LOTUS LAKE

WATERFORD & INDEPENDENCE TOWNSHIPS

OAKLAND COUNTY

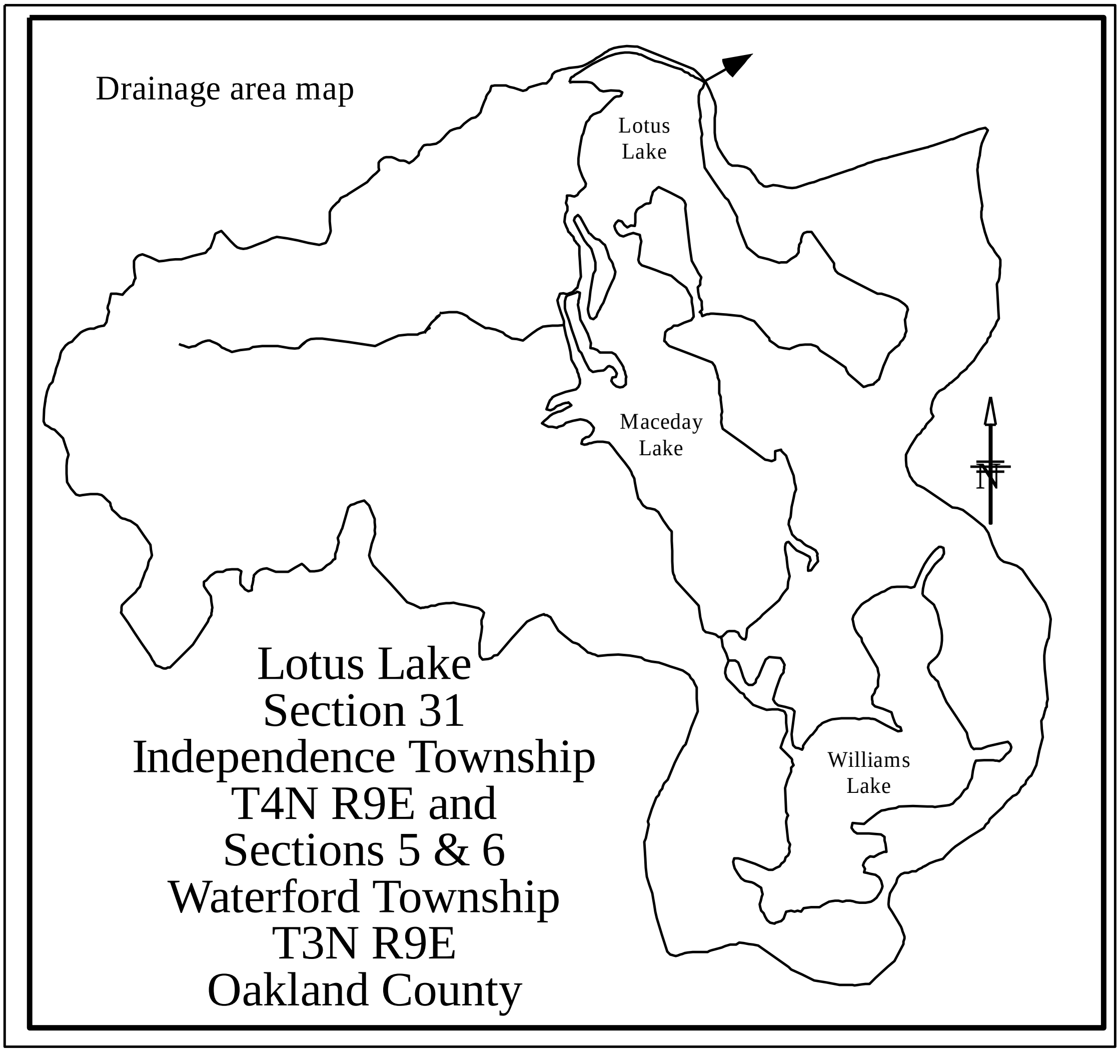
1990, 2000 & 2010 WATER QUALITY STUDIES

LOTUS LAKE DATA

Lotus Lake is a 211-acre natural hard-water kettle lake located in Section 31, Independence Township (T4N R9E) and Sections 5 and 6, Waterford Township (T3N R9E) Oakland County, Michigan. There are several islands in the lake totaling 2 acres, so the surface area is 209 acres. It is connected to Maceday Lake through a shallow canal on the north end. Tree stumps in this area indicate the lake was several feet lower in the recent past than it is now. The level was probably raised when the dam was installed in Waterford to create Van Norman Lake, probably known as the Waterford millpond at that time. Lotus Lake consists of two basins separated by a shallow shelf about four feet deep. The north west basin has a maximum depth of about 40 feet and the southeast basin has a maximum depth of 67 feet. The lake has a maximum depth of 67 feet, a water volume of 3787 acre-feet, and a mean depth of 18.2 feet.

Lotus Lake has 22075 feet of shoreline, not including the shorelines of the islands. The elevation of the lake is 966 feet above sea level. The lake is in the Clinton River basin.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake is large, 2363 acres. The drainage area, which includes the lake and the watershed, is 2574 acres (See map below). The watershed to lake ratio is 11.2 to 1, which is on the high side of normal for a Michigan inland lake. The lake flushes about once every 1.76 years, on an average. The longitude and latitude of the 67-foot deep hole is 83° 25.202W and 42° 41.580N.



THE SAMPLE DATES

In 1990 WQI limnologists took ten surface samples plus Secchi disk readings at the sites shown on the map and top to bottom samples every ten feet in the 67-foot deep hole on March 28th and August 24th. Bottom sediments were also collected at the ten sites in spring.

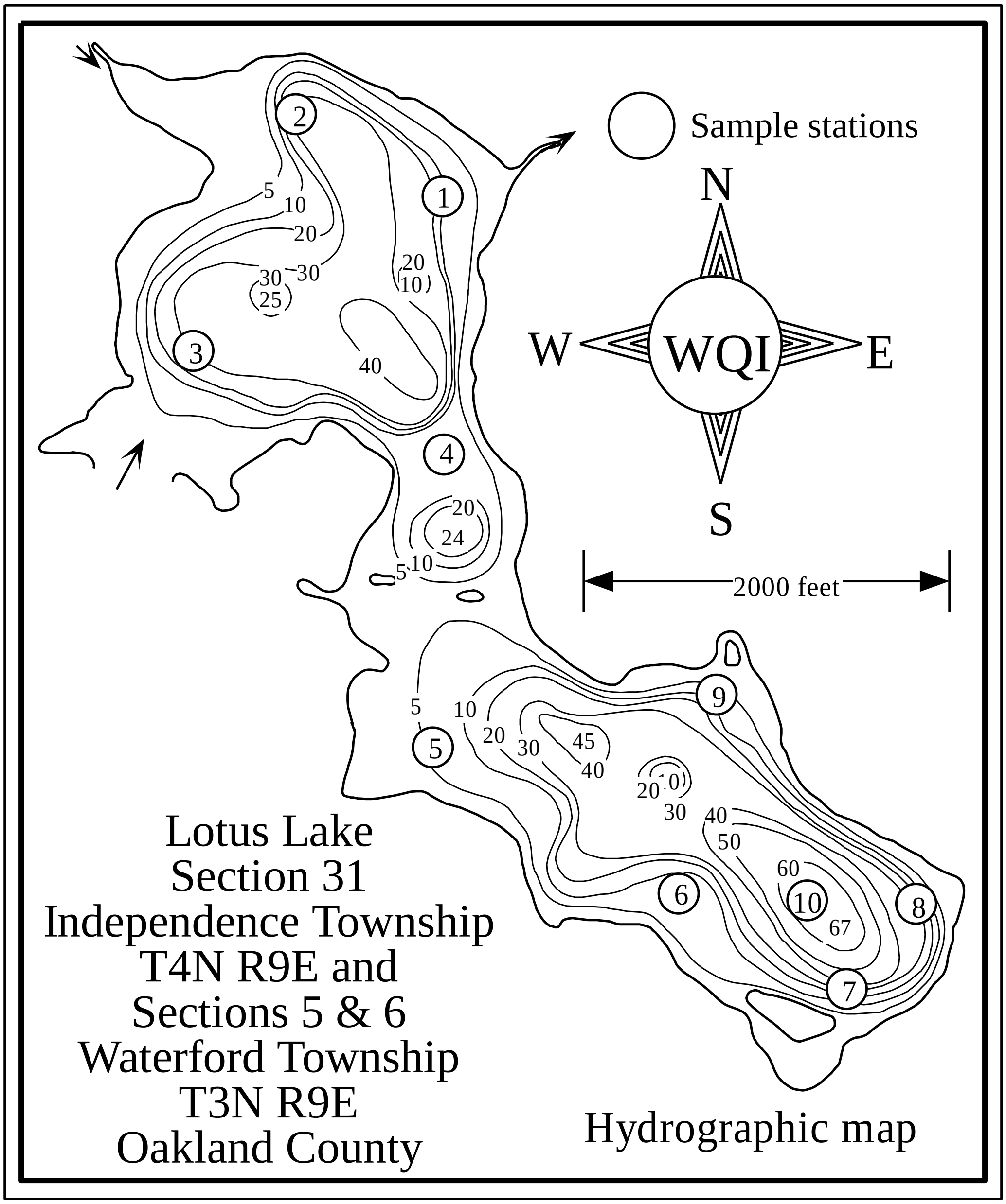
In 2000 WQI limnologists collected ten surface samples plus Secchi disk readings at the 10 sites shown on the map and top to bottom samples every ten feet in the 67-foot deep hole on April 24th, and August 14th. Bottom sediments were again collected at the ten sites in spring.

