FT. GIBSON LAKE
HYDROGRAPHIC SURVEY REPORT

Final Report

July 26, 2012

Prepared by:

State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

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INTRODUCTION

The Oklahoma Water Resources Board (OWRB) conducted a hydrographic survey of Ft. Gibson Lake May 21st through June 13th, 2012. The purpose of this survey was to collect hydrographic data of the lake and convert this information into an elevation-area-capacity table. Ft. Gibson Lake is not meeting the state's water quality standards for dissolved oxygen. The Oklahoma Department of Environmental Quality (ODEQ) funded the project for the purpose of developing a Total Maximum Daily Load (TMDL) for nutrient and turbidity levels that are impairing Ft. Gibson Lake.

LAKE BACKGROUND

Ft. Gibson Lake, (**Figure 1**), is located on the Grand (Neosho) River about 5 miles northwest of historic Fort Gibson, Oklahoma, from which it draws its name. It is about 7.7 miles above the confluence of the Grand (Neosho) and Arkansas Rivers. The lake lies in Wagoner, Cherokee, and Mayes Counties and extends upriver to the Markham Ferry Dam (Lake Hudson).

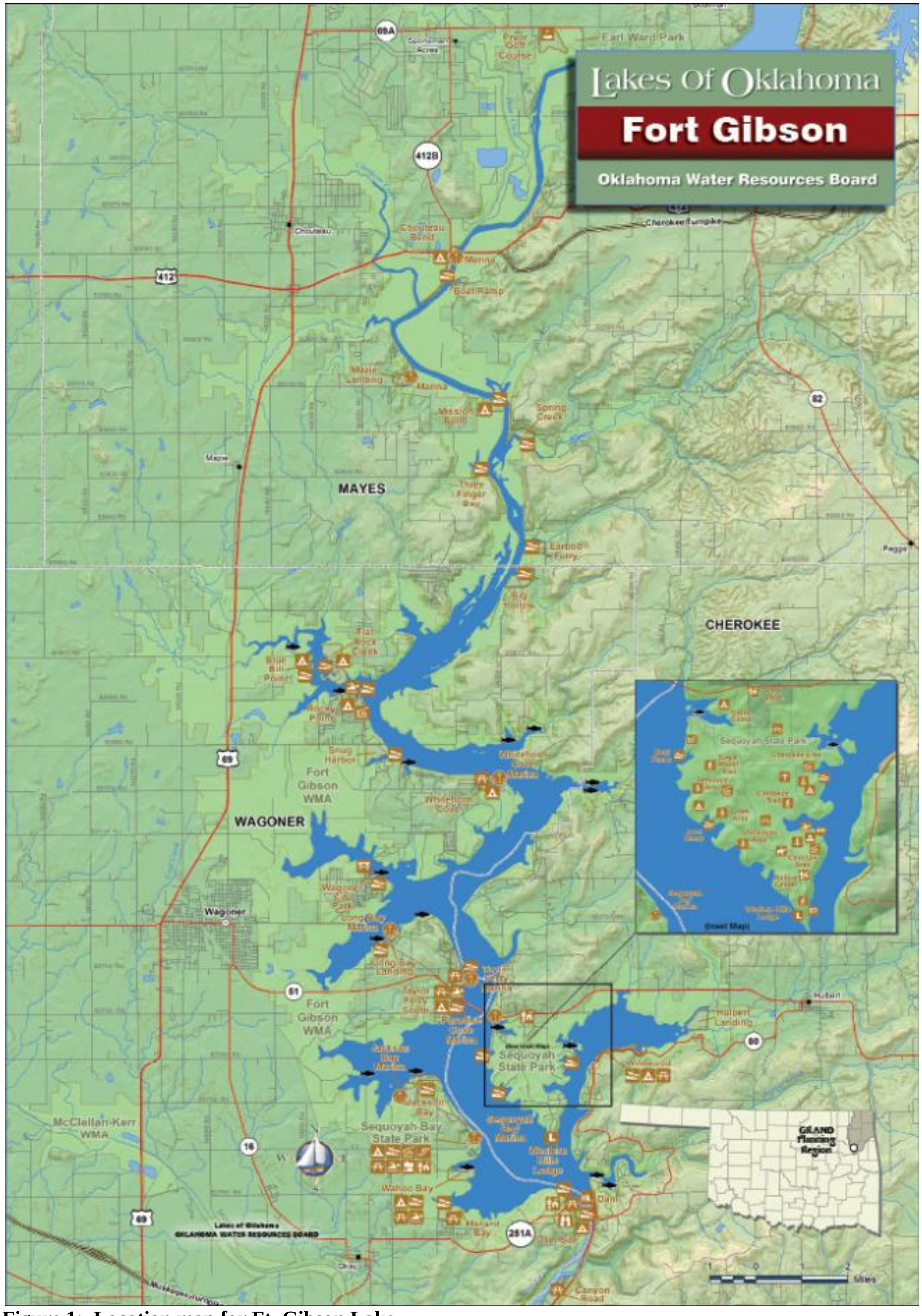


Figure 1: Location map for Ft. Gibson Lake.

