Bathymetric and Sediment Survey of Garnett City Lake, Anderson County, Kansas

Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2013-04 (May 2013)

This work was funded by the Kansas Water Office through the State Water Plan Fund in support of the Reservoir Sustainability Initiative.

SUMMARY

On June 7, 2012, the Kansas Biological Survey (KBS) performed a bathymetric survey of Garnett City Lake in Anderson County, Kansas. The survey was carried out using acoustic echosounding apparatus linked to a global positioning system. The bathymetric survey was georeferenced to both horizontal and vertical reference datums.

Sediment samples were collected from three sites within the reservoir: One sample was taken near the dam; a second at mid-lake; and a third in the upper end. Sampling was performed on the same day as the bathymetric survey, following completion of the survey. Sediment samples were analyzed for particle size distributions.

Summary Data:

Bathymetric Survey:		
	Dates of survey:	June 7, 2012
Reservoir Statistics:		
	Elevation on survey date	999.66 ft
	Area on survey date:	45.6 acres
	Volume on survey date:	723 acre-feet
	Maximum depth:	37.7 ft
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	303999.2, 4242090.7
	UTM Zone:	15N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	1004.95 ft.
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	June 7, 2012

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LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Garnett City Lake in Anderson County, Kansas.

The following is reprinted from page 305 in *Anderson County, Kansas, Histories* by Judge James Y. Campbell and W. A. Johnson and edited by the Anderson County Historical Society (Anderson County, Kan.), originally published by Cornell University, reprinted 1977 by Walsworth, 843 pp.

Chapter 11. Lakes in Anderson County
"The great advance in the way of lakes in Anderson County in now being placed in evidence. Through the efforts of the Garnett Chamber of Commerce, with Walter Osborne as President and many public-spirited citizens of the town cooperating, a state lake was advocated. The Chamber of Commerce succeeded in interesting a number of prominent and influential men such as Senator Arthur Capper, who was born in Garnett, member of the Game and Fish Commission, Governor Landon., and other officials in the project. The citizens of Garnett voted the money necessary to purchase the needed land at the April election of 1934, and in the November election of that year voted to deed the portion of the land that would be covered by water when the dam was built to the state. Both questions carried by a big majority. It is now estimated the project will be completed early in 1937, perhaps sooner. P. F. Brown, living north of Garnett, donated sixty-seven acres of land with no strings attached to the proposition. Had it not been for Mr. Brown's generosity the proposition would most probably have failed. The city purchased the old Stokes farm – as it was known in the early days – consisting of 243 acres, giving $7776 for the tract. A fourteen-room residence was included in the deal. When completed, the lake will cover about forty-five acres with a maximum depth of approximately fifty feet. A surfaced road from the city to the lakesite is now under construction. Two hundred Civilian Conservation Corps boys have barracks erected on the tract consisting of a number of buildings which will eventually belong to the city. These CCC boys will remain until they have eomp1eted the project. Considerable work has already been done and work will begin in earnest as soon as the weather will permit. The expense of completing the lake is estimated to amount to about one-half million dollars."