In 2010 WQI limnologists collected ten surface samples plus Secchi disk readings at the 10 sites shown on the map and top to bottom samples every ten feet in the 67-foot deep hole on April 15th, and August 6th. Bottom sediments were again collected at the ten sites in spring.

No one collected Secchi disk data through the warm months in 1990, 2000 or 2010.

THE SAMPLE STATIONS

The locations of the ten in-lake sample stations are shown as circles on the hydrographic map of the lake.



THE ANALYSES

The tests performed on the samples included total phosphorus, total nitrate nitrogen, total alkalinity, pH, conductivity, chlorophyll a, Secchi disk depth, 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).

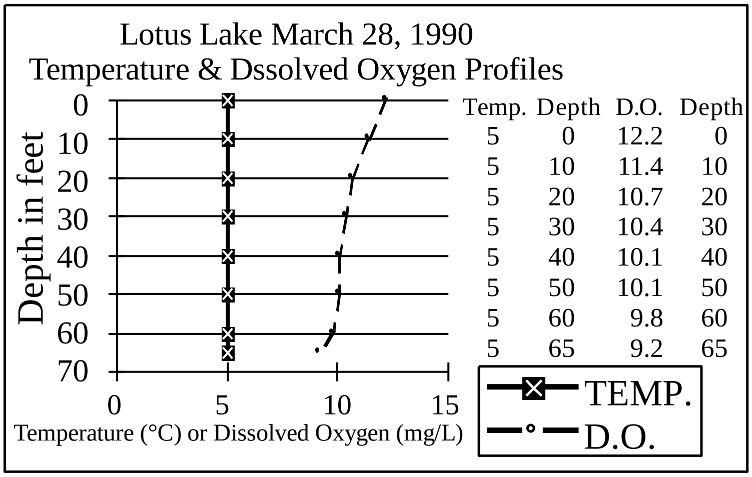
THE TEST RESULTS

The results of the tests are found in the text, in the tables 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 at that time.

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



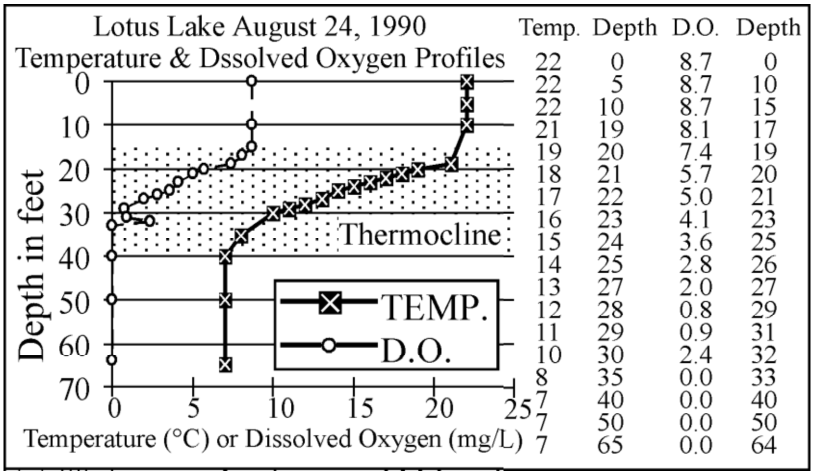
Temp.	Depth	D.O.	Depth
5	0	12.2	0
5	10	11.4	10
5	20	10.7	20
5	30	10.4	30
5	40	10.1	40
5	50	10.1	50
5	60	9.8	60
5	65	9.2	65

1990

The graph shows the spring 1990 top to

bottom temperature and dissolved oxygen data.

It shows temperature was uniform top to bottom being five degrees Centigrade. Dissolved oxygen exceeded 12 milligrams per liter at the surface, and gradually decreased to 9.2 milligrams per liter at 65 feet. These data indicate the lake mixed in spring 1990.



Lotus Lake August 24, 1990
Temperature & Dssolved Oxygen Profiles

Temp.	Depth	D.O.	Depth
22	0	8.7	0
22	5	8.7	10
22	10	8.7	15
21	19	8.1	17
19	20	7.4	19
18	21	5.7	20
17	22	5.0	21
16	23	4.1	23
15	24	3.6	25
14	25	2.8	26
13	27	2.0	27
12	28	0.8	29
11	29	0.9	31
10	30	2.4	32
8	35	0.0	33
7	40	0.0	40
7	50	0.0	50
7	65	0.0	64

The graph shows the summer 1990 top to bottom temperature and dissolved oxygen data.

In late summer the water column was divided into the three layers we typically find in deep Michigan inland lakes, the upper and lower layers being separated by a middle layer, called a thermocline, where the temperature changes more than one degree C per meter of depth, and shown shaded on the graphs.

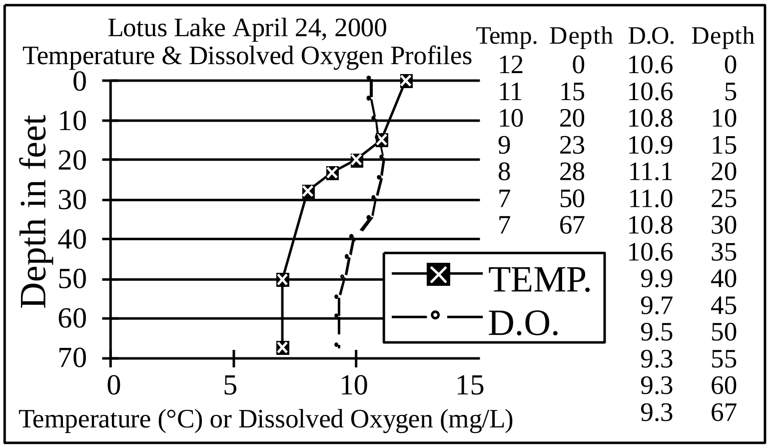
Above the thermocline temperature was uniform, and at normal summer conditions. It dropped rapidly in the 25-foot thick thermocline, which extended from 15 to 40 feet. Below the thermocline, the temperature was again uniform, but colder, 7 degrees C.

Dissolved oxygen was plentiful above the thermocline. It started to drop at the top of the thermocline, and reached zero at 33 feet. That no-dissolved oxygen condition remained to the bottom. The hypsographic (depth-area) graph shows about 23 percent of the lake is deeper than 33 feet.

SPRING 2000

The graph below shows the 2000 spring top to bottom temperature and dissolved oxygen data.

This graph shows typical spring conditions. Temperature is relatively uniform top to bottom, and dissolved oxygen is relatively uniform top to bottom. These data indicate the lake mixed prior to sampling.

