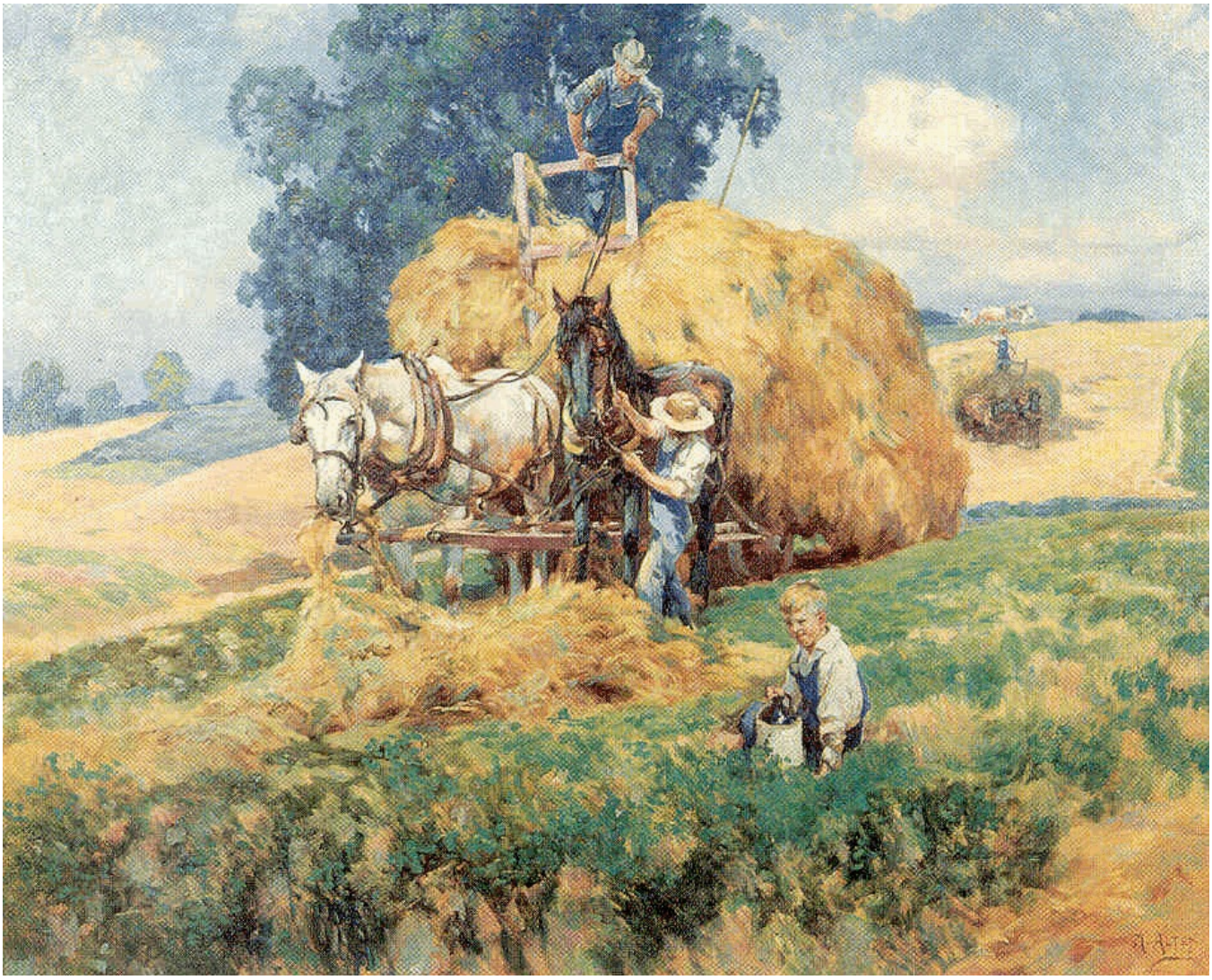

Mathias J. Alten: *Haying Time*, **1926**

Using Organic Carbon Amendments to Improve Water Clarity in Valley Lake, Lakeville, Minnesota, 2006

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Summary

Organic carbon amendments are defined as organic carbon compounds added to lakes and ponds with the objective to improve water clarity. Barley straw is an example of an organic carbon amendment and another example is the use of crushed corn. Both have been used in Valley Lake.

Barley straw was first installed in Valley Lake in 1999 at 100 pounds/acre and in subsequent years from 2000 through 2004 at 200 to 250 pounds/acre in 8-acre Valley Lake. In 2005, crushed corn at 160 pounds/ac, was used and in 2006, crushed corn at 250 pounds/ac was used. For the seventh consecutive summer, with either barley dose over 200 pounds/acre or with crushed corn, summer water clarity was better compared to years without organic carbon amendments. Prior to organic carbon amendments, a three year summer water clarity average was 2.8 feet. A seven-year summer water clarity average with barley straw (5 years) or with crushed corn (2 years) is 5.8 feet.

Figure 1. Crushed corn was added to Valley Lake in 2006.

The mechanism of how barley straw or crushed corn inhibits algal growth has been researched in Valley Lake with help of the Metropolitan Council since 2001. Initially in an attempt to identify potential inhibiting compounds, water analysis of up to 57 base/neutral/acid organic compounds were conducted in 2001 and 2002 for a total of 26 dates. Included in the suite of analyses were 10 phenolic compounds on each sampling date. With detection limits down to 2 ppb, no barley straw derived BNA compounds were detected. Chemical inhibition did not appear to be the mechanism that controlled algae growth.

However, another potential algal control mechanism was researched. It was theorized that if a carbon source with a low phosphorus content was added to a lake that the carbon-limited microbial community production would increase but as the microbes grew, they would be forced to use water column phosphorus because of the deficient phosphorus content of the organic carbon source. Ultimately, the phosphorus concentration in the pond would decrease. Other research has shown that microbes can outcompete algae for phosphorus (Currie and Kalff, 1984). Planktonic algal growth would be limited not by inhibiting compounds but rather by a lack of phosphorus. Results of special sampling from 2003 through 2006 supported the "high carbon, low phosphorus" mechanism as an explanation of how barley or corn could control algae (McComas and Anhorn, in preparation).

Water quality results for Secchi disc, total phosphorus, and chlorophyll a for the summer growing season (May-September) are shown in Figure 2. Water quality in Valley Lake was poor in 2006 and there is a declining trend noted since 2004. In 2006, only water clarity was better compared to conditions before the use of barley or corn. It is suspected than an increasing bluegill sunfish population may be responsible for the increase in phosphorus which may be negating the effects of the barley and corn additions over the past several years.

