the surface, the scale has been extended: 4.5 is equivalent to a near solid surface canopy and a 5 is equivalent to a solid surface canopy. Heavy growth conditions have rake densities of a 4 (early to mid-season with the potential to reach the surface), 4.5, or 5.



Curlyleaf Pondweed Density and Abundance in Fish Lake, Scott County, 2014

Introduction

After four years of herbicide applications (2005-2008), no herbicide treatments with Aquathol K (active ingredient is an endothal salt) were conducted in Fish Lake (171 acres) in 2009 through 2014.

The short term objective for herbicide treatments was to reduce, to the greatest extent possible, the occurrence of heavy growth of the non-native plant, curlyleaf pondweed. The long-term objective was to reduce the standing crop of curlyleaf pondweed to non-nuisance conditions.

This report summarizes the curlyleaf abundance after four years of annual herbicide treatment (from 2005-2008). Curlyleaf density was sampled at one site on Fish Lake at a 6-foot depth and was assessed at other sites within a 15.5-acre treatment area.



Figure 1. Herbicides were applied to a 15-acre area from 2005 through 2008. No herbicides were applied in 2009 through 2014.

Methods

After four years of herbicide treatments on 15.5 acres (from 2005-2008)(Figure 2), no Aquathol K has been applied to Fish Lake in 2009 through 2014. Two surveys were conducted in 2014, an early season delineation on May 21, 2014 when curlyleaf was starting to grow and a follow-up assessment survey on June 19, 2014, when curlyleaf was at it's peak biomass.

In 2014, sites within a former treatment area were monitored with a rake sampler. At each sampling site, water depth, plant species, and abundance of the plant species were recorded (Figure 2).

Curlyleaf Stem Density Methods: In 2014, one site (4-7 feet) was sampled on two sample dates. At the site, a total of ten curlyleaf stem density samples were taken sampling an area of a 0.10 m² (Figure 2). The stem density samples were randomly collected along a 50 meter transect line that ran parallel to the shoreline at each station. Other plant species were also counted if present.

