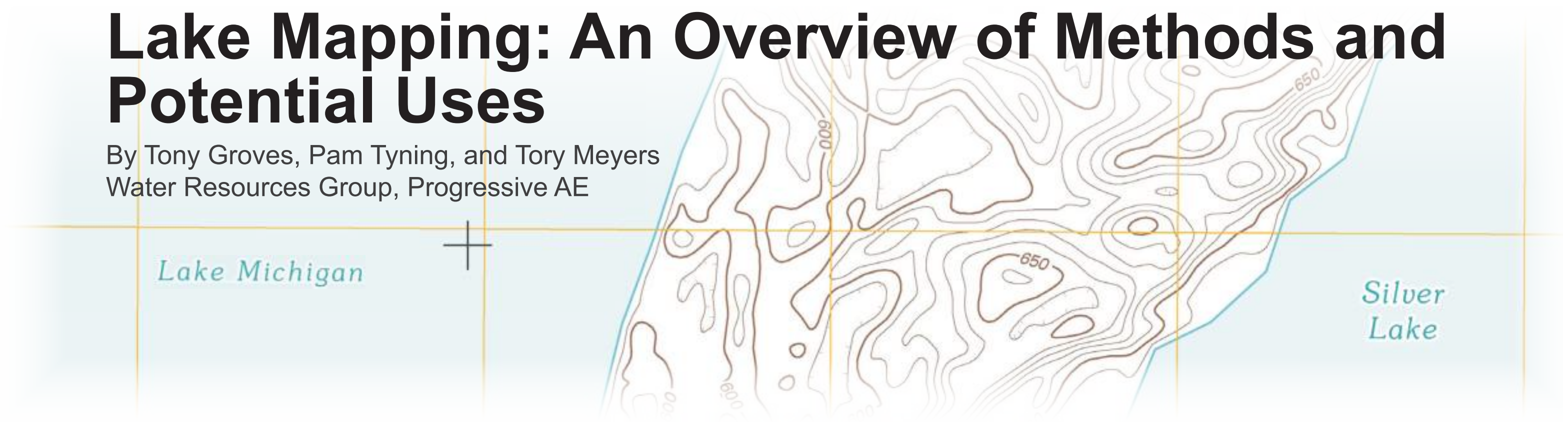
Lake Mapping: An Overview of Methods and Potential Uses

By Tony Groves, Pam Tyning, and Tory Meyers
Water Resources Group, Progressive AE



A primary use of any map is navigation, but a map can also show prime fishing locations, bottom substrate, plant growth areas, spawning sites, depth and shoreline changes, and a variety of other features. This article provides an overview of historical and current lake mapping methods and how this information may be useful in understanding and managing your lake.

Historical Mapping Techniques

Many of Michigan's inland lakes were mapped by the Michigan Conservation Department (predecessor agency to our present day Department of Natural Resources [DNR] and Department of Environmental Quality). Although some lakes were mapped as early as the 1930's, most of the mapping took place in the timeframe between 1940 and 1970, and focused primarily on public inland lakes (Department of Natural Resources 2000). Depth measurements in those days were often conducted during the winter months. Holes were drilled through the ice and water depths were measured with weighted drop lines (Figure 1). Aerial photography was used to map the shoreline. It was not uncommon for field crews to spend several days on a lake drilling holes and taking meticulous measurements of water depths and bottom substrate. Benchmarks were typically established to measure lake level fluctuations. Mapping procedures followed strict guidelines and the maps created were of excellent quality and accuracy (see excerpt from DNR manual in text box, right). Although most of these lake maps were created more than a half-century ago, many remain quite accurate and are in common use today. Conservation Department maps can be found online at www.michigan.gov/dnr. Click on "Press Releases, Maps & Publications," then on "Maps." "Inland Lakes by County" can be found under "Fisheries and Water Resources."

Figure 1. Weighted depth sounding line. (Left: weight; right: line on reel.)

The following is an excerpt from the Department of Natural Resources internal guidance for winter lake mapping (Department of Natural Resources 2000).

