HORSESHOE LAKE

NORTHFIELD TOWNSHIP

WASHTENAW COUNTY

1995-1999 WATER QUALITY STUDIES

HORSESHOE LAKE DATA

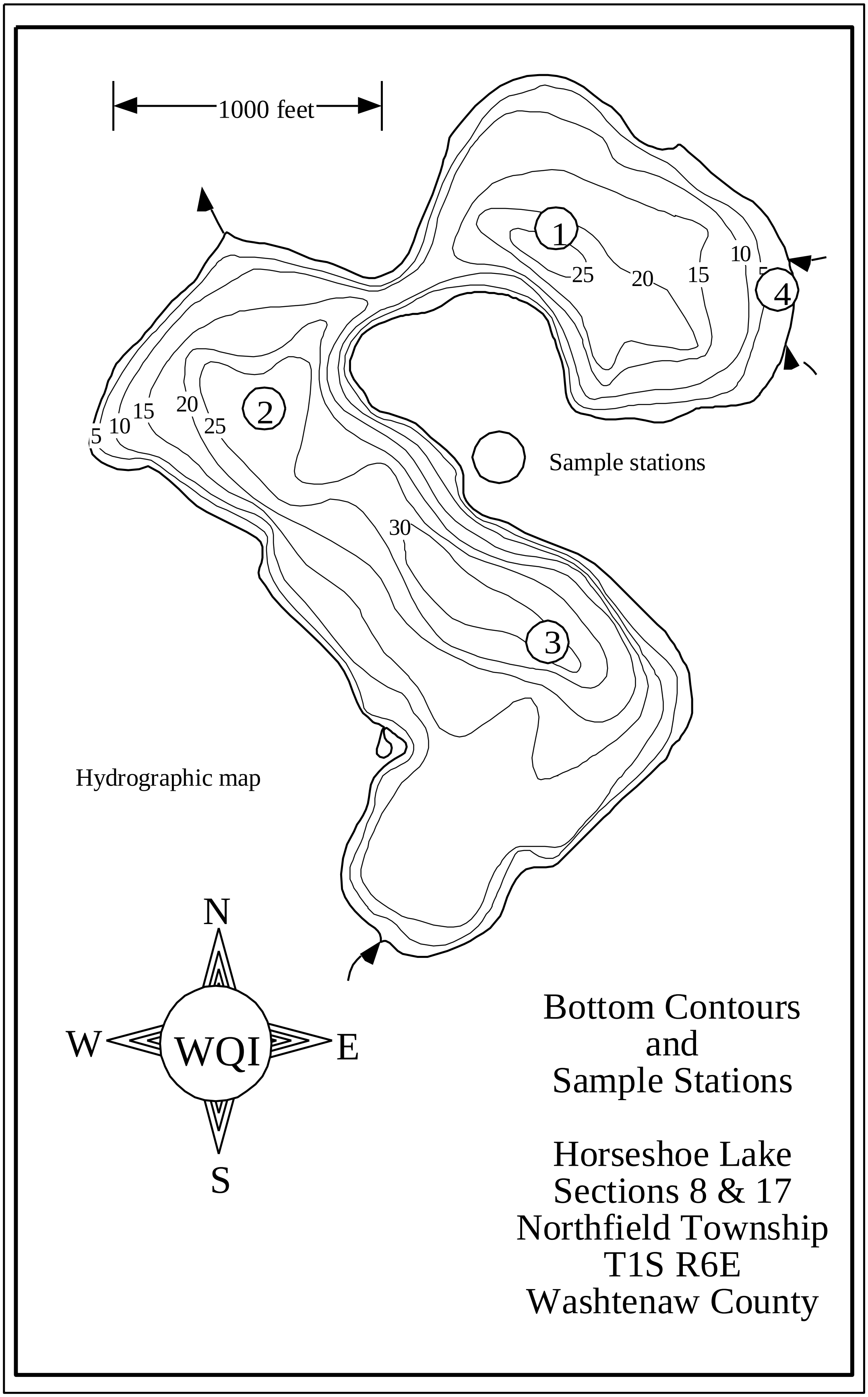
Horseshoe Lake is an 87-acre natural hard water kettle lake located in Sections 8 and 17, Northfield Township (T1S R6E), Washtenaw County, Michigan. The lake has a maximum depth of 30 feet, a water volume of 1283 acre-feet, and a mean depth of 14.8 feet. The elevation of the lake is 898 feet above sea level.

The lake consists of two basins, a 58-acre, 30-foot-deep west basin and a 29-acre 25-foot-deep northeast basin. A 12-foot deep narrows separates the basins.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is 12265 acres. The drainage area, which includes the lake and the watershed, is 12352 acres. The watershed to lake ratio is large, 141 to 1. Because of this the lake flushes rapidly, once every 0.13 years (or 47 days) on an average.

There are three inlets. A small unnamed inlet flows into the east side of the northeast basin. O'Connor Drain, which drains 6285 acres also flows into the northwest basin. An unnamed drain draining 4160 acres flows into the south side of the west basin. The outlet which discharges into the Horseshoe Lake Outlet is on the north end of the west basin. The Horseshoe Lake outlet flows into the Huron River above Strawberry Lake.

The longitude and latitude of the 30-foot deep hole in the west basin is 83° 45.366W and 42° 23.995N.


1000 feet
1
2
3
4
5
10
15
20
25
30
Sample stations
Hydrographic map
N
S
E
W
WQI
Bottom Contours
and
Sample Stations
Horseshoe Lake
Sections 8 & 17
Northfield Township
T1S R6E
Washtenaw County

THE SAMPLE DATES

Horseshoe Lake residents Carl Kayden and Tom Fuller took spring samples on various dates at surface stations 1, 2 and 3 shown on the enclosed map. They sampled the lake April 2, 1995, July 12, 1996, June 6, 1998 and June 11, 1999.

