HESS LAKE

GRANT & BROOKS TOWNSHIPS
NEWAYGO COUNTY
MICHIGAN

WATER QUALITY TESTING
2014

Prepared by:

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Hess Lake

Hess Lake is a 755-acre hard-water lake, located in Sections 4 and 5 of Grant Twp (T11N R12W) and in Sections 31, 32, and 33 of Brooks Twp (T12N R12W), Newaygo County, MI. The lake has a maximum depth of 24 feet, and a mean depth of 7.2 feet. The length of the shoreline is 29,454 feet.

The lake has a couple of inlets. The lake itself is part of the Muskegon River system. Alger Creek and the Wheeler Drain flow into the lake on the south. The outlet is on the northeast side and the water flows into Brooks Lake.

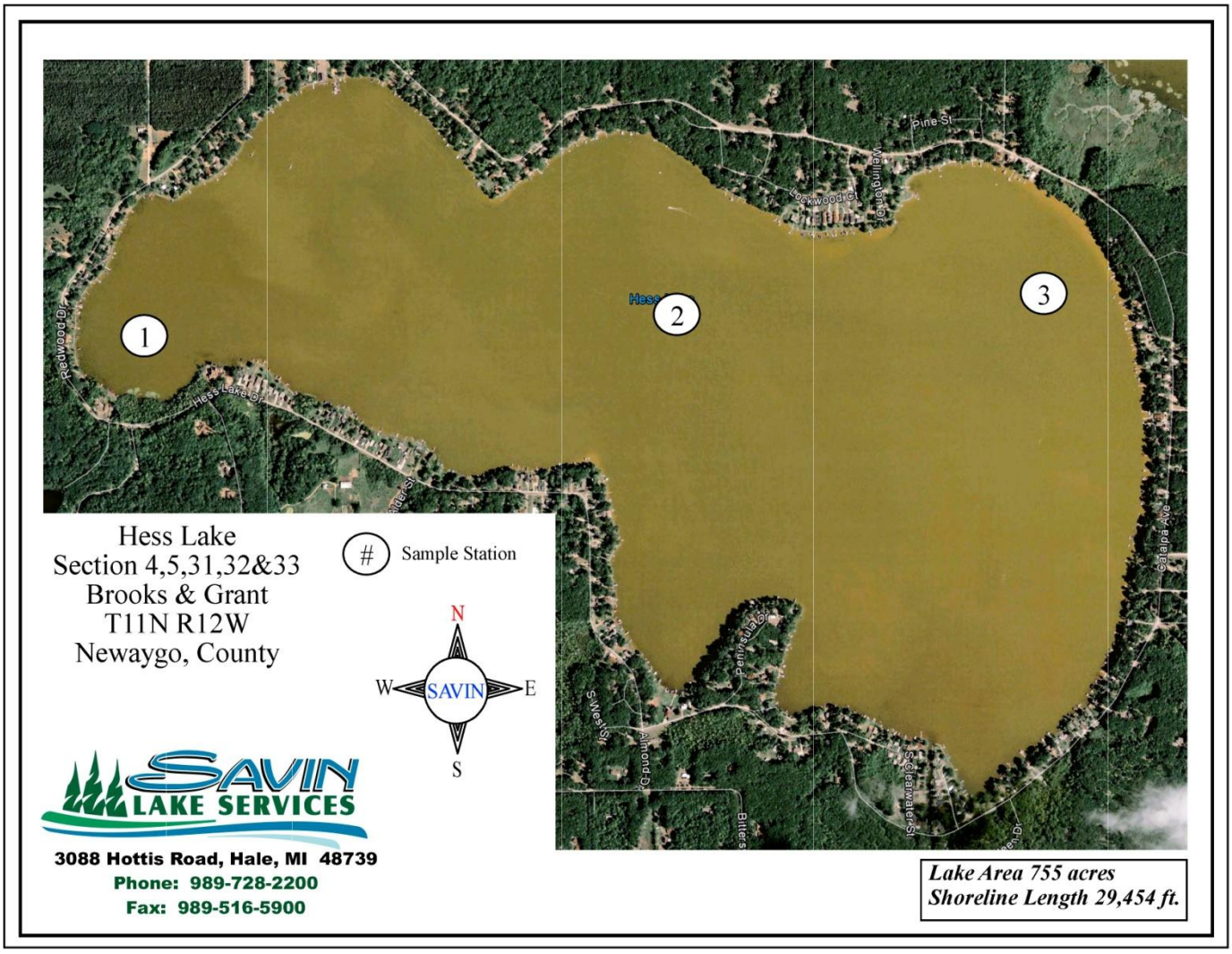
The elevation of the lake is 764 feet above sea level.

