Acknowledgments

The authors would like to thank Steve Nelms and John Krywicki of the City of Shawnee for assistance with project planning and also for providing data for past storage capacity studies.

The authors also thank U.S. Geological Survey colleagues for their contributions to this bathymetric survey. Molly Shivers and Shelby Hunter helped with data collection and surveying. James Hanlon was instrumental in custom fabrication and boat preparation in regards to instrument deployment. Rick Huizinga and Jason Lewis provided thorough and helpful reviews of the draft report and bathymetric survey data.

Introduction

Shawnee Reservoir (locally known as Shawnee Twin Lakes) is a man-made reservoir on South Deer Creek with a drainage area of 32.7 square miles (U.S. Geological Survey, 2016a) in Pottawatomie County, Oklahoma (fig. 1). The reservoir consists of two lakes connected by an equilibrium channel. The southern lake (Shawnee City Lake Number 1) was impounded in 1935, and the northern lake (Shawnee City Lake Number 2) was impounded in 1960. Shawnee Reservoir serves as a municipal water supply, and water is transferred about 9 miles by gravity to a water treatment plant in Shawnee, Oklahoma. Secondary uses of the reservoir are for recreation, fish and wildlife habitat, and flood control. Shawnee Reservoir has a normal-pool elevation of 1,069.0 feet (ft) above North American Vertical Datum of 1988 (NAVD 88) (Steve Nelms, City of Shawnee, written commun., 2016). The auxiliary spillway, which defines the flood-pool elevation, is at an elevation of 1,075.0 ft.

The U.S. Geological Survey (USGS), in cooperation with the City of Shawnee, has operated a real-time stage (water-surface elevation) gage (USGS station 07241600) at Shawnee Reservoir since 2006 (U.S. Geological Survey, 2016a). For the period of record ending in 2016, this gage recorded a maximum stage of 1,078.1 ft on May 24, 2015, and a minimum stage of 1,059.1 ft on April 10–11, 2007 (U.S. Geological Survey, 2016a). This gage did not report reservoir storage prior to this report (2016) because a sufficiently detailed and thoroughly documented bathymetric (reservoir-bottom elevation) survey and corresponding stage-storage relation had not been published. A 2011 bathymetric survey with contours delineated at 5-foot intervals was published in Oklahoma Water Resources Board (2016), but that publication did not include a stage-storage relation table. The USGS, in cooperation with the City of Shawnee, performed a bathymetric survey of Shawnee Reservoir in 2016 and released the bathymetric-survey data in 2017 (Smith and others, 2017). The purposes of the bathymetric survey were to (1) develop a detailed bathymetric map of the reservoir and (2) determine the relations between stage and reservoir storage capacity and between stage and reservoir surface area. The bathymetric map may serve as a baseline to which temporal changes in storage capacity, due to sedimentation and other factors, can be compared. The stage-storage relation may be used in the reporting of real-time Shawnee Reservoir storage capacity at USGS station 07241600 to support water-resource management decisions by the City of Shawnee.

Methods

Raw bathymetric-survey data (water-depth and position measurements) were collected by using methods described by Wilson and Richards (2006) and Mueller and others (2013). These data were collected for the area where land-surface elevations are generally below 1,072 ft and on selected fair-weather days during the study period of June 21–September 7, 2016. The commercial hydrographic software HYPACK (HYPACK, Inc., 2016) was used to create transect lines to be followed during the survey. Bathymetric-survey data were collected along primary transects aligned parallel to the dam and separated by 100 ft, which is approximately 1 percent of the longitudinal length of each of the lakes. Control transects were aligned at 45 degrees from the primary transects and separated by 500 ft. Additional transects were added as needed to increase data resolution in areas with important lake-bottom features (such as submerged roads) or steep lake-bottom slopes (such as the upstream face of the dam).

Most water-depth measurements were made from a flat-bottom boat by using an Odom Hydrographic Systems Echotrac CV100 single-beam echo sounder with a dual frequency 200-kilohertz transducer (Odom Hydrographic Systems, Inc., 2008). Supplemental water-depth measurements were collected by using a kayak-towed Teledyne RD Instruments RiverRay acoustic Doppler current profiler (ADCP; Teledyne RD Instruments, 2016) in Shawnee City Lake Number 2 west of Walker Road (NS 331, fig. 1) because that area (see area enclosed by 1,072 contour in fig. 1) was inaccessible by the flat-bottom boat. Smaller isolated areas on both lakes could not be surveyed by ADCP because they were too remote or too shallow to be accessible by kayak. The area surveyed by ADCP was about 1.6 percent of the total area surveyed by flat-bottom boat and kayak.

