GENEVA LAKE'S SEDIMENTS AND WHAT THEY TELL US ABOUT THE LAKE'S HISTORY*

INTRODUCTION

A lake's present water quality is easy to identify by analyzing water samples collected from the lake. The lake's water quality history is more difficult to assess. Natural aging of lakes generally results in lake quality changing over a period of time. Changes in land use within the lake's watershed from undisturbed prairie or woods to rural agriculture to urban development can also change the lake's water quality. Historical water quality is important in establishing lake management objectives and goals.

Paleoecological studies can give the lake manager some idea of the lake's water quality history. Just as growth rings in trees can tell the history of the tree, so can a sediment core (figure 1) tell the history of a lake. Working from the premise that lakes act as partial sediment traps for things that have gotten into the lake over the years, paleoecological studies look at the sediments for signs that can tell the lake's water quality history.

In 1995 Geneva Lake sediments samples were collected from three locations (figure 2) to conduct sediment studies. Samples were used to do sediment dating, to look at what is in or found within the sediments and to study the rate of sediment buildup.

This Summary Information Sheet looks at the findings of the sediment work that was done at each site and compares the findings between sites. It will also present some general findings on the lake's water quality history.

Figure 1.
Typical Sediment Core. WDNR

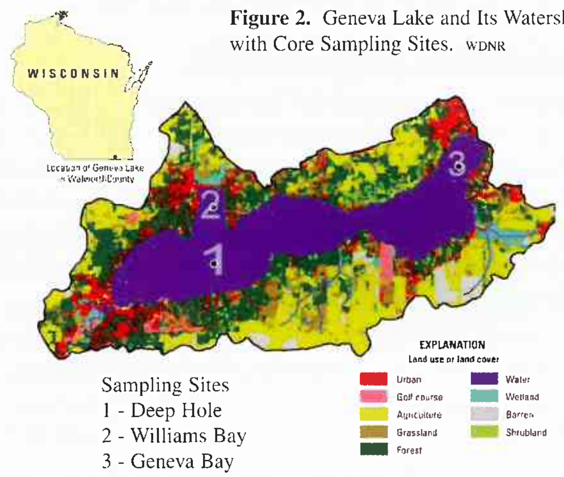


Figure 2. Geneva Lake and Its Watershed with Core Sampling Sites. WDNR

GENEVA LAKE DESCRIPTION AND WATERSHED HISTORY

Geneva Lake is located in southcentral Walworth County in southeastern Wisconsin. It is 5,426 acres in size and has a watershed of 12,806 acres (figure 3). It is a long, deep narrow lake with several large bays. It exhibits desirable water quality. The watershed is mostly developed in low-density residential development with urban development around the bays.

Lake Area	2117 ha
Drainage Area	5,260 ha
Maximum Depth	41.2 m
Mean Depth	19.1 m

Figure 3. Physical Lake Data

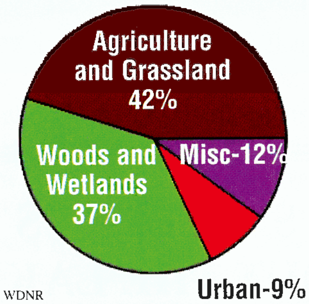
First inhabited by mound building Native Americans, the area was settled by the Potawatomie Tribe when the first Europeans arrived in the area. The first cabin was built around 1836 in what is now the City of Lake Geneva. In 1837 a cabin was built in Williams Bay. The first U.S. governmental survey map was completed in 1851 and settlement of the whole lake began shortly thereafter.

Italicized, blue colored words are defined in the glossary on the last page of this Summary Information Sheet.

*** This Summary Information Sheet is a shortened form of a more in-depth report entitled "Water Quality History of Geneva Lake, Wisconsin" by Paul Garrison, Wisconsin Department of Natural Resources.**

During the late 19th century settlement increased with the city and villages being incorporated. Many large estates, resorts and camps were built around the lake as the lake's unique beauty and quality became more widely known. Today two villages and one city are located within the lake's watershed. Most of the watershed has been settled with homes or miscellaneous rural land uses (figure 4). It is still very attractive to tourists from throughout the Midwest.