> The spacing of soundings has an important bearing on both mapping accuracy and speed. Insufficiency of depth records may result in an inaccurate map, or one that does not give adequate information for management. On the other hand, over-intensive sounding wastes time and effort. It is difficult to prescribe a definite pattern for spacing depth measurements because of the variability of lake basins. Good decisions on how frequently soundings should be made increases with experience. The following is a general guide relating lake acreage to sounding interval when mapping is done on ice: 5-acre lakes - 50-foot intervals; 10-25 acres - 100 foot; 50-300 acres- 200 foot; larger lakes - 300- to 400-foot intervals. Additional soundings are often necessary between shore and the drop-off, in and around shoal areas that occur well out from shore in some fairly deep lakes, and throughout the basins of lakes in which depths are highly variable. Incompleteness of depth data may become evident as a set pattern of sounding is in progress; in such cases additional measurements should be made in the questionable area...
>
> Soft bottom can cause significant errors in depth measurements. The bottom may be so soft that the sounding weight passes through it almost as freely as water. In such areas sounding must be done with extreme care, and the cup which collects bottom materials should be inspected often to determine the top level of the deposits. After some experience, one acquires a "feel" for the difference in descent of the weight through water and through very soft bottom, which helps greatly in locating the boundary between the two strata...
>
> Bench marks are established for measuring lake level fluctuations. They can be very useful. Trees, bridge or dam abutments, and concrete foundations are among the objects that may serve as bench mark monuments. Spikes serve as reference points in trees, and a cold chisel is used to etch concrete or steel objects. Measurements of water elevations are made with either a surveyor's level and leveling rod, or a line level, chalk line, and leveling rod. Plainly record elevation, location, and establishment date for each bench mark on the field map. Bench marks should be established at the time the lake is mapped so that those data can be included on the finished map...

Re-Mapping Silver Lake, Oceana County

Silver Lake is located in Oceana County not far from Lake Michigan. With respect to mapping, Silver Lake is of special interest in that it is bordered on the west by sand dunes that separate Silver Lake from Lake Michigan (Figures 2 and 3). In fact, geological records indicate that prior to the last glaciation some 10,000 years ago, Silver Lake was connected to the big lake (Fisher et al. 2007). An analysis of aerial photography from the 60-year time frame between 1938 and 1998 indicates that the dune has both encroached and receded over the years, with periods of encroachment into Silver Lake more evident during periods of high Lake Michigan water levels (Fisher et al. 2007). In addition to the physical migration of the dune, sand from the dune is frequently carried to Silver Lake with the prevailing west winds off Lake Michigan.

Figure 2. Aerial view of Silver Lake sand dunes.

Depth soundings of Silver Lake were first conducted by the Michigan Fish Commission in 1892 (Figure 4). More extensive field surveys were conducted by the Department of Conservation during the winter of 1950, and a detailed depth contour map of the lake was produced (Figure 5). Silver Lake is relatively shallow with a maximum depth of just over 20 feet. A shallow shelf extends out several hundred feet from shore around much of the lake, except along the face of the dune on the west shoreline where the water depth drops rapidly toward the 20-foot maximum.

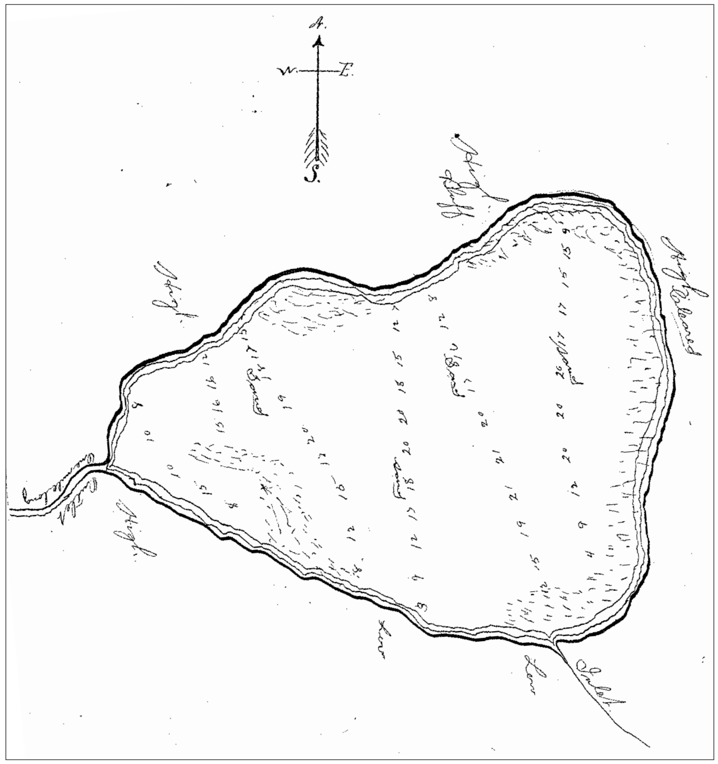


Figure 4. Silver Lake 1892 depth transects (Michigan Fish Commission).