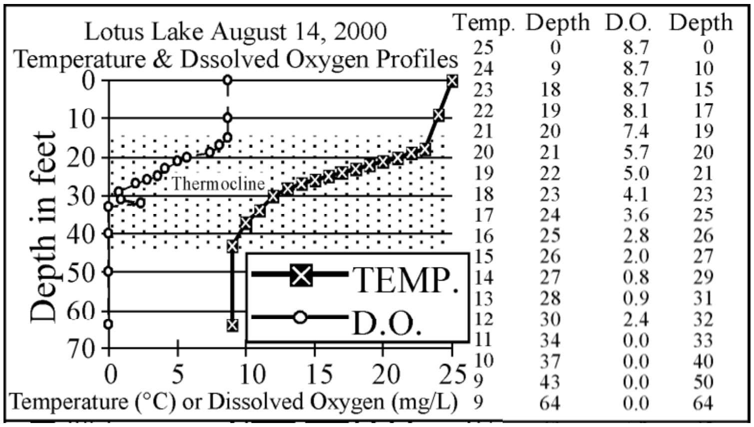

Lotus Lake April 24, 2000
Temperature & Dissolved Oxygen Profiles

Temp.	Depth
12	0
11	15
10	20
9	23
8	28
7	50
7	67

D.O.	Depth
10.6	0
10.6	5
10.8	10
10.9	15
11.1	20
11.0	25
10.8	30
10.6	35
9.9	40
9.7	45
9.5	50
9.3	55
9.3	60
9.3	67

SUMMER 2000

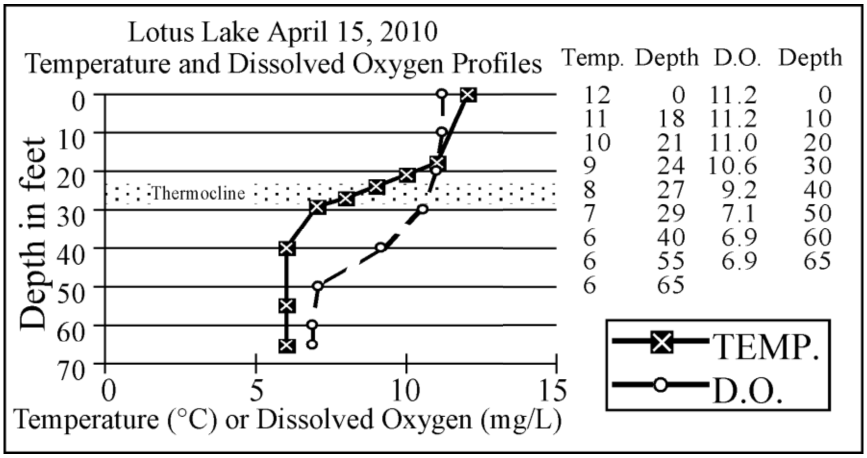
The graph shows the summer 2000 top to bottom dissolved oxygen and temperature data in the 67-foot deep hole.


Lotus Lake August 14, 2000
Temperature & Dssolved Oxygen Profiles

Temp.	Depth	D.O.	Depth
25	0	8.7	0
24	9	8.7	10
23	18	8.7	15
22	19	8.1	17
21	20	7.4	19
20	21	5.7	20
19	22	5.0	21
18	23	4.1	23
17	24	3.6	25
16	25	2.8	26
15	26	2.0	27
14	27	0.8	29
13	28	0.9	31
12	30	2.4	32
11	34	0.0	33
10	37	0.0	40
9	43	0.0	50
9	64	0.0	64

In mid-August the lake formed a 19-foot-thick thermocline from 18 to 37 feet. Temperature was uniform and normal above the thermocline, and dropped rapidly in it. Below the thermocline, the temperature was colder, 9 degrees C.

Dissolved oxygen was again plentiful above the thermocline. It started to drop at the top of the thermocline, and reached zero at 33 feet. That condition remained to the bottom.


Lotus Lake April 15, 2010
Temperature and Dissolved Oxygen Profiles

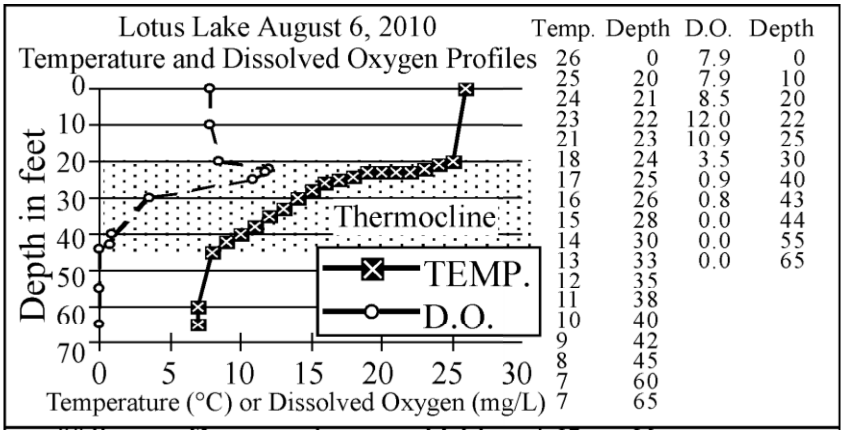
Temp.	Depth
12	0
11	18
10	21
9	24
8	27
7	29
6	40
6	55
6	65

D.O.	Depth
11.2	0
11.2	10
11.0	20
10.6	30
9.2	40
7.1	50
6.9	60
6.9	65

SPRING 2010

In spring 2010 the graph shows Lotus Lake was just beginning to stratify in that a 5-foot thick thermocline formed from 24 to 29 feet. The temperature at the surface was 12 degrees, C while the temperature at the bottom was 6 degrees C. The concentration of dissolved oxygen was saturated in the top 30 feet and started to decrease below that depth. It was 6.9 mg/L at 65 feet, the bottom of the lake. These are normal spring conditions for a high quality Michigan inland lake.

SUMMER 2010



Temp.	Depth	D.O.	Depth
26	0	7.9	0
25	20	7.9	10
24	21	8.5	20
23	22	12.0	22
21	23	10.9	25
18	24	3.5	30
17	25	0.9	40
16	26	0.8	43
15	28	0.0	44
14	30	0.0	55
13	33	0.0	65
12	35		
11	38		
10	40		
9	42		
8	45		
7	60		
7	65		

The graph shows the lake formed a 25-foot thick thermocline from 20 to 45 feet in late summer 2010. The temperature at the surface was 26 degrees C and 25 degrees C at the top of the thermocline. In the thermocline the temperature dropped from 20 to 8 degrees C. Below the thermocline the temperature was 7 degrees C.

Dissolved oxygen concentrations were plentiful above the thermocline and actually increased in the top layer of the thermocline to 12.0 mg/L at 22 feet, probably the result of an algal bloom which settled there. From that depth, the concentration of dissolved oxygen gradually decreased. It was zero at 44 feet, and that condition remained to the bottom.

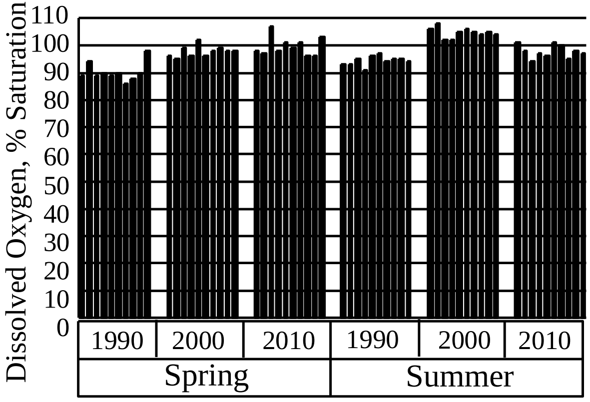
A NOTE ABOUT THE FOLLOWING GRAPHS

The surface sample and top to bottom graphs which follow are first sorted by spring and summer, then by year, then by sample station. The purpose for this is to detect differences between the various sample stations in spring and summer.

DISSOLVED OXYGEN PERCENT SATURATION

Since the amount of dissolved oxygen a water can hold is temperature dependent, with cold water holding dissolved oxygen (and other gasses) than warm water, the percent saturation of dissolved oxygen is often a better way to determine if dissolved oxygen supplies are adequate. Best is between 90 and 110 percent.