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 Ft. Gibson Lake was on-screen digitized from the 2006 color digital orthoimagery quarter quadrangle (DOQQ) mosaic of Wagoner County, Oklahoma. The screen scale was set to 1:1,500. A line was drawn 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 500 ft increments and ran perpendicular to the original stream channels and tributaries. Approximately 449 virtual transects were created for the Ft. Gibson Lake project

Field Survey

Lake Elevation Acquisition

The lake elevation for Ft. Gibson Lake was obtained at the U.S. Army Corps of Engineers Tulsa District website. http://www.swt-wc.usace.army.mil/FGIB.lakepage.html

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; Syqwest Bathy 1500 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 Ft. Gibson Lake occurred during May 21st to June 13th, 2012. The water level elevation (**Table 1**) for Ft. Gibson Lake was measured in U.S. Survey Feet Geodetic Vertical Datum (NGVD).

Table 1: Elevation Table for Ft. Gibson Lake

May 2012	Elevation (U.S. FT)	June 2012	Elevation (U.S. FT)
21	554.67	11	554.29
22	554.67	12	554.27
23	554.51	13	554.16
24	554.52		
29	554.15		
30	554.00		

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, the Syqwest Bathy 1500 Echo Sounder was calibrated 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. **Table 2** shows the average speed of sound in the water during the Ft. Gibson Lake survey.

Table 2: Average Sound Velocity

May 2012	Average Sound Velocity	June 2012	Average Sound Velocity
21	4891.64	11	4919.34
23	4891.42	12	4920.69
29	4909.86	13	4920.69
30	4922.07		

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 77 cross-sections points at Ft. Gibson Lake were used to compute error estimates. A mean difference of 0.022 ft and a standard deviation of 0.118 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 ± 0.24 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 0.022 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. 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 0.2 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 0.4 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. The average elevation of the lake during the survey was 554.36ft (NGVD).

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 Ft. Gibson Lake are located on the DVD entitled *Ft. Gibson 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.** The bathymetric maps of the Ft. Gibson Lake are shown in **APPENDIX B: Ft. Gibson 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 Ft. Gibson Lake is located on the DVD entitled *Ft. Gibson HYPACK/GIS Metadata*.

RESULTS

Results from the 2012 OWRB survey indicate that Ft. Gibson Lake encompasses 19,897 acres and contains a cumulative capacity of 306,133 ac-ft at the normal pool elevation 554 ft (NGVD). The average depth for Ft. Gibson Lake was 15.4 ft.

The outputs for the Ft. Gibson hydrographic survey include a copy of the final report, an elevation-area-capacity table, a map showing approximate survey lines used to collect the positioning and sounding data, and a digital elevation model (DEM). The DEM data is in the file: Gibson_Collected_Points.shp, which is located on the DVD entitled *Ft. Gibson HYPACK/GIS Metadata.*

SUMMARY and COMPARISON

Table 3 is a comparison of area and volume changes of Ft. Gibson Lake at the normal pool elevation. Based on the design specifications, Ft. Gibson Lake had an area of 19,100 acres and cumulative volume of 365,000 acre-feet of water at normal pool elevation 554 ft (NGVD). Surface area data suggests that the lake has had an increase of 796.6acres or approximately 4.2%. The 2012 survey shows that Ft. Gibson Lake has an apparent decrease in capacity of 16.1% or approximately 58,867 acre-feet. Caution should be used when directly comparing between the design specifications and the 2012 survey conducted by the OWRB because different methods were used to collect the data and extrapolate capacity and area figures. It is the recommendation of the OWRB that another survey using the same method used in the 2012 survey be conducted in 10-15 years. By using the 2012 survey figures as a baseline, a future survey would allow an accurate sedimentation rate to be obtained.

Table 3: Area and Volume Comparisons of Ft. Gibson Lake at normal pool of 554 ft (NGVD)

Feature	Survey Year	
	1946 Design Specifications	2012
Area (acres)	19,100	19,896.6
Cumulative Volume (acre-feet)	365,000	306,133
Average depth (ft)	19.1	15.4
Maximum Depth (ft)	-	60.24

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). 2007. Oklahoma Water Atlas.