Figure 4. Geneva Lake Watershed Land Use.



SEDIMENTATION RATES

Sediment dating allows for the estimation of when certain things may have happened in the lake and its watershed. It also allows for an estimation of how much sediment accumulated over a given period of time. Several different means of sediment dating were used as a means of checking the accuracy of any one method. Overall mean sedimentation rates could be dated back 150-185 years.

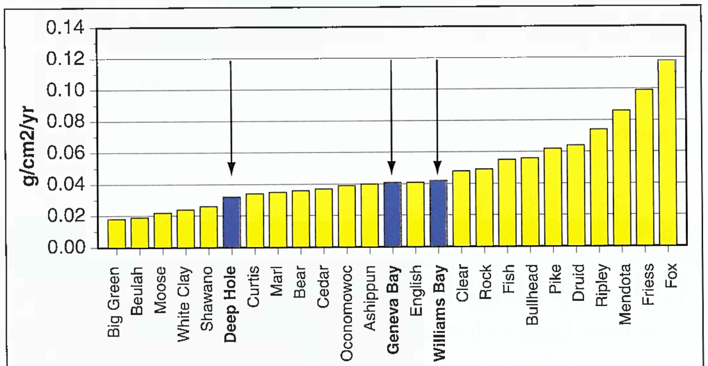


Figure 5. Mean Sedimentation Rates. WDNR

Williams Bay and Geneva Bay (east end of lake) had overall sedimentation rates (figure 5) that were very similar (0.042g/cm2 and 0.041 g/cm2 per year). The deepest point had a sedimentation rate (0.032g/cm2 per year) that was less than both bays. These rates are similar to other lakes in southern Wisconsin. The lower rate in the deepest point is a result of the sediment entering the lake and much of it staying in the bays. The small lake-to-watershed ratio (2.4:1) also plays a role in the deepest point's reduced sedimentation rates.

The peak rate in both bays occurred around 1900 (figure 6). This reflects the two incorporated municipalities' early construction and development. After the initial peak, sedimentation rates decreased back to near pre-settlement rates. There appears to be a gradual increase up to the present time. The last 20 years showed a significant increase in sedimentation rates in the bays. Williams Bay showed the greatest increase since the 1970's, with rates almost doubling.

The early 1900's peak did not occur at the deepest point indicating again that as much of the sediment entered the lake it settled out and stayed in the bays.

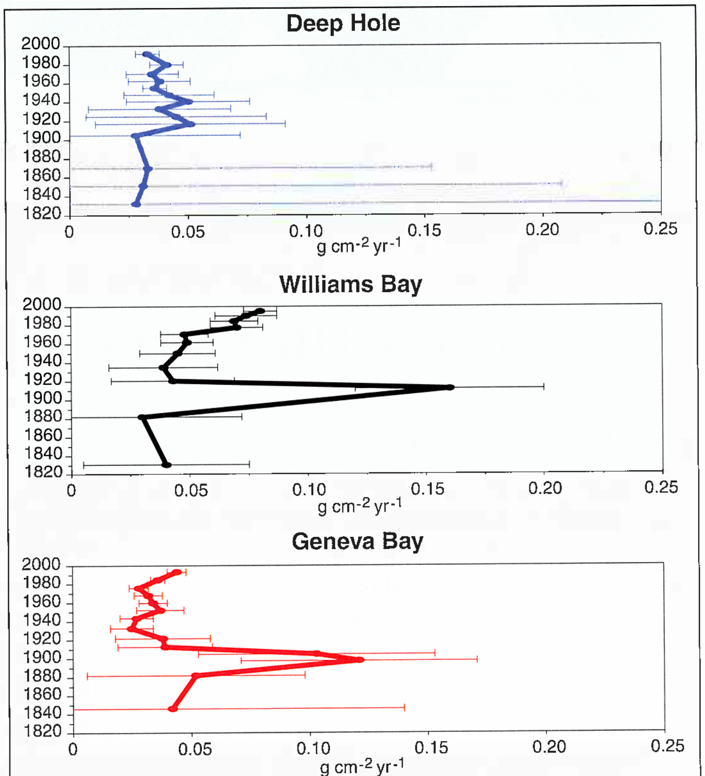


Figure 6. Sedimentation rates in Geneva Lake. WDNR

SEDIMENT CHEMISTRY

By looking at what chemicals are found in association with the sediments, where the sediment may have come from within the watershed can be inferred. This process is called sediment geochemistry. Titanium, iron and aluminum are found in association with sediments from soil erosion. Zinc and copper are found in storm water runoff from urban sources. When found in the sediments they can give clues to where the sediment came from.