Conclusions and Recommendations

For the seventh year in a row the use of barley straw or corn as organic carbon amendments (OCAs) improved clarity in Valley Lake compared to pre-OCA years (Figure 2)

Although there have been positive impacts of organic carbon amendments on water quality, in the past, it does not appear to be effective under present lake conditions. It is recommended for 2007 that 90 to 100 pounds of fish/acre be removed from Valley Lake (up to a total of 800 pounds) with trapnets. The netted fish could be transferred to other ponds in the metro area.

Another project area to consider is managing Eurasian watermilfoil in Valley Lake. It was first observed in August of 2005 on the east side of the lake. If dense matting occurs in 2007, it is recommended that cutting and removing the milfoil in various spots around the lake which would allow fishing from shore.

Also, an aquatic plant survey should be conducted in 2007. The last survey was in 2003, and there was abundant plant growth out to 8-feet of water depth. In the last couple of years, with more algae growth, it appears aquatic plant coverage has decreased. An aquatic plant survey would quantify this and delineate the distribution of Eurasian watermilfoil as well.

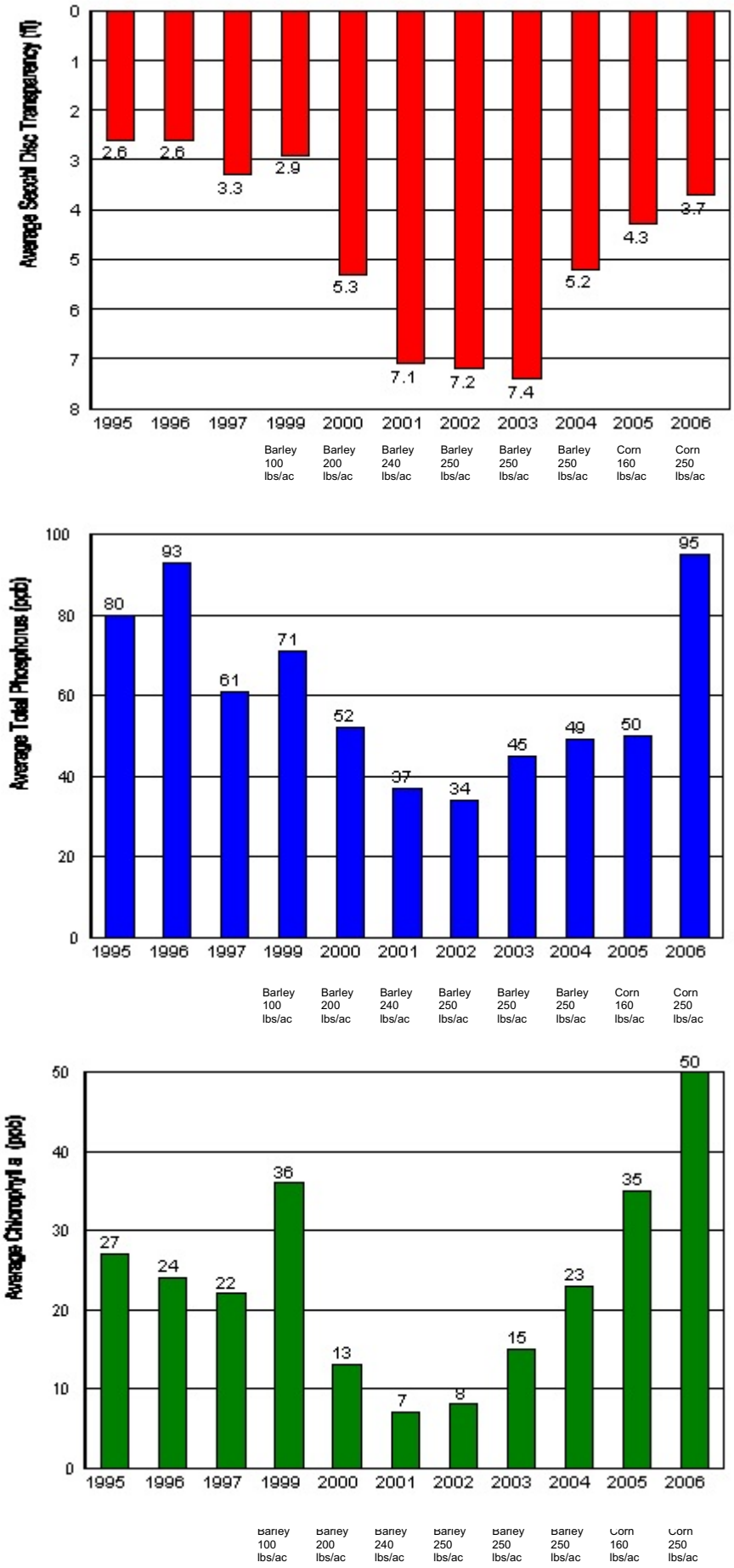


Figure 2. Growing season averages (May-Sept) in Valley Lake for Secchi disk, total phosphorus, and chlorophyll from 1995-2006.

Valley Lake: Introduction and Project Setting

Valley Lake is an 8 acre lake (Figure 1) located in the City of Lakeville, Minnesota (MnDNR ID 19-348). The maximum depth of Valley Lake is 3.4 m (11 feet). The total watershed area is about 117 acres. Valley Lake's water level is maintained by one stormwater inflow. Water leaves Valley Lake through an open water channel at the southeast end of the lake. Valley Lake has an aeration system, running from ice out throughout the summer, that consists of a single compressor with four diffuser heads in the lake.

The land use in the direct drainage area to Valley Lake consists of a swimming area, a playground, a walking path around the perimeter of the lake, and residential single family homes. Over the entire 117 acre watershed, the composite impervious surface area is 25%. To the west of Valley Lake is a storm water pond that receives stormwater before it enters Valley Lake. The stormwater pond has typical phosphorus concentrations of around 100 ppb total phosphorus.

In the 1990s, Valley Lake experienced nuisance algae blooms. The objective of the use of barley straw or crushed corn in Valley Lake has been to improve water quality. The first barley installation occurred in 1999 at 100 pounds per lake acre. From 2000 through 2004, barley straw was installed at 200 pounds or more per lake acre. In 2005 and 2006, crushed corn was used instead of barley straw to maintain good water clarity. In theory, crushed corn should work the same way that barley straw does. This report summarizes water quality results through the 2006 growing season.