Lotus Lake 1990, 2000 & 2010 Dissolved Oxygen Saturation



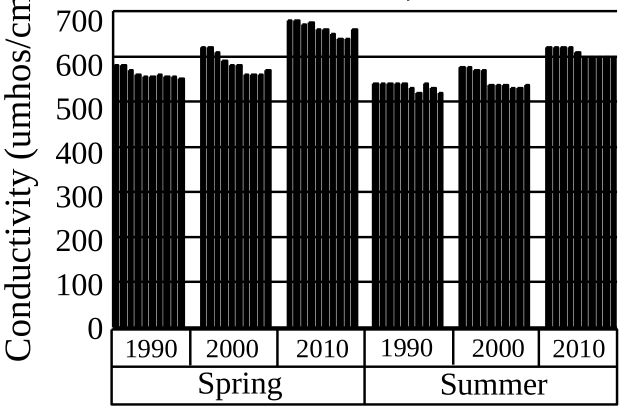
Spring			Summer		
1990	2000	2010	1990	2000	2010
89	96	98	93	106	101
94	95	97	93	108	98
89	99	107	95	102	94
90	96	98	91	102	97
89	102	101	96	105	96
90	96	99	97	106	101
86	98	101	94	105	100
88	99	96	95	104	95
90	98	96	95	105	98
98	98	103	94	104	97

The graph shows 1990 values were low but adequate in both spring and summer. Spring and summer 2000 and 2010 saturations were in the normal range and very good.

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, 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 agree. Lower is usually better.

Lotus Lake 1990, 2000 & 2010 Conductivity



Spring			Summer		
1990	2000	2010	1990	2000	2010
580	620	680	540	575	620
580	620	680	540	575	620
570	610	670	540	570	620
560	590	675	540	570	620
555	580	660	540	535	610
555	580	660	530	535	600
560	560	650	520	535	600
555	560	640	540	530	600
555	560	640	530	530	600
550	570	660	520	535	600

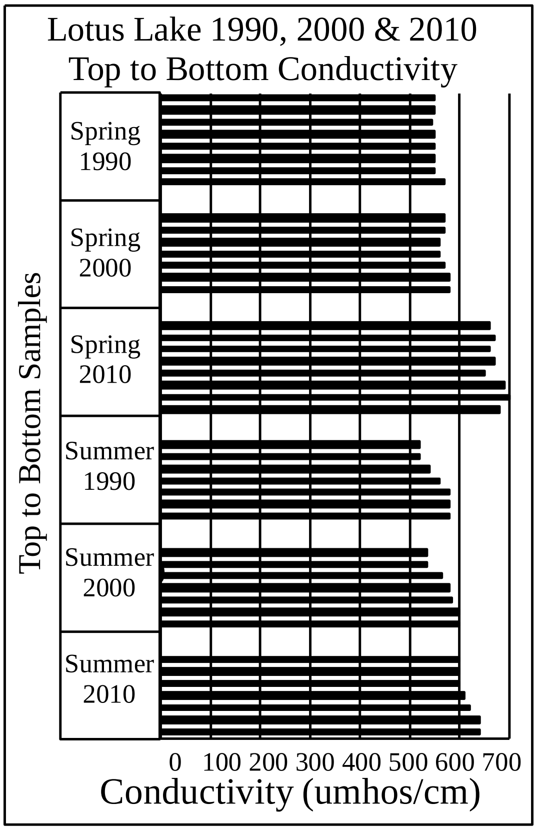
The graph above shows 1990 spring and summer conductivities ranged from 520 to 580 micromhos per centimeter, which is higher than we normally see for a Michigan inland lake. The data show salts from road salting operations or water softeners are probably affecting the lake. In 2000, the conductivities ranged from 530 to 620 umhos/cm.

In 2010 spring conductivities ranged from 640 to 680 umhos/cm while summer values were lower, ranging from 600 to 620 umhos/cm.

The graph shows conductivities are increasing as years pass. And the 2010 values are higher than we normally see in most inland lakes, and may be affected by winter road-salting programs, since spring 2010 values are considerably higher than 2010 summer values.

The graph seems to indicate in all three sample periods, conductivity decreases in both spring and summer from Station 1 through Station 10, which means there is more salt in the water at the north end of the lake compared to the southeast end.

TOP TO BOTTOM CONDUCTIVITIY



The graph below shows the top to bottom spring and summer 1990, 2000 and 2010 conductivities.

It shows in spring 1990, 2000 and 2010 top to bottom conductivities were fairly uniform top to bottom indicating the lake mixed in spring of each year. On the other hand, the spring 2010 conductivities were higher than the 1990 and 2000 conductivities.

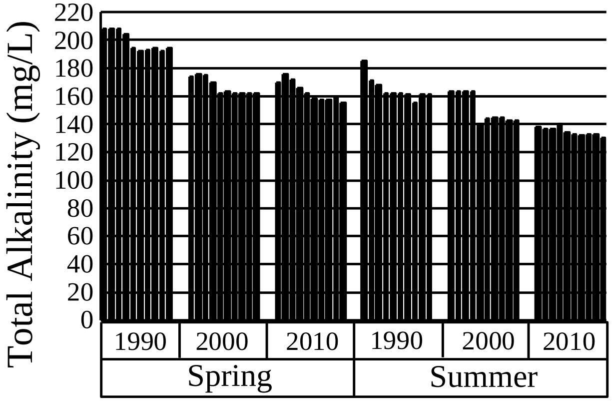
The graph shows summer conductivities increase near the bottom every year. This is the normal condition we see in most Michigan inland lakes. It is probably due to increased solubility due to pressure.

What's interesting is the graph shows summer top to bottom conductivities in all three years are pretty much the same, while the spring 2010 top to bottom conductivities are considerably higher than the other two years.

TOTAL ALKALINITY

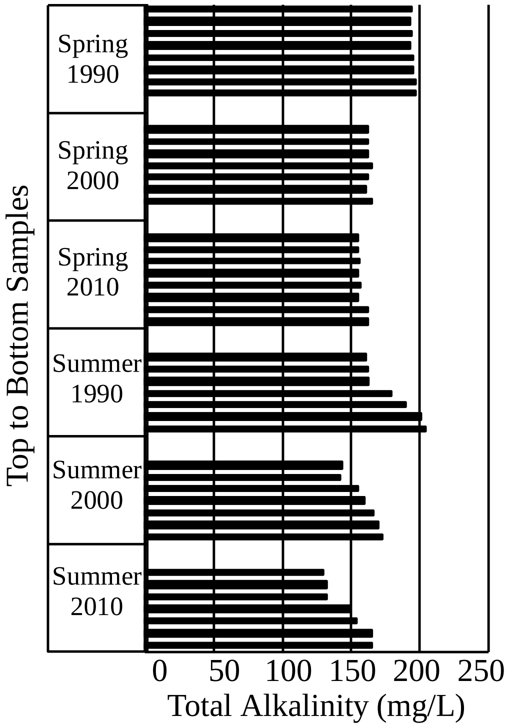
Alkalinity measures carbonates and bicarbonates in water. Soft water lakes have alkalinities below 75 milligrams per liter. Moderately hard water lakes have alkalinities between 75 and 150 milligrams per liter. Hard water lakes have alkalinities above 150 mg/L.

Lotus Lake 1990, 2000 & 2010 Alkalinity



Spring			Summer		
1990	2000	2010	1990	2000	2010
208	174	170	185	163	138
208	176	176	171	163	137
208	175	172	168	163	137
204	170	166	162	163	140
194	162	162	162	140	134
192	163	158	162	144	133
193	162	157	161	145	132
194	162	157	155	145	133
192	162	160	161	143	133
194	162	155	161	143	130

Lotus Lake 1990, 2000 & 2010
Top to Bottom Alkalinity



The graph shows the 1990, 2000 and 2010 alkalinity data. It shows in spring 1990 alkalinity concentrations were in the 190 to 210 mg/L range, while in spring 2000 and 2010, they were lower, in the 150, 160 and 170 mg/L range.

