A Paleolimnological Study of the Water Quality Trends in Moose Lake, Waukesha County, Wisconsin

Written By

Bob Wakeman

Wisconsin Department of Natural Resources

This project was undertaken in cooperation with the Town of Merton and the Moose Lake Advancement Association and is one component of a comprehensive assessment of the water resources in the Upper Rock River Basin. Funding was provided by the Department of Natural Resources through the Wisconsin Lake Management Planning Grant Program and the Moose Lake Advancement Association.

The other lakes included in this assessment were Ashippun Lake, Druid Lake, Friess Lake, Fowler Lake, Oconomowoc Lake, Okauchee Lake, Pike Lake, Pine Lake, and Silver Lake.

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Objective

This study's objective was to determine the water quality trends in Moose Lake, dating back to presettlement times. A sediment core was collected and dated using Lead-210 to determine sediment age and accumulation rate. Total carbon, organic carbon, organic nitrogen, total phosphorus, total iron and total manganese were also analyzed. Diatom frustules were identified in the core. Periods of known watershed activities from early settlement to the present were compared with changes in sedimentation rates, sediment chemistry profiles and changes in water quality inferred from the preserved diatom record.

Introduction

Moose Lake is located in the northwest portion of Waukesha County, southeastern Wisconsin. The lake is a seepage lake, it has no inlet and no outlet. The lake has low productivity (oligotrophic). Moose Lake is 81 acres, 61 feet deep and has a drainage area of 553 acres resulting in a direct drainage area to lake area ratio of 6.9 to 1. The 1990 land use in the direct drainage area is summarized in table 1.

Table 1. 1990 Land use in the direct drainage area of Moose Lake, Waukesha County, Wisconsin.

Land Use Type	Percent	Acres
Developed	23.3	128.8
Agriculture/Open	32.8	181.3
Woodlands	27.2	150.4
Wetlands	3.6	19.3
Water	13.1	72.4

Background

The water quality of Moose Lake has never been extensively monitored. Some sampling was conducted between the 1970's and present but none sufficient to determine any long term trends in water quality. The water clarity has been monitored by a volunteer on the lake since 1993. No trends can be determine based upon the existing information.

The historical water quality of Moose Lake can be determined by using techniques which rely upon known relationships between algal communities, sediment/water interactions, and the rate of sedimentation. The sedimentation rate is determined by the lead-210 activity in the sediment core. An analogy would be counting and measuring the width of tree rings for determining the age and rate of growth of a tree. The concentration of nutrients and other chemical parameters in the core provides a clue to the condition of the lake at a known period in time. The relative water quality was determined by examining the algal remains, specifically diatoms, in the core. Diatoms are algae which have cell walls composed of silica which resist degradation. Lead-210 is a naturally occurring radionucleid with a half life of 22.3 years. The decay of lead-210 provides a means for determining the age of sediment and the rate of sedimentation.

Materials and Methods

The following discussion describes the methods used to analyze the sediment parameters as well as what each parameter means in regards to interpreting watershed land use activities and water quality changes.

Field Sampling

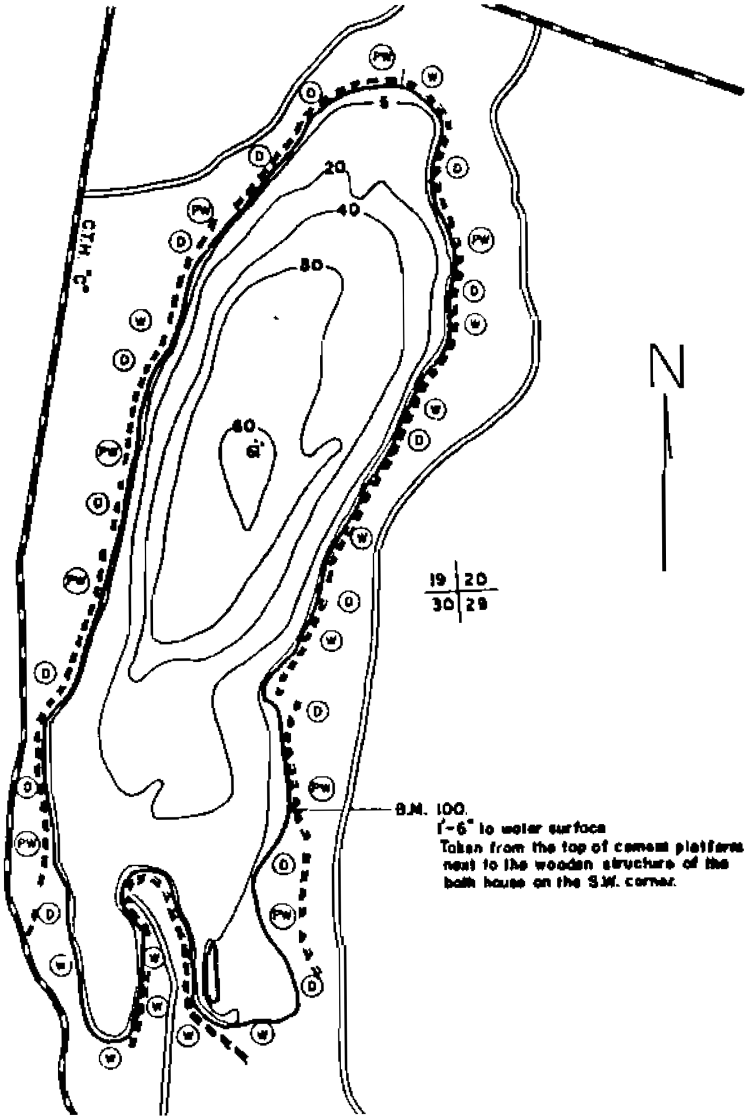
A sediment core was collected from the deepest part of the lake (Figure 1), with a gravity corer. The core was taken back to the lab and sectioned into 2 centimeter (cm) sections. The sediment samples were placed in labeled preweighed bottles, weighed again then dried to a constant weight. The difference in wet and dry weight is used to calculate the porosity of the sediment (Formula A). The samples are then ground to a fine powder and stored until used.