Water-depth measurements were converted to NAVD 88 bathymetric-survey elevation data during post-processing. Water-depth measurements were subtracted from a daily mean water-surface elevation at USGS station 07241600 located on the intake tower of Shawnee City Lake Number 1. The daily mean water-surface elevation, which was assumed to be constant for all areas of Shawnee Reservoir, was calculated from beginning-of-day and end-of-day manual staff-plate measurements. These measurements never differed by more than 0.03 ft on any day, though the measurements ranged from about 1,074.3 to 1,075.4 ft during the study period. The station datum (NAVD 88) was established by using static global navigation satellite systems (GNSS) techniques (Rydlund and Densmore, 2012) over two control points, reference mark 1 (RM1) and reference mark 3 (RM3) (fig. 1). RM1 is a chiseled square on the eastern wing wall of the auxiliary spillway, 15 ft north of the centerline of Belcher Road; RM3 is a stainless-steel concrete anchor bolt with a stainless-steel washer stamped "USGS Survey Marker" on the western wing wall of the auxiliary spillway, 15 ft south of the centerline of Belcher Road (fig. 1). Each control point had a minimum 4-hour static GNSS occupation which was processed by using the National Geodetic Survey Online Positioning User Service (OPUS; National Geodetic Survey, 2016), resulting in time-weighted average elevations of 1,085.82 ft (RM1) and 1,085.62 ft (RM3). The estimated uncertainty of these static observations was 0.03 ft on the basis of a differential level survey between the independent points. Differential levels were also run from RM1 to the staff plate located on the intake tower and the USGS standard wire-weight gage mounted to the handrail of the intake tower to ensure that both were reading correctly in gage datum (NAVD 88).

During the bathymetric survey, position was measured by using a differentially corrected Global Positioning System (DGPS) mounted directly above the single-beam echo sounder and ADCP. The positional accuracy of the DGPS data collected at 2 hertz was 1.97 ft 95 percent of the time (Hemisphere GNSS, Inc., 2013). The hydrographic software utilized the time provided by the DGPS to synchronize data from the echo sounder or ADCP and eliminate system latency.

Bathymetric-survey data were compiled in a geographic information system (GIS) by using Esri ArcGIS 10.3.1 software and processed by using methods described by Wilson and Richards (2006). Breaklines were generated to reinforce linear features such as submerged stream channels and roads. Contours generated from lidar-derived land-surface elevation data (U.S. Geological Survey, 2016c) were used to extend the bathymetric survey to cover areas inundated only during floods. Bathymetric-survey data, breaklines, and lidar-derived land-surface contours were combined and modeled as a triangulated irregular network (TIN) by using the "Create TIN" tool (Esri, Inc., 2016a). The TIN was converted to a 4-ft-resolution digital elevation model (DEM) by using the "TIN To Raster" tool (Esri, Inc., 2016b). Bathymetric contours at 1-ft intervals (fig. 1) were derived from the DEM by using the "Contour" tool (Esri, Inc., 2016c) and smoothed for cartographic representation at a 1:10,000 scale by using the "Smooth Line" tool (Esri, Inc., 2016d). The bathymetric contours with values between 1,072 and 1,080 ft were generated primarily from lidar-derived land-surface elevation data (U.S. Geological Survey, 2016c), and contours with values less than 1,072 ft were generated primarily from bathymetric-survey data. A stage-storage and stage-area data table (table 1) was derived from the DEM for 1-ft stage increments by using the "Surface Volume" tool (Esri, Inc., 2016e). The stage-storage and stage-area relations are graphically represented in figure 2A and figure 2B, respectively, by using data from table 1.