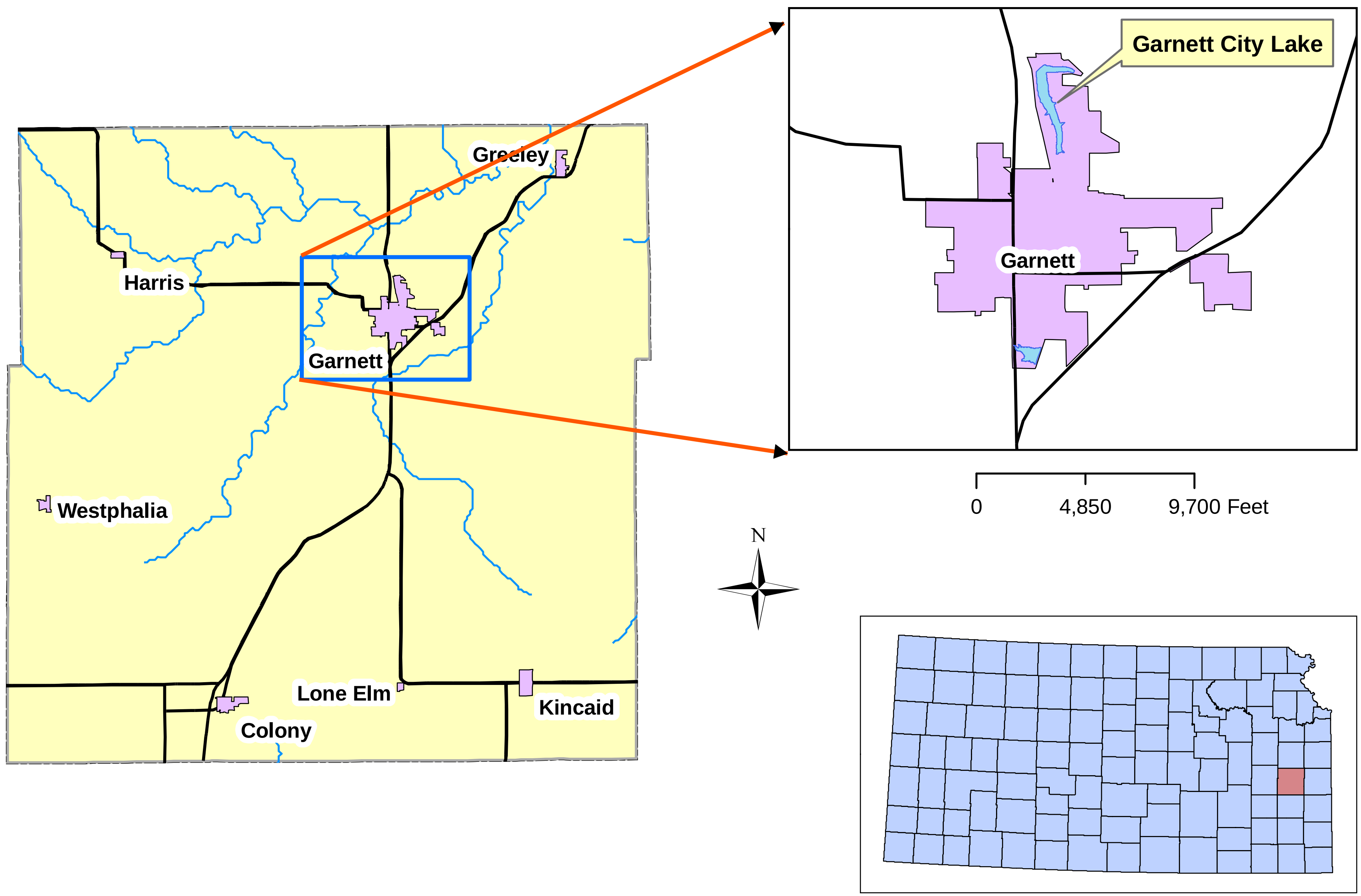

Figure 2. Location of Garnett City Lake in the City of Garnett in Anderson County, Kansas

II. RESERVOIR BATHYMETRIC (DEPTH) SURVEYING PROCEDURES

KBS operates a Biosonics DT-X echosounding system (www.biosonicsinc.com) with a 200 kHz split-beam transducer and a 38-kHz single-beam transducer. Latitude-longitude information is provided by a global positioning system (GPS) that interfaces with the Biosonics system. ESRI's ArcGIS is used for on-lake navigation and positioning, with GPS data feeds provided by the Biosonics unit through a serial cable. Power is provided to the echosounding unit, command/navigation computer, and auxiliary monitor by means of a inverter and battery backup device that in turn draw power from the 12-volt boat battery.

Pre-survey preparation:

Geospatial reference data: Prior to conducting the survey, existing geospatial data of the target lake was acquired, including georeferenced National Agricultural Imagery Project (NAIP) photography. The lake boundary was digitized as a polygon shapefile from the Farm Service Agency (FAS) NAIP 2008 georeferenced aerial photography obtained online from the Data Access and Service Center (DASC) at the Kansas Geological Survey (http://www.kansasgis.org). Prior to the lake survey, a series of transect lines are created as a shapefile in ArcGIS for guiding the boat during the survey.