THE WATER QUALITY STUDY

During certain periods, Michigan lakes have poorer water quality than the rest of the year. Usually our studies involve sampling the lake in early spring when phosphorus from the bottom sediments may be mixed into the water column causing early spring algal blooms; and late summer when the water is warmest, and the lake is stratified (if it stratifies). Thus, if the lake gets high marks for water quality during early spring and late summer it probably has pretty good water quality all year.

This study looked at the 2014 late summer sampling periods.

THE SAMPLE STATIONS



The locations of the three in-lake sample stations are shown as circles on the map of the lake. The location of station 2 is at the deepest part of the lake.

SAMPLE DATES

Savin Lake Services personnel collected three surface samples at the stations shown on the map on September 18, 2014. Top to bottom temperature and dissolved oxygen profile data were also collected at Station 2 in the deepest part of the lake.

THE ANALYSES

Dissolved oxygen, temperature, pH and Secchi disk transparency measurements were conducted in the field. Total phosphorus, conductivity, alkalinity, total nitrate, and chlorophyll α analysis was completed at an independent laboratory.

THE DATA

The data discussed below are found in the table at the end of this report. The late summer laboratory's detection limits were not set correctly for nitrate and phosphorus, which is why the values are shown as below the limits. This problem will be corrected in future analysis.

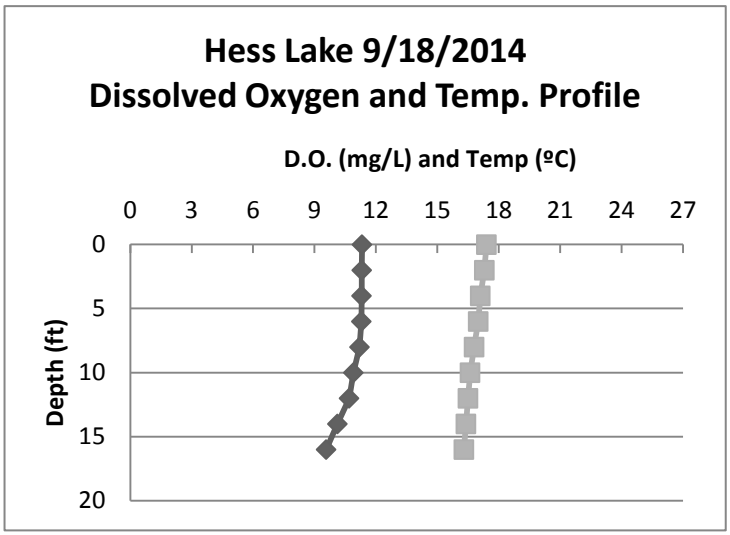
TEMPERATURE AND DISSOLVED OXYGEN

Temperature exerts a wide variety of influences on most lakes, such as the separation of layers of water (stratification), solubility of gases, and biological activity.

Dissolved oxygen is the parameter most often selected by lake water quality scientists as being important. Besides providing oxygen for aquatic organisms in natural lakes, dissolved oxygen is involved in phenomena such as phosphorus precipitation to, and release from, the lake bottom sediments and decomposition of organic material in the lake.

2014

A thermocline may have developed in the summer, but did not appear during the last summer sampling date. Despite a late start to the summer, temperatures dropped off in the water resulting in an early mix. The dissolved oxygen levels are still good for the temperature, and both values stayed steady to the bottom of the lake.



