A Water Quality Study

of

Pleasant Lake

located in Freedom Township
Washtenaw County, Michigan

Includes:
Recommendations for Lake Preservation
Bottom Contour Mapping
A Theoretical Nutrient Budget
A Historical Survey
Near–lake Soils Identification
Water Quality Analyses
Bottom Sediment Analyses

This report prepared for the

Pleasant Lake Property Owners Association

February 1986

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LETTER OF TRANSMITTAL

February 10, 1986

Mrs. Annette Phillips, President
Pleasant Lake Property Owners Association
11695 Pleasant Shore Drive
Manchester, Michigan 48158

Dear Mrs. Phillips,

We ar pleased to submit this report on Pleasant Lake to you in accordance with our prior agreeement.

We wish to thank you and Mr. Bob Frakes for the assistance we received during the study. We also wish to thank Mr. Richard Dimond and Mr. Phil Jones of the Aura Inn for allowing us to use their boat launch site whenever needed.

Our aim in preparing this report was to provide information to help lakefront homeowners understand their lake and to provide a practical guide for those who must manage the future of Pleasant Lake. We hope that the people who use this report will find it useful and interesting.

Sincerely yours,

Wallace E. Fusilier

Wallace E. Fusilier Ph.D.

Gerald A Cleary

Gerald A Cleary P.E.

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DISCUSSION AND RECOMMENDATIONS

- Oxygen concentrations do not appear to be depleted in any part of the lake, therefore fish populations should find adequate supplies throughout the year. Hypolimnetic aeration is not recommended at this time.

- As shown in the calculated theoretical nutrient budget, Pleasant lake has a large amount of phosphorus in the bottom sediments (over 20 tons). The nutrient budget shows that the two main sources of phosphorus are septic tank effluents and lawn fertilizers.

- Lawn fertilizer used in the immediate lake watershed should be phosphorus free, for two reasons. First, enough phosphorus is already in the soil. Secondly, phosphorus does not make lawns green. Nitrogen does. Phosphorus is a root-growth nutrient.

- Some method of exporting the septic tank effluent from the immediate watershed should be explored. The cluster system concept is a possibility. In a cluster system, each house has a septic tank and pump, which the individual home owner maintains. The effluent from each septic tank is pumped via a pressure sewer to a large tile field some distance from the lake and serves 10-15 houses. The purpose of this type of system is to remove a large amount of phosphorus from lakeshore areas, preventing it from flowing into the lake and causing more serious problems than the lake currently has.

As early as 1924, reports by the Michigan Department of Conservation (now the DNR) show that Pleasant Lake has had weed problems.

An aquatic weed survey found that the major weed problems in Pleasant lake during the fall of 1984 were native pondweeds (Potomogeton spp.) and native milfoils (Myriophyllum sp.) See map 6.

Several attempts were made during the spring, summer and fall of 1985 to map problem weed areas, but for some reason, the weed growth was greatly diminished that year.

- For Pleasant Lake, weed harvesting is the method of choice for weed control, for several reasons.

1. Weed harvesting does not introduce any potentially toxic materials into the lake water.

2. Vegetation would be removed from the lake, so oxygen supplies are not depleted when the material settles to the bottom and decomposes. Hypolimnetic dissolved oxygen would remain high and the sediment phosphorus would remain precipitated.

3. Harvesting minimizes fish kills.

4. The area is immediately useable.

- If an infestation of curly leaf pondweed (Potamogeton crispus) should occur in mid to late May, no control measures should be initiated. Usually this plant dies back by the middle of June which, in most cases, is before the lake is used extensively for recreation. Many times lake front property owners become needlessly concerned with this aquatic weed, but in most cases, their concern will diminish rapidly as the weed dies back rather quickly.

- Not all weeds should be removed or killed. Aquatic plants remove nutrients from the water column, and provide habitat for fishes. One of the problems often seen on local lakes is that everyone wants a sandy beach and no weeds. Since all of the shoreline nutrient filters are removed, the problems moves out into the lake. Since the process is gradual, most lake front property owners don't realize the consequences of their actions.

- Chara beds should be maintained. Chara, although it looks looks like an aquatic plant, is an alga which removes phosphorus from the water column. Chara can be recognized by its musty odor and the crusty feeling of the leafy portions of the plant in late summer.

- Temperature monitoring for the Michigan Gas Pipeline thermal discharge should be conducted at the edge of each 500 foot radius mixing zone.

- The monitoring results discussed in the Consumers Power Company August 1975 proposal, if they were implemented, should be available for public inspection.

- The high summer surface phosphorus concentrations at the two west sample stations were unusual (113 and 68 micrograms per liter). If these results can be duplicated, a study should be conducted to find the source or sources of these nutrients.

- Laundry drains from the houses in the immediate lake watershed should be dye tested to determine if this wastewater is bypassing the normal sewage system.

- A newsletter should be published several times a year informing lake residents about current problems and solutions.

- The Pleasant Lake Property Owners Association should consider joining the Michigan Lake and Stream Associations if they are not currently members. This group is aware, concerned and knowledgeable about lake problems.

- A Pleasant Lake Property Owners Association should be formed to manage the lake management program.

- To pay for any lake management activities, several options exist.

1. Base the assessment on the present lake lot assessment roll.

2. Base the assessment on the front footage for each lot.

3. Base the assessment on an "equal benefit" basis. This would mean equal division of costs among the riparian owners.

SCOPE OF WORK—BASIC SERVICES

1. Lake Bottom Contour Mapping

A hydrogeologic map of Pleasant Lake, including bottom contours, and lake and watershed geometry shall be prepared. Maps shall be based upon existing information, including USGS maps. Bottom contours will be determined by echo-sound readings on various lake transects.

Aquatic vegetation shall be field or laboratory identified and mapped. All sampling stations will be noted on the map.

2. Lake Water Quality

Samples shall be taken in late summer while the lake is stratified, and in early spring while the lake is well mixed; at not less than ten sample stations. The following lake water quality tests will be run:

Dissolved Oxygen (surface to bottom profiles)
Temperature (surface to bottom profiles)
pH (surface to bottom profiles)
Conductivity
Alkalinity
Total Phosphorus
Total Nitrate and Nitrite Nitrogen
Secchi Disk transparency
Chlorophyll a

A theoretical nutrient budget shall be prepared, based on the results of the tests. (If additional tests are required because of sample contamination or other types of analytical error, they shall be completed at no additional charge.)

3. Evaluation

The dissolved oxygen concentration at various levels shall be evaluated and the possible effect on fish populations shall be discussed. The thermal stratification as it occurs in the lake in late summer will be discussed. The water quality test results shall be evaluated to determine the causes of the lake problems. Possible corrective actions will be suggested where appropriate. The rooted aquatic plant populations will be evaluated for practical control measures.

4. Report

A report shall be prepared in accordance with PA 345 of 1966 (the Inland Lake Improvement Act of 1966) which will discuss the results of the tests and measurements made on Pleasant Lake, and summarize the findings and recommendations to control existing problems. It will also recommend possible methods of preventing future problems. Above all, the report will be written in a clear, concise and understandable manner.

5. Meetings

Meetings will be attended when requested by the Pleasant Lake board to review the project plan and progress. At the final meeting with the Lake Board and lake residents, the final report and results will be presented.

6. Costs for the Pleasant Lake Study and Evaluation. $1500

Includes the following:
1. All sampling and lake measurements, including sampling equipment and supplies, boats, sample containers, etc.
2. All lab tests, including personnel costs and computer time.
3. All historical information, including mapping, lake volume calculations and nutrient budgets.
4. The report, including all secretarial, duplicating and graphics costs.
5. Engineers signature

PLEASANT LAKE DATA

Name....................	Pleasant Lake
Size	202 Acres
Volume..................	2105 Acre feet
or.....................	91,693,800 cubic feet
or.....................	685,869,624 gallons
or.....................	5,720,152,664 pounds
Maximum depth............	35 feet
Mean depth..............	10.4 feet
Location................	Sections 21 & 22 (T3S R4E) Freedom Township, Washtenaw County, Michigan
Drainage basin..........	Huron River System
Lake drainage area.......	692 acres
Elevation...............	951 feet above sea level

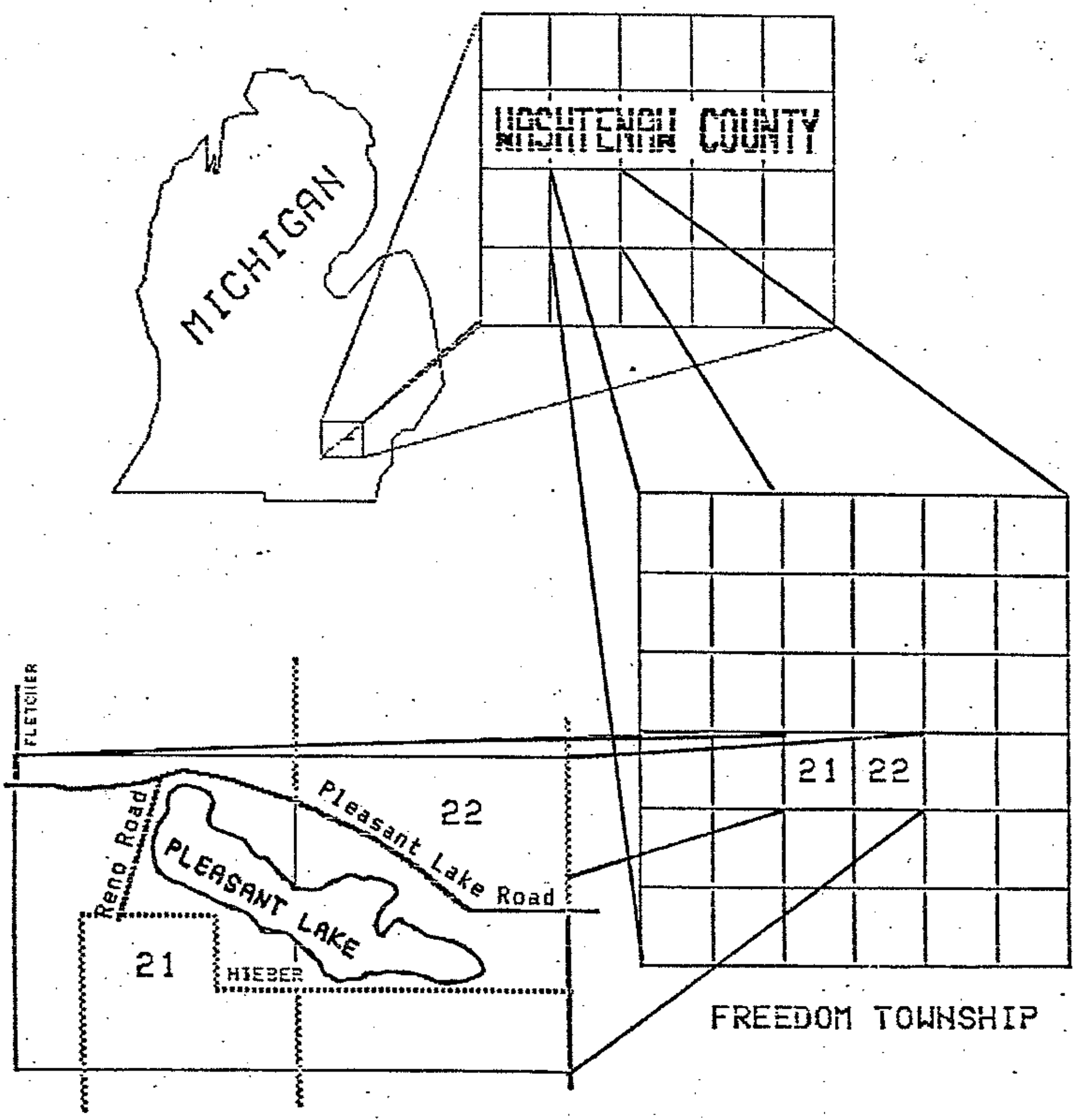
PLEASANT LAKE DESCRIPTION AND LOCATION

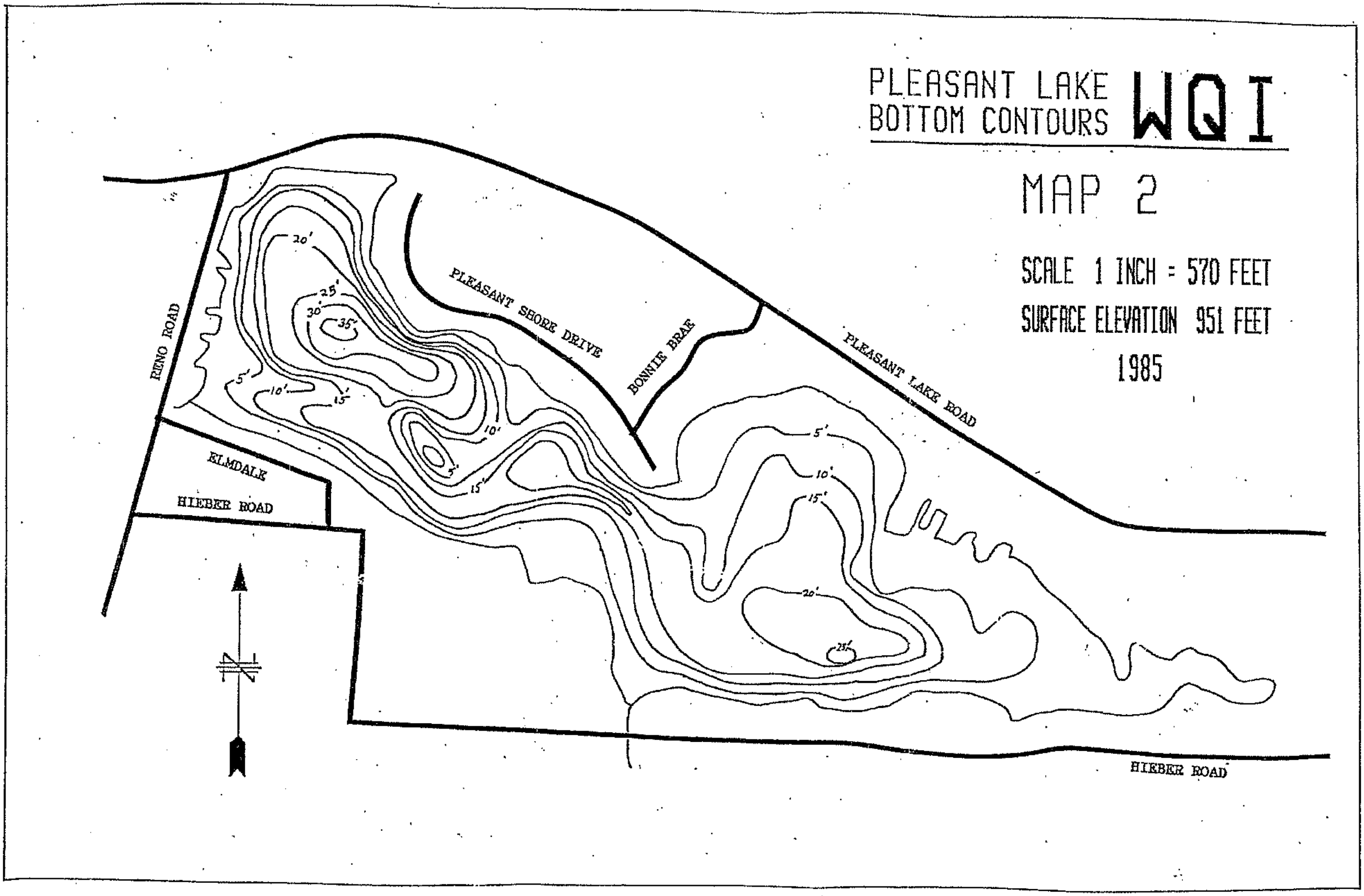
Pleasant Lake is a 202-acre kettle lake located in Sections 21 and 22 of Freedom Township (T3S R4E), Washtenaw County, Michigan. See Map 1. The lake was formed 10-14,000 years ago when the retreating glacier left a block of ice buried in the glacial drift. The bottom contour map of Pleasant Lake shows the various irregular ridges, mounds, and depressions which are often found in this type of lake. See Map 2. The lake is fed by groundwater from springs. The lake surface elevation is 951 feet above sea level and is an expression of the groundwater table. The lake has one surface inlet, and a single rarely-intermittent outlet. The lake is located on the southern edge of the Mill Creek Basin, part of the Huron River basin. Water from this system enters Lake Erie above Monroe, Michigan. The drainage basin for Pleasant Lake is 692 acres (Marsh & Borton, 1974). See Map 3. There are 107 or more residences surrounding the lake, all served with on-site septic tanks and tile fields; plus a 24 unit trailer park served by a community septic system.

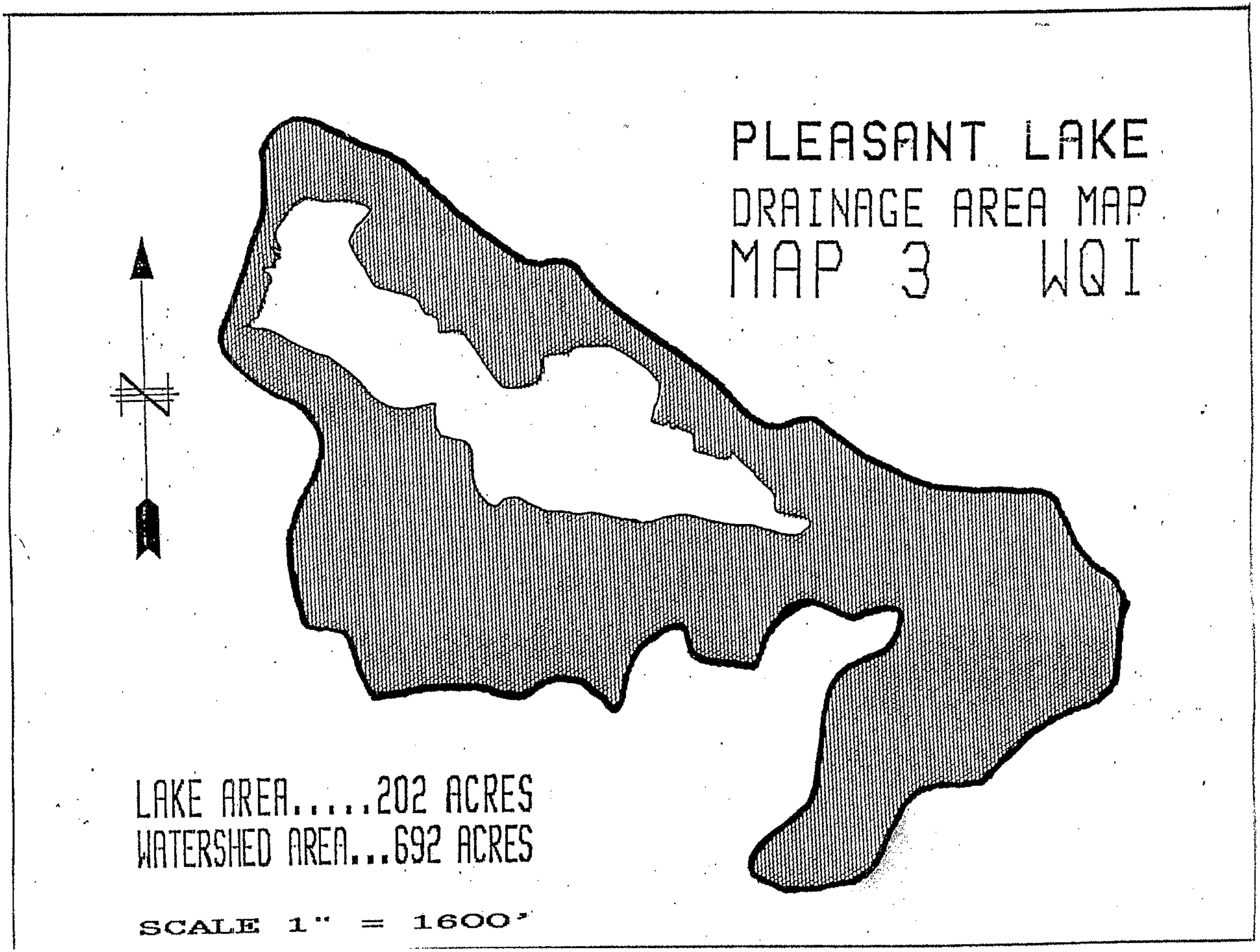
Since 1948, Michigan Gas Storage Company, a division of Consumers Power Company, has been operating the Freedom Natural Gas Compressor Station west of the lake. The plant uses Pleasant Lake as a source of cooling water and also as a discharge point for the heated water. It is capable of operating 24 hours per day. It has an intake channel and three thermal discharge pipes at the west end of the lake. At full operational capacity, 8210 gallons of cooling water per minute can be pumped through the plant. The water is used to cool as many as 13 natural gas compressors; and the compressed gas.

MAP 1

LOCATION MAP




PLEASANT LAKE
BOTTOM CONTOURS
WQI
MAP 2
SCALE 1 INCH = 570 FEET
SURFACE ELEVATION 951 FEET
1985
RENO ROAD
PLEASANT SHORE DRIVE
BONNIE BRAE
PLEASANT LAKE ROAD
ELMDALE
HIEBER ROAD
HIEBER ROAD
5'
10'
15'
20'
25'
30'
35'


PLEASANT LAKE
DRAINAGE AREA MAP
MAP 3 WQI
LAKE AREA.....202 ACRES
WATERSHED AREA...692 ACRES
SCALE 1" = 1600'

HISTORICAL RECORD

The following information was taken from the records of the Institute of Fisheries Research of the Michigan Department of Natural Resources located on the University of Michigan Ann Arbor campus. The files are open to the public and can be seen during normal business hours.

- From *Michigan Lakes and Streams Directory*, East Lansing, MI, 1931.

Pleasant Lake--Washtenaw County, Freedom Twp near M-11, ne of Manchester. 600 [*sic*] acres. A road touches lake on N.W. and S. sides. Extensive resort development. Boat livery, good swimming, gravel beach, sparse woods, one island, hilly land on S. High & rolling on other sides. Lake much frequented. Large and small mouth bass, blue gills, perch, pike.

- Michigan Department of Conservation, 1924

Vegetation thick, much Vallisneria (wild celery). Bottom thickly covered with vegetation.

Immediate shore--Several cottages
Surrounding country--mostly cultivated
Point of examination--S. side of lake
Species of fish--Pike & large mouth bass, blue gills & pumpkinseed, small mouth bass. Caught fingerling perch in abundance. Encourage large mouth bass and great lakes perch.

signed Metzelaar September 12, 1924

- 16 October 1930, Institute of Fisheries Research (Ashley, Tarzwell, Eschmeyer) Michigan Department of Conservation, Division of Fisheries

No outlet.
Vegetation fairly abundant. Chara, Niads, P. Amplifolius.
Animal life--minnows, crawfish & insects fairly numerous.
Bottom--mostly sand and gravel
Immediate shore--Mostly sand and gravel
Point of examination--North shore. About 60 blue gills, 16 pumpkin seed sunfish, several blue gill-sunfish hybrids, 1 green sunfish, 4 large mouth bass, 10 small perch, 2 rock bass, 75 blunt nosed minnows, 5 IOA darters.