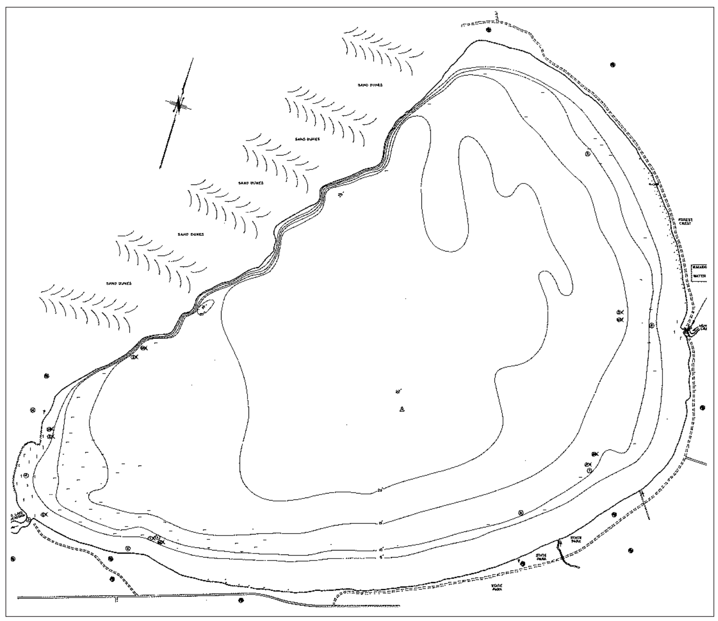


Figure 5. Silver Lake 1950 depth contour map (Conservation Dept.).

Figure 3. Silver Lake sand dunes.

To evaluate the impact of dune migration, Silver Lake was re-mapped in 2012. The lake shoreline configuration was traced from 2010 orthodigital aerial photography and depth readings were taken with a GPS-enabled electronic depth finder at geo-referenced grid points spaced at 300-foot intervals across the surface of the lake (Figure 6). At each point, a depth measurement was recorded and computer software was used to create depth contours (Figure 7). The new map was compared to the original 1950 depth map to evaluate changes in the lake bottom (Table 1).

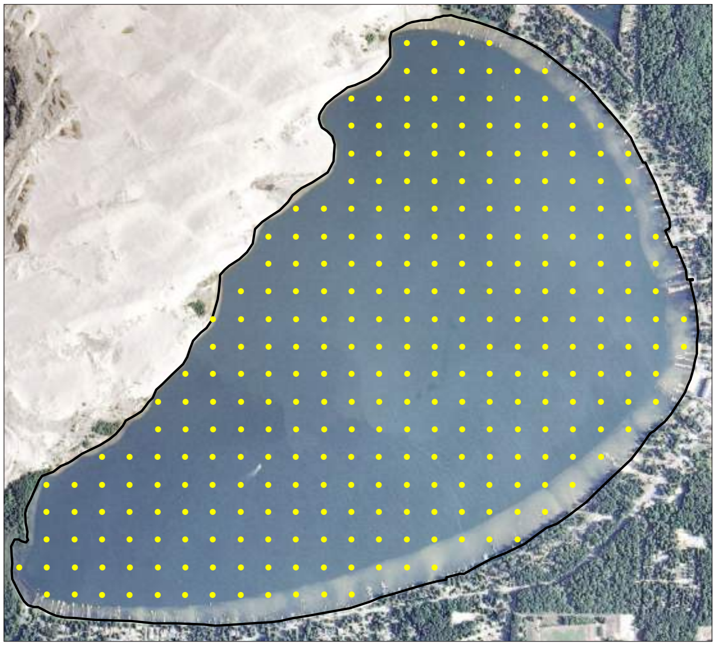


Figure 6. Silver Lake geo-referenced survey points.