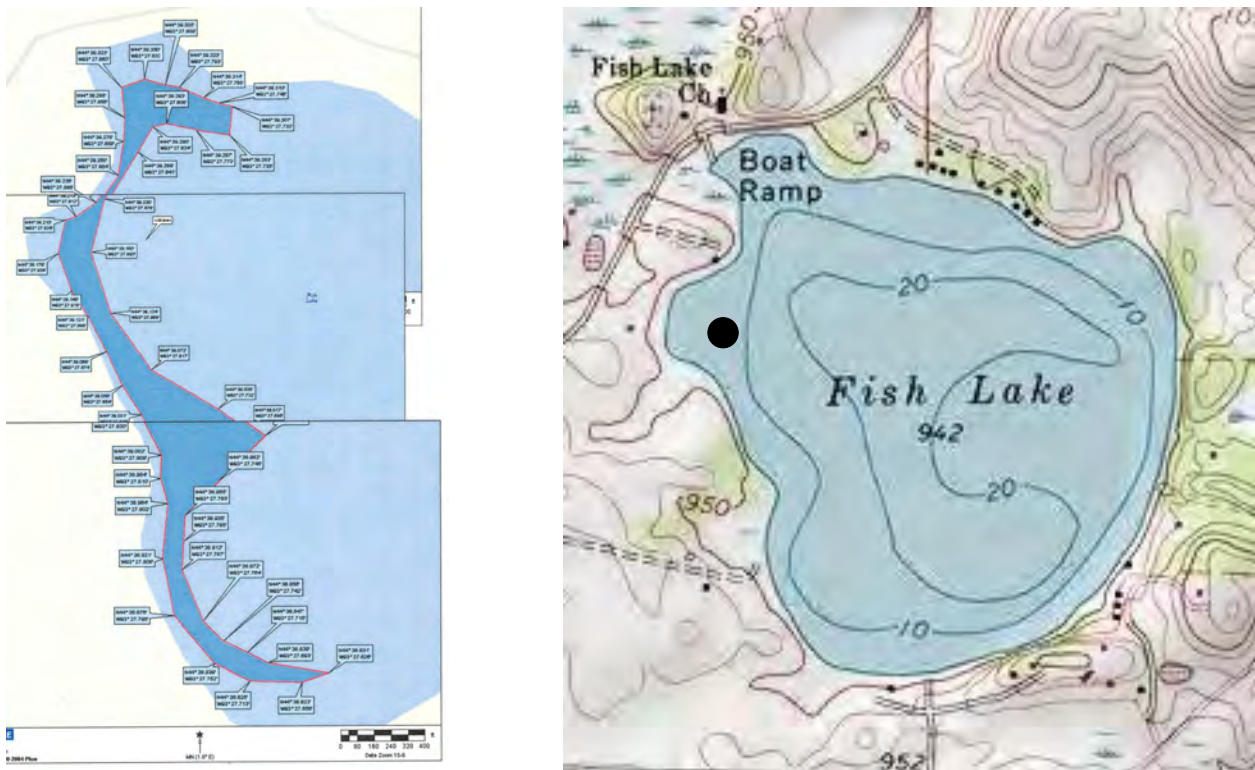


Figure 2. [left] The area treated from 2005-2008 is shown in dark blue is shown on the map to the left. Sites were samples within the dark blue shading on May 21 and June 19, 2014.

[right] Stem density determinations (10 samples) were collected from one site within an area treated from 2005-2014. Stem densities were determined using scuba diving and a 0.1 m² quadrat.

Curlyleaf Pondweed Delineation in Fish Lake, May 21, 2014

A total of 16 sites were monitored with rake sampling on May 21, 2014 in areas that previously had been treated for four consecutive years with an endothal herbicide (Figure 4). Curlyleaf was found at 6 sample sites out of the 15 that were monitored (Table 1). In the May delineation, based on stem counts, it was predicted curlyleaf would produce heavy growth in June at two sites, totaling about 2 acres (Table 1 and Figure 4). Herbicide treatments were not conducted in the delineated areas in 2014.

Table 1. Aquatic plant densities based on rake sampling for May 21, 2014. Densities are based on a scale from 1 to 5 with 5 being the densest. Curlyleaf stems per rake sample were also noted. Areas with green shading are predicted to have light to moderate growth at the peak of the curlyleaf growth cycle. Areas with yellow shading are predicted to have moderate to heavy curlyleaf growth and red shading indicates the potential for future heavy growth.

Site	Depth (ft)	Coontail	CLP - density	CLP - stems	Filamentous Algae
1	5 - 7	3			
2	5 - 7	2			2
3	5 - 7	3			
4	5 - 7	1			
5	5 - 7	2			2
6	5 - 7	3			
7	5 - 7	3			
8	5 - 7	3	1	1	
9	5 - 7	2, 2	1	2	
10	5 - 7	1, 3	2	9	2
11	5 - 7	2	2, 2	6, 5	
12	5 - 7	2	1, 1	3, 3	
13	5 - 7	2			
14	7	3			
15	6	2	1	2	
Average		2.2	1.4	3.9	2.0
Occurrence (15 sites sampled)		15	6	8	3
% occurrence		100	40	40	15



Figure 3. [left] Curlyleaf pondweed density of "1". [right] Coontail at a density of a "3".

Curlyleaf Conditions in Fish Lake, May 21, 2014



Figure 4. Curlyleaf delineation in Fish Lake on May 21, 2014. Black dots = no curlyleaf pondweed, green dots = potential light growth with 1-2 stems per rake, yellow dots = potential moderate growth based on 3 stems per rake, and red dots = potential heavy growth based on 4 stems or more per rake sample. A two acre area was delineated as an area with potential heavy growth at peak biomass conditions in June. No herbicides were applied in 2014.

Curlyleaf Pondweed Assessment in Fish Lake, June 19, 2014

There was no herbicide use in 2014. A total of 27 sites were sampled with rake sampling on June 19, 2014 in the area that previously had been treated for four consecutive years in 2005-2008 with an endothall herbicide as well as around the rest of the lake. Curlyleaf was found at 4 out of 27 sample sites. Coontail was found at 26 out of 27 sample sites. In June, the entire nearshore area of Fish Lake was surveyed. No curlyleaf was observed in the eastern nearshore areas (Sites 19-26)(Table 2 and Figure 5).

Table 2. Aquatic plant densities based on rake sampling for June 14, 2014. Densities are based on a scale from 1 to 5 with 5 being the densest. Curlyleaf stems per rake sample were also noted. Areas with green shading are predicted to have light to moderate growth at the peak of the curlyleaf growth cycle. Areas with yellow shading are predicted to have moderate to heavy curlyleaf growth.

