SILVER LAKE

BLAIR & GARFIELD TOWNSHIPS

GRAND TRAVERSE COUNTY

2007-2010 WATER QUALITY STUDIES

SILVER LAKE DATA

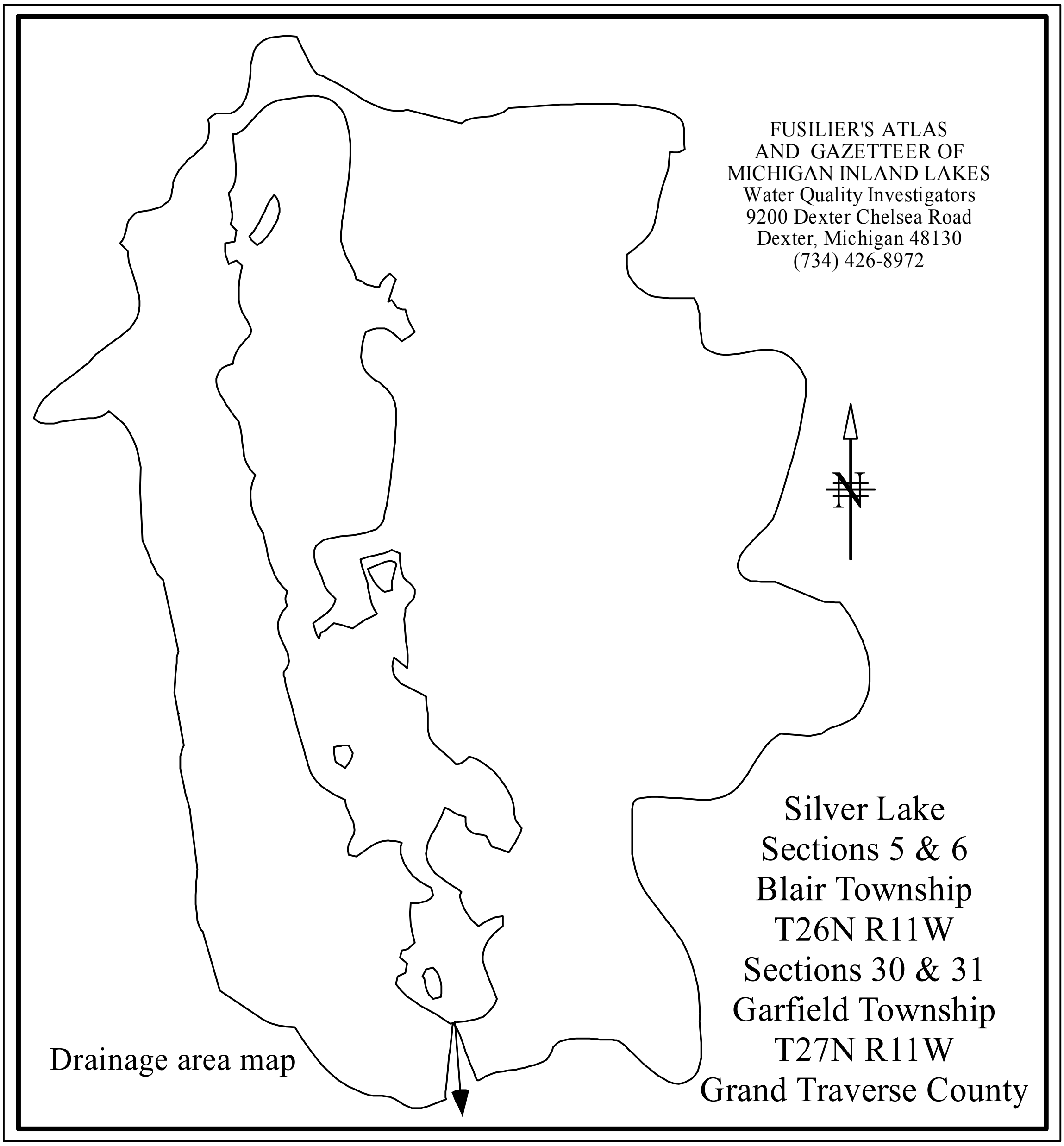
Silver Lake is a 600-acre natural moderately hard water kettle lake located in Sections 5 and 6, Blair Township (T26N R11W) and Sections 30 and 31, Garfield Township (T27N R11W) Grand Traverse County, Michigan. There are six islands in the lake totaling about 8 acres. Hence the water surface is about 592 acres. The lake has a maximum depth of 96 feet, a water volume of 13,887 acre-feet, and a mean depth of 23.4 feet. The elevation of the lake is 881 feet above sea level. The lake has 49,514 feet of shoreline, not including the shorelines of the islands.

The lake consists of several basins which were formed when blocks of ice broke off the retreating glacier. As the glacier continued to melt, debris from the melting glacier surrounded the ice blocks. Finally the ice blocks melted, forming the present lake basins, which range from 20 to 96 feet deep.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is 2362 acres. The drainage area, which includes the lake and the watershed, is 2962 acres. (See map below.) The watershed to lake ratio is 3.93 to 1 which is on the low side of normal for a Michigan inland lake. The lake flushes about once every 3.9 years, on an average.

According to Kevin McElyea, Grand Traverse County drain commissioner, an outlet and control structure was constructed on the south end of the lake.

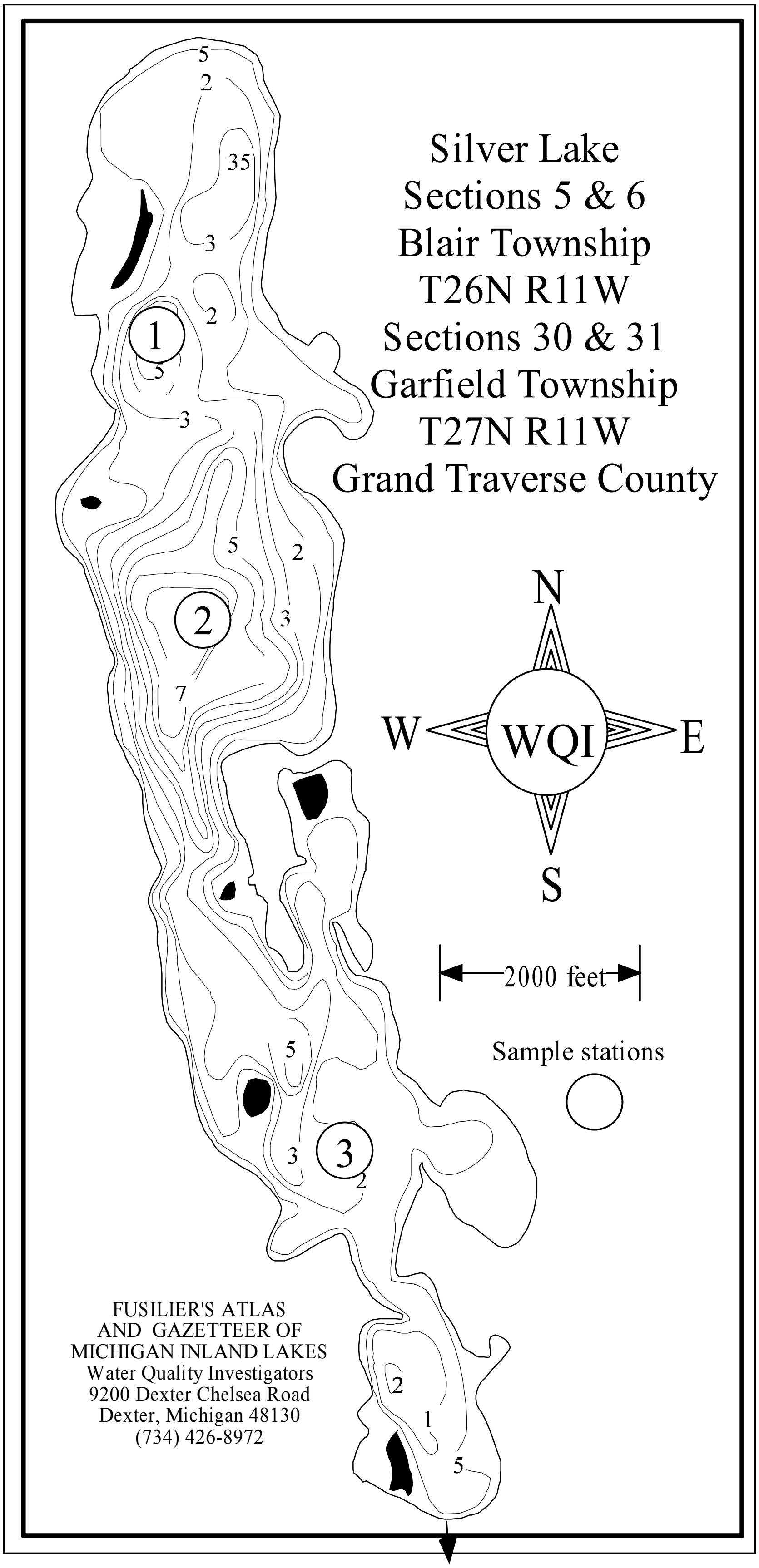
Water from the lake flows into Beitner Creek which then flows into the Boardman River. The Boardman River flows into east Grand Traverse Bay at Traverse City.