WQI limnologists collected late summer surface samples at the stations shown on the map on September 1, 1995, August 10, 1996, August 25, 1998 and August 29, 1999. Temperature and dissolved oxygen data were collected each time the lake was sampled in late summer at the deepest part of the lake. Bottom sediment samples were collected in 1995.

Neither spring nor summer samples were collected in 1997.

THE SAMPLE STATIONS

The location of the in-lake sample stations is shown on the 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, 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

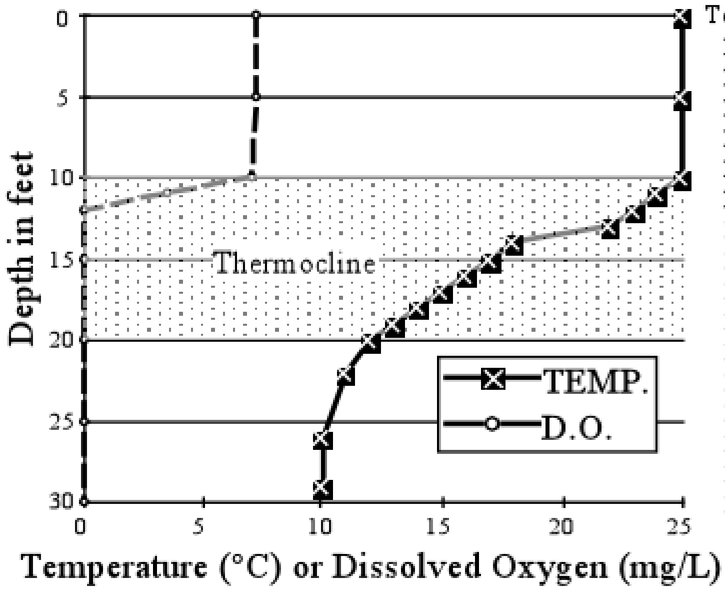
The results of the tests are found on the enclosed atlas pages.

TEMPERATURE AND DISSOLVED OXYGEN

1995

In late summer 1995, Horseshoe Lake formed a 10-foot-thick thermocline (defined as a layer of water in a lake where the temperature changes rapidly with depth, and shown shaded on the graphs) from 10 to 20 feet. Dissolved oxygen was plentiful above the thermocline. The lake ran out of dissolved oxygen at 12 feet and that condition remained to the bottom. The hypsographic (depth-area) graph shows about 63 percent of the lake is deeper than 12 feet.

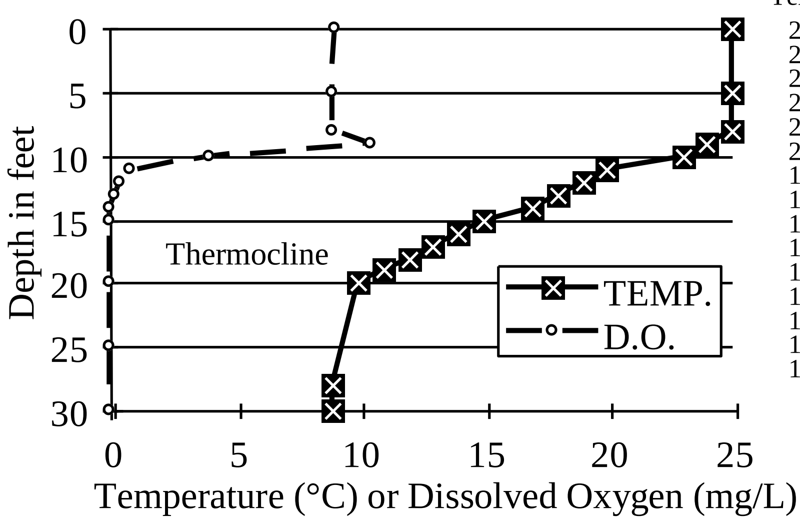
Horseshoe Lake, Washtenaw County Temperature and Dissolved Oxygen Profiles (September 2, 1995)



Temp.	Depth	D.O.	Depth
25	0	7.2	0
25	5	7.2	5
25	10	7.0	10
24	11	3.5	11
23	12	0.0	12
22	13	0.0	15
18	14	0.0	20
17	15	0.0	25
16	16	0.0	30
15	17		
14	18		
13	19		
12	20		
11	22		
10	26		
10	29		

1996

Horseshoe Lake, Washtenaw County August 11, 1996 Temperature and Dissolved Oxygen Profiles

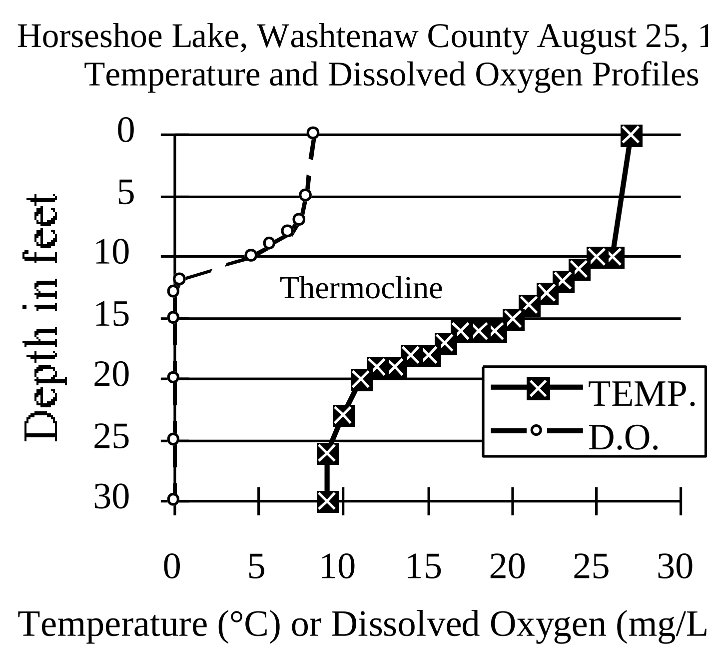


Temp.	Depth	D.O.	Depth
25	0	9.1	0
25	5	9.0	5
25	8	9.0	8
24	9	10.5	9
23	10	4.0	10
20	11	0.8	11
19	12	0.4	12
18	13	0.2	13
17	14	0.0	14
15	15	0.0	15
14	16	0.0	20
13	17	0.0	25
12	18	0.0	30
11	19		
10	20		
9	28		
9	30		

