

Abstract

The U.S. Geological Survey, in cooperation with the Iowa Department of Natural Resources, conducted bathymetric surveys on seven lakes in Iowa during 2005 (Arrowhead Pond, Central Park Lake, Lake Keomah, Manteno Park Pond, Lake Miami, Springbrook Lake, and Yellow Smoke Lake). The surveys were conducted to provide the Iowa Department of Natural Resources with information for the development of total maximum daily load limits, particularly for estimating sediment load and deposition rates. The bathymetric surveys provide a baseline for future work on sediment loads and deposition rates for these lakes. All of the lakes surveyed in 2005 are man-made lakes with fixed spillways.

Bathymetric data were collected using boat-mounted, differential global positioning system, echo depth-sounding equipment, and computer software. Data were processed with commercial hydrographic software and exported into a geographic information system for mapping and calculating area and volume. Lake volume estimates ranged from 47,784,000 cubic feet (1,100 acre-feet) at Lake Miami to 2,595,000 cubic feet (60 acre-feet) at Manteno Park Pond. Surface area estimates ranged from 5,454,000 square feet (125 acres) at Lake Miami to 558,000 square feet (13 acres) at Springbrook Lake.

Introduction

Bathymetric mapping can provide useful information for water-quality managers to address a variety of issues on Iowa's lakes and reservoirs. The Iowa Water Science Center of the United States Geological Survey (USGS) began a lake bathymetric mapping program in June 2001 on Lake Delhi in east central Iowa, which resulted in a published bathymetric map and report (Schnoebelen and others, 2003). The USGS, in cooperation with the Iowa Department of Natural Resources (IDNR), conducted a bathymetric survey of Arrowhead Pond in 2005 to provide the IDNR with information for the development of total maximum daily load limits (TMDLs), particularly for estimating sediment load and deposition rates. The bathymetric contours also can provide a baseline for future work on sediment load and deposition rates for Arrowhead Pond.

Arrowhead Pond was constructed in 1962 and is located in south-eastern Iowa about 1.5 miles (mi) southeast of Neola in Pottawattamie County in Arrowhead Park, and is owned by the Pottawattamie County Conservation Board. Arrowhead Pond is used primarily for recreational activities. Arrowhead Pond receives flow from two unnamed creeks, one from the north and one from the south. Discharge from Arrowhead Pond is through a bottom outlet at the dam on the western end of the lake into Mosquito Creek.

Methods

Bathymetry data were collected on August 30 and 31 and September 1, 2005. Bathymetric mapping was accomplished using boat-mounted global positioning system (GPS), echo depth-sounding equipment, and computer software. The GPS allowed for accuracies of about 3.28 feet (ft) (approximately 1 meter) in the horizontal direction. The echo sounder emits sound pulses that are reflected off the lake bottom and received by a transducer. The echo sounder transmitted at a frequency of 200 kilohertz; water depths were determined by the echo sounder based on the speed of sound in water compensated for temperature (Specialty Devices, Inc., 2003). In some areas of the lake, the depth limitations (less than 3.3 ft) of the echo-sounding equipment necessitated determining the depths manually at target points using a measuring device marked in 0.10-ft increments. Using the echo sounder, the bathymetry data were collected along planned transect lines spaced 50 ft apart. Individual data-collection locations along a transect line generally were 5 to 10 ft apart. The depth data later were converted to elevation, in the post-processing software (Coastal Oceanographics, Inc., 2002), by subtracting the depths at each location from the reference surface elevation of the lake. The reference surface elevation was determined on the days of bathymetric data collection by measuring from a reference point of known elevation at the dam. The elevation of the reference point was determined using a combination of GPS and standard surveying techniques. The water-surface elevation for the siltation ponds were determined by leveling from the water surface of the main lake to the water surface of the siltation ponds. The bathymetry data then were filtered (fig. 1) to reduce the density of data points and entered into geographic information system (GIS) software to produce a three-dimensional surface of the lake-bottom elevations. The three-dimensional surface was contoured, and the contours were adjusted manually to correct for interpretive errors. (See the Arrowhead Pond metadata at <http://water.usgs.gov/lookup/getgislst> for a more detailed explanation of methods used to collect and process the bathymetric data.)

