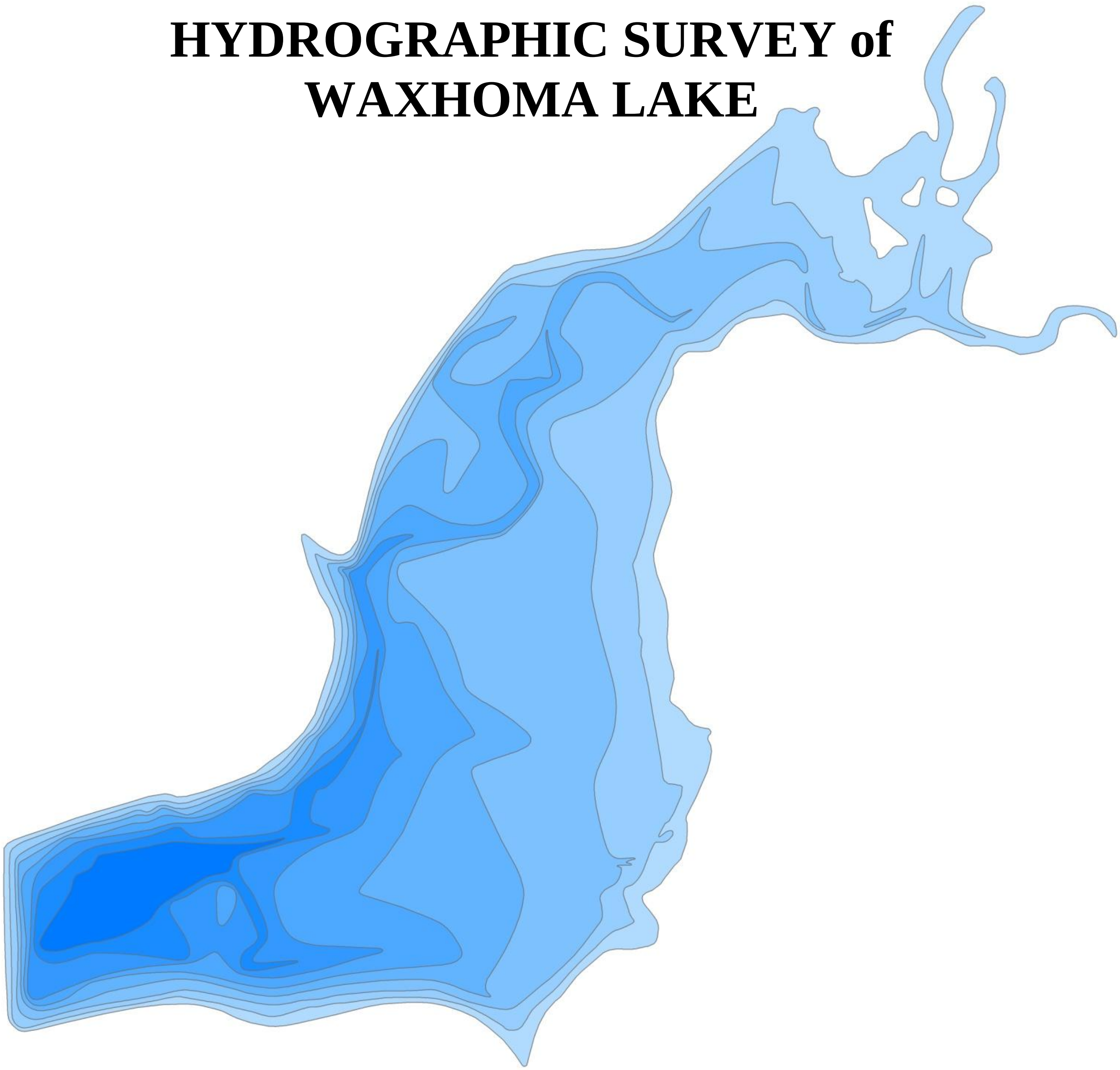
HYDROGRAPHIC SURVEY of WAXHOMA LAKE



Final Report

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State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

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WAXHOMA LAKE
HYDROGRAPHIC SURVEY REPORT

INTRODUCTION

The Oklahoma Water Resources Board (OWRB) conducted a hydrographic survey of Waxhoma Lake in August of 2011. The purpose of this survey was to collect hydrographic data of the lake and convert this information into an elevation-area-capacity table. This project was funded by the OWRB's Dam Safety Program.

LAKE BACKGROUND

Waxhoma Lake is located on Little Dog Thresher Creek in Osage County (**Figure 1**). The dam was completed in 1955 and is located approximately three miles east of the city of Barnsdall, OK. Its purposes are water supply, and recreation. The dam on this reservoir is classified as a high hazard dam. The "high hazard" classification means that dam failure, if it occurred, may cause loss of life, serious damage to homes, industrial or commercial buildings, important public utilities, main highways or railroads. This classification does not mean that it is likely to fail.