The longitude and latitude of the 96-foot deep hole is 85° 41.181W and 44° 41.818N.

THE SAMPLE STATIONS

The location of the three in-lake sample stations are shown as circles on the



hydrographic map of the lake.

THE SAMPLE DATES

WQI limnologists took three spring surface samples plus Secchi disk, temperature and dissolved oxygen concentration measurements at the sites shown on the map May 11, 2007, May 9, 2008, April 24, 2009 and April 29, 2010.

They also collected late summer surface samples at the same three stations August 1, 2007, August 19, 2008, August 18, 2009 and August 24, 2010.

Top to bottom samples for water quality testing were collected every 10 feet in the 96-foot deep hole in late summer each year.

Top to bottom temperature and dissolved oxygen profile data were collected in the 96-foot deep hole on those dates as well. Three bottom sediment samples were collected in 2007.

THE ANALYSES

The tests performed on the samples included total phosphorus, total nitrate nitrogen, total alkalinity, pH, conductivity, chlorophyll a, Secchi disk depth, and in summer, temperature and dissolved oxygen.

Temperature, dissolved oxygen and Secchi disk depths were measured in the field. Chlorophyll a, phosphorus, nitrate nitrogen, alkalinity, pH and conductivity tests were performed at the Water Quality Investigators laboratory in Dexter, Michigan. All test procedures followed those outlined in *APHA's Standard Methods for the Examination of Water and Wastewater* (1985).

THE TEST RESULTS

The results of the tests are found in the text, in the table at the end of this report and on the enclosed atlas pages.

TEMPERATURE AND DISSOLVED OXYGEN

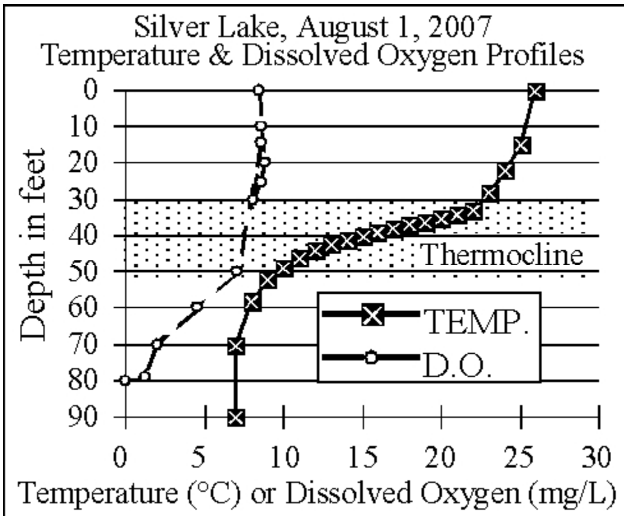
Temperature exerts a wide variety of influences on most lakes, such as the separation of layers of water (stratification), solubility of gasses and biological activity. In spring temperature generally doesn't need to be determined because we've found temperatures are low and dissolved oxygen is near saturation top to bottom at that time.

Dissolved oxygen is the test most often selected by lake scientists as being important. Besides providing oxygen for aquatic organisms, in natural lakes oxygen is involved the capture and release of various chemicals, such as iron and phosphorus.

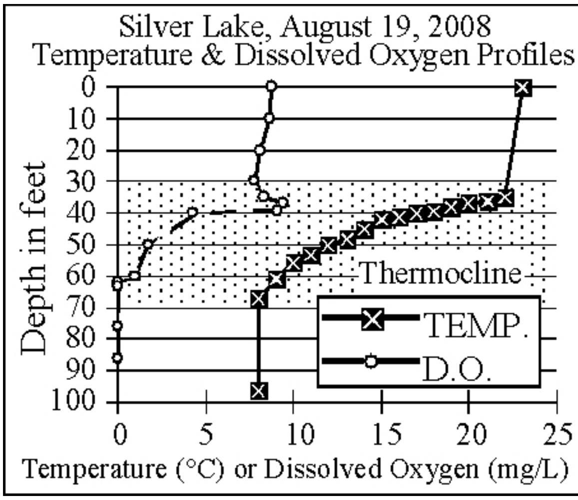
2007

In late summer 2007 Silver Lake formed a 20-foot thick thermocline from 30 to 50 feet. Dissolved oxygen concentrations were above 4 mg/L above

60 feet. The lake ran out of dissolved oxygen at 80 feet in 2007 and that condition remained to the bottom. About 2 percent of the lake is deeper than 80 feet, according to the hypsographic (depth-area) graph. The best indication of a high quality lake is dissolved oxygen below the thermocline, and Silver Lake had it to 80 feet in 2007.



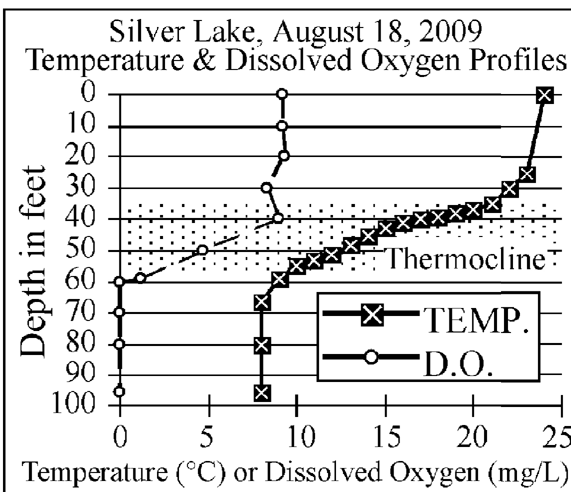
Temp.	Depth	D.O.	Depth
26	0	8.5	0
25	15	8.6	10
24	22	8.8	20
23	28	8.6	25
22	33	8.1	30
21	34	8.6	14
20	35	7.1	50
19	36	4.6	60
18	37	2.0	70
17	38	1.3	79
16	39	0.0	80
15	40		
14	41		
13	42		
12	44		
11	46		
10	49		
9	52		
8	58		
7	70		
7	90		



Temp.	Depth	D.O.	Depth
23	0	8.8	0
22	35	8.8	10
21	36	8.7	20
20	37	8.1	30
19	38	7.8	35
18	39	8.3	37
17	40	9.4	39
16	41	9.1	40
15	42	4.3	50
14	45	1.7	60
13	48	1.0	62
12	50	0.0	63
11	53	0.0	76
10	56	0.0	86
9	61	0.0	96
8	67		
8	96		

2008

In late summer 2008 the lake formed a 26-foot thick thermocline from 30 to 56 feet. Dissolved oxygen concentrations were adequate in the water above the thermocline. A small dissolved oxygen maximum occurred in the thermocline at 39 feet, probably the result of an algal bloom which settled there. Below that depth, the dissolved oxygen concentration gradually



Temp.	Depth	D.O.	Depth
24	0	9.2	0
23	25	9.2	10
22	30	9.3	20
21	35	8.3	30
20	37	9.0	40
19	38	4.7	50
18	39	1.2	59
17	40	0.0	60
16	41	0.0	70
15	43	0.0	80
14	45	0.0	96
13	48		
12	51		
11	53		
10	55		
9	59		
8	66		
8	80		
8	96		

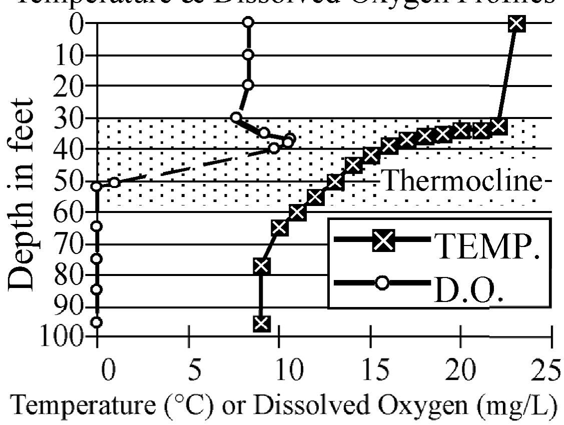
decreased. It was zero at 63 feet, and that condition remained to the bottom. About 6 percent of the lake is deeper than 63 feet.