Quality Assurance

A bar check on the echo sounder was performed at the beginning of the day of data collection following established protocols (U.S. Army Corps of Engineers, 1994, Chapter 9). This was done to ensure that the echo sounder was calibrated correctly. The bar check involved suspending a 2-ft-diameter flat aluminum plate directly below the echo sounder. The suspension line was marked in 5-ft increments. An initial calibration was made at 5 ft by entering the speed of sound in water, and adjusting the offset of the transducer in the computer software. The offset is the draft of the transducer below the lake surface. The aluminum plate was then lowered in 5-ft increments, depending on the range of depths expected to be encountered, and adjustments in the speed of sound were made until depth readings and the depth of the aluminum plate agreed to within approximately 0.1 ft.

A second independent bathymetry data set was collected for a smaller area of Arrowhead Pond. The control data set was used to estimate the precision (repeatability) of the sounding data collected with the echo sounder, to estimate the accuracy of the interpolation in the three-dimensional surface, and to estimate the accuracy of the contours (Wilson and Richards, 2006). Within 1.0 ft of each other there were 14 paired data and control points with a calculated Root Mean Square Error (RMSE) of 0.18 ft. At corresponding locations there were 679 paired three-dimensional surface elevations and control points with a calculated RMSE of 0.35 ft, and within 0.50 ft of each other there were 29 paired contours and control points with a calculated RMSE of 0.60 ft.

Bathymetric Contours

The water-surface elevations of Arrowhead Pond, the north siltation pond, and the south siltation pond, on August 30 through September 1, 2005, were 1,133.8 ft, 1,143.5 ft, and 1,148.4 ft above North American Vertical Datum of 1988 (NAVD88), respectively. Generally, the water depth increases toward the dam (fig. 2). The deepest part of the lake is located approximately 190 ft east of the dam, and the lowest elevation measured was 1,120.9 ft (12.9 ft deep). The average elevation of the lake bottom, not including the siltation ponds, based on the three-dimensional surface was 1,127.3 ft (6.5 ft deep). The lowest elevation measured in the north siltation pond was 1,136.5 ft (7.0 ft deep). Average elevation in the north siltation pond was 1,141.9 ft (1.6 ft deep). The lowest elevation measured in the south siltation pond was 1,143.8 ft (4.6 ft deep). Average elevation in the south siltation pond was 1,146.8 ft (1.6 ft). The slope of the lake bottom generally is greatest along the west shoreline south of the dam. Data from this survey indicate that the total surface area of Arrowhead Pond and the siltation ponds, based on their respective water-surface elevations, is approximately 683,000 square feet (ft²) (16 acres) and the total water volume is approximately 3,832,000 cubic feet (ft³) (88 acre-feet). For the main part of Arrowhead Pond, surface area is approximately 556,000 ft² (13 acres) and water volume is approximately 3,624,000 ft³ (83 acre-feet). For the north siltation pond, surface area is approximately 72,000 ft² (1.7 acres) and water volume is approximately 117,000 ft³ (3 acre-feet). For the south siltation pond, surface area is approximately 55,000 ft² (1.3 acres) and water volume is approximately 91,000 ft³ (2 acre-feet).

References

- Coastal Oceanographics, Inc., 2002, HYPACK MAX[®], hydrographic survey software user's manual: Middlefield, Connecticut, Coastal Oceanographics, Inc. [variously paged].
- Schnoebelen, D.J., Mcvay, J.C., Barnes, K.K., and Becher, K.D., 2003, Bathymetric mapping, sediment quality, and water quality of Lake Delhi, Iowa, 2001–02: U.S. Geological Survey Water-Resources Investigations Report 03–4085, 38 p.
- Specialty Devices, Inc., 2003, Bathymetric survey system BSS+5 with omnistar manual: Plano, Texas, Specialty Devices, Inc., 38 p.
- U.S. Army Corps of Engineers, 1994, Engineering and design—hydrographic surveying EM 1110-2-1003: Washington, DC, Department of the Army, chap. 9-3, p. 9-4 to 9-9; accessed January 2004 at <http://www.usace.army.mil/publications/eng-manuals/em1110-2-1003/c-9.pdf>.
- Wilson, G.L., and Richards, J.M., 2006, Procedural documentation and accuracy assessment of bathymetric maps and area/capacity tables for small reservoirs: U.S. Geological Survey Scientific Investigations Report 06–5208, 24 p., CD-ROM.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