Quality Assurance

Accuracy of the bathymetric surface and derived contours is a function of the survey data accuracy, survey data density (transect interval and data-collection frequency), and the processing steps that occur during creation of the bathymetric surface and contours (Wilson and Richards, 2006). Survey data accuracy is also dependent on factors such as vessel draft, platform stability, vessel velocity, and subsurface material density (Wilson and Richards, 2006). According to the manufacturer's specifications, the survey-grade echo sounder used in this study had a resolution of better than 0.1 ft for depths less than 600 ft and an accuracy of ±0.1 percent (Odom Hydrographic, 2008). A hand-held sound velocimeter (Odom Hydrographic Systems, Inc., 2001) was used to measure the speed of sound through the water column, and bar checks were performed daily to calibrate the single-beam echo sounder (U.S. Army Corps of Engineers, 2013) to two known depths (at about 5 ft and about 30 ft) in the water column. These depths were chosen to span the expected range of most water-depth measurements. Vessel speed was kept at less than 5 ft per second to ensure adequate point spacing (U.S. Army Corps of Engineers, 2013).

For locations where primary-transect bathymetric-survey elevation data were coincident with (that is, within 1 ft of) control-transect bathymetric-survey elevation data, the data were compared to evaluate the internal precision of bathymetric-survey elevation data. The internal precision (calculated at the 95-percent confidence level; Wilson and Richards, 2006) was 0.46 ft. About 100 percent of primary bathymetric-survey elevation data were within 1 ft of coincident control bathymetric-survey elevation data, and about 96 percent of primary bathymetric-survey elevation data were within 0.5 ft of coincident control bathymetric-survey elevation data. Bathymetric-survey elevation data from both primary and control transects were compared to lidar-derived land-surface elevation data (U.S. Geological Survey, 2016c) in areas where the two datasets overlapped, generally at elevations 1,068–1,073 ft, to evaluate the accuracy of bathymetric-survey elevation data. About 91 percent of bathymetric-survey elevation data points were within 1 ft of coincident lidar-derived land-surface elevation data points, and about 73 percent of bathymetric-survey elevation data points were within 0.5 ft of coincident lidar-derived land-surface elevation data points. As compared to the lidar-derived land-surface elevation data, the bathymetric-survey elevation data had a vertical root-mean-square error (RMSE; Wilson and Richards, 2006) of 0.59 ft and a vertical accuracy (calculated at the 95-percent confidence level; Wilson and Richards, 2006) of 1.16 ft; however, the lidar point-cloud data were not available, and this accuracy assessment compared bathymetric-survey elevation data points to topographic-survey elevation values summarized over about a 10-ft square area (the cell size of the lidar surface) and placed at the center of each cell of the lidar surface.

Results

The minimum bathymetric-survey elevation of Shawnee City Lake Number 1 was 1,026.4 ft, which corresponds to a normal-pool maximum depth of 42.6 ft. The minimum bathymetric-survey elevation of Shawnee City Lake Number 2 was 1,037.7 ft, which corresponds to a normal-pool maximum depth of 31.3 ft. Because of the spacing of the survey transects (100 ft), lake-bottom features with a maximum dimension less than 100 ft generally could not be resolved by this bathymetric survey. Some submerged stream channels, however, were clearly visible in the bathymetric-survey data. Several submerged roads were also identified, including continuations of Patterson Road (NS 332) and Lake Road (EW 116) in Shawnee City Lake Number 1 and McCloud Road (NS 332) and Pecan Grove Road (Lake Drive) in Shawnee City Lake Number 2 (fig. 1). Additionally, a small berm was identified about 0.3 miles west of the intake tower in Shawnee City Lake Number 2, and a large berm was identified extending southwest from the intake tower of Shawnee City Lake Number 1 (fig. 1).

According to the 2016 bathymetric survey, the storage capacity of Shawnee Reservoir was 22,096 acre-feet (acre-ft) at the normal-pool stage of 1,069.0 ft and 33,220 acre-ft at the flood-pool stage of 1,075.0 ft (table 1). The storage capacity of Shawnee City Lake Number 1 in 2016 was 15,234 acre-ft at the normal-pool stage of 1,069.0 ft and 22,336 acre-ft at the flood-pool stage of 1,075.0 ft (table 1). The storage capacity of Shawnee City Lake Number 2 in 2016 was 6,863 acre-ft at the normal-pool stage of 1,069.0 ft and 10,884 acre-ft at the flood-pool stage of 1,075.0 ft (table 1).