- October 12, 1936, Institute of Fisheries Research (Eschmeyer) Michigan Department of Conservation Summary Sheet, Division of Fisheries.

Description--Lake is shallow in most places but has some deeper holes (about 30 feet deep). The shore line is mostly sand and gravel with many boulders. Vegetation is plentiful and minnows seem rather abundant. The lake contains some golden shiners which the natives took for Cisco. Fish are very abundant in the lake, possibly due to the fact that it is heavily fished. Conditions seem ideal for fish. Natives report that illegal fishing has been done to a considerable extent in the lake. At present however, the laws are being observed due, at least to some extent to Mr. E. J. Sodt, who has a store on the lake and also quite a few boats to rent. Mr. Sodt is a deputy game warden as well as a deputy sheriff, and is doing what he can for the good of the lake. There are a number of cottages along the shore--about 15.

The rather large number of fish taken is due to the fact that a number of hauls were made with a 125' sein. These fish (blue gills & sunfish) were taken to the Northville hatchery. Fish in the lake are not so abundant as figures seem to indicate.

Water--clear
Vegetation--Some Potomogeton robbinsonii and P. amplifolius.
Bottom--Pulpy peat
Immediate shore--sand and gravel
Surrounding country--higher, cultivated
Point of examination--central part of lake
10 blue gills, 3 golden shiners, 2 perch.
Large and small mesh gill nets were used.

- INSTITUTE OF FISHERIES RESEARCH (MAPPING) 1943

About 200 acres, 36 feet deep, 1¼ mile long, 1/3 mile wide.

Water level at time of mapping was about two feet high according to Mr. Maurice Sodt who has an Inn on the lake shore. The shore has a few marshy areas, but most of it is high and has sand and gravel.

Sodt has a good sized area for camping and picnicking. This is the main entrance to the public, although the road passes within 100' of the w. end. Cottage development is good, but not all suitable shore has cottages.

Fishing is only fair. The predominant species are bluegills, crappies, sunfish, pike, and large mouth bass. There was seldom a fisherman on the lake during the mapping period, but one day two weeks before there were about two dozen fishermen. Fishing success varies little in summer or winter, and is light at all times.

Water supply comes from springs and neighboring drainage. Outlet is through marsh at east end.

Mapped Feb 2-9, 1943
W.F. Carbine
George Washburn
L.E. Perry

THE WATER QUALITY STUDY

Samples were taken at two different times. A summer series of samples were taken to detect possible high Chlorophyll a concentrations, shallow Secchi disk transparencies, and oxygen depletion from the deep bottom waters, which may occur during this period. This date was August 29, 1984. Bottom contour measurements were made at this time.

A spring series of samples was obtained to detect high phosphorus levels which often occur in Michigan lakes when the lake waters reach the same temperature (isothermal) from top to bottom and the entire lake mixes by wind action. This date was April 15, 1985.

THE SAMPLING STATIONS

The sampling stations involved nine in-lake sites and the outlet. However no water was found flowing from it during any of the visits to the lake. The sample sites are shown on Map 4.

THE ANALYSES

Dissolved oxygen, temperature, Secchi disk transparency, conductivity and depth measurements were conducted in the field. Alkalinity, pH, total phosphorus, total nitrate, chlorophyll a and sediment analyses were performed in the Water Quality Investigators laboratory near Dexter, Michigan. All tests followed the procedures outlined in *Standard Methods for the Examination of Water and Wastewater.*

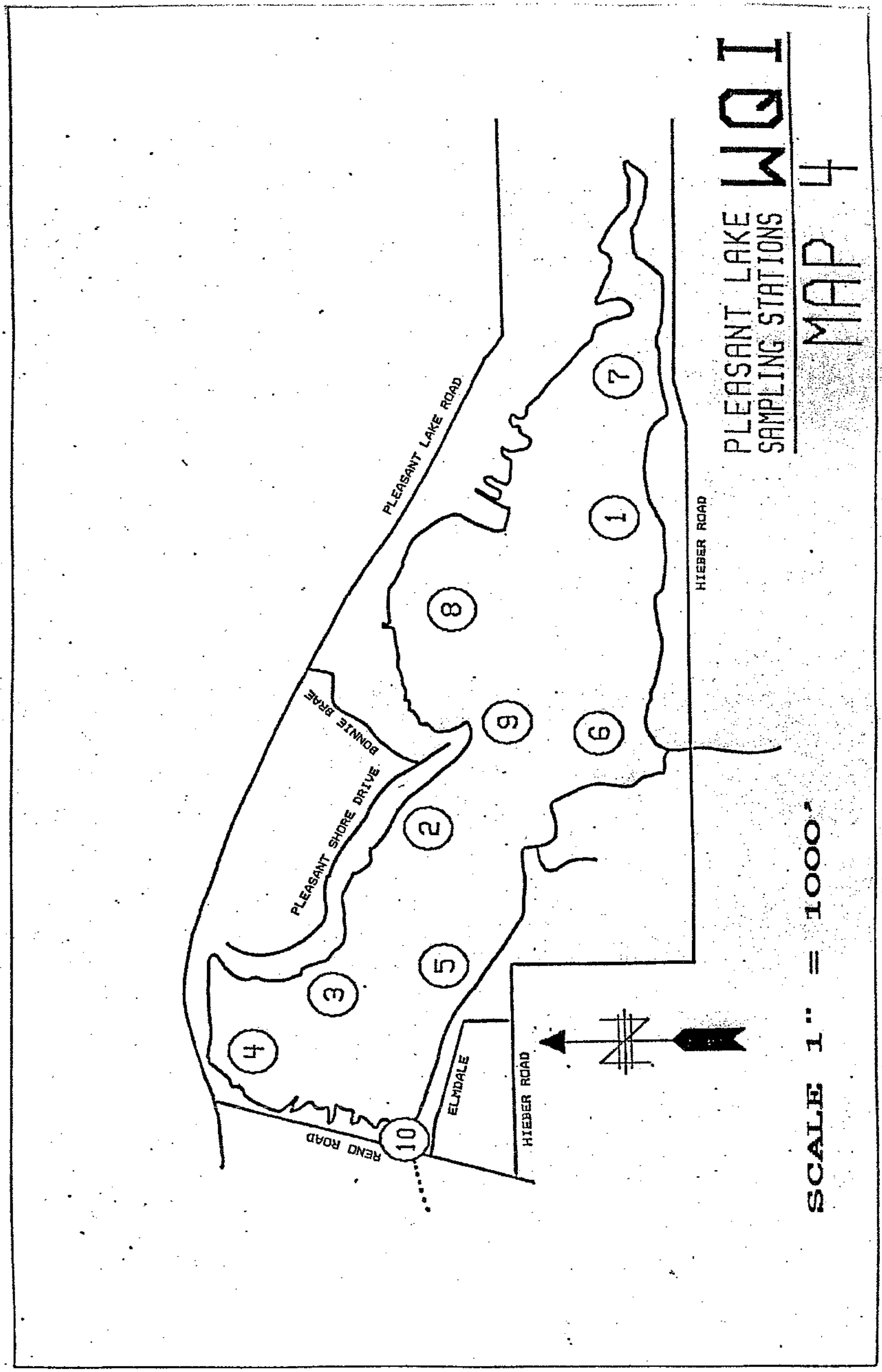
THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index (LWQI) was developed for two reasons:

1) There was no consensus of opinion among lake scientists regarding which tests should be run to define the water quality of a lake; and,

2) there was no consensus of opinion among lake scientists regarding the meaning of the data collected during lake studies.

The study involved the use of two questionnaires sent out to 555 lake water quality scientists (selected from the membership of the American Society of Limnology and Oceanography). The first questionnaire asked the scientists to indicate which tests they felt would give the best definition of lake water quality. 70% of the questionnaires were returned. The tests most often selected by the scientists became the index parameters. They are:


PLEASANT LAKE
SAMPLING STATIONS
WQI
MAP 4
PLEASANT LAKE ROAD
HIEBER ROAD
BONNIE BRAE
PLEASANT SHORE DRIVE
ELMDALE
RENO ROAD
HIEBER ROAD
N
1
2
3
4
5
6
7
8
9
10
SCALE 1" = 1000'

Dissolved Oxygen (Percent saturation)	pH
Total Phosphate	Chlorophyll a
Secchi Disk depth	Total Nitrate
Temperature	Alkalinity
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. The above parameters, and the accompanying rating curves were combined into a lake water quality index. The index values range from 1 to 100, with 100 being excellent lake water quality. The index seems to rate 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 Lake Water Quality Index value for Pleasant lake ranges from 51 to 85. This indicates that the water quality of Pleasant Lake ranges from failing to good. Lake Water Quality Indexes from the summer sampling data ranged from 81 to 85, indicating good water quality. Spring indexes ranged from 81 to 84, indicating good water quality, with the exceptions of station 4 which had an index of 51 (failing water quality), and station 5 which had an index of 76 (fair water quality). The index sheets show by the low position of the red marks on the thermometer-type rating curves that the problem parameter at both sites was a high concentration of phosphorus. Station 4 had a phosphorus concentration of 113, while station 5 had a phosphorus concentration of 68. The cause of these high phosphorus concentrations is unknown at this time.

The highest index for a southeast Michigan lake studied by the author is 95.

A DISCUSSION OF THE INDEX PARAMETERS

TEMPERATURE (AND DISSOLVED OXYGEN AND PHOSPHORUS)

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

Variations in the temperature of lake water effectively isolate layers of water in a lake during the summer: (and to a lesser extent in winter). Since water is heaviest at 4 degrees Centigrade (39 degrees Fahrenheit), the cold water remains on the bottom as the surface water warms in summer. Since the warm water is lighter, it remains on the surface. Oxygen readily diffuses from the air to the surface water of a lake, so although warm water holds less oxygen than cold water, high lake surface dissolved oxygen levels are generally maintained. There are instances when this condition could be upset.

For example, bacterial decomposition occurs at a much higher rate in warm water than in cold water. And since warm water holds less oxygen (and other gasses) than cold water, the increased use of oxygen by bacteria when they decompose materials, along with the lower amount of oxygen dissolved in warm water, leads to a much greater possibility that the lake oxygen will be depleted.

However, the oxygen in the cold, bottom water can be depleted in late summer, usually by bacterial decomposition of dead plants. This was found to be the case in 98% of southeast Michigan lakes and 85% of northern Michigan lakes studied by the author. This loss of oxygen in the bottom of lakes is important because of the role it plays in phosphorus release from the sediments.

Phosphorus will precipitate (usually in combination with iron) when there is oxygen present in the water. This means that in good quality lakes, the bottom sediments of a lake act as a trap for phosphorus. However, if the oxygen in the bottom water becomes depleted by bacterial decomposition of dead plant material, the phosphorus will become soluble and enter the water column. Once there, it can easily be taken up by plants and algae, which can then create the unsightly surface conditions found in many of the lakes in southern Michigan.

High dissolved oxygen conditions can occur when anaerobic conditions cause large sediment phosphorus releases which produce algal communities. Algae produce oxygen during daytime photosynthesis, so it is possible to have very high concentrations of dissolved oxygen during the late afternoon of a sunny summer day in a eutrophic lake. However, the algae use oxygen the same way animals do, in a process called respiration. It is possible for high concentrations of algae to remove almost all the oxygen in the surface water of a lake or stream during the night. Thus although it would seem that oxygen is in plentiful supply if the sample was taken in the afternoon, if the sample was taken just before daylight, test results might show that there is very little or no oxygen present.

Surface temperatures were 13 °C in the spring, and 25 °C in the summer. The bottom of the deep hole was 20°C in the summer. The thermocline, defined as a change in temperature of greater than 1°C per meter was not evident at any time.

DISSOLVED OXYGEN

Dissolved oxygen is the parameter most often selected by lake water quality scientists as being important. Besides its importance in providing oxygen for aquatic organisms to use, oxygen is involved in phenomena such as phosphorus precipitation and release from the lake sediments.

Summer surface dissolved oxygen concentrations for Pleasant Lake ranged from 8.1 to 9.1. The oxygen concentration at the 30 foot level in the deep hole was 1.6 milligrams per liter.

TOTAL PHOSPHORUS

Although there are several forms of phosphorus found in lakes, the experts selected total phosphorus as being the most important. This is probably because all forms of phosphorus can be converted to the other forms. Currently, most lake scientists feel that phosphorus, which is measured in parts per billion (1 part per billion is one second in 31 years), is the one chemical 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. It should be pointed out that if limiting the amount of phosphorus which enters a lake will prevent eutrophic conditions, all of the other nutrients are present in the lake which will permit this condition to occur. In other words, the quality of the lake water is poor, but if phosphorus input is limited, it is hoped that the plants and algae won't grow in excess. 50 parts per billion is considered to be a high value by the Michigan DNR.

Spring total phosphorus concentrations in Pleasant Lake ranged from 8 to 113 micrograms per liter, with an average value of 30.7 micrograms per liter. As noted above, station 4 had the highest phosphorus concentration, 113 ug/l and station 5 had the second highest, 68 ug/l. Both of these samples were taken from sites on the west end of the lake.

Summer surface in-lake phosphorus concentrations ranged from 19 to 33 micrograms per liter, with an average concentration of 25 micrograms per liter.

TOTAL NITRATE

Nitrate, also measured in the parts per billion range, has traditionally be considered by lake scientists to also be a limiting nutrient. However, nitrates can be made from nitrogen by nitrifying bacteria, lightning, and a variety of other sources. Therefore it is not controllable. The experts felt that any value below 200 parts per billion was excellent in terms of lake water quality. The highest value found by the author was 633 parts per billion in Inchwagh lake in Livingston county, a lake that has a sewage treatment plant discharging into it.

Pleasant Lake had very low summer nitrate concentrations, ranging from 17 to 18 micrograms per liter, with an average value of 18 micrograms per liter. The spring values were considerably higher, ranging from 155 to 305 micrograms per liter with an average of 238 micrograms per liter. These values were within normal ranges found in southeast Michigan lakes.

HYDROGEN ION CONCENTRATION (pH) AND ALKALINITY

pH has traditionally been a measure of water quality. Today it is an excellent indicator of the effects of acid rain on the lake. About 95% of the rain events in southeastern Michigan are below a pH of 5.6 and are thus considered acid. There seems to be no lakes in southeast Michigan which are being affected by acid rain. Most lakes have a pH value between 7.5 and 8.

Summer surface pH values for Pleasant Lake were exceedingly uniform at 8.4 at all stations except one which had an 8.5. Spring pH values were constant at 8.4 for all stations.

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 sources. In lower Michigan, acidification of the lakes should not be a problem because of the high alkalinity concentrations. The presence of carbonates in water also provides a source of carbon which plants may use for photosynthesis.

Pleasant Lake had an average summer surface alkalinity of 129 milligrams per liter with a range from 125 to 132. The average spring alkalinity was 152 milligrams per liter with a range from 149 to 152. These high alkalinity values, and the high pH value noted above, classifies Pleasant Lake as a hard water lake. It also means that Pleasant Lake will not be affected by acid rain in the forseeable future.

CONDUCTIVITY

Conductivity, measured with a meter, detects the capacity of a water to conduct an electric current. More importantly, however, conductivity measures the amount of materials dissolved in the water, since only dissolved materials will permit an electric current to flow. 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. We concur with this perception.

The summer surface conductivity for Pleasant Lake averaged 427 with a range of 420 to 440 at the surface. The value didn't change with depth. The spring surface conductivity was 410 at all stations. These values show that the chemical makeup of Pleasant Lake water changes little.

SECCHI DISK TRANSPARENCY (originally Secchi's disk)

In 1865, Angelo Secchi of Rome, Italy devised a 20 centimeter white disk for studying the transparency of the water in the Mediterranean Sea. Later a limnologist named Whipple divided the disk into black and white quadrants which many are familiar with today.

To take a Secchi disk reading, the disk is lowered into the water on the shaded side of the boat to a point where it disappears. Then it is raised to a point where it is visible. The average of these two readings is the Secchi disk depth. It should be pointed out that the reading 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. Wave action influences the visibility of the disk more than sunny or cloudy days.

The Secchi disk transparency is a lake water quality test widely used and accepted by lake scientists. The experts generally felt that the greater the Secchi disk depth, the better quality the water. However, one Canadian scientist pointed out that acid lakes have very deep Secchi disk values. (Would you consider a very clear lake a good quality lake, even if it had no fish in it? It would be almost like your swimming pool.) Most lakes in southeast Michigan have Secchi disk readings of less than ten feet. The spring reading was 5 feet at all stations. The summer Secchi disk readings ranged between 6 and 7 feet, with an average of 7 feet. These readings do not appear to be unusual for a southeast Michigan lake.

If there are sample sites where the lake is too shallow and the disk can still be seen when it rests on the bottom, the reading should be taken at a near-by site. Since the sampling procedure is supposed to be designed to obtain representative samples, the concept of moving the boat to an area where a Secchi disk reading can be properly taken is valid.

CHLOROPHYLL a

Chlorophyll a is used by lake scientists as a measure of the biological productivity of the water. The experts felt the best quality water had about 5 milligrams per cubic meter of Chlorophyll a. They felt that very low levels of Chlorophyll were not desirable, probably from the point of view that there was a good chance that there were very few plants (and animals) living in the lake. On the other hand, they felt that high levels of Chlorophyll a were indicative of poor lake water quality. The highest Chlorophyll a found by the author in southeast Michigan lakes was 63 milligrams per cubic meter. However readings as high as 160 milligrams per cubic meter have been reported.

Pleasant Lake had an average summer chlorophyll a concentration of 11 micrograms per liter, with a range from 9 to 14 micrograms per liter. These are somewhat high chlorophyll a concentrations, indicative of a lake with some biological productivity.

THE LAKE WATER QUALITY INDEX (LWQI) CALCULATION SHEETS

The Lake Water Quality Index calculation sheets which follow were developed to show graphically what the results of nine different lake water quality tests selected by a large group of lake water quality scientists meant in terms of lake water quality.

HOW TO READ THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

The calculation sheets show the tests selected by the panel and the method of relating the test results to the concept of lake water quality. The various test names are listed at the top of the sheet.

The thermometer-type rating curves convert the test results to a uniform 0-100 lake water quality rating. The quality rating for each test is found inside the thermometer.

The index combines all 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 seems to rate lakes about the same way professors rate students; 90-100 = Excellent, 80-90 = good, 70-80 = fair, 60-70 = poor, and below 60, failing.

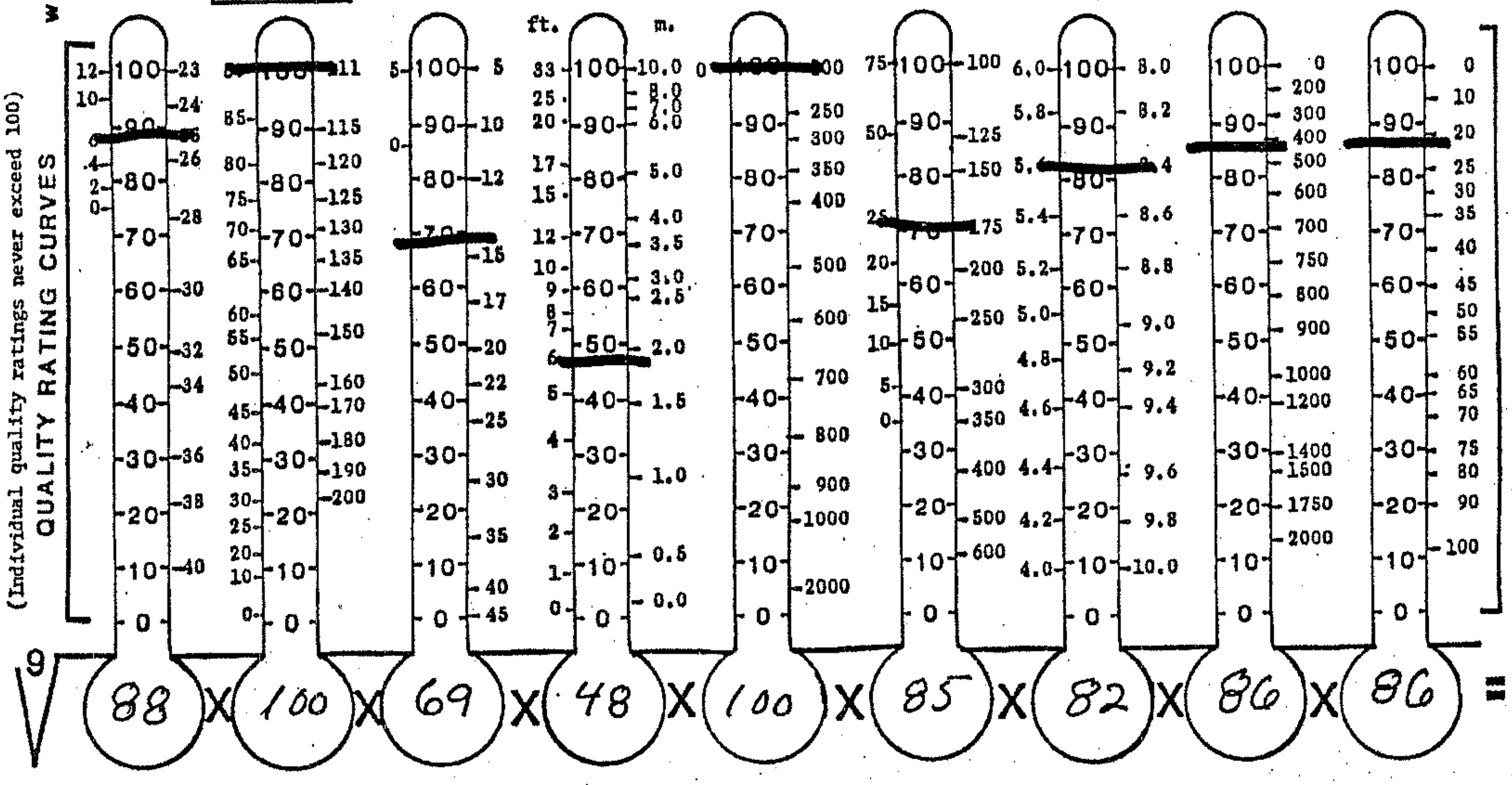
The index is portrayed in three different ways, as a number ranging between 1 and 100 in the circle marked LWQI, and by a color and position on the sheet edge scale. The purpose of the sheet-edge scale is to review quickly large numbers of lakes or test sites within a lake and determine how the quality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

The position of the red line on the thermometer-type rating scales permits determination of the parameter (or parameters) which cause the index to be depressed. The lower the red line, the greater the problem. A glance at the top of the problem thermometer-type 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.