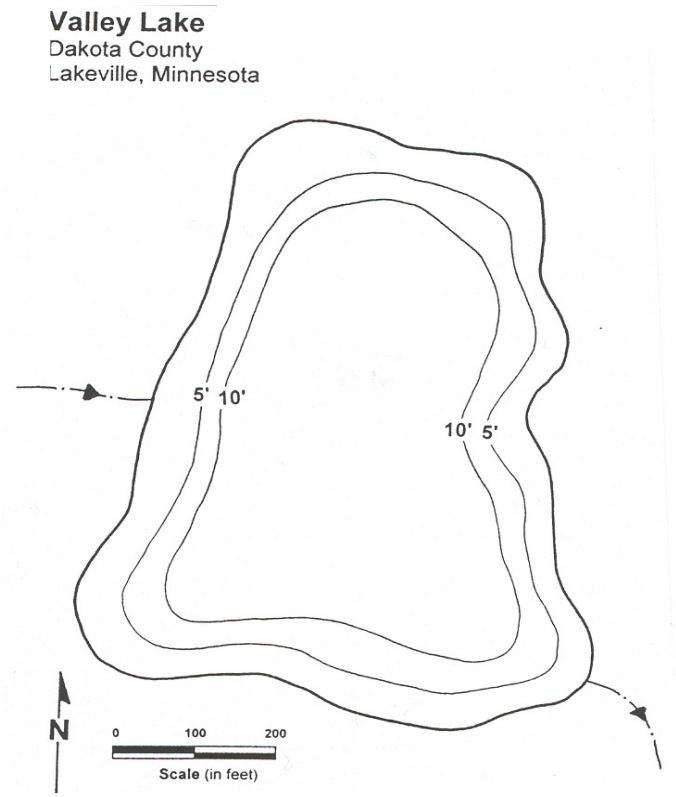


Figure 1. Valley Lake contour map.

Methods of Barley Straw and Crushed Corn Installation in Valley Lake

1999: The use of barley straw to control nuisance algae growth was first attempted in Valley Lake in 1999. Nineteen standard bales of barley straw weighing about 38 pounds per bale were repacked into mesh vegetable bags purchased from a produce company. Each mesh bag contained about 6 pounds of barley. They were deployed in Valley Lake in 6 to 8 bags per "pod". About 725 pounds of barley straw were placed in the 7.5 acre Valley Lake, or about 100 pounds of straw per acre, on April 28, 1999 and May 4, 1999. It took 8 hours using two people to fill and place bags at 11 g/m^2.

2000: In mid May 2000, barley straw was added to Valley Lake for the second summer. A total of 1,500 pounds of barley straw was installed in Valley Lake representing about 200 pounds of straw per acre or 21 g/m^2. We used a Christmas tree bailer and Christmas tree mesh netting for repacking barley straw for the lake installation. A nine-foot long tube weighed about 60 pounds. It took 4 hours using two people to fill and place bags at 21 g/m^2. Costs for 1999 and 2000 were about $20/acre for straw and netting (transportation and labor was extra).

2001: In May 2001, barley straw was purchased for $0.25/pound already packed in mesh bags measuring 4-feet long and 16 inches in diameter and weighing 20 pounds. On May 14, 2001, 1,800 pounds of barley straw were divided into 12 sets and installed in Valley Lake for the third summer. This represented a dose of 240 pounds of barley per lake acre or 27 g/m^2.

2002 - 2004: In early May 2002, 2003, and 2004, 2000 pounds of barley straw were added to the 8 acre lake for a dose of 250 pounds/acre. The barley was delivered to the Valley Lake parking lot on pallets by a trucking firm. Barley straw was deployed in the lake in sets of 120 to 200 pounds. The cost of barley was $0.43 per pound in 2004.

2005: This was the first year that crushed corn was added to Valley Lake instead of barley straw. Crushed corn is field corn that is ground at a mill. It was picked up at the mill in 50-pound bags. At Valley Lake, it was added to the lake at a rate of 32 pounds per acre, once per month from May through September.

2006: This was the second year that crushed corn was added to Valley Lake instead of barley straw. Crushed corn is field corn that is ground at a mill. It was picked up at the mill in 50-pound bags. At Valley Lake, it was added to the lake at a rate of 50 pounds per acre, once per month from May through September (Figure 2).

Figure 2. [top] Crushed corn was brought to the lake in 50-pound bags. Then a couple of bags were brought out on a kayak to be distributed around the lake.
[bottom] Crushed corn was added to the lake by scooping it out of the bags and applying it to the lake.

Results from Additions of Organic Carbon Amendments

Summary: In 1999, the barley straw application at a dose of 100 pounds/lake acre (10 g/m^2) seemed to inhibit filamentous algae growth, but did not appear to reduce planktonic (open water) algae. In 2000, a barley straw dose at 200 pounds/acre reduced both filamentous and algae growth. In 2001, a barley straw dose of 240 pounds/ac dramatically improved water clarity and the same result was produced with 250 pounds/ac in 2002 and 2003. However, in 2004 using a dose of 250 pounds of barley per acre, clarity declined and chlorophyll and phosphorus concentrations increased compared to 2001, 2002, and 2003. In 2005 and 2006 years using crushed corn, water clarity has continued to decrease, but is still slightly better compared to years without barley or corn additions (1995 - 1997).

Secchi Disc Transparency: Valley Lake's average summer water transparency measurements from 1995 through 2006 are shown in Figure 3. The growing season clarity average for 1999 was similar to previous year's averages, even though barley straw at 100 pounds per acre was added to Valley Lake in early May of 1999. Transparency was greater in 2000 through 2006 compared to years without barley from 1995 through 1997.

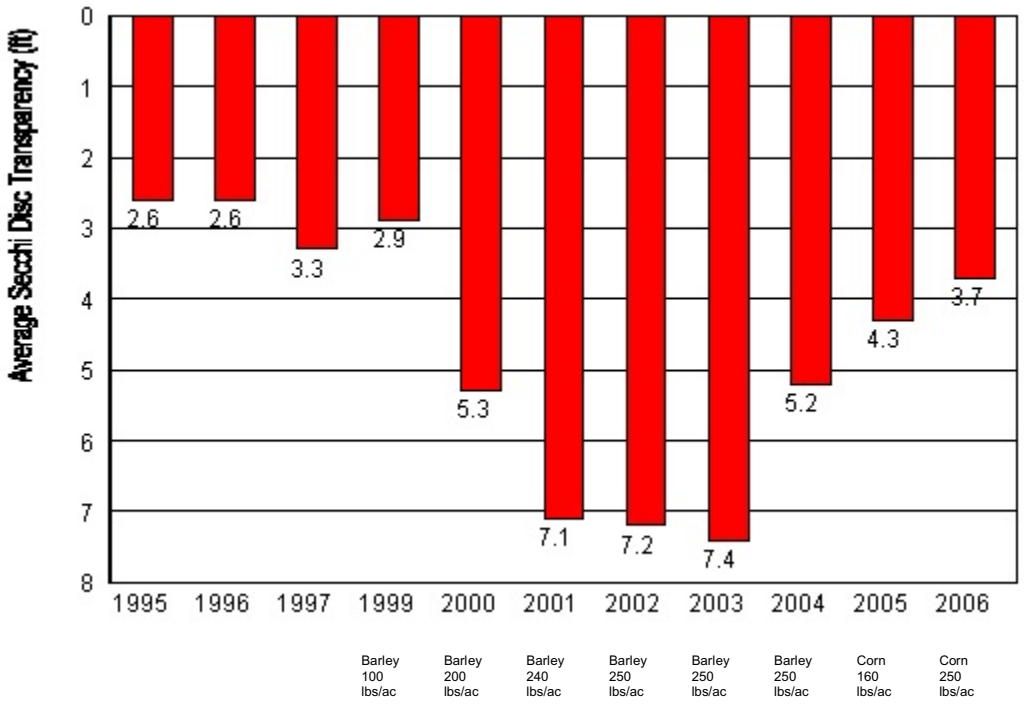
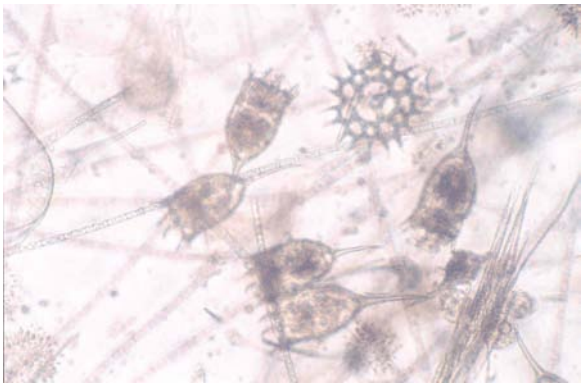


