Bathymetric Survey of Lake Arrowhead at Camp Baiting Hollow Long Island, New York

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Abstract

Standard survey techniques were employed to measure the depth of Lake Arrowhead at Camp Baiting Hollow, Riverhead, New York. Data were imported into GIS and used to construct bathymetric maps. Morphometric characteristics were estimated using algebraic and GIS calculations. These data will be used for the design and reconstruction of the dam that separates Lake Arrowhead from the adjacent tidal wetland.

Introduction

Camp Baiting Hollow is located in the town of Riverhead on Long Island, New York. It is owned and operated by the Boy Scouts of America. Lake Arrowhead is a small fresh water lake located on the northeastern portion of the camp property. It was once a spring-fed stream that was dammed in the 1920s to form a lake for recreational purposes [1]. The lake level is managed by the addition and removal of boards from the dam's spillway. Fresh Pond Marsh to the north of the dam is owned by the New York State Department of Environmental Conservation (NYSDEC) and flows into Long Island Sound. This tidal wetland developed in a glacial depression and is underlain by Harbor Hill till [1]. Lake Arrowhead and Fresh Pond Marsh are home to diverse populations of flora and fauna.

Bathymetry is the mapping of the bottom of a body of water. Bathymetric studies of lakes give essential morphometric information for the management of these resources. Morphometric data include surface area, volume, average depth, and shoreline development. These parameters influence water quality, seasonal water levels, shoreline erosion and deposition, and availability of wildlife habitat. [2] Fresh water lakes often mark the interface between surface water and ground water resources and play a critical role in the water balance of a region [3]. Construction of dams provides some control over the flow of water through these systems [4]. Recognition of the connection between physical and ecological characteristics and an understanding of how lakes change over time will lead to better resource management and planning for future use by humans and wildlife [4, 5, 6]. Furthermore, lake levels are sensitive to climate fluctuation and can be indicators of regional or larger scale climate change [4, 5].

Bathymetric studies can be accomplished using many different techniques. The simplest approach is to measure depth using a weighted line or an echo sounding device [2, 6, 7, 8]. Transects across a lake are typically followed along a line of sight between reference points with regularly spaced sampling points [7, 9]. Some recent studies employed the use of satellite technology such as interferometric synthetic aperture radar (INSAR) to measure lake depth [5]; one advantage of this method is that it can be used on frozen lakes. Regardless of sampling technique, depth data are located on base maps or photographs. The most common method for sample location is the recording of Global Positioning System (GPS) coordinates. Depth and location data can then be imported into a Geographic Information System (GIS) to generate bathymetric maps or three-dimensional models and calculate lake area and volume. [9, 10, 11]

Purpose

The purpose of this investigation is to conduct a detailed bathymetric survey of Lake Arrowhead at Camp Baiting Hollow in order to provide the NYSDEC with water depth and volume data required for the design and reconstruction of the dam and spillway that separate Lake Arrowhead from the adjacent Fresh Pond wetland area.

Study Area

Lake Arrowhead occupies an area of approximately 4 acres near the boundary between Camp Baiting Hollow and Fresh Pond Marsh (Figure 1) . Figure 2 illustrates the locations of 26 line transects and associated sampling points.

Figure 1: Lake Arrowhead and Surrounding Hydrology Baiting Hollow, NY

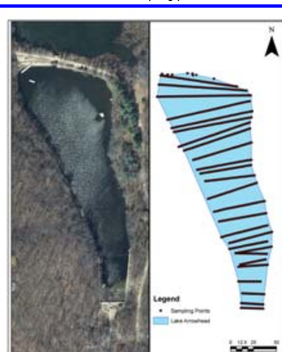

Figure 2: Locations of Sampling Points

Materials and Methods

Lake Arrowhead's length and width were measured using a satellite image and GIS software ArcInfo 9.2. The widest section of the lake is approximately 100 m. A transect rope to accommodate this width was marked every 1 m with electrical tape. The rope was placed on a garden hose reel for easy winding. A sound line was created by attaching a 624 gram weight at one end of a 50 m rope and marking every 0.5 m with electrical tape. A rowboat was used to access tie off points along the shoreline. A transect was created by tying off each end of the rope either on a shoreline feature or a grounded stake. Flagging tape was attached to the tie off point. GPS coordinates were taken with a THALES MobileMapper CE handheld unit. The rope was pulled taut to set the transect line. The rowboat was clipped to the rope. The boat was pulled along the rope. Depth readings were recorded at 2 m intervals using the sound line and Depth Mate SM5 transponder. Transects ran east to west with north-south spacing approximately every 10 m. Random points were taken to delineate the northern shoreline closest to the spillway. Figure 3 illustrates the procedure for setting and collecting data along a transect.