Formula A

$$\text{Porosity} = \frac{(1-f)/D_w}{(1-f)/D_w + (f/D_s)}$$

Where: D_w = Water Density (1.0 g/cm^3)
D_s = Sediment Density (2.45 g/cm^3)
f = Fraction Dry Weight (g/cm^3)

Sediment porosity is used to determine the size of sedimenting particles. A high porosity value indicates finer or smaller grained material compared to low porosity values which mean coarser matorial. Coarser material is characteristic of upland erosion. During periods of land disturbance or high erosion we would expect the sediment porosity to decrease.



B.M. 100.
1'-6" to water surface
Taken from the top of cement platform next to the wooden structure of the bath house on the S.W. corner.

Figure 1. **Moose Lake Map.**

Lead-210 (Aging sediment samples)

Geochronology with the naturally occurring Lead-210 is based on the principle that the isotope has been continuously delivered to the earth's surface and undergoes continuous radioactive decay following incorporation into steadily accumulating sediments. The activity of Lead-210 in the sediment core was used to determine the rate of sediment accumulation. Lead-210 is a weak beta emitter, with low activity and is not readily detected therefore Polonium-210, is actually measured. Polonium-210 is the alpha emitting granddaughter of Lead-210, and can be used to represent the actual Lead-210 activity in each sample because the two isotopes are assumed to be in seqular equilibrium. The daughter is used because in an acidic solution *it* will spontaneously plate on to a copper disk, which can then be counted on a high resolution alpha spectrometry system. A yield monitor, Polonium-206, is added to each sample *so* that the exact activity of Polonium-210 can be determined, The activity of Lead-210 at the time of sediment sampling is calculated from the count rates corrected for counting background, growth and *decay*, counting efficiency and recovery of the yield monitor.

The sediment accumulation rate discussed above is expressed as an accumulation of a mass of sediment (gm/cm2/yr) rather than as an accumulated depth. Since layers of sediment will become compacted *by* the addition of new sediment the depth can not be used to determine accumulation rates. Sediment mass is used to determine accumulation rates since no matter how compacted a layer becomes it's mass will remain.

The rate of sediment accumulation will vary depending on the sampling location in the lake. The greatest accumulation rate occurs at the maximum depth because of the lateral movement of sediment from shallow depths towards the deepest part of the lake (sediment focusing).

Total Iron and Total Manganese Analysis

Analysis of the Total Iron, and Total Manganese in the sediment was done using a acid digestion followed by analysis with a Atomic Absorption Analyzer. A known quantity of dried and ground sediment was digested using nitric acid and hydrogen peroxide. Following heated digestion the solution is filtered, and brought up to a known volume. This solution is then analyzed for iron and manganese.

The ratio of iron to manganese is used to assess the presence of oxygen in the hypolimnion of a lake. In addition the ratio of iron to phosphorus can be used to indicate periods of erosion in the watershed.

Carbon and Nitrogen Analysis

Total carton, organic nitrogen and organic carbon are measured in a Carlo Erba Elemental Analyzer 1106. The technique used is flash combustion. The samples are held in a lightweight tin container and dropped at preset intervals of time into a vertical quartz tube, maintained at 1,030 degrees celsius (°C), through which a constant flow of helium is run. When the samples are introduced, the helium stream is temporarily enriched with pure oxygen. Flash combustion takes place, primed by the oxidation of the container. The individual components are then separated and eluted as N_2, CO_2, and H_2O. They are measured by a thermal conductivity detector, whose signal is fed into an integrator with digital printout of peak area. The instrument is calibrated by combustion of standards of known elemental composition. A sediment sample of known composition is also included in each sample run. The inorganic carbon is determined by subtracting the organic carbon from the total carbon in the sample.

The total carbon accumulation rate is a combination of organic and inorganic carbon (carbonates) sources. Organic carbon accumulation rates are used to infer overall lake productivity. Productive lakes have more algae, and aquatic plants and the sediment organic carbon is higher. Inorganic carbon accumulation rates are useful in determining the overall water quality and the source of sediment. The accumulation of inorganic carbon is typically found in hardwater or marl lakes which tend to he less productive.

Total Phosphorus

A known amount of dried, ground sediment is digested with nitric and sulfuric acids. Following digestion the solution is filtered, diluted and analyzed with a spectrophotometer.

The iron to phosphorus ratio is used as a surrogate to watershed erosion. As erosion in the watershed increases the ratio of iron to phosphorus also tends to increase. The phosphorus accumulation rate can be used alone as an indicator of water nutrient levels. The sediment/water interactions regulating phosphorus are complex and can make the interpretation of the profile difficult. Therefore, the phosphorus accumulation rate is generally used as supportive evidence with other sediment parameters.

Diatoms

A known amount of wet sediment is digested with a known amount of hydrogen peroxide and potassium dichromate. Following digestion the residue is washed with distilled water at least four times. A known amount of glass microspheres is added to the sample to more accurately determine diatom concentrations in the sample. A portion of the diatom suspension is dried on a coverslip and samples are mounted in Hyrax. A minimum of 100 frustules were identified and counted under oil immersion objectives (1400X).

All partial valves containing unique features such as identifiable central areas, or ends were tabulated. Counts were made continuously along randomly selected transects and all identifiable fragments were included in the count. In the case when a fragment or frustule could not be identified, it was recorded as unknown and included in the total count. In the case when valve ends were tabulated, the number recorded was divided by the number of ends a complete frustule would possess. Frustules and fragments were counted if they were completely in the field of view or in the case when only a portion of the frustule was visible, when the appropriate characteristic was visible in the right half of the field of view.

The diatom accumulation rate is used as a surrogate to lake productivity. As a lake becomes more nutrient rich and productive the diatom accumulation rate also increases. Changes in the diatom community within a core can also be used to indicate periods of changing water quality. The species also indicate the relative water quality. Since the relationship between certain species of diatoms and general water quality conditions is known, they provide an excellent *tool* to determine the historical water quality changes.

Results

The results are presented as accumulation rates rather than concentration for a particular period of time, with the exception of porosity and chemical ratios. The accumulation rate is calculated by multiplying the parameter concentration at a particular sediment depth with the corresponding calculated instantaneous sediment accumulation rate. The rate of accumulation gives the most accurate picture of changing lake conditions. An analogy is a small river flowing into Moose Lake. The concentration of phosphorus in the water may be very high but if there is little flow in the river the total quantity reaching the lake is small, however if the concentration of phosphorus is low but the river is in flood stage then the total amount of phosphorus entering the lake may be very high. While the concentration is important, the load to the lake or sediment is critical to measure.