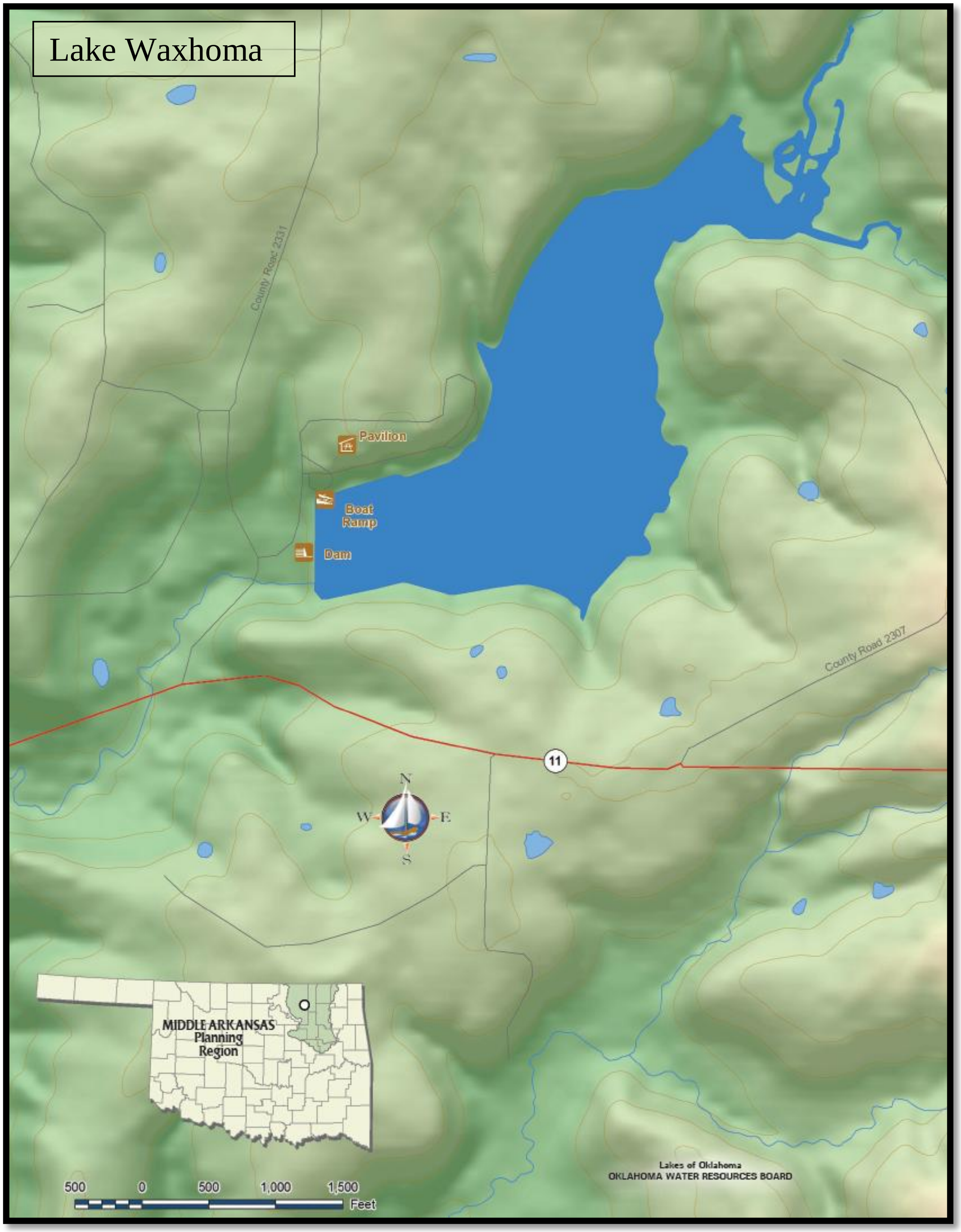


Figure 1: Location map for Waxhoma Lake.

HYDROGRAPHIC SURVEYING PROCEDURES

The process of surveying a reservoir uses a combination of Geographic Positioning System (GPS) and acoustic depth sounding technologies that are incorporated into a hydrographic survey vessel. As the survey vessel travels across the lake's surface, the echosounder gathers multiple depth readings every second. The depth readings are stored on the survey vessel's on-board computer along with the positional data generated from the vessel's GPS receiver. The collected data files are downloaded daily from the computer and brought to the office for editing. During editing, data "noise" is removed or corrected, and average depths are converted to elevation readings based on the daily-recorded lake level elevation on the day the survey was performed. Accurate estimates of area-capacity can then be determined for the lake by building a 3-D model of the reservoir from the corrected data. The process of completing a hydrographic survey includes four steps: pre-survey planning, field survey, data processing, and GIS application.

Pre-survey Planning

Boundary File

The boundary file for Waxhoma Lake was on-screen digitized from the 2006 color digital orthoimagery quarter quadrangle (DOQQ) mosaic of Osage County, Oklahoma. The screen scale was set to 1:1,500. A line was to represent the shoreline as closely as possible. Due to the photography being a summer photo, it was difficult to determine the actual shoreline when there are trees and other vegetation hanging over the lake. The 2008 and 2010 DOQQs of the lakes were used as back ground reference. The reservoir boundaries were digitized in NAD 1983 State Plane Coordinates (Oklahoma North-3501).

Set-up

HYPACK software from Hypack, Inc. was used to assign geodetic parameters, import background files, and create virtual track lines (transects). The geodetic parameters assigned were State Plane NAD 83 Zone OK-3501 Oklahoma North with distance units and depth as US Survey Feet. The survey transects were spaced according to the accuracy required for the project. The survey transects within the digitized reservoir boundary were at 300 ft increments and ran perpendicular to the original stream channels and tributaries. Approximately 24 virtual transects were created for Waxhoma Lake.

Field Survey

Lake Elevation Acquisition

The lake elevation for Waxhoma Lake was obtained by collecting positional data over a period of approximately 179 minutes with a survey-grade Global Positioning System (GPS) receiver. The receiver was placed over the water's surface. A measurement was taken from the antenna to the surface of the water. The collected data and antenna height was then uploaded to the On-line Positioning Users Service (OPUS) website. The National Geodetic Survey (NGS) operates OPUS as a means to provide GPS users easier access to the National Spatial Reference System (NSRS). OPUS allows users to submit their GPS data files to NGS, where the data is processed to determine a position using NGS computers and software. Calculated coordinates are averaged from three independent single-baseline solutions computed by double-differenced, carrier-phase measurements between the collected data file and 3 surrounding Continuously Operating Reference Stations (CORS). Under ideal conditions, OPUS can easily resolve most positions to within centimeter accuracy. A report containing the newly calculated positional data was electronically returned via email. This report contained the elevation of the surface of the water corrected for the antenna height.