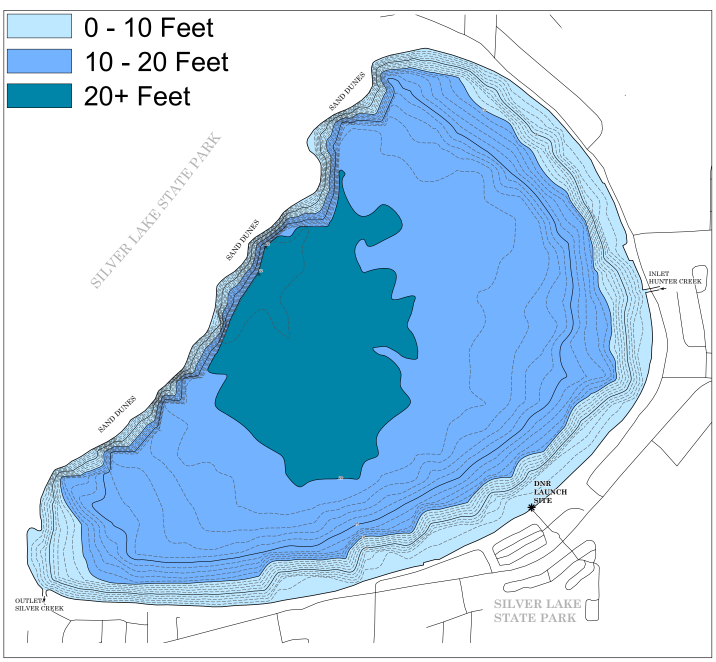


Figure 7. Silver Lake 2012 depth contour map (Progressive AE).

Table 1
Comparison of Silver Lake Physical Characteristics 1950 and 2012

Measurement	1950	2012	Difference
Lake Surface Area (Acres)	690	672	-18 (3%)
Maximum Depth (Feet)	25	22	-3 (12%)
Mean Depth (Feet)	14.9	14.6	-0.3 (2%)
Lake Volume (Acre-feet)	10,287	9,823	-464 (5%)

Lake volume calculated by conical frustra summation (Wetzel and Likens 1991); mean depth calculated by dividing volume by lake surface area.

Table 1 shows that the sand dunes migrated 18 acres into Silver Lake between 1950 and 2012. Despite that, the mean (average) depth and lake volume declined only 2% and 5%, respectively. The mean depth declined by 0.3 feet, which equates to a fill-in rate of about one inch every 17 years.

Although detailed depth measurements prior to 1950 are not available, aerial photography from as far back as 1938 illustrates sand dune migration into Silver Lake (Figure 8).

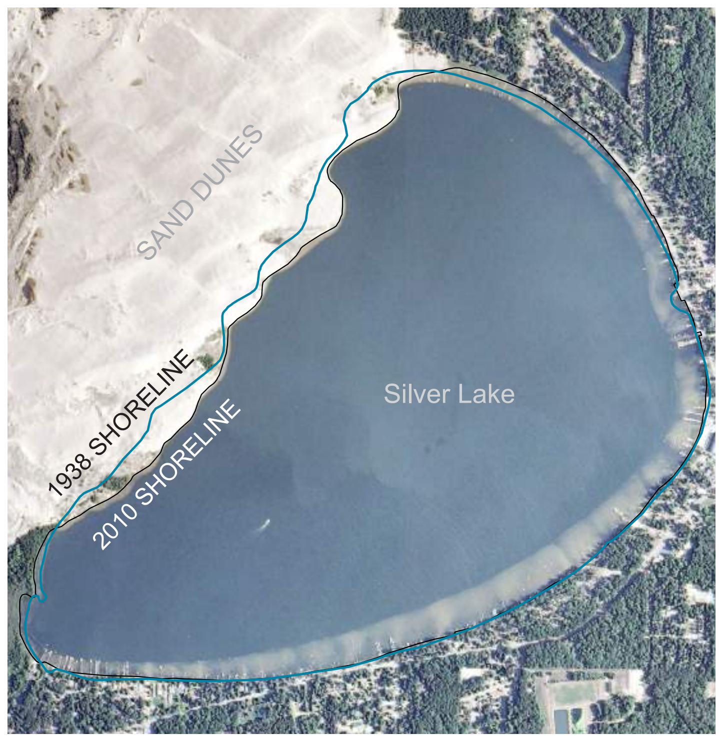


Figure 8. Silver Lake dune migration 1938 to 2010.

General Considerations

Although dated, many of the maps created by the Department of Conservation are still reasonably accurate with respect to depth. In most lakes, the natural rate of sediment accumulation on the lake bottom is imperceptibly slow, and off-shore lake depths would not be expected to change significantly in a 50-year or even a 100-year time frame. However, if a lake is experiencing excessive sediment loading, for example via tributary inflows, sediment accumulation can occur much faster and be more pronounced, at least in the areas of sediment deposition.

While lake depths typically remain relatively static, shoreline configurations often change dramatically over time. On many lakes, extensive channelization and dredging activities occurred prior to modern environmental regulation and, as a result, shoreline configurations today are often much different than when the original lake maps were created decades ago. Some of these changes are profound.

On the old maps, shoreline structures and reference points were often scant and, in the absence of some distinct feature such as a point or cove, it can be difficult to orient to shore features. With today's mapping technology, this issue can be addressed by plotting depth contours on registered aerial photography and/or USGS topographic maps (Figure 9).