Appendix 1 graphically summarizes the sediment results and appendix 2 contains the sediment chemistry concentrations for future reference. Appendix 3 summarizes the sediment accumulation results. The sediment core results are truncated at the early 1800's since the lead-210 sediment dating technique is accurate for the last 150 years. Prior to the early 1800's the dates are only marginally accurate.

Lead-210 (Sedimentation Rate)

The accumulation rate increased substantially after the early 1900's (Figure 2). Presettlement accumulation rate is 0.018 $gm/cm^2/yr$, then the rate peaked in the 1950's to 0.046 $gm/cm^2/yr$. Following the 1950's the sedimentation rate decreased steadily to the present (1995) rate which is equal to that observed during presettlement.

Porosity

Prior to the late 1800's the sediment porosity changed very little (Figure 3). After the 1890's the sediment porosity decreased to a minimum of 0.8906 during the 1950's. After the 1950's the porosity increased to maximum of 0.9785 at the surface (1995).

Iron to Phosphorus Ratio

The ratio of total iron to total phosphorus in the sediment increased in the early 1900's and peaked between the 1930's and 1970's (Figure 4). By 1995 the ratio decreased to presettlement levels.

Carbon Accumulation Rates

The total carbon accumulation rate was relatively high from presettlement to the 1870's (Figure 5). After the 1870's the rate decreased to a minimum during the early 1900's. The accumulation rate increased rapidly to a peak in the 1950's. The increase was due to an increase in inorganic carbon accumulation. Following the peak in the 1950's the rate of accumulation decreased rapidly to levels observed in the early 1900's.

Diatoms

Prior to the 1830's, the diatom community was dominated by *Staurosira construens* var. venter, *Staurosira construens* and *Staurosira pinnata* indicating excellent water quality (Figure 6). Beginning around the 1950's these taxa started to decline, and *Cylotella michiganiana* indicative of good water clarity became more abundant indicating a slight increase in nutrient levels. However, the lake still exhibited very good water quality. Between the 1920's and 1930's there is a major change in the diatom taxa. Three species which indicate an increase in nutrient loading to the lake increased in abundance including *Asterionella formosa*, *Fragilaria crotonensis* and *Stephanodiscus medius*. These three species have remained the dominant species to present.

The rate of accumulation Increased significantly after the 1830's and continued to increase until the 1950's (Figure 7). Following the 1950's the diatom accumulation rate decreased for approximately a decade before resuming a steady increase to present (1995). The diatom accumulation rate has never been higher than what is currently (1995) observed.

Discussion

The following discussion will first focus on the watershed activities which were taking place at known periods of time. This will then be related to the sediment core results to show the impact the land use activities had on the water quality of Moose Lake.

A brief examination of the historical watershed activities will help explain the results of this study. Initial settlement of southeastern Wisconsin started in the 1830's and continued through the 1850's. German farmers settled the area and cultivated wheat with some minor amounts of corn, oats and hay. Around the 1880's wheat farming crashed and farmers turned to corn, oats, hay and began to develop dairy herds. By the 1930's farming was beginning to grow rapidly, and was becoming mechanized. Through the 1980's dairy farming was king in southeastern Wisconsin. Most recently there has been a trend away from dairy farming and a movement toward cash crops which require less labor but can also result in greater soil loss.

From the 1940's to the 1960's there was a tremendous increase in the population, especially around the lakes in the Washington, Waukesha County areas. Lake shorelines that were once farmed were being sold for seasonal homes. By 1940 the majority of the shoreline had been developed with seasonal homes.

Continued urbanization of the watershed contributes additional stormwater to the lakes and rivers. This stormwater is the source of nutrients and other pollutants which is conveyed in stormsewers directly to the surface waters rather than being filtered in vegetated drainage ways.

The results of the sediment analysis will be broken into time periods which reflect either a period of status quo or periods of significant change. These periods can then be compared to watershed activities to see how the activity on the land influenced the lake. Table 2 summarizes the watershed activities and corresponding sediment core results.

1800 - 1830

Presettlement water quality conditions for Moose **Lake** was excellent. The **lake experienced** a very **low** sedimentation **rate** of 0.018 gm/cm^2/yr and had **diatom** taxa which **were indicative** of **excellent water** clarity and low **nutrient levels.**

Table 2. Summary of **watershed activities** and **sediment** core results.

Time Period	watershed Activity	Sediment Core Results
1600 - 1830	Presettlement **conditions**	**Low sedimentation** rate **0.018** gm/cm^2/yr Diatom **community** indicative **of excellent water clarity** and **low nutrient levels**
1830 - 1890	1830 - *50's* Initial **settlement** of **a ea** **1850** - 1880 Wheat **farming** dominates	No **significant changes in water quality** indicators
1890 - 1950	1890 - **1930** wheat farming **being replace? with** corn, hay, **vats and some dairy** 1930's **farming becoming mechanized** 1940's - **80's** dairy **farming** booming 1950's **rapid** development **of shoreline**	**Increasing** sedimentation rate to a peak of 0.046 gm/cm^2/yr **Porosity decreases** indicating **Increased** erosion Fe:P ratic **increases** supporting **increased erosion** **Steady** increase in diatom accumulation rate
1950 - 1995	Reduction in land **disturbance** activities **Transition** from **seasonal to year** round homes	**Reduction in sedimentation rate** **Porosity increases suggesting reduction** of erosion in **watershed** Fe:P ratio **decreases suggesting** reduction of **erosion** in **watershed** Diatom accumulation **rate** continued to increase indicating nutrient loading

1830 - 1890

Between the 1830's and 1890's the lake maintained excellent water quality conditions. The diatom taxa and sedimentation rate were indicative of presettlement time. No significant changes had occurred during this time period.

1890 - 1950

The greatest changes in the sediment profile occurred between this 60 year period. A steady increase in sedimentation rate reaching a peak of 0,046 gm/cm^2/yr by the 1950's, a significant decrease in the porosity indicating a supply of coarser grained material to the lake, and an increase in the total iron to total phosphorus ratio suggests a period of increased erosion to the lake. A substantial increase in the nutrient loading which is indicated by the change in the diatom community and a steady increase in the diatom accumulation rate during this period indicates increased primary productivity (more algae).