2009

In late summer 2009 the lake formed a 20-foot thick thermocline from 35 to 55 feet. Dissolved oxygen was plentiful and uniform in the water above the thermocline. A small dissolved oxygen maximum occurred in the thermocline at 40 feet. Below that depth the concentration of dissolved oxygen gradually decreased. At 60 feet it was zero. That condition remained to the bottom at 96 feet.

2010

Silver Lake, August 29, 2010
Temperature & Dissolved Oxygen Profiles



Temp.	Depth	D.O.	Depth
23	0	8.3	0
22	33	8.3	10
21	34	8.3	20
19	35	7.7	30
18	36	9.2	35
17	37	10.6	37
16	39	10.5	38
15	42	9.8	40
14	45	1.0	51
13	50	0.0	52
12	55	0.0	65
11	60	0.0	75
10	65	0.0	85
9	77	0.0	96
9	96		

In late summer 2010 the lake formed a 15-foot thick thermocline from 30 to 45 feet. Dissolved oxygen was plentiful and uniform in the water above the thermocline. A small dissolved oxygen maximum occurred in the thermocline at 37 feet. Below that depth the concentration of dissolved oxygen decreased. At 52 feet it was zero. That condition remained to the bottom at 96 feet.

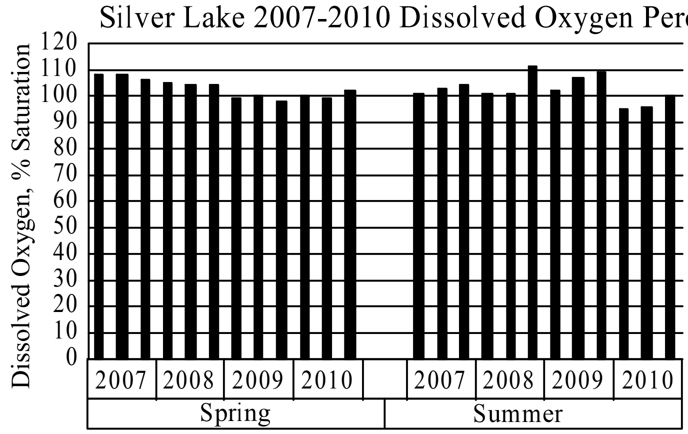
A NOTE ABOUT THE GRAPHS BELOW

The data on the following graphs are first sorted by spring and summer, then by year, then by sample station. The purpose is to detect any differences between the spring and summer samples, and differences over the years.

SURFACE DISSOLVED OXYGEN SATURATION

Because the amount of oxygen dissolved in water is temperature dependent, with cold water holding more than warm water, dissolved oxygen saturation is often a better way to determine if oxygen supplies are adequate.

The dissolved oxygen saturation graph shows both spring and summer dissolved oxygen concentrations were near saturation, which is good. Best is between 90 and 110 percent. The higher 2007 spring values were the result of gale force winds mixing the lake when it was sampled. This introduced dissolved oxygen into the water. The cause of the higher value at Station 3

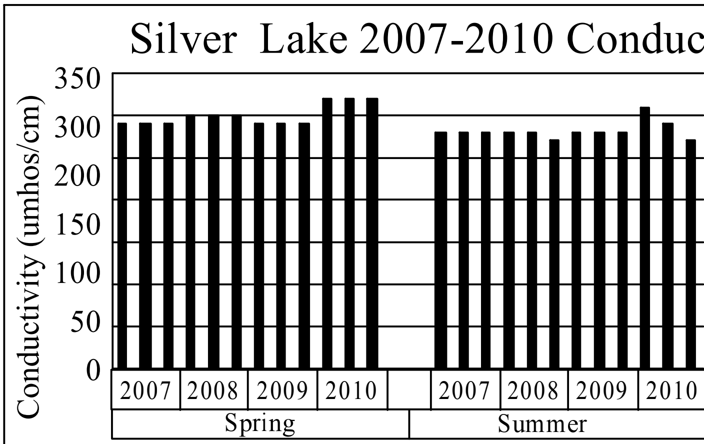


5/11/07	108	8/1/07	101
5/11/07	108	8/1/07	103
5/11/07	106	8/1/07	104
5/9/08	105	8/19/08	101
5/9/08	104	8/19/08	101
5/9/08	104	8/19/08	111
4/24/09	99	8/18/09	102
4/24/09	100	8/18/09	107
4/24/09	98	8/18/09	109
4/29/10	100	8/24/10	95
4/29/10	99	8/24/10	96
4/29/10	102	8/24/10	100

in late summer 2008 (111%) is unknown. In summer of all four years, dissolved oxygen saturation increased from north to south.

CONDUCTIVITY

Conductivity, measured with a meter, detects the capacity of a water to conduct an electric current. More importantly however, it measures the amount of materials dissolved in the water (salts), since only dissolved materials will permit an electric current to flow. Theoretically, pure water will not conduct an electric current. It is the perception of the experts that poor quality water has more dissolved materials than good quality water. I

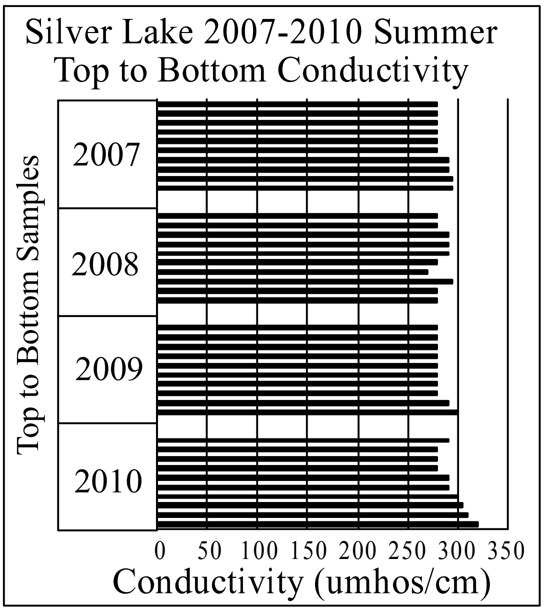


5/11/07	290	8/1/07	280
5/11/07	290	8/1/07	280
5/11/07	290	8/1/07	280
5/9/08	300	8/19/08	280
5/9/08	300	8/19/08	280
5/9/08	300	8/19/08	270
4/24/09	290	8/18/09	280
4/24/09	290	8/18/09	280
4/24/09	290	8/18/09	280
4/29/10	320	8/24/10	310
4/29/10	320	8/24/10	290
4/29/10	320	8/24/10	270

agree. Lower is usually better.

The graph shows the surface conductivity of Silver Lake ranges from 270 to 320 micromhos per centimeter. These are low conductivities for a Michigan moderately hard water inland lake. Spring 2010 values were higher than the other three years in spring.

The graph shows summer conductivities are usually less than spring conductivities. The higher spring conductivities may be the result of winter road salting operations.



TOP TO BOTTOM CONDUCTIVITIES

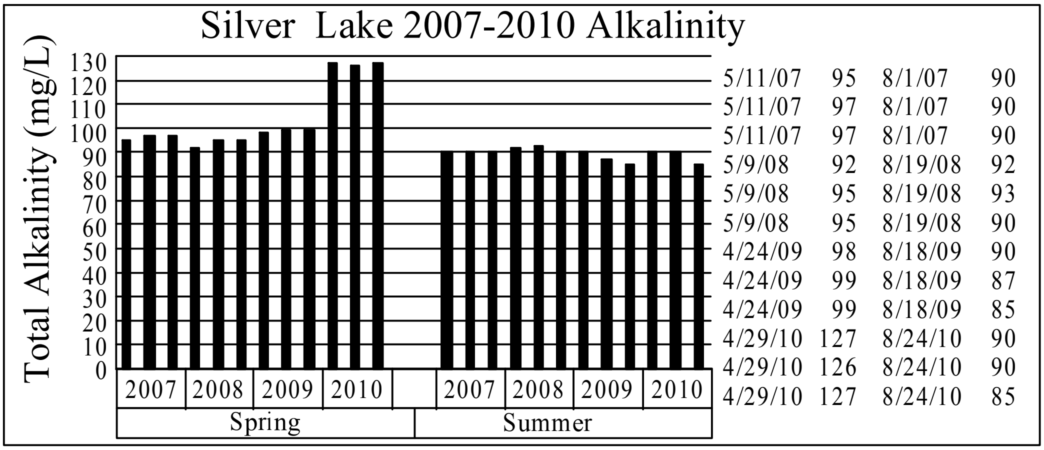
The graph of top to bottom late summer conductivities shows in 2007, 2009 and 2010 conductivities increase near the bottom, probably due to increased solubility due to pressure. This is normal for a Michigan inland lake. The 2008 data are not what we would expect to see unless the lake mixed just before it was sampled. The 2008 late summer top to bottom conductivities are much more variable than we usually see.