Site	Depth (ft)	White lilies	Coontail	CLP - density	CLP - stems	Flatstem	NWM	Water celery	Fila Algae
1	4		4						3
2	5		1						2
3	7		2						
4	6		3						
5	7		3						
6	7		2				1		
7			3	1	5				
8	5		3	2	12				
9	8		2	1	1				
10	6		3						
11	4	2	3						
12	6		3						
13	6		2						
14	6		1						
15	6		2						
16	6		1	3	15				
17	5		2						
18	6		2						
19	9		2						
20	9		2						
21	7		3						
22	6		2					1	
23	8		1						
24	6		2						
25	10								
26	9		3						
27	5		3			1	1	1	
Average		2.0	2.3	1.8	8.3	1.0	1.0	1.0	2.5
Occurrence (27 sites)		1	26	4	4	1	2	2	2
% occurrence		4	96	15	15	4	7	7	7

Curlyleaf Conditions in Fish Lake, June 19, 2014

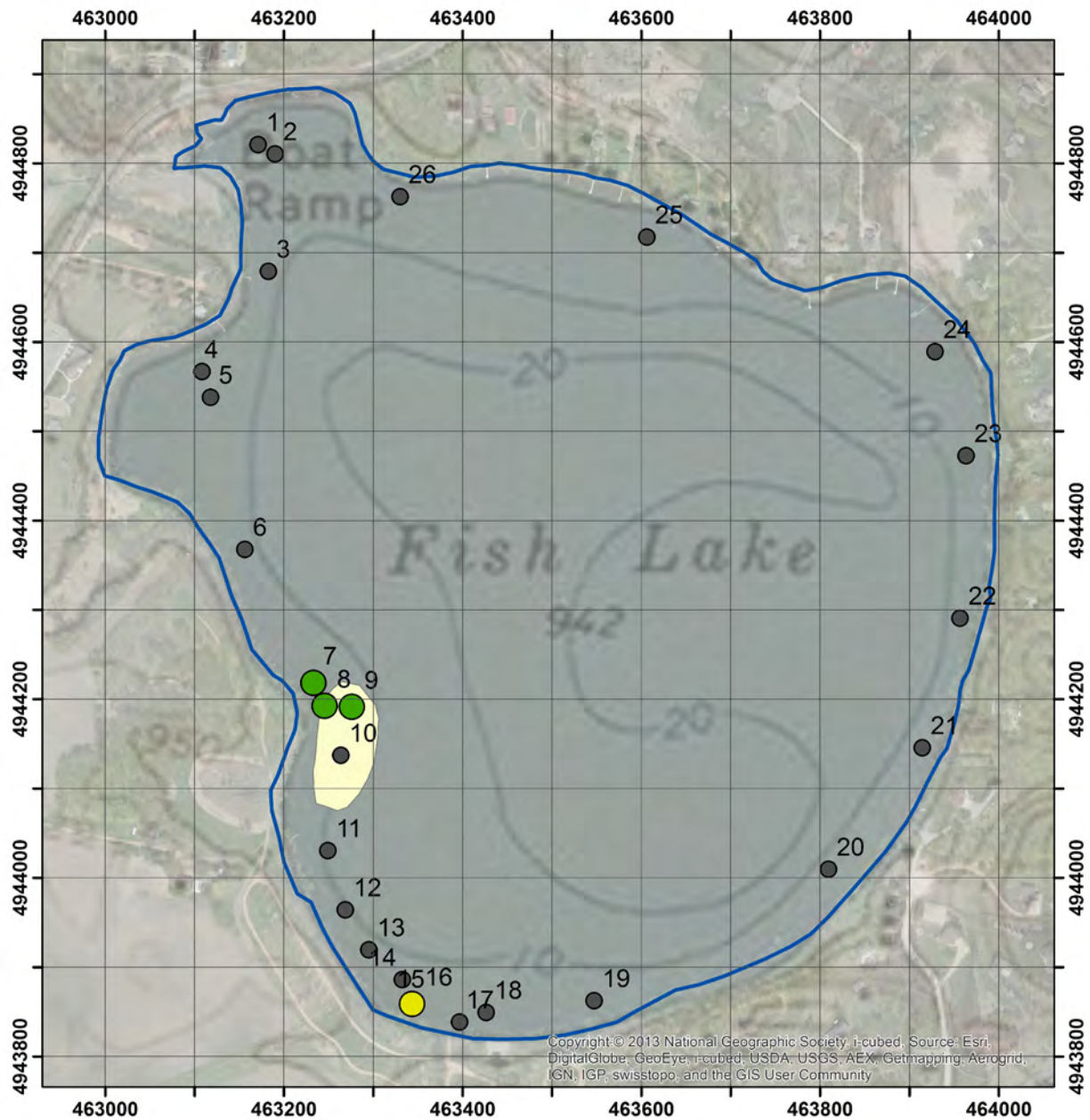


Figure 5. Curlyleaf assessment in Fish Lake on June 19, 2014. Black dots = no curlyleaf pondweed, green dots = light growth, and yellow dots = moderate growth. No herbicides were applied in 2009 through 2014.