Oklahoma Water Resources Board (OWRB). 1977. Upper Bayou Watershed, Site No. 10, Multi-purpose Project, Review of Plans, Project Report.

U.S. Army Corps of Engineers. Water Control website with Ft. Gibson lake readings: http://www.swt-wc.usace.army.mil/FGIB.lakepage.html

APPENDIX A: Area-Capacity Data

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

FT. GIBSON LAKE AREA-CAPACITY TABLE
OKLAHOMA WATER RESOURCES BOARD
2012 Survey
Capacity in acre-feet by tenth foot elevation increments
Area in acres by tenth foot elevation increments

Elevation (ft NGVD)		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
493	Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0008	0.0063
	Capacity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0003
494	Area	0.019	0.0361	0.0546	0.0739	0.0942	0.1171	0.1445	0.1765	0.2129	0.2526
	Capacity	0.0015	0.0043	0.0088	0.0152	0.0236	0.0341	0.0472	0.0632	0.0826	0.1059
495	Area	0.2938	0.3369	0.3823	0.4288	0.4771	0.527	0.5785	0.632	0.6869	0.7453
	Capacity	0.1332	0.1647	0.2007	0.2412	0.2865	0.3367	0.392	0.4525	0.5184	0.59
496	Area	0.8079	0.8745	0.9437	1.0164	1.1099	1.2168	1.3452	1.5097	1.6957	1.8746
	Capacity	0.6677	0.7518	0.8427	0.9406	1.0468	1.1631	1.291	1.4334	1.5937	1.7723
497	Area	2.0613	2.2717	2.5209	2.8149	3.1315	3.4566	3.7924	4.1483	4.5163	4.8993
	Capacity	1.969	2.1855	2.4248	2.6912	2.9885	3.3179	3.6803	4.0773	4.5104	4.9811
498	Area	5.2937	5.7	6.1249	6.5726	7.048	7.5974	8.2313	8.9411	9.8074	10.756
	Capacity	5.4908	6.0405	6.6316	7.2663	7.9471	8.6787	9.4697	10.328	11.264	12.292
499	Area	11.846	13.112	14.447	15.864	17.584	19.577	21.857	24.108	26.241	28.629
	Capacity	13.42	14.667	16.045	17.559	19.228	21.085	23.154	25.456	27.972	30.712
500	Area	30.976	33.36	35.953	38.676	41.345	43.954	46.582	49.262	51.978	54.64
	Capacity	33.692	36.91	40.372	44.103	48.106	52.372	56.899	61.692	66.754	72.086
501	Area	57.336	60.047	62.7	65.306	67.843	70.346	72.813	75.231	77.637	80.049
	Capacity	77.685	83.556	89.695	96.095	102.75	109.67	116.83	124.23	131.87	139.76
502	Area	82.614	85.601	88.5	91.412	94.29	97.32	100.5	103.85	107.42	111.27
	Capacity	147.89	156.3	165.01	174	183.29	192.87	202.76	212.98	223.54	234.48
503	Area	115.54	120.07	125.03	129.83	134.29	138.64	142.96	147.33	151.64	155.95
	Capacity	245.81	257.6	269.85	282.59	295.8	309.45	323.54	338.05	353	368.38
504	Area	160.34	164.66	168.73	172.62	176.55	180.56	184.68	188.97	193.1	197.2
	Capacity	384.2	400.46	417.13	434.2	451.66	469.52	487.78	506.47	525.57	545.09
505	Area	201.34	205.59	209.59	213.45	217.34	221.29	225.43	229.79	233.78	237.74
	Capacity	565.02	585.37	606.14	627.29	648.83	670.77	693.1	715.87	739.05	762.63
506	Area	242	245.86	249.6	253.31	256.98	260.6	264.19	267.77	271.45	275.15
	Capacity	786.63	811.02	835.8	860.95	886.47	912.35	938.6	965.2	992.16	1019.5
507	Area	278.91	282.86	286.92	290.79	294.53	298.24	301.96	305.64	309.3	312.96
	Capacity	1047.2	1075.3	1103.8	1132.7	1161.9	1191.6	1221.6	1252	1282.7	1313.9
508	Area	316.64	320.39	324.3	328.32	332.46	336.52	340.58	344.65	348.76	352.94
	Capacity	1345.3	1377.2	1409.4	1442.1	1475.1	1508.6	1542.4	1576.7	1611.4	1646.4
509	Area	357.3	361.88	366.76	371.64	376.41	381.29	386.36	391.61	397.02	402.77
	Capacity	1682	1717.9	1754.4	1791.3	1828.7	1866.6	1905	1943.9	1983.3	2023.3
510	Area	408.89	415.48	422.22	428.89	435.49	442.27	449.18	456.24	463.1	469.82
	Capacity	2063.9	2105.1	2147	2189.6	2232.8	2276.7	2321.3	2366.5	2412.5	2459.2
511	Area	476.43	482.98	489.6	496.1	502.42	508.62	514.77	520.89	527.01	533.19
	Capacity	2506.5	2554.5	2603.1	2652.4	2702.3	2752.9	2804.1	2855.9	2908.2	2961.3
512	Area	539.45	545.71	552.05	558.56	565.14	571.86	578.8	586.07	593.42	601.25
	Capacity	3014.9	3069.2	3124.1	3179.6	3235.8	3292.7	3350.2	3408.4	3467.4	3527.2
513	Area	609.1	616.9	624.76	632.73	640.58	648.5	656.77	665.26	673.43	681.38
	Capacity	3587.7	3649	3711.1	3774	3837.7	3902.1	3967.4	4033.5	4100.4	4168.2