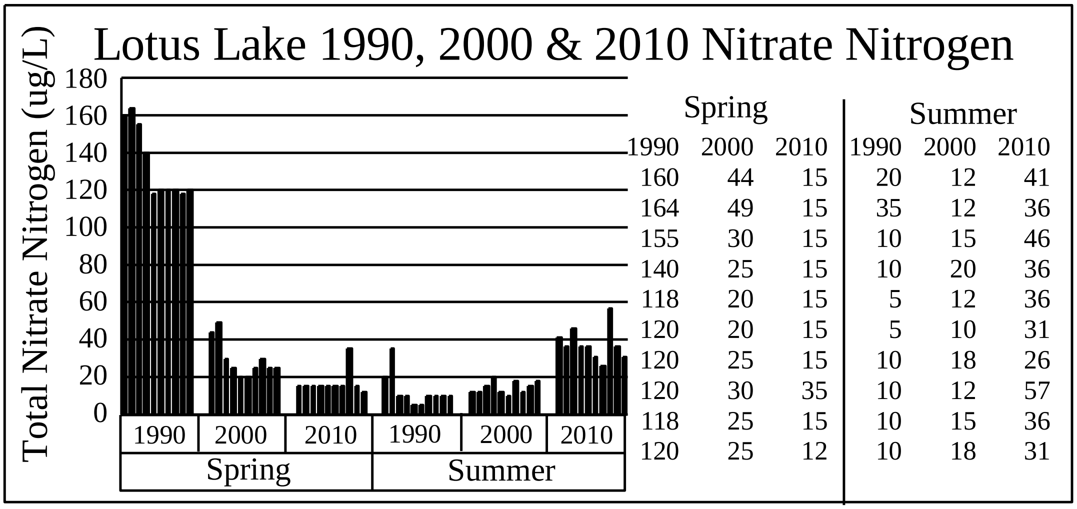
In summer 1990 the alkalinities were all in the 150 to 180 mg/L range, while in summer 2000 there were for the most part, in the 140 to 160 mg/L range. In summer 2010 alkalinities were 130 to 140 mg/L. The graph seems to show alkalinity concentrations are decreasing in Lotus Lake. This is neither good or bad but it it's rather dramatic.

Top to bottom alkalinities show about the same trend, lower alkalinities in 2000 and 2010. And in summer in all three years, alkalinity concentrations increase with depth, probably because of increased solubility with depth.

The above data indicates Lotus Lake is a hard water lake. 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.

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 micrograms per liter range.



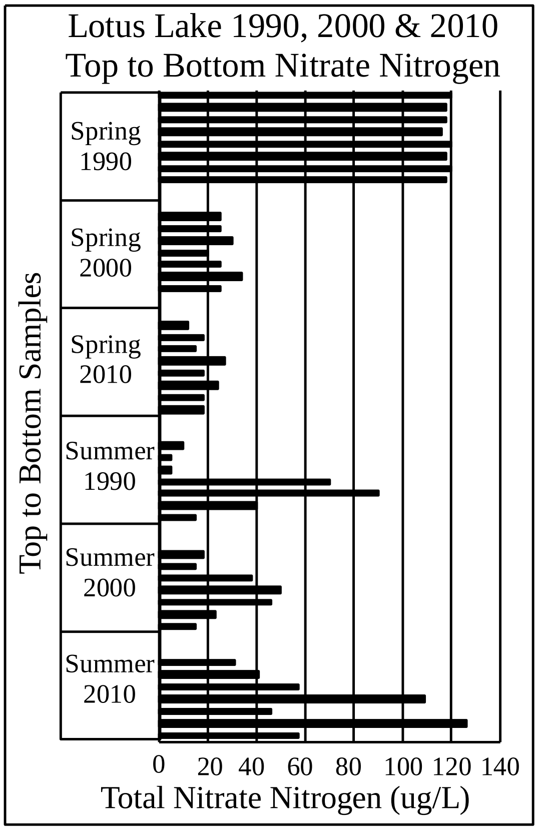
Spring			Summer		
1990	2000	2010	1990	2000	2010
160	44	15	20	12	41
164	49	15	35	12	36
155	30	15	10	15	46
140	25	15	10	20	36
118	20	15	5	12	36
120	20	15	5	10	31
120	25	15	10	18	26
120	30	35	10	12	57
118	25	15	10	15	36
120	25	12	10	18	31

The graph shows the surface nitrate nitrogen concentrations in 1990, 2000 and 2010.

Spring 1990 surface nitrate nitrogen concentrations ranged from a low of 118 ug/L to a high of 164 ug/L. These are normal surface nitrate nitrogen concentrations. However, the nitrate nitrogen concentrations in the north west basin were higher (140 to 164 ug/L) than the southeast basin (118-120 ug/L).

Spring surface nitrate nitrogen concentrations in 2000 ranged from a low of 20 ug/L to a high of 49 ug/L. Spring 2010 surface nitrate nitrogen concentrations ranged from 15 to 35 ug/L. These are low spring surface nitrate nitrogen concentrations.

Summer surface nitrate nitrogen concentrations in 1990 ranged from a low of 5 micrograms per liter to a high of 35 micrograms per liter. Summer 2000 surface nitrate nitrogen concentrations ranged from a low of 10 micrograms per liter to a high of 20 micrograms per liter and summer 2010 surface nitrate nitrogen concentrations ranged from 26 to 57 ug/L. These are normal summer surface nitrate nitrogen concentrations.

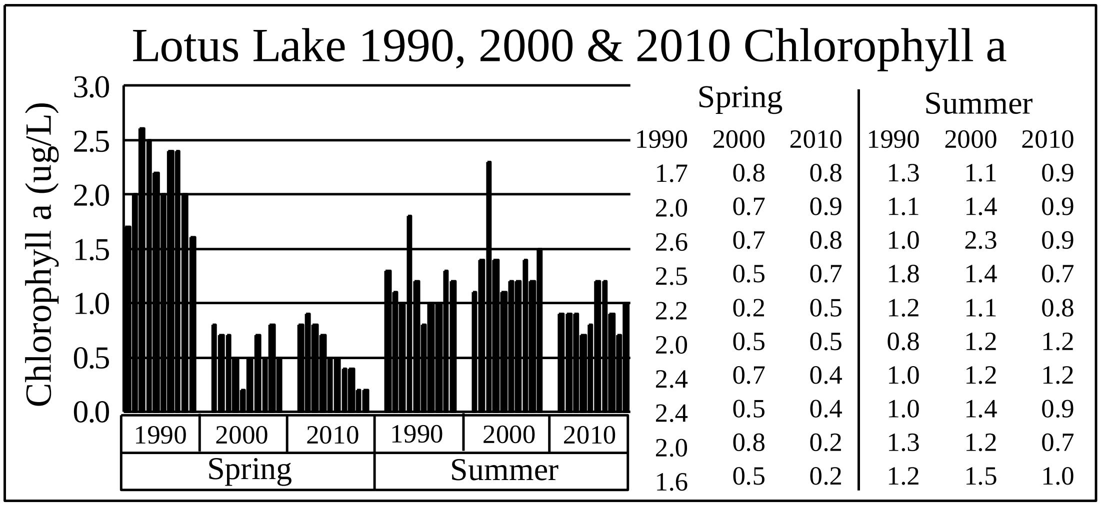


Spring top to bottom nitrates, although higher in 1990 than in the other two years, were essentially uniform, indicating the lake mixed in spring.

In summer, top to bottom nitrates were low at the surface all three years, but increased in mid-depth. This is normal for a high quality inland lake.

The nitrate nitrogen data indicate Lotus Lake is probably nitrate rather than phosphorus limited, especially in summer. It also means no fertilizers containing either nitrogen or phosphorus should be used on near-lake areas.

CHLOROPHYLL A



Spring			Summer		
1990	2000	2010	1990	2000	2010
1.7	0.8	0.8	1.3	1.1	0.9
2.0	0.7	0.9	1.1	1.4	0.9
2.6	0.7	0.8	1.0	2.3	0.9
2.5	0.5	0.7	1.8	1.4	0.7
2.2	0.2	0.5	1.2	1.1	0.8
2.0	0.5	0.5	0.8	1.2	1.2
2.4	0.7	0.4	1.0	1.2	1.2
2.4	0.5	0.4	1.0	1.4	0.9
2.0	0.8	0.2	1.3	1.2	0.7
1.6	0.5	0.2	1.2	1.5	1.0

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

The graph shows the spring and summer chlorophyll a data for all three sample periods. This is a test for surface water, hence no top to bottom data are included.

The chlorophyll data shows in spring 1990 Lotus Lake had a small algal bloom (chlorophyll a concentration = 1.6-2.6 ug/L). In summer 1990 it was in the 0.8 to 1.8 microgram per liter range, which was good.

In spring 2000 and 2010, chlorophyll a concentrations were below 1.0 ug/L. This is better than 1990, and represents the ideal situation.

Summer chlorophylls were for the most part, below 1.5 ug/L.