Curlyleaf Stem Densities at One Location from May to June

Curlyleaf stem densities were determined by rake sampling at a location between sample sites 4-5 (Figure 6). Ten quadrat samples were taken at this location. The results for 2014 show curlyleaf was found at low stem densities (Table 3 and Figure 7).

Table 3. Curlyleaf pondweed stem densities for June 16, 2014. Samples collected at the 6 to 7 foot depth.

Site 4 - 5 Quadrats	Curlyleaf (stems/m ²)	
	May 21, 2014	June 19, 2014
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
Ave	0	0



Figure 6. Monitoring site (shown with a black dot).

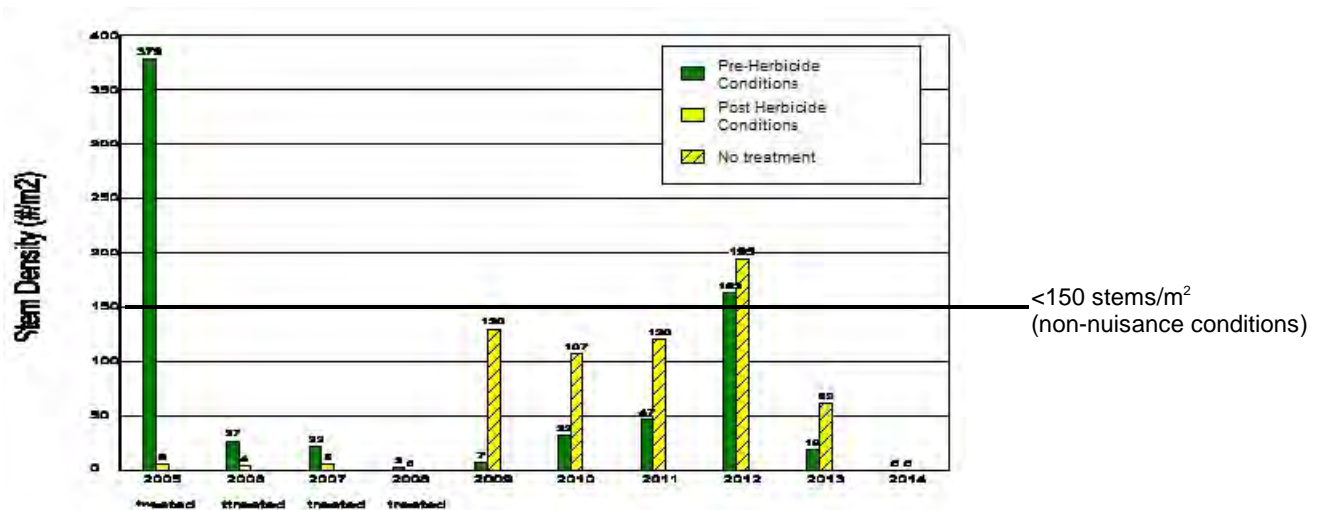


Figure 7. Average of Fish Lake curlyleaf pondweed stem densities for early season and late season conditions in 2005 through 2014 at a 6.0-foot water depth at the monitoring site shown in Figure 6.

Comparison of Early Season to Late Season Curlyleaf Growth

In the delineation survey on May 21, 2014, an area of predicted heavy growth of curlyleaf pondweed was delineated that measured about 2 acres (Figure 8). However, no treatment occurred. In a recheck on June 19, 2014, the curlyleaf assessment found curlyleaf was found in the same area as the May delineation, but curlyleaf growth was light. It did not turn into a heavy growth conditions (Figure 8). It is possible that high water levels may have limited curlyleaf growth in June.