1950 - Present

Since 1950 sediment accumulation rate, porosity profile and iron to phosphorus ratio indicate a substantial reduction in sediment loading to Moose Lake. In fact the sedimentation rate has reached presettlement rates, although the diatom community composition and accumulation rate suggests that nutrient levels have steadily increased over this time period.

Conclusions

Agricultural activity and urban growth in the watershed had a substantial adverse impact upon the water quality of Moose Lake. Sedimentation rates, sediment chemistry and diatom indicators suggest that presettlement water quality conditions of Moose Lake was excellent. Increased agricultural activity and concentrated urban development around the perimeter of Moose Lake resulted in a steady increase in the sedimentation rate and nutrient levels until the 1950's when the sedimentation rate decreased. Following the 1950's the nutrient loading remained elevated and has resulted in decreased water quality conditions.

The management implications of this work clearly point to the need to manage nutrient loading to Moose Lake. Since Moose Lake is phosphorus limited every effort should be made to reduce the phosphorus load. Sediment appears to be less of a problem than phosphorus at the present time.

Public Access

As a condition of the Wisconsin Lake Management Planning Grant awarded to the Town of Merton, an assessment of the opportunities for acquiring public access needed to be completed in conjunction with this project.

Based upon personal knowledge and interviews with Department of Natural Resources staff and local citizens the author has determined that the greatest potential for obtaining public access on Moose Lake is through the Haslingers Resort. Either acquiring property from the current owner or establishing a long term agreement which would allow the public to launch boats and park vehicles with trailers at an approved price would need to be obtained. While efforts to secure public access have been attempted in the past they have been unsuccessful primarily due to monetary constraints on the Department of Natural Resources. Another private access site is available on the south shore. This site is known by locals and strictly regulated by the owner. The site has a launch but extremely limited parking and a narrow and winding access road. The owner of this site was kind enough to allow the Department to access Moose Lake for the purposes of this study.

Acknowledgments

The author would like to acknowledge the assistance of Mr. Paul Garrison and Ms. Molli MacDonald from the Department of Natural Resources for completion of the diatom identification and interpretation of the sediment profiles. Mr. Pat Anderson from the Center for Great Lakes Studies deserves special thanks for his analytical prowess and for his assistance in the interpretation of the sediment chemistry results. Dr. David Edgington from the Center for Great Lakes Studies was also very helpful in interpreting the lead-210 and sediment chemistry profiles. I wish to thank Mr. Mike Bruch from the Department of Natural Resources for his assistance in the collection of the sediment core. Dan Helsel provided excellent comments on the organization and content of this report. Dr. Jeff Thornton from the Southeastern Wisconsin Regional Planning Commission was most helpful in providing land use, soils, urban growth information and interpretative skills which added substantially to our understanding of the sediment results. The author also wishes to thank Mr. Greg Jackson for his permission to use his private launch facility for this project. The author would also like to thank the Town of Merton and the Moose Lake Advancement Association for participating in this study. The results have provided an insight into the historical water quality and the need to manage nutrient levels reaching Moose Lake.