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	TOTAL ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
25	8.9/8.4 106	14	6 ft	17	132	8.4	420	22



$$\sqrt[9]{88 \times 100 \times 69 \times 48 \times 100 \times 85 \times 82 \times 86 \times 86} = 81$$

LWQI 81

HYPOLIMNI
23 | 4.8
TEMP. °C | D.O. mg/1
x| 79% Hime
WEED COVER | BOTTOM TYPE
HURON
DRAINAGE BASIN
692 AC ~~miles²~~ kilometers²
DRAINAGE AREA
2105 ~~meters³~~ acre-feet
LAKE VOLUME
WASHTENAW MI
COUNTY & STATE
FREEDOM
TOWNSHIP
WQI
ANALYST
36 feet ~~meters~~
LAKE DEPTH
202 acres ~~hectares~~
LAKE AREA

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

DATE 29AUG84

STATION 1

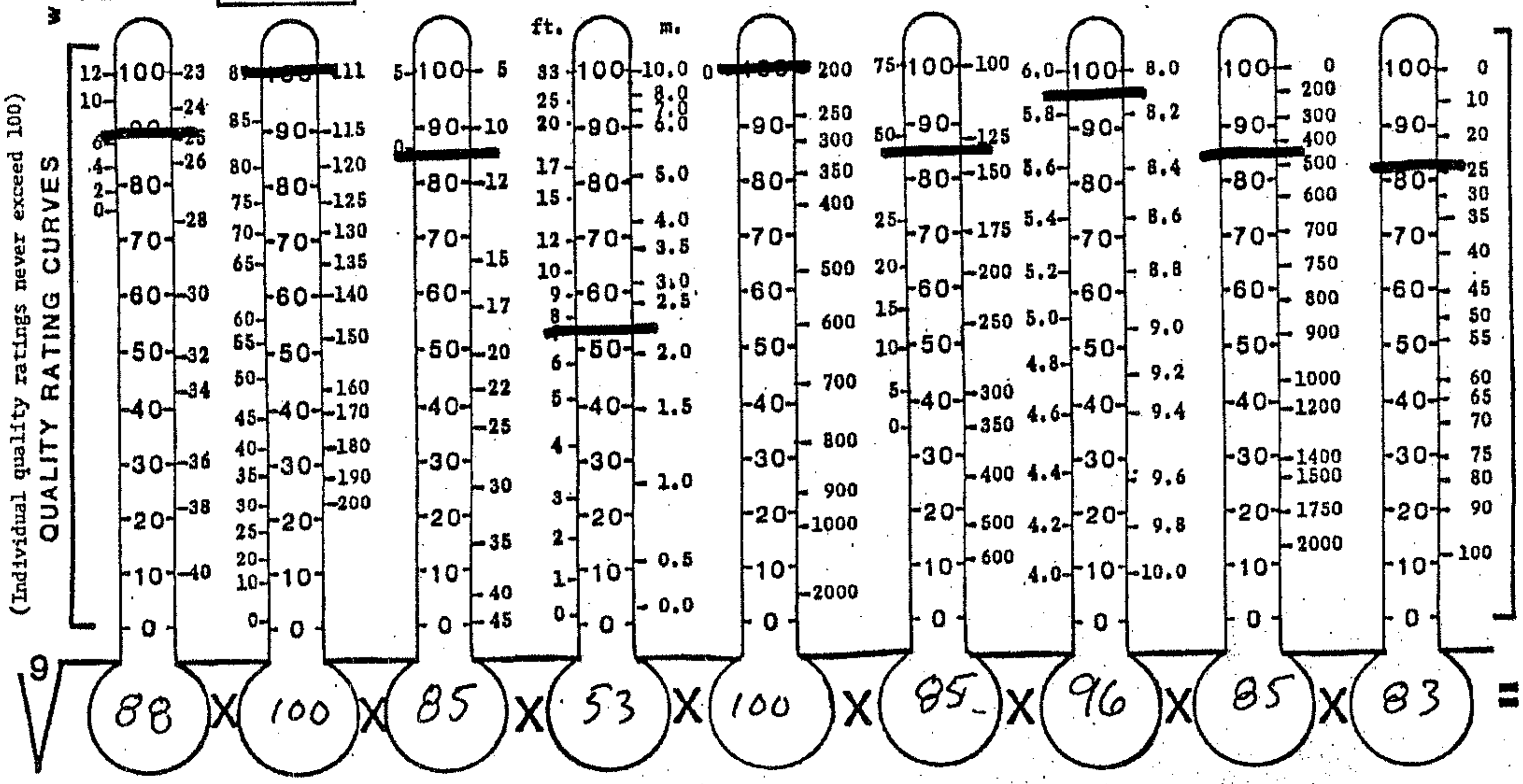
LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

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	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

	TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	.AL. ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
Value	25	8.4/8.4 100	11	7 ft __m	18	129	8.1	420	24
Rating	88	100	85	53	100	85	96	85	83



$\sqrt[9]{88 \times 100 \times 85 \times 53 \times 100 \times 85 \times 96 \times 85 \times 83} = 85$ (LWQI)

HYPOLIMNION

TEMP. °C | D.O. mg/l

% | WEED COVER | BOTTOM TYPE: HURON

DRAINAGE BASIN: 692 AC (~~miles²~~ kilometers²)

DRAINAGE AREA: 2105 (~~meters³~~ acre-feet)

LAKE VOLUME: WASHTENAW MI

COUNTY & STATE: FREEDOM

TOWNSHIP: WQI

ANALYST: 36 (feet ~~meters~~)

LAKE DEPTH: 202 (acres ~~hectares~~)

LAKE AREA

LWQI: 85

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

DATE 29AUG84

STATION 2

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

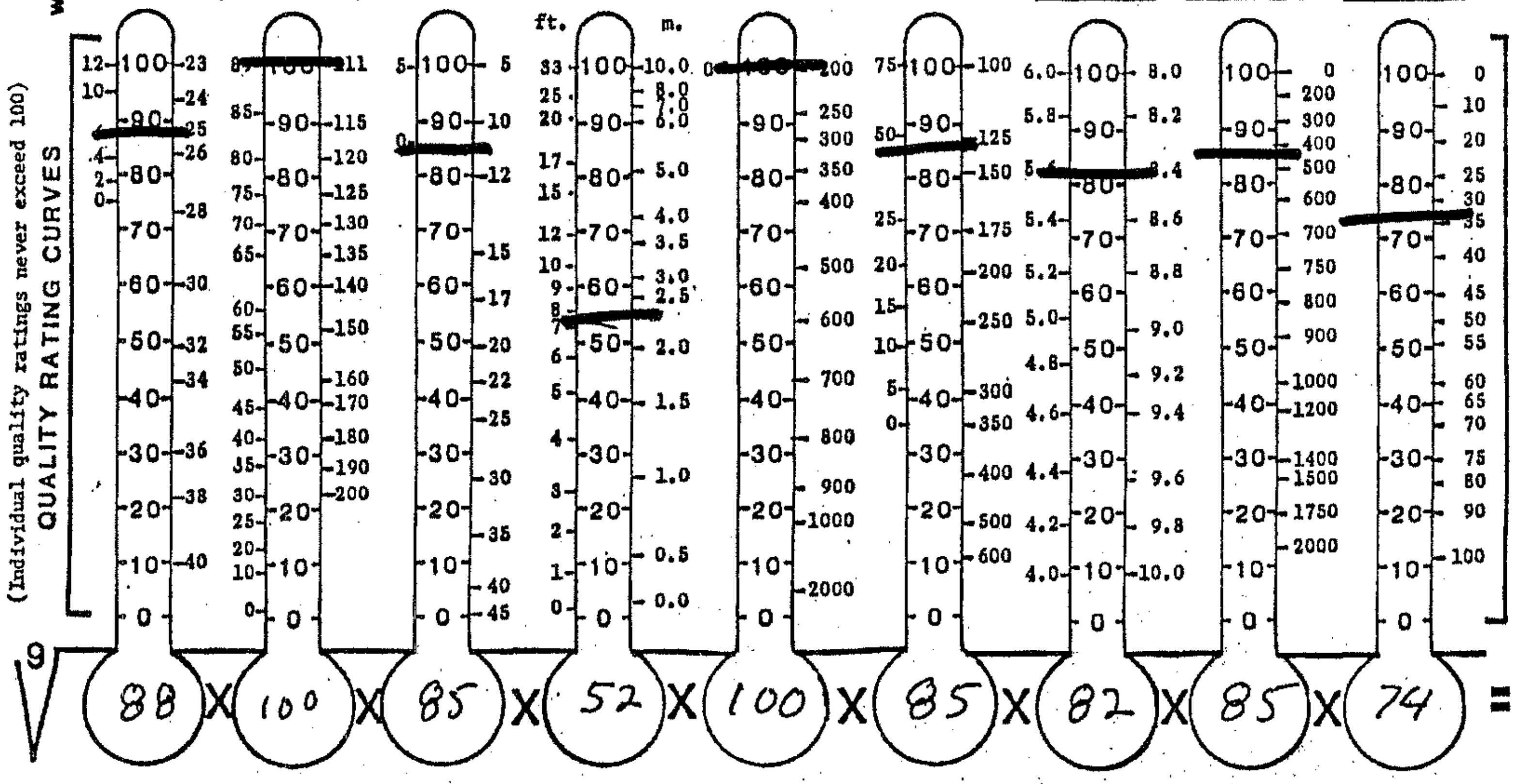
0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
25	8.1/8.4	11	7 ft	18	132	8.4	420	33

QUALITY RATING CURVES
(Individual quality ratings never exceed 100)



HYPOLIMNION	
TEMP. °C	D.O. mg/l
20	1.6

WEED COVER % | BOTTOM TYPE: 74% mineral

HURON
DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²
DRAINAGE AREA

2405 ~~meters³~~ acre-feet
LAKE VOLUME

WASHTENAW MI
COUNTY & STATE

FREEDOM
TOWNSHIP

WQI
ANALYST

36 feet ~~meters~~
LAKE DEPTH

202 acres ~~hectares~~
LAKE AREA

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

LAKE WATER QUALITY INDEX

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	green blue	blue

DATE 29AUG84

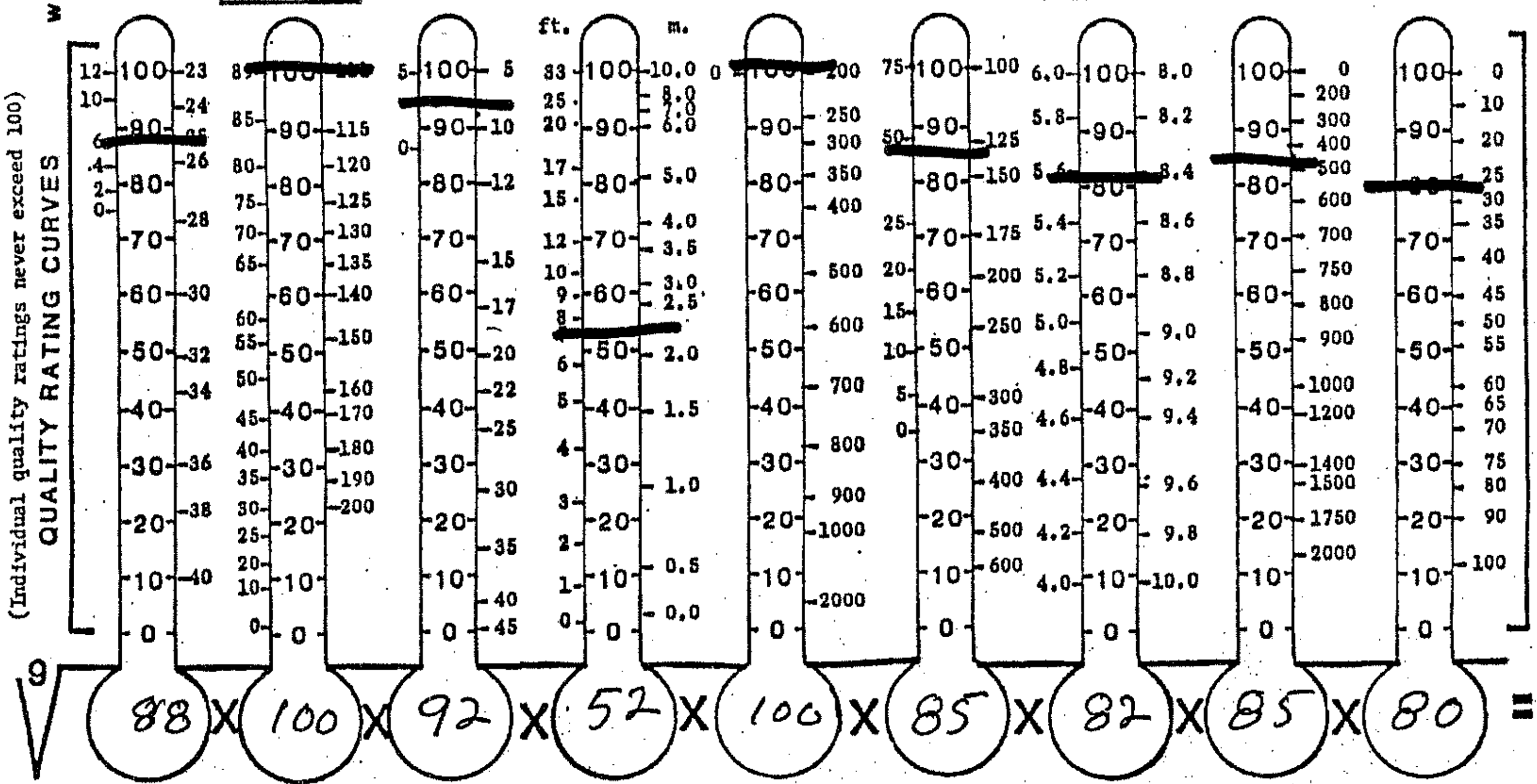
STATION 3

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
25	8.3/8.4 / 99	9	7 ft	18	129	8.4	420	27



$\sqrt[9]{88 \times 100 \times 92 \times 52 \times 100 \times 85 \times 82 \times 85 \times 80} = 84$ LWQI

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

HYPOLIMNION

TEMP. °C | D.O. mg/l

%

WEED COVER | BOTTOM TYPE: HURON

DRAINAGE BASIN: 692 AC ~~miles²~~ kilometers²

DRAINAGE AREA: 2105 ~~meters³~~ acre-feet

LAKE VOLUME: WASHTENAW MI

COUNTY & STATE: FREEDOM

TOWNSHIP: WQI

ANALYST: 36 feet ~~meters~~

LAKE DEPTH: 202 acres ~~hectures~~

LAKE AREA

DATE 29AUG84

STATION 4

LAKE PLEASANT LAKE

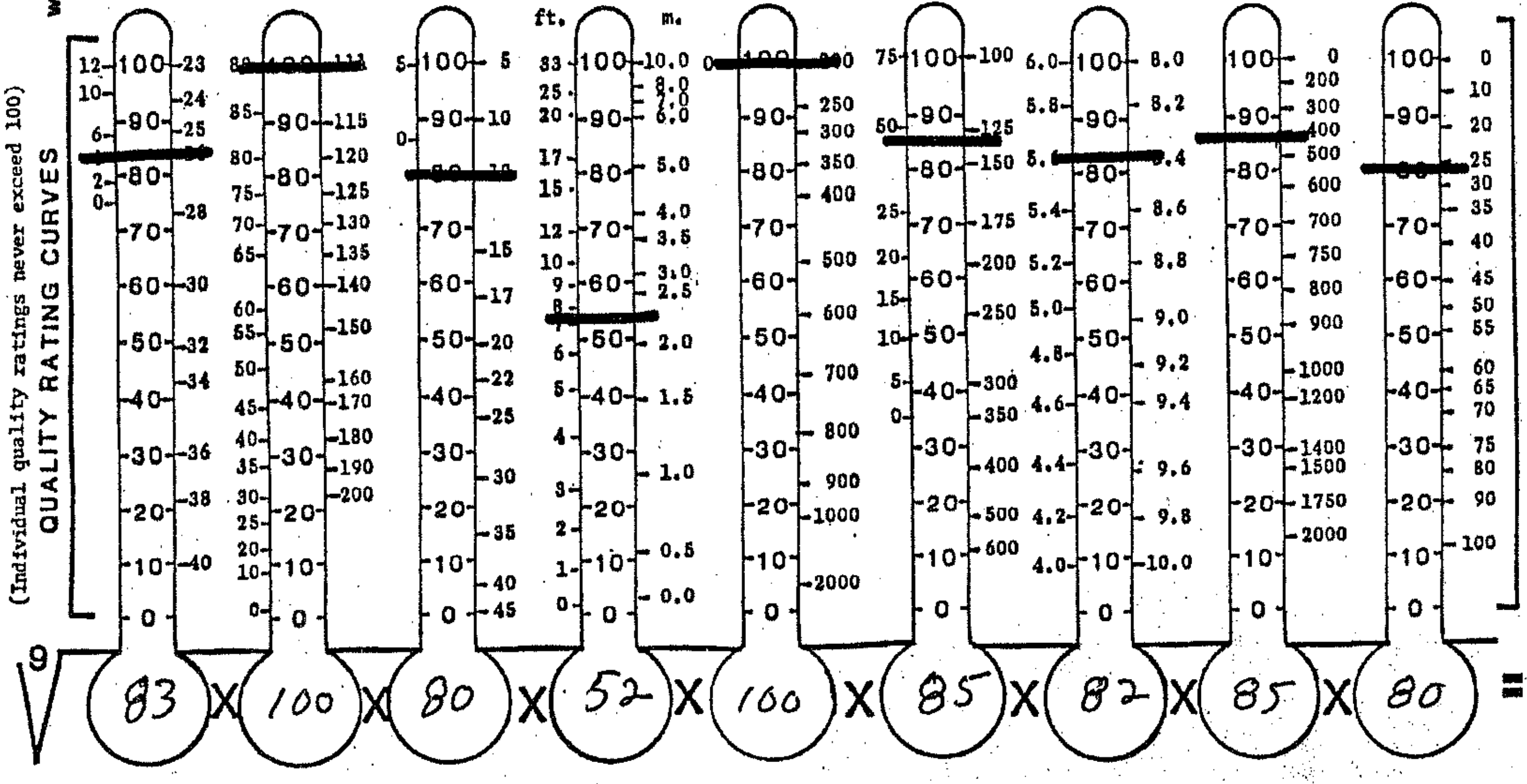
LAKE WATER QUALITY INDEX

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	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO₃— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO₄-P ug/l
26	8.1/8.2 99	12	7 ft	18	130	8.4	420	27



$\sqrt[9]{83 \times 100 \times 80 \times 52 \times 100 \times 85 \times 82 \times 85 \times 80} = 82$

LWQI 82

HYPOLIMNION

TEMP, °C	D.O. mg/l
	%

WEED COVER | BOTTOM TYPE
HURON
DRAINAGE BASIN
692 AC ~~miles²~~ kilometers²
DRAINAGE AREA
2105 ~~meters³~~ acre-feet
LAKE VOLUME
WASHTENAW MI
COUNTY & STATE
FREEDOM
TOWNSHIP
WQI
ANALYST
36 feet ~~meters~~
LAKE DEPTH
202 acres ~~hectares~~
LAKE AREA

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

DATE 29AUG84

STATION 5

LAKE PLEASANT LAKE

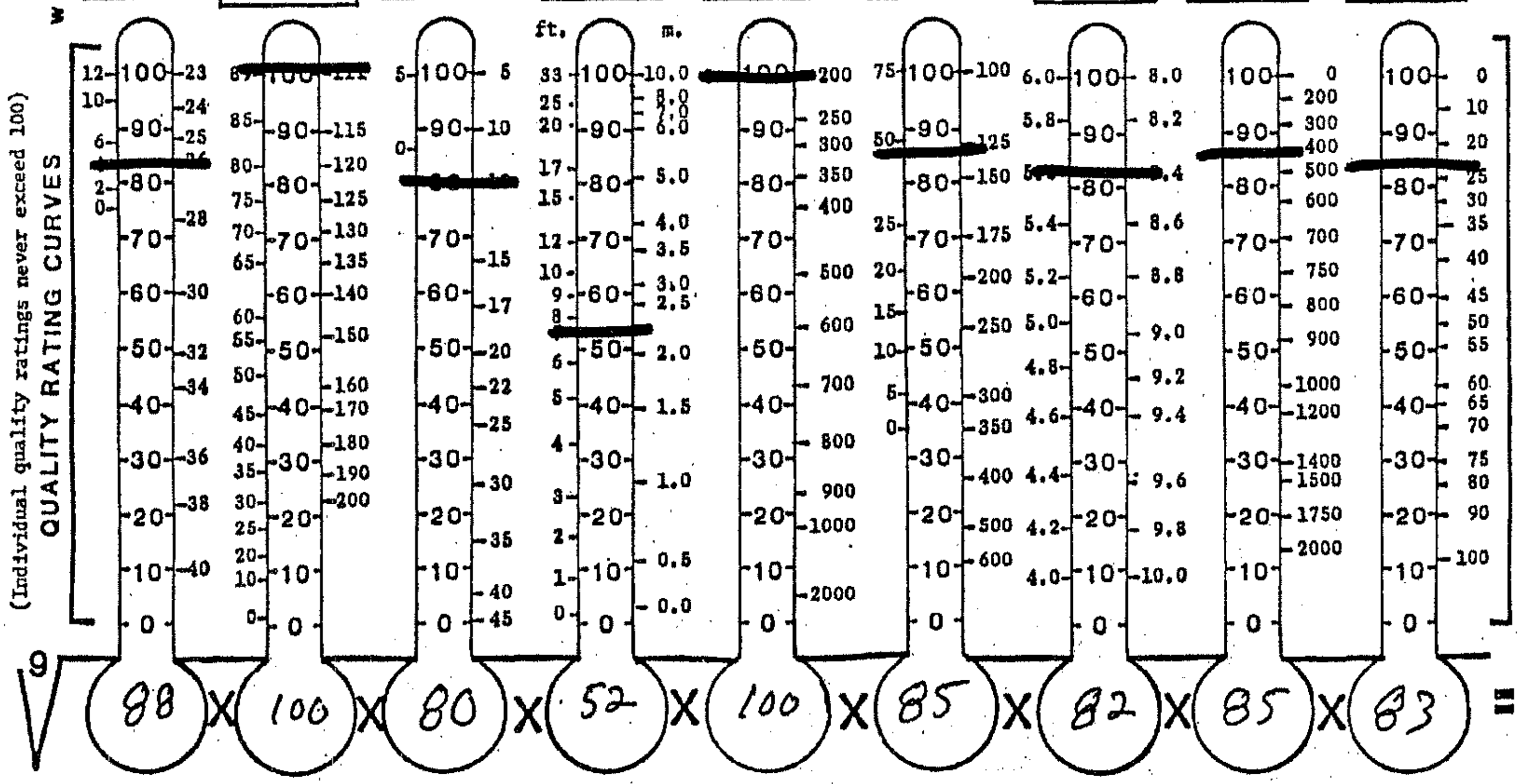
LAKE WATER QUALITY INDEX

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	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	TOTAL ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
25	8.8/9.4 105	12	7 ft	18	130	8.4	420	23



$\sqrt[9]{88 \times 100 \times 80 \times 52 \times 100 \times 85 \times 82 \times 85 \times 83} = 83$ (LWQI)