In late summer 1996, Horseshoe Lake formed an 11-foot-thick thermocline from 8 to 20 feet. Dissolved oxygen was plentiful above the thermocline. A small dissolved oxygen maximum occurred in the thermocline indicating the presence of an algal bloom that settled there.

The lake ran out of dissolved oxygen at 14 feet and that condition remained to the bottom.

1998



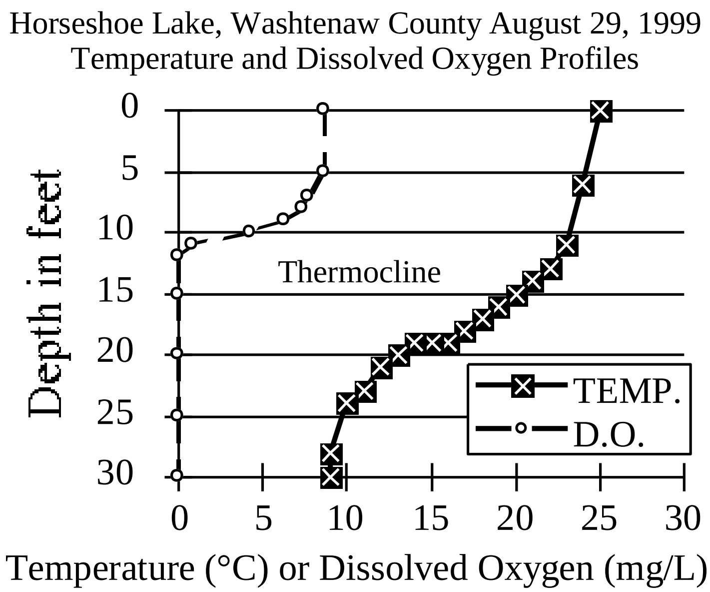
Temp.	Depth	D.O.	Depth
27	0	8.3	0
26	10	7.8	5
24	11	7.5	7
23	12	6.8	8
22	13	5.7	9
21	14	4.6	10
20	15	0.4	12
17	16	0.0	13
16	17	0.0	15
15	18	0.0	20
14	18	0.0	25
13	19	0.0	30
11	20		
10	23		
9	26		
9	30		

In late summer 1998, Horseshoe Lake formed an 18-foot-thick thermocline from 7 to 20 feet.

The lake ran out of dissolved oxygen at 13 feet and that condition remained to the bottom.

1999

In late summer 1999, Horseshoe Lake formed a 19-foot-thick thermocline from 5 to 24 feet. Dissolved oxygen was plentiful above the thermocline. The lake ran out of dissolved oxygen at 12 feet and that condition remained to the bottom.



Temp.	Depth	D.O.	Depth
25	0	8.7	0
24	6	8.7	5
23	11	7.7	7
22	13	7.3	8
21	14	6.3	9
20	15	4.3	10
19	16	0.8	11
18	17	0.0	12
17	18	0.0	15
16	19	0.0	20
15	19	0.0	25
14	19	0.0	30
13	20		
12	21		
11	23		
10	24		
9	28		
9	30		

It appears that the amount of dissolved oxygen below the thermocline is not changing each year. This is good.

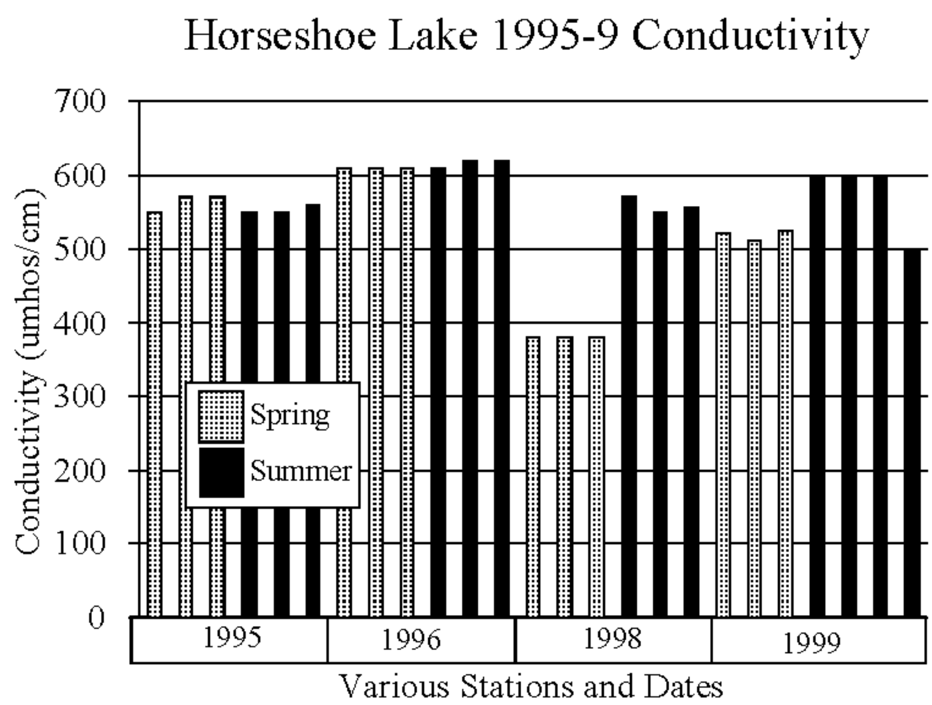
CONDUCTIVITY

Conductivity generally measures salts, and lower is usually better.