Table A. 2: Ft. Gibson Lake Capacity/Area by 0.1-ft Increments.

FT.GIBSON LAKE AREA-CAPACITY TABLE
OKLAHOMA WATER RESOURCES BOARD
2012 Survey
Capacity in acre-feet by tenth foot elevation increments
Area in acres by tenth foot elevation increments

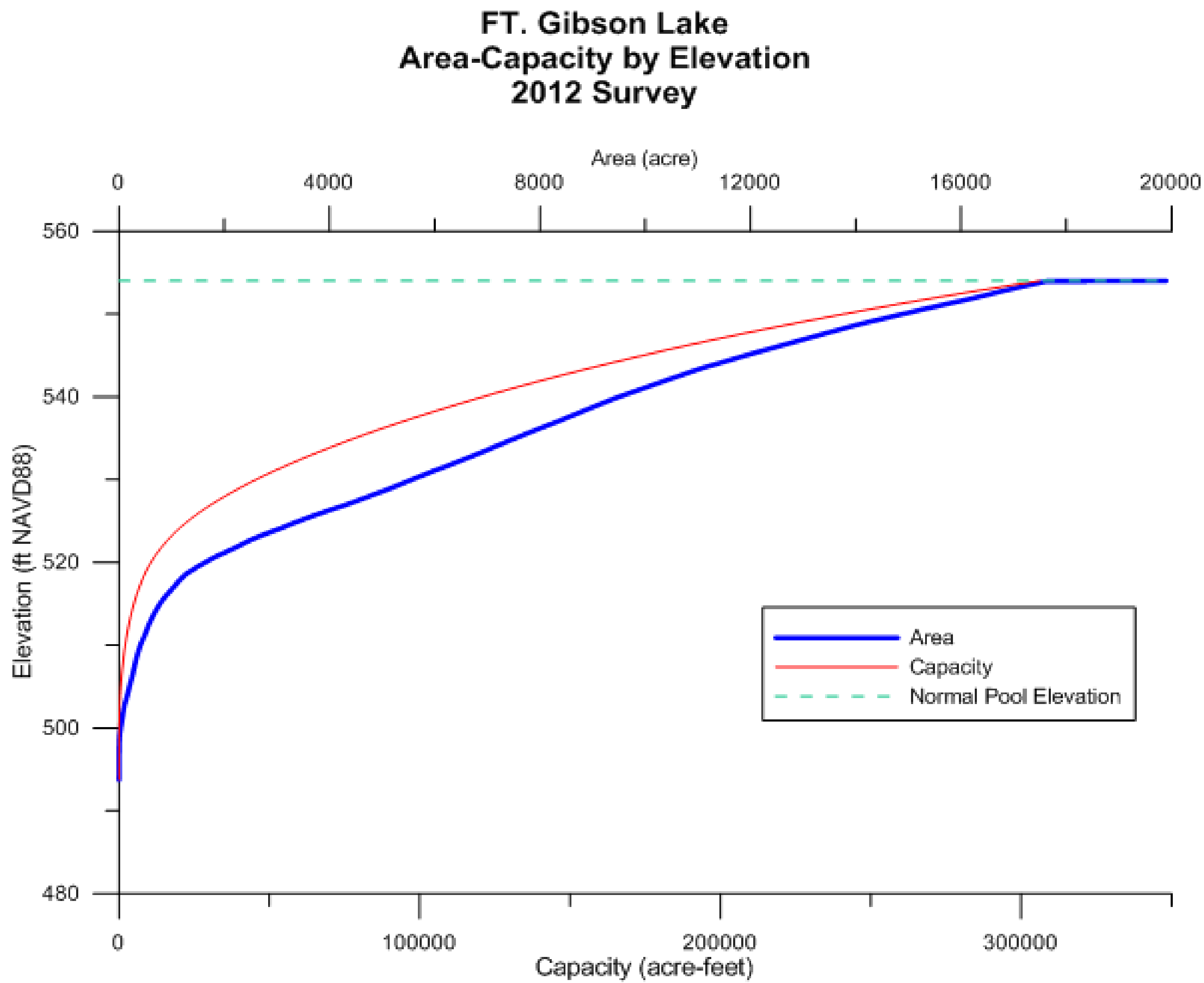
Elevation (ft NGVD)		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
514	Area	689.35	697.44	705.93	714.79	724.21	734.18	743.97	753.65	763.31	772.78
	Capacity	4236.7	4306.1	4376.3	4447.3	4519.3	4592.2	4666.1	4741	4816.8	4893.7
515	Area	782.35	792.61	803.57	815.05	827	839.42	852.01	864.19	876.58	889.41
	Capacity	4971.4	5050.2	5130	5210.9	5293.1	5376.4	5460.9	5546.8	5633.8	5722.2
516	Area	902.72	916.75	931.05	945.48	960.19	974.74	988.27	1001.5	1014.7	1028.1
	Capacity	5811.7	5902.7	5995.1	6089	6184.3	6281	6379.2	6478.7	6579.5	6681.7
517	Area	1041.4	1055.2	1069.3	1083.1	1096.6	1110.3	1124	1138	1153.5	1169.7
	Capacity	6785.2	6890	6996.3	7103.9	7212.9	7323.2	7434.9	7548.1	7662.6	7778.9
518	Area	1186.1	1202.3	1219.1	1236.1	1252.7	1269.7	1288.9	1312.4	1338.7	1364.6
	Capacity	7896.6	8016	8137.2	8259.9	8384.4	8510.5	8638.4	8768.5	8901	9036.3
519	Area	1391.4	1414.8	1438.7	1462.9	1487.2	1512.5	1539.7	1569.4	1598.1	1626.4
	Capacity	9174.1	9314.4	9457.1	9602.2	9749.7	9899.7	10052	10208	10366	10527
520	Area	1653.9	1681.2	1709	1737.8	1766.7	1794.8	1824.9	1855.7	1888.8	1925.1
	Capacity	10691	10858	11028	11200	11375	11553	11734	11919	12106	12296
521	Area	1962.7	1998.6	2031.9	2064	2096.8	2129.5	2164.1	2197.8	2231.6	2263.6
	Capacity	12491	12689	12891	13095	13303	13515	13729	13948	14169	14394
522	Area	2294.9	2324.7	2355.5	2386.7	2417.1	2447.9	2481.7	2516.5	2552.3	2589.1
	Capacity	14622	14853	15087	15324	15564	15808	16054	16304	16557	16815
