U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
CITY OF DURHAM DEPARTMENT OF WATER RESOURCES and the
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT, HEALTH and NATURAL RESOURCES

WATER RESOURCES INVESTIGATIONS REPORT 93-4031
SHEET 1 OF 1

ABSTRACT

This map report presents the results of a bathymetric survey conducted as part of a 1990-92 study on the effects of sedimentation on Lake Michie, located in northeastern Durham County, North Carolina. Bathymetric data collected at the lake during 1990-92 indicate that, under normal pool conditions at the spillway elevation of 341.0 feet above sea level, the storage volume is 11,070 acre-feet, and the surface area is 508.7 acres. The maximum depth recorded in the lake was 75 feet at approximately 500 feet upstream of Lake Michie Dam.

INTRODUCTION

During 1990-92, the U.S. Geological Survey conducted a bathymetric survey of Lake Michie in northeastern Durham County, North Carolina (fig. 1), as part of a study to examine the effects of sedimentation on the lake. The study was conducted in cooperation with the City of Durham Department of Water Resources and the North Carolina Department of Environment, Health, and Natural Resources. This is the first study conducted in the North Carolina Reservoir Sedimentation Program begun in 1989 by the U.S. Geological Survey and the North Carolina Department of Environment, Health, and Natural Resources to examine the effects of sedimentation on lakes and reservoirs throughout North Carolina.

Purpose and Scope

This report documents the bathymetric survey made of Lake Michie during 1990-92, presents a map depicting depth contours of the lake, and discusses bathymetry of the lake, including volume computations. This investigation included (1) selection and digitization of the base map, (2) collection of bathymetric data, and (3) development of depth contours for the lake. Data collection included rod soundings, fathometer surveys, and dry lake-bottom elevations. Surface-area and storage-volume computations were made to update depth-area and depth-volume curves.

Description of Lake Michie

Lake Michie is in the northeastern Piedmont Province of North Carolina approximately 12 mi northeast of the city of Durham in Durham County (fig. 1). The lake is an impoundment of the Flat River in a short, narrow valley where rock outcrops occur on some steep slopes. From its headwaters to the dam, Lake Michie is approximately 4.5 mi long and varies in width from less than 100 ft in the headwaters to about 1,200 ft one-half mile upstream of Lake Michie Dam. At the dam, the drainage area of the Flat River is 167.2 mi^2. At the U.S. Geological Survey stream-gaging station on the Flat River at Bahama one-half mile upstream of Lake Michie, the drainage area is 149 mi^2 (fig. 2). The intervening 18.2 mi^2 drain into Lake Michie by way of a number of small streams that surround the lake, including Dial Creek, Dry Creek, and Rocky Creek (fig. 2).

The Lake Michie Dam is 960 ft long and consists of a concrete masonry section 660 ft long and a 300 ft-long earth-fill section. The crest of the 300 ft-long principal spillway within the concrete masonry section is 81 ft above the old channel bed of Flat River and is at an elevation of 341.0 ft above sea level (City of Durham, 1981).

Lake Michie began filling in April 1926 after completion of the dam, and initially overtopped the principal spillway in December 1926 (City of Durham, 1981). Lake Michie was the sole water-supply source for the City of Durham until 1988, when nearby Little River Reservoir, located 5 mi southwest of Lake Michie, began operation. In addition to water supply, Lake Michie has been used for hydroelectric-power generation for the city and is a popular recreational facility for many area residents.

Previous Investigations

Since 1926, Lake Michie has been surveyed five times to monitor and assess the loss of storage due to sediment deposition. Prior to the construction of Lake Michie, a contour map of the pre-impoundment valley showing ground elevations at 10-ft intervals was compiled by the Durham Water Works (1923). Additionally, 10 cross sections were established throughout the length of the lake by the North Carolina Department of Conservation and Development (Eakin and Brown, 1939). Three surveys were made at some or all of these cross sections between 1926 and 1930 (Eakin and Brown, 1939). In 1935, H.M. Eakin used surveys obtained at 32 cross sections to compute the first post-construction storage volume for Lake Michie (Eakin and Brown, 1939). In 1970, surveys were made of 24 cross sections in Lake Michie as part of a University of North Carolina Water Resources Research Institute study (Maki and Hafley, 1972). No bathymetric maps showing contours of either lake-bottom elevations or water depths were published as a result of the 1935 and 1970 bathymetric surveys.

In November 1983, a contour map of exposed areas of the lake was developed from aerial photogrammetry taken by Landmark Engineering, Inc., during a drought in which the lake level had fallen approximately 16 ft below spillway elevation (Landmark Engineering, Inc., 1983). Although the Landmark map reveals much of the topography in the upper reaches of Lake Michie, little of the bottom terrain in the lower two-thirds of the lake is shown on this map. No storage volume for Lake Michie was computed from the map.