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

LAKE WATER QUALITY INDEX

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	green blue	blue

HYPOLIMNION

TEMP. °C	D.O. mg/1

% WEED COVER | BOTTOM TYPE

HURON
DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²
DRAINAGE AREA

2405 ~~meters³~~ acre-feet
LAKE VOLUME

WASHTENAW MI
COUNTY & STATE

FREEDOM
TOWNSHIP

WQI
ANALYST

36 feet ~~meters~~
LAKE DEPTH

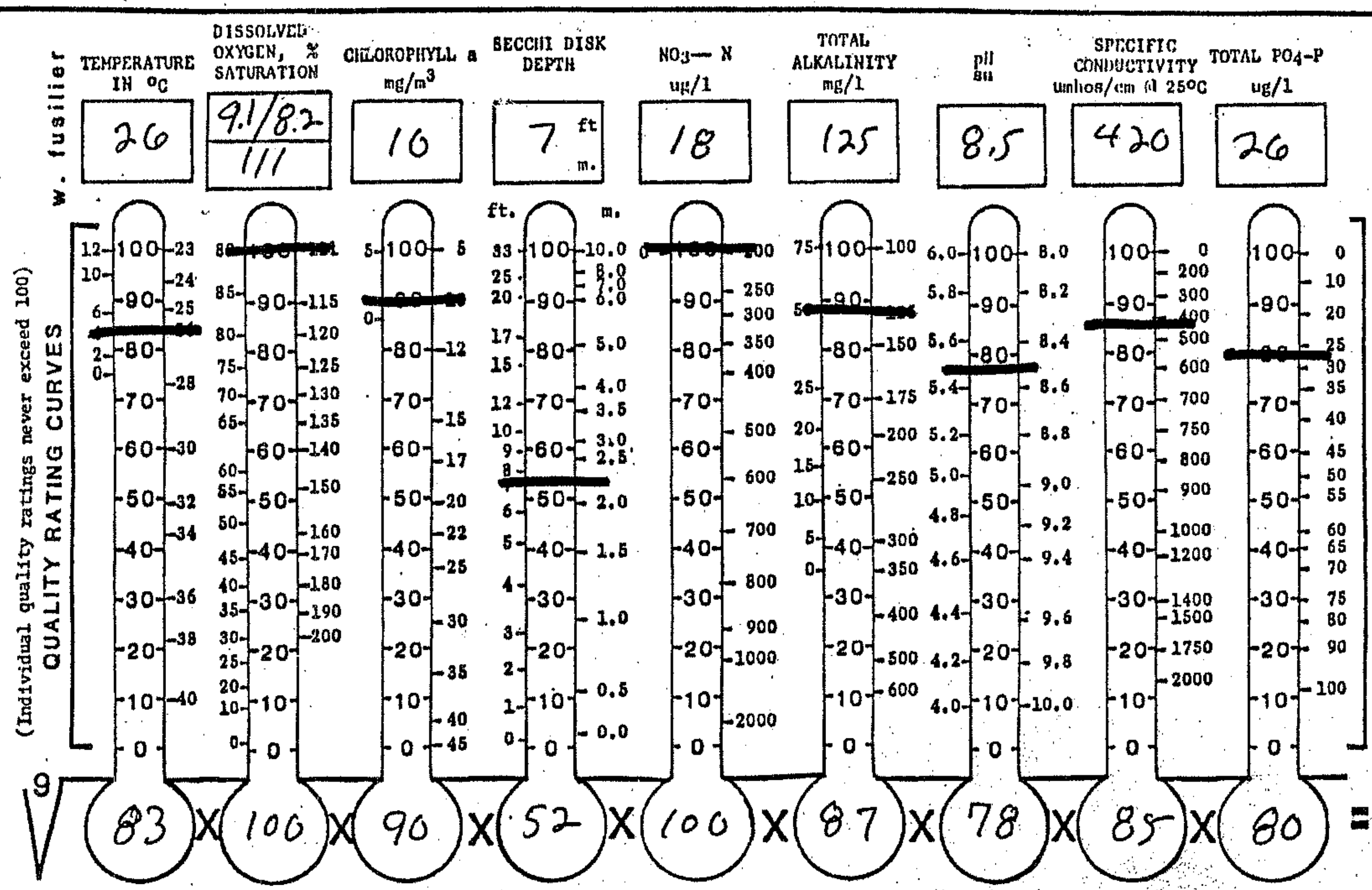
202 acres ~~hectares~~
LAKE AREA

DATE 29AUG84

STATION 6

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES



HYPOLIMNION

TEMP. °C	D.O. mg/l
	%

WEED COVER | BOTTOM TYPE: HURON

DRAINAGE BASIN: 692 AC ~~miles²~~ kilometers²

DRAINAGE AREA: 2105 ~~meters³~~ acre-feet

LAKE VOLUME: WASHTENAW MI

COUNTY & STATE: FREEDOM

TOWNSHIP: WQI

ANALYST: 36 feet ~~meters~~

LAKE DEPTH: 202 acres ~~hectares~~

LAKE AREA

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

LAKE WATER QUALITY INDEX

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	green blue	blue

DATE 29AUG84

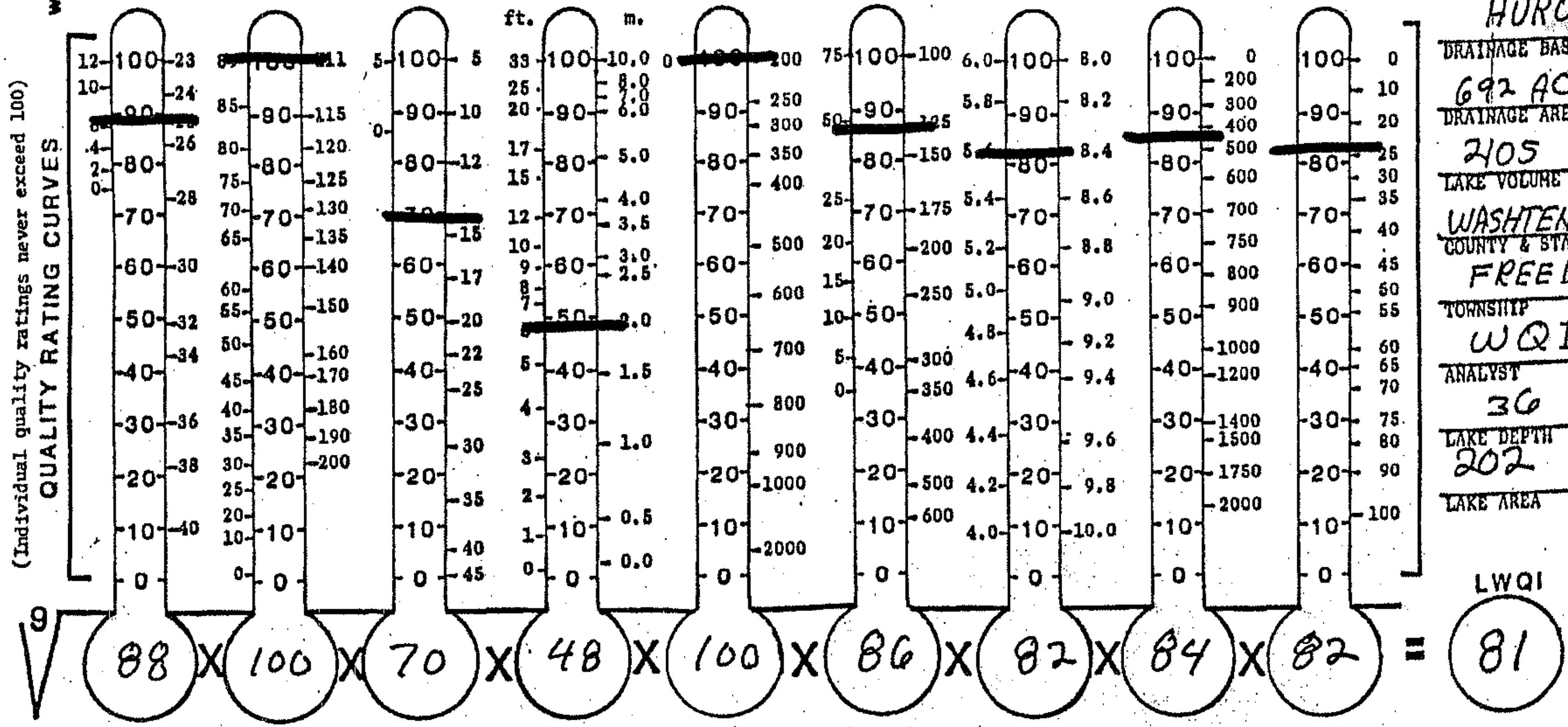
STATION 7

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED ILTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
25	90/8.4 / 107	14	6 ft	18	126	8.4	440	24



HYPOLIMNION

TEMP. °C | D.O. mg/l

%

WEED COVER | BOTTOM TYPE

HURON

DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²

DRAINAGE AREA

2105 ~~meters³~~ acre-feet

LAKE VOLUME

WASHTENAW MI

COUNTY & STATE

FREEDOM

TOWNSHIP

WQI

ANALYST

36 feet ~~meters~~

LAKE DEPTH

202 acres ~~hectares~~

LAKE AREA

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

LAKE WATER QUALITY INDEX

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	green blue	blue

DATE 29AUG84

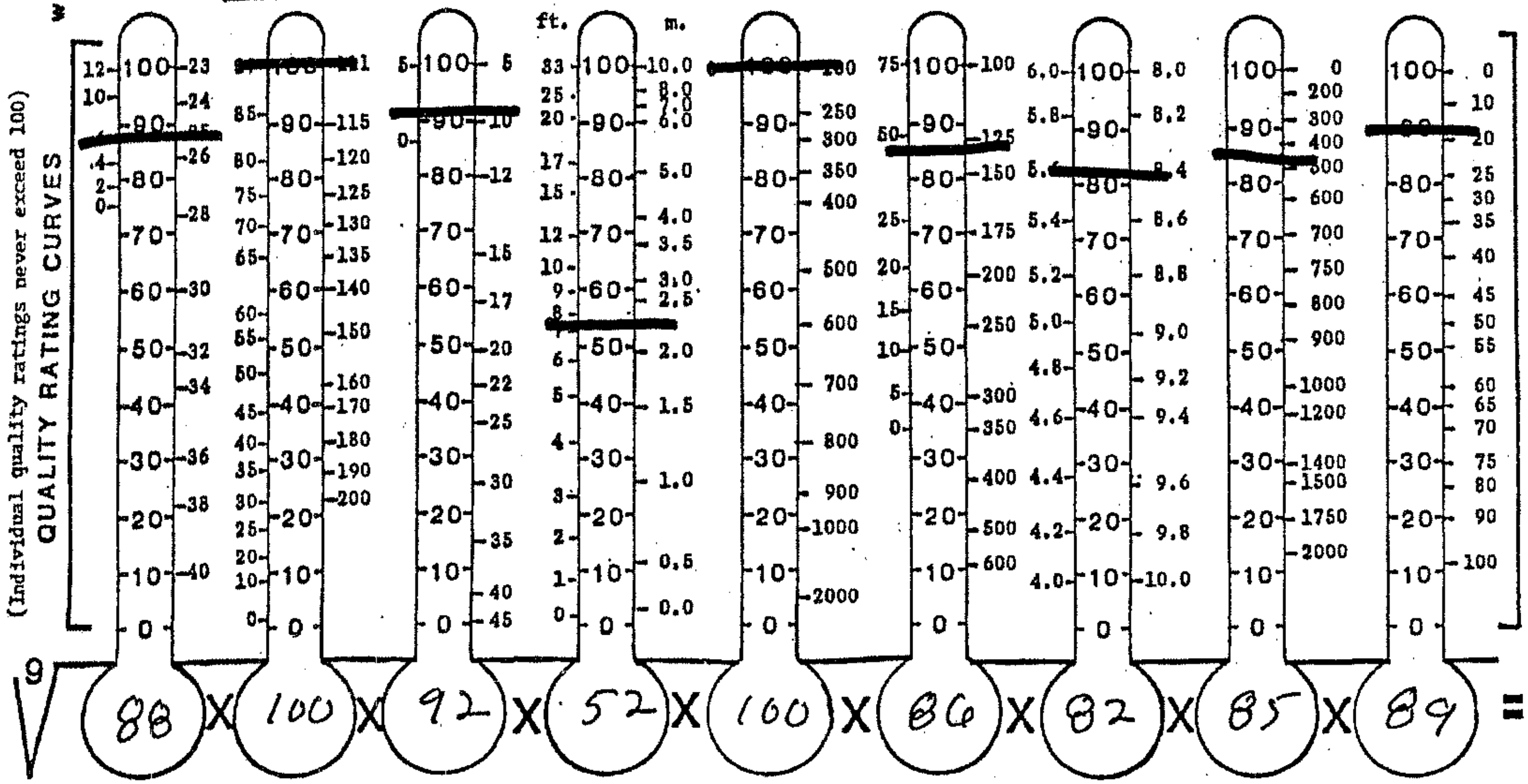
STATION 8

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED ...LTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	TOTAL ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
25	8.6/8.4 101	9	7 ft	16	127	8.4	440	19
88	100	92	52	100	86	82	85	89



$\sqrt[9]{88 \times 100 \times 92 \times 52 \times 100 \times 86 \times 82 \times 85 \times 89} = 85$

LWQI 85

HYPOLIMNION

TEMP. °C	D.O. mg/1

% WEED COVER | BOTTOM TYPE

HURON
DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²
DRAINAGE AREA

2105 ~~meters³~~ acre-feet
LAKE VOLUME

WASHTENAW MI
COUNTY & STATE

FREEDOM
TOWNSHIP

WQI
ANALYST

36 feet ~~meters~~
LAKE DEPTH

202 acres ~~hectares~~
LAKE AREA

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

LAKE WATER QUALITY INDEX

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	green blue	blue

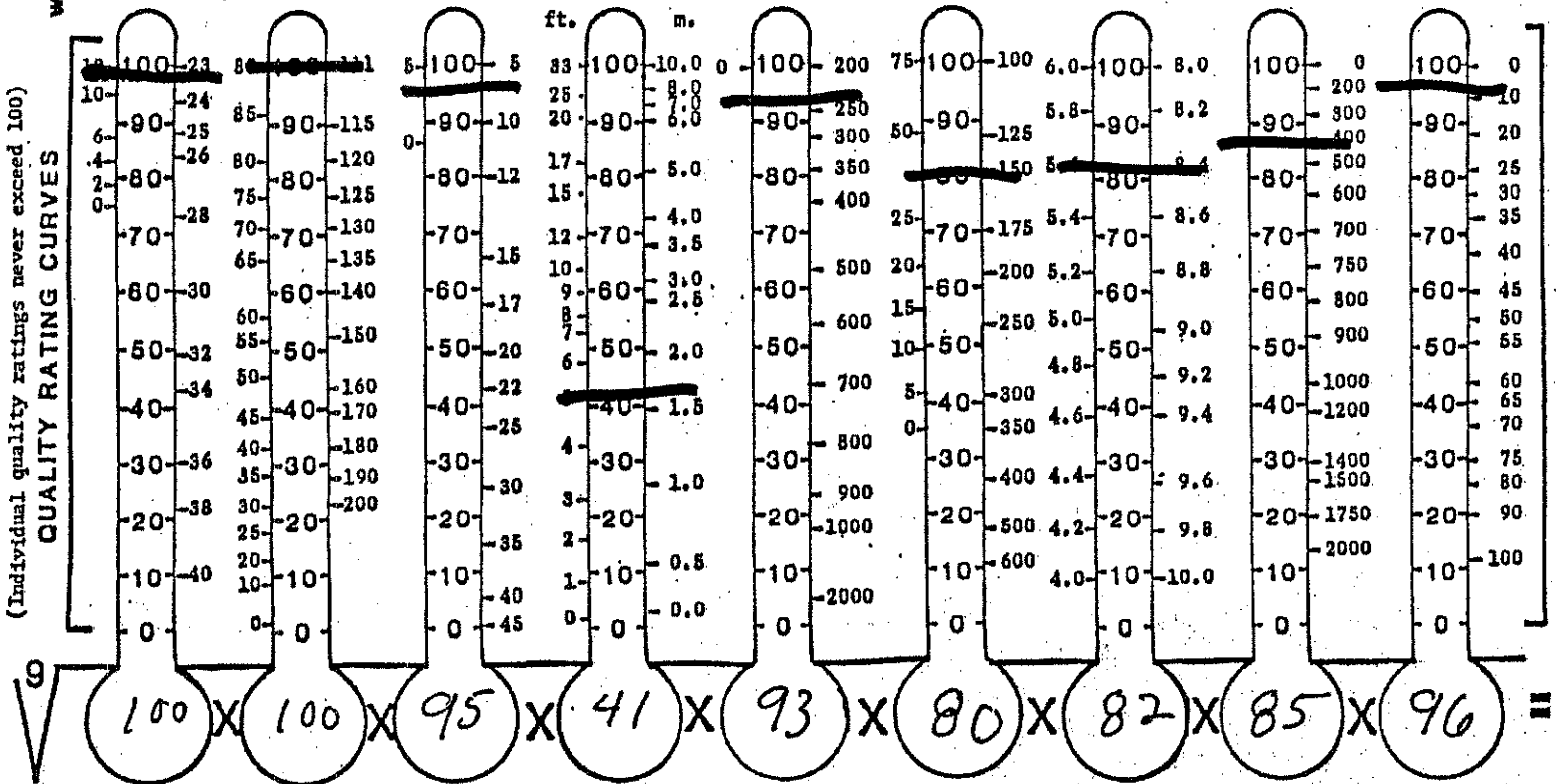
DATE 29AUG84

STATION 9

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED ·LTIPLICATIVE WATER QUALITY INDEX for LAKES

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
13	10.1/	3	5 ft	235	152	8.4	410	8



$\sqrt[9]{100 \times 100 \times 95 \times 41 \times 93 \times 80 \times 82 \times 85 \times 96} = 83$

LWQI 83

HYPOLIMNION

TEMP. °C	D.O. mg/l
	%

WEED COVER | BOTTOM TYPE
HURON
DRAINAGE BASIN
692 AC ~~miles²~~ kilometers²
DRAINAGE AREA
2105 ~~meters³~~ acre-feet
LAKE VOLUME
WASHTENAW MI
COUNTY & STATE
FREEDOM
TOWNSHIP
WQI
ANALYST
36 feet ~~meters~~
LAKE DEPTH
202 acres ~~hectares~~
LAKE AREA

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

DATE 15 APR 85

STATION 1

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

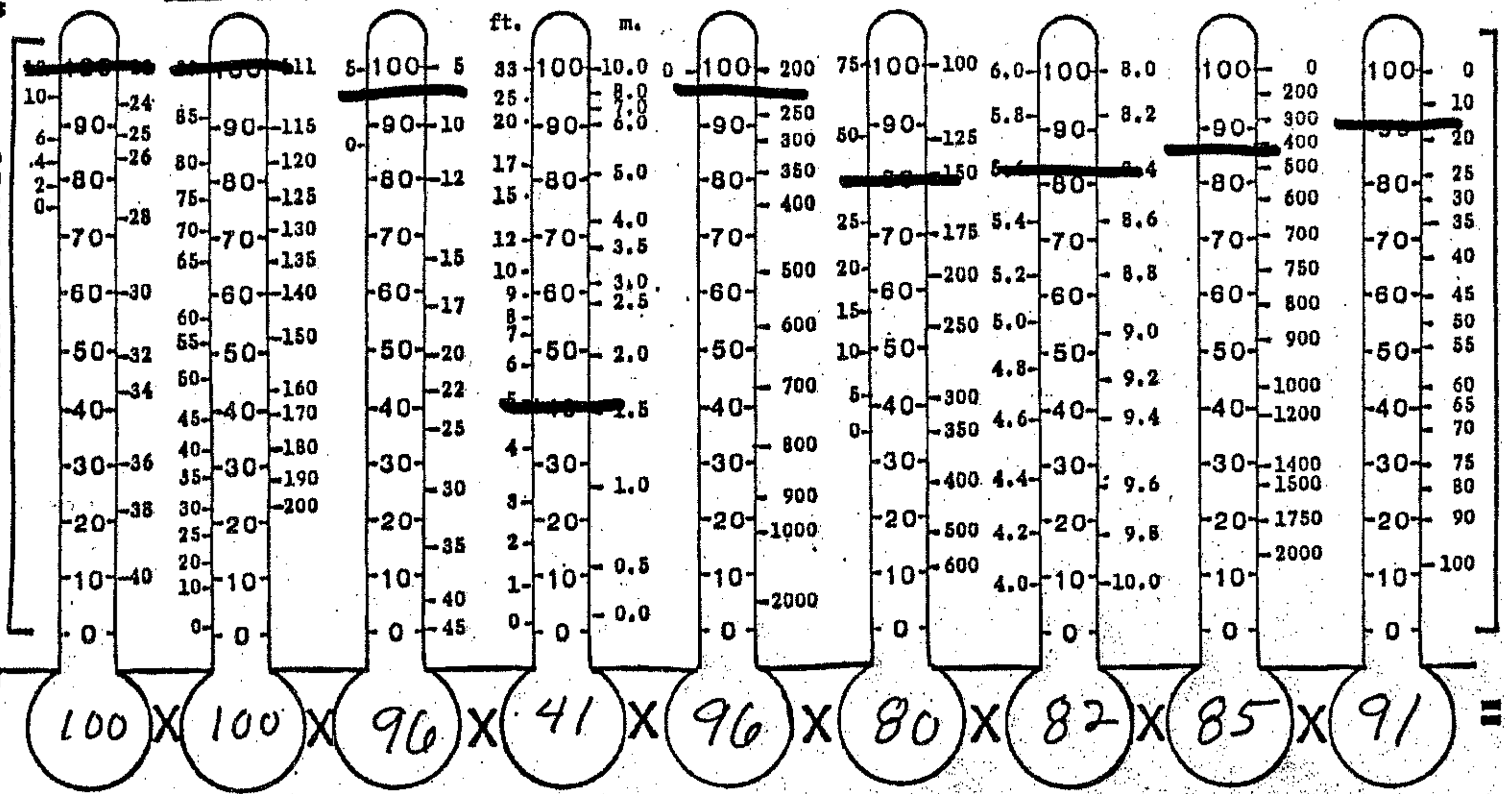
0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue

CALCULATION SHEET for the UNWEIGHTED M_TIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	TOTAL ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
13	101	3	5 ft	225	152	8.4	410	15

QUALITY RATING CURVES
(Individual quality ratings never exceed 100)



$\sqrt[9]{100 \times 100 \times 96 \times 41 \times 96 \times 80 \times 82 \times 85 \times 91} = 83$ LWQI

HYPOLIMNION

TEMP. °C	D.O. mg/1

% WEED COVER | BOTTOM TYPE
HURON
DRAINAGE BASIN
692 AC ~~miles²~~ kilometers²
DRAINAGE AREA
2105 ~~meters³~~ acre-feet
LAKE VOLUME
WASHTENAW MI
COUNTY & STATE
FREEDOM
TOWNSHIP
WQI
ANALYST
36 feet ~~meters~~
LAKE DEPTH
202 acres ~~hectares~~
LAKE AREA