Summary

The U.S. Geological Survey, in cooperation with the City of Shawnee, performed a detailed bathymetric survey of Shawnee Reservoir (locally known as Shawnee Twin Lakes) in Oklahoma during June 21–September 7, 2016. The purposes of the bathymetric survey were to (1) develop a detailed bathymetric map of the reservoir and (2) determine the relations between stage and reservoir storage capacity and between stage and reservoir surface area. The bathymetric map may serve as a baseline to which temporal changes in storage capacity can be compared. The stage-storage relation may be used in the reporting of real-time Shawnee Reservoir storage capacity at U.S. Geological Survey station 07241600 to support water-resource management decisions by the City of Shawnee. According to the 2016 bathymetric survey, the storage capacity of Shawnee Reservoir was 22,096 acre-feet at the normal-pool stage of 1,069.0 feet above North American Vertical Datum of 1988 and 33,220 acre-feet at the flood-pool stage of 1,075.0 feet above North American Vertical Datum of 1988.

References

Esri, Inc., 2016a, ArcGIS for desktop help—Create TIN tool: Esri Web page, accessed October 25, 2016, at http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/create-tin.htm.

Esri, Inc., 2016b, ArcGIS for desktop help—TIN To Raster tool: Esri Web page, accessed October 25, 2016, at http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/tin-to-raster.htm.

Esri, Inc., 2016c, ArcGIS for desktop help—Contour tool: Esri Web page, accessed October 25, 2016, at http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/contour.htm.

Esri, Inc., 2016d, ArcGIS for desktop help—Smooth Line tool: Esri Web page, accessed October 25, 2016, at http://desktop.arcgis.com/en/arcmap/10.3/tools/cartography-toolbox/smooth-line.htm.

Esri, Inc., 2016e, ArcGIS for desktop help—Surface Volume tool: Esri Web page, accessed October 25, 2016, at http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/surface-volume.htm.

Hemisphere GNSS, Inc., 2013, A101 Smart Antenna user guide: Scottsdale, Ariz., Hemisphere GNSS, Inc., 34 p.

HYPACK, Inc., 2016, HYPACK® Hydrographic survey software user's manual: Middletown, Conn., 2200 p.

Mueller, D.S., Wagner, C.R., Rehmel, M.S., Oberg, K.A., and Rainville, Francois, 2013, Measuring discharge with acoustic Doppler current profilers from a moving boat (ver. 2.0, December 2013): U.S. Geological Survey Techniques and Methods, book 3, chap. 22.

National Geodetic Survey, 2016, OPUS—Online Positioning User Service: National Geodetic Survey Web page, accessed July 2016 at https://www.ngs.noaa.gov/OPUS/.

Odom Hydrographic Systems, Inc., 2001, DIGIBAR-Pro Profiling Sound Velocimeter Operation Manual: Baton Rouge, La., Odom Hydrographic Systems, Inc., 29 p., accessed July 2016 at http://www.odomhydrographic.com/wp-content/uploads/2014/01/DIGIBAR-Pro-user-manual1.pdf.

Odom Hydrographic Systems, Inc., 2008, Echotrac CV100 User Manual version 4.04: Baton Rouge, La., Odom Hydrographic Systems, Inc., 43 p., accessed July 2016 at http://www.odomhydrographic.com/wp-content/uploads/2013/12/Echotrac-CV100-user-manual.pdf.

Oklahoma Water Resources Board, 2016, Bathymetric lake studies: Oklahoma Water Resources Board Web page, accessed September 14, 2016, at http://www.owrb.ok.gov/maps/pmg/owrbdata_Bathy.html.

Rydlund, P.H., Jr., and Densmore, B.K., 2012, Methods of practice and guidelines for using survey-grade global navigation satellite systems (GNSS) to establish vertical datum in the United States Geological Survey: U.S. Geological Survey Techniques and Methods, book 11, chap. D1, 102 p. with appendixes.

Smith, S.J., Ashworth, C.E., and Smith, K.A., 2017, Bathymetry and capacity of Shawnee Reservoir, Oklahoma, 2016: U.S. Geological Survey Data Release, accessed January 16, 2017, at https://doi.org/10.5066/F728056C.

Teledyne RD Instruments, 2016, RiverRay ADCP datasheet: Teledyne RD Instruments, Poway, Calif., 2 p., accessed July 2016 at http://rdinstruments.com/__documents/riverray_datasheet_lr.pdf.