The graph below shows the conductivity of Horseshoe Lake ranges from a low of 370 micromhos per centimeter (in the spring of 1998), to a high of 620 micromhos per centimeter in the summer of 1996.

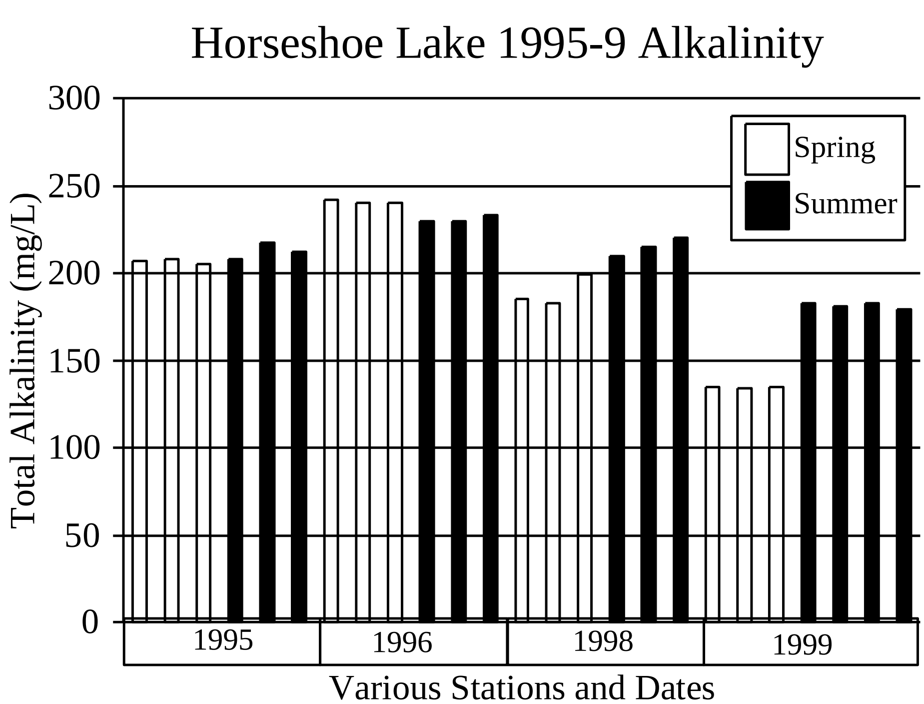
The graph shows these are higher than normal conductivities for a Michigan moderately hard water inland lake. The data shows salts are probably entering the lake from U.S. 23 road salting activities.

Conductivities in the 600+ range generally indicate the presence of salts in the lake from other than natural sources.



4/22/95	550
4/22/95	570
4/22/95	570
9/1/95	550
9/1/95	550
9/1/95	560
7/12/96	610
7/12/96	610
7/12/96	610
8/10/96	610
8/10/96	620
8/10/96	620
6/9/98	380
6/9/98	380
6/9/98	380
8/25/98	570
8/25/98	550
8/25/98	555
6/11/99	520
6/11/99	510
6/11/99	525
8/29/99	600
8/29/99	600
8/29/99	600
8/29/99	500

TOTAL ALKALINITY



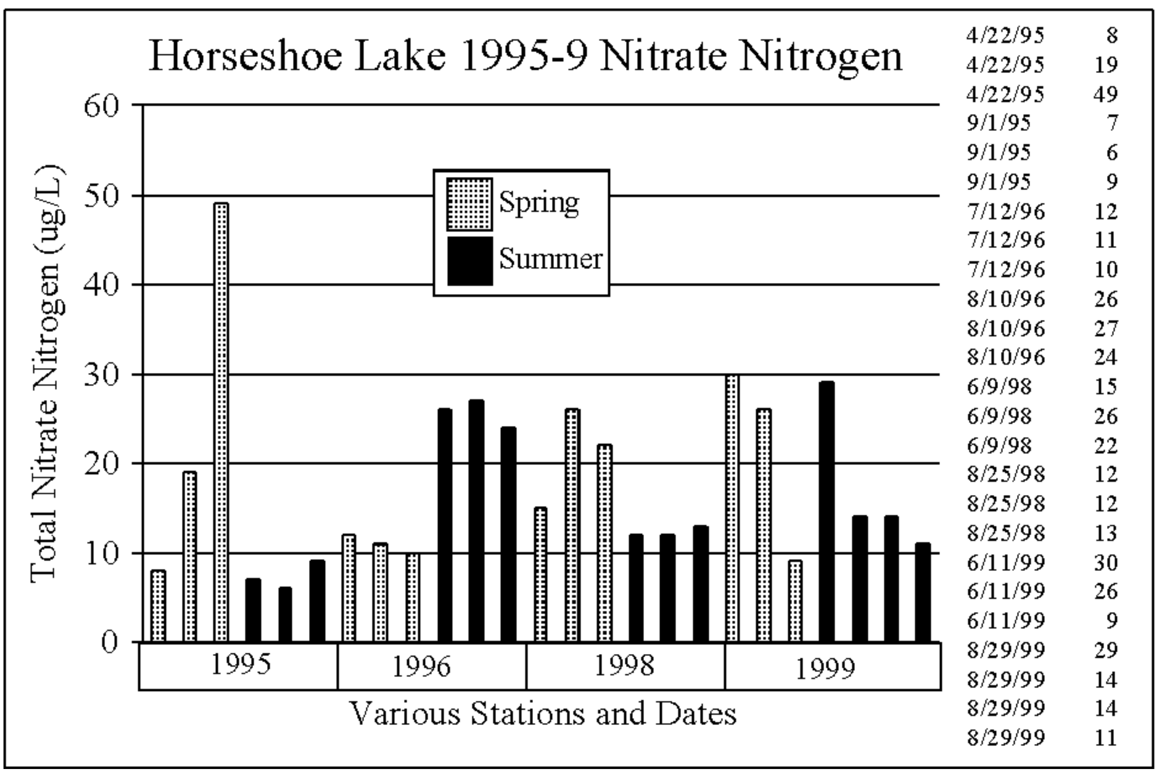
4/22/95	207
4/22/95	208
4/22/95	205
9/1/95	208
9/1/95	217
9/1/95	212
7/12/96	242
7/12/96	240
7/12/96	240
8/10/96	230
8/10/96	230
8/10/96	233
6/9/98	185
6/9/98	183
6/9/98	199
8/25/98	210
8/25/98	215
8/25/98	220
6/11/99	135
6/11/99	134
6/11/99	135
8/29/99	183
8/29/99	181
8/29/99	183
8/29/99	179