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

LAKE WATER QUALITY INDEX

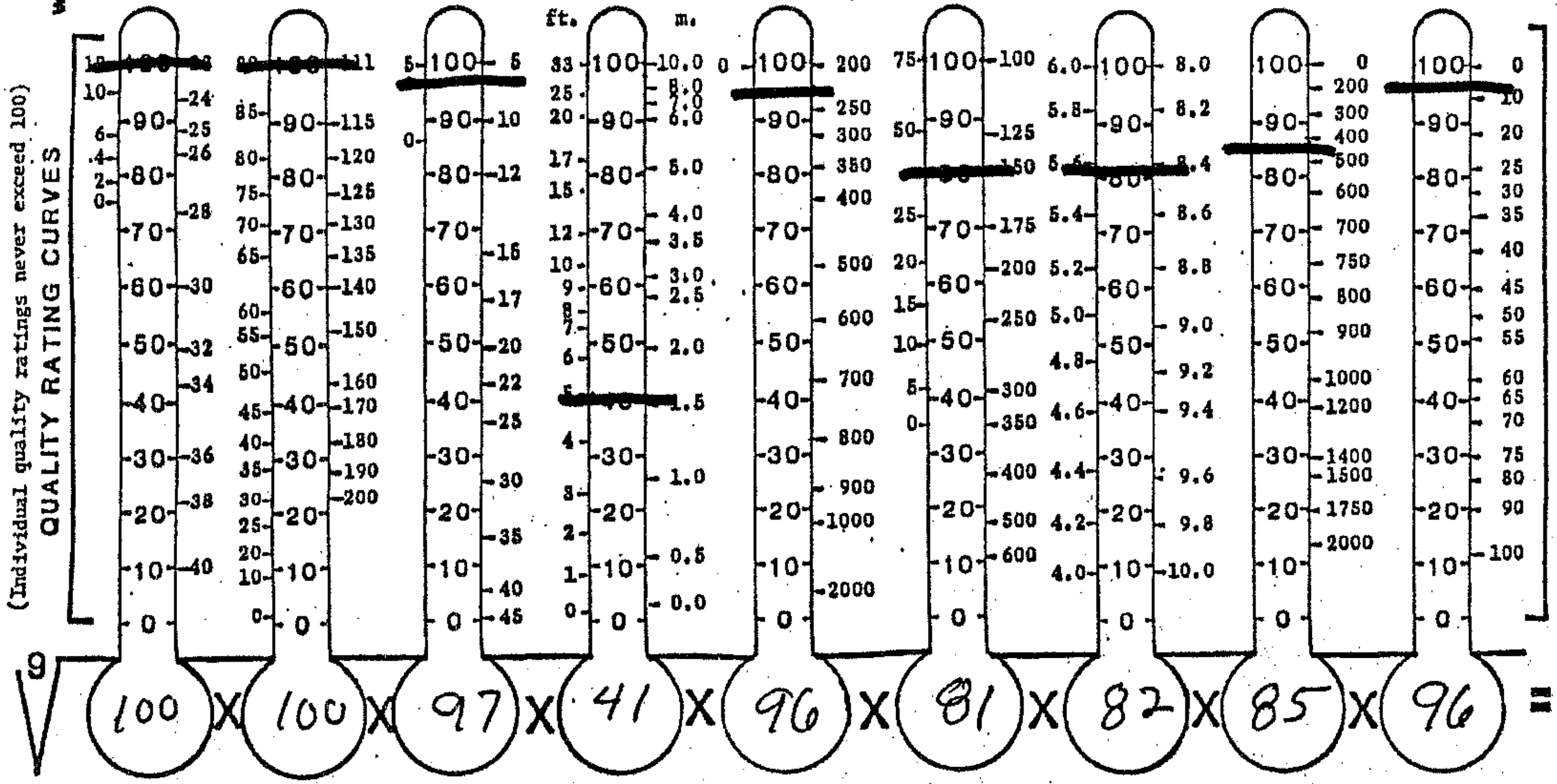
	15	25	35	45	55	65	75	85	100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue	

DATE 15 APR 85
STATION 2
LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
13	10.1/	4	5 ft	225	149	8.4	410	8



HYPOLIMNION

TEMP. °C | D.O. mg/l

%

WEED COVER | BOTTOM TYPE

HURON

DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²

DRAINAGE AREA

2105 ~~meters³~~ acre-feet

LAKE VOLUME

WASHTENAW MI

COUNTY & STATE

FREEDOM

TOWNSHIP

WQI

ANALYST

36 feet ~~meters~~

LAKE DEPTH

202 acres ~~hectares~~

LAKE AREA

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

LAKE WATER QUALITY INDEX

	15	25	35	45	55	65	75	85	100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue	

DATE 15 APR 85

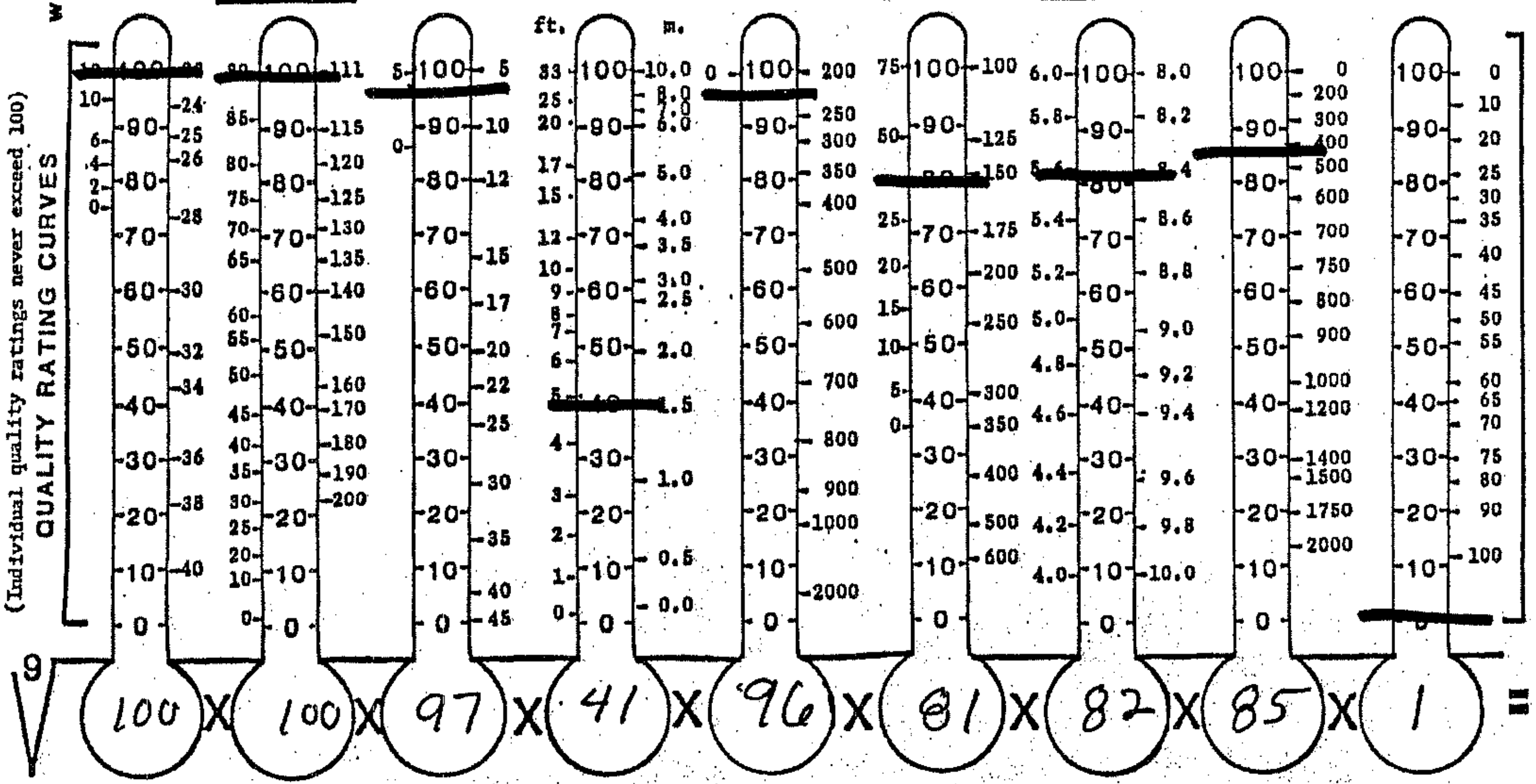
STATION 3

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
14	9.9/	4	5 ft	220	149	8.4	410	113



$\sqrt[9]{100 \times 100 \times 97 \times 41 \times 96 \times 81 \times 82 \times 85 \times 1} = 51$

LWQI 51

HYPOLIMNION

TEMP. °C | D.O. mg/l

%

WEED COVER | BOTTOM TYPE

HURON

DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²

DRAINAGE AREA

2105 ~~meters³~~ acre-feet

LAKE VOLUME

WASHTENAW MI

COUNTY & STATE

FREEDOM

TOWNSHIP

WQI

ANALYST

36 feet ~~meters~~

LAKE DEPTH

202 acres ~~hectares~~

LAKE AREA

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

DATE 15 APR 85

STATION 4

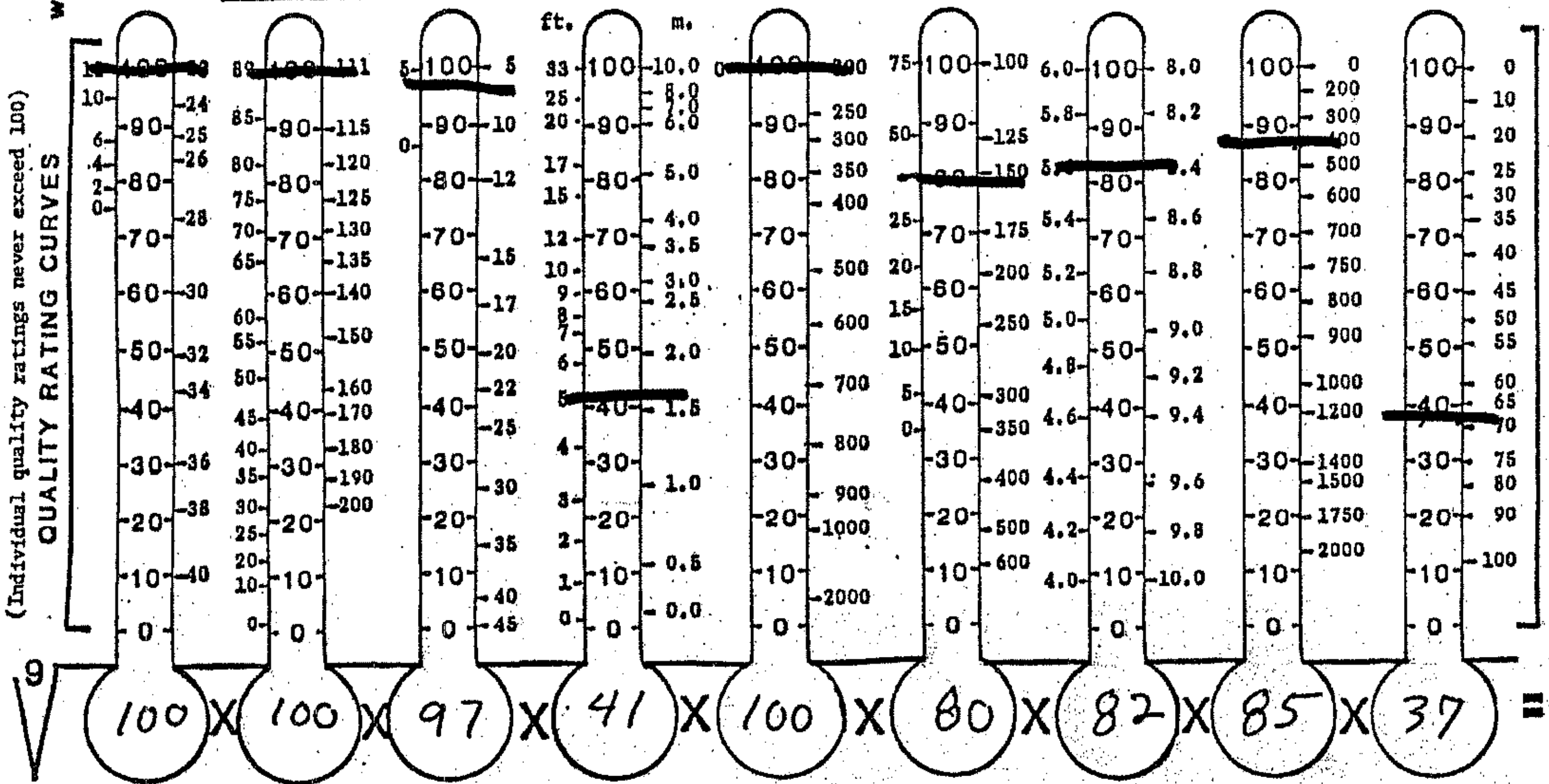
LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

	15	25	35	45	55	65	75	85	100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue	

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO₃— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO₄-P ug/l
13	10	4	5 ft	155	152	8.4	410	68



$\sqrt[9]{100 \times 100 \times 97 \times 41 \times 100 \times 80 \times 82 \times 85 \times 37} = 76$ (LWQI)

HYPOLIMNION	
TEMP. °C	D.O. mg/l
%	

WEED COVER / BOTTOM TYPE	HURON
DRAINAGE BASIN	692 AC (miles² / kilometers²)
DRAINAGE AREA	2105 (meters³ / acre-feet)
LAKE VOLUME	WASHTENAW MI
COUNTY & STATE	FREEDOM
TOWNSHIP	WQI
ANALYST	36 (feet / meters)
LAKE DEPTH	202 (acres / hectares)
LAKE AREA	

LWQI: 76

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

DATE 15 APR 85

STATION 5

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

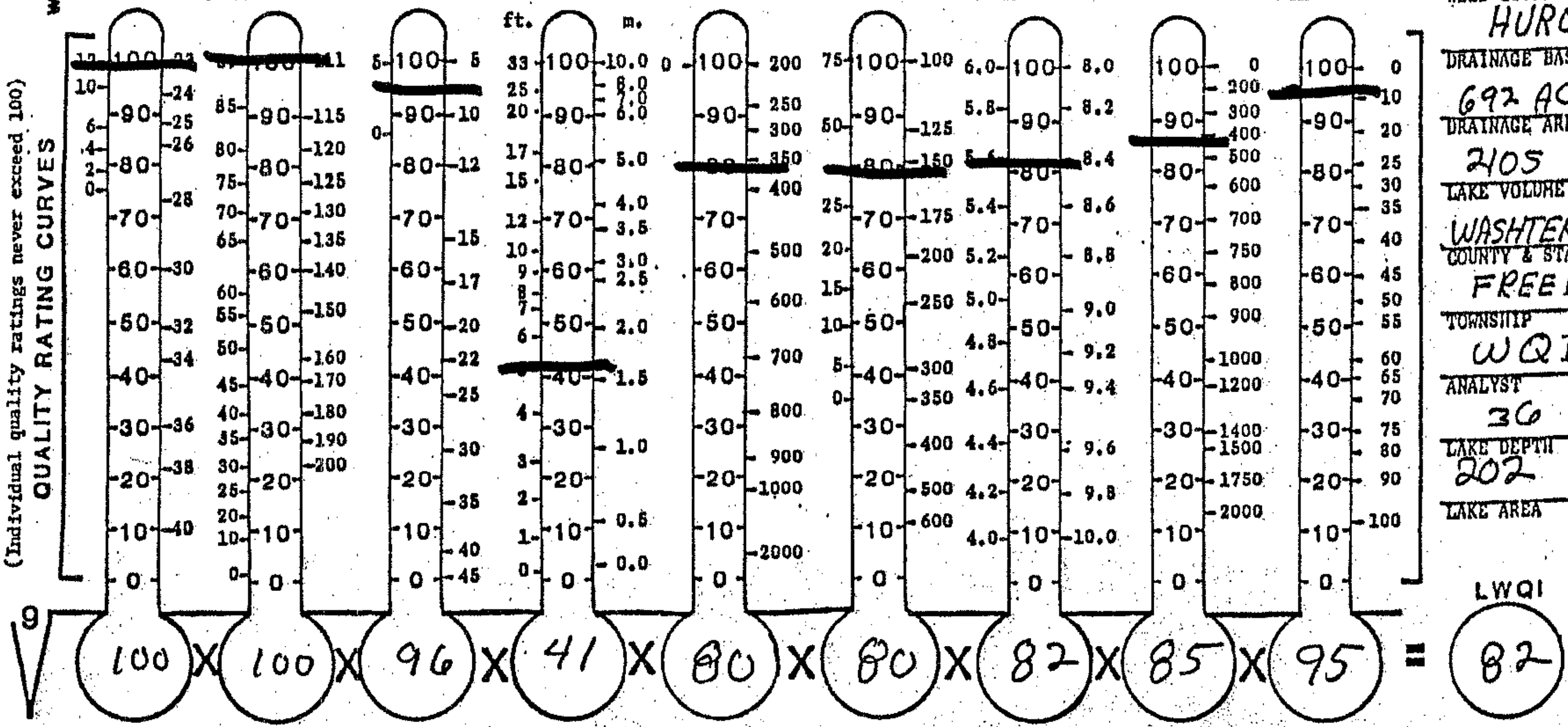
0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO₃— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO4-P ug/l
12	10/	3	5 ft	355	152	8.4	410	9

QUALITY RATING CURVES
(Individual quality ratings never exceed 100)



HYPOLIMNION

TEMP. °C	D.O. mg/l
	%

WEED COVER | BOTTOM TYPE: HURON

DRAINAGE BASIN: 692 AC ~~miles²~~ kilometers²

DRAINAGE AREA: 2405 ~~meters³~~ acre-feet

LAKE VOLUME: WASHTENAW MI

COUNTY & STATE: FREEDOM

TOWNSHIP: WQI

ANALYST: 36 feet ~~meters~~

LAKE DEPTH: 202 acres ~~hectares~~

LAKE AREA

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

DATE 15 APR 85

STATION 6

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

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	green blue	blue

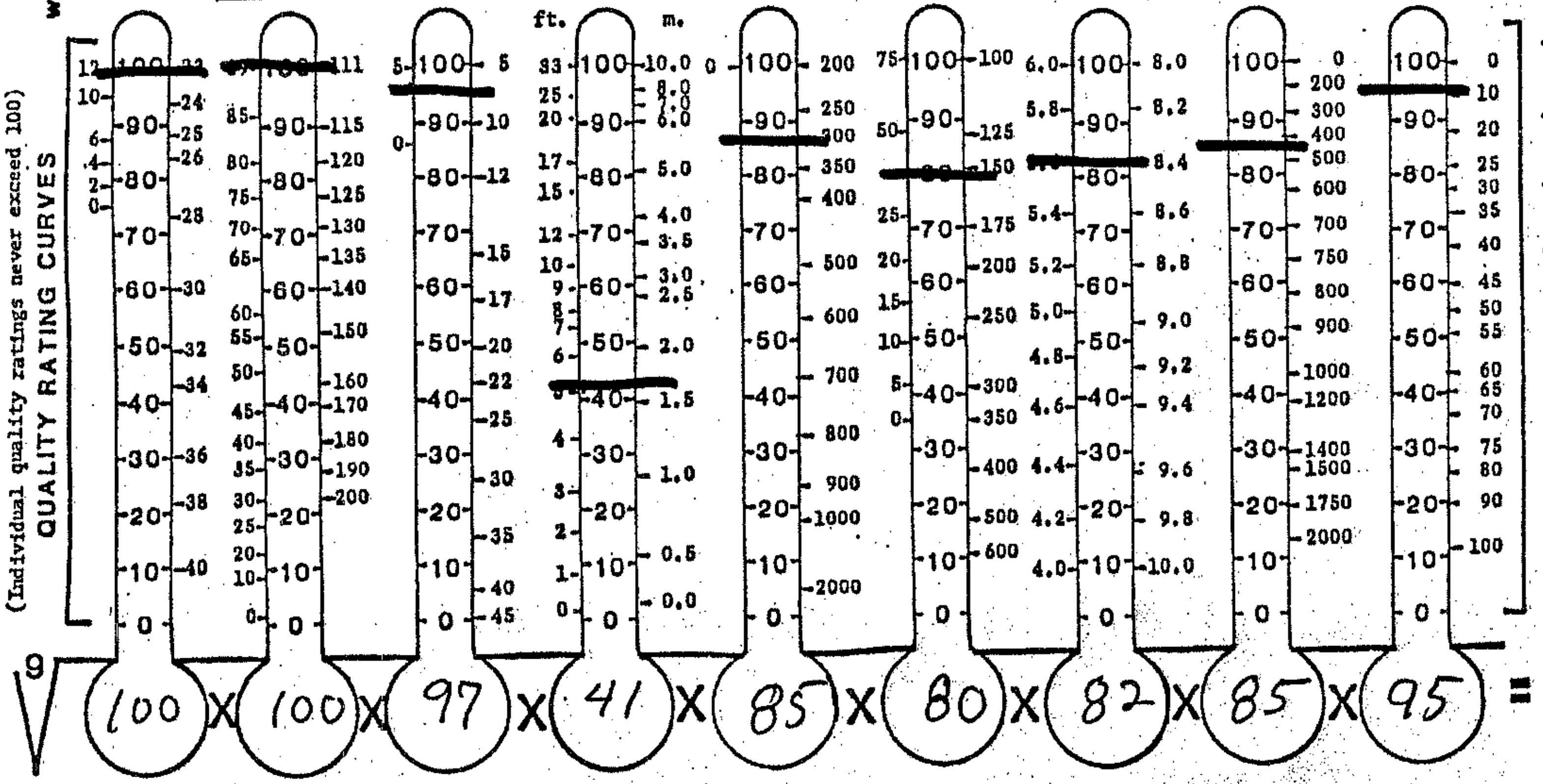
CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
13	10/	4	5 ft	305	152	8.4	410	8

w. fusilier

QUALITY RATING CURVES

(Individual quality ratings never exceed 100)



$$\sqrt[9]{100 \times 100 \times 97 \times 41 \times 85 \times 80 \times 82 \times 85 \times 95} = 83$$