Had spring top to bottom conductivities been measured, they probably would have been uniform top to bottom because the lake mixed in spring.

TOTAL ALKALINITY

Alkalinity measures carbonates and bicarbonates in water. Soft water lakes have alkalinities below 75 milligrams per liter. Moderately hard water lakes have alkalinities between 75 and 150 milligrams per liter. Hard water lakes have alkalinities above 150 milligrams per liter.

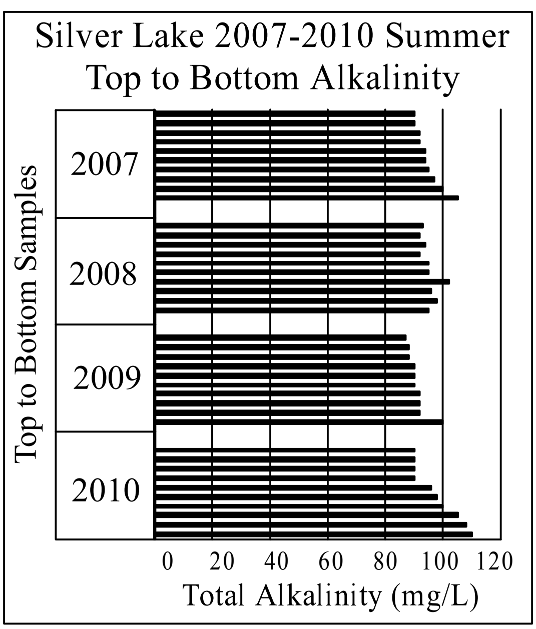
The graph shows Silver Lake surface alkalinities range from 90 to 127 milligrams per liter. This indicates Silver Lake is a moderately hard water lake, but not by a lot. The reason for the higher spring 2010 alkalinities is unknown. On the other hand, it's not a problem.



Hard water lakes are tougher than soft water lakes because they have the ability to precipitate some phosphorus to the bottom sediments as calcium phosphate.

The graph also shows spring alkalinities are higher than summer alkalinities, which is normal because carbonates and bicarbonates precipitate from the surface water to the bottom as the water warms from spring to summer.

TOP TO BOTTOM ALKALINITIES



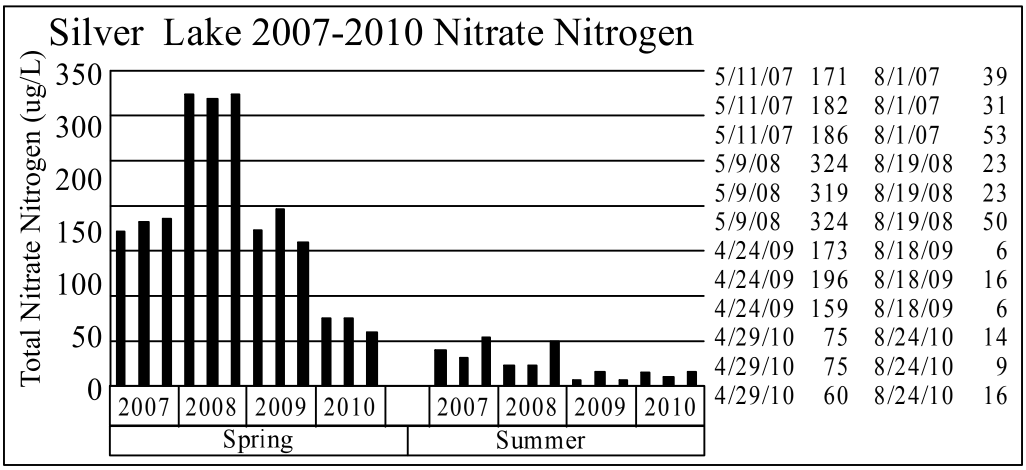
The graph of top to bottom alkalinities shows in late summer 2007, 2009 and 2010 carbonates and bicarbonates are higher near the bottom. This is because these materials precipitate from the surface water layer to the bottom as the water warms. This is normal.

Like the conductivity data, the 2008 top to bottom alkalinity data do not show a uniform increase with depth like the other data. The reason is unknown, because the lake did stratify that year.

NITRATE NITROGEN

Most Michigan inland lakes have spring nitrate nitrogen concentrations around 200 micrograms per liter (or parts per billion). Summer nitrate nitrogen concentrations are generally much lower, in the 10 to 40 microgram per liter range.

The graph shows spring surface Silver Lake nitrate nitrogen concentrations range from 159 to 196 micrograms per liter in 2007 and 2009 and from 319 to 324 ug/L in 2008. 2010 spring nitrates were lower, ranging from 60 to 75 ug/L.

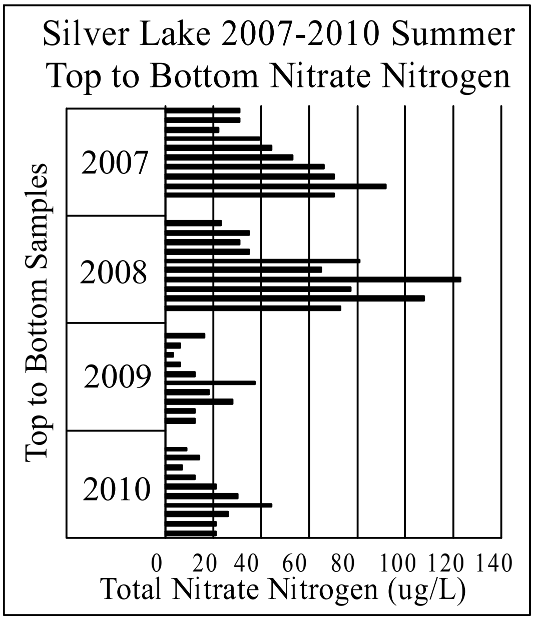


Summer nitrates are lower than spring nitrates, ranging from 6 to 53 micrograms per liter. These are normal nitrate nitrogen concentrations for a Michigan inland lake in both spring and summer.

These data indicate Silver Lake may be nitrate rather than phosphorus limited in summer. It also means no fertilizers containing either nitrogen or phosphorus should be used on near-lake areas.

LATE SUMMER TOP TO BOTTOM NITRATES

The graph of top to bottom late summer nitrates shows nitrates increase in the deeper water, The cause of the higher deep water nitrates is probably because they are left over from spring when the top to bottom nitrates were higher. The reason they remain in summer is they are not broken down by bacteria searching for oxygen to decompose algae in the lake because there

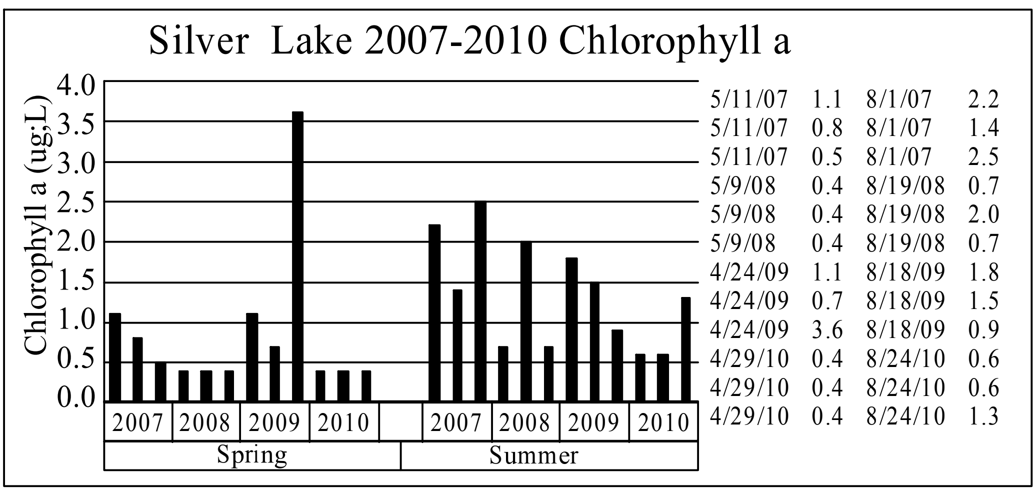


simply isn't a lot of algae in the lake. We often see these higher deep water nitrate nitrogen concentrations in high quality lakes.