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 below shows the alkalinity of Horseshoe Lake ranges from 130 to 242 milligrams per liter. This indicates Horseshoe Lake is a hard water lake. Alkalinity varies more in Horseshoe Lake than in most natural lakes, but that is probably a result of the large upstream drainage area.

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.

Horseshoe Lake nitrate nitrogen concentrations were low every time the lake was sampled in both spring and summer. They ranged from 7 to 49 micrograms per liter.

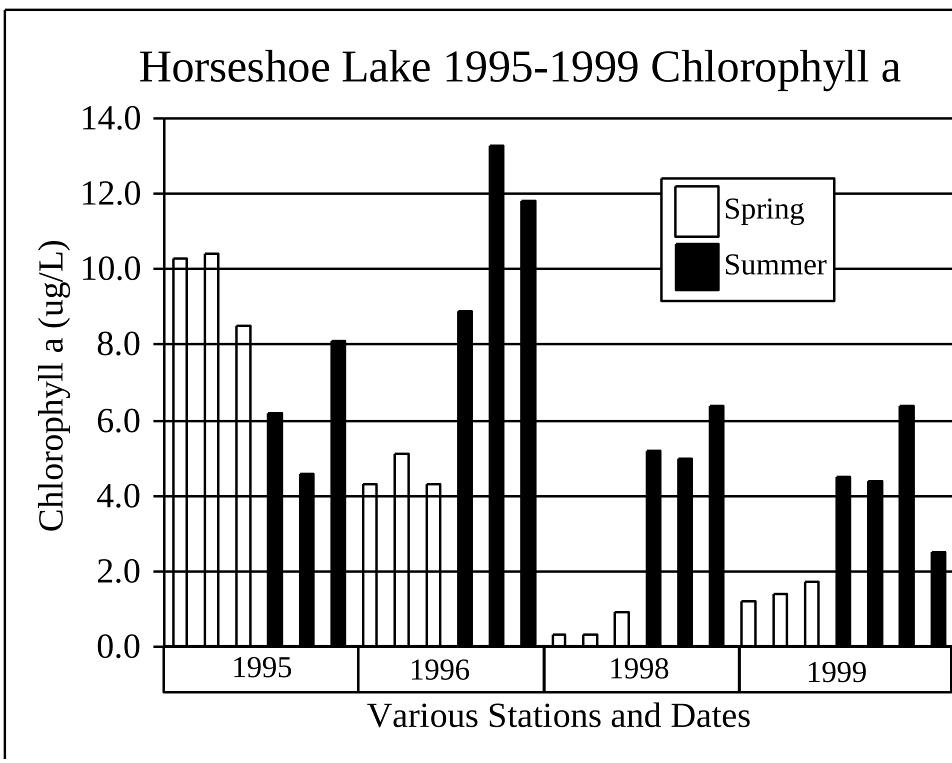
These data indicate Horseshoe Lake is nitrate rather than phosphorus limited. It also means no fertilizers containing either nitrogen or phosphorus should be used on near lake areas.

CHLOROPHYLL A

Chlorophyll a generally gives an estimate of algal densities. Best is below 1 microgram per liter.

The graph below shows Horseshoe Lake has significant algal blooms from time to time. At least the data shows chlorophyll a concentrations were lower in 1998 and 1999 than they were in 1995 and 1996.

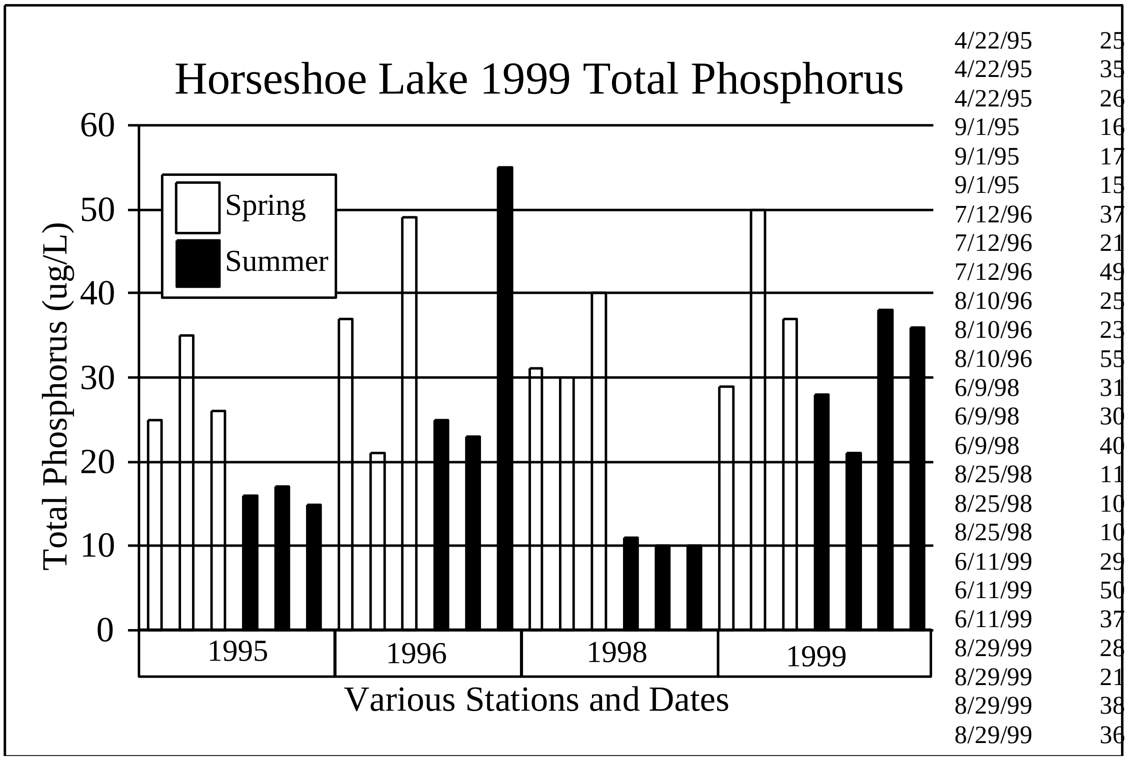
The data also shows Horseshoe Lake generally has denser algal blooms in summer, although 1995 was an exception.