Method

The procedures followed by the OWRB during the hydrographic survey adhere to U.S. Army Corps of Engineers (USACE) standards (USACE, 2002). The quality control and quality assurance procedures for equipment calibration and operation, field survey, data processing, and accuracy standards are presented in the following sections.

Technology

The Hydro-survey vessel is an 18-ft aluminum Silverstreak hull with cabin, powered by a single 115-Horsepower Mercury outboard motor. Equipment used to conduct the survey included: a ruggedized notebook computer; Innerspace 456Xpe Echo Sounder, with a depth resolution of 0.1 ft; Trimble Navigation, Inc. Pro XR GPS receiver with differential global positioning system (DGPS) correction; and an Odom Hydrographics, Inc, DIGIBAR-Pro Profiling Sound Velocimeter. The software used was HYPACK.

Survey

A two-man survey crew was used during the project. Data collection for Waxhoma Lake occurred in August of 2011. The water level elevation for Waxhoma Lake was 766.5 ft Geodetic Vertical Datum (NAVD88). Data collection began at the dam and moved upstream. The survey crew followed the parallel transects created during the pre-survey planning while collecting depth soundings and positional data. Data was also collected along a path parallel to the shoreline at a distance that was determined by the depth of the water and the draft of the boat – generally, two to three feet deep. Areas with depths less than this were avoided.

Quality Control/Quality Assurance

While on board the Hydro-survey vessel, a sound velocity profile was collected each day using a DIGIBAR-Pro Profiling Sound Velocimeter, by Odom Hydrographics. The sound velocimeter measures the speed of sound at incremental depths throughout the water column. The factors that influence the speed of sound—depth, temperature, and salinity—are all taken into account. Deploying the unit involved lowering the probe, which measures the speed of sound, into the water to the calibration depth mark to allow for acclimation and calibration of the depth sensor. The unit was then gradually lowered at a controlled speed to a depth just above the lake bottom, and then was raised to the surface. The unit collected sound velocity measurements in feet/seconds (ft/sec) at 1 ft increments on both the deployment and retrieval phases. The data was then reviewed for any erroneous readings, which were then edited out of the sample. The sound velocity corrections were then applied to the to the raw depth readings.

A quality assurance cross-line check was performed on intersecting transect lines and channel track lines to assess the estimated accuracy of the survey measurements. The overall accuracy of an observed bottom elevation or depth reading is dependent on random and systematic errors that are present in the measurement process. Depth measurements contain both random errors and systematic bias. Biases are often referred to as systematic errors and are often due to observational errors. Examples of bias include a bar check calibration error, tidal errors, or incorrect squat corrections. Bias, however, does not affect the repeatability, or precision, of results. The precision of depth readings is affected by random errors. These are errors present in the measurement system that cannot be easily reduced by further calibration. Examples of random error include uneven bottom topography, bottom vegetation, positioning error, extreme listing of survey vessel, and speed of sound variation in the water column. An assessment of the accuracy of an individual depth or bottom elevation must fully consider all the error components contained in the observations that were used to determine that measurement. Therefore, the ultimate accuracy must be estimated (thus the use of the term "estimated accuracy") using statistical estimating measures (USACE, 2002).

The depth accuracy estimate is determined by comparing depth readings taken at the intersection of two lines and computing the difference. This is done on multiple intersections. The mean difference of all intersection points is used to calculate the mean difference (MD). The mean difference represents the bias present in the survey. The standard deviation (SD), representing the random error in the survey, is also calculated. The mean difference and the standard deviation are then used to calculate the Root Mean Square (RMS) error. The RMS error estimate is used to compare relative accuracies of estimates that differ substantially in bias and precision (USACE, 2002). According the USACE standards, the RMS at the 95% confidence level should not exceed a tolerance of ± 2.0 ft for this type of survey. This simply means that on average, 19 of every 20 observed depths will fall within the specified accuracy tolerance.

HYPACK Cross Statistics program was used to assess vertical accuracy and confidence measures of acoustically recorded depths. The program computes the sounding difference between intersecting lines of single beam data. The program provides a report that shows the standard deviation and mean difference. A total of 54 cross-sections points at Waxhoma Lake were used to compute error estimates. A mean difference (arithmetic mean) of -0.025 ft and a standard deviation of 0.299 ft were computed from intersections. The following formulas were used to determine the depth accuracy at the 95% confidence level.

$$RMS = \sqrt{\sigma^2{}_{Randomerror} + \sigma^2{}_{Bias}}$$

where:

Random error = Standard deviation
Bias = Mean difference
RMS = root mean square error (68% confidence level)

and:

$$RMS\ (95\%)\ depth\ accuracy = 1.96 \times RMS(68\%)$$

An RMS of ± 0.59 ft with a 95% confidence level is less than the USACE's minimum performance standard of ± 2.0 ft for this type of survey. A mean difference, or bias, of -0.025

ft is well below the USACE's standard maximum allowable bias of ± 0.5 ft for this type of survey.

The GPS system is an advanced high performance geographic data-acquisition tool that uses DGPS to provide sub-meter positional accuracy on a second-by-second basis. Potential errors are reduced with differential GPS because additional data from a reference GPS receiver at a known position are used to correct positions obtained during the survey. Before the survey, Trimble's Pathfinder Controller software was used to configure the GPS receiver. To maximize the accuracy of the horizontal positioning, the horizontal mask setting was set to 15 degrees and the Position Dilution of Precision (PDOP) limit was set to 6. The position interval was set to 1 second and the Signal to Noise Ratio (SNR) mask was set to 4. The United States Coast Guard reference station used in the survey is located near Sallisaw, Oklahoma.