523	Area	2627.4	2667.6	2709.1	2749.5	2790.4	2831.4	2873.5	2915.8	2960.9	3007.3
	Capacity	17075	17340	17609	17882	18159	18440	18725	19015	19309	19607
524	Area	3049	3088.3	3126.9	3164.8	3203.2	3242.7	3282.2	3321.8	3365.6	3409.4
	Capacity	19910	20217	20528	20843	21161	21483	21810	22140	22474	22813
525	Area	3449.7	3489.9	3531	3573.2	3616	3660.1	3703.2	3747.4	3792.5	3838.1
	Capacity	23156	23503	23854	24209	24569	24933	25301	25674	26051	26432
526	Area	3883.7	3929.1	3975.4	4022.6	4070.4	4117	4165.5	4215.4	4264.6	4310.5
	Capacity	26818	27209	27604	28004	28409	28818	29232	29652	30076	30505
527	Area	4354.2	4398.6	4443.3	4486.6	4528	4569.2	4610.9	4655.9	4697.7	4738.8
	Capacity	30938	31376	31818	32264	32715	33170	33629	34093	34560	35032
528	Area	4779.7	4820.6	4861.8	4905.5	4950.3	4997.3	5042.2	5083.8	5124.3	5164.1
	Capacity	35508	35988	36472	36961	37454	37951	38453	38960	39470	39985
529	Area	5203.2	5242.5	5282.4	5321.9	5361.5	5399.5	5437.3	5475.7	5514.4	5552.2
	Capacity	40503	41025	41552	42082	42616	43154	43696	44242	44791	45345
530	Area	5590.4	5628.3	5667	5707.4	5749	5789.3	5828.4	5867.8	5907.1	5945.9
	Capacity	45902	46463	47028	47597	48170	48747	49327	49913	50501	51094
531	Area	5985	6025.5	6068.7	6112.2	6154.3	6195.6	6236.5	6276.2	6316.2	6356.3
	Capacity	51691	52291	52896	53505	54119	54736	55358	55984	56613	57247
532	Area	6395.8	6435.2	6475	6516.8	6557.8	6597.8	6637.3	6676.7	6716.4	6755.5
	Capacity	57885	58526	59172	59822	60476	61133	61795	62461	63131	63805
533	Area	6793.9	6833.1	6875.5	6915.2	6953.3	6990.1	7025.9	7061.2	7096.6	7131.8
	Capacity	64482	65163	65849	66538	67232	67929	68630	69335	70043	70754
534	Area	7169.2	7208.5	7248.3	7287.8	7326.9	7364.4	7401.7	7439.5	7479.2	7518.7
	Capacity	71469	72188	72911	73638	74369	75104	75842	76584	77330	78080