4/22/95	10.3
4/22/95	10.4
4/22/95	8.5
9/1/95	6.2
9/1/95	4.6
9/1/95	8.1
7/12/96	4.3
7/12/96	5.1
7/12/96	4.3
8/10/96	8.9
8/10/96	13.3
8/10/96	11.8
6/9/98	0.3
6/9/98	0.3
6/9/98	0.9
8/25/98	5.2
8/25/98	5.0
8/25/98	6.4
6/11/99	1.2
6/11/99	1.4
6/11/99	1.7
8/29/99	4.5
8/29/99	4.4
8/29/99	6.4
8/29/99	2.5

TOTAL PHOSPHORUS

The graph below shows Horseshoe Lake has phosphorus concentrations that are high enough to cause problems if sufficient nitrates were present.



Phosphorus concentrations range from a low of 10 micrograms per liter (which is ideal) to a high of 55 micrograms (which is not ideal at all). The graph shows spring phosphorus concentrations are generally higher than summer phosphorus concentrations.

The two inlet streams need to be sampled on a regular basis to determine if they are the source of the high phosphorus concentrations.

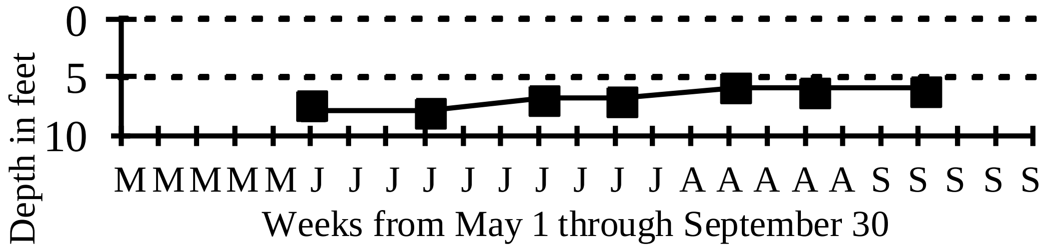
Best is below 10 micrograms per liter.

Other than showing the spring phosphorus concentrations are generally higher than summer phosphorus concentrations, no significant trend is shown by the graph below.

1998 AND 1999 HORSESHOE LAKE SECCHI DISK DATA

Carl Kayden does a good job taking Secchi disk readings through the warm months. The graphs below show the data he collected in 1998 and1999.

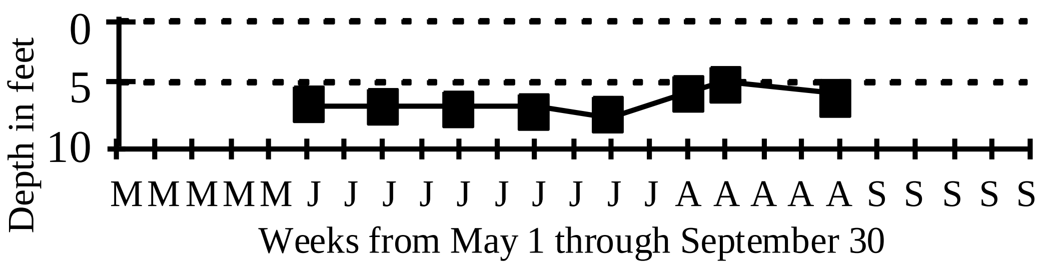
Horseshoe Lake, Washtenaw County 1998 Secchi Disk Depths



JUN	8	.	.	8
JUL	.	7	.	7
AUG	.	6	.	6
SEP	.	6	.	.

Carl's collected Secchi disk data at the three in-lake stations, but they were uniform, varying no more than a foot between stations. Hence only a single graph is shown.

Horseshoe Lake, Washtenaw County 1999 Secchi Disk Depths

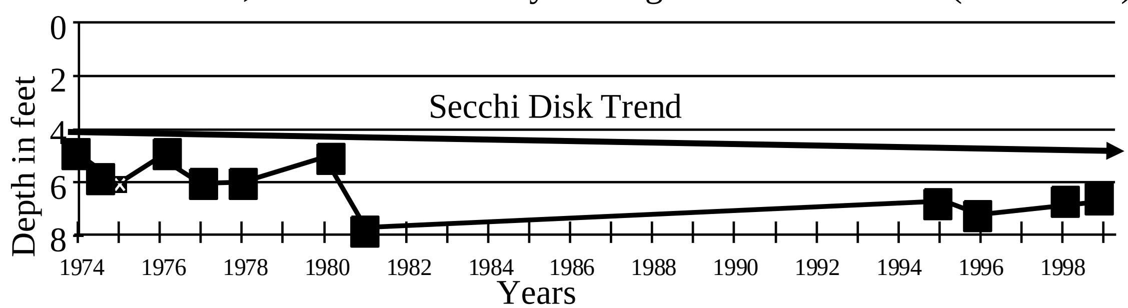


JUN	7	.	7	.	.
JUL.		7	.	8	.
AUG	6	5	.	.	6
SEP	.	.	.	.	.