U.S. Army Corps of Engineers, 2013, Engineering and design—Hydrographic surveying: Washington, D.C., U.S. Army Corps of Engineers, manual no. EM 1110–2–1003, 684 p. [Also available at http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1003.pdf?ver=2014-01-06-155809-307.]

U.S. Board on Geographic Names, 2016, Geographic Names Information System (GNIS): U.S. Board on Geographic Names, accessed September 14, 2016, at http://geonames.usgs.gov/domestic/.

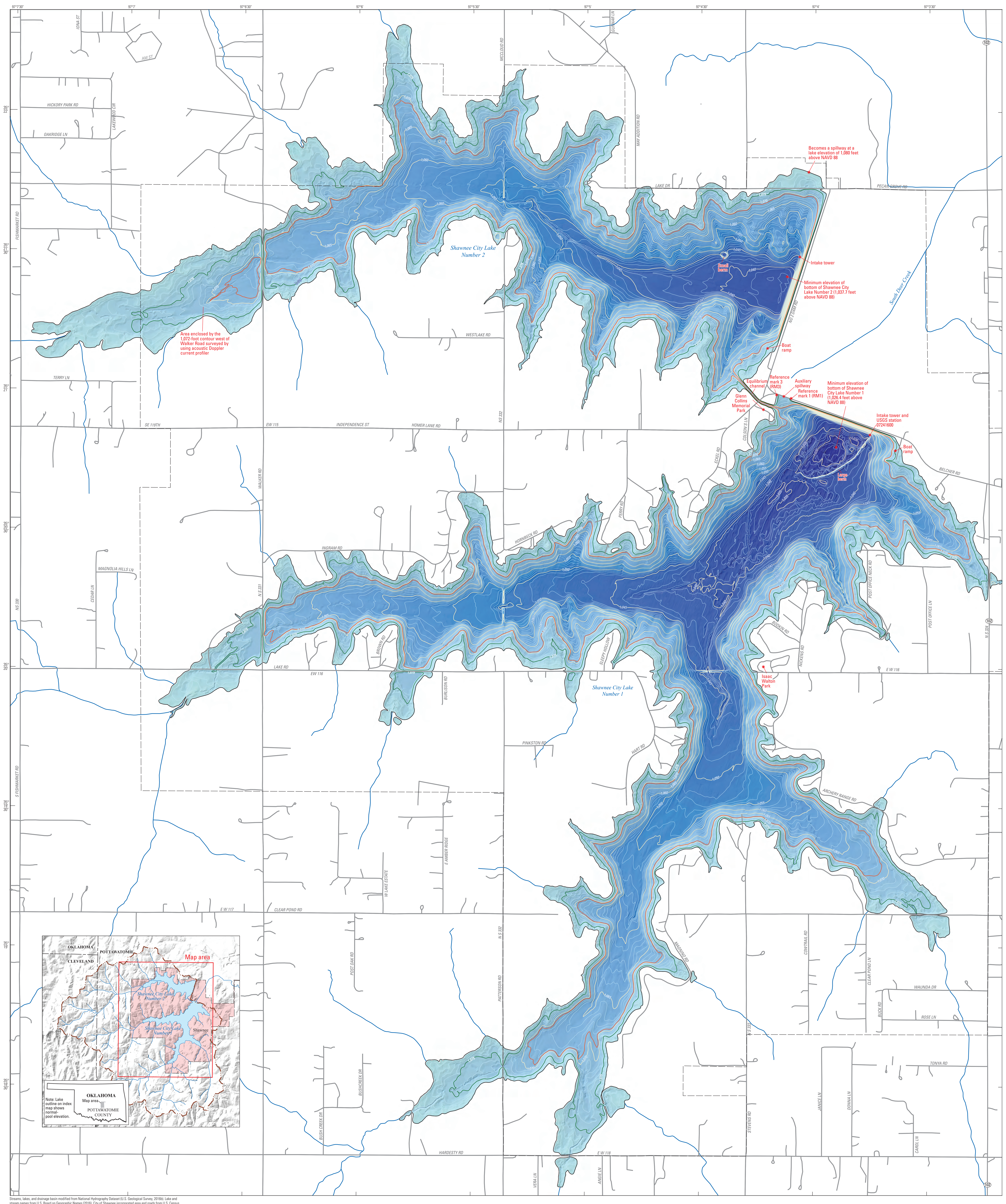
U.S. Census Bureau, 2016, TIGER/Line Shapefiles and TIGER/Line Files: U.S. Census Bureau database, accessed September 14, 2016, at http://www.census.gov/geo/maps-data/data/tiger-line.html.