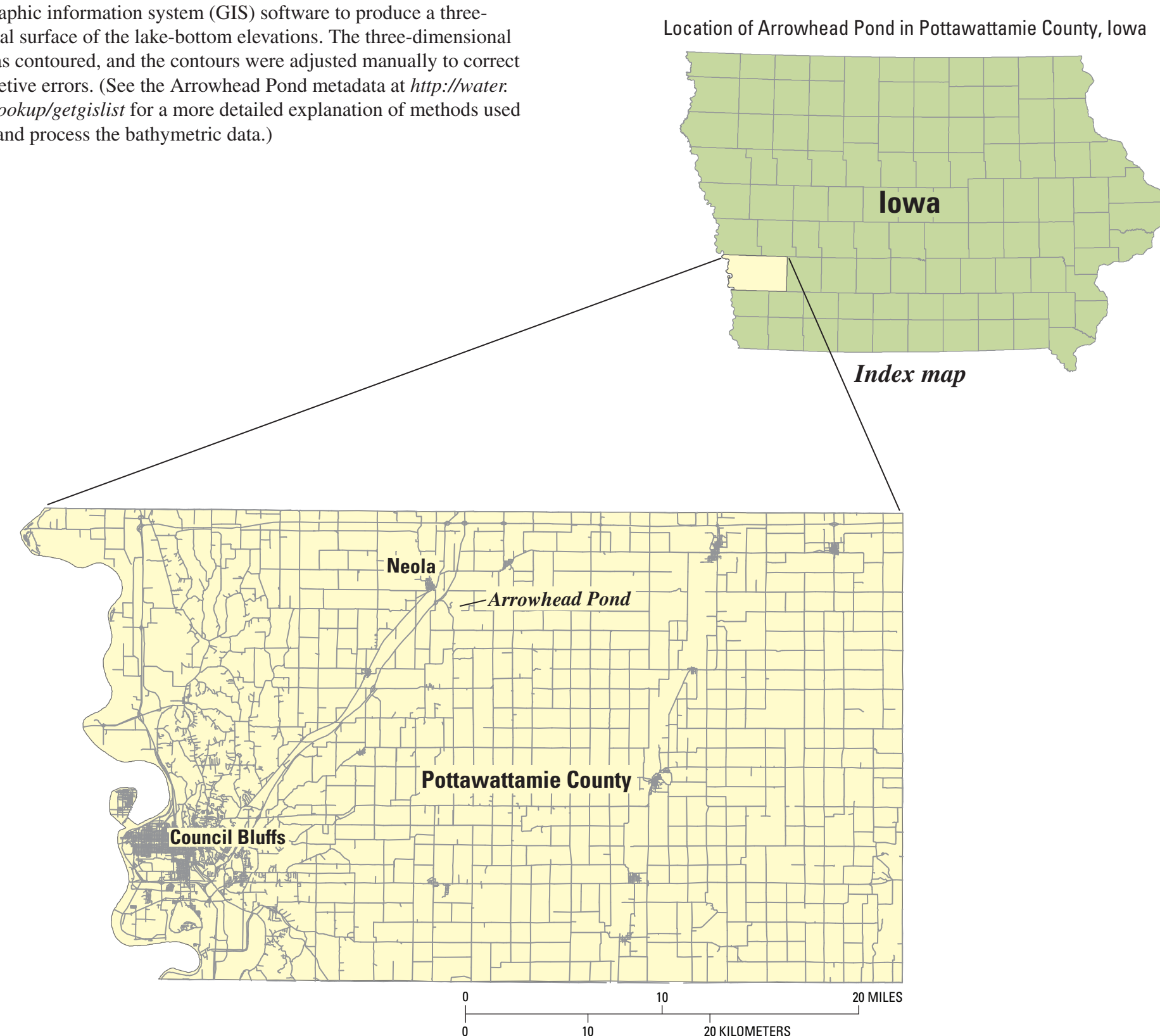