A latency test was performed to determine the fixed delay time between the GPS and single beam echo sounder. The timing delay was determined by running reciprocal survey lines over a channel bank. The raw data files were downloaded into HYPACK - LATENCY TEST program. The program varies the time delay to determine the "best fit" setting. A position latency of 0.4 seconds was produced and adjustments were applied to the raw data in the EDIT program.

Data Processing

The collected data was transferred from the field computer onto an OWRB desktop computer. After downloading the data, each raw data file was reviewed using the EDIT program within HYPACK. The EDIT program allowed the user to assign transducer offsets, latency corrections, tide corrections, display the raw data profile, and review/edit all raw depth information. Raw data files are checked for gross inaccuracies that occur during data collection.

Offset correction values of 3.2 ft. starboard, 6.6 ft. forward, and -1.1 ft. vertical were applied to all raw data along with a latency correction factor of 0.1 seconds. The speed of sound corrections were applied during editing of raw data.

A correction file was produced using the HYPACK TIDES program to account for the variance in lake elevation at the time of data collection. Within the EDIT program, the corrected depths were subtracted from the elevation reading to convert the depth in feet to an elevation.

After editing the data for errors and correcting the spatial attributes (offsets and tide corrections), a data reduction scheme was needed due to the large quantity of collected data.. To accomplish this, the corrected data was resampled spatially at a 5 ft interval using the Sounding Selection program in HYPACK. The resultant data was saved and exported out as a xyz.txt file. The HYPACK raw and corrected data files for Waxhoma Lake are located on the DVD entitled *FEMA 2011 Disk 2 HYPACK/GIS Metadata.*

GIS Application

Geographic Information System (GIS) software was used to process the edited XYZ data collected from the survey. The GIS software used was ArcGIS Desktop and ArcMap, version 9.3.1, from Environmental System Research Institute (ESRI). All of the GIS datasets created are in Oklahoma State Plane North Coordinate System referenced to the North American Datum 1983. Horizontal and vertical units are in feet. The edited data points in XYZ text file format were converted into ArcMap point coverage format. The point coverage contains the X and Y horizontal coordinates and the elevation and depth values associated with each collected point.

Volumetric and area calculations were derived using a Triangulated Irregular Network (TIN) surface model. The TIN model was created in ArcMap, using the collected survey data points and the lake boundary inputs. The TIN consists of connected data points that form a network of triangles representing the bottom surface of the lake. The lake volume was calculated by slicing the TIN horizontally into planes 0.1 ft thick. The cumulative volume and area of each slice are shown in **APPENDIX A: Area-Capacity Data.**

Contours, depth ranges, and the shaded relief map were derived from a constructed digital elevation model grid. This grid was created using the ArcMap Topo to Raster Tool and had a spatial resolution of five feet. A low pass 3x3 filter was run to lightly smooth the grid to improve contour generation. The contours were created at a 5-ft interval using the ArcMap Contour Tool. The contour lines were edited to allow for polygon topology and to improve accuracy and general smoothness of the lines. The contours were then converted to a polygon coverage and attributed to show 5-ft depth ranges across the lake. The bathymetric maps of the lakes are shown with 5-ft contour intervals in **APPENDIX B: Waxhoma Lake** Maps.

All geographic datasets derived from the survey contain Federal Geographic Data Committee (FGDC) compliant metadata documentation. The metadata describes the procedures and commands used to create the datasets. The GIS metadata file for both lakes is located at on the DVD entitled *FEMA 2011 Disk 2 HYPACK/GIS Metadata.*

RESULTS

Results from the 2011 OWRB survey indicate that Waxhoma Lake encompasses 128 acres and contains a cumulative capacity of 1,832 ac-ft at the normal pool elevation (768 ft NAVD88). The average depth for Waxhoma Lake was 14.31 ft.

SUMMARY and COMPARISON

Table 1 is a comparison of area and volume changes of Waxhoma Lake at the normal pool elevation. Based on the design specifications, Waxhoma Lake had an area of 140 acres and cumulative volume of 2,000 acre-feet of water at conservation pool elevation (768 ft NAVD88). The surface area of the lake has had an increase of 12 acres or approximately 8.6%. The 2011 survey shows that Waxhoma Lake has had an apparent decrease in capacity of 8.4% or approximately 168 acre-feet. Caution should be used when directly comparing between the design specifications and the 2011 survey conducted by the OWRB because different methods were used to collect the data and extrapolate capacity and area figures. This could account for the apparent loss in capacity. It is the recommendation of the OWRB that another survey using the same method used in the 2011 survey be conducted in 10-15 years. By using the 2011 survey figures as a baseline, a future survey would allow an accurate sedimentation rate to be obtained.

Table 1: Area and Volume Comparisons of Waxhoma Lake at normal pool (768 ft NAVD88).

Feature	Survey Year	
	1955 Design Specifications	2011
Area (acres)	140	128
Cumulative Volume (acre-feet)	2,000	1,832
Mean depth (ft)	14.29	14.31
Maximum Depth (ft)	--	39.89

REFERENCES

U.S. Army Corps of Engineers (USACE). 2002. Engineering and Design - Hydrographic Surveying, Publication EM 1110-2-1003, 3rd version.

Oklahoma Water Resources Board (OWRB). 1978. Phase 1 Inspection Report; National Dam Safety Program.