U.S. Geological Survey, 2016a, National Water Information System—Web Interface: U.S. Geological Survey database, accessed September 14, 2016, at http://dx.doi.org/10.5066/F7P55KJN.

U.S. Geological Survey, 2016b, National Hydrography Dataset: U.S. Geological Survey database, accessed September 14, 2016, at http://nhd.usgs.gov/data.html.

U.S. Geological Survey, 2016c, National Elevation Dataset (NED) 1/9 arc-second: U.S. Geological Survey database, accessed September 14, 2016, at http://viewer.nationalmap.gov/basic/?basemap=b1&category=ned&q=&zoom=14&bbox=-97.13793755,35.31099293,-97.04240799,35.36700562&preview=&avail=DEM 1/9 arc-second.

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 2006–5208, 24 p. [Also available at https://pubs.usgs.gov/sir/2006/5208/.]



Streams, lakes, and drainage basin modified from National Hydrography Dataset (U.S. Geological Survey, 2016b). Lake and stream names from U.S. Board on Geographic Names (2016). City of Shawnee incorporated area and roads from U.S. Census Bureau (2016). Coordinate Reference System: Oklahoma State Plane South Projection, North American Datum of 1983.

Figure 1. Bathymetric map of Shawnee Reservoir, Oklahoma, 2016.

Table 1. Storage capacity and surface area at selected stages, Shawnee Reservoir, Oklahoma, 2016.

[NAVD 88, North American Vertical Datum of 1988. Values are rounded to the nearest acre-foot or acre. Columns may not sum to total because of rounding]

Stage (water-surface elevation; feet above NAVD 88)	Shawnee City Lake Number 1		Shawnee City Lake Number 2		Shawnee Reservoir (total)	
	Storage capacity (acre-feet)	Surface area (acres)	Storage capacity (acre-feet)	Surface area (acres)	Storage capacity (acre-feet)	Surface area (acres)
[1]1,027.0	0	0	0	0	0	0
1,028.0	1	2	0	0	1	2
1,029.0	3	4	0	0	3	4
1,030.0	9	7	0	0	9	7
1,031.0	18	10	0	0	18	10
1,032.0	30	14	0	0	30	14
1,033.0	46	18	0	0	46	18
1,034.0	65	21	0	0	65	21
1,035.0	91	31	0	0	91	31
1,036.0	129	46	0	0	129	46
1,037.0	183	62	0	0	183	62
1,038.0	253	80	0	2	253	81
1,039.0	344	102	8	14	352	116
1,040.0	456	123	26	25	483	147
1,041.0	591	145	56	35	647	180
1,042.0	746	166	96	46	843	212
1,043.0	926	195	147	55	1,073	250
1,044.0	1,133	218	208	69	1,341	287
1,045.0	1,362	240	282	79	1,645	320
1,046.0	1,614	262	367	90	1,981	352
1,047.0	1,888	285	462	101	2,350	386
1,048.0	2,183	308	569	114	2,753	422
1,049.0	2,504	333	690	128	3,195	461
1,050.0	2,850	360	824	140	3,675	501
1,051.0	3,224	387	971	154	4,196	541
1,052.0	3,624	410	1,133	170	4,757	580
1,053.0	4,044	431	1,310	184	5,354	616
1,054.0	4,490	464	1,501	198	5,992	661
1,055.0	4,971	497	1,707	213	6,678	710
1,056.0	5,484	529	1,929	231	7,412	760
1,057.0	6,029	560	2,169	249	8,198	809
1,058.0	6,602	587	2,427	268	9,030	855
[2]1,059.0	7,203	614	2,706	289	9,909	904
1,060.0	7,832	644	3,007	314	10,839	958
1,061.0	8,492	676	3,332	336	11,824	1,012
1,062.0	9,186	711	3,678	357	12,864	1,068
1,063.0	9,915	749	4,046	380	13,961	1,128
1,064.0	10,684	790	4,438	403	15,122	1,193
1,065.0	11,495	833	4,854	431	16,349	1,264
1,066.0	12,352	883	5,304	468	17,656	1,352
1,067.0	13,262	936	5,791	505	19,052	1,440
1,068.0	14,224	987	6,311	536	20,535	1,523
[3]1,069.0	15,234	1,032	6,863	568	22,096	1,600
1,070.0	16,289	1,077	7,446	599	23,735	1,676
1,071.0	17,390	1,126	8,059	628	25,449	1,754
1,072.0	18,542	1,191	8,704	671	27,246	1,862
1,073.0	19,758	1,243	9,396	712	29,154	1,955
1,074.0	21,021	1,293	10,123	745	31,144	2,038
[4]1,075.0	22,336	1,347	10,884	789	33,220	2,136
1,076.0	23,707	1,401	11,692	838	35,399	2,238
1,077.0	25,136	1,466	12,552	889	37,687	2,356
[5]1,078.0	26,632	1,536	13,463	941	40,095	2,477
1,079.0	28,200	1,606	14,427	995	42,627	2,601
1,080.0	29,836	1,657	15,445	1,033	45,280	2,690