Survey procedures:

Calibration (Temperature and ball check): After boat launch and initialization of the Biosonics system and command computer, system parameters are set in the Biosonics Visual Acquisition software. The temperature of the lake at 1-2 meters is taken with a research-grade metric electronic thermometer. This temperature, in degrees Celsius, is input to the Biosonics Visual Acquisition software to calculate the speed of sound in water at the given temperature at the given depth. Start range, end range, ping duration, and ping interval are also set at this time. A ball check is performed using a tungsten-carbide sphere supplied by Biosonics for this purpose. The ball is lowered to a known distance (1.0 meter) below the transducer faces. The position of the ball in the water column (distance from the transducer face to the ball) is clearly visible on the echogram. The echogram distance is compared to the known distance to assure that parameters are properly set and the system is operating correctly.

On-lake survey procedures: Using the GPS Extension of ArcGIS, the GPS data feed from the GPS receiver via the Biosonics echosounder, and the pre-planned transect pattern, the location of the boat on the lake in real-time is shown on the command/navigation computer screen. The transect pattern is maintained except when modified by obstructions in the lake (e.g., partially submerged trees) or shallow water and mudflats. Data are automatically logged in new files every half-hour (approximately 9000-ping files) by the Biosonics system.

Establishment Of Lake Level On Survey Dates:

State and Local Reservoirs:

Most state and local lakes in Kansas do not have water surface elevation gauges. Therefore, a local benchmark at the edge of a lake is established, typically a concrete pad or wall adjacent to the water. The location of the benchmark is photographed and a description noted. On the day of the survey, the vertical distance between the water surface and the surface of the benchmark is measured. In cases where the benchmark must be established a distance away from the lake, a survey-grade laser level is used to establish the vertical distance between benchmark and water surface.

A TopCon HiPerLite+ survey-grade static global positioning system is used to establish the height of the benchmark. The unit is set at a fixed distance above the benchmark, and the vertical distance between the benchmark and the Antenna Reference Point recorded. The unit is allowed to record data points for a minimum of two hours at a rate of one point every 10 seconds.

Following GPS data acquisition, the data are downloaded at the office from the GPS unit, converted from TopCon proprietary format to RINEX format, and uploaded to the National Geodetic Survey (NGS) On-line Positioning User Service (OPUS). Raw data are processed by OPUS with respect to three NGS CORS (Continuously Operating Reference Stations) locations and results returned to the user.

The elevation of the benchmark is provided in meters as the orthometric height (NAVD88, computed using GEOID03). The vertical difference between the lake surface on the survey day is subtracted from the OPUS-computer orthometric height to produce the lake elevation value, in meters. This lake elevation value is entered as an attribute of the lake perimeter polygon shapefile in postprocessing.

The ASTRA elevation benchmark for Garnett City Lake is the northeast corner of the concrete walkway leading to the fishing dock at the north end of the lake(Figure 3).

The water surface elevation of Garnett City Lake on June 7, 2012 was 999.66 feet AMSL, NAVD88.

UTM Zone 15N
303999.2
4242090.7

Location of Lake Elevation Benchmark:

Garnett City Lake:

Figure 3. General view of benchmark, view south-southwest.

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FILE: log0108t.12O OP1336587224938 – Garnett City Lake

                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

      USER: mjakub@ku.edu                              DATE: May 09, 2012
RINEX FILE: log0108t.12o                               TIME: 18:20:37 UTC

  SOFTWARE: page5  1108.09 master10.pl 030912      START: 2012/04/17  19:13:00
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  NAV FILE: brdc1080.12n                        OBS USED:  4588 /  5833   :
79%
  ANT NAME: TPSHIPER_PLUS   NONE               # FIXED AMB:    47 /    56   :
84%
ARP HEIGHT: .78105                             OVERALL RMS: 0.021(m)


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(EPOCH:2012.2947)