Figure 3. Valley Lake Secchi disc transparency based on growing season averages from May - September.

Algae: Valley Lake typically produced "nuisance algae blooms" over the course of the summer from 1995 through 1997. In 1999, the year with the first barley straw application of 100 pounds per acre, open water algae was actually greater then the previous years. In 2000, 2001, 2002, and 2003, the years with at least 200 pounds of barley per acre, open water algae, as measured by chlorophyll, were less compared to years without barley (Figure 4).

However, starting in 2004, a barley year, and continuing in 2005 and in 2006, both crushed corn years, chlorophyll levels have been increasing and are approaching and even exceeding the pre-barley conditions in 1995 - 1997.



Green algae and rotifers were the dominant algal species on August 31, 2006.

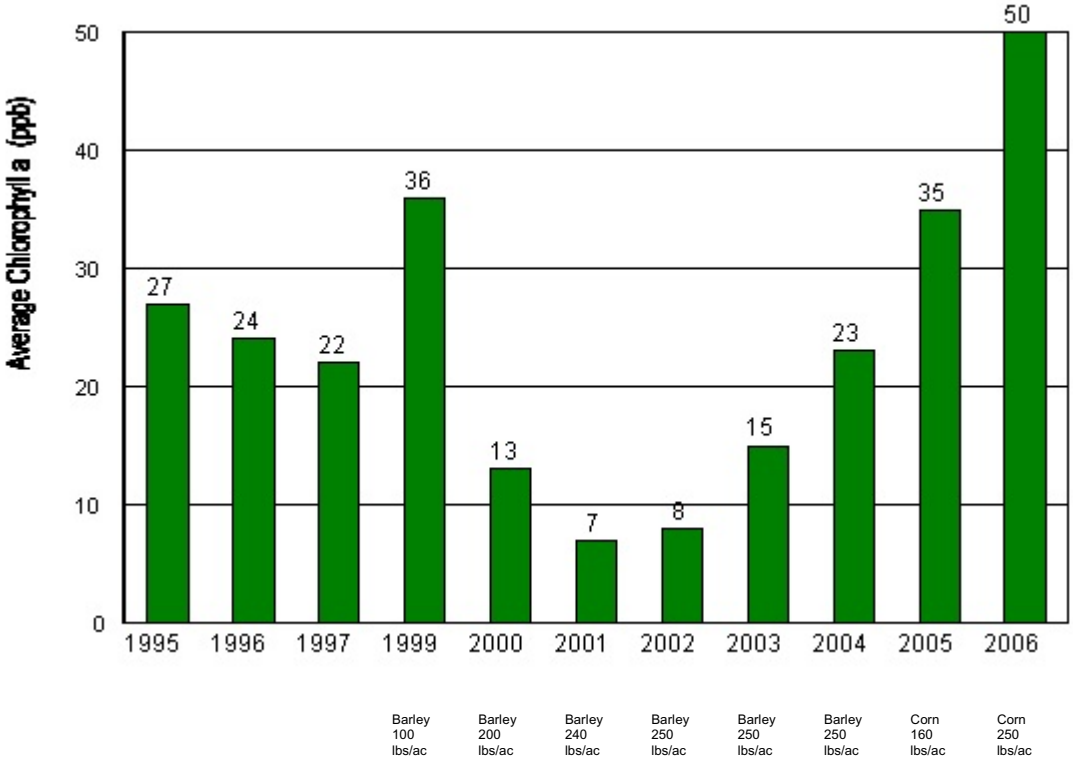


Figure 4. Valley Lake chlorophyll data.

Phosphorus: Before any significant barley or corn was added to Valley Lake, phosphorus concentrations were high averaging over 60 parts per billion (ppb) for the growing seasons of 1995, 1996, 1997, and 1999 (Figure 5).

In years 2000 - 2004, with at least 200 pounds of barley per acre, the phosphorus levels were less compared to the previous 4 years of record. In 2000, the total phosphorus growing season average was 52 and then declined further in 2001 and 2002. Phosphorus concentrations increased in 2003, 2004, and 2005 but were still below pre-barley levels.

In 2005, the first year of using crushed corn, the summer phosphorus average was comparable to the barley years of 2003 and 2004, but higher than the barley years of 2001 and 2002. The lake summer phosphorus average in 2005 was still less than the pre-barley years of 1995 - 1997. However in 2006, the second year of adding crushed corn, the summer average phosphorus concentration was high at 95 ppb.