Carl's data shows the clarity of Horseshoe Lake doesn't change much as the water warms.

The Secchi disk trend graph below shows the water in Horseshoe Lake is gradually getting clearer. This is good.

Horseshoe Lake, Washtenaw County Average Secchi Disk Data (1974-1999)



Data:	1974	1975	1976	1977	1978	1980	1981	1995	1996	1998	1999
	4.9	6.1	5.1	6.1	6.0	5.1	7.7	6.7	7.3	6.9	6.7

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Horseshoe 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:

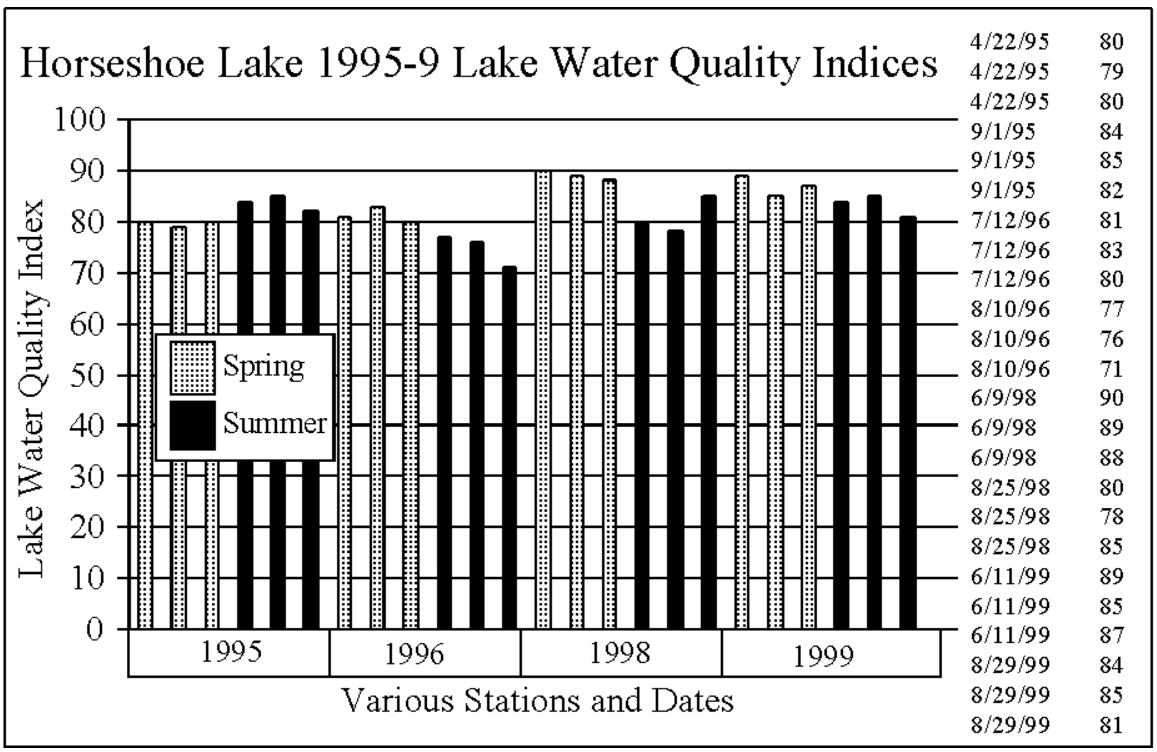
Dissolved oxygen (percent saturation)
Total phosphorus
Chlorophyll a
Secchi disk depth
Total nitrate nitrogen
Total alkalinity
Temperature
Conductivity
pH

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 Horseshoe Lake in Grand Traverse County, with a spring LQWI of 100. The lowest LWQI seen by this author was 16 at Lake Macatawa in Ottawa County.

THE 1995-1999 SPRING AND SUMMER LAKE WATER QUALITY INDICES



The graph shows the spring Lake Water Quality Indices for Horseshoe Lake range from a low of 79 (in 1995) to a high of 90 (in 1998). This indicates the water quality of Horseshoe Lake in spring was in the high C to B range.

The graph shows the late summer Lake Water Quality Indices for Horseshoe Lake range from 71 (in 1996) to 85 (in 1998). This indicates the water quality of Horseshoe Lake in summer is in the C to B range.

The graph shows no significant trend except that spring water quality is generally better than summer water quality.

HORSESHOE LAKE 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 burning.

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.