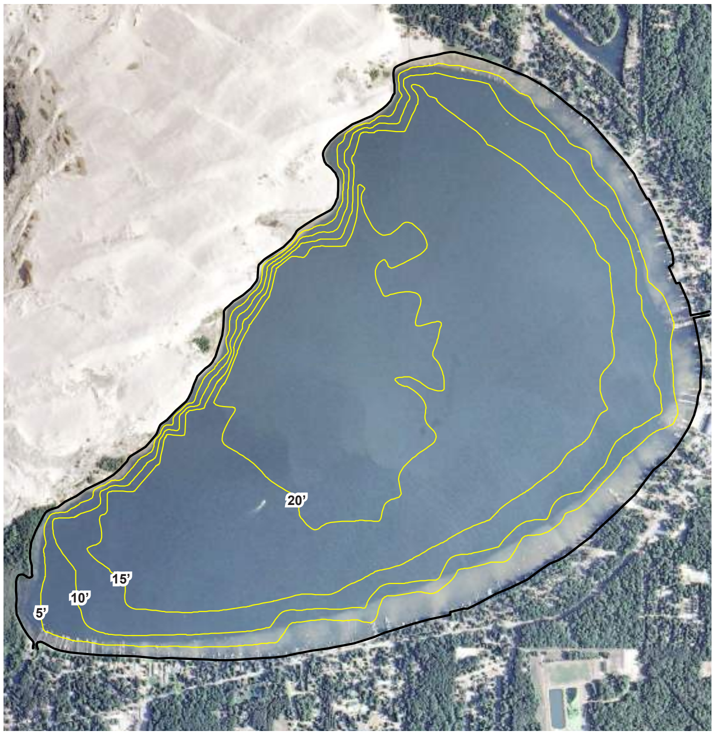


Figure 9. Silver Lake depth contours on registered aerial photography.

While new technology can greatly facilitate mapping, historical standards of accuracy can provide excellent guidelines for today's mapping projects.

Potential Uses

In the case of Silver Lake, a new depth contour map was created to evaluate the impact dune migration was having on the lake. However, an accurate lake depth contour map can provide a myriad of uses, not the least of which is identifying areas of the lake that fish might frequent. With the more widespread use of GPS in recent years, reference points can be established on a map and used to identify sampling locations, invasive plant species locations, natural shoreline areas, or simply where the "big one" got away. An accurate depth contour map can also be used to perform several useful calculations.

Mean depth is a calculation of the volume divided by a lake's surface area. In general, rooted aquatic plants can grow to a depth of about 15 feet. Silver Lake has a mean depth of just under 15 feet that indicates that about 50% of the lake is shallow enough to support rooted plant growth.

Shoreline development factor is a measure of the irregularity of the shoreline. A lake that is perfectly round would have a shoreline development factor of 1.0. Silver Lake's shoreline development factor is 1.2, indicating the shoreline of Silver Lake is 0.2 or 20% (nearly 1 mile) longer than if the lake were perfectly round. Lakes with highly convoluted shorelines have the potential to support much more shoreland development per unit area of lake surface. Wagner (1991) noted:

> The ratio of the length of shoreline around the lake to the circumference of a circle with the same area as the lake [shoreline development factor] provides a size-independent measure of the lake shape and indicates much about how motorized watercraft could affect the water body. Higher ratios suggest irregular shorelines with more waterfront per unit area than smaller ratios. Numerous coves may serve to isolate impacts, but there is a greater potential for the shoreline to be affected. High ratios also imply greater safety risks as well as ecological consequences.

The shallowness ratio compares the area of the lake less than 5 feet deep to the total lake area, and indicates the degree to which the lake bottom area is likely to be directly affected by motorized watercraft. Impacts of primary concern would include sediment suspension, turbidity, and destruction of fish habitat. Shallowness ratios range from low (<0.10) for lakes unlikely to be impacted to high (>0.50) for lakes with a high potential for impact. Silver Lake has a shallowness ratio of 0.14 which indicates that the impact of motorized watercraft on the lake is unlikely.

Percent natural shoreline is a useful measure to evaluate how much of a lake's shoreline has been physically altered by seawalls and other hard structures. In a recent nationwide study, the Environmental Protection Agency (2010) noted that lakes that have lost natural shoreline vegetation were three times more likely to be in poor biological condition. Thus, periodic measurements of the percent natural shoreline can provide an indication of the overall health of your lake.

An accurate lake map can provide valuable information about your lake.

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