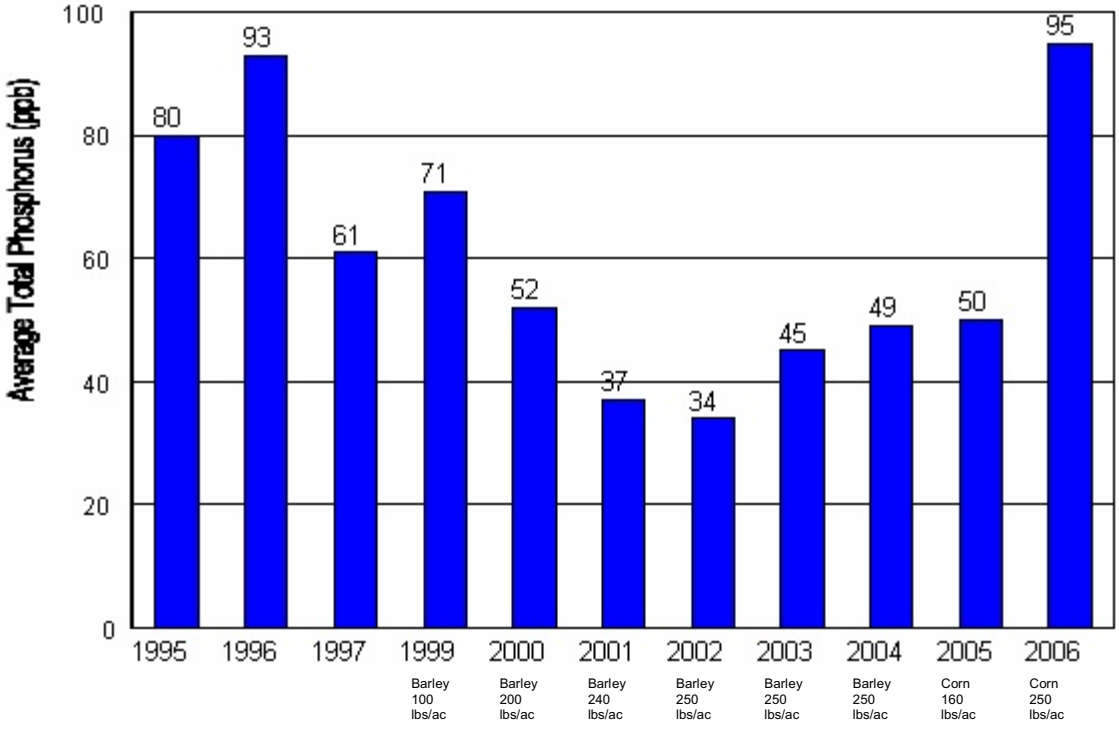


Figure 5. Valley Lake total phosphorus concentrations.

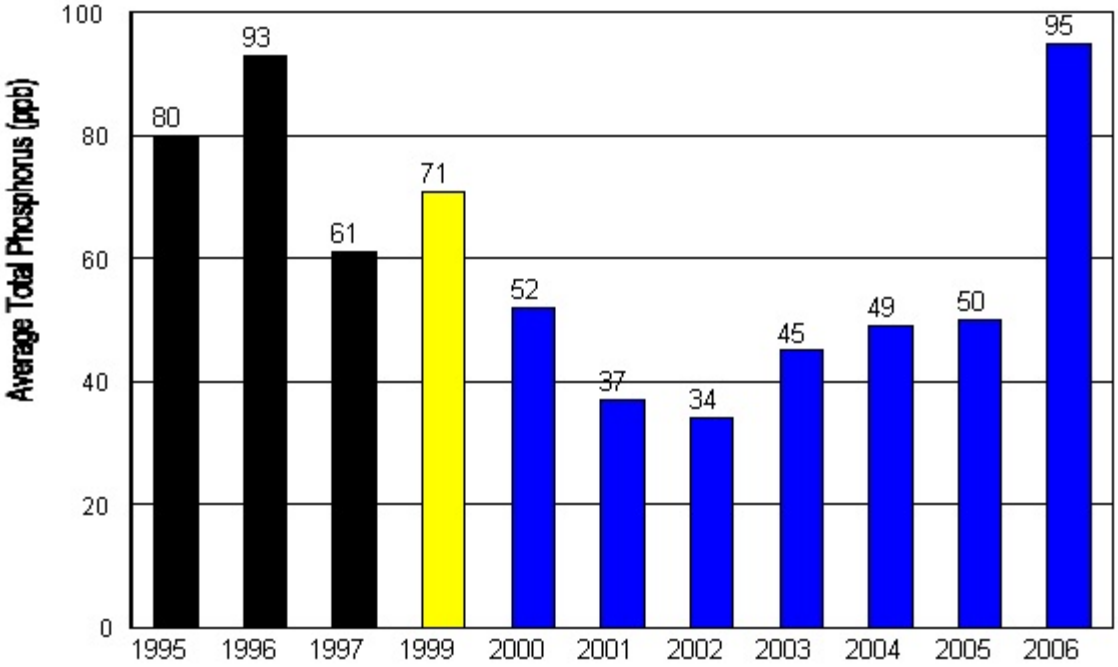
Discussion

Why Has Valley Lake Water Quality Declined in the Last Few Years? Overall, water clarity has been better in Valley Lake in years with organic carbon amendments compared to years without organic carbon amendments. For seven consecutive summers, with either a barley dose over 200 pounds/acre (5 years) or with a crushed corn addition (2 years), summer water clarity was better compared to years prior to organic carbon amendments. However, even with the carbon amendments, water clarity has been declining since 2003. Why has clarity declined in the last three years?

It is suspected than an increasing bluegill sunfish population may be responsible for the increase in phosphorus and chlorophyll and a decrease in clarity.

One of the factors leading to increased bluegill density has been fish stocking by the MnDNR coupled with bluegill spawning success and a lack of a sufficient number of predator fish. The end result is that bluegills are now very abundant in Valley Lake. The increase in bluegills correlates with an increase in lake phosphorus concentrations (Figure 5).

The results from Valley Lake fish stomach contents (unpublished) indicate there is a potential for the high fish density in Valley Lake to contribute to excessive nutrient loading which could overwhelm the effects of barley straw or corn. Results from other fish studies in lakes with installations of barley straw or its equivalent, crushed corn, found that with high densities of bluegill sunfish, their stomach contents were dominated by detritus which is primarily lake sediments. Stomach content analysis of bluegill sunfish from Valley Lake found all fish had detritus and 45% of the fish had stomach contents with greater than 50% detritus (Table 3) indicating bluegills are feeding on lake sediments.



	2000	2001	2002	2003	2004	2005	2006
Barley or Corn Dose (lbs/ac)	250	250	250	250	250	160	250
Bluegill Stocking	--	1,458	988	200	600	0	0
Cumulative Stocking	--	1,458	2,446	2,696	3,246	3,246	3,246
Stocked Fish per Acre (cumulative total)	--	182	306	337	406	406	406

Figure 5. Valley Lake fish stocking data and lake phosphorus concentrations. Black bars indicate no organic carbon amendments. The yellow bar represents a low dose of barley straw of 100 pounds per acre and the blue bars represent years with either barley or corn amendments to the lake.

For comparison, stomach contents of bluegill sunfish from Twin Lake were examined. Twin Lake has a low fish density and barley straw or corn has been effective in sustaining clear water conditions. Fish stomach contents from Twin Lake had a low percentage of detritus, with only 20% of the fish found with low amounts of detritus (less than 50% of the stomach contents)(Table 3).

It appears that in lakes with low densities of bluegills, they feed in the water column, and thus recycle existing water column phosphorus. In lakes with high densities of bluegills, they deplete food options in the water column and feed in the sediments to acquire necessary nutrition. In the process of feeding in this manner, the fish ingest sediments and excrete them as well. Therefore, sediment phosphorus is introduced into the water column that normally would have stayed in the sediments and would have been unavailable to algae. This is "new" phosphorus compared to the "recycled" phosphorus that comes from feeding on zooplankton in the water column.