CHLOROPHYLL A

Chlorophyll a, reported in micrograms per liter (or parts per billion) generally gives an estimate of algal densities. Best is below 1 ug/L.

The graph shows in spring 2007 and 2008 Silver Lake did not have a significant algal bloom in that chlorophyll a concentrations were at or below 1.1 ug/L. However Station 3 at the south end of the lake in spring 2009 had a chlorophyll a concentration of 3.6 ug/L, which was high compared to the other chlorophyll data in the lake. Spring 2010 chlorophylls were low, 0.4 ug/L at all three stations.



The lake had a small algal bloom (1.4-2.5 ug/L) in late summer 2007 and a small one at Station 2 in late summer 2008 (2.0 ug/L). In late summer 2009 chlorophyll a concentrations decreased from a high of 1.8 ug/L at Station 1 on the north end to 0.9 ug/L at the south end. In summer 2010 chlorophylls were 0.6 ug/L at Stations 1 and 2, and 1.3 ug/L at Station 3. Even then these as a group, were the lowest summer chlorophylls since we started sampling the lake.

pH (Hydrogen ion concentration) (no graph)

pH has traditionally been a measure of water quality. pH values less than 7 are acid and pH values above seven are basic. Most Michigan inland lakes have pH values between 7.5 and 8.6.

pH values for Silver Lake ranged from 7.9 to 8.5. These are normal values for a high quality Michigan inland lake.

Lakes with extensive plant communities often have high summer pH values (greater than 9) because the plants use the carbonates and bicarbonates in the water as a carbon source. This causes a decrease in the buffering capacity of the water and allows the pH to increase.

TOTAL PHOSPHORUS

Although there are several forms of phosphorus found in lakes, the experts selected total phosphorus as being most important. This is probably because all forms of phosphorus can be converted to the other forms. Currently, most lake scientists feel phosphorus, which is measured in parts per billion (1 part per billion is one second in 31 years) or micrograms per liter (ug/L), is the one nutrient which might be controlled. If its addition to lake water could be limited, the lake might not become covered with the algal communities so often found in eutrophic lakes.

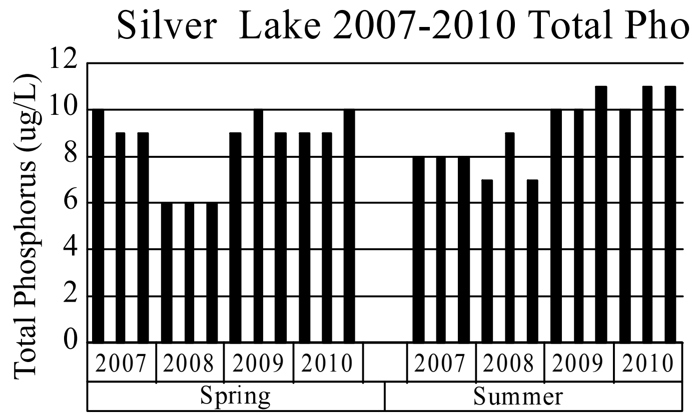
However, based on our studies of many Michigan inland lakes, we've found many lakes were phosphorus limited in spring (so don't add phosphorus) and nitrate limited in summer (so don't add nitrogen).

10 parts per billion is considered a low concentration of phosphorus in a lake and 50 parts per billion is considered a high value in a lake by many limnologists.

The graph shows Silver Lake had spring surface phosphorus concentrations of 9 or 10 micrograms per liter in 2007, 6 ug/L in 2008 and 9 or 10 ug/L in 2009 and 2010.

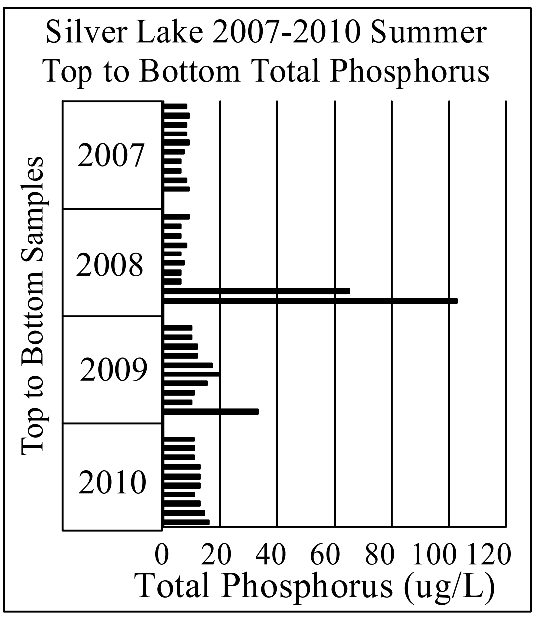
Summer surface phosphorus concentrations were 8 ug/L in 2007, 7 and 9 ug/L in 2008 and 10 or 11 ug/L in 2009 and 2010.

Best is below 10 micrograms per liter. These are very good phosphorus concentrations for a Michigan inland lake.



5/11/07	10	8/1/07	8
5/11/07	9	8/1/07	8
5/11/07	9	8/1/07	8
5/9/08	6	8/19/08	7
5/9/08	6	8/19/08	9
5/9/08	6	8/19/08	7
4/24/09	9	8/18/09	10
4/24/09	10	8/18/09	10
4/24/09	9	8/18/09	11
4/29/10	9	8/24/10	10
4/29/10	9	8/24/10	11
4/29/10	10	8/24/10	11

TOP TO BOTTOM PHOSPHORUS



The graph of top to bottom phosphorus concentrations shows they were essentially uniform top to bottom in 2007. In 2008 bottom phosphorus was high, 65 and 103 ug/L. In 2009 they were higher than the rest of the phosphorus concentrations in the water column, 33 ug/L. In 2010 phosphorus concentrations were essentially the same top to bottom.

Based on the data, it appears the lake occasionally releases phosphorus from the bottom sediments during anoxic periods, but it doesn't appear to be a serious problem, for two reasons. First, the phosphorus concentrations in the bottom water are not really high, and second, because there is such a small amount of water at the bottom of the lake.

We often see increases in phosphorus concentration near the bottom during summer anoxia. This is phosphorus released from the bottom sediments. It is an undesirable condition because it indicates a lake is starting to recycle its own nutrients. However the amount of water in Silver Lake at that depth is less than 1 percent, so the effect of these higher phosphorus concentrations is minimal.

SECCHI DISK TRANSPARENCY (originally Secchi's disk)

In 1865, Angelo Secchi, the Pope's astronomer in Rome, Italy devised a 20 centimeter (8 inch) white disk for studying the transparency of the water in the Mediterranean Sea. Later an American limnologist (lake scientist) named Whipple divided the disk into black and white quadrants which many are familiar with today.

The Secchi disk transparency is a lake test widely used and accepted by limnologists. The experts generally felt the greater the Secchi disk depth, the better quality the water. However, one Canadian scientist pointed out acid lakes have very deep Secchi disk readings. Most lakes in southeast Michigan have Secchi disk transparencies of less than ten feet. On the other hand, Elizabeth Lake in Oakland County had 34 foot Secchi disk readings in summer 1996, evidently caused by a zebra mussel invasion a couple of years earlier.

Most limnology texts recommend the following: to take a Secchi disk transparency reading, lower the disk into the water on the shaded side of an anchored boat to a point where it disappears. Then raise it to a point where it's visible. The average of these two readings is the Secchi disk transparency depth.

We do it slightly differently. We lower the disk on the shaded side of an anchored boat until the disk disappears, and note the depth, then report the depth to the next deepest foot. For example if the disk disappears at six and a half feet, we report the Secchi disk depth as 7 feet. The reason we do this is some suggest using a water telescope (a device that works like an underwater mask and eliminates water roughness) to view the disk as it disappears. Since we don't use this device, we compensate for it by noting the slightly deeper depth.

We feel it is only necessary to report Secchi disk measurements to the closest foot. Secchi disk measurements should be taken between 10 AM and 4 PM. Rough water will give slightly shallower readings than smooth water. Sunny days will give slightly deeper readings than cloudy days. However, roughness influences the visibility of the disk more than sunny or cloudy days. Furthermore, it's been reported that most adults can see the Secchi disk disappear at about the same depth, but grand-children see it disappear 3-4 feet deeper than grand-parents.