Sediment Accumulation Rate

Moose Lake, Waukesha County

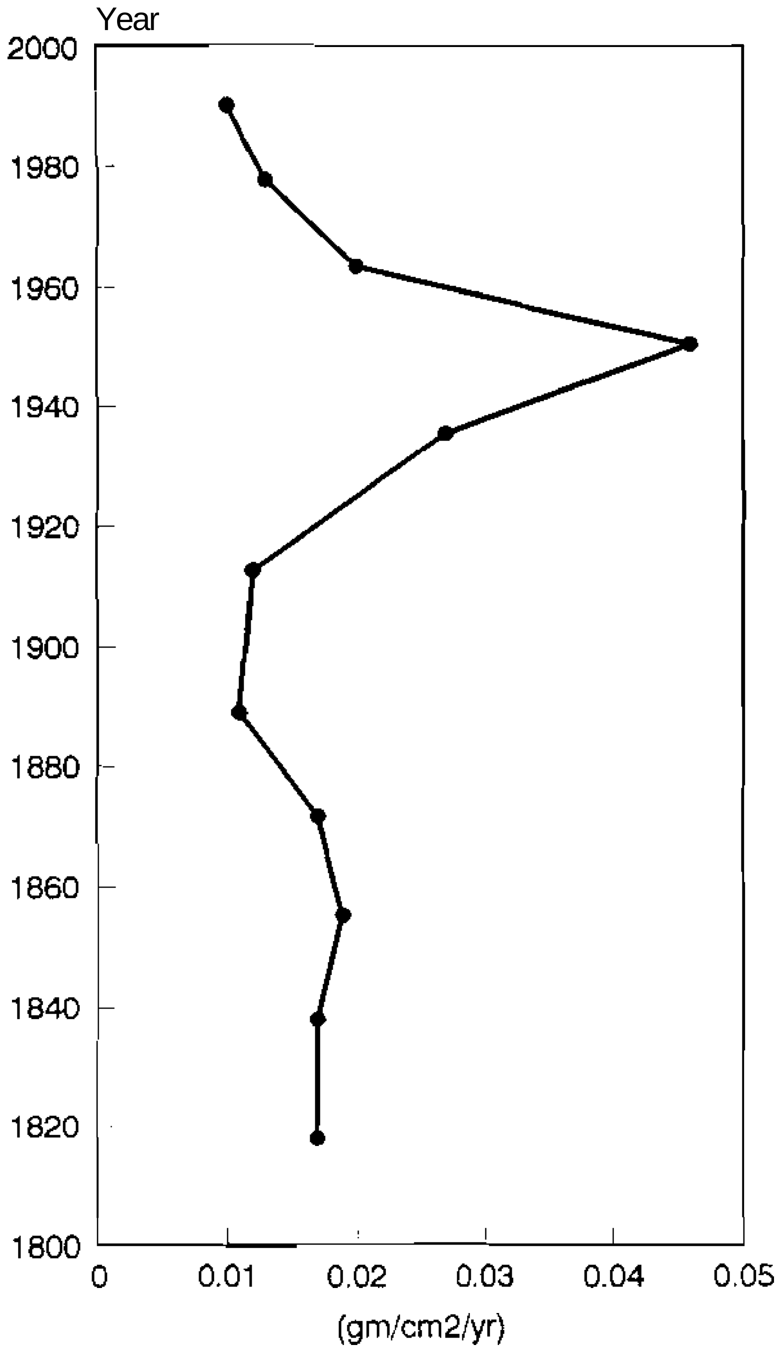


Figure 2. **1995 Upper Rock** River Basin **Assessment**

Porosity

Moose Lake, Waukesha County

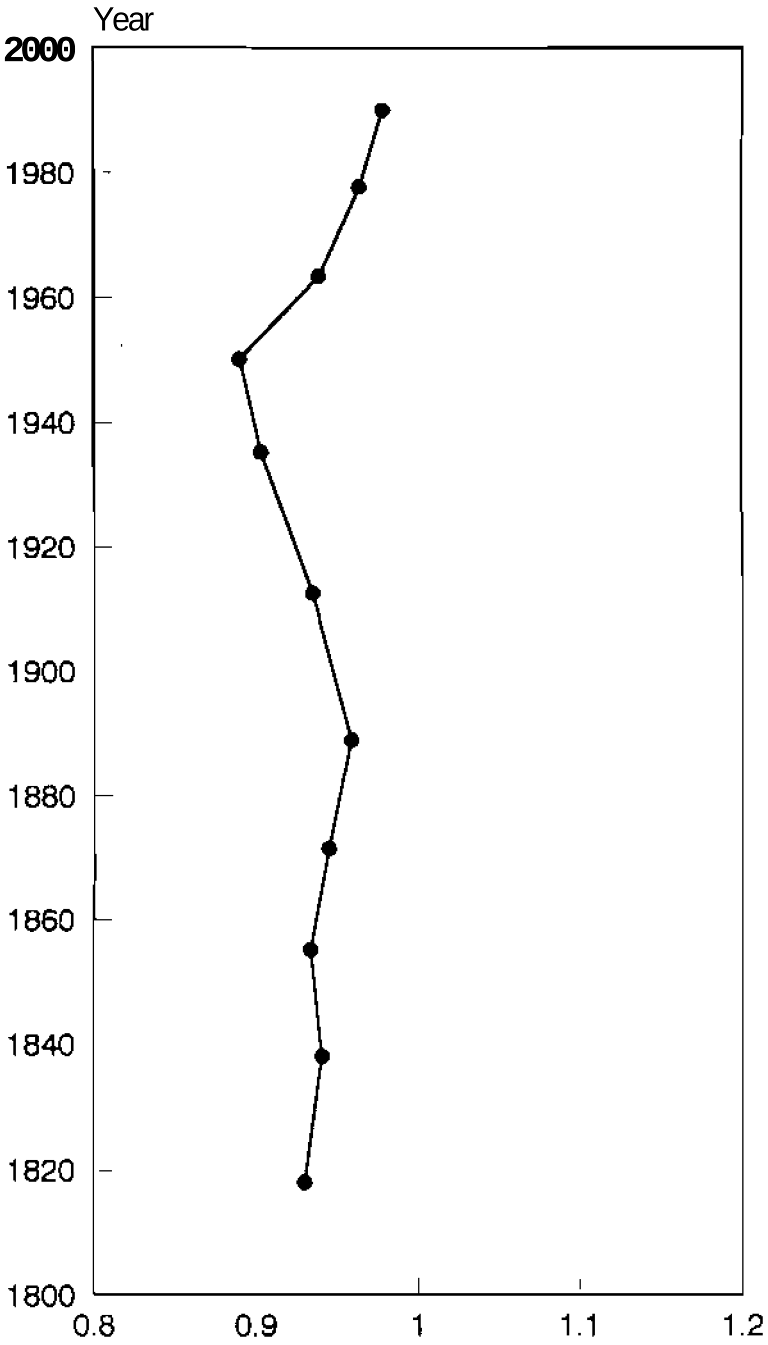


Figure 3. 1995 **Upper Rock River** Basin Assessment