Table 3. Summary of trapnet results and fish stomach contents from lakes with varying densities of fish.

		Trapnet Results (fish/net)			Bluegill Stocking (last 3 years)	Lake Water Quality (May - September)			Barley or Corn (lbs/ac)	Bluegill Stomach Contents
		Black Bullhead	Bluegill	Black Crappie		Secchi disc (m)	Total Phos (ppb)	Chl a (ppb)		
Pond 213P	2003	0	1,406	0	0	0.6	64	--	0	100% of fish with detritus (n=6)
Lee (107 pounds of fish/ac were removed prior to mid-June, 2006)	2006	--	--	--	0	1.7	79	16	barley: 350	no data
	2004	97	465	31	0	1.2	55	26	barley: 200	100% with detritus, 70% with detritus >50% (n=8)
Alimagnet	2005	50	193	16	0	0.7	113	43	corn: 160	--
Valley	2005	0	31	--	1,788	1.3	50	35	corn: 160	100% with detritus, 45% with detritus >50% (n=9)
	2001	1	7	1	1,458	2.1	37	7	barley: 240	--
Powderhorn	2005	9	30	13	2,130	1.3	91	14	barley: 360	60% with detritus, 35% with detritus >50% (n=8)
	2003	28	26	25	3,126	0.8 (1.3)*	96 (87)*	34 (33)*	0	--
	1995	96	40	30	2,552	--	128	43	0	--
Twin	2005	low	low	low	0	1.8	40	6.8	corn: 160	20% with detritus. Both fish with <50% detritus (n=10)

* seasonal averages (May-Sept) for Powderhorn when a single May date is included. This date represents extreme water improvement conditions from an alum treatment conducted several days earlier. These water quality conditions were short lived and effected the summer seasonal average.

Conclusions and Recommendations

For the seventh year in a row the use of barley straw or corn as organic carbon amendments (OCAs) improved clarity in Valley Lake compared to pre-OCA years (Figure 2)

Because of the positive impacts of organic carbon amendments on water quality, the use of crushed corn is recommended for 2007. However, in conjunction with OCA's, it is also recommended that 90 to 100 pounds of fish/acre be removed from Valley Lake (up to a total of 800 pounds) with trapnets in 2007. The netted fish could be transferred to other ponds in the metro area.

Another project area to consider is managing Eurasian watermilfoil in Valley Lake. It was first observed in August of 2005 on the east side of the lake. If dense matting occurs in 2007, it is recommended that cutting and removing the milfoil in various spots around the lake which would allow fishing from shore.

Also, an aquatic plant survey should be conducted in 2007. The last survey was in 2003, and there was abundant plant growth out to 8-feet of water depth. In the last couple of years, with more algae growth, it appears aquatic plant coverage has decreased. An aquatic plant survey would quantify this and delineate the distribution of Eurasian watermilfoil as well.

References

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Figure 8. Clear water conditions helped produce a lot of fishing interest from neighborhood youngsters.

Appendix

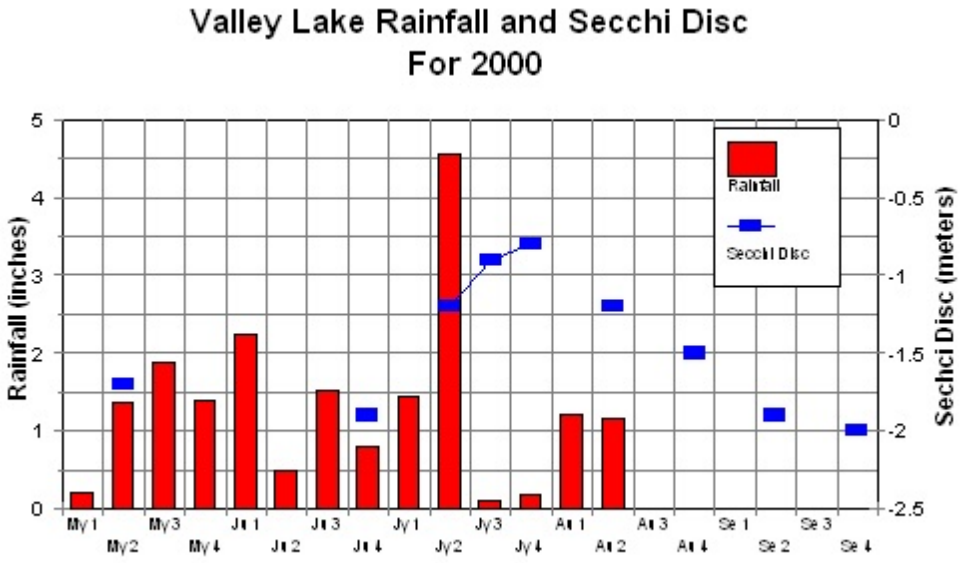
Valley Lake Water Quality Data

Secchi Disc Transparency

Table A-1. Secchi disc transparency data. Data are in meters.

		1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006
April	week 1										2.1	
	week 2								1.3	2.8		
	week 3						2.75	2.2				1.5
	week 4							2.5	1.5	2.8		
May	week 1	1.2	1.2		1.8							1.8
	week 2	0.9				1.7	2	2	1.4	2.0	1.6	
	week 3		1	1.5	1.2		2					2.2
	week 4	0.7					2	2.25	1.9	2.2	1.6	2.3
June	week 1		1.1							2.0	2.2	
	week 2	0.8	1	1.1			1.8	2	1.6			
	week 3									1.2	1.4	1.4
	week 4	0.9	1	1.0/1.0		1.9	2	2	3.4+			0.6
July	week 1	0.7			0.9					2.4	1.1	
	week 2	0.8	0.9	0.9		1.2	2	1.2	3.2+			0.9
	week 3			0.8	1.1	0.9			3.2+	1.9	1.6	
	week 4		0.6		0.8	0.8	3.5	1.8				0.6
August	week 1	0.6		0.8			2.25	2	2.7	1.6	0.6	
	week 2		0.4			1.2						0.6
	week 3	0.5/0.5		0.7			2.1	2.8	1.3	1.1	0.7	
	week 4		0.4		0.6	1.5				1.3	1.1	0.6
September	week 1	0.4	0.4	0.7			1.7	2.5	1.4			0.8
	week 2					1.9				1.4	0.9	
	week 3	0.6	0.4/0.5				2.1	2.7	1.5			0.6
	week 4	0.8			0.7			3.5	2.5	1.7	0.9	
October	week 1						1.65					0.6
	week 2								2.0	1.2	1.1	
	week 3							3.7				0.9
Growing Season Average		0.8	0.8	1	0.9	1.6	2.14	2.19	2.2+	1.6	1.3	1.1

Week 1 = 1-7 days; week 2 = 8-14 days; week 3 = 15-21 days, week 4 = 22+ days



Chlorophyll a

Table A-2. Chlorophyll a data for Valley Lake. Concentrations are shown in parts per billion.