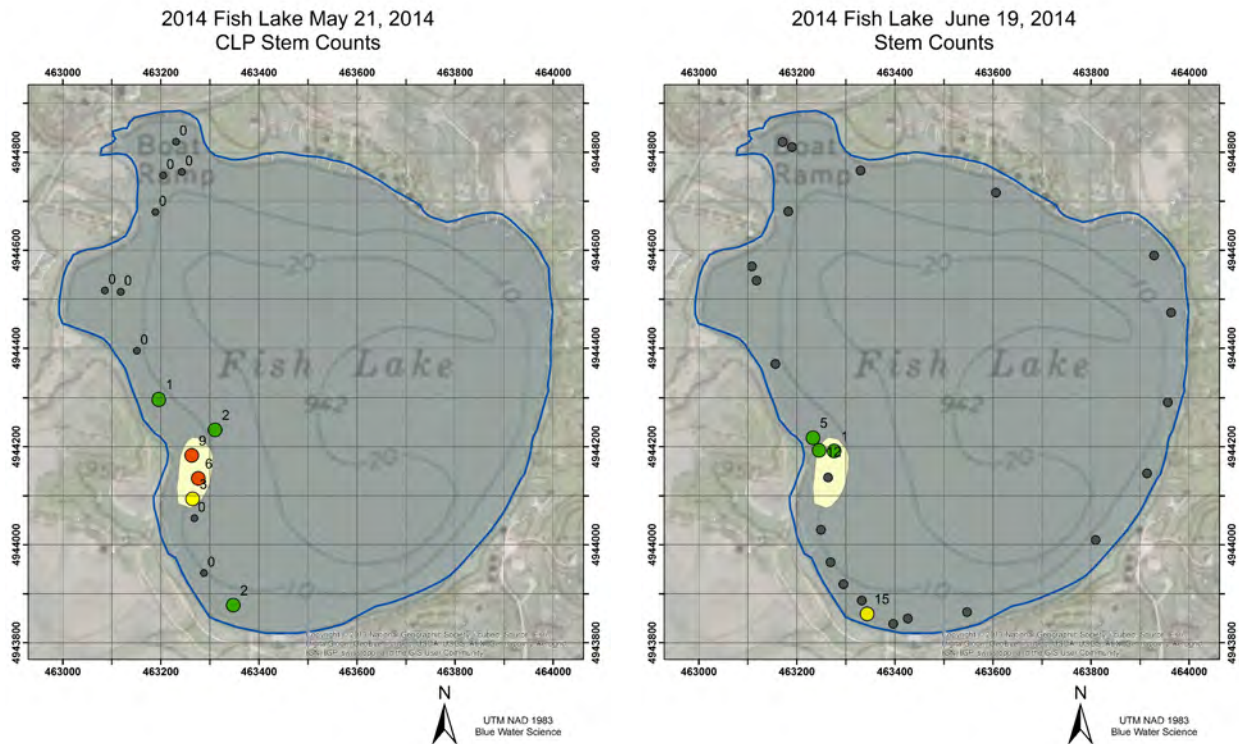


Figure 8. [left] Stem counts for the sample sites monitored on May 21, 2014. [right] Stem counts for the sample sites monitored on June 19, 2014.

Results for 2005-2014

Curlyleaf Pondweed Stem Densities at Long-Term Sample Site (location shown in Figure 6): Curlyleaf has been monitored at the same site on early and late season dates from 2005 through 2014. Curlyleaf stem densities were initially high on April 18, 2005. Curlyleaf was treated within this site for four years (2005-2008). No herbicide was used in 2009 through 2014. The early season stem density was 0 stems/m² on May 21, 2014, which was lower compared to Years 2009-2013. The next sample date on June 19, 2014, curlyleaf stem density increased to 0 stems/m² (Table 4).

Table 4. Summary of curlyleaf pondweed stem densities prior to the effects of herbicide treatment and after the herbicide treatment.

Site	Stem Density (stems/m ²)									
	Spring Status									
	5 - 6 foot Depth									
	2005 (Apr 18) (n=10)	2006 (Apr 25) (n=10)	2007 (Apr 16) (n=10)	2008 (Apr 29) (n=10)	2009 (Apr 23) (n=10)	2010 (Apr 27) (n=10)	2011 (May 12) (n=10)	2012 (Apr 17) (n=10)	2013 (May 23) (n=10)	2014 (May 21) (n=10)
1	290	50	0	10	10	20	60	120	30	0
2	460	0	0	20	10	60	70	180	40	0
3	270	0	0	0	20	60	100	90	30	0
4	260	10	0	0	0	80	50	220	0	0
5	480	20	30	0	30	0	60	90	0	0
6	250	80	40	0	0	40	30	240	0	0
7	540	60	30	0	0	40	30	30	0	0
8	370	20	80	0	0	20	50	280	60	0
9	270	30	20	0	0	0	20	360	0	0
10	600	30	20	0	0	0	20	20	30	0
Ave	379	27	22	3	7	32	47	163	19	0