Table A. 3: Ft. Gibson Lake Capacity/Area by 0.1-ft Increments.

FT. GIBSON LAKE AREA-CAPACITY TABLE
OKLAHOMA WATER RESOURCES BOARD
2012 Survey
Capacity in acre-feet by tenth foot elevation increments
Area in acres by tenth foot elevation increments

Elevation (ft NGVD)		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
535	Area	7557.9	7596.1	7634.6	7672.7	7711.3	7750.8	7789.6	7828.6	7868.6	7908.7
	Capacity	78834	79592	80354	81119	81889	82662	83439	84220	85005	85794
536	Area	7949.2	7989	8028.4	8067.1	8105.5	8145.1	8186.9	8229.5	8271.3	8311.4
	Capacity	86587	87384	88185	88990	89799	90611	91427	92249	93074	93903
537	Area	8350.4	8388.7	8426.6	8465	8503.2	8541.1	8579.5	8618.4	8658.2	8697
	Capacity	94736	95573	96414	97259	98108	98960	99816	100676	101540	102408
538	Area	8735.6	8773.3	8810.7	8848.4	8886.7	8924.9	8963.5	9002.9	9042.4	9082
	Capacity	103280	104155	105035	105917	106805	107695	108589	109488	110390	111297
539	Area	9120.7	9159.7	9199	9238.3	9278.8	9319.1	9359.5	9400.6	9441.8	9485.1
	Capacity	112207	113121	114039	114961	115887	116817	117751	118690	119632	120578
540	Area	9529.4	9574.9	9619.9	9664.8	9710.3	9756.5	9803.4	9849.1	9893.6	9938.2
	Capacity	121529	122484	123444	124408	125378	126351	127329	128312	129299	130291
541	Area	9982.5	10027	10071	10116	10160	10204	10248	10293	10338	10384
	Capacity	131287	132287	133293	134302	135316	136334	137357	138384	139416	140453
542	Area	10430	10476	10523	10569	10614	10660	10706	10751	10797	10843
	Capacity	141493	142538	143589	144643	145703	146766	147835	148908	149985	151068
543	Area	10889	10937	10984	11032	11081	11130	11181	11237	11294	11348
	Capacity	152154	153246	154342	155443	156549	157659	158775	159896	161023	162155
544	Area	11402	11455	11508	11563	11618	11672	11724	11777	11831	11885
	Capacity	163293	164436	165584	166738	167897	169062	170231	171407	172587	173774
545	Area	11942	11998	12055	12113	12171	12228	12286	12344	12401	12457
	Capacity	174965	176162	177365	178573	179788	181008	182234	183466	184703	185946
546	Area	12513	12569	12625	12682	12741	12798	12855	12913	12970	13028
	Capacity	187195	188449	189709	190974	192246	193523	194805	196094	197388	198689
547	Area	13085	13142	13199	13255	13312	13368	13425	13483	13541	13599
	Capacity	199994	201305	202623	203946	205275	206609	207948	209294	210645	212003
548	Area	13657	13716	13774	13831	13888	13946	14005	14067	14130	14194
	Capacity	213366	214734	216109	217489	218876	220268	221665	223069	224479	225896
549	Area	14260	14327	14394	14462	14530	14597	14663	14729	14797	14865
	Capacity	227318	228748	230184	231627	233077	234534	235996	237467	238943	240427
550	Area	14934	15002	15070	15137	15204	15273	15344	15415	15485	15556
	Capacity	241916	243413	244918	246428	247945	249469	251000	252539	254083	255636
551	Area	15628	15703	15775	15847	15918	15991	16063	16136	16206	16274
	Capacity	257195	258762	260336	261917	263506	265102	266704	268315	269932	271557
552	Area	16339	16402	16466	16529	16593	16658	16723	16789	16855	16922
	Capacity	273187	274824	276468	278118	279775	281437	283106	284783	286465	288154
553	Area	16990	17058	17128	17197	17268	17339	17411	17484	17557	17632
	Capacity	289850	291552	293262	294978	296702	298432	300170	301915	303667	305428
554	Area	19897									
	Capacity	306133									