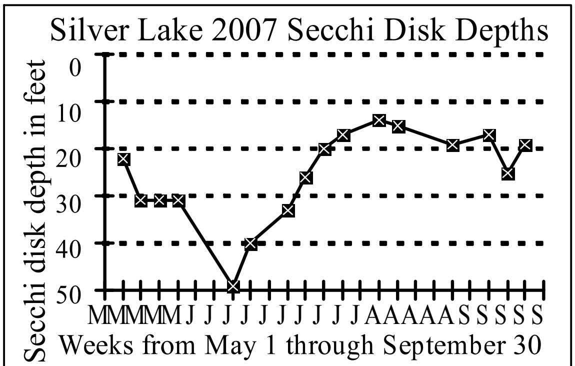
If there are sample sites where the lake is too shallow and the disk is visible when resting on the bottom, the reading should be taken at a nearby deeper site. Since the sampling procedure is designed to obtain "representative samples" moving the boat to an area where a Secchi disk transparency reading can be properly taken is appropriate. In the case of Secchi disk readings, this procedure is more valid than reporting the disk is visible on the lake bottom.

SILVER LAKE SECCHI DISK DATA

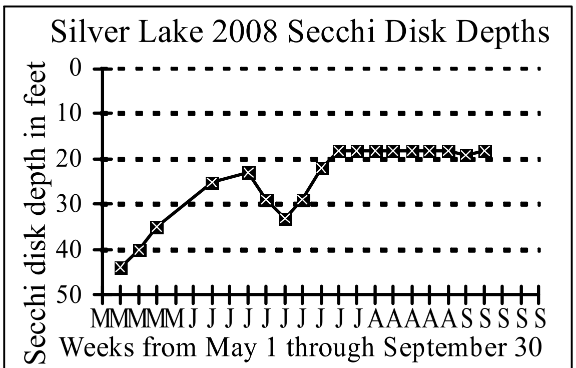
Russ Adams was able to provide Secchi disk data for both 2007 and 2008, along with data from a number of earlier years. The graphs show his 2007 and 2008 data.

2007

In 2007 the clarity in Silver Lake was 22 feet in early May, then increased to a maximum of 49 feet in mid June before gradually decreasing to between 14 and 19 feet the remainder of the warm months.



MAY	.	22	31	31	31
JUN	.	.	49	40	.
JUL	33	26	20	17	.
AUG	14	15	.	.	19
SEP	.	17	25	19	.



MAY	.	44	40	35	.
JUN	.	25	.	23	29
JUL	33	29	22	18	18
AUG	18	18	18	18	18
SEP	19	18	.	.	.

2008

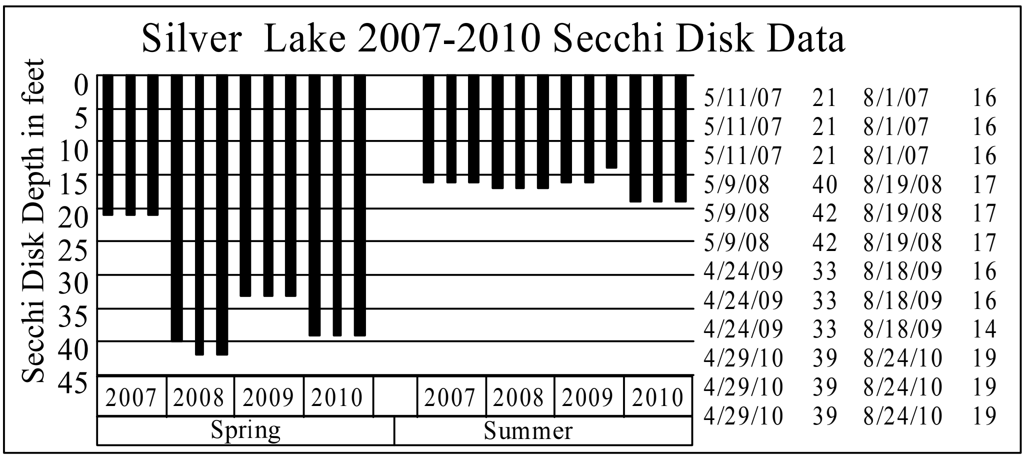
In 2008 the clarity of Silver Lake was at is best in early May, 44 feet. From that depth it gradually decreased to 23 feet the end of June, then increased to a maximum of 33 feet the first part of July. After that it decreased to 18 and 19 feet from mid-July through September.

2009 & 2010

No Secchi disk readings were collected during the warm months in 2009 or 2010 except for the ones taken with the spring and summer samples.

SECCHI DISK READINGS TAKEN WITH THE WATER SAMPLES

The graph shows the Secchi disk readings taken with the spring and summer samples.



The graph shows spring 2007 readings (21 feet) were better than summer readings (16 feet).

In spring 2008 the water clarity was 40 and 42 feet, the best this author has ever measured on a Michigan inland lake. Summer 2008 were 17 feet, which was about the same as the summer 2007 readings.

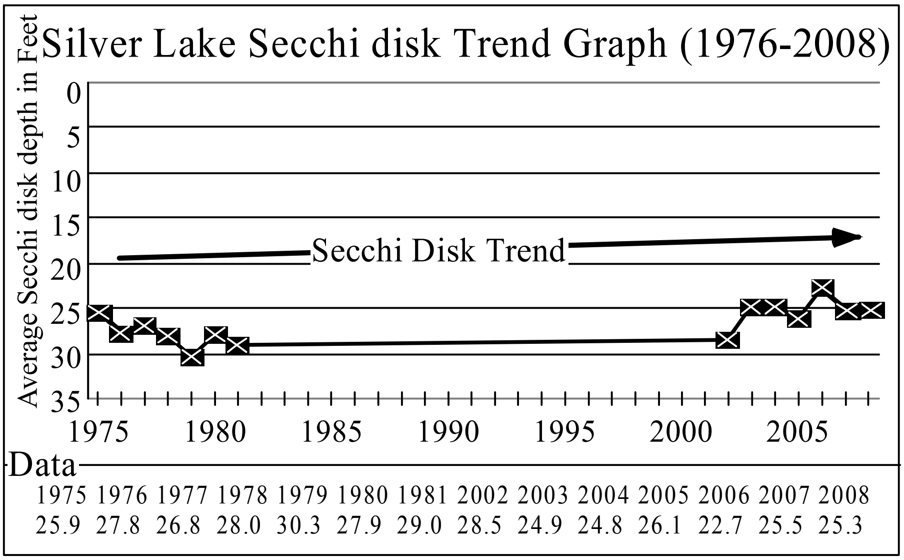
In spring 2009 Secchi disk readings were 33 feet, while the summer readings were 14 and 16 feet, about the same as the three prior summer data sets.

Spring 2010 Secchi disk readings were 39 feet, which is very good. Summer readings were 19 feet, which is very good for the clarity of a Michigan inland lake in summer.

THE SECCHI DISK TREND GRAPH

Because Ralph Bednarz (MDEQ) and Russ Adams provided us with earlier Secchi disk data we were able to construct a Secchi disk Trend graph.

Although a number of years of data are missing (1992-2001 and 2009-2010), the graph still shows the clarity of Silver Lake is slowly decreasing over time. However, they are still very good and better than most Michigan inland lakes. Secchi disk readings should be taken on a regular basis through the warm months every year to follow what is happening in the lake.



THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Silver Lake was developed for two reasons. First, there was no agreement among lake scientists regarding which tests should be used to define the water quality of lakes, and second, there was no agreement among lake scientists regarding what the results of various tests meant in terms of lake water quality.

Development of the index invoked the use of two questionnaires sent to a panel of 555 lake scientists who were members of the American Society of Limnology and Oceanography. The panel was specifically selected because they were chemists and biologists with advanced degrees who studied lake water quality.

The first questionnaire asked the scientists to choose tests which they felt should be used to define lake water quality. The tests most often selected by the panel became the index parameters (or tests). They were:

Dissolved oxygen (percent saturation)
Total phosphorus
Chlorophyll a
Secchi disk depth
Total nitrate nitrogen
Total alkalinity
Temperature
Conductivity
pH

The second questionnaire, sent out after the first was returned, asked the scientists what the results of the tests they selected as good indicators of lake water quality meant.

After the responses to the second questionnaire were returned and tabulated, the nine parameters and the accompanying rating curves were combined into a Lake Water Quality Index.