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         Y:     -4990738.059(m)   0.084(m)         -4990736.689(m)   0.084(m)
         Z:      3932281.496(m)   0.036(m)          3932281.355(m)   0.036(m)

       LAT:   38 18 19.85452      0.080(m)       38 18 19.87695      0.080(m)
     E LON:  264 45 30.16583      0.026(m)      264 45 30.12920      0.026(m)
     W LON:   95 14 29.83417      0.026(m)       95 14 29.87080      0.026(m)
    EL HGT:           274.753(m)  0.050(m)               273.650(m)  0.050(m)
 ORTHO HGT:           306.309(m)  0.085(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 15)         SPC (1502 KS S)
Northing (Y) [meters]     4242090.730           586869.512
Easting (X)  [meters]      303999.295           684930.341
Convergence  [degrees]    -1.38992089           2.00236574
Point Scale                1.00007313           0.99995878
Combined Factor            1.00003002           0.99991567

US NATIONAL GRID DESIGNATOR: 15SUC0399942090(NAD 83)

                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DL2740 MOSB SEILER BELTON CORS ARP         N384948.687 W0943204.448   84792.2
DF9221 ZKC1 KANSAS CTY WAAS 1 CORS ARP     N385248.550 W0944726.964   74912.6
DM4686 MONE MODOT NEVADA CORS ARP          N375156.719 W0942058.369   92238.6


                 NEAREST NGS PUBLISHED CONTROL POINT
JE1057      Y 44                           N381833.    W0951454.        713.5


This position and the above vector components were computed without any
knowledge by the National Geodetic Survey regarding the equipment or
field operating procedures used.
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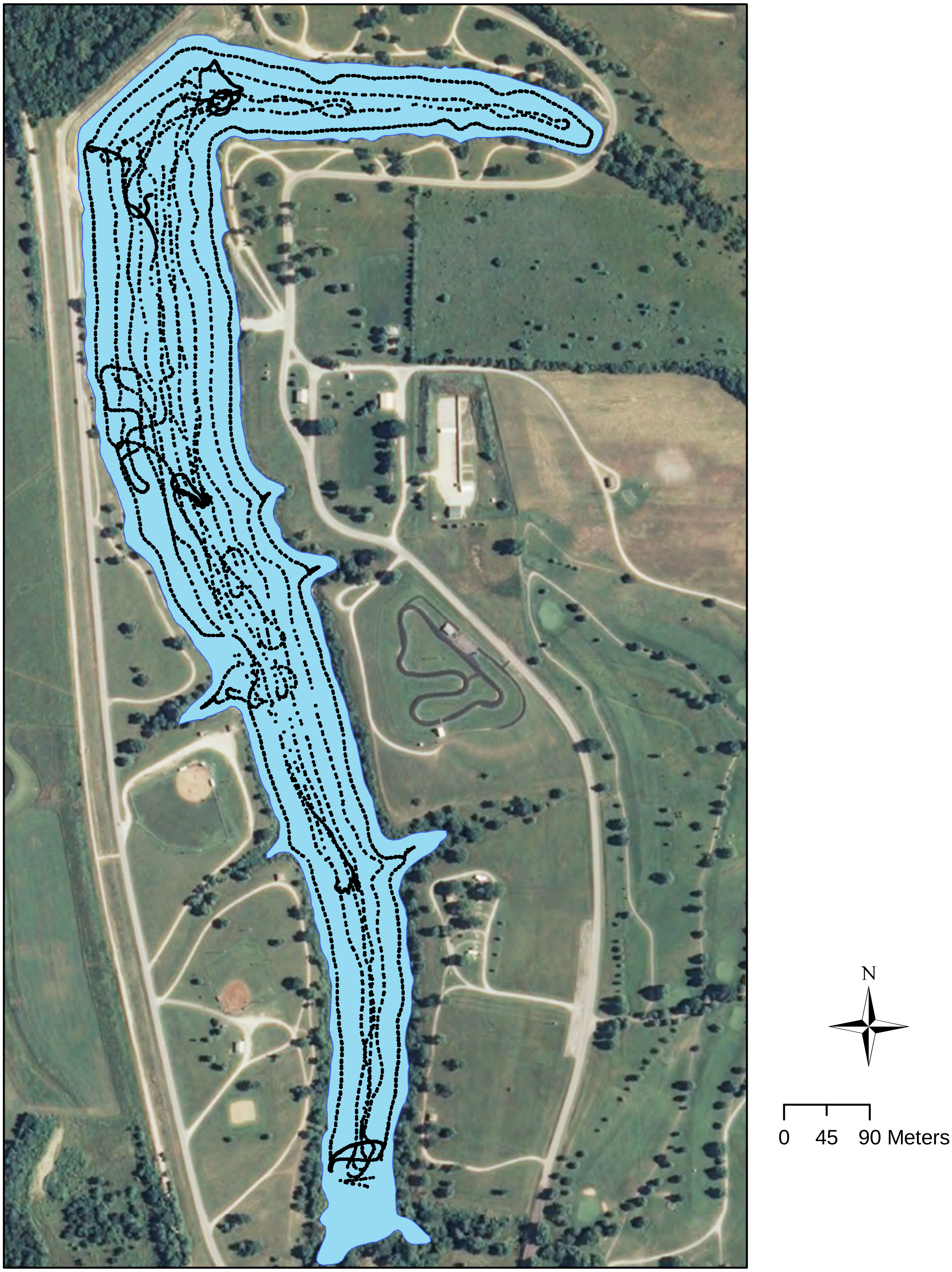