The graph shows in spring 1990 chlorophylls were quite a bit higher than in 2000 or 2010. It also shows summer chlorophylls were about the same all three years, and two of the three years (2000 and 2010), they were higher than the spring chlorophylls.

pH (Hydrogen ion concentration) (no graph)

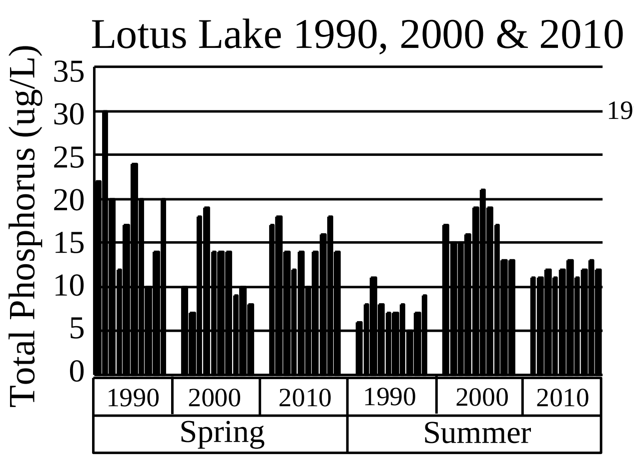
pH has traditionally been a measure of water quality. Today it is an excellent indicator of the effects of acid rain on lakes. About 99% of the rain events in southeastern Michigan are below a pH of 5.6 and are thus considered acid. However, there seems to be no lakes in southern Michigan which are being affected by acid rain. Most lakes have pH values between 7.5 and 9.0.

Spring and summer surface pH values for all three sample periods ranged from 8.1 to 8.7. These are normal pH values for a Michigan inland lake.

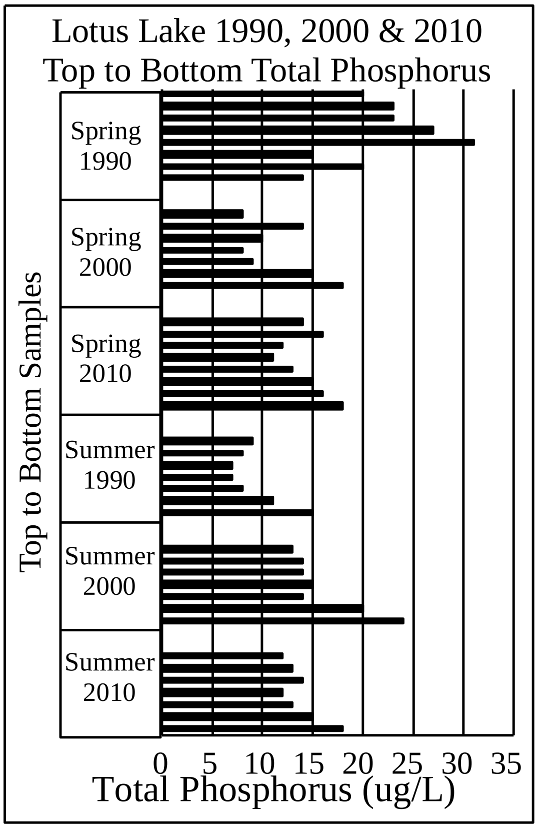
Lakes with extensive plant communities often have high summer pH values (greater than 9) because the plants use the carbonates in the water as a carbon source. This causes a decrease in the buffering capacity of the water, and allows the pH to rise.

TOTAL PHOSPHORUS

Phosphorus is a major nutrient in lakes. There are many forms, but they can all be converted to the other forms. Because of this, the experts selected total phosphorus as the most meaningful test. Best is below 10 micrograms per liter.



Spring			Summer		
1990	2000	2010	1990	2000	2010
22	10	17	6	17	11
30	7	18	8	15	11
20	18	14	11	15	12
12	19	12	8	16	11
17	14	14	7	19	12
24	14	10	7	21	13
20	14	14	8	19	11
10	9	16	5	17	12
14	10	18	7	13	13
20	8	14	9	13	12



The graph shows spring phosphorus concentrations in 1990 ranged from 10 to 30 ug/L, while in 2000 they ranged from 7 to 18 ug/L and in 2010 they ranged from 12 to 18 ug/L.

It shows in summer phosphorus concentrations in 1990 ranged from 5 to 11 ug/L, while in 2000 they ranged from 13 to 21 ug/L and in 2010 they ranged from 11 to 13 ug/L. The graph does not seem to show any specific trend.

The graph shows the spring and summer top to bottom phosphorus concentrations in 1990, 2000 and 2010.

The main thing we are looking for here is high phosphorus concentrations in the bottom water in late summer. This is phosphorus released from the bottom sediments during anoxic periods (periods of no dissolved oxygen in the bottom water.)

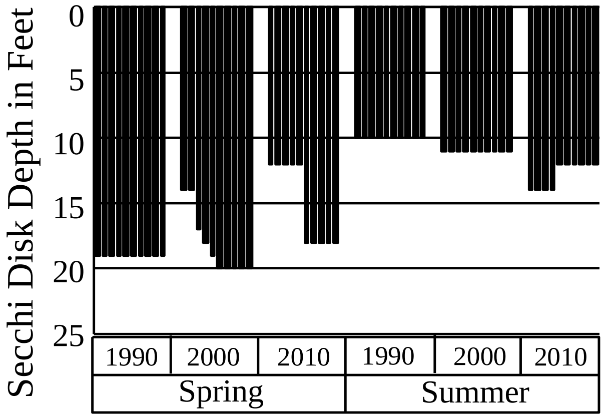
This occurred to a slight extent in 1990 and 2010, and to a greater extent in late summer 2000. It appears phosphorus is just starting to be released from the bottom sediments of Lotus Lake in the deep areas during periods of anoxia.

LOTUS LAKE SECCHI DISK DATA

We have no Secchi disk data through the warm months for Lotus Lake for any year. This is something Lotus Lake residents should consider starting.

The following graph shows the Secchi disk data collected with the spring and summer samples.

Lotus Lake 1990, 2000 & 2010 Secchi Disk Depths



Spring			Summer		
1990	2000	2010	1990	2000	2010
19	14	12	10	11	14
19	14	12	10	11	14
19	17	12	10	11	14
19	18	12	10	11	14
19	19	12	10	11	12
19	20	18	10	11	12
19	20	18	10	11	12
19	20	18	10	11	12
19	20	18	10	11	12
19	20	18	10	11	12

It shows the clarity of the lake has not changed much in spring. It shows in spring 2010 the north end of the lake had shallower readings than the south end. The graph shows summer readings, although not as deep as spring readings appear to be getting clearer (deeper). If that is indeed the case, it is a plus.

THE SECCHI DISK TREND GRAPH

If we had long term Secchi disk data, we would be able to develop a Secchi disk Trend graph, which shows whether the lake is getting clearer or cloudier as years pass. Residents of Lotus Lake should take Secchi disk readings through the warm months every year. This is data that will serve them well in the future.

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Lotus 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 select 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 Lake Macatawa in Ottawa County.

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.

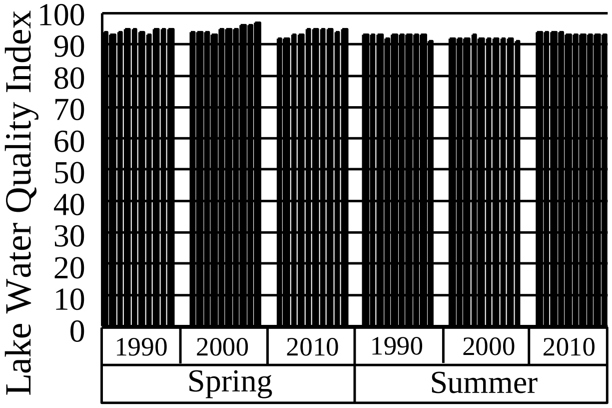
The thermometer rating scales also allow you to determine what test results would be considered excellent in terms of lake water quality. They are the numbers found outside the thermometer near the top.

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 LOTUS LAKE WATER QUALITY INDICES

The graph shows the Lake Water Quality Indices for Lotus Lake in spring and summer of 1990, 2000 and 2010.

Lotus Lake 1990, 2000 & 2010 Lake Water Quality Indices



Spring			Summer		
1990	2000	2010	1990	2000	2010
94	94	92	93	92	94
93	94	92	93	92	94
94	94	93	93	92	94
95	93	93	92	93	94
95	95	95	93	92	93
94	95	95	93	92	93
93	95	95	93	92	93
95	96	95	93	92	93
95	96	94	93	92	93
95	97	95	91	91	93

The graph shows spring 1990 LWQIs ranged from 93 to 95, (A), spring 2000 LWQIs ranged from 93 to 97 (A), and 2010 LWQIs ranged from 92 to 95 (A). The data show spring LWQIs decreased slightly over the years.