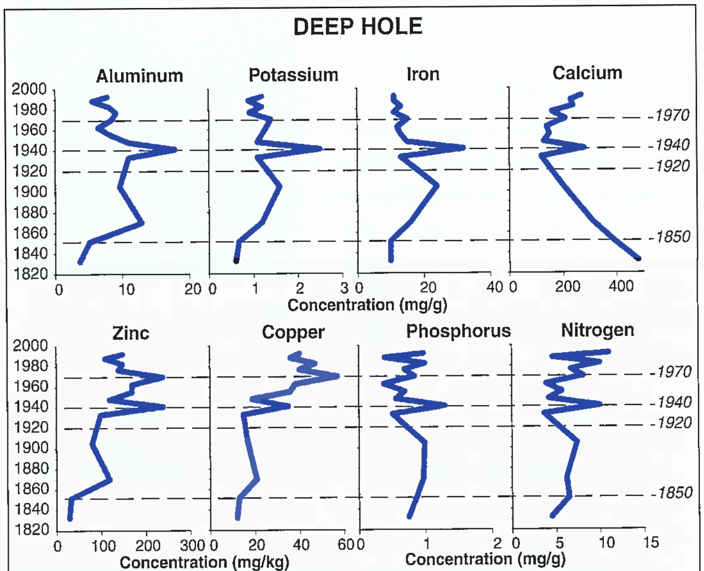


Figure 7. Profiles of Chemicals in Deep Hole Core. WDNR

DEEP HOLE SEDIMENTS

Sediment derived from soil erosion increased in the Deep Hole soon after 1850 (figure 7) as a result of plowing the prairies. It peaked around 1940. Sediment from urban runoff increased around 1870, then decreased somewhat, with significant increases around 1940, 1970 and remains relatively high today. This is an indication of watershed urbanization having a greater impact on the sediment loading than rural sources.

Nitrogen and phosphorus are pollutants of major concern in lakes. They are major nutrients that can lead to increased plant growth and accelerated lake aging.

The nutrient levels in the Deep Hole core remained largely unchanged with a minor peak around the 1940's. Phosphorus levels declined shortly thereafter and have fluctuated since, with a minor increase in the last twenty years.

Nitrogen levels in the Deep Hole sediments followed a similar pattern. Nitrogen increases in the last twenty years have been more significant.

In the early settlement days rural soil erosion was an important source of these nutrients. For the last 50 years urban runoff has been an increasingly important contributor of phosphorus. In recent years both soil and urban runoff have become important sources in the main portion of the lake, with urban runoff becoming more dominant.

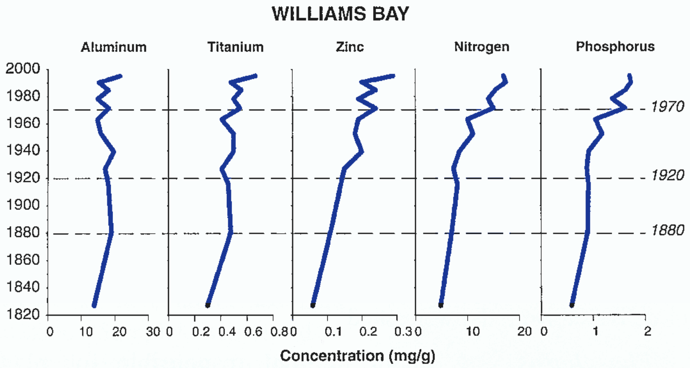


Figure 8. Williams Bay Sediment Chemistry. WDNR

WILLIAMS BAY SEDIMENT

In Williams Bay, rural soil erosion played a major role in sediment loading around 1880. The core indicated a five-fold increase in soil erosion from pre-settlement times (figure 8). Urban runoff's role increased through time. Both nitrogen and phosphorus increased as time progressed with a significant increase since 1970.