The index ranges from 1 to 100 and rates lakes about the same way professors rate students: 90-100=A, 80-90=B, 70-80=C, 60-70=D, and below 60 = E. The lake with the highest LWQI was Long Lake in Grand Traverse County, with a spring LQWI of 100. The lowest was 16 at an Ottawa County lake.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

The Lake Water Quality Index calculation sheets which follow were developed to show graphically what the results of the nine different lake water quality tests mean in terms of lake water quality.

HOW TO READ THE LAKE WATER QUALITY INDEX CALCULATION SHEETS.

Listed across the top of the calculation sheets are the tests selected by the Panel of experts as being good indicators of lake water quality. The results of the tests are entered into the square boxes immediately under the names of the tests.

The figures which look like thermometers are actually graphs which convert the test results (the numbers found outside the thermometer) to a uniform 1-100 lake water quality rating (found inside the thermometer).

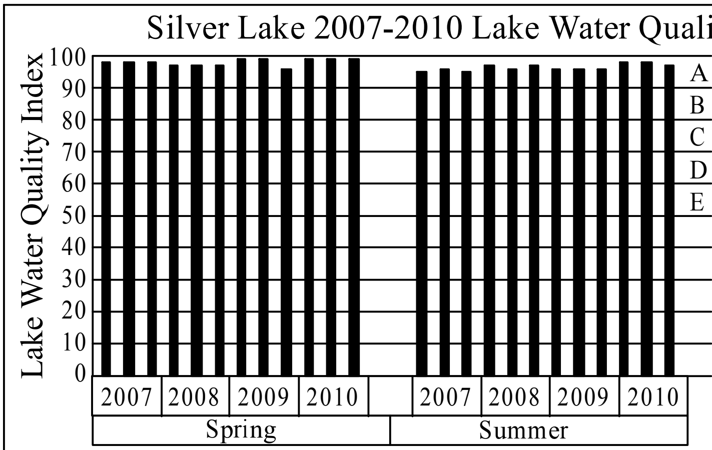
The calculation sheet permits calculation of the Lake Water Quality Index, using the results of all nine lake water quality tests.

The position of the red lines across the thermometer indicates how the results of each test compare in terms of lake water quality. Test results indicating excellent water quality are indicated by red lines near the top of the thermometer. Test results indicating poor water quality are indicated by red lines lower on the thermometer. And the lower the red line on the thermometer, the greater the water quality problem. A glance at the top of the calculation sheet indicates the test and the actual test results.

The thermometer rating scales also allow you to determine what test results would be considered excellent in terms of lake water quality. They are the numbers found outside the thermometer near the top.

The index is shown three different ways, as a number between 1 and 100 in the circle marked LWQI, and by a color and position on the sheet edge scale. The purpose of the sheet edge scale is to review quickly large numbers of lakes or test sites within a lake, and determine how the water quality of the various lakes, or test sites within a lake compare.

THE LAKE WATER QUALITY INDICES FOR SILVER LAKE



5/11/07	98	8/1/07	95
5/11/07	98	8/1/07	96
5/11/07	98	8/1/07	95
5/9/08	97	8/19/08	97
5/9/08	97	8/19/08	96
5/9/08	97	8/19/08	97
4/24/09	99	8/18/09	96
4/24/09	99	8/18/09	96
4/24/09	96	8/18/09	96
4/29/10	99	8/24/10	98
4/29/10	99	8/24/10	98
4/29/10	99	8/24/10	97

The graph shows the spring 2007 Lake Water Quality Indices for Silver Lake were 98 at all three stations, or in the A range.

It shows summer 2007 LWQIs were 95 or 96, again in the A range.

In 2008 the LWQIs in both spring and summer were 96 or 97, or in the A range.

In 2009 spring LWQIs were 99 or 96, while in summer, they were all 96, again in the A range in both spring and summer.

In 2010 spring LWQIs were all 99, while in summer, they were 97 or 98, again in the A range in both spring and summer. The graph shows the 2010 LWQIs for Silver Lake were as a group, the highest since we started studying the lake. That's a plus. Let's hope this trend continues

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the spring and summer Lake Water Quality Indices in 2010 were similar, only two Lake Water Quality Index calculation sheets are included in this report, one for the three spring 2010 surface samples, using averaged data, and a second for the three summer 2010 surface samples, using averaged data.

In the report marked MASTER, all 6 of the LWQI calculation sheets are included. That is the only difference between the MASTER and the rest of the reports.

BOTTOM SEDIMENTS

Many times bottom sediments tell us more about what is happening in a lake than the water quality tests do. That's because bottom sediments provide sort of a history of what's been happening in a lake, while water testing just provides a snapshot.

Bottom sediments are collected with a Pederson dredge, transferred to pint freezer containers and allowed to air dry. Once they are dry, the (usually) shrunken block of material is measured to determine volume, then ground, placed in porcelain dishes, dried at 100 degrees C, weighed, burned at 550 degrees C, and weighed again. Color after air-drying and after burning is also noted.

Bottom sediments almost always come up from the lake bottom black, and many people consider these black sediments "muck". However that's not usually the case.

The bottom sediments are black because no oxygen penetrates them, so the decomposition processes which occur use sulfur rather than oxygen, and in this process, they produce iron sulfides, which are black. However once the sediments are exposed to air, they usually turn some other color.

If the sediments remain black after air drying it usually means they are less than about 65 percent mineral (or more than 35% organic material). Sediments also remain black if they are from soft water lakes, but there's a reason for that.

If the sediments turn gray after air drying it usually means they are made up primarily of carbonates. This is what we usually see in moderately hard water and hard water lakes.

If the sediments turn tan, it usually means they are made up primarily of clays. Further evidence of this occurs when we burn the sediments at 550 degrees C.

We determine how much bottom sediments shrink when they air dry because this information is useful when considering dredging a lake. Normal shrinkage after air-drying is in the range of 50 to 80 percent. However sands and gravels don't shrink at all. Excessive shrinkage is more than 95 percent. In other words, there is only five percent or less of the material remaining after air-drying.

If the gray bottom sediments remain gray after burning they are considered carbonates and bicarbonates, and the loss of material during this process is considered organic material. The results are expressed in the percentage of minerals in the bottom sediments.

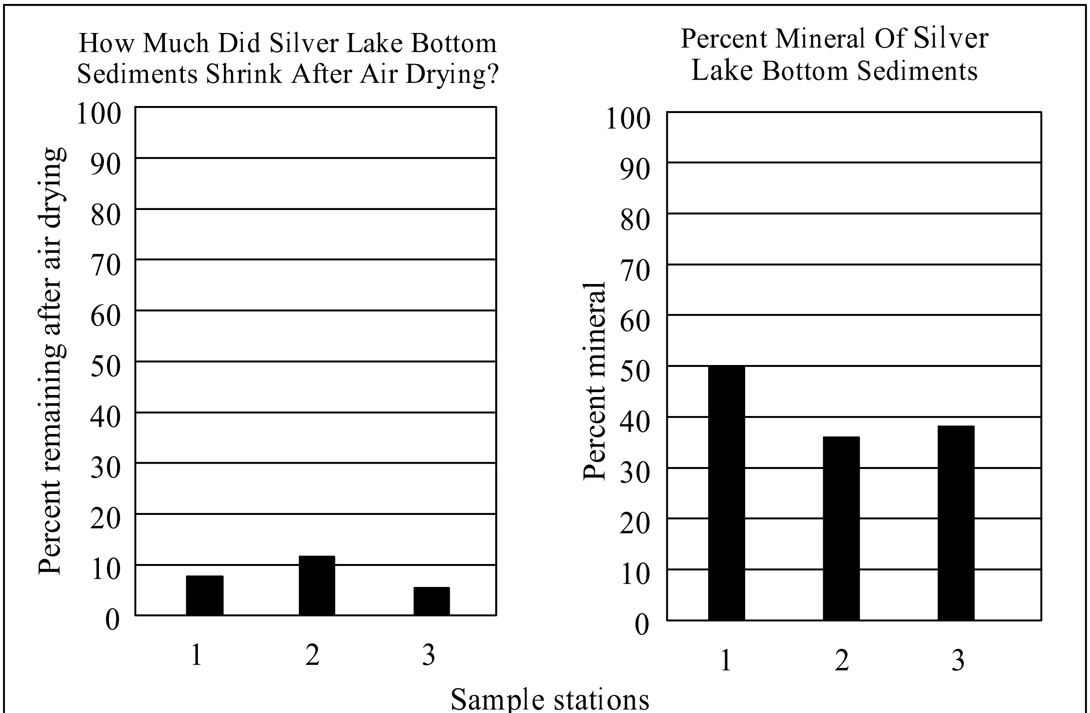
If the tan bottom sediments turn red after burning, it means the lake is filling with clay. Clay enters the lake from near-lake activities such as road building, home building or farming. Usually clay is not a material that makes up the bottom sediments of most inland lakes.