Iron:Phosphorus Ratio

Moose Lake, Waukesha County

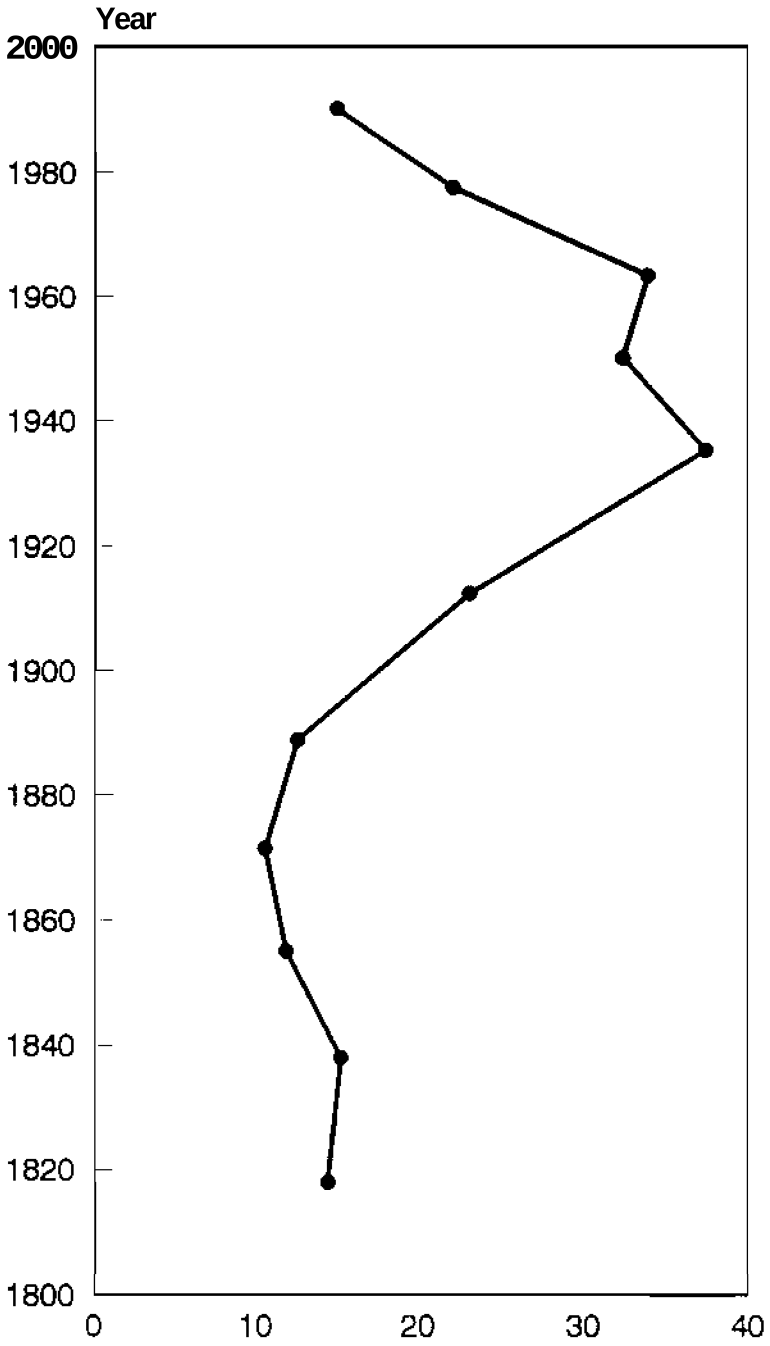


Figure **4.** 1995 **Upper** Rock River Basin **Assessment**

Carbon Accumulation Rate

Moose Lake, Waukesha County

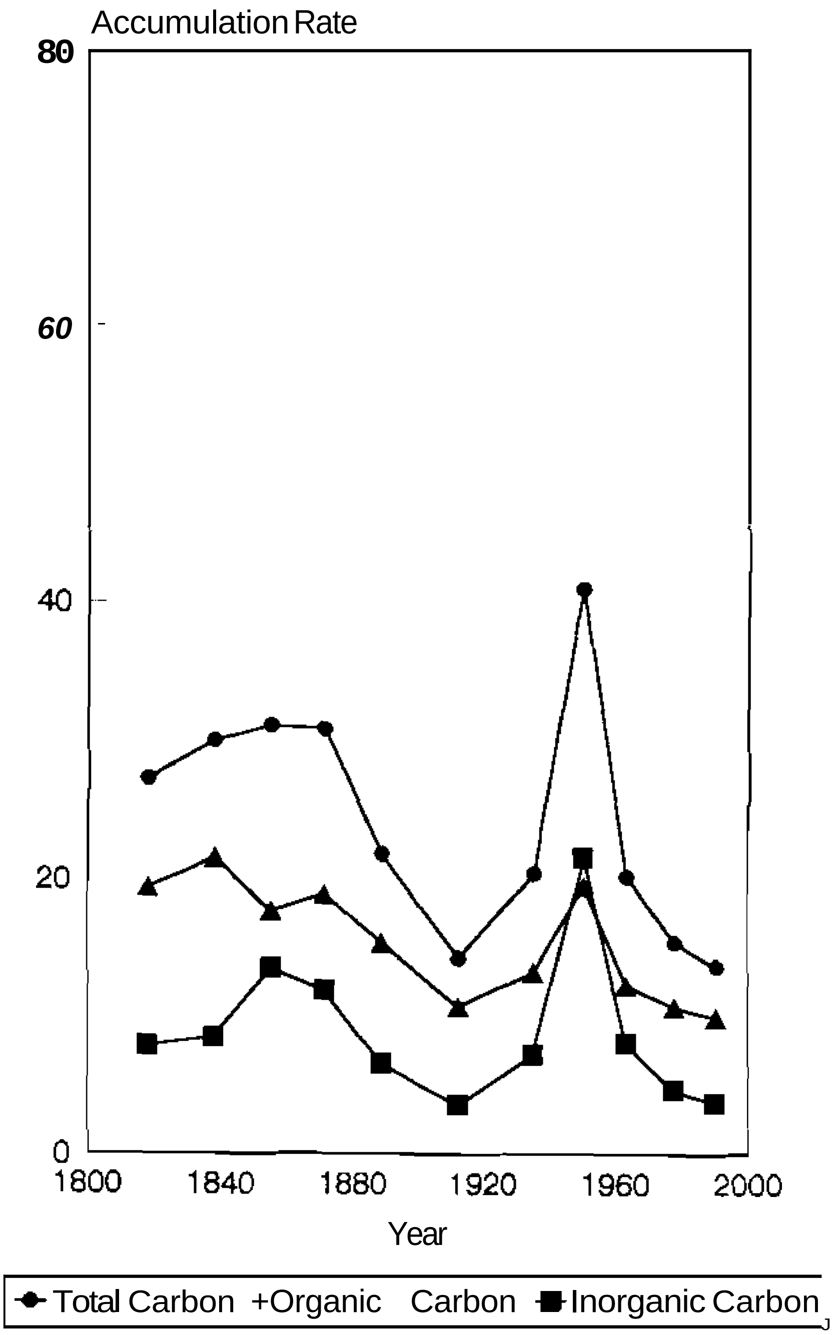
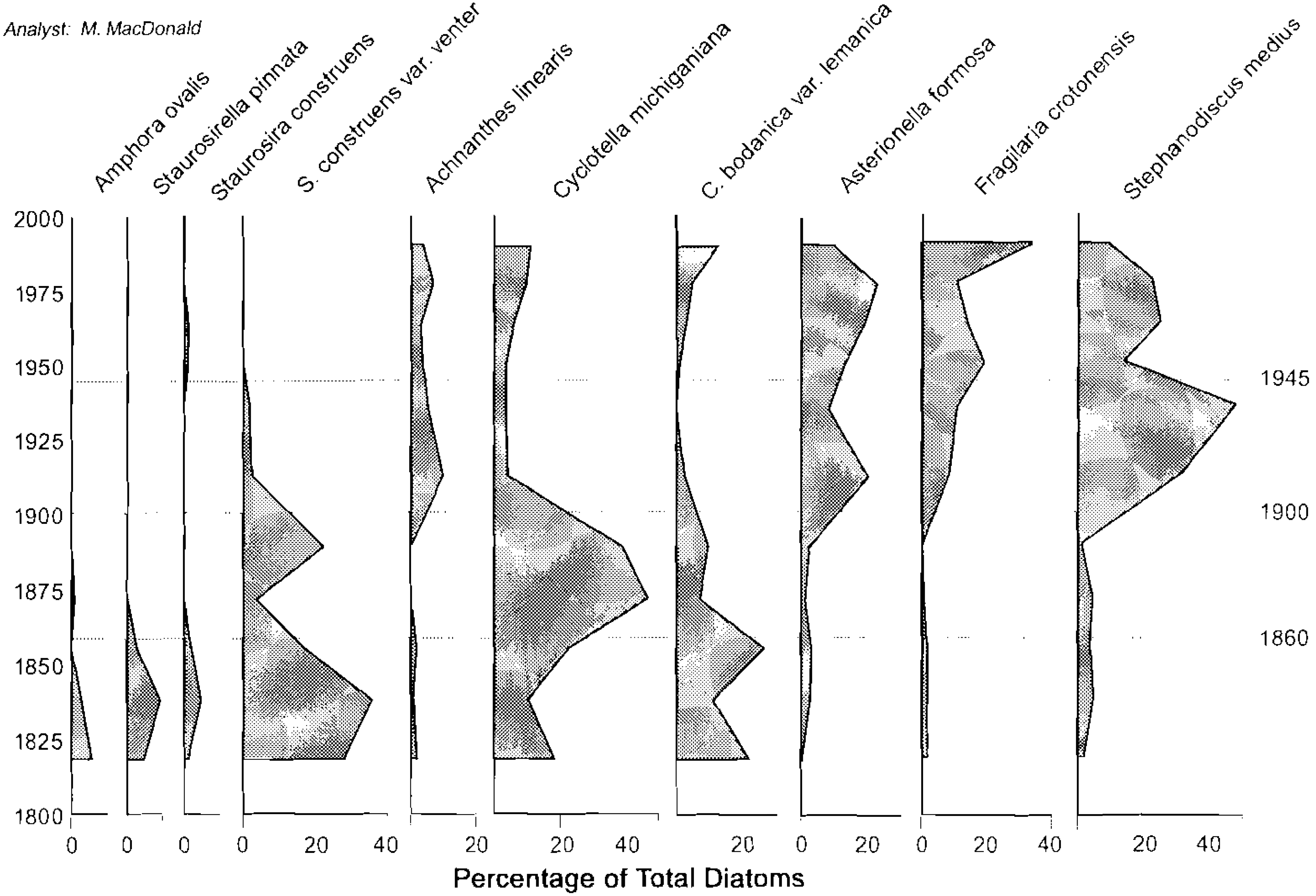