LWQI: 83

HYPOLIMNION

TEMP. °C | D.O. mg/l

%

WEED COVER | BOTTOM TYPE

HURON

DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²

DRAINAGE AREA

2105 ~~meters³~~ acre-feet

LAKE VOLUME

WASHTENAW MI

COUNTY & STATE

FREEDOM

TOWNSHIP

WQI

ANALYST

36 feet ~~meters~~

LAKE DEPTH

202 acres ~~hectares~~

LAKE AREA

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

DATE 15 APR 85

STATION 7

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

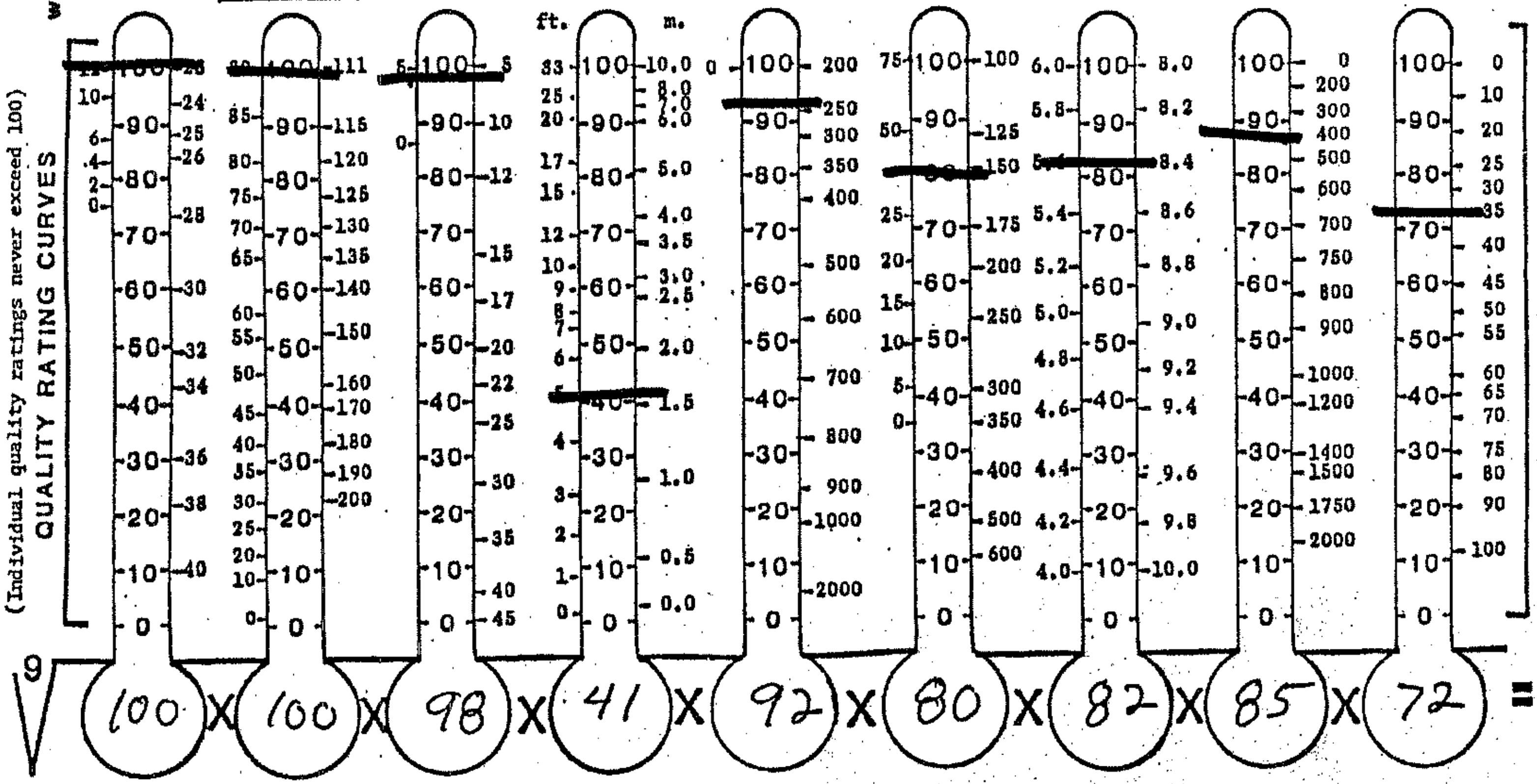
0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
red	red orange	orange	orange yellow	yellow	yellow green	green	green blue	blue

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
13	99	4	5 ft	245	152	8.4	410	35

QUALITY RATING CURVES
(Individual quality ratings never exceed 100)



$\sqrt[9]{100 \times 100 \times 98 \times 41 \times 92 \times 80 \times 82 \times 85 \times 72} = 81$

LWQI 81

HYPOLIMNION

TEMP. °C	D.O. mg/l

% WEED COVER | BOTTOM TYPE

HURON
DRAINAGE BASIN

692 AC ~~miles²~~ kilometers²
DRAINAGE AREA

2105 ~~meters³~~ acre-feet
LAKE VOLUME

WASHTENAW MI
COUNTY & STATE

FREEDOM
TOWNSHIP

WQI
ANALYST

36 feet ~~meters~~
LAKE DEPTH

202 acres ~~hectares~~
LAKE AREA

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

LAKE WATER QUALITY INDEX

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	green blue	blue

DATE 15 APR 85

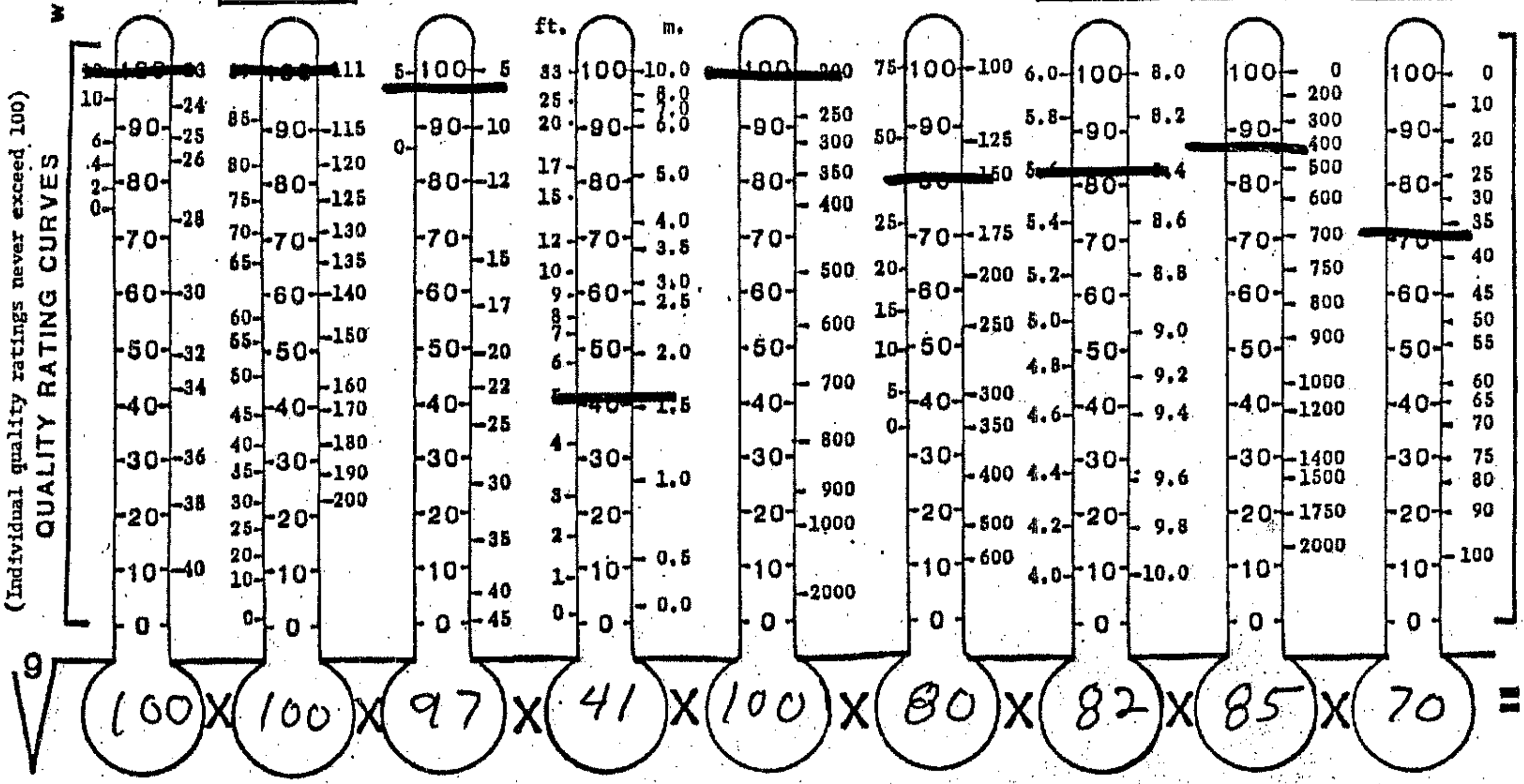
STATION 8

LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/l	TOTAL ALKALINITY mg/l	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/l
13	10.1	4	5 ft	145	153	8.4	410	37



HYPOLIMNION	
TEMP. °C	D.O. mg/l
% WEED COVER	BOTTOM TYPE: HURON

DRAINAGE BASIN: 692 AC miles² / kilometers²

DRAINAGE AREA: 2105 meters³ / acre-feet

LAKE VOLUME

COUNTY & STATE: WASHTENAW MI

TOWNSHIP: FREEDOM

ANALYST: WQI

LAKE DEPTH: 36 feet / meters

LAKE AREA: 202 acres / hectares

LWQI = 81

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

LAKE WATER QUALITY INDEX

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	green blue	blue

DATE 15 APR 85

STATION 9

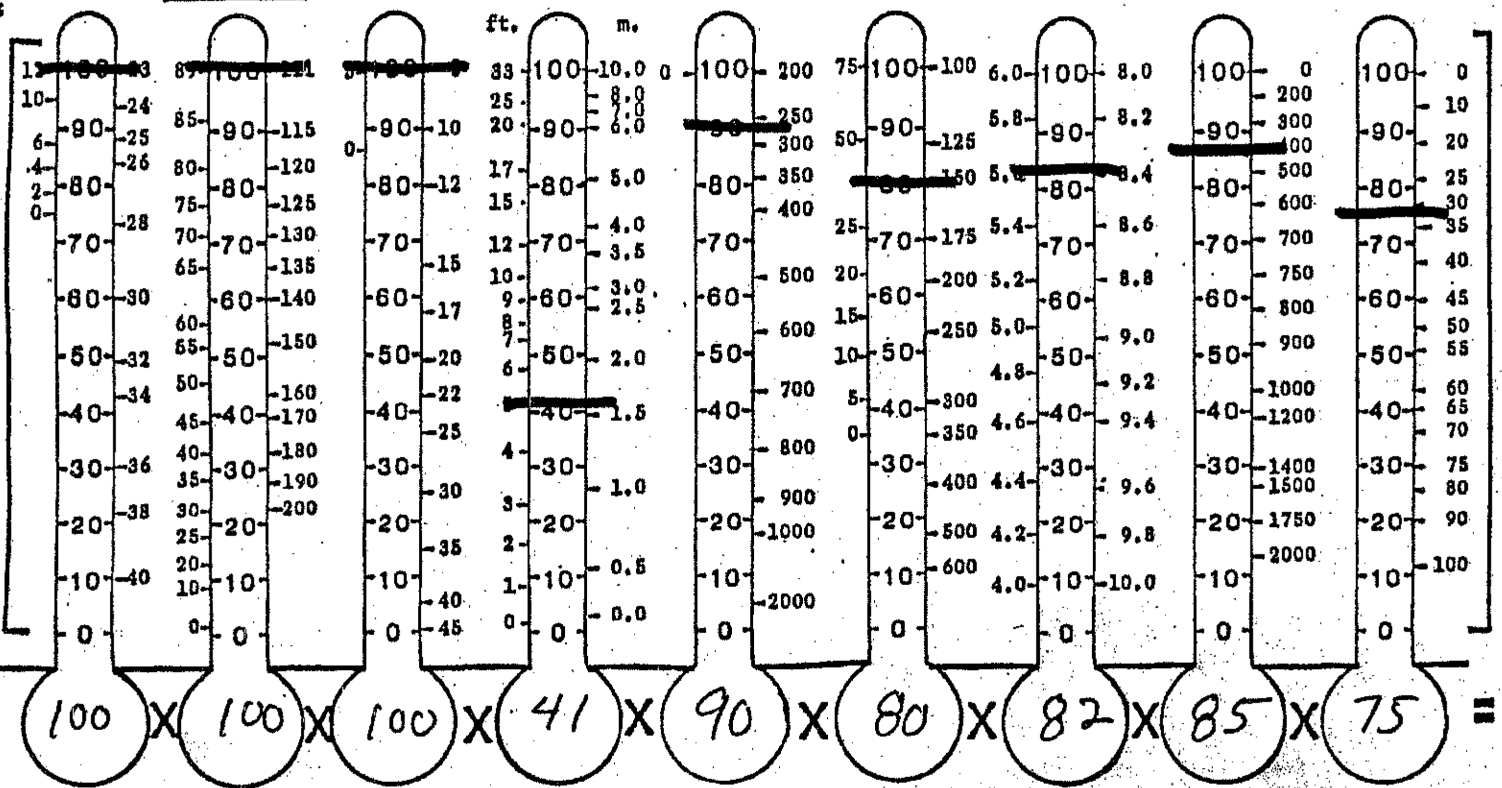
LAKE PLEASANT LAKE

CALCULATION SHEET for the UNWEIGHTED MULTIPLICATIVE WATER QUALITY INDEX for LAKES

w. fusilier

TEMPERATURE IN °C	DISSOLVED OXYGEN, % SATURATION	CHLOROPHYLL a mg/m³	SECCHI DISK DEPTH	NO_3— N ug/1	TOTAL ALKALINITY mg/1	pH su	SPECIFIC CONDUCTIVITY umhos/cm @ 25°C	TOTAL PO_4-P ug/1
13	99/	5	5 ft	265	152	8.4	410	31

QUALITY RATING CURVES
(Individual quality ratings never exceed 100)



$$\sqrt[9]{100 \times 100 \times 100 \times 41 \times 90 \times 80 \times 82 \times 85 \times 75} = 81$$

LWQI 81

HYPOLIMNION

TEMP. °C | D.O. mg/1

%

WEED COVER | BOTTOM TYPE
HURON

DRAINAGE BASIN
692 AC ~~miles²~~ kilometers²

DRAINAGE AREA
2105 ~~meters³~~ acre-feet

LAKE VOLUME
WASHTENAW MI

COUNTY & STATE
FREEDOM

TOWNSHIP
WQI

ANALYST
36 feet ~~meters~~

LAKE DEPTH
202 acres ~~hectares~~

LAKE AREA

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

DATE 15 APR 85

STATION 10

LAKE PLEASANT LAKE

LAKE WATER QUALITY INDEX

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	green blue	blue

NUTRIENT BUDGETS

Calculating a theoretical nutrient budget can help lake residents understand the sources, sinks, pathways and amounts of nutrients which can cause unwanted plant conditions in their lake. Although nitrogen and phosphorus are both nutrients, phosphorus, more than any other element, has been identified as the key element for triggering plant growth. This is because it is relatively scarce in the environment, and it is the one nutrient which man can control. Nitrogen is less often considered in nutrient budget calculations because it can be fixed in the environment by a variety of mechanisms, such as lightning and/or bacteria, thus it is pretty much uncontrollable.

Currently, most people involved in lake management feel that if the amount of phosphorus in a lake could be reduced, the lake water quality problems will be less.

A NUTRIENT BUDGET FOR PLEASANT LAKE

The following is a theoretical nutrient budget for Pleasant Lake. Two sampling runs were made on the lake, one in early April to detect possible high phosphorus concentrations, and one in late August to detect high chlorophyll a concentrations, low or high dissolved oxygen concentrations, shallow Secchi disk transparencies, shifts in pH and changes in alkalinity.

The following assumptions are being made when calculating the nutrient budget of Pleasant Lake.

- The laboratory test results were representative of the concentrations of nutrients for a six month period.

- All lake lots are 1 acre lots, and 50% of each lot is lawn.

- The volume of the lake remained constant throughout the year.

- Phosphorus is the limiting nutrient.

- The mean residency rate was 3 persons per household.

The following data (and sources) were used in the nutrient budget calculations.

- Lake volume = 2105 acre feet (WQI)
  91,693,800 cubic feet (calculated)
  686 million gallons (calculated)
  5.72 billion pounds (calculated)

- Pleasant Lake drainage area, including lake = 692 acres. (Marsh & Borton, 1974)

- Average flow from lake = none observed

- Spring in-lake mean phosphorus concentration = 30.7 ug/l (WQI).

- Summer in-lake mean phosphorus concentration = 25 ug/l (WQI)

- Average daily per capita water use = 45.6 gallons (USEPA, 1980).

- Mean phosphorus concentration in domestic waste water = 23 milligrams per liter (USEPA, 1980).

- Canadian geese release 2 grams of phosphorus per day (WCSCD Newsletter, June 85)

- Yearly household phosphorus released = 9.58 pounds (45.6 gallons X 3 persons X 8.34# X 365 X 23/1,000,000 = 9.58 pounds.)

- Mean phosphorus concentration of septage = 232 milligrams per liter (USEPA, 1980).

- Mean % phosphorus of spring lawn fertilizer = 4% (Sloans Nursery).

- Mean % phosphorus of fall lawn fertilizer = 20% (Sloans Nursery).

- 50% of the homes fertilized their lawns. (estimated)

- The mean phosphorus concentration of stormwater runoff = .8 milligrams per liter (Gannon, et al, 1975).

- Water weighs 62.4 pounds per cubic foot or 8.34 pounds per gallon.

- There are 7.48 gallons in each cubic foot of water.

- There are 107 homes and 24 trailers within 300 feet of the Pleasant Lake shoreline.

- Water yield per square mile = .54 cfs (USGS, 1972)

- One tenth of average water yield represents overland sheet flow.

PLEASANT LAKE PHOSPHORUS RETENTION

Using the 5.72 billion pounds of water figure, the amount of phosphorus in the lake water in the spring is 176 pounds.

The amount of phosphorus in the lake in summer is 143 pounds. The yearly average in-lake phosphorus concentration is 28 ug/l.

Since almost no water flows out of the lake, nutrients which enter the lake remain.

PHOSPHORUS FROM SEPTIC TANKS

(These figures assume that all the phosphorus released from septic tanks reach the lake after a period of years.)
Using the EPA figures of 23 milligrams of phosphorus per liter in human sewage, an average flow of 136.8 gallons per day per household (45.6 gallons per capita per day X 3 people per household), and 131 households with septic tank effluents discharging into the soils surrounding the lake, it is calculated that 1255 pounds of phosphorus is released into the soils surrounding Pleasant lake. Soils have quite an ability to absorb phosphorus, but eventually all soils become saturated. As the soils become saturated, the total septic tank phosphorus load could reach the lake if the tile fields are located near it.

Assuming that septic tanks are pumped once every ten years, that the tanks are 1000 gallon tanks, that the tank is half full of sludge (500 gallons) when it is pumped, and the concentration of phosphorus in the sludge is 232 milligrams per liter, less than one pound of phosphorus is removed with the septic tank sludge when the tank is pumped once in a ten year period. The above figures show that regular pumping of the septic tank is not a very feasible method of removing phosphorus from the lake watershed. If all 131 tanks are pumped once every ten years, less than 13 pounds of phosphorus per year will be removed from the lake watershed.

PHOSPHORUS ADDITIONS FROM LAWN FERTILIZERS

The 66 houses (50% of 131) that use lawn fertilizer at a commonly applied rate, 40 pounds of phosphorus per acre per year, will now be considered.

As stated above it is assumed that the lots are one acre in size, that half the lot is lawn, and that a spring and a fall fertilizer application is made each year (a local nurseryman reports he sells almost as much lawn fertilizer in the fall as he does in the spring, but the fall fertilizer has a much higher phosphorus concentration. Mean spring fertilizer phosphorus concentration is 4%, while mean fall fertilizer phosphorus concentration is 20%.) Most fertilizer is sold in 40 pound bags that cover 10,000 square feet. Thus each person buys 80 pounds of lawn fertilizer in the spring at 4% phosphorus and 80 pounds of fertilizer in the fall at 20% phosphorus. Each home owner who fertilizes his lawn uses about 20 pounds of phosphorus per year (4% X 80# + 20% X 80# = 19.2#). That's 1267 pounds per year for the 66 houses. Assuming that half the phosphorus is taken up by the lawn, 633 pounds could potentially be washed into the lake.

PHOSPHORUS ADDITIONS FROM STORM WATER RUNOFF

It is assumed that the storm water phosphorus is delivered only from the lake watershed of .77 square miles (692-202/640). Sheet-flow stormwater is considered to be about one tenth of the average flow from this area, or about .04 cfs. Using the .04 cfs figure and the .8 milligrams per liter stormwater phosphorus concentration reported by Gannon, 63 pounds of phosphorus per year are contributed to the lake through stormwater runoff from the entire watershed.

Lake area	202 acres
Total Watershed area	692 acres
Watershed area minus lake area	490 acres
Average Flow (USGS, 1972) (Mill Creek gage)	.54 CFS/Sq. Mi.
Stormwater sheet flow from Pleasant lake watershed (minus lake area)	.04 CFS
Average stormwater phosphorus concentration	.8 mg/l

PHOSPHORUS ADDITIONS FROM GEESE

Pleasant Lake attracts a large population of Canadian geese over the winter because of open water which in years past was caused by the heated outfall of the gas pumping station. During the 1984-85 winter period, it was estimated that between 500 and 1000 geese remained on the lake all winter. If 500 geese remained on the lake from January 1 to March 1, and half the fecal material remained in the lake (or on the ice), the phosphorus load added by the geese during those three months is about 100 pounds. Current thinking by lake scientists is that waterfowl more often recycle rather than add nutrients.

SUMMARY OF POTENTIAL PHOSPHORUS ADDITIONS PER YEAR

Potential phosphorus input from septic tanks	1255 pounds
Phosphorus removed by septic tank pumping	-13 pounds
Potential input from lawn fertilizers	633 pounds
Phosphorus additions from stormwater runoff	63 pounds
Phosphorus additions from geese	100 pounds
TOTAL POTENTIAL PHOSPHORUS INPUT	**2038 pounds**

SUMMARY

The above calculations show that the single largest contributor of phosphorus to Pleasant Lake are the septic tanks surrounding the lake. Lawn fertilizers are the second highest contributor. This is based on the assumptions that only half of the houses fertilize the lawns, and half the applied fertilizer is captured by the soil. Neither of these assumptions may be correct.

The above calculations show that pumping septic tanks once every ten years removes very little phosphorus from the watershed. Likewise, although the geese appear to be plentiful, the phosphorus load added by them is minimal, compared to septic tanks and lawn fertilizers.

WHERE DOES ALL THE PHOSPHORUS GO?

As the above summary shows, it is possible for 2038 pounds of phosphorus could enter the lake each year, yet the lake as an average has about 160 pounds of phosphorus in it. Where did the rest go?

As long as there is oxygen in the water phosphorus will precipitate to the bottom sediments. And that is probably where most of it is going, to the bottom sediments of the lake. If the rates of input and precipitation to the sediments were constant over the last 20 years, over 20 tons are being retained by the lake sediments. This breaks down to almost 200 pounds of phosphorus per acre. The above calculations show that Pleasant Lake may have almost 5 times more phosphorus in the lake sediments than is recommended for lawn application (at 40 lbs per acre per year).

It is certainly valid to ask why one should worry if the phosphorus is precipitated to the bottom sediments?

Right now, there are too many plants in the lake. However, the real problem will be when the amount of oxygen required to decompose the plant materials in the lake is exceeded, and the phosphorus which has been precipitating over the years will go back into solution, and algal blooms will occur. These are extremely undesirable conditions. The algae not only form a green scum over the entire surface of the lake, but when they die and decompose, they stink.

The ability of the lake to precipitate phosphorus to the bottom sediments was not addressed in this nutrient budget calculation. The reason it was not addressed is because in the future, it is quite possible for the precipitated phosphorus to re-dissolve and cause serious water quality problems.

GEOLOGY OF THE PLEASANT LAKE BASIN

Pleasant lake is located in the Huron River basin which is underlain by two major types of earth materials; consolidated bedrock and unconsolidated glacial deposits. Overlying the bedrock are glacial drift materials deposited during glacial time, about 14,000 years ago.