Figure A. 1. Area-Capacity Curve for Ft. Gibson Lake



APPENDIX B: Ft. Gibson Lake Maps

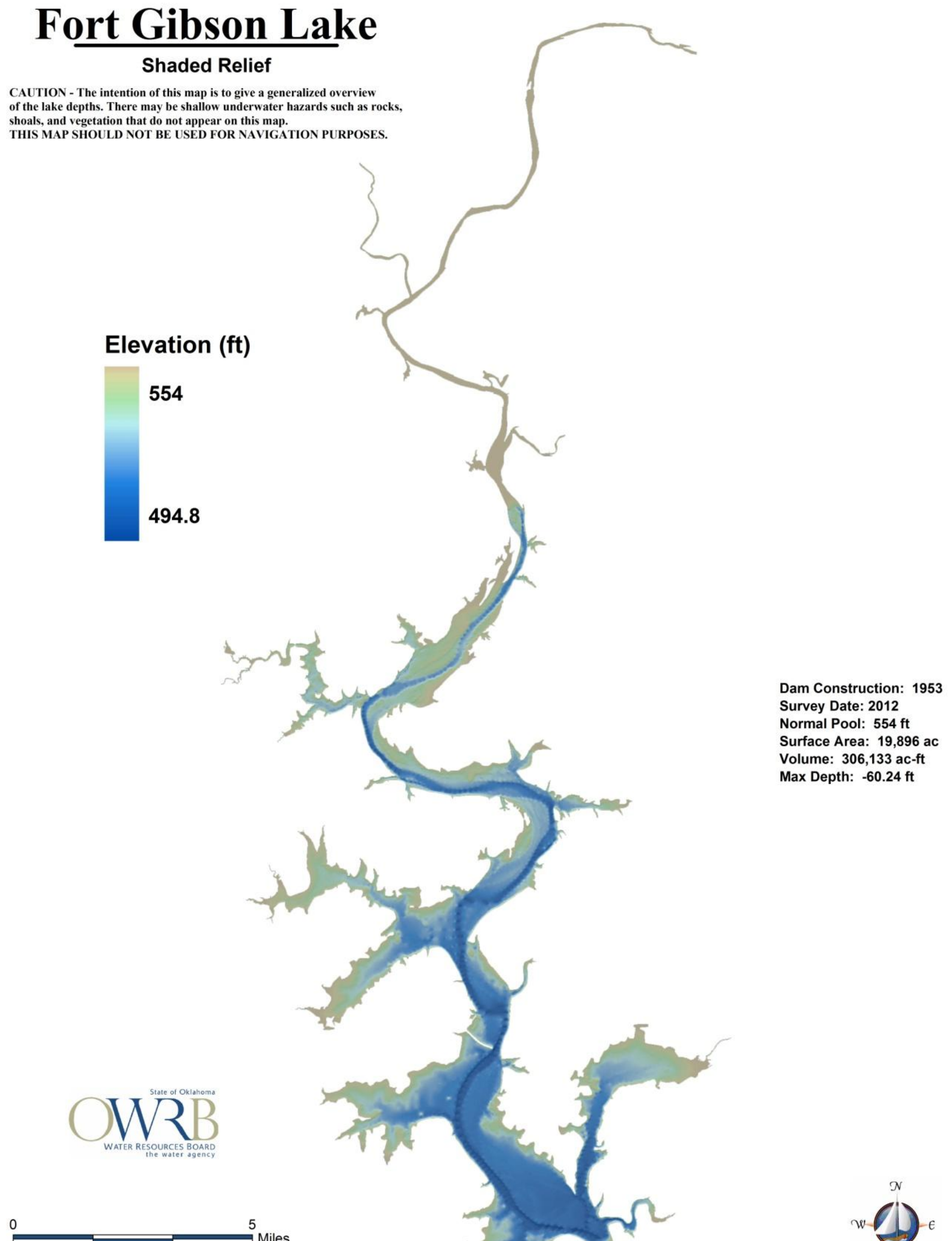


Figure B. 1: Ft. Gibson Shaded Relief Bathymetric Map.