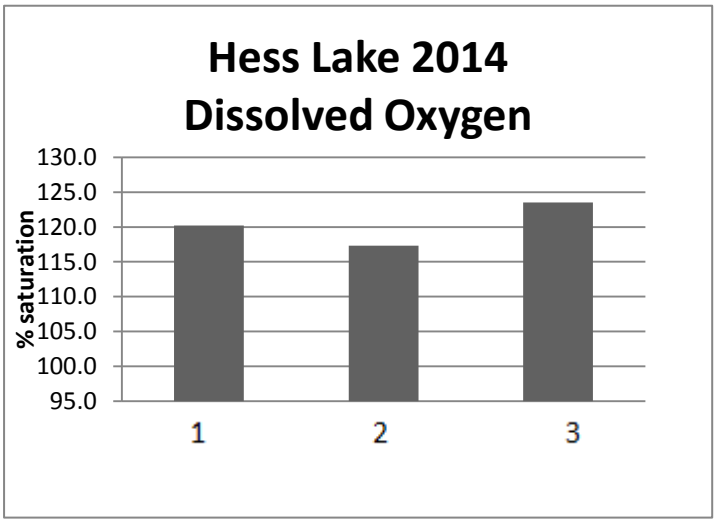
Temperature (ºC)	D.O. (mg/L)	Depth (ft)
17.4	11.32	0
17.3	11.31	2
17.1	11.30	4
17.0	11.29	6
16.8	11.20	8
16.6	10.90	10
16.5	10.69	12
16.4	10.12	14
16.3	9.57	16
16.2	8.31	18
16.1	8.23	20

Hess Lake did not show that a thermocline developed during the sampling date. However that does not mean that one did not develop during 2014 as the sampling date was later than usual. The date was chosen based on other natural events that happened later in 2014. Sampling in 2015, if taken, will occur at the end of August. In this sampling, the dissolved oxygen levels were high for the temperature, but gradually decreased to the bottom of the lake to a concentration of 8.23 mg/L. It would be interesting to see if any stratification occurs during the summer, with future samplings.

Low dissolved oxygen concentrations (below 4 milligrams per liter) are generally insufficient to support fish life. In most Michigan lakes, there is no dissolved oxygen below the thermocline in late summer. Some experts like to see some dissolved oxygen in the bottom water of a lake, even if it is almost zero. This is because as long as there is some dissolved oxygen in the water at the bottom of the lake, phosphorus precipitated by iron to the bottom sediments will remain there. Once a lake runs out of dissolved oxygen in the water at the bottom iron comes back into solution. When that happens, it releases the phosphorus back into the water. This can cause additional algae to grow when the lake mixes.

DISSOLVED OXYGEN, PERCENT SATURATION

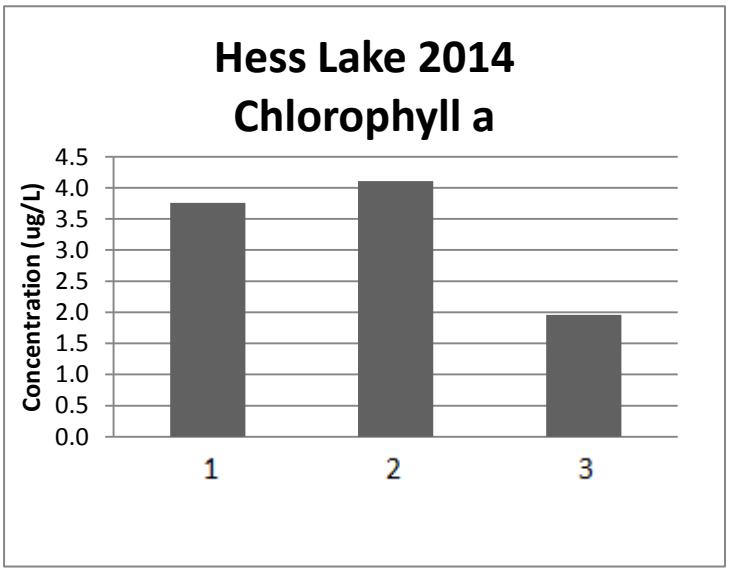
Because the amount of dissolved oxygen a water can hold is temperature dependent with cold water holding more than warm water, dissolved oxygen saturation is often a better way to determine if oxygen supplies are adequate. The best is between 90 and 110 percent.



In the late summer of 2014, the dissolved oxygen concentrations ranged from 117 to 124 percent. These values are slightly high for the temperature of the lake, but still ok.