Site	Stem Density (stems/m ²)									
	Early Summer Status									
	5 - 6 foot Depth									
	2005 (May 23) (n=10)	2006 (June 2) (n=10)	2007 (June 5) (n=10)	2008 (June 13) (n=10)	2009 (June 10) (n=10)	2010 (June 2) (n=10)	2011 (June 13) (n=10)	2012 (June 5) (n=10)	2013 (June 13) (n=10)	2014 (June 19) (n=10)
	treated	treated	treated	treated						
1	10	10	0	0	50	70	200	60	10	0
2	20	10	0	0	50	120	160	240	20	0
3	30	10	0	0	220	20	40	290	20	0
4	0	10	10	0	130	20	240	320	230	0
5	0	0	30	0	90	10	100	190	40	0
6	0	0	10	0	50	360	60	170	210	0
7	0	0	0	0	100	140	110	320	0	0
8	0	0	0	0	150	90	120	250	80	0
9	0	0	0	0	110	230	60	50	10	0
10	0	0	0	0	320	10	100	60	0	0
Ave	6	4	5	0	130	107	119	195	62	0

Conclusions: Two curlyleaf pondweed (CLP) surveys were conducted in Fish Lake within the 15.5 acre area that was treated with an endothall herbicide from 2005-2008. A curlyleaf pondweed delineation was conducted on May 21 and a curlyleaf assessment was conducted on June 19, 2014. In the delineation on May 21, 2014 curlyleaf pondweed was found at 6 out of the 15 sites sampled. However, CLP growth was mostly light with predicted potential heavy growth. On the assessment, curlyleaf abundance increased, but rather remained about the same as in the May survey. Overall curlyleaf growth has been mostly light to moderate in the last few years and that was also the case for 2014. No herbicides have been used in the 15.5 acre area from 2009 through 2014.