Oklahoma Water Resources Board (OWRB). 2010. Lakes of Oklahoma.

APPENDIX A: Area-Capacity Data

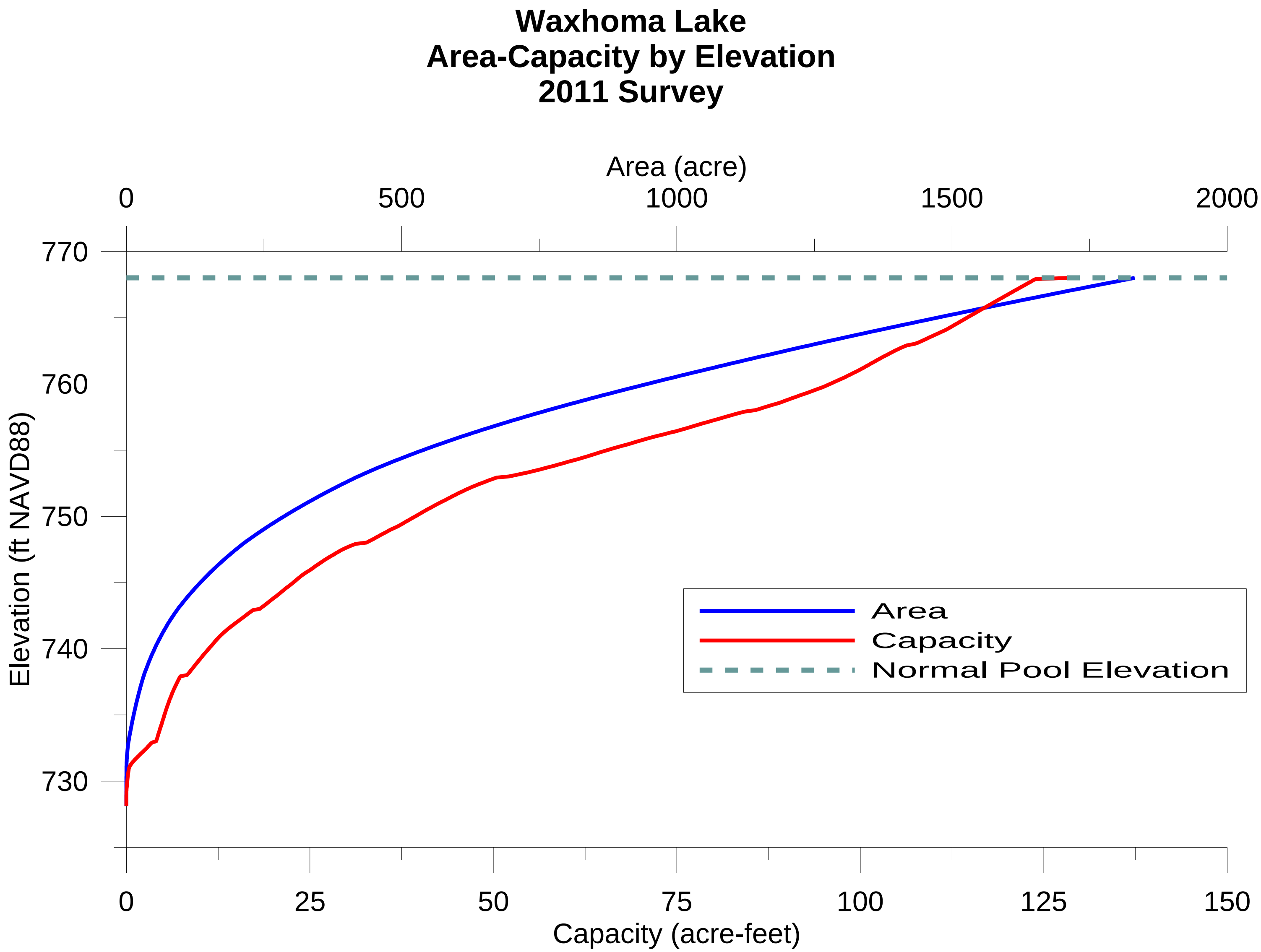
Table A. 1: Waxhoma Lake Capacity/Area by 0.1-ft Increments.