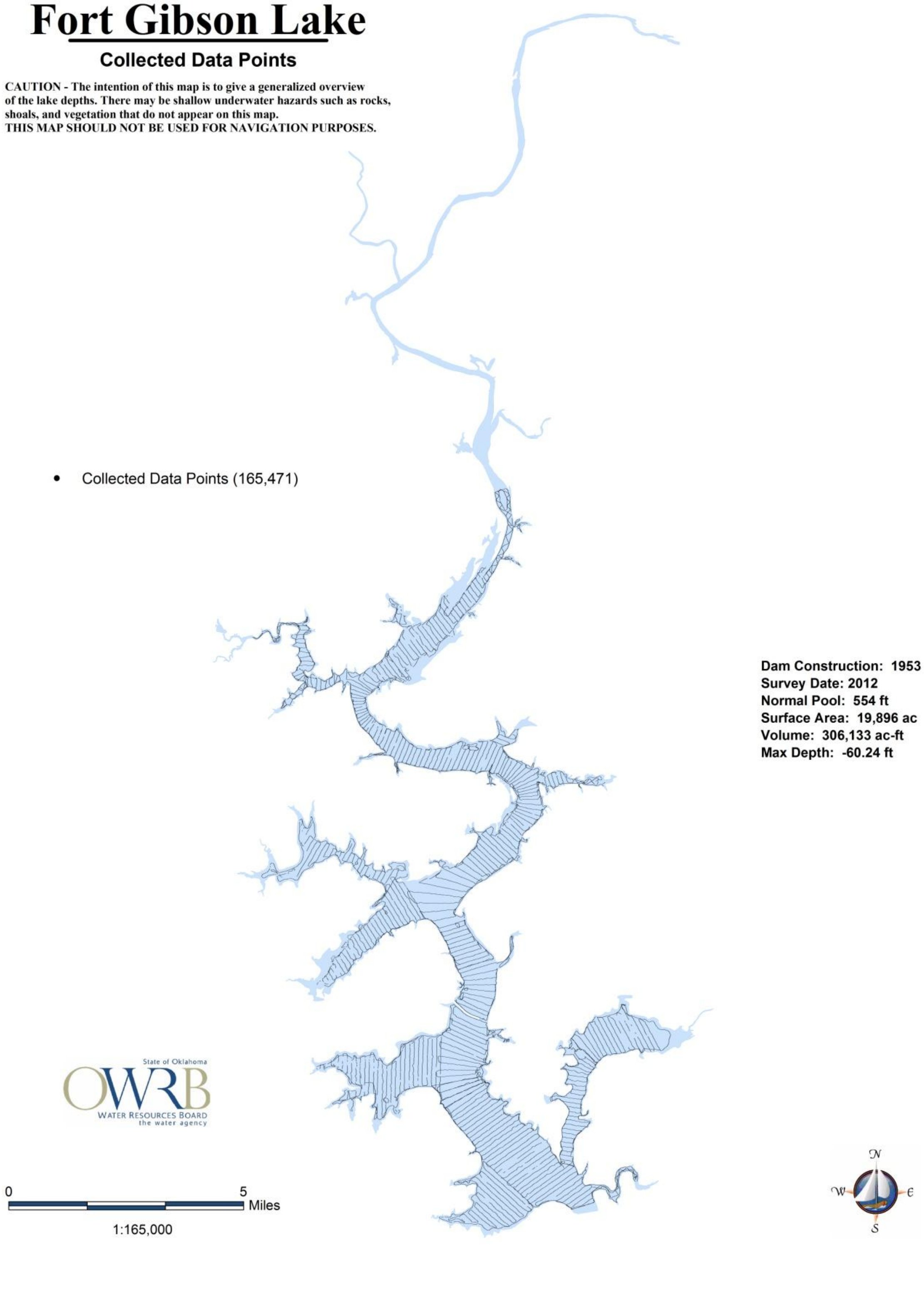


Figure B. 2: Ft. Gibson Lake Collected Data Points.