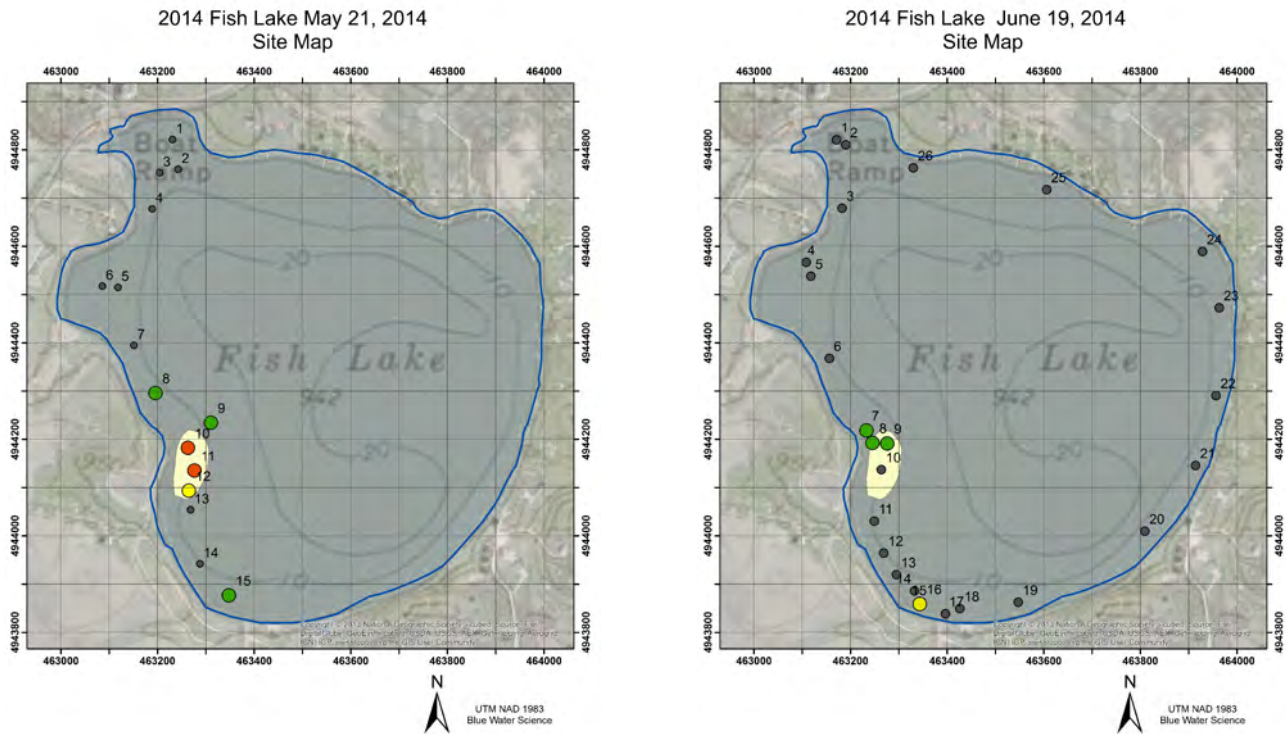


Figure 9. [left] Fifteen sites within an area that was treated from 2005-2008 were monitored on May 21, 2014 and curlyleaf was detected at 3 sites at low densities (green dots), 1 site at moderate densities (yellow dot), and 2 sites at high densities (red dots). Black dots indicate no curlyleaf pondweed observed. [right] In June, the same areas were monitored and curlyleaf was detected at four sites. Green dots indicates were curlyleaf pondweed was observed at low densities (3 sites) and yellow dot indicates curlyleaf was observed a moderate density (1 site).

APPENDIX

Subsurface Curlyleaf Pondweed Conditions in Fish Lake in 2005 Through 2012. Herbicides Were Used in 2005-2008.