LAKE MICHIE BATHYMETRIC MAP

The bathymetric map for Lake Michie, the first to cover the entire range in depth since the lake was filled, was constructed from depth and position data collected on the lake and superimposed on a base map created from the Landmark map (Landmark Engineering, Inc., 1983). For broader use of the bathymetric map, contours were drawn to depict lake depth below the principal spillway level of 341.0 ft rather than sea level elevation.

Base Map

The Landmark map, provided by the City of Durham, was used to construct base-map features such as the shoreline, selected contours, and some facilities used as landmarks. This map was based on aerial photographs of the lake taken in November 1983 when the lake level was at 325 ft above sea level. The map depicts ground elevations ranging from 326 to 342 ft above sea level at a contour interval of 2 ft (Landmark Engineering, Inc., 1983). The Landmark map is in the North Carolina State Plane Coordinate System (NCSPCS).

Using Geographic Information System (GIS) software, the first step in producing the base map involved digitizing the 340- and 342-ft elevation contours from the Landmark map. The 341-ft elevation contour was assumed to be the "zero depth" (shoreline) contour and was interpolated between the 340- and 342-ft elevation contours and was digitized. Additionally, contours for elevations depicting the 5-, 10-, and 15-ft depths were digitized from the Landmark map for comparison with new data collected during this investigation. Lake facilities including the bridge located on Secondary Road (SR) 1616, the boat house and dock, power transmission lines, and Lake Michie Dam were also digitized from the Landmark map to assist in orientation of the base map. Base map features are shown in blue in this report (figs. 2, 3, and 4).

The accuracy of the base map with respect to changes in the shoreline configuration since 1983 was confirmed by field reconnaissance. In addition, accuracy of the base map with respect to orientation and configuration of the shoreline was also confirmed by overlaying the base map on a map of the surrounding area digitized from U.S. Geological Survey (1983) topographic quadrangles (fig. 2)

Data Collection

Data for the construction of the bathymetric map were collected during 1990-92. The lake surface was used as the datum for all depth soundings. Lake-surface elevations were obtained from a water-level recorder at Lake Michie Dam (fig. 3). The elevation of the recorder gage datum was based on sea level using a U.S. Geological Survey benchmark located on the dam. Two additional reference marks established near the SR 1616 bridge also were used in the NCSPCS for horizontal control and were related to sea level for vertical control using a North Carolina Department of Transportation benchmark near the bridge (fig. 3).

In March 1991, 23 cross sections were surveyed in the lake upstream of the SR 1616 bridge (fig. 3). The end points of the cross sections on the east shoreline were tied into NCSPCS. Depths were obtained by rod soundings made from a small boat, and position was obtained using a tagline.

During an extended dry period in late 1991, the lake level fell to about 12 ft below the spillway level. This afforded an opportunity to collect more detailed position and elevation data using ground-surveying techniques on the dry lake bottom. Approximately 480 additional ground points were surveyed in December in the shallow headwaters of the lake in the vicinity of the boat dock and the mouth of Dial Creek (fig. 3). Horizontal and vertical control for the survey were obtained using reference marks near the SR 1616 bridge.

In early January 1992, runoff from a storm refilled the lake. Forty-one additional cross sections were surveyed throughout the lake using a boat and a fathometer (fig. 3). Positions of cross-section end points were determined from planimetric features shown on the base map.

Map Development

The Lake Michie bathymetric map was developed from measured point depths and cross sections obtained during the surveys and plotted on the base map. At the scale chosen for the final map (1:4,800), steep valley slopes dictated the selection of a 5-ft contour interval in the lower two-thirds of the lake to avoid excessive merging of contours. In the upper one-third of the lake, gentle to mild lake-bottom slopes allowed the use of a 2-ft contour interval that permits greater bathymetric detail to be shown.

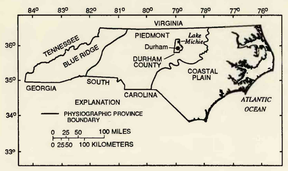
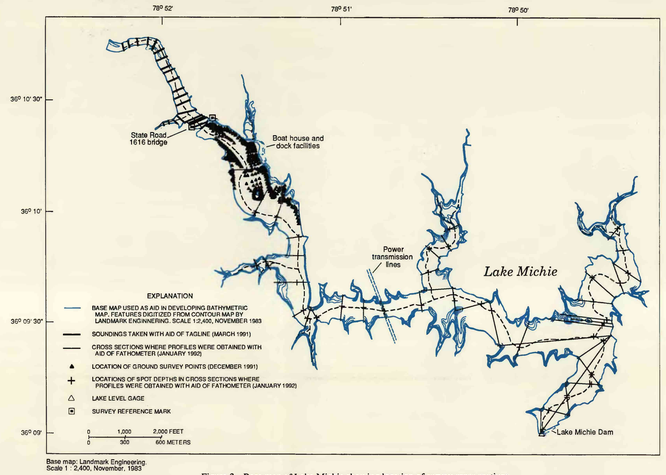


Figure 1.--Lake Michie in Durham County, North Carolina.



Base map: Landmark Engineering
Scale 1 : 2,400, November, 1983

Figure 3.--Base map of Lake Michie showing location of survey cross sections and around points.