CHLOROPHYLL A

Chlorophyll a is used by lake scientists as a measure of the biological productivity of the water. Generally, the lower the chlorophyll a, the better. High concentrations of chlorophyll a are indicative of an algal bloom in the lake, an indication of poor lake water quality. The highest surface chlorophyll a concentration found by Wallace Fusilier (Water Quality Investigators, WQI) in a Michigan lake was 216 micrograms per liter. Best is below one microgram per liter.



The graph shows Hess Lake 2014 late summer concentrations were 3.8, 4.1, and 2.0 micrograms per liter. These values are slightly high, and this data suggests Hess Lake contains a moderate amount of algae growth.

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.

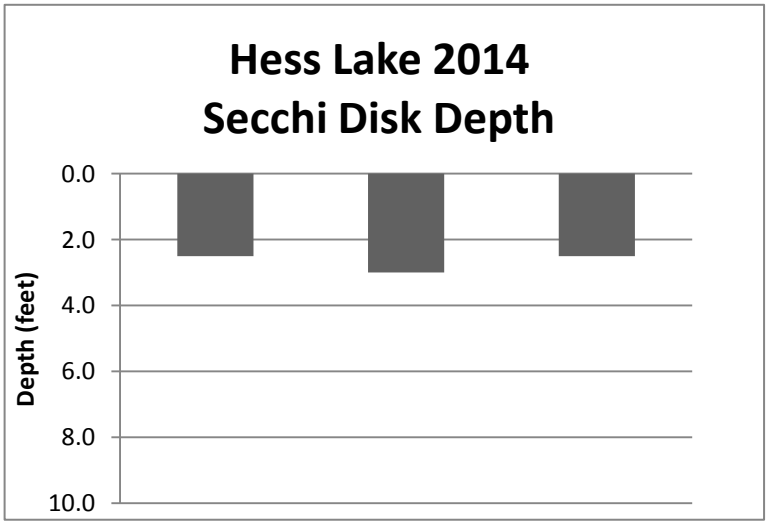
The Secchi disk transparency is a lake test widely used and accepted by limnologists. The experts generally felt the greater the Secchi disk depth, the better quality the water. However, one Canadian scientist pointed out acid lakes have very deep Secchi disk readings. (Would you consider a very clear lake a good quality lake, even if it had no

fish in it? It would be almost like a swimming pool.) 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.

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.

SECCHI DISK DATA



Hess Lake's secchi disk readings were 2.5, 3.0, and 2.5 feet. These values are bad. One would expect a 24 foot deep lake, as large as Hess Lake is, to reach far below these values. Algae, sediment, among other factors most likely are contributing to this.

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.

Based on WQI's studies of many Michigan inland lakes, they'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.

Hess Lake's 2014 late summer readings were all below 20 ug/L. 20 ug/L was the detection limit used by the laboratory. Although this info is ok, it is not exact, which would be ideal. Anything below 20 ug/L is satisfactory. The detection limit problem will be corrected in future samplings.

NITRATE NITROGEN

Nitrate, also measured in the parts per billion range, has traditionally been considered by lake scientists to also be a limiting nutrient. The experts felt any concentration below 200 parts per billion was excellent in terms of lake water quality. The highest value found by Fusilier was 48,000 parts per billion in an Ottawa County river which flowed into Lake Macatawa in Holland, Michigan

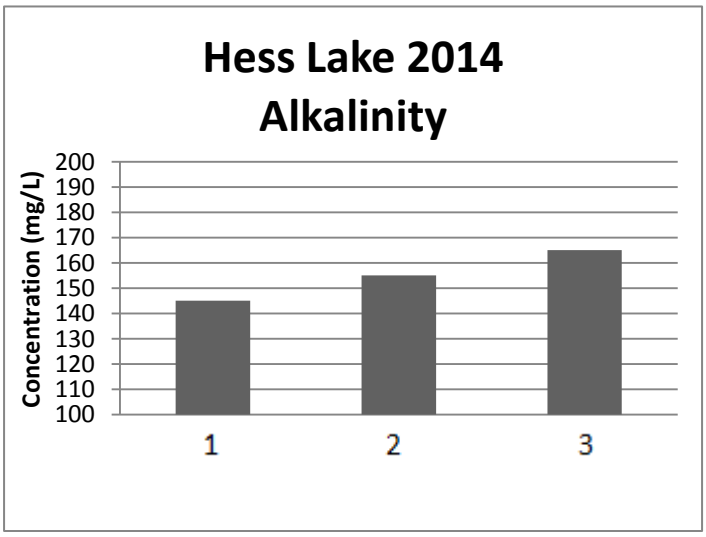
On the other hand, WQI has studied hundreds of Michigan inland lakes, and many times we find them nitrate limited (very low nitrate nitrogen concentrations), especially in summer.