The bedrock formations that directly underlie the glacial deposits dip generally west and north west. Coldwater Shale is found under the Pleasant Lake Basin at depths of 150-175 feet. This shale is primarily a greenish to bluish gray shale with some lenticular beds of sandstone. Its thickness ranges from 400 to 700 feet.

All surface geologic features of the area were formed by the continental glaciers that formerly covered most of North America north of the Ohio and Missouri rivers, including all of Michigan. The moraines--hilly belts of mixed material--were deposited by recurrent forward movements of the ice front during the period of its final retreat. The till plains--level areas of mixed material--were deposited by downward melting of forward ice sheets as the glacier lay temporarily stagnant.

Pleasant Lake is located in the Defiance terminal moraine.

SOIL TYPES SURROUNDING PLEASANT LAKE

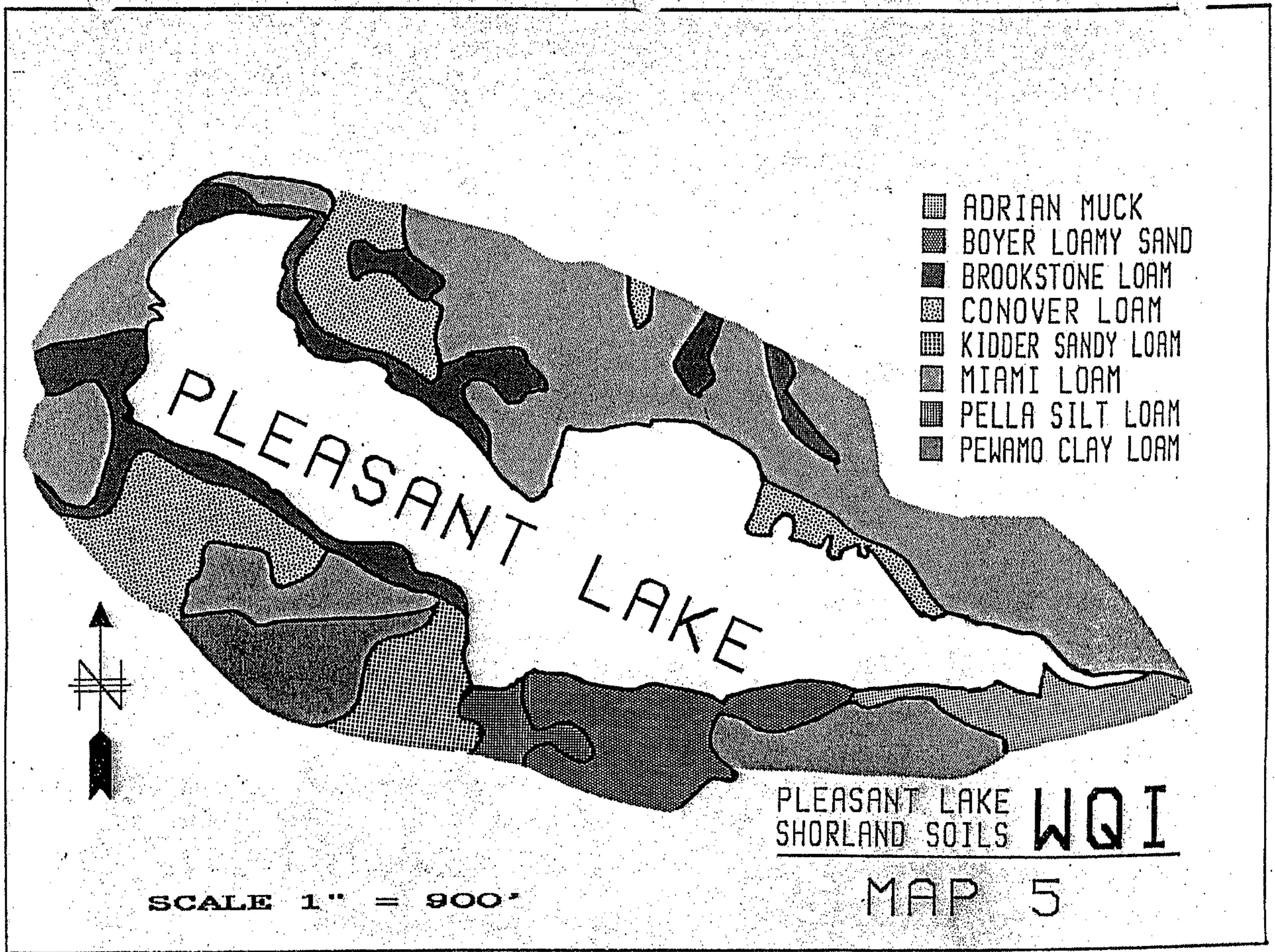
A literature review was conducted to identify the soil types which form the immediate shore of Pleasant Lake. In most cases, the soils were loams, which are made up of between 7-27% clay.

Listed below are the SOIL TYPES and PERCENT OF DISTANCE around lake.

TABLE ONE

SOIL TYPE	PERCENT OF DISTANCE
Brookstone Loam	40
Miami loam	18
Conover Loam	15
Boyer sandy loam	13
Adrian muck	10
Kidder sandy loam	3
Pella loam	1
	100%

Map 5 shows the locations of the various soil types around Pleasant Lake.


ADRIAN MUCK
BOYER LOAMY SAND
BROOKSTONE LOAM
CONOVER LOAM
KIDDER SANDY LOAM
MIAMI LOAM
PELLA SILT LOAM
PEWAMO CLAY LOAM
PLEASANT LAKE
PLEASANT LAKE
SHORLAND SOILS
WQI
MAP 5
SCALE 1" = 900'

BOTTOM SEDIMENT ANALYSES

Bottom sediment samples were taken at all in-lake sample stations with a Peterson Dredge. The samples were air dried, then dried at 103 °C over-night. After weighing, the samples were fired at 500 °C for 2 hours to burn off the organics, then weighed again.

The amount of mineral material found in the bottom sediments varied from 60 to 99%, with an average of 76%. See Table 2 below. This is greater variation than is usually found in lakes, but may be an aberration due to different sampling depths. The 99% mineral sample was taken near the island on the west end of the lake.

Sediment organic losses as high as 60% (40% mineral) have been observed in highly eutrophic lakes.

TABLE 2.

BOTTOM SEDIMENT ANALYSES

Site	% Mineral	Comments
1	79	
2	68	
3	74	
4	81	
5	99	All sand & gravel
6	60	
7	82	
8	70	
9	68	
	76%	Mean sediment mineral content

THE WEED SURVEY

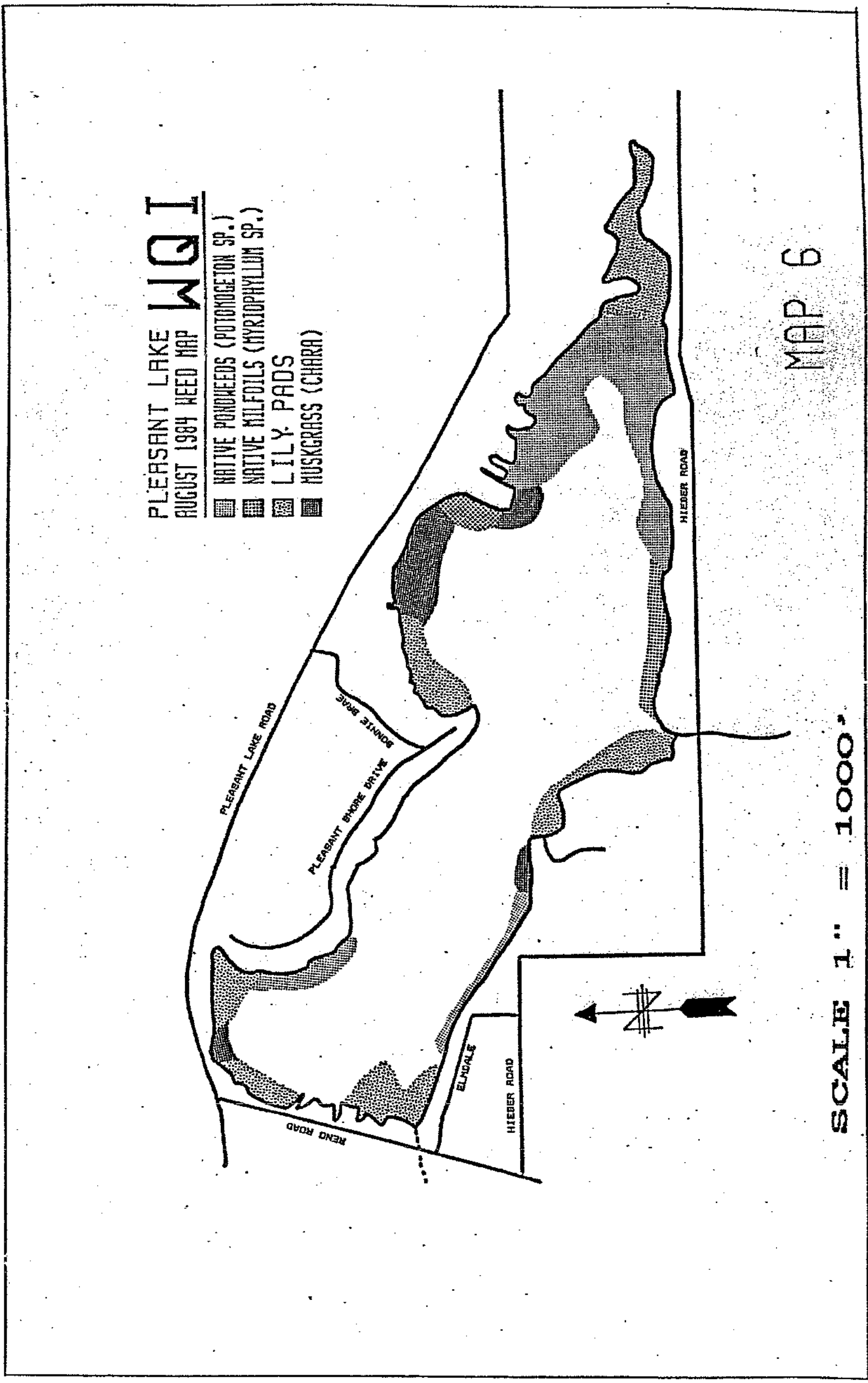
A weed survey of Pleasant Lake was conducted during the Fall of 1984. All near-shore waters were inspected for weeds which would interfere with boating or swimming. Weed beds were mapped when discovered, and field identified. Map 6. shows the location, extent and identification of the major weed areas in the lake during the fall of 1984.

Several trips were made to the lake in 1985 in an attempt to discover weed problems, but for some unknown reason, there appeared to be few. In late August, all near-shore waters were inspected, but problem weed beds were not found.

The 1984 Fall survey found four weeds filled most of the shallow areas. Native pondweeds *(Potomogeton sp.)* were the dominant species, with large stands found on the shallow east end and smaller stands on the west end. Native milfoils *(Myriophyllium sp.)*, water lilys, and musk grass *(Chara)* were found in scattered beds as shown on the weed map. Some wild celery *(Vallisneria sp.)* was found scattered through-out the shallow areas.

Weeds have been a problem for years in Pleasant Lake. As early as 1924, employees with the Michigan Department of Conservation noted that the lake bottom was "thickly covered with vegetation".

Weeds have a function in a lake. In Pleasant Lake they remove phosphorus from the water column, making it unavailable for phytoplankton. All four of the dominant weeds are considered excellent for fish, for a variety of reasons. Blue gills eat pond weed. Chara is an excellent producer of fish food, especially for trout. Milfoils and water lilys provide fish shelter and food in the form of insects.


PLEASANT LAKE
AUGUST 1984 WEED MAP
WQI
NATIVE PONDWEEDS (POTOMOGETON SP.)
NATIVE MILFOILS (MYRIOPHYLLUM SP.)
LILY PADS
MUSKGRASS (CHARA)
MAP 6
PLEASANT LAKE ROAD
BONNIE BRAE
PLEASANT SHORE DRIVE
HIEBER ROAD
RENO ROAD
ELMDALE
HIEBER ROAD
SCALE 1" = 1000'

THE THERMAL DISCHARGE AND ITS EFFECTS ON PLEASANT LAKE

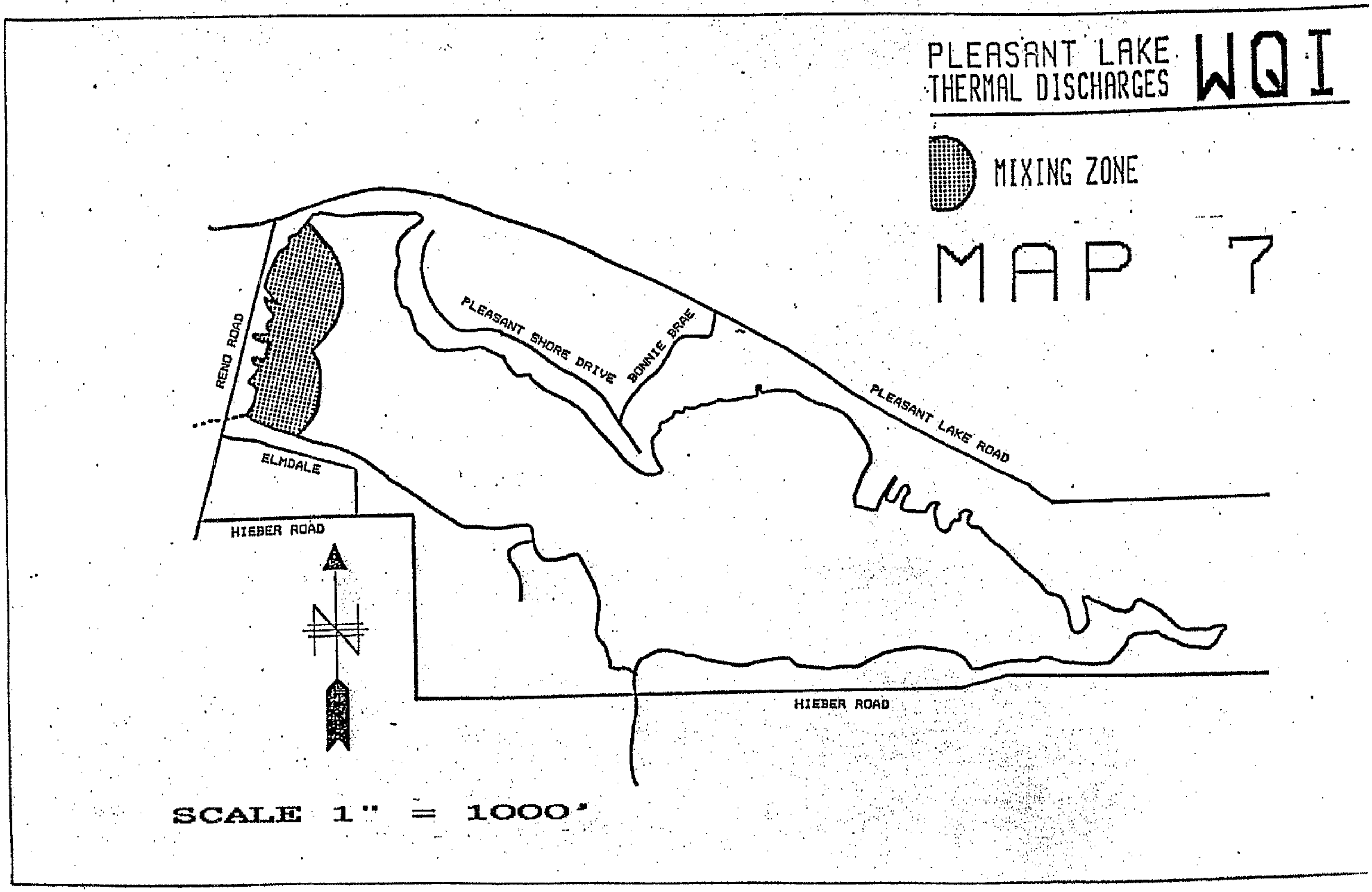
The Freedom Compressor Station, (12201 Pleasant Lake Road, Manchester, Michigan) located at the west end of Pleasant Lake, is owned by Michigan Gas Storage Company, a division of Consumers Power Company. A NPDES (National Pollution Discharge Elimination System) permit which expires October 31, 1985, authorizes the discharge of non-contact cooling water into Pleasant Lake from two natural gas compressor stations, consisting a total of 13 compressors on the site. The water is used to cool both the natural gas as it is compressed, and the diesel engines which power the compressors. The cooling water for both stations is drawn from a common source, a small brick building on the west end of the lake. When all compressors are on-line, 8210 gallons of water per minute are used for cooling purposes. Peak loads are reached only during the summer months when gas from southern states is pumped to various underground storage wells in Michigan. During the winter months, 0 to 5 compressors may be operating. The plant also circulates water to keep the equipment from freezing up.

There are three permitted thermal discharge outfalls; 001 located immediately north of the intake site, 002 near the outlet at the S.W. corner of the lake, and 003 in the intake pipe.

Outfalls 001 and 002 are permitted to discharge a maximum of 11,450,000 gallons per day of non-contact cooling water between April-November of each year. The permit requires that the discharge shall not increase the temperature of the receiving water at the edge of a 500-foot radius mixing zone by more than 3°F. (The temperature limitations and other permit requirements don't apply in mixing zones.) See Map 7. No discharge is permitted during the months of December-March from outfalls 001 and 002.

Outfall 003 is the water intake. The permit requires that during the months of April-November, no water shall be discharged from this outfall. This is not unusual because during this time period, this is used as a water intake. During the winter months, (December-March) the permit authorizes 3,000,000 gallons of cooling water per minute to be discharged to Pleasant Lake. The same 3°F restriction outside the 500-foot radius mixing zone applies.

Samples for monitoring permit compliance are required to be taken at each outfall prior to discharge. It's interesting to note that the permit allows a 500-foot radius mixing zone and sets temperature limits at the edge of it, but doesn't require temperature measurements at the edge of the mixing zone; nor is an ambient temperature monitoring station established. How can one tell if the permit requirements are being observed if the lake water temperatures at the


PLEASANT LAKE
THERMAL DISCHARGES
WQI
MIXING ZONE
MAP 7
PLEASANT SHORE DRIVE
BONNIE BRAE
PLEASANT LAKE ROAD
REND ROAD
ELMDALE
HIEBER ROAD
HIEBER ROAD
SCALE 1" = 1000'

edge of the mixing zone, and at an ambient (control) site are not measured?

The monitoring requirements of the August 15, 1975 plan prepared by Consumers Power engineers, if they were implemented, are not being made public. Among the monitoring requirements of the program are; weekly winter aerial photo surveys of Pleasant Lake during ice conditions; weekly sampling of ice thickness and water temperatures during icing conditions, and; determination, if possible, safe and unsafe areas of ice. This may pose some liability problems for Consumers Power if someone breaks through thin ice caused by their heated discharge and drowns, and it is shown that they knew about the thin-ice conditions and didn't warn the public.

SOME NOTES ON HEATED WATER DISCHARGES TO LAKES

When heated water is discharged to standing water bodies, the water, if it is warmer than the lake water, rises quickly to the surface. The greater the temperature difference between the heated water and the lake water, the faster it rises to the surface.

Furthermore, the greater the difference between the water and air temperature, the greater the rate of heat exchange between the water and the air becomes.

Thus heated water discharges rise quickly to the surface of the lake and dissipate fairly rapidly into the air.

WHAT ARE THE EFFECTS OF THE HEATED WATER DISCHARGE ON PLEASANT LAKE?

The open water areas created during the winter months by the heated water discharge provides both disadvantages and advantages for Pleasant Lake. These effects depend on each persons particular outlook regarding the purpose and uses of Pleasant Lake.

Most lake scientists would consider winter heated water discharges to be a benefit to the lake. The lack of ice cover would permit continuous diffusion of oxygen into the lake water throughout the winter months, preventing oxygen depletion problems which often occur under ice cover conditions in Michigan lakes. Since the oxygen levels would remain high, winter fish kills would rarely occur. Furthermore, since phosphorus remains tied up in the sediments of highly oxygenated water, it would not circulate throughout the water column in the spring when the entire lake mixed. This would serve to limit the productivity problems of the lake during the warmer months.

Ice fishermen would have a problem with the lack of ice, but there is some evidence from thermal discharge studies of power plants that the warmer water provides better fishing than cold water in winter. Fishing may have to be done from a boat, but the fishing might actually improve.

Ice skaters, ice fishers, and snow mobilers would have a problem with the channels of thin ice created by the warm water. Since it is extremely difficult to determine the thickness of ice without boring a hole through it, this condition could be life threatening.

Boaters should find the open water beneficial, since they could use the lake year round. Water skiiers and swimmers, except for the stout hearted, should not notice any effect on their activity.

Bird watchers, especially those who like ducks and geese, should welcome the open water because it will attract hordes of ducks and geese. The amount of phosphorus added to Pleasant Lake by the winter goose population seems minimal. (see Nutrient Budgets).

People who fish should perceive the open water to be beneficial because it would prevent most winter fish kills, thus providing more fish in the lake during the summer months.

In summer, a slightly different story emerges.

Most lake scientists, although they recognize that the warm water rises quickly to the lake surface and dissipates rapidly into the air, would feel the heated water discharge less than desirable because warm water holds less oxygen than cold water. Thus the oxygen available to aquatic organisms would be less. However, the problem would be minimal because the rest of the lake is open during the summer. The fish can easily move to other areas of the lake.

Boaters and water skiiers should not find their uses impaired by warmer surface water temperatures in summer. Swimmers in the immediate area of the heated water discharge might find the water temperature uncomfortable, although summer water temperature measurements near the discharges (inside the mixing zone) found 81°F temperatures, while ambient (control) temperatures were 77°F. Bird watchers should not find their use of the lake impaired, although the birds may move to other parts of the lake. (During the late summer survey, most of the geese were found on the east end of the lake. This is probably more related to the extensive shallow water areas on the east end rather than the heated water discharge on the west end.)

The lake was checked for open water in January, February and March 1985. A small area, about 200 feet across was open. It was located about 200 feet from the west end of the lake, almost directly east of outfall 003 but within the 500-foot mixing zone. Since the exact location of outfall 003 is unknown at this time, it is difficult to determine if the open water was caused by discharges from that outfall.

It might be assumed that perhaps the large flock of geese kept the small area of water open all winter. But if they did it here, why don't they do it on other lakes?

LAKES

Lakes form layers. Water temperature differences in a lake cause the water to form layers. These layers are given names by lake scientists. The top layer, which in summer is the warmest water, is called the epilimnion. In many lakes the temperature of this surface layer will reach 25°C (77°F) or more.

The middle layer, defined as the layer where the temperature changes most, is called the thermocline (or metalimnion).

The bottom layer, below the thermocline, is called the hypolimnion, and in summer is the coolest water in the lake.

The greater the temperature differences between the top and bottom layers of water in the lake, more resistant to mixing the different layers are. Because of this stability (or resistance to mixing), the layers of water generally do not mix during the summer months.