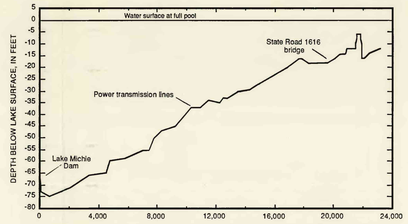


Figure 5.--Thalweg profile of Lake Michie.

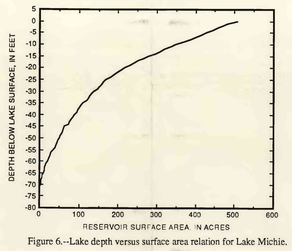


Figure 6.--Lake depth versus surface area relation for Lake Michie.

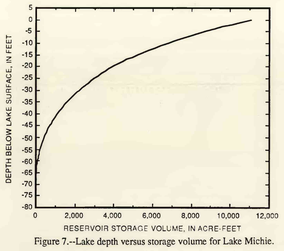


Figure 7.--Lake depth versus storage volume for Lake Michie.

In most areas in the lower two-thirds of the lake, there was good agreement between locations of the 5-, 10-, and 15-ft depth contours as determined from field data compared with those from the Landmark map. For this reason, the base map contours used for these depths in this part of the lake were assumed to be adequate for extending contours into areas where field data were not collected. In the upper third of the lake, where more sediment deposition and reworking of sediments would be expected, the agreement was not as good. Here the field data were used almost exclusively to draw new contours.

Depth contours were hand drawn and then digitized using GIS for production of the finished map and for subsequent surface-area and volume computations. The digitized depth contours were used to build a triangulated irregular network (TIN), which is a series of "adjacent, non-overlapping triangles connecting irregularly spaced points having both x,y coordinates [position] and z coordinates [depth]" (Environmental Systems Research Institute, 1988, p. 1-1). The TIN approximates the lake-bottom terrain and is the basis for surface-area and volume computations.

BATHYMETRY OF LAKE MICHIE

The maximum depth recorded in Lake Michie during the survey was 75 ft, located about 500 ft upstream of Lake Michie Dam (fig. 4). Bathymetric data collected at the lake indicate that at the normal pool spillway elevation of 341.0 ft, the surface area of the lake was 508.7 acres. Storage volume computations based on the TIN terrain reveal that the storage volume of Lake Michie at the normal pool spillway elevation was 11,070 acre-ft. Computations using Eakin's Range Method (Eakin and Brown, 1939; Vanoni, 1975) as applied to the lake bottom defined by the TIN terrain generated a storage volume of 10,530 acre-ft at elevation 341.0 ft. These values are within approximately 5 percent of each other.

The usable storage is the volume above the elevation of the intake in the dam. At the intake elevation of 300.0 ft, the storage volume was computed to be 1,015 acre-ft. Thus, the usable storage volume between elevations 300.0 and 341.0 ft was 10,055 acre-ft.

Two distinct slopes and a significant scour hole can be seen in the profile of the main thalweg in Lake Michie (fig. 5). The average slope of the thalweg from Lake Michie Dam to the area adjacent to the boat house and dock facilities (distance of about 17,700 ft) is approximately 18 ft/mi. From the latter area upstream to the headwaters region, the average slope is approximately 4 ft/mi. The change in slope is indicative of where significant sediment deposition could occur in the upper part of Lake Michie. The thalweg profile also reveals a scour hole approximately 1,000 ft downstream from the headwaters region which can also be seen in the depth contours on the bathymetric map (fig. 4). Upstream of the scour hole, the smaller cross-sectional areas of the lake may prevent significant sediment deposition because of higher velocities in this area during flood flows.

Depth-area and depth-volume curves for Lake Michie were computed using surface areas and storage volumes for depth intervals of 1 ft from the spillway elevation to the maximum observed depth (figs. 6 and 7, respectively). Depths are converted to lake elevations by subtracting the depth from 341.0 ft, the spillway elevation.

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
	Volume	
acre-foot (acre-ft)	1,233	cubic meter
acre-foot (acre-ft)	0.001233	cubic hectometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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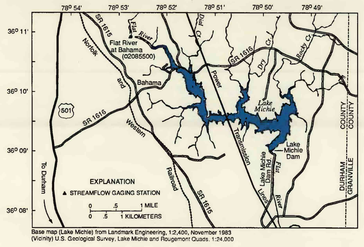

Base map (Lake Michie) from Landmark Engineering, 1:2,400, November 1983
(Vicinity) U.S. Geological Survey, Lake Michie and Rougemont Quads. 1:24,000

Figure 2.--Lake Michie and surrounding area.

Base map digitized from
City of Durham Department of Water Resources
Unpublished map compiled by Landmark Engineering Company
Scale 1 inch : 200 feet, 2 sheets, November, 1983

BATHYMETRY OF LAKE MICHIE, DURHAM COUNTY, NORTH CAROLINA, 1990-92

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