Similar to phosphorus, the detection limit for nitrate used by the laboratory was set too high. Therefore, we can only tell that the concentrations were all below 100 ug/L for the 3 sites. However, despite the detection limit, anything below 100 ug/L for nitrate is great.

Generally limnologists feel optimal nitrate nitrogen concentrations (which encourage maximum plant and algal growth) are about 10-20 times higher than phosphorus concentrations. The reason more nitrogen than phosphorus is needed is because nitrogen is one of the chemicals used in the production of plant proteins, while phosphorus is used in the transfer of energy, but is not used to create plant material. If the nitrate concentration is less than 10-20 times the phosphorus concentration, the lake is considered nitrogen limited. If the nitrate concentration is higher than 10-20 times the phosphorus concentration, the lake is considered phosphorus limited.

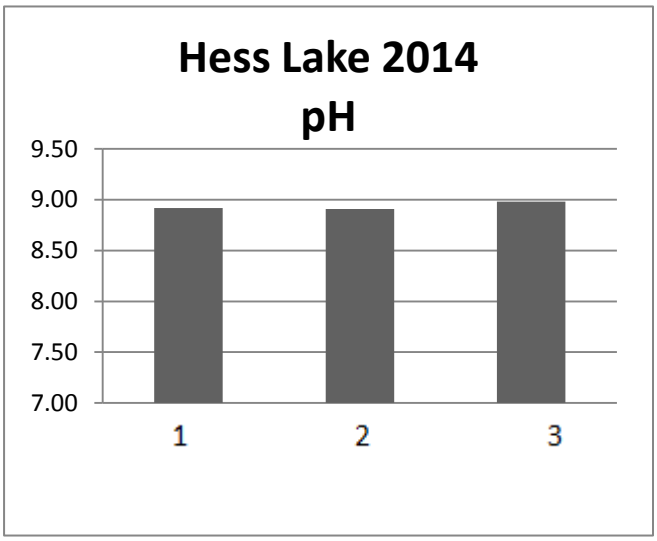
TOTAL ALKALINITY

Alkalinity is a measure of the ability of the water to absorb acids (or bases) without changing the hydrogen ion concentration (pH). It is, in effect, a chemical sponge. In most Michigan lakes, alkalinity is due to the presence of carbonates and bicarbonates which were introduced into the lake from ground water or streams which flow into the lake. In lower Michigan, acidification of most lakes should not be a problem because of the high alkalinity concentrations.



Hess Lake's surface alkalinity data (145-165 milligrams per liter in 2014) indicates it is a hard water lake, which is ok. This is because hard water lakes have the ability to precipitate some of the phosphorus that enters the lake to the bottom sediments as calcium phosphate. This pretty much ties up that phosphorus in the sediments. Soft water lakes lack this ability.

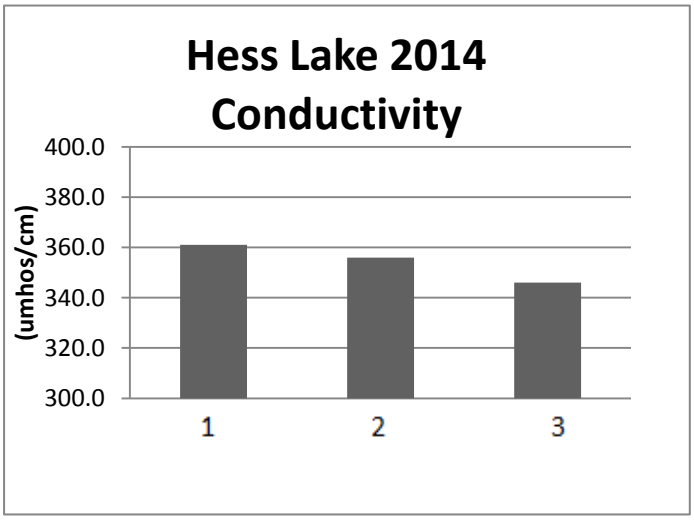
HYDROGEN ION CONCENTRATION (pH)



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.