Pre-Herbicide (Early) Conditions

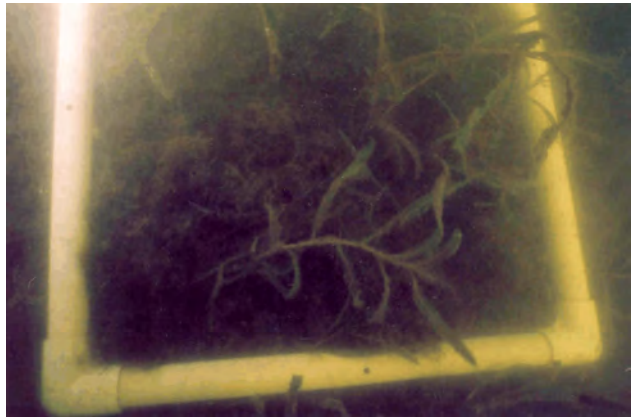
Post Herbicide (Late) Conditions



April 18, 2005



May 23, 2005



April 25, 2006



June 2, 2006



April 16, 2007



June 5, 2007

Pre-Herbicide (Early) Conditions

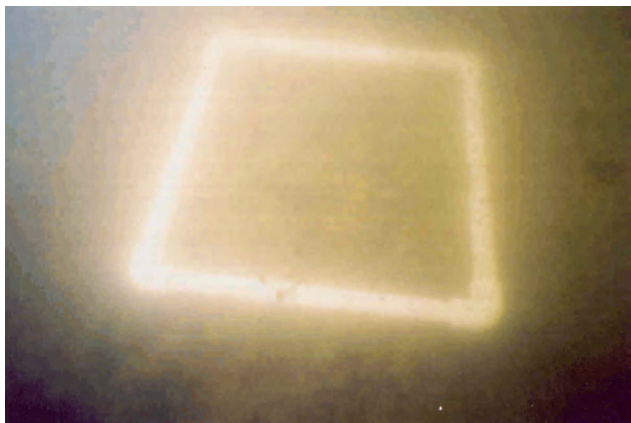
Post Herbicide (Late) Conditions



April 29, 2008



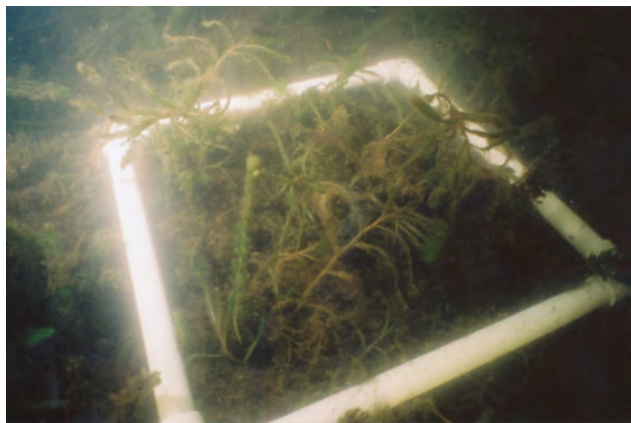
June 13, 2008



April 23, 2009



June 10, 2009



April 27, 2010



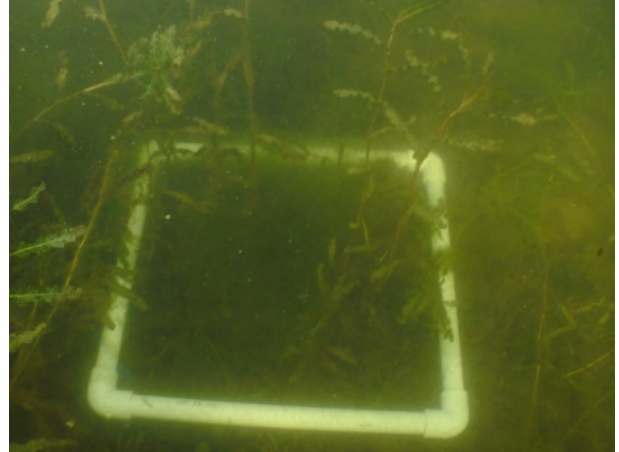
June 2, 2010

Pre-Herbicide (Early) Conditions



May 12, 2011

Post Herbicide (Late) Conditions



June 13, 2011



April 17, 2012



June 5, 2012

Curlyleaf Pondweed Conditions in early June in 2003 and 2005-2013



2003



2005



2006

2007



2008

2009

Curlyleaf Pondweed Conditions in early June in 2003 and 2005-2013



2010



2011



2012



2013

Predicted Curlyleaf Pondweed Growth Based on Lake Sediment Characteristics

Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth in Fish Lake. Based on the key sediment parameters of pH, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table A-1 and Figure A-1.

If herbicide applications were to stop in Fish Lake, curlyleaf pondweed growth is predicted to produce mostly light nuisance growth (where plants occasionally top out) for a number of locations around Fish Lake (Figure A-1).

Table A-1. Fish Lake sediment data and ratings for potential curlyleaf pondweed growth. Sediment collected in 2006.

Site	Depth (ft)	pH (su)	Organic Matter (%)	Fe:Mn Ratio	Potential for Heavy Curlyleaf Pondweed Growth
Light Growth		6.8	5	4.6	Low (green)
Moderate Growth		6.2	11	5.9	Medium (yellow)
Heavy Growth		>7.7	>20	<1.6	High (red)
1	5	7.6	3.5	2.38	
2	5	7.7	2.5	4.39	
3	5	7.7	5.1	3.12	
4	5	7.6	6.4	4.13	
5	5	8.1	0.9	13.33	
6	5	7.6	3.7	2.56	
7	5	7.5	2.2	3.32	
8	5	7.5	35.7	2.74	

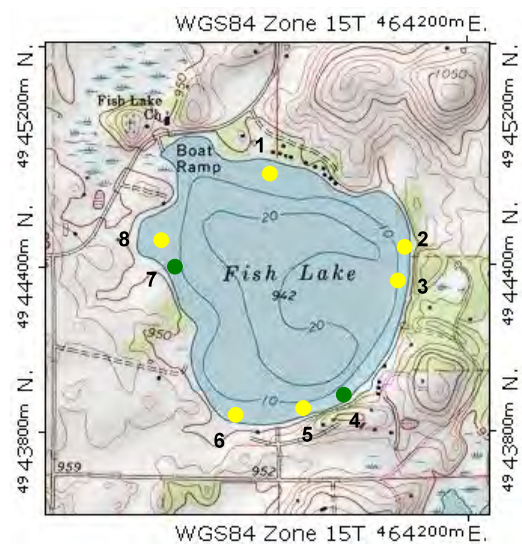


Figure A-1. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red =

Light nuisance growth has intermediate growth characteristics between non-nuisance and nuisance growth. Non-nuisance growth refers to curlyleaf growth that is mostly below the surface and is not a recreational nor an ecological problem. Heavy growth refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a low iron to manganese ratio. A chart showing the three types of growth conditions is shown on the next page.

Examples of Curlyleaf Pondweed Growth Characteristics

Light Growth Conditions

Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m²
Biomass: 0 - 50 g-dry wt/m²
Estimated TP loading: <1.7 lbs/ac

MnDNR rake sample density equivalent for light growth conditions: 1, 2, or 3.



Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m²
Biomass: 50 - 85 g-dry wt/m²
Estimated TP loading: 2.2 - 3.8 lbs/ac

MnDNR rake sample density equivalent for moderate growth conditions: 2, 3 or sometimes, 4.



Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m²
Biomass: >300 g-dry wt/m²
Estimated TP loading: >6.7 lbs/ac

MnDNR rake sample density has a scale from 1 to 4. For certain growth conditions where plants top out at the surface, the scale has been extended: 4.5 is equivalent to a near solid surface canopy and a 5 is equivalent to a solid surface canopy. Heavy growth conditions have rake densities of a 4 (early to mid-season with the potential to reach the surface), 4.5, or 5.