In summer 1990 the LWQIs ranged from 91 to 93 (A), 2000 LWQIs ranged from 91 to 93 (A), and 2010 LWQIs were 93 or 94. These data indicate summer LWQIs, although lower than the spring LWQIs, increased slightly during the same period.

The graph shows the Lake Water Quality Indices for Lotus Lake have been in the 90s every time it was sampled, indicating the water quality of Lotus is in the A range in both spring and summer.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the Lake Water Quality Indices were relatively uniform in spring and in summer, only a single Lake Water Quality Index calculation sheet is included for spring 2010, using averaged data and for summer 2010, using averaged data.

In the report marked MASTER, all 20 of the 2010 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 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.

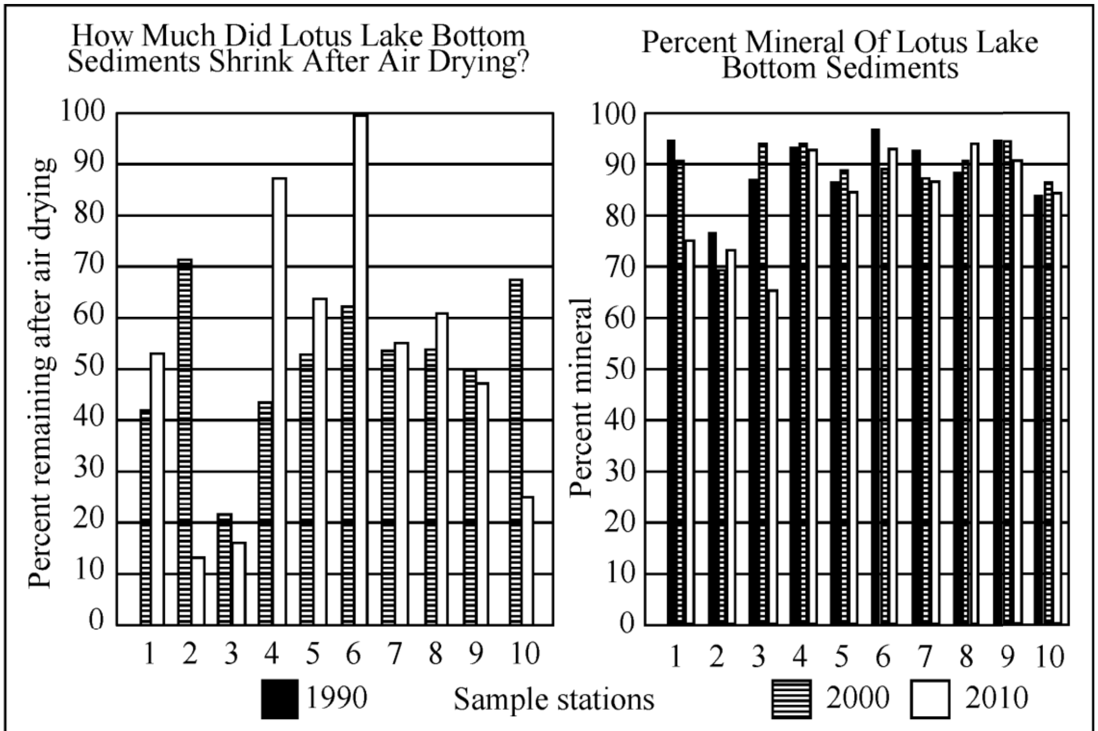
I consider high quality bottom sediments from natural lakes to be above 85 percent mineral. And I consider bottom sediments less than 50 percent mineral to be muck.

Ten bottom sediment samples were collected from Lotus Lake in 1990, 2000 and 2010. The graph shows the data.

In 1990 we did not determine the amount of shrinkage of bottom sediment samples. In 2000, sediments shrunk between 28 and 79 percent, while in 2010 they shrunk between 0 and 84 percent. This is a normal amount of shrinkage. Excessive shrinkage is more than 95 percent.

In 1990, all the samples except one turned gray after air-drying. The sample from Station 4 remained black. In 2000 and 2010 all samples turned gray after air-drying. All except the Station 9 in 2010 turned gray after burning at 550 degrees C. The Station 9 sample turned tan.

The gray color indicates the lake is filling with carbonates and bicarbonates which precipitate to the sediments when groundwater entering the lake warms in summer. These materials tie up some of the phosphorus from the water column in the sediments, pretty much making them unavailable for plant or algal production.



Characteristics of Lotus Lake Bottom Sediments (1990, 2000 & 2010)

I.D.	Percent Shrinkage		Percent Mineral			Dried at 100°C Color & Description			Color after burning at 550°C			Depth of water (feet)		
	2000	2010	1990	2000	2010	1990	2000	2010	1990	2000	2000	1990	2000	2010
1	58	46	94	90	73	Gray	Gray	Gray	Gray	Gray	Gray	8	10	5
2	28	82	76	79	72	Gray	Gray	Gray	Gray	Gray	Gray	28	22	30
3	79	84	86	93	63	Gray	Gray	Gray	Gray	Gray	Gray	5	25	33
4	57	12	92	93	91	Black	Gray	Gray	Gray	Gray	Gray	5	5	6
5	47	36	87	89	84	Gray	Gray	Gray	Gray	Gray	Gray	5	4	6
6	38	0	94	89	92	Gray	Gray	Gray	Gray	Gray	Gray	10	6	11
7	47	44	92	87	86	Gray	Gray	Gray	Gray	Gray	Gray	20	6	25
8	47	39	88	90	93	Gray	Gray	Gray	Gray	Gray	Gray	42	25	35
9	50	53	93	93	90	Gray	Gray	Gray	Gray	Gray	Tan	7	6	8
10	32	75	82	86	84	Gray	Gray	Gray	Gray	Gray	Gray	67	66	65

Average mineral content of bottom sediments: 1990 = 88%, 2000 = 89%, 2010 = 83%

In 1990 the mineral content of Lotus Lake bottom sediments ranged from 76 to 94 percent and averaged 88 percent.

In 2000 the mineral content of Lotus Lake bottom sediments ranged from 79 to 93 percent and averaged 89 percent.

In 2010 the mineral content of the sediments ranged from 63 to 93 percent and averaged 83 percent.

The bottom sediment data indicates the percentage of minerals decreased 5 to 6 percent in the last ten years, showing the lake is just starting to build up organic material in the sediments. Residents should make every effort to prevent this from happening. And one of the major sources of the organic material in the sediments, (which is replacing the minerals) is nutrients entering the lake from lawn fertilizers.

COMMENTS

We did find zebra mussels in the sediments at Station 7, so the lake does have zebra mussels, or it did in the past. We did not see starry stonewort (*Nitellopsis obtusa*) as we moved about the lake, but since Maceday Lake has this pesky alga, it is only a matter of time before it will be in Lotus Lake as well.

Wallace E. Fusilier, Ph.D.
Consulting Limnologist
Water Quality Investigators
Dexter, Michigan
January 2011