Figure 5. 1995 Upper Rock River Basin Assessment

Moose Lake

Waukesha County

Analyst: M. MacDonald



Diatom Accumulation Rate

Moose Lake, Waukesha County

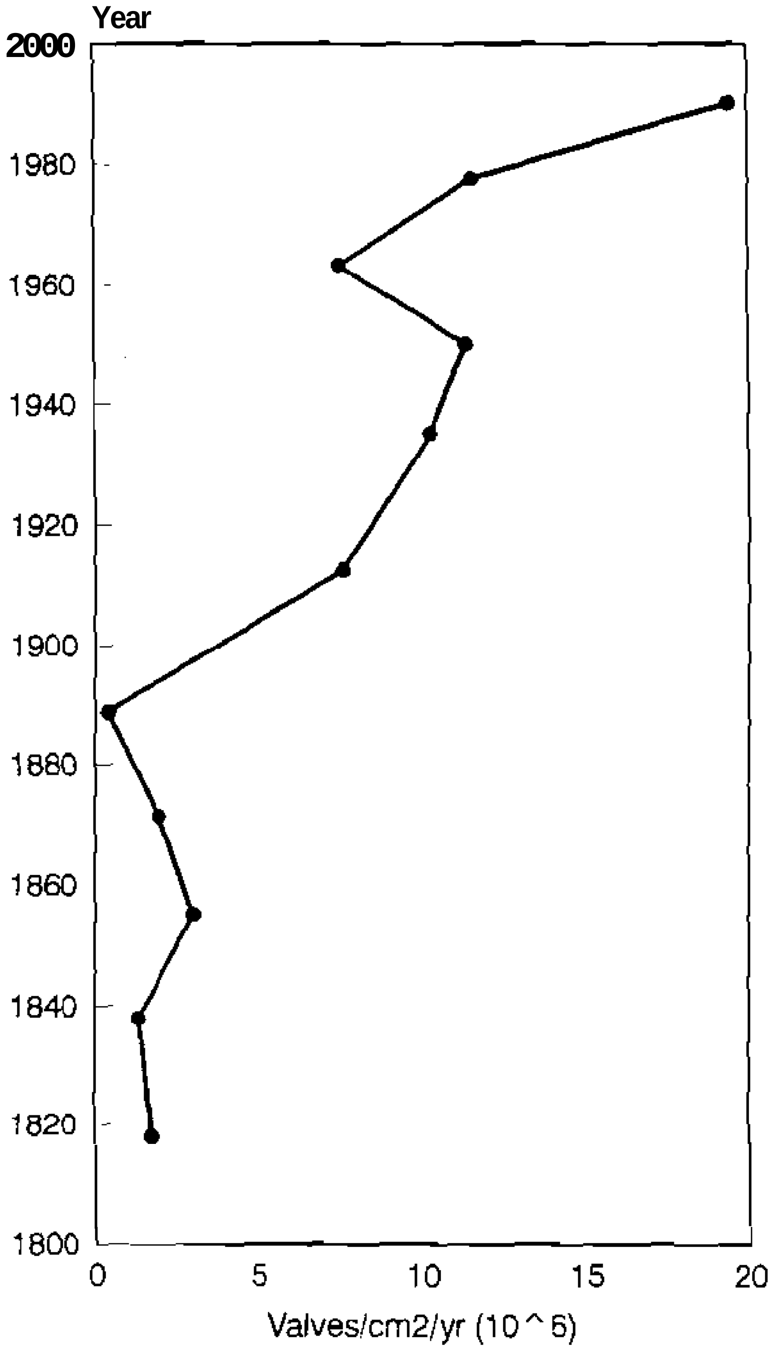


Figure **7.** 1995 Upper Rock River Basin Assessment

Moose Lake, Waukesha County sediment chemistry results.