Hess Lake's 2014 pH values (8.9 to 9.0) are within the normal range for a hard water Michigan inland lake.

SPECIFIC 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 does good quality water.

The graph shows Hess Lake's 2014 conductivities range from 346 to 361 micromhos per centimeter. These values are good for a hard water Michigan lake.

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index (LWQI) (Fusilier, 1982) used in this study to define the water quality of Hess 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 a lake; and second, there was no agreement among lake scientists regarding the meaning of the data collected during lake studies.

Development of the index involved two questionnaires which were sent to a panel of 555 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 scientists became the index parameters (or tests). They were:

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

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.

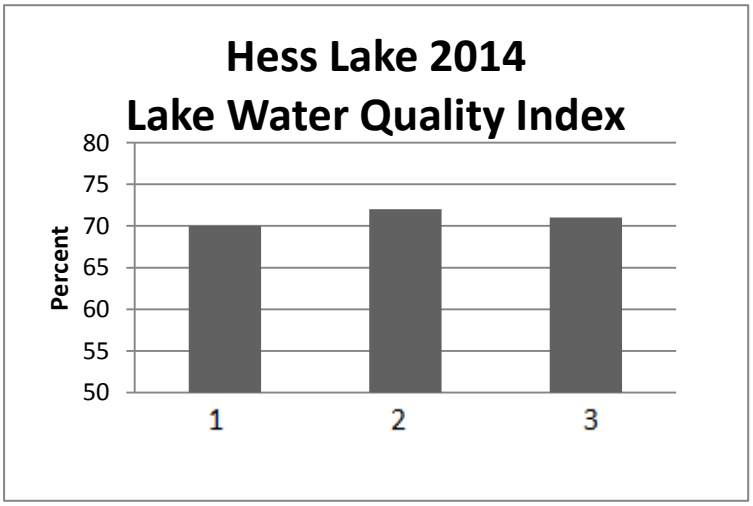
After the responses to the second questionnaire were tabulated, the nine tests and the accompanying rating curves were combined into a Lake Water Quality Index.

The index ranges from 1 to 100, with 100 indicating excellent lake water quality. The index rated lakes about the same way teachers rate students: 90-100=A, 80-90=B, 70-80=C, 60-70=D, and below 60=E.

The highest index for a Michigan lake studied by Fusilier was Long Lake in Grand Traverse County at 100 in the spring of 1994. The lowest was 16 in an Ottawa County lake.

HESS LAKE 2014 LAKE WATER QUALITY INDICES

The graph shows the 2014 water quality of Hess Lake in the late summer they were 70, 72, and 71. All values are given a C. Although the overall quality of the lake based on these measurements is not great, it would be wise to continue monitoring the quality in order to show any trends in the quality.



THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

The Lake Water Quality Index calculation sheets were developed to show graphically what the results of the nine different lake water quality tests meant 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 figures which look like thermometers are graphs which convert the test results (the values found on the outside of the thermometer) to a uniform 0-100 lake water quality rating (found on the inside of the thermometer).

The calculation sheet combines all nine of the individual quality ratings into a single Lake Water Quality Index. The index ranges from 1 (very poor lake water quality) to 100 (excellent lake water quality).
The index is portrayed in three different ways: as a number ranging 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 sample sites within a lake and determine how the quality of the various lakes or sites compare.

The position of the lines on the thermometer rating scales permits determination of the parameter (or parameters) which cause the index to be depressed. The lower the line, the greater the problem. A glance at the top of the problem rating scale identifies the test and the test results. The rating scales also permit determination of what test results would be considered excellent in terms of lake water quality by the panel of experts surveyed. They are the numbers on the outside the thermometers, near the top.