Lotus Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen		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
			(mg/L)	Percent Saturation									
3/28/90	1	6	11.1	89	1.7	19	160	208	8.2	580	22	94	A
3/28/90	2	7	11.5	94	2.0	19	164	208	8.1	580	30	93	A
3/28/90	3	6	11.1	89	2.6	19	155	208	8.1	570	20	94	A
3/28/90	4	7	11.0	90	2.5	19	140	204	8.1	560	12	95	A
3/28/90	5	6	11.1	89	2.2	19	118	194	8.1	555	17	95	A
3/28/90	6	6	11.0	90	2.0	19	120	192	8.1	555	24	94	A
3/28/90	7	6	10.8	86	2.4	19	120	193	8.1	560	20	93	A
3/28/90	8	6	11.0	88	2.4	19	120	194	8.1	555	10	95	A
3/28/90	9	6	11.2	90	2.0	19	118	192	8.1	555	14	95	A
3/28/90	10	6	12.2	98	1.6	19	120	194	8.1	550	20	95	A
3/28/90	10-0	6	12.2	98	1.6	19	120	194	8.1	550	20	95	A
3/28/90	10-10	5	11.4	89	---	---	118	193	8.1	550	23	---	---
3/28/90	10-20	5	10.7	84	---	---	118	194	8.1	545	23	---	---
3/28/90	10-30	5	10.4	81	---	---	116	193	8.1	550	27	---	---
3/28/90	10-40	5	10.1	79	---	---	120	195	8.1	550	31	---	---
3/28/90	10-50	5	10.1	79	---	---	118	195	8.1	550	15	---	---
3/28/90	10-60	5	9.8	77	---	---	120	197	8.1	550	20	---	---
3/28/90	10-65	5	9.2	72	---	---	118	197	8.0	570	14	---	---
8/24/90	1	22	8.2	93	1.3	10	20	185	8.4	540	6	93	A
8/24/90	2	23	8.1	93	1.1	10	35	171	8.3	540	8	93	A
8/24/90	3	23	8.3	95	1.0	10	10	168	8.3	540	11	93	A
8/24/90	4	22	8.0	91	1.8	10	10	162	8.3	540	8	92	A
8/24/90	5	24	8.2	96	1.2	10	5	162	8.4	540	7	93	A
8/24/90	6	23	8.4	97	0.8	10	5	162	8.4	530	7	93	A
8/24/90	7	22	8.3	94	1.0	10	10	161	8.4	520	8	93	A
8/24/90	8	22	8.4	95	1.0	10	10	155	8.4	540	5	93	A
8/24/90	9	22	8.4	95	1.3	10	10	161	8.4	530	7	93	A
8/24/90	10	22	8.3	94	1.2	10	10	161	8.4	520	9	93	A
8/24/90	10-0	22	8.3	94	1.2	10	10	161	8.4	520	9	93	A
8/24/90	10-10	22	8.2	93	---	---	5	162	8.3	520	8	---	---
8/24/90	10-20	18	3.9	41	---	---	5	163	8.3	540	7	---	---
8/24/90	10-30	10	0.7	6	---	---	70	179	7.8	560	7	---	---
8/24/90	10-40	7	0.0	0	---	---	90	190	7.6	580	8	---	---
8/24/90	10-50	7	0.0	0	---	---	40	201	7.6	580	11	---	---
8/24/90	10-60	7	0.0	0	---	---	15	204	7.6	580	15	---	---
4/24/00	1	12	10.4	96	0.8	14	44	174	8.3	620	10	94	A
4/24/00	2	12	10.3	95	0.7	14	49	176	8.3	620	7	94	A
4/24/00	3	13	10.5	99	0.7	17	30	175	8.3	610	18	94	A
4/24/00	4	13	10.2	96	0.5	18	25	170	8.3	590	19	93	A
4/24/00	5	12	10.8	102	0.2	19	20	162	8.4	580	14	95	A
4/24/00	6	13	10.4	96	0.5	20	20	163	8.4	580	14	95	A
4/24/00	7	12	10.4	98	0.7	20	25	162	8.4	560	14	95	A
4/24/00	8	13	10.5	99	0.5	20	30	162	8.4	560	9	96	A
4/24/00	9	12	10.4	98	0.8	20	25	162	8.4	560	10	96	A
4/24/00	10	12	10.6	98	0.5	20	25	162	8.4	570	8	97	A
4/24/00	10-0	12	10.6	98	0.5	20	25	162	8.4	570	8	97	A
4/24/00	10-10	12	10.8	100	---	---	25	162	8.4	570	14	---	---
4/24/00	10-20	10	11.1	97	---	---	30	162	8.4	560	10	---	---
4/24/00	10-30	8	10.8	91	---	---	20	165	8.3	560	8	---	---
4/24/00	10-40	8	9.9	84	---	---	25	162	8.3	570	9	---	---
4/24/00	10-50	8	9.5	80	---	---	34	161	8.3	580	15	---	---
4/24/00	10-60	8	9.3	79	---	---	25	165	8.2	580	18	---	---
8/14/00	1	25	8.9	106	1.1	11	12	163	8.6	575	17	92	A
8/14/00	2	25	9.1	108	1.4	11	12	163	8.6	575	15	92	A
8/14/00	3	25	8.7	102	2.3	11	15	163	8.5	570	15	92	A
8/14/00	4	25	8.6	102	1.4	11	20	163	8.5	570	16	93	A
8/14/00	5	25	8.8	105	1.1	11	12	140	8.6	535	19	92	A
8/14/00	6	25	8.9	106	1.2	11	10	144	8.6	535	21	92	A
8/14/00	7	25	8.8	105	1.2	11	18	145	8.6	535	19	92	A
8/14/00	8	25	8.7	104	1.4	11	12	145	8.6	530	17	92	A
8/14/00	9	25	8.8	105	1.2	11	15	143	8.6	530	13	92	A
8/14/00	10	25	8.7	104	1.5	11	18	143	8.7	535	13	91	A
8/14/00	10-0	25	8.7	104	1.5	11	18	143	8.7	535	13	91	A
8/14/00	10-10	24	8.7	103	---	---	15	142	8.7	535	14	---	---
8/14/00	10-20	21	5.7	64	---	---	38	155	8.1	565	14	---	---
8/14/00	10-30	12	0.8	7	---	---	50	160	7.9	580	15	---	---
8/14/00	10-40	10	0.0	0	---	---	46	166	7.8	585	14	---	---
8/14/00	10-50	9	0.0	0	---	---	23	170	7.8	600	20	---	---
8/14/00	10-60	9	0.0	0	---	---	15	173	7.6	600	24	---	---

Lotus Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen		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
			(mg/L)	Percent Saturation									
4/15/10	1	13	10.4	98	0.8	12	15	170	8.2	680	17	92	A
4/15/10	2	1	10.3	97	0.9	12	15	176	8.2	680	18	92	A
4/15/10	3	12	11.6	107	0.8	12	15	172	8.2	670	14	93	A
4/15/10	4	13	10.4	98	0.7	12	15	166	8.2	675	12	93	A
4/15/10	5	12	10.9	101	0.5	12	15	162	8.2	660	14	95	A
4/15/10	6	13	10.5	99	0.5	18	15	158	8.2	660	10	95	A
4/15/10	7	12	10.9	101	0.4	18	15	157	8.3	650	14	95	A
4/15/10	8	12	10.4	96	0.4	18	35	157	8.3	640	16	95	A
4/15/10	9	12	10.4	96	0.2	18	15	160	8.2	640	18	94	A
4/15/10	10	12	11.2	103	0.2	18	12	155	8.3	660	14	95	A
4/15/10	10-10	12	11.2	103	---	---	18	155	8.3	670	16	---	---
4/15/10	10-20	11	11.0	99	---	---	15	156	8.2	660	12	---	---
4/15/10	10-30	7	10.6	87	---	---	27	155	8.2	670	11	---	---
4/15/10	10-40	6	9.2	74	---	---	18	157	8.0	650	13	---	---
4/15/10	10-50	6	7.1	57	---	---	24	155	8.0	690	15	---	---
4/15/10	10-60	6	6.9	55	---	---	18	162	8.0	700	16	---	---
4/15/10	10-65	6	6.9	55	---	---	18	162	7.9	680	18	---	---
8/6/10	1	26	8.3	101	0.9	14	41	138	8.5	620	11	94	A
8/6/10	2	26	8.0	98	0.9	14	36	137	8.4	620	11	94	A
8/6/10	3	26	7.6	94	0.9	14	46	137	8.4	620	12	94	A
8/6/10	4	26	7.9	97	0.7	14	36	140	8.3	620	11	94	A
8/6/10	5	26	7.8	96	0.8	12	36	134	8.3	610	12	93	A
8/6/10	6	26	8.3	101	1.2	12	31	133	8.4	600	13	93	A
8/6/10	7	26	8.2	100	1.2	12	26	132	8.4	600	11	93	A
8/6/10	8	26	7.7	95	0.9	12	57	133	8.4	600	12	93	A
8/6/10	9	26	8.0	98	0.7	12	36	133	8.4	600	13	93	A
8/6/10	10	26	7.9	97	1.0	12	31	130	8.4	600	12	93	A
8/6/10	10-10	26	7.9	97	---	---	41	132	8.4	600	13	---	---
8/6/10	10-20	25	8.5	101	---	---	57	132	8.3	600	14	---	---
8/6/10	10-30	14	3.5	34	---	---	109	150	8.3	610	12	---	---
8/6/10	10-40	10	0.9	8	---	---	46	154	8.0	620	13	---	---
8/6/10	10-50	8	0.0	0	---	---	126	165	7.9	640	15	---	---
8/6/10	10-60	7	0.0	0	---	---	57	165	7.8	640	18	---	---