Transect lines and sampling points were created on the base map using ArcInfo 9.2 (Figure 2). Depth data were entered into an Excel spreadsheet and average depths were calculated for the sound line and transponder data. The lake outline was traced onto graph paper as shown in Figure 4a. Lake area was calculated by two methods. In method 1, area was determined by counting squares and converting the total number of boxes within the lake outline to square feet and acres using the photo scale.

1 square = 900 ft^2 area (ft^2) = # squares * 900 ft^2 area (acres) = area (ft^2) / 43,560

In method 2, the long axis of the lake was measured. The lake was visually divided into three sections. The width of each section was estimated and used to calculate average width.

area (ft^2) = length of long axis (ft) * avg. width (ft) area (acres) = area (ft^2) / 43,560

Lake volume for each method was calculated using the following equations:

volume (ft^3) = area (ft^2) * avg. depth (ft) volume (acre-ft) = area (acres) * avg. depth (ft)

Depths were imported into GIS to join depths to sampling points (Figure 4b) and the data were used to create a bathymetric 3-D model (Figure 5). Area and volume were calculated using ArcInfo 9.2 GIS software (method 3).

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Figure 3

Figure 4a

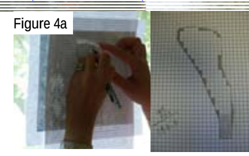
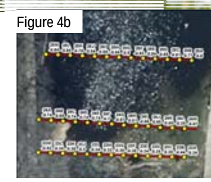


Figure 4b



Results

Figure 5 is a bathymetric map of Lake Arrowhead constructed using sound line depth data imported into ArcInfo 9.2. Tables 1 and 2 summarize morphometric characteristics of Lake Arrowhead. Table 3 depicts the percent differences between area and volume estimates calculated using the three methods described in the previous section.

Figure 5: Bathymetric Map of Lake Arrowhead

Table 1 Average Depths of Lake Arrowhead

	Weighted Sound Line	DepthMate SM5 Handheld Sounder	% Difference
Average Depth (meters)	1.18	1.17	0.85
Average Depth (feet)	3.88	3.85	0.78

Note: Depths were measured relative to lake surface.
Field measurements were recorded in meters and converted to feet for use in the GIS model.

Table 2 Estimated Area and Volume of Lake Arrowhead

	Method 1		Method 2		Method 3
Area ($feet^2$)	171,450		178,350		171,000
Area (acres)	3.94		4.09		3.93
	Method 1a	Method 1b	Method 2a	Method 2b	Method 3
Volume ($feet^3$)	665,226	660,083	691,998	686,648	857,000

Note: Volumes for Methods 1a, 2a and 3 were calculated using depth data measured with sound line; methods 1b and 2b used data from DepthMate.

Table 3 Comparison of Area and Volume Estimates

	Method 1a to Method 3	Method 2a to Method 3
% Difference Area ($feet^2$)	0.26	4.12
% Difference Area (acres)	0.25	3.91
% Difference Volume ($feet^3$)	22.38	19.25

Discussion

Depths were measured using two traditional methods, a weighted sound line and a handheld echosounding device. Measurements using the echosounder were generally limited to areas with relatively clear water and depths greater than 0.5 meters. Due to the shallow nature of the lake and the presence of submerged vegetation, the sound line method provided more complete coverage. Most differences observed between the two methods appeared to be related to the presence of soft bottom sediment. Data in table 1 show the percent difference in depths measured by the two methods is negligible. For shallow water body surveys, a sound line is sufficient if time allows [6, 11].

Figure 5 shows that Lake Arrowhead has a relatively flat and shallow bottom with isolated slightly deeper regions. The greatest depths measured were between 6 to 8 feet. These areas are located near the northern end of the swimming section and next to the spillway on the northern shore. Tables 2 and 3 illustrate that the area calculations were relatively consistent regardless of the method used. Volume estimations were not as constant between methods. The difference may be attributed to the way depths are applied in the calculation. The algebraic calculation (methods 1 and 2) apply a single average depth whereas the GIS model (method 3) associates a depth to each sampling point. This lack of averaging depth likely yields a more accurate and larger volume estimate which should be used in the planning and design of a new dam and spillway.

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