The Williams Bay's sediment geochemistry indicates that the rural soil erosion plays less of a role while the urban runoff's role was increasing. During the late 1960's Highway 67 was improved and the drainage of Southwick Creek was channeled, increasing the delivery of runoff.

GENEVA BAY SEDIMENTS

The increase in soil erosion during the last 160 years was greatest in Geneva Bay. With increased development around the

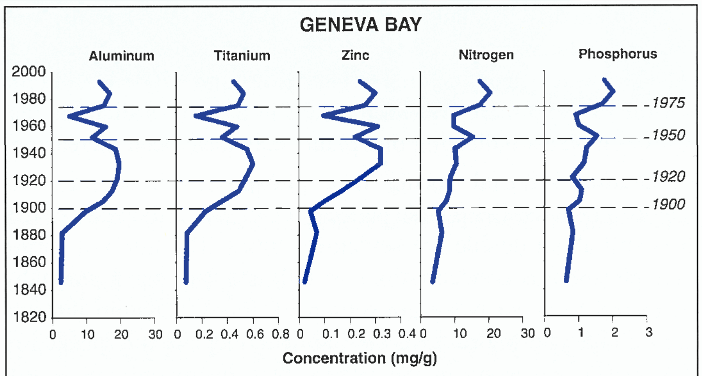


Figure 9. Chemical Profiles in Geneva Bay Core. WDNR

early 1900's sedimentation to Geneva Bay started to show a significant increase (figure 9). Both urban and rural erosion increased and peaked around 1930. Between 1945 and 1970 rural sediment appeared to decline. Since 1975 it has again increased.

Nutrients steadily increased throughout the core, with the highest increases since 1975. During the mid 1970's a significant land use change took place that resulted in a filling of a wetland and discharge of a new storm sewer to the lakefront.

There appears to be a tripling of nutrient levels in the cores since the early 1800's. Like Williams Bay, urban runoff remains the most significant source of phosphorus in Geneva Bay, yet soil erosion is a more significant source of phosphorus in Geneva Bay than in Williams Bay.

INDICATOR ORGANISMS

Aquatic organisms are good indicators of water chemistry because they are in direct contact with the water, grow fast and respond quickly to changes. Diatoms are a type of algae with silicon cell walls that are usually preserved in the sediments.

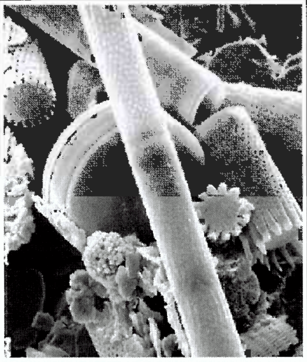


Figure 10. Magnified Diatoms WDNR

Different types of diatoms leave very unique cell walls (figure 10) in the sediment that can be used to identify what type of diatoms were present at a given time in the sediment history. The presence of specific diatoms can give a clue to water quality.

Based upon the diatom cell wall remnants found in the sediments, Geneva Lake had desirable water quality during much of the 1800's. Around 1900 the type of diatoms started to change to a type more common of lakes with higher nutrients. The presence of two new diatoms around 1920 indicated a continual increase in nutrients. The rapid decline of one diatom and the appearance of another around 1950 indicated an increase in lake phosphorus. Phosphorus levels in the main portion of the lake apparently declined somewhat after the 1970's.