[1]Shawnee Reservoir minimum bottom elevation was 1,026.4 feet above NAVD 88.
[2]Approximate minimum stage of record (1,059.1 feet above NAVD 88, April 10–11, 2007).
[3]Normal-pool elevation.
[4]Auxiliary-spillway and flood-pool elevation.
[5]Approximate maximum stage of record (1,078.1 feet above NAVD 88, May 24, 2015).

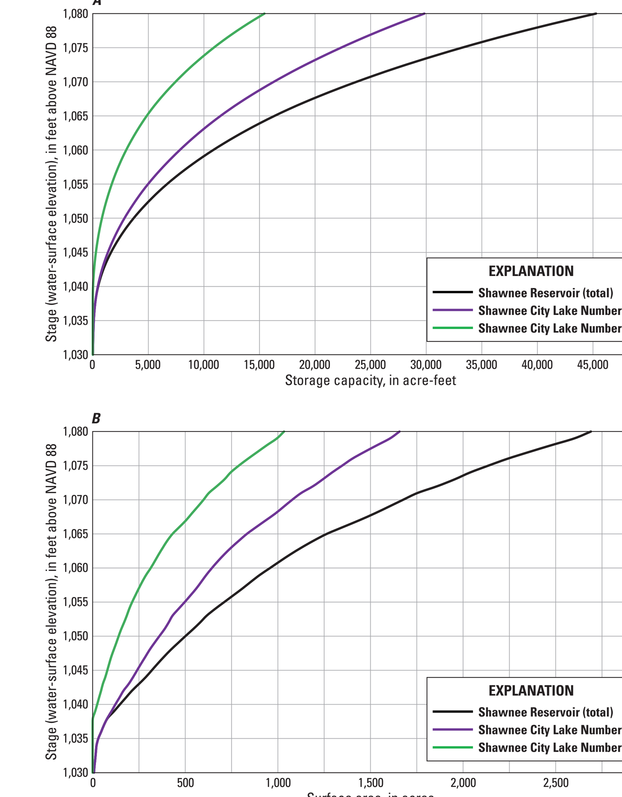


Figure 2. Graphs showing *A*, stage-storage relation and *B*, stage-area relation for Shawnee Reservoir, Oklahoma, 2016.

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

ADCP	acoustic Doppler current profiler
DEM	digital elevation model
DGPS	differentially corrected Global Positioning System
GIS	geographic information system
GNSS	global navigation satellite system
OPUS	National Geodetic Survey Online Positioning User Service
RMSE	root-mean-square error
TIN	triangulated irregular network
USGS	U.S. Geological Survey

Suggested citation:
Ashworth, C.E., Smith, S.J., and Smith, K.A., 2017, Bathymetry and capacity of Shawnee Reservoir, Oklahoma, 2016: U.S. Geological Survey Scientific Investigations Map 3374, 1 sheet, https://doi.org/10.3133/sim3374.

Printed on recycled paper

ISSN 2329-1311 (print)
ISSN 2329-132X (online)
ISBN 978-1-4113-4111-1
https://doi.org/10.3133/sim3374

ISBN 7-978-4113-4111-1

Bathymetry and Capacity of Shawnee Reservoir, Oklahoma, 2016

By
Chad E. Ashworth, S. Jerrod Smith, and Kevin A. Smith
2017