		1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006
April	week 1										12	
	week 2								12	4		
	week 3						8	1.7				4.2
	week 4							2.1	15	9		
May	week 1	49	6.9									7.8
	week 2	6				5/17	7	6	13	5	8.1	
	week 3		11	7			6					15
	week 4	9			24		4	3.4	5.5	8	7.8	6.5
June	week 1		10			3				13	8.9	
	week 2	13	9	15			3	5.8	11			
	week 3									59	42	33
	week 4	51	45	17/22		6	3	8	6.1			140
July	week 1	33								16	68	
	week 2	35	21	17		19	3	33	5.3			64
	week 3			35		32			6.9	18	26	
	week 4		28		52	22	10	12				53
August	week 1	23		46			8	1	12	27	73	
	week 2		36		45							68
	week 3	57/50		29	25	20	21	3.4	54	40	86	
	week 4		21			1				23	35	59
September	week 1	26	27	20	48		3	3.6	29			52
	week 2									24	5.7	
	week 3	22	21/25		22		3	4.7	19			52
	week 4	14			27			4.8	6	22	53	
October	week 1											39
	week 2								6	32	28	
	week 3				10							27
Growing Season Average		27	24	22	36	13	7	8	15	23	35	50

Week 1 = 1-7 days; week 2 = 8-14 days; week 3 = 15-21 days, week 4 = 22+ days

Table A-3. Chlorophyll a concentrations related to algae blooms (MPCA 1994).

Chlorophyll a concentrations	Degree of algae bloom
0-9 µg/l	No bloom
10 - 20 µg/l	Mild bloom
21 - 29 µg/l	Nuisance bloom
30 µg/l and greater	Severe bloom

Total Phosphorus

Table A-4. Total phosphorus data. Data are in parts per billion.

		1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006
April	week 1										45	
	week 2								49	26		
	week 3				50		30	25				28
	week 4							24	40	41		
May	week 1	50	60		35							33
	week 2	30				50/80	30	34	45	37	40	
	week 3		60	40	36		40					25
	week 4	40					20	35	52	34	25	24
June	week 1		50			30				42	38	
	week 2	40	80	60			30	38	58			
	week 3									62	57	99
	week 4	80	100	60/60		50	30	36	37			211
July	week 1	80			83					63	43	
	week 2	70	80	70		90	40	31	22			147
	week 3			80	79	70			30	57	53	
	week 4		140			60	40	42				164
August	week 1	130		60			50	26	52	48	70	
	week 2		130									115
	week 3	140/150		80		50	60	31	60	54	60	
	week 4		110		112	50				50	47	85
September	week 1	100	110	60			30	28	84			74
	week 2									51	40	
	week 3	80	90/100			30		44	33			71
	week 4	80			56			30	26	34	88	
October	week 1											84
	week 2								37	28	21	
	week 3							20				74
November	week 4				64							
Growing Season Average		80	93	61	71	52	37	34	45	49	50	95

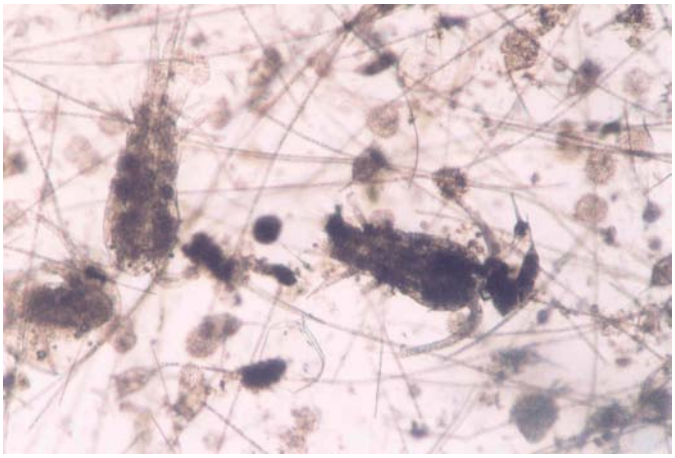
Week 1 = 1-7 days; week 2 = 8-14 days; week 3 = 15-21 days, week 4 = 22+ days

Water Quality Comparison Between Valley Lake and Valley Storm Pond

In 2005, sampling was also conducted on the Valley Storm Pond. The Valley Storm Pond is a 0.5-acre pond with a maximum depth of 6 feet and a watershed area of 105 acres. It was constructed as a stormwater treatment pond to treat stormwater before it enters Valley Lake. No barley has been installed in the Valley Storm Pond. Results for Secchi disc transparency, total phosphorus, and chlorophyll a are shown in Table 1. Over the years, the water quality in the untreated storm pond has been worse than Valley Lake. It appears without barley straw in Valley Lake, it's water quality would be worse as well.

Table 1. Valley Lake and Valley Storm Pond summer water quality averages for (May-September). Number of data points is in parenthesis.

	Secchi Disc Transparency (m)		Chlorophyll a (ppb)		Total Phosphorus (ppb)	
	Valley	Storm Pond	Valley	Storm Pond	Valley	Storm Pond
1995	0.8 (13)	--	27 (13)	--	80 (13)	--
1996	0.8 (12)	--	24 (12)	--	93 (12)	--
1997	1.0 (9)	--	22 (9)	--	61 (9)	--
1999	0.9 (7)	--	36 (7)	--	71 (6)	--
2000	1.6 (8)	--	13 (9)	--	52 (10)	--
2001	2.1 (11)	--	7 (11)	--	37 (10)	--
2002	2.2 (11)	0.6 (3)	8 (11)	48 (5)	34 (11)	103 (5)
2003	2.3 (11)	--	15 (11)	54 (11)	45 (11)	146 (11)
2004	1.6 (11)	--	23 (11)	12 (11)	49 (11)	62 (11)
2005	1.3 (11)	--	35 (11)	29 (7)	50 (11)	76 (11)
2006	1.1 (11)	--	50 (11)	--	95 (11)	--



Copepods were common on August 31, 2006 in Valley Lake.

Valley Storm Pond Data for 2005

Summer water quality data for 2005 from the Valley Storm Pond and from Valley Lake.