HESS LAKE WATER QUALITY INDICES CALCULATION SHEETS

Eight water quality index calculation sheets are included in this report. Six of the eight are from each sample site for the two different sampling dates. The other two are averaged sheets for each sampling date.

Matthew Novotny
Geochemist
Savin Lake Services
Hale, Michigan
January, 2015

Hess Lake Water Quality Data

Date	Sample Station Number	Temperature (ºC)	Dissolved Oxygen		Chlorophyll α (ug/L)	Secchi Disk Depth (ft)	Total Nitrate Nitrogen (ug/L)	Alkalinity (mg/L)	pH	Conductivity umhos per cm at 25 ºC	Total Phosphorus (ug/L)	Lake Water Quality Index	Grade
			(mg/L)	Percent Saturation									
9/18/2014	1	17.6	11.36	120.2	3.8	2.5	<100	145	8.92	361.0	<20	70	C
9/18/2014	2	17.4	11.32	117.3	4.1	3.0	<100	155	8.91	356.0	<20	72	C
9/18/2014	3	17.4	11.92	123.5	2.0	2.5	<100	165	8.98	346.0	<20	71	C

Wallace E. Fusilier, Ph.D. is a highly regarded consulting limnologist. Information and styling found within this report are the result of Fusilier's dedication and professionalism as a limnologist.

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLICATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

(Individual Quality Ratings never exceed 100)

QUALITY RATING CURVES

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophylla ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S.U.	Specific Conductivity um hos/cm @ 25C	Total Phosphorus ug/L
17.6	11.4 / 9.5 / 120.2	3.8	2.5	<100	145	8.92	361	<20
	approx		Feet					

Newaygo
County

Grant/Brooks
Township

Savin
Analyst

24 feet
Lake Depth

755 acres
Lake Area

8									
100	X 83	X 72	X 19	X 100	X 100	X 58	X 90	X N/A	= LW QI 70

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

DATE 09/18/2014

STATION 1

LAKE Hess Lake

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow green	Green	Blue Green	Blue

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLICATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

(Individual Quality Ratings never exceed 100)

QUALITY RATING CURVES

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophyll a ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S.U.	Specific Conductivity um hos/cm @ 25C	Total Phosphorus ug/L
17.4	11.3 / 9.7 / 117.3	4.1	3.0	<100	155	8.91	356	<20
	approx		Feet					

Newaygo
County

Grant/Brooks
Township

Savin
Analyst

24 feet
Lake Depth

755 acres
Lake Area

8	100	X	87	X	69	X	22	X	100	X

100	X	59	X	90	X	N/A	=

LW QI

72

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

DATE 09/18/2014

STATION 2

LAKE Hess Lake

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow green	Green	Blue Green	Blue

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLICATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

(Individual Quality Ratings never exceed 100)

QUALITY RATING CURVES

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophylla ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S.U.	Specific Conductivity um hos/cm @ 25C	Total Phosphorus ug/L
17.4	11.9 / 9.7 / 123.5	2.0	2.5	<100	165	8.98	346	<20
	approx		Feet					
100	78	90	19	100	100	55	91	N/A

Newaygo
County

Grant/Brooks
Township

Savin
Analyst

24 feet
Lake Depth

755 acres
Lake Area

LW QI = 71

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

DATE 09/18/2014

STATION 3

LAKE Hess Lake

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow green	Green	Blue Green	Blue

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLICATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

(Individual Quality Ratings never exceed 100)

QUALITY RATING CURVES

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophylla ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S.U.	Specific Conductivity um hos/cm @ 25C	Total Phosphorus ug/L
17.5	11.5 / 9.7 / 119.5 (approx)	3.3	2.7	<100	155	8.94	354	<20
100	83	77	20	100	100	57	90	N/A

LW QI = 71

369 : 1
Watershed to Lake Ratio

6.1 days
Flushing rate

265,520 acres
Drainage Basin

266,240 acres
Drainage Area

3618 acre-feet
Lake Volume

Isabella
County

Broomfield/Sherman
Township

Savin
Analyst

24 feet
Lake Depth

719 acres
Lake Area

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

DATE 09/18/2014

STATION Average

LAKE Hess Lake