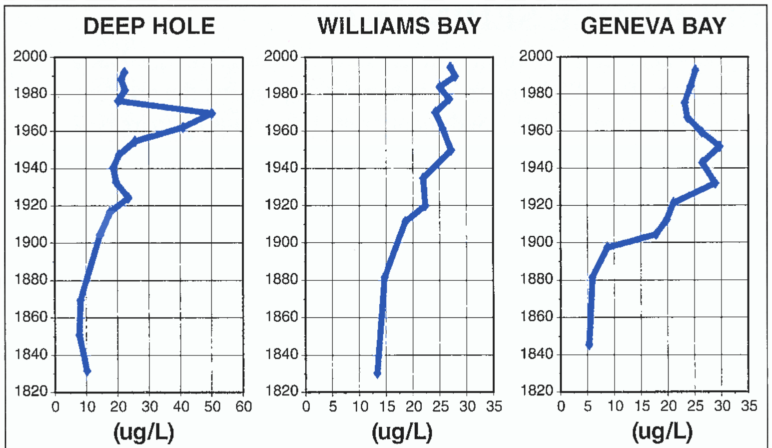


Figure 11. Inferred Spring Phosphorus Levels. WDNR

Williams Bay initially had diatoms that are found on the lake bottom, indicating good water clarity. Like the main portion of the lake, water quality started to change around 1900. During the period 1950-90 there was an increase in a form of diatoms that grows on plants indicating that plants may have been increasing.

Diatom inferred spring lake phosphorus concentrations (figure 11) in the Deep Hole peaked in the 1970's then decreased. It is still about double pre-settlement times. The inferred spring lake phosphorus concentrations in Williams Bay have gradually increased to about twice pre-settlement times. Diatom inferred spring lake phosphorus concentrations in Geneva Bay peaked in the 1930's and again in the 1950's, then decreased, yet is still 5 times greater than pre-sediment times.

SUMMARY

- **Sedimentation rates for the Deep Hole are slower than for most lakes in Southern Wisconsin while the rates in Williams and Geneva Bays are about the same as other lakes in Southern Wisconsin.**
- **Most sediment entering the lake appeared to settle out in close proximity to where it entered the lake.**
- **Sediment rates peaked at the Geneva and Williams Bay sites around the turn of the century. Rates peaked shortly after the turn of the century in the Deep Hole.**
- **Sedimentation rates in Williams Bay decreased shortly after the first peak, but have continually increased since.**
- **Sedimentation rates in Geneva Bay have been similar to Williams Bay but not to the same extreme.**
- **Although there is some variability in the inferred spring lake phosphorus concentration at the three sites, it is greater than in the pre-settlement times.**
- **Initially rural land use was the major source of sediment to Geneva Lake.**
- **Urban runoff is presently the major sediment and phosphorus source even though urban areas only comprise 8% of the watershed.**

GLOSSARY

Geochemistry - The use of chemistry to identify what is in the sediments for understanding watershed processes that have affected water chemistry.

Indicator Organisms - Organisms that are found in a relatively defined range of environmental conditions. Their presence is often used to identify the quality of a specific environment.

Lake-to-watershed ratio - The comparison of lake surface area to the size of the lake's drainage area. The lower the ratio the less land area to potentially pollute a lake.

Nitrogen - A major nutrient responsible for plant fertilization. When found in lakes at high levels it can result in excessive plant growth.

Nutrients - Food for plant growth.

Paleoecological lake study - The study of a lake's history as defined by its sediment with the assumption that lakes act as partial sediment traps for particles that are created within the lake or delivered from the watershed.

Phosphorus - A major nutrient responsible for plant fertilization. Often times it is the limiting nutrient for excessive plant growth.

Sediment dating - The use of advanced scientific techniques to identify the age of sediments found in the bottom of a lake. Sediment dating can also look at global activities that may have affected what and when deposition took place.

Sedimentation rates - Using sediment dating to calculate sediment deposition over a period of time.

Watershed - The area of land that drains directly into a lake or other surface waters.

This information sheet is the first in a series of information sheets that are being put together for those who wish to have a better understanding of Geneva Lake and its management. Summary Sheets are educational publications that summarize larger more detailed reports on Geneva Lake. These summaries are prepared by the Geneva Lake Environmental Agency with the assistance of the original authors and are financially made possible by a Wisconsin Department of Natural Resources Lake Planning Grant and with local monies from the Geneva Lake Environmental Agency. Additional copies are available at the Geneva Lake Environmental Agency, 262-248-5253 or Email at glea@genevaonline.com. Ask for SIS #1.