2005	Secchi Disc (m)		Total Phosphorus (ppb)		Chlorophyll a (ppb)	
	Valley Lake	Valley Storm Pond	Valley Lake	Valley Storm Pond	Valley Lake	Valley Storm Pond
4.6	2.1	--	45	--	12	--
4.26	--	--	--	103	--	35
5.9	1.6	--	40	140	8.1	57
5.24	1.6	--	25	60	7.8	15
6.6	2.2	--	38	74	8.9	35
6.21	1.4	--	57	68	42	30
7.5	1.1	--	43	70	68	34
7.20	1.6	--	53	72	26	21
8.2	0.6	--	70	41	73	17
8.16	0.7	--	60	16	86	--
8.29	1.1	--	47	81	35	--
9.13	0.9	--	40	54	5.7	--
9.27	0.9	--	88	125	53	--
10.10	1.1	--	21	--	28	--
May-Sept Ave	**1.3**	**--**	**50**	**76**	**35**	**29**

Barley Straw Installation Techniques: 1999-2004

1999

Figure 2. [top] In 1999, we used 38-pound barley bales and repacked them into mesh bags that originally held onions. Each bag weighed about 6 pounds.
[bottom] Pods of 6 or 8 bags were staked in Valley Lake.

2000

Figure 3. [top] In 2000, we used 600-pound barley bales and repacked the straw into mesh bags using a Christmas tree bailer.
[bottom] The barley tubes were 7 to 9 feet long and weighed up to 60 pounds.

2001

Figure 4. [top] In 2001, we purchased barley directly from a farmer who had already packed the barley into mesh bags. In the past, this barley has been used by landscapers who would break the bags open and use the straw for mulch. However the 20 pound bags worked well for installing directly into the lake intact.
[bottom] A load of 1,800 pounds of barley straw was transported to Valley Lake on May 14, 2001 using an 8' x 16' trailer.

2002

Figure 5. (top) In 2002, barley straw was delivered on pallets to Valley Lake from a farmer in Cambridge, Minnesota. Each bag weighed about 20 pounds.
(bottom) Barley bags were installed in sets of about 120 to 200 pounds in nearshore areas.

2003

Figure 6. [top] Barley straw was delivered to Valley Lake from a farm in Cambridge, Minnesota. [bottom] Twenty pound barley bags were tied together in sets of about 120 pounds.

2002 - 2004

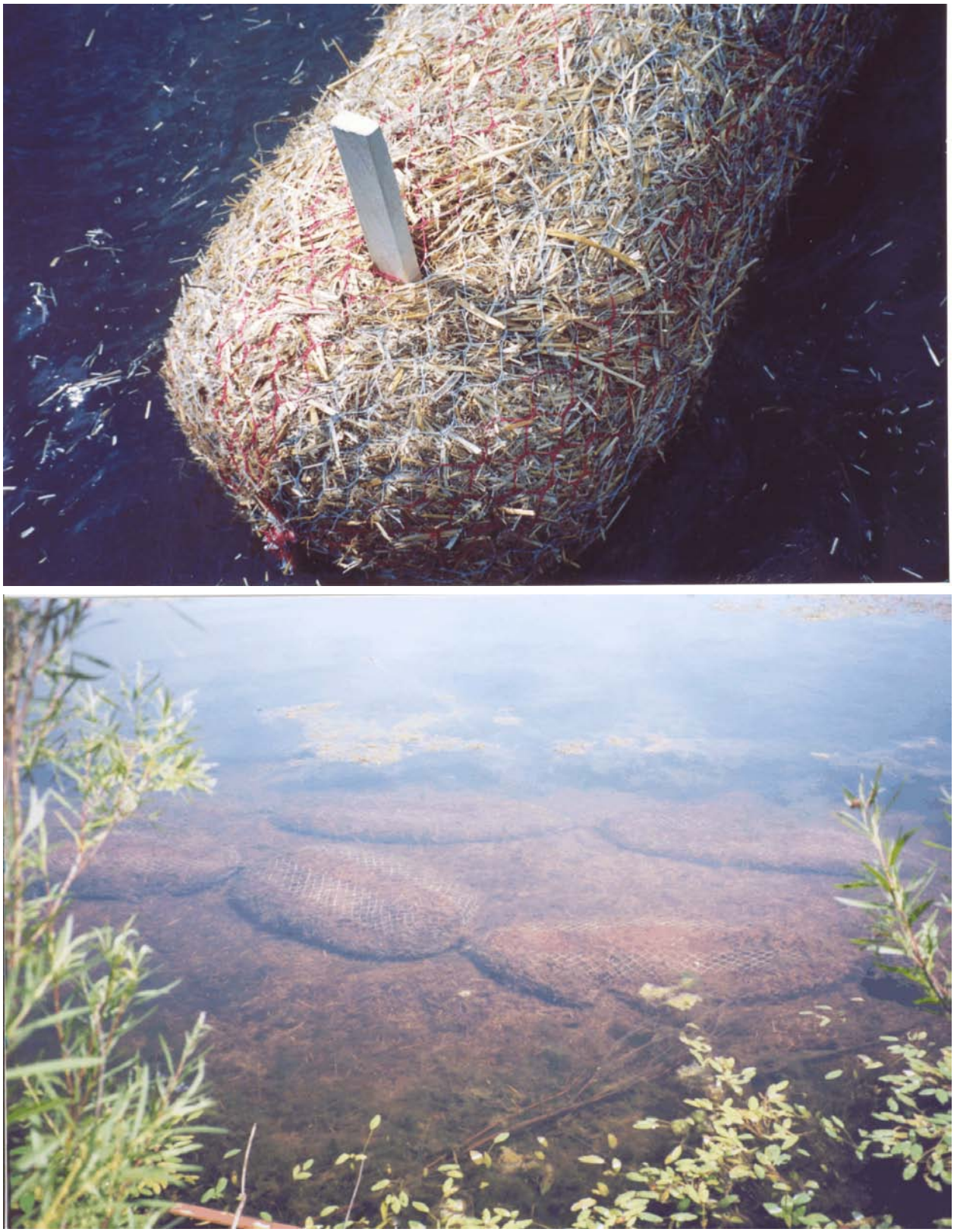
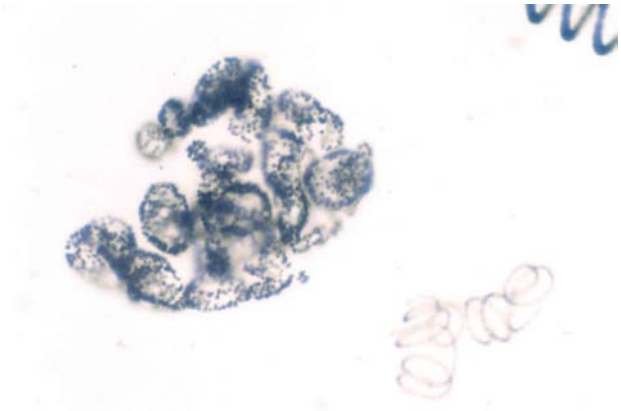


Figure 7. [top] A set was staked to the pond bottom.
[bottom] Barley bags are placed out of the way of nearshore areas. They do not appear to interfere with lake recreational activities.

Volvox was a dominant algal species on September 25, 2003 in Valley Lake.



Blue-green algae were the dominant algal species in 2004.