WAXHOMA LAKE AREA-CAPACITY TABLE OKLAHOMA WATER RESOURCES BOARD 2011 Survey Capacity in acre-feet by tenth foot elevation increments Area in acres by tenth foot elevation increments											
Elevation (ft NAVD 88)		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
728	Area	0.0000	0.0000	0.0003	0.0009	0.0017	0.0025	0.0034	0.0045	0.0057	0.0080
	Capacity	0.0000	0.0000	0.0000	0.0001	0.0002	0.0004	0.0007	0.0011	0.0016	0.0023
729	Area	0.0113	0.0160	0.0228	0.0320	0.0430	0.0556	0.0693	0.0842	0.1001	0.1167
	Capacity	0.0032	0.0046	0.0065	0.0092	0.0130	0.0179	0.0241	0.0318	0.0410	0.0518
730	Area	0.1339	0.1518	0.1703	0.1895	0.2094	0.2299	0.2512	0.2769	0.3039	0.3365
	Capacity	0.0644	0.0786	0.0947	0.1127	0.1327	0.1546	0.1787	0.2050	0.2341	0.2660
731	Area	0.3898	0.4725	0.5727	0.6948	0.8380	0.9954	1.1603	1.3324	1.5091	1.6897
	Capacity	0.3021	0.3450	0.3972	0.4603	0.5368	0.6283	0.7361	0.8607	1.0028	1.1627
732	Area	1.8716	2.0607	2.2588	2.4468	2.6269	2.8012	2.9694	3.1356	3.3102	3.4938
	Capacity	1.3408	1.5373	1.7534	1.9888	2.2425	2.5141	2.8026	3.1080	3.4301	3.7703
733	Area	4.0688	4.1276	4.1836	4.2397	4.2963	4.3528	4.4084	4.4630	4.5175	4.5739
	Capacity	4.1332	4.5430	4.9588	5.3799	5.8067	6.2393	6.6774	7.1212	7.5701	8.0246
734	Area	4.6320	4.6905	4.7507	4.8087	4.8659	4.9222	4.9778	5.0336	5.0906	5.1478
	Capacity	8.4851	8.9512	9.4235	9.9014	10.385	10.875	11.370	11.871	12.377	12.889
735	Area	5.2044	5.2606	5.3170	5.3742	5.4343	5.4948	5.5564	5.6187	5.6824	5.7473
	Capacity	13.407	13.930	14.459	14.993	15.534	16.080	16.633	17.192	17.757	18.328
736	Area	5.8137	5.8810	5.9498	6.0200	6.0906	6.1628	6.2365	6.3119	6.3889	6.4675
	Capacity	18.907	19.491	20.083	20.682	21.287	21.900	22.520	23.148	23.783	24.425
737	Area	6.5479	6.6307	6.7161	6.8020	6.8892	6.9787	7.0699	7.1641	7.2666	7.3829
	Capacity	25.076	25.735	26.403	27.079	27.763	28.457	29.159	29.871	30.593	31.325
738	Area	8.2663	8.4355	8.5836	8.7310	8.8776	9.0225	9.1657	9.3089	9.4542	9.6007
	Capacity	32.077	32.913	33.764	34.630	35.510	36.406	37.315	38.239	39.177	40.130
739	Area	9.7480	9.8959	10.044	10.191	10.339	10.489	10.640	10.794	10.949	11.106
	Capacity	41.098	42.080	43.078	44.089	45.116	46.157	47.214	48.286	49.373	50.476
740	Area	11.264	11.423	11.581	11.738	11.892	12.047	12.203	12.363	12.528	12.697
	Capacity	51.595	52.729	53.880	55.046	56.227	57.425	58.637	59.866	61.110	62.371
741	Area	12.879	13.072	13.273	13.484	13.691	13.900	14.126	14.361	14.596	14.834
	Capacity	63.651	64.948	66.266	67.603	68.962	70.342	71.743	73.168	74.616	76.087
742	Area	15.076	15.316	15.556	15.802	16.038	16.275	16.513	16.752	16.996	17.248
	Capacity	77.583	79.103	80.647	82.215	83.807	85.423	87.063	88.727	90.414	92.126
743	Area	18.201	18.439	18.675	18.911	19.141	19.373	19.601	19.830	20.056	20.297
	Capacity	93.871	95.703	97.560	99.439	101.34	103.27	105.22	107.19	109.18	111.20
744	Area	20.531	20.759	20.985	21.205	21.423	21.644	21.870	22.107	22.339	22.567
	Capacity	113.24	115.31	117.40	119.50	121.64	123.79	125.97	128.17	130.39	132.63
745	Area	22.789	23.009	23.221	23.424	23.638	23.869	24.116	24.390	24.669	24.967
	Capacity	134.90	137.19	139.50	141.84	144.19	146.57	148.96	151.39	153.84	156.32
746	Area	25.243	25.489	25.723	25.983	26.247	26.513	26.783	27.059	27.350	27.650
	Capacity	158.84	161.37	163.93	166.52	169.13	171.77	174.43	177.13	179.85	182.60
747	Area	27.958	28.268	28.570	28.878	29.200	29.544	29.915	30.326	30.773	31.259
	Capacity	185.38	188.19	191.03	193.91	196.81	199.75	202.72	205.73	208.79	211.89
748	Area	32.741	33.095	33.428	33.755	34.085	34.421	34.756	35.092	35.429	35.762
	Capacity	215.05	218.34	221.67	225.03	228.42	231.85	235.31	238.80	242.33	245.89

Table A. 2: Waxhoma Lake Capacity/Area by 0.1-ft Increments (cont).