Highly organic sediments that remained black after air drying usually turn tan after burning, but the mineral content is usually quite low.

I consider high quality bottom sediments from natural lakes to be above 85 percent mineral. And I consider bottom sediments less than 50 percent mineral to be muck.

SILVER LAKE BOTTOM SEDIMENTS

Bottom sediment samples were collected on Silver Lake in late summer 2007. The graph shows the data.



Characteristics of Silver Lake Bottom Sediments (2007)					
Sample I.D.	Percent Shrinkage	Percent Mineral	Dried at 100°C Color & Description	Color after burning at 550°C	Depth of water (feet)
1	92	50	Black	Red	50
2	88	36	Black	Red	90
3	95	39	Black	Red	16
Average mineral content of bottom sediments = 42%.					

The sample from Station 1, collected in 50 feet of water was black when retrieved, remained black after air drying, shrunk 92 percent, and was 50 percent mineral and red in color after burning at 550 degrees C.

The sample from Station 2, collected in 90 feet of water was black when retrieved, remained black after air drying, shrunk 88 percent, and was 36 percent mineral and red in color after burning at 550 degrees C.

The sample from Station 3, collected in 16 feet of water was black when retrieved, remained black after air drying, shrunk 95 percent, and was 39 percent mineral and red in color after burning at 550 degrees C.

These data indicate the sediments are highly organic. This may be because the lake is just barely a moderately hard water lake, hence not a lot of carbonates and bicarbonates are in the water, or it may be because organic material is being produced faster than the lake can decompose it.

The red color after burning at 550 degrees C indicates the presence of clay, which as noted above is not a normal constituent of lake bottom sediments. Clays usually come from farming, road building or home building activities.

It is unusual to see a moderately hard water lake with plentiful supplies of dissolved oxygen below the thermocline in late summer, and highly organic bottom sediments.

Wallace E. Fusilier, Ph.D.
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Water Quality Investigators
Dexter, Michigan
February 2011

Silver Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen (mg/L)	Dissolved Oxygen Percent Saturation	Chlorophyll a ug/L	Secchi Disk Depth (feet)	Total Nitrate Nitrogen ug/L	Alkalinity mg/L	pH	Conductivity umhos per cm at 25°C	Total Phosphorus ug/L	Lake Water Quality Index	Grade
5/11/07	1	15	10.9	108	1.1	21	171	95	8.3	290	10	98	A
5/11/07	2	15	10.9	108	0.8	21	182	97	8.2	290	9	98	A
5/11/07	3	17	10.2	106	0.5	21	186	97	8.2	290	9	98	A
8/1/07	1	26	8.3	101	2.2	16	39	90	8.5	280	8	95	A
8/1/07	2	26	8.5	103	1.4	16	31	90	8.5	280	8	96	A
8/1/07	3	26	8.6	104	2.5	16	53	90	8.4	280	8	95	A
5/9/08	1	12	11.3	105	0.4	40	324	92	8.1	300	6	97	A
5/9/08	2	12	11.2	104	0.4	42	319	95	7.9	300	6	97	A
5/9/08	3	12	11.2	104	0.4	42	324	95	8.0	300	6	97	A
8/19/08	1	23	8.8	101	0.7	17	23	92	8.4	280	7	97	A
8/19/08	2	23	8.8	101	2.0	17	23	93	8.3	280	9	96	A
8/19/08	3	24	9.5	111	0.7	17	50	90	8.4	270	7	97	A
4/24/09	1	8	11.8	99	1.1	33	173	98	8.2	290	9	99	A
4/24/09	2	8	11.9	100	0.7	33	196	99	8.1	290	10	99	A
4/24/09	3	8	11.7	98	3.6	33	159	99	8.1	290	9	96	A
8/18/09	1	24	8.7	102	1.8	16	6	90	8.3	280	10	96	A
8/18/09	2	24	9.2	107	1.5	16	16	87	8.3	280	10	96	A
8/18/09	3	24	9.4	109	0.9	14	6	85	8.3	280	11	96	A
4/29/10	1	11	11.1	100	0.4	39	75	127	8.2	320	9	99	A
4/29/10	2	11	11.0	99	0.4	39	75	126	8.1	320	9	99	A
4/29/10	3	12	11.3	102	0.4	39	60	127	8.2	320	10	99	A
8/24/10	1	22	8.2	95	0.6	19	14	90	8.3	310	10	98	A
8/24/10	2	13	8.3	96	0.6	19	9	90	8.3	290	11	98	A
8/24/10	3	23	8.7	100	1.3	19	16	85	8.3	270	11	97	A
Top to bottom data													
8/1/07	2-0	26	8.5	103	1.4	16	31	90	8.5	280	8	96	A
8/1/07	2-10	26	8.6	106	---	---	31	90	8.5	280	9	---	---
8/1/07	2-20	24	8.8	106	---	---	22	92	8.5	280	8	---	---
8/1/07	2-30	23	8.1	94	---	---	39	92	8.4	280	8	---	---
8/1/07	2-40	15	8.8	87	---	---	44	94	8.2	280	9	---	---
8/1/07	2-50	10	4.2	37	---	---	53	94	8.1	280	7	---	---
8/1/07	2-60	8	4.6	11	---	---	66	95	8.0	290	6	---	---
8/1/07	2-70	7	2.0	0	---	---	70	97	7.8	290	6	---	---
8/1/07	2-80	7	0.0	0	---	---	92	100	7.8	295	8	---	---
8/1/07	2-90	7	0.0	0	---	---	70	105	7.8	295	9	---	---
8/19/08	2-0	23	8.8	101	2.0	17	23	93	8.3	280	9	96	A
8/19/08	2-10	23	8.8	101	---	---	35	92	8.4	280	6	---	---
8/19/08	2-20	23	8.7	100	---	---	31	94	8.3	290	6	---	---
8/19/08	2-30	23	8.1	93	---	---	35	92	8.4	290	8	---	---
8/19/08	2-40	17	9.1	94	---	---	81	95	8.2	290	6	---	---
8/19/08	2-50	12	4.3	40	---	---	65	95	8.3	280	7	---	---
8/19/08	2-60	10	1.7	15	---	---	123	102	7.9	270	6	---	---
8/19/08	2-70	8	0	0	---	---	77	96	8.1	295	6	---	---
8/19/08	2-80	8	0	0	---	---	108	98	7.9	280	65	---	---
8/19/08	2-90	8	0	0	---	---	73	95	8.2	280	103	---	---
8/18/09	2-0	24	9.2	107	1.5	16	16	87	8.3	280	14	96	A
8/18/09	2-10	24	9.2	107	---	---	6	88	8.1	280	10	---	---
8/18/09	2-20	24	9.3	108	---	---	3	88	8.4	280	12	---	---
8/18/09	2-30	22	8.3	94	---	---	6	90	8.4	280	12	---	---
8/18/09	2-40	17	9	93	---	---	12	90	8.1	280	17	---	---
8/18/09	2-50	13	4.7	42	---	---	37	90	8.0	280	20	---	---
8/18/09	2-60	9	0	0	---	---	18	92	7.9	280	15	---	---
8/18/09	2-70	8	0	0	---	---	28	92	7.8	280	11	---	---
8/18/09	2-80	8	0	0	---	---	12	92	7.8	290	10	---	---
8/18/09	2-90	8	0	0	---	---	12	100	7.7	300	33	---	---
8/24/10	2-0	13	8.3	96	0.6	19	9	90	8.3	290	11	98	A
8/24/10	2-10	13	8.3	96	---	---	14	90	8.4	280	11	---	---
8/24/10	2-20	13	8.3	98	---	---	7	90	8.3	280	11	---	---
8/24/10	2-30	13	7.7	89	---	---	12	90	8.4	280	13	---	---
8/24/10	2-40	16	9.8	98	---	---	21	96	8.2	290	13	---	---
8/24/10	2-50	13	9.8	92	---	---	30	98	8.1	290	13	---	---
8/24/10	2-60	11	0.0	0.0	---	---	44	100	7.9	300	11	---	---
8/24/10	2-70	10	0.0	0.0	---	---	26	105	7.8	305	13	---	---
8/24/10	2-80	9	0.0	0.0	---	---	21	108	7.6	310	14	---	---
8/24/10	2-90	9	0.0	0.0	---	---	21	110	7.6	320	16	---	---