SEDIMENT DEPTH	POROSITY	TOTAL PHOSPHORUS	TOTAL CARBON	TOTAL NITROGEN	TOTAL ORGANIC CARBON	IRON Fe	MANGANESE Mn	YEAR (MID)
cm		ug/gm	WT. %	WT. %	WT. %	ug/gm	ug/gm	
0-2	0.9785	753	14.09	1.18	10.21	11332	378	1990.1
2-4	0.9642	619	11.92	0.91	8.32	13673	389	1977.6
4-6	0.9392	493	9.84	0.65	5.95	16700	368	1963.3
6-8	0.8906	406	8.91	0.37	4.23	13168	356	1950.1
8-10	0.9033	473	7.49	0.52	4.84	17700	340	1935.3
10-12	0.9353	581	11.85	0.88	8.92	13446	319	1912.5
12-14	0.9590	696	20.23	1.48	14.20	8765	299	1888.9
14 16	0.9453	600	17.82	1.07	10.96	6375	279	1871.5
16-18	0.9341	502	16.00	0.90	9.08	5988	275	1855.2
18-20	0.9408	567	17.56	1.16	12.67	8687	250	1838
20-22	0.9300	525	16.01	0.96	11.42	7624	277	1818
22-24	0.9337	579	16.75	1.05	10.22	7937	298	1799
24-26	0.9399	624	18.57	1.29	14.93	11876	250	1782
26-28	0.9363	659	18.15	1.20	14.64	9300	220	1764
28 30	0.9313	639	18.90	1.17	12.61	8812	219	1744
30-32	0.9176	564	17.25	0.90	12.62	7030	248	1720
32-34	0.9290	658	18.76	1.18	14.36	8631	238	1699
34-36	0.9289	649	18.48	1.18	12.09	8829	218	1679
36-38	0.9154	554	17.76	0.98	10.58	8267	229	1655
38-40	0.9243	645	18.44	1.12	11.60	9245	219	1633
40-42	0.9352	727	20.39	1.37	14.10	11541	199	1615
42-44	0.9443	744	21.73	1.64	16.88	14741	169	1599

Moose Lake, Waukesha County sediment chemistry results.

SEDIMENT DEPTH	Fe:Mn	Fe:P	YEAR (MID)	SEDIMENT ACCUM. RATE	TOTAL DIATOMS
cm				gm/cm2/yr	valves/g dry wt.
0-2	30.0	15.0	1990.1	0.010	2.01e+09
2-4	35.1	22.1	1977.6	0.013	9.04e+08
4-6	45.4	33.9	1963.3	0.020	3.67e+08
6-8	36.9	32.4	1950.1	0.046	2.48e+08
8-10	52.1	37.4	1935.3	0.027	3.77e+08
10-12	42.2	23.1	1912.5	0.012	6.35e+08
12-14	29.3	12.6	1889.9	0.011	1.48e+07
14-16	22.9	10.6	1871.5	0.017	1.13e+08
16-18	21.4	11.9	1855.2	0.019	1.57e+08
18-20	34.8	15.3	1838	0.017	7.87e+07
20-22	27.5	14.5	1818	0.017	1.03e+08
22-24	27.2	13.5	1799	0.017	6.82e+07
24-26	47.6	19.0	1782	0.017	1.61e+08
26-28	42.3	14.1	1764	0.017	9.77e+07
28-30	40.5	13.8	1744	0.017	3.92e+07
30-32	28.4	12.5	1720	0.017	3.12e+07
32-34	36.3	13.1	1699	0.017	5.38e+07
34-36	40.5	13.6	1679	0.017	5.58e+07
36-38	36.1	14.9	1655	0.017	4.99e+07
38-40	42.3	14.3	1633	0.017	9.66e+07
40-42	58.0	15.9	1615	0.017	8.76e+07
42-44	87.1	14.8	[illegible]	0.017	8.03e+07

Moose Lake, Waukesha County sediment chemistry accumulation results.

YEAR	TOTAL PHOSPHORUS	TOTAL NITROGEN	TOTAL CARBON	TOTAL ORGANIC CARBON	INORGANIC CARBON (CaCO3)	IRON Fe	MANGANESE Mn	TOTAL DIATOMS
	ug/cm2/yr					ug/cm2/yr	ug/cm2/yr	valve/cm2/yr *10^6
1990.1	0.07	0.01137	13.6	9.9	3.7528	1.09	0.04	19.43
1977.6	0.08	0.01159	15.3	10.6	4.60925	1.75	0.05	11.57
1963.3	0.10	0.01322	20.2	12.2	7.97121	3.42	0.08	7.52
1950.1	0.19	0.01679	41.0	19.5	21.5353	6.06	0.16	11.40
1935.3	0.13	0.01424	20.4	13.2	7.21069	4.83	0.09	10.28
1912.5	0.07	0.01059	14.2	10.7	3.52042	1.61	0.04	7.61
1888.9	0.07	0.01591	21.8	15.3	6.48317	0.94	0.03	0.37
1871.5	0.10	0.01854	30.8	18.9	11.8666	1.10	0.05	1.95
1855.2	0.10	0.01748	31.0	17.6	13.4025	1.16	0.05	3.03
1838	0.10	0.01968	29.9	21.5	8.381	1.48	0.04	1.34
1818	0.09	0.01628	27.2	19.4	7.7945	1.30	0.05	1.75
1799	0.10	0.01789	28.5	17.4	11.1095	1.33	0.05	1.50
1782	0.11	[illegible]	31.6	[illegible]	6.1795	[illegible]	0.04	2.74
1764	0.11	[illegible]	30.8	[illegible]	[illegible]	1.50	0.04	[illegible]
1744	0.11	0.01985	[illegible]	[illegible]	10.693	1.50	0.04	0.67
1720	0.10	0.01526	29.3	21.5	7.8625	1.20	0.04	0.53
1699	0.11	0.0201	31.9	24.4	7.48	1.47	0.04	0.92
1679	0.11	0.0201	31.4	20.5	10.8715	1.50	0.04	0.95
1655	0.09	0.01666	30.2	18.0	12.1975	1.41	0.04	0.85
1633	0.11	0.01908	31.3	19.7	11.528	1.57	0.04	1.64
1615	0.12	0.02333	34.7	24.0	10.7015	1.96	0.03	1.49
1599	0.13	0.02784	36.9	28.7	8.245	2.51	0.03	1.36