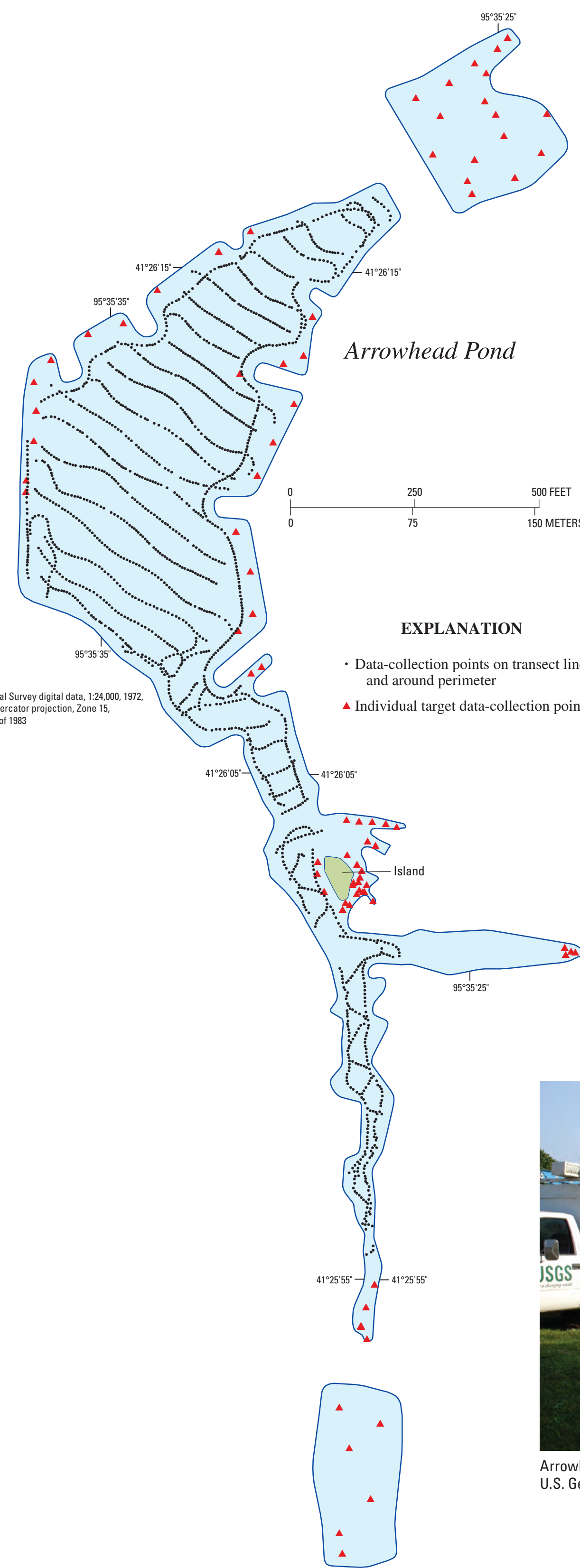