The layering of lake waters causes significant effects within a lake which are not visible to most lake users. The biggest problem relates to the amount of oxygen dissolved in the water. And the amount of oxygen dissolved in the water has significant effects on the chemicals dissolved in it.

In a lake, the most significant source of dissolved oxygen is the atmosphere. Oxygen diffuses into water from the air, and diffuses faster if the amount of oxygen in the water is low. Since the surface layer of water, the epilimnion, is in closest contact with the air, this layer usually has an adequate supply of oxygen during the summer months. (Oxygen, and most other gasses, by the way, are <u>less</u> soluble in warm water than in cold water.) The two other layers of water in a lake, the thermocline and the hypolimnion, since they don't mix with the surface water, can become depleted of oxygen during the later summer months. The organisms which live there use the oxygen to live just as we do, but since there is no oxygen being added, it is possible for them to remove all of the oxygen from these layers. Once the layers of water have been depleted of oxygen, no animals such as fishes, live here. Interesting chemical changes take place however.

Phosphorus is of particular concern when addressing lake problems because it is felt that if the amount of phosphorus which enters a lake can be controlled, the amount of plant life, both floating (planktonic) and rooted will also be controlled.

Phosphorus entering a lake from various sources will be precipitated to the bottom sediments <u>if there is oxygen in the layers of water in the lake.</u> The reverse is also true. If there is no oxygen, especially in the bottom layers of water in a lake, the phosphorus in the bottom sediments will redissolve and enter the water column where it will be picked up by plants, incorporated into their tissues, and show up as increased floating or rooted plant masses. Once this happens, the cycle becomes more pronounced. The plants grow over the summer, die back during the winter and settle to the bottom, where they are decomposed by the bacteria which live there. The bacteria use oxygen to decompose the plants, and in the process, deplete the oxygen from the bottom layer of water. Then the phosphorus, which had been precipitated to the bottom sediments over the years, redissolves, enters the water column and causes more plant growth the next year. Once this cycle has started, it is difficult to break.

Although some feel it might be possible to keep the phosphorus tied up in the bottom sediments by pumping oxygen into the bottom layers of lake water, this is seen by others as a temporary measure which will eventually have to be addressed. The goal of most lake scientists is to try to limit the amount of phosphorus which enters the lake in the first place.

Although this discussion has focused on the various layers of water formed by lake stratification during the summer, and to a lesser extent during the winter, there are times when the the lake is isothermal (same temperature) from top to bottom and has no layers. In Michigan lakes, this usually occurs twice each year, once in the spring and once in the fall. When the temperature of the water in a lake is uniform from top to bottom, the lake water is easily mixed by the wind.

The spring and late summer sampling periods used in this study were selected to take advantage of phenomena related to various temperature related effects.

The purpose of the early spring sampling run was to detect potential high phosphorus concentrations which are often found immediately after ice-out. Here is what happens. After ice has formed on the lake, no further atmospheric oxygen diffuses into it. If oxygen consumption rates are high in the water under the ice, it is possible to cause depletion of oxygen in the water column, and subsequent release of phosphorus from the bottom sediments. After ice-out, when the temperature is uniform throughout the lake, winds mix it, bringing up water from the bottom highly laden with phosphorus, which is then mixed through-out the water column.

In late summer, after stratification occurs, oxygen is often depleted from the deep waters of lakes. To determine if this occurred in Pleasant lake, dissolved oxygen and temperature profiles were taken during this period.

Chlorophyll a concentrations, which indicate the existence of floating plant communities (phytoplankton) are often highest in late summer when the water is warmest, and adequate sunlight exists. The late summer sampling run also attempted to detect high chlorophyll a concentrations, if they existed in Pleasant Lake.

FOAM ALONG THE LAKESHORE

Many people are concerned about the foam they see along the shore line of lakes, especially in the early spring. They think it is indicative of some sort of pollution. This is usually not the case. There are two possible sources for the materials which make up the foam. The first is a natural source.

Bubbles such as those which make up foam are made up of long molecules. Fats and oils are examples of these types of molecules. For example, soap is made from fats and oils. All plants, including aquatic ones, produce make some type of oil. When these plants decompose, the oils are released and, being lighter than water, float to the surface. The wave action, caused by the winds across the lake surface pushes the oil film to the shore, concentrating it. The waves also introduce air into the oil film, which makes the bubbles. These bubbles combine with other bubbles to form the foam found on lake shorelines. These foams seem to appear early in the year, soon after the ice disappears. Ordinarily bacteria would break these molecules down, but the water is so cold that the necessary bacterial action is very slow or non-existent.

A second potential source of molecules which could make foam is oils from snow mobiles or fuel oil from fishing shantys which is spilled on the ice. When the ice melts, the oil would remain on the surface and wave action would again concentrate it.

SEWAGE TREATMENT SYSTEMS: FACTS AND FICTION

Generally, there are two types of sewage treatment systems, municipal sewage treatment plants, and on-site septic tank systems.

As a general rule, one never hears that a municipal sewage treatment plant is "failing". It may be "overloaded", or not meeting the permit requirements, but it is never termed a "failing" sewage treatment plant.

It is this authors feeling that all municipal sewage treatment plants are failing, in that none put out an effluent even close to the quality of the water in the receiving stream. Recently, two new sewage treatment plant effluents (Dexter and Ann Arbor) and two old sewage treatment plant effluents (Loch Alpine and Milford) were studied using the National Sanitation Foundation Water Quality Index for Rivers. The index ranges from 0 (poor water quality) to 100 (excellent water quality). The index for the Huron River was about 80. The Ann Arbor Sewage Treatment Plant (STP) effluent index was 44, the Dexter STP effluent index was 38, the Loch Alpine STP effluent index was 37 and the Milford STP effluent index was 29.

What this study says is that the quality of the effluent from all four of the sewage treatment plants studied is poor when compared to the quality of the river, and that the new, expensive sewage treatment plants are not doing a much better job than the old plants. All of these sewage treatment plants are still polluting our rivers.

The real questions is ...Are we wasting billions of dollars building new sewage treatment plants which are doing a uniformly poor job of treating sewage?

The above discussion was included to provide a background for a discussion of on-site sewage systems (septic tanks and tile fields), which are often termed "failing".

The individual on-site system consists of a septic tank and a tile absorption field.

The septic tank is a large watertight concrete tank which is buried in the ground. It has an inlet on one end, an outlet on the other, and a lid which can be removed for inspection or pump-out. Generally, sewage flows from the house to the tank, and from the tank to the tile field by gravity. The purpose of the septic tank is hold the sewage for a period of time to allow the organisms in it to decompose the sewage into methane, carbon dioxide, water, and heat.

The warm methane and carbon dioxide gasses travel back up the sewer pipes and leave the system from the roof vents on the house. The water flows into the tile absorption field, where it is introduced into the soil. The heat generated by the decomposition of sewage, along with the heat in the sewage itself, prevents the sewers, septic tank, and tile field from freezing in the winter.

The tile absorption field is made up of a series of lines of loosely placed clay tiles or perforated plastic pipe which are supposed to provide distribution of the septic tank effluent over a large area and allow percolation into the soil. Some think septic tank effluent is "pure", but this is not the case. It contains many bacteria and viruses, along with high concentrations of salts, including phosphorus and nitrogen, and some organic material. The tile field itself provides little treatment. The soil is expected to do a great deal. Some soils, generally clays, have a high capacity to absorb a variety of materials, including bacteria, viruses, and phosphorus. The absorptive capacity of sands and gravels is less.

The phosphorus binding capacity of the soils does not appear to be total or permanent. In many cases, after a lake has been subject to human habitation for 20 to thirty years, lake problems appear. It seems that small amounts of phosphorus slowly move through the soil and enter the lake. However, the process is continuous. So even if a lake is sewered, the phosphorus in the soils can continue to enter the lake for a number of years.

There are some who feel that septic tank systems which release phosphorus into the lake are failing. These systems are not failing. They are working as they should. What many do not realize is that the systems do release nutrients into the environment, and that in time, they can reach the lake.

This author feels there are two conditions which indicate septic tank or tile field failure. One, when the effluent from the tile field appears on top of the ground, and two; when the toilets, sinks, or drains back up in the house.

The effluent from the tile field generally appears on the soil surface when the lines in the tile field can no longer introduce the effluent into the soil. Generally, this condition is caused by a build up of black sulfide slime around the pipes in the absorption field.

Backing up of sewage in the toilets, drains and sinks in the house can be caused by a plugged tile field (discussed above), or by a plug of material somewhere in the sewer lines or septic tank.

Some of the causes of on-site system failure.

1. A lack of oxygen in the soil cover of the tile field. In the absence of oxygen, bacteria in the soil form the

black sulfide slime which prevents percolation of the effluent in the soil. The best type of cover for a tile field is a light friable soil which passes air easily. The worst type is clay.

2. Floating chunks of undecomposed material break loose in the septic tank and plug the outlet pipe.

3. The tank is not pumped often enough, and the sludge from the bottom builds up and plugs the outlet pipe. The important point here is that the tank should be inspected about every two to three years, and pumped when necessary.

4. A solid plug forms in the cast iron pipe which connects two septic tanks together.

5. A layer of solidified grease builds up gradually and plugs the sewer pipes.

6. Vehicles drive over the sewer pipes or tile field and crush the pipes.

7. Tree roots enter the tile field pipes and plug them up.

8. There is some indication that the salts from a water softener can cause clogging of the soils under a tile field.

SOME FALLACIES ABOUT SEPTIC TANK SYSTEMS

1. Septic tank systems remove nutrients. As noted above, phosphorus seems to reach lakes 20 to thirty years after people move on a lake.

2. Don't use a garbage grinder. Why this is often recommended is not understood by the author. Most of the materials put into a garbage grinder are vegetable in origin. Septic tank systems are designed to handle these types of wastes. It's not a good idea to put meats or fat in a garbage grinder but that's because they decompose slowly.

3. Have the septic tank pumped out every three years. The author's septic tank has been in service for fifteen years, and has been pumped out once. As noted above, the tanks need to be checked occasionally, and pumped when necessary.

PLEASANT LAKE WATER QUALITY DATA

SPRING SAMPLING DATA

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
4/15/85	1	0 ft.	13	10.1	3	5 ft.	235	152	8.4	410	8
4/15/85	2	0 ft.	13	10.1	3	5 ft.	225	152	8.4	410	15
4/15/85	3	0 ft.	13	10.1	4	5 ft.	225	149	8.4	410	8
4/15/85	4	0 ft.	14	9.9	4	5 ft.	220	149	8.4	410	113
4/15/85	5	0 ft.	13	10.0	4	5 ft.	155	152	8.4	410	68
4/15/85	6	0 ft.	12	10.0	3	5 ft.	355	152	8.4	410	9
4/15/85	7	0 ft.	13	10.0	4	5 ft.	305	152	8.4	410	8
4/15/85	8	0 ft.	13	9.9	4	5 ft.	245	152	8.4	410	35
4/15/85	9	0 ft.	13	10.1	4	5 ft.	145	153	8.4	410	37
4/15/85	10	0 ft.	13	9.9	5	5 ft.	265	152	8.4	410	31
SPRING AVERAGES			13	10.0	4	5 ft.	238	152	8.4	410	33.2

DEPTH PROFILE AT STATION ONE

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
4/15/85	1	5 ft.	11	10.1	---	---	---	---	---	---	---
4/15/85	1	10 ft.	9	10.6	---	---	---	---	---	---	---
4/15/85	1	15 ft.	7	10.1	---	---	---	---	---	---	---

DEPTH PROFILE AT STATION THREE

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
4/15/85	3	5 ft.	13	10.1	---	---	---	---	---	---	---
4/15/85	3	10 ft.	11	10.0	---	---	---	---	---	---	---
4/15/85	3	15 ft.	9	9.6	---	---	---	---	---	---	---
4/15/85	3	20 ft.	7	9.0	---	---	---	---	---	---	---
4/15/85	3	25 ft.	6	8.4	---	---	---	---	---	---	---
4/15/85	3	30 ft.	6	8.1	---	---	---	---	---	---	---

TEMP. Temperature in degrees Centigrade
D.O. Dissolved Oxygen in milligrams per liter
CHL. A. Chlorophyll a in micrograms per liter
SECCHI Secchi Disk transparency in feet
NITR. Total Nitrate nitrogen in micrograms per liter
ALK. Alkalinity as Calcium Carbonate in milligrams per liter
pH Hydrogen ion concentration
COND. Conductivity in umhos per cm at 25 degrees Centigrade
PHOS. Total Phosphorus in micrograms per liter

PLEASANT LAKE WATER QUALITY DATA

FALL SAMPLING DATA

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
8/24/84	1	SURF.	25	8.9	22	6	14	132	8.4	420	22
8/24/84	2	SURF.	25	8.4	11	7	18	129	8.1	420	24
8/24/84	3	SURF.	25	8.1	11	7	18	132	8.4	420	33
8/24/84	4	SURF.	25	8.3	9	7	18	129	8.4	420	27
8/24/84	5	SURF.	26	8.1	12	7	18	130	8.4	440	27
8/24/84	6	SURF.	25	8.8	12	7	18	130	8.4	420	23
8/24/84	7	SURF.	25	9.1	10	7	18	125	8.5	420	26
8/24/84	8	SURF.	25	9.0	14	6	18	126	8.4	440	24
8/24/84	9	SURF.	25	8.6	9	7	16	127	8.4	440	19
FALL AVERAGES			25	8.6	11	7	18	129	8.4	427	25

DEPTH PROFILE AT STATION ONE

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
8/24/84	1	5 ft.	25	8.9	---	---	---	---	---	---	---
8/24/84	1	10 ft.	24	8.8	---	---	---	---	---	---	---
8/24/84	1	15 ft.	24	8.2	---	---	---	---	---	---	---
8/24/84	1	19 ft.	23	4.8	---	---	---	---	---	---	---

DEPTH PROFILE AT STATION THREE

DATE	STA.	DEPTH	TEMP.	D.O.	CHL.A	SECCHI	NITR.	ALK.	pH	COND.	PHOS.
8/24/84	3	5 ft.	13	10.1	---	---	---	---	---	---	---
8/24/84	3	10 ft.	11	10.0	---	---	---	---	---	---	---
8/24/84	3	15 ft.	9	9.6	---	---	---	---	---	---	---
8/24/84	3	20 ft.	7	9.0	---	---	---	---	---	---	---
8/24/84	3	25 ft.	6	8.4	---	---	---	---	---	---	---
8/24/84	3	30 ft.	6	8.1	---	---	---	---	---	---	---

TEMP. Temperature in degrees Centigrade
D.O. Dissolved Oxygen in milligrams per liter
CHL. A Chlorophyll a in micrograms per liter
SECCHI Secchi disk depth in feet
NITR. Nitrate nitrogen in micrograms per liter
ALK. Alkalinity in milligrams per liter as calcium carbonate
pH Hydrogen ion concentration
COND. Conductivity in umhos per centimeter
PHOS. Total phosphorus concentration in micrograms per liter

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AN ADDENDUM TO THE 1985 PLEASANT LAKE WATER QUALITY REPORT

EURASIAN WATER MILFOIL INFESTATION IN PLEASANT LAKE

On a visit to Pleasant Lake on June 22, 1986 milfoil was discovered at the boat launch site. On June 25, a weed survey of the lake was conducted. The accompanying weed map of the lake shows the results of the weed survey. The stippling represents areas infested with eurasian water milfoil *(Myriophyllum spicatum)*, the area being about 50 acres. This plant was not found during the 1985 study period although a thorough search was made. There is estimated to be about 350 acre-feet infested with milfoil.

Eurasian water milfoil is termed an "exotic" weed because it is not a native lake weed, being imported from Europe a number of years ago. This weed causes real problems in lakes for several reasons:

- It grows to deeper depths, (as deep as 15 feet) so it can reduce the recreational area of a lake considerably.

- Since it is not a native plant species it has no recognized natural enemies to limit its growth.

- Since it grows from roots that can survive over the winter, it gets an earlier start in the spring and crowds out beds of native weeds. (Current thinking among many aquatic botanists is that most other aquatic plants grow from seeds.)

- It has two growth periods, one in late spring and another in late summer.

Control of eurasian water milfoil is difficult at best. Lake level draw-down is preferred by this author because it is a cheap control measure that introduces no harmful chemicals into the lake and appears to work as well as any other. However Pleasant Lake cannot be drawn down. There are several other methods of control available, none which are really satisfactory.

Eurasian water milfoil can be harvested using a mechanical weed harvester. The harvested weeds should be removed from the lake. One of the problems with this procedure is that it is not very long-lasting because the weed re-grows about an inch per day, so it requires several harvests per year to keep the lake useable. A second problem is that this weed <u>naturally</u> reproduces by fragmentation. This also means that any weed fragments left in the lake by the harvesting operation can reproduce in other parts of the lake. It should be noted that boat propellers also cause fragmentation. However, most areas of Pleasant Lake that can be infested with this weed are probably already infested so the problem of cut fragments infesting other parts of the lake is not great. There are some reports that multiple harvests reduce the vitality of the plant.

Aquatic contact herbicides such as Aquathol and Diquat will kill the leafy parts of the plant but not the roots. Thus the milfoil will be back after a period of time. A problem with the use of any herbicide is that the plants settle to the bottom when they die and can deplete oxygen supplies as they decompose.

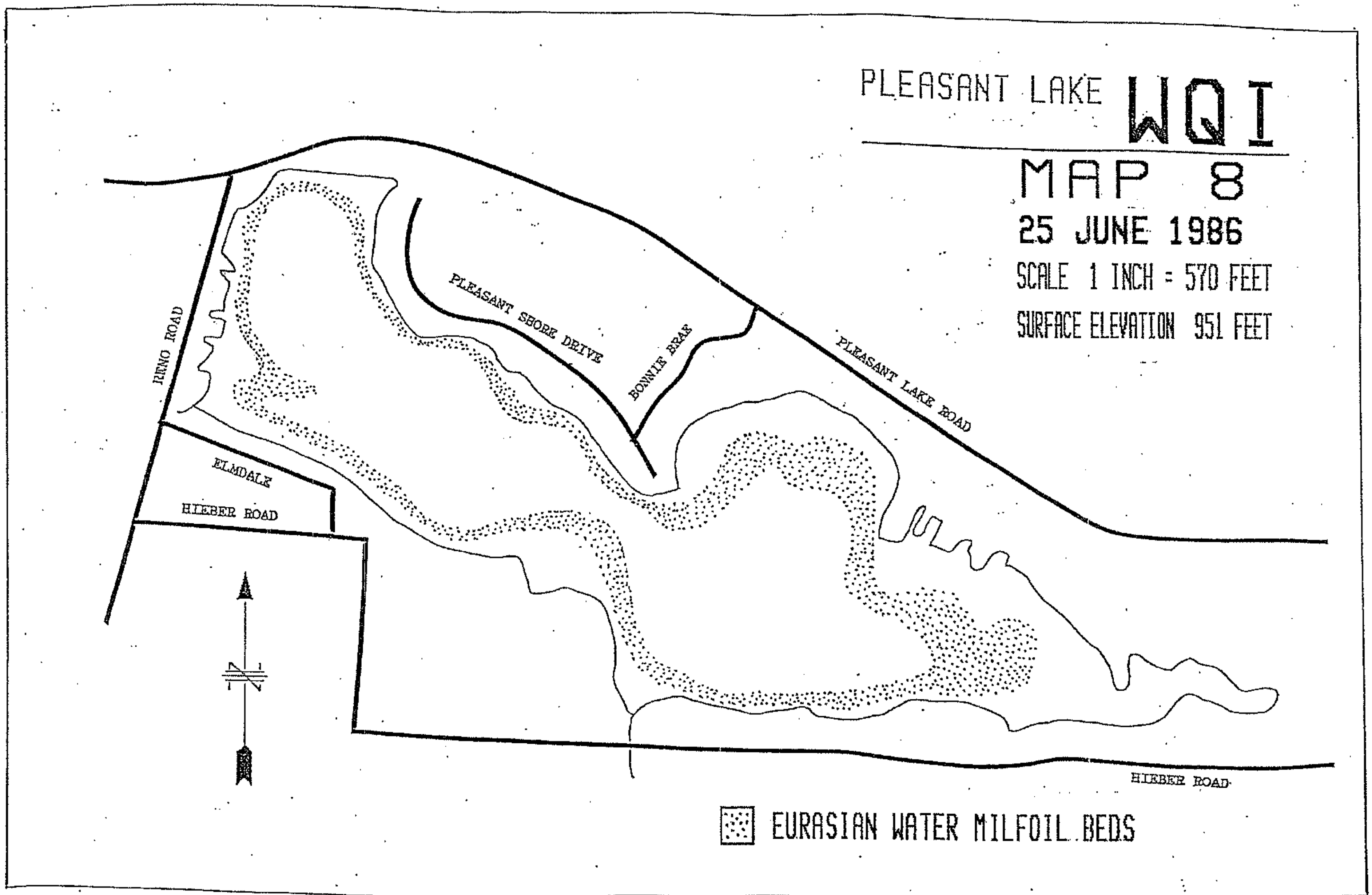
2,4-D, a systemic herbicide, seems to be the method of choice for control of eurasian water milfoil. (2,4-D is a chlorinated benzene ring which leads this author to feel that it is not a safe as many suggest. It is, however, the broad-leaf weed-killer presently used on many lawns.)

Although there is some confusion as to the specific action, most seem to think it's absorbed by the leaves and then transported to the roots so it kills the entire plant. This researcher has been watching the results of using 2,4-D to kill eurasian water milfoil in several reservoirs in the area and has yet to observe complete eradication. One of the possible reasons the milfoil is not completely eradicated is that many of the plants grow far enough below the surface to escape detection by the herbicide applicator.

The following is suggested if the Pleasant Lake POA might want to use 2,4-D to attempt to control the milfoil infestation. Apply 2,4-D now to the milfoil. The services of a professional aquatic herbicide applicator are recommended. (A permit from the DNR is needed.) In late August, survey the lake for any residual infestation. Since this would coincide with the late August growth period, any milfoil that was missed should be discovered. Apply 2,4-D to the areas of surviving milfoil. About this time next summer, survey the lake again for additional milfoil and treat as needed. Survey again in fall and treat as needed. This procedure should pretty much control the milfoil. The lake should be surveyed yearly after that to identify potential milfoil problems. It should be possible for residents to detect and report, or map the milfoil to keep costs down. Besides, those living on a lake are more quickly aware of potential problems than is one who visits the lake occasionally.

If 2,4-D is used to kill the milfoil, it is suggested that contact herbicides not be applied at the same time because they will kill the leaves. The action of a systemic herbicide such as 2,4-D depends on it being taken up by healthy leaves and translocated to the roots. If you kill the leaves with a contact herbicide, translocation will not occur and the roots will remain viable.

It should be noted that in some cases for reasons not well known, eurasian water milfoil infestations disappear without any human intervention. Some think it may be the result of a plant virus infection.


PLEASANT LAKE WQI
MAP 8
25 JUNE 1986
SCALE 1 INCH = 570 FEET
SURFACE ELEVATION 951 FEET
PLEASANT SHORE DRIVE
BONNIE BRAE
PLEASANT LAKE ROAD
RENO ROAD
ELMDALE
HIEBER ROAD
HIEBER ROAD
EURASIAN WATER MILFOIL BEDS