WAXHOMA LAKE AREA-CAPACITY TABLE OKLAHOMA WATER RESOURCES BOARD 2011 Survey Capacity in acre-feet by tenth foot elevation increments Area in acres by tenth foot elevation increments											
Elevation (ft NAVD 88)		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
749	Area	36.086	36.493	36.906	37.241	37.549	37.858	38.170	38.487	38.807	39.123
	Capacity	249.48	253.11	256.78	260.49	264.23	268.00	271.80	275.64	279.50	283.40
750	Area	39.439	39.755	40.069	40.383	40.698	41.023	41.345	41.677	42.005	42.343
	Capacity	287.33	291.29	295.28	299.30	303.35	307.44	311.56	315.71	319.90	324.11
751	Area	42.694	43.048	43.408	43.757	44.107	44.458	44.813	45.161	45.529	45.915
	Capacity	328.37	332.65	336.98	341.34	345.73	350.16	354.62	359.12	363.66	368.23
752	Area	46.292	46.682	47.105	47.550	48.009	48.468	48.932	49.411	49.908	50.422
	Capacity	372.84	377.49	382.18	386.91	391.69	396.52	401.39	406.31	411.27	416.29
753	Area	52.157	53.013	53.889	54.731	55.485	56.216	56.923	57.605	58.273	58.928
	Capacity	421.37	426.63	431.98	437.41	442.92	448.51	454.16	459.89	465.69	471.55
754	Area	59.565	60.206	60.847	61.513	62.136	62.743	63.326	63.904	64.474	65.053
	Capacity	477.47	483.46	489.52	495.63	501.82	508.06	514.37	520.73	527.15	533.63
755	Area	65.630	66.246	66.877	67.548	68.210	68.807	69.401	70.011	70.640	71.292
	Capacity	540.16	546.76	553.41	560.14	566.92	573.78	580.69	587.66	594.69	601.79
756	Area	71.970	72.696	73.406	74.099	74.838	75.515	76.113	76.711	77.321	77.926
	Capacity	608.95	616.19	623.49	630.87	638.31	645.84	653.42	661.06	668.76	676.53
757	Area	78.529	79.181	79.827	80.441	81.063	81.689	82.327	82.963	83.615	84.289
	Capacity	684.35	692.24	700.19	708.20	716.28	724.42	732.62	740.89	749.22	757.61
758	Area	85.710	86.300	86.860	87.441	88.050	88.686	89.216	89.718	90.199	90.710
	Capacity	766.09	774.69	783.35	792.06	800.84	809.68	818.57	827.52	836.52	845.56
759	Area	91.216	91.725	92.233	92.752	93.249	93.742	94.226	94.722	95.156	95.568
	Capacity	854.66	863.81	873.01	882.26	891.56	900.91	910.31	919.76	929.26	938.79
760	Area	95.973	96.371	96.768	97.177	97.574	97.954	98.328	98.696	99.054	99.418
	Capacity	948.37	957.99	967.65	977.35	987.08	996.87	1006.7	1016.5	1026.4	1036.3
761	Area	99.762	100.10	100.45	100.77	101.09	101.41	101.73	102.06	102.38	102.71
	Capacity	1046.3	1056.3	1066.3	1076.4	1086.5	1096.6	1106.8	1117.0	1127.2	1137.4
762	Area	103.05	103.38	103.72	104.06	104.41	104.77	105.15	105.53	105.94	106.36
	Capacity	1147.7	1158.1	1168.4	1178.8	1189.2	1199.7	1210.2	1220.7	1231.3	1241.9
763	Area	107.40	107.89	108.30	108.68	109.06	109.45	109.85	110.24	110.63	111.03
	Capacity	1252.6	1263.3	1274.2	1285.0	1295.9	1306.8	1317.8	1328.8	1339.8	1350.9
764	Area	111.42	111.79	112.12	112.43	112.74	113.05	113.36	113.68	113.99	114.30
	Capacity	1362.0	1373.2	1384.4	1395.6	1406.9	1418.2	1429.5	1440.9	1452.2	1463.7
765	Area	114.62	114.93	115.24	115.56	115.87	116.19	116.50	116.82	117.14	117.45
	Capacity	1475.1	1486.6	1498.1	1509.6	1521.2	1532.8	1544.5	1556.1	1567.8	1579.6
766	Area	117.77	118.09	118.41	118.73	119.05	119.37	119.69	120.01	120.33	120.65
	Capacity	1591.3	1603.1	1614.9	1626.8	1638.7	1650.6	1662.6	1674.6	1686.6	1698.6
767	Area	120.97	121.29	121.61	121.94	122.26	122.58	122.91	123.23	123.56	123.88
	Capacity	1710.7	1722.8	1735.0	1747.1	1759.4	1771.6	1783.9	1796.2	1808.5	1820.9
768	Area	128.68									
	Capacity	1832.1									

Figure A. 1. Area-Capacity Curve for Waxhoma Lake



APPENDIX B: Waxhoma Lake Maps

Figure B. 1: Waxhoma Lake Bathymetric Map with 5-foot Contour Intervals.