Figure 4. Bathymetric survey transects for Garnett City Lake.

Post-processing *(Visual Bottom Typer)*

The Biosonics DT-X system produces data files in a proprietary DT4 file format containing acoustic and GPS data. To extract the bottom position from the acoustic data, each DT4 file is processed through the Biosonics Visual Bottom Typer (VBT) software. The processing algorithm is described as follows:

> *"The BioSonics, Inc. bottom tracker is an "end_up" algorithm, in that it begins searching for the bottom echo portion of a ping from the last sample toward the first sample. The bottom tracker tracks the bottom echo by isolating the region(s) where the data exceeds a peak threshold for N consecutive samples, then drops below a surface threshold for M samples. Once a bottom echo has been identified , a bottom sampling window is used to find the next echo. The bottom echo is first isolated by user_defined threshold values that indicate (1) the lowest energy to include in the bottom echo (bottom detection threshold) and (2) the lowest energy to start looking for a bottom peak (peak threshold). The bottom detection threshold allows the user to filter out noise caused by a low data acquisition threshold. The peak threshold prevents the algorithm from identifying the small energy echoes (due to fish, sediment or plant life) as a bottom echo."* (Biosonics Visual Bottom Typer User's Manual, Version 1.10, p. 70).

Data is output as a comma-delimited (*.csv) text file. A set number of qualifying pings are averaged to produce a single report (for example, the output for ping 31 {when pings per report is 20} is the average of all values for pings 12-31). Standard analysis procedure for all 2008 and later data is to use the average of 5 pings to produce one output value. All raw *.csv files are merged into one master *.csv file using the shareware program File Append and Split Tool (FAST) by Boxer Software (Ver. 1.0, 2006).

Post-processing **(*Excel*)**

The master *.csv file created by the FAST utility is imported into Microsoft Excel. Excess header lines are deleted (each input CSV file has its own header), and the header file is edited to change the column headers "#Ping" to "Ping" and "E1' " to "E11", characters that are not ingestable by ArcGIS. Entries with depth values of zero (0) are deleted, as are any entries with depth values less than the start range of the data acquisition parameter (0.49 meters or less) (indicating areas where the water was too shallow to record a depth reading).

In Excel, depth adjustments are made. A new field – Adj_Depth – is created. The value for AdjDepth is calculated as AdjDepth = Depth + (Transducer Face Depth), where the Transducer Face Depth represents the depth of the transducer face below water level in meters (Typically, this value is 0.2 meters; however, if changes were made in the field, the correct level is taken from field notes and applied to the data). Depth in feet is also calculated as DepthFt = Adj_Depth * 3.28084.

These water depths are RELATIVE water depths that can vary from day-