Figure 1. Data-collection points used to construct bathymetric contours.



Arrowhead Pond in Pottawattamie County, Iowa (photograph by Jon Nania, U.S. Geological Survey).

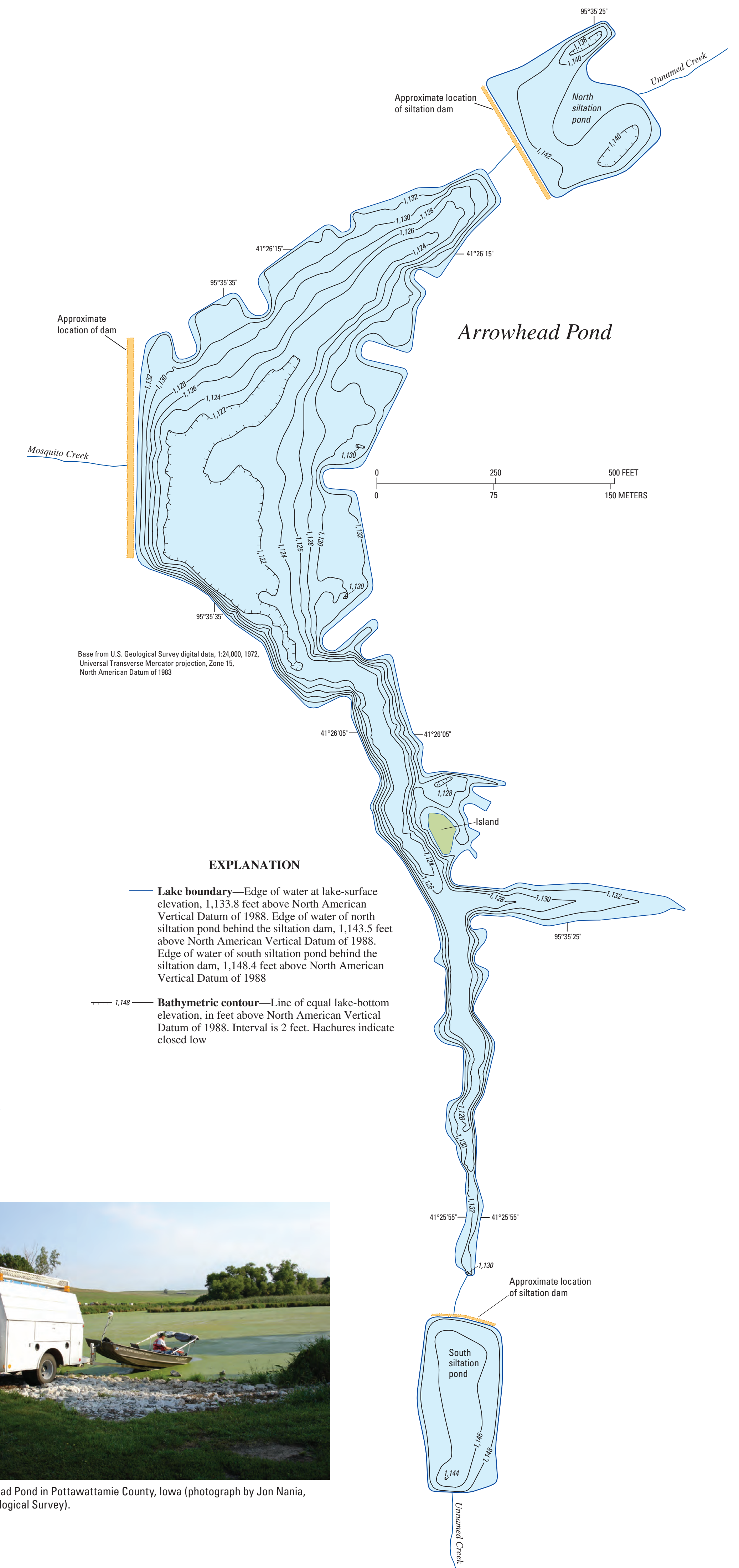


Figure 2. Bathymetric contours of Arrowhead Pond, 2005 (not for navigational use).

Bathymetric Contours for Arrowhead Pond, Pottawattamie County, Iowa

By
S.M. Linhart and K.D. Lund
2008

Suggested citation:
Linhart, S.M., and Lund, K.D., 2008, Bathymetric contour maps of lakes surveyed in Iowa in 2005: U.S. Geological Survey Scientific Investigations Map 3037, 7 sheets.
For more information about USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: <http://www.usgs.gov>

Publishing support provided by:
Rolla Publishing Service Center
For additional information concerning this publication, contact:
Director, USGS Iowa Water Science Center
400 South Clinton Street, Room 269
Iowa City, IA 52240
(319) 337-4191
Or visit the Iowa Water Science Center Web Site at:
<http://ia.water.usgs.gov>