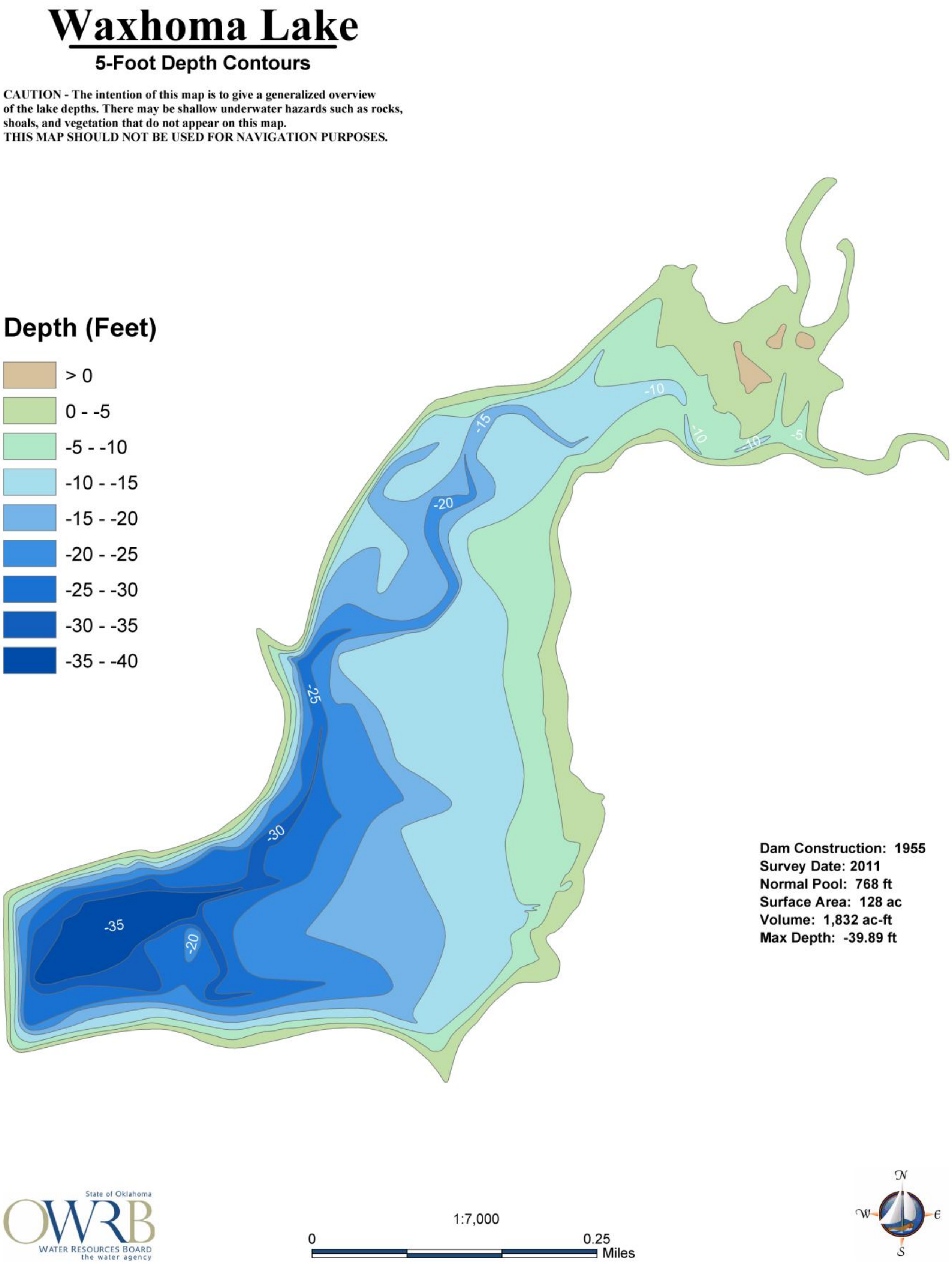


Figure B. 2: Waxhoma Lake Shaded Relief Bathymetric Map.

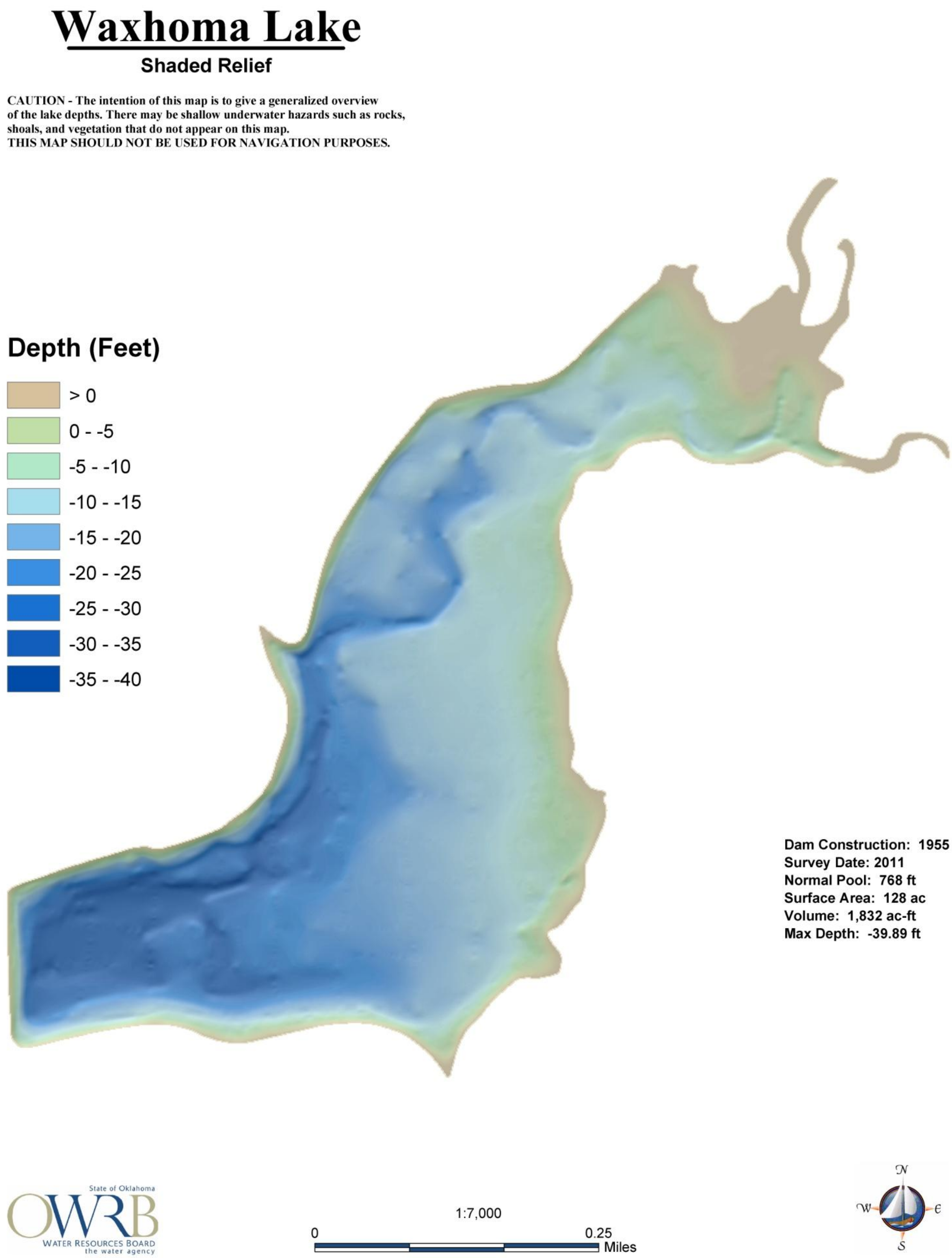


Figure B. 3: Waxhoma Lake Collected Data Points.