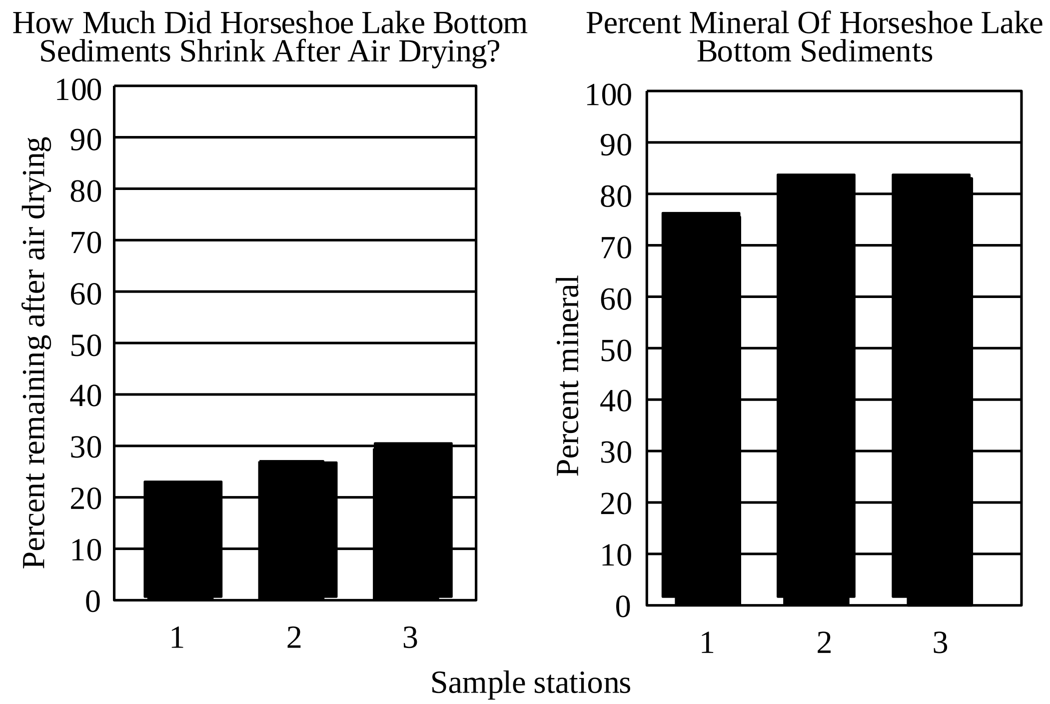
Highly organic sediments that remained black after air drying usually turn tan after burning, but the mineral content is usually quite low.

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.

The three bottom sediment samples collected from Horseshoe Lake in 1995 shrunk between 70 and 79 percent. They all turned gray after air-drying.

After burning at 550 degrees C, all sediment samples turned tan gray. That's not a meaningful color. At least they didn't turn red, because the red color would have indicated the presence of clay, usually from near-lake home or road construction.

The mineral content ranged from 76 to 82 percent. This is pretty good, but the lake is starting to accumulate organic material in the sediments.



Characteristics of Horseshoe Lake Bottom Sediments (1995)

Sample I.D.	Percent Shrinkage	Percent Mineral	Dried at 100°C Color & Description	Color after burning at 550°C	Depth of water (feet)
1	70	76	Gray smooth	Tan gray	24
2	77	82	Gray smooth	Tan gray	26
3	79	82	Gray smooth	Tan gray	29
80 percent = average mineral content of bottom sediments					

Residents need to stop using lawn fertilizers. The rule is simple if you want to preserve your lake. Don't use any. Period.

One of the most important things Horseshoe Lake homeowners can do is to make sure the mineral content doesn't change, and organic material starts to build up. If the mineral content of the bottom sediments doesn't change, it means the homeowners around the lake are taking proper care of their lake.

COMMENTS AND OBSERVATIONS

Things don't seem to be changing much in Horseshoe Lake. However, the two drains should be sampled on a monthly basis for a year to determine if either is contributing significant nutrients to Horseshoe Lake.

The lake appears to be nitrate rather than phosphorus limited. At least that's what the data shows. That means no fertilizers should be used in the near lake areas, and by near lake areas, I mean no closer than 400 feet from the lake.

Wallace E. Fusilier
Consulting Limnologist
Water Quality Investigators
Dexter, Michigan
April 2000

Surface 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
4/22/95	1	---	---	---	10.3	7.6	8	207	8.3	550	25	80	B
4/22/95	2	---	---	---	10.4	7.6	19	208	8.3	570	35	79	C
4/22/95	3	---	---	---	8.5	7.6	49	205	8.4	570	26	80	B
9/1/95	1	25	7.4	88	6.2	8	7	208	8.4	550	16	84	B
9/1/95	2	25	7.3	87	4.6	8	6	217	8.4	550	17	85	B
9/1/95	3	25	7.2	86	8.1	8	9	212	8.3	560	15	82	B
7/12/96	1	---	---	---	4.3	7	12	242	8.2	610	37	81	B
7/12/96	2	---	---	---	5.1	7	11	240	8.1	610	21	83	B
7/12/96	3	---	---	---	4.3	7	10	240	8.1	610	49	80	B
8/10/96	1	25	9.3	111	8.9	6	26	230	8.5	610	25	77	C
8/10/96	2	25	9.2	110	13.3	6	27	230	8.5	620	23	76	C
8/10/96	3	25	9.1	108	11.8	6	24	233	8.5	620	55	71	C
6/9/98	1	---	---	---	0.3	8	15	185	8.5	380	31	90	A
6/9/98	2	---	---	---	0.3	7	26	183	8.2	380	30	89	B
6/9/98	3	---	---	---	0.9	7	22	199	7.6	380	40	88	B
8/25/98	1	28	8.5	108	5.2	5	12	210	8.7	570	11	80	B
8/25/98	2	29	8.2	103	5.0	4	12	215	8.7	550	10	78	C
8/25/98	3	29	8.3	104	6.4	4	13	220	8.7	555	10	85	B
6/11/99	1	---	---	---	1.2	7	30	135	8.2	520	29	89	B
6/11/99	2	---	---	---	1.4	7	26	134	8.2	510	50	85	B
6/11/99	3	---	---	---	1.7	7	9	135	8.0	525	37	87	B
8/29/99	1	25	8.3	99	4.5	7	29	183	8.4	600	28	84	B
8/29/99	2	25	8.5	101	4.4	7	14	181	8.4	600	21	85	B
8/29/99	3	25	8.7	104	6.4	6	14	183	8.4	600	38	81	B
8/29/99	4	---	---	---	2.5	---	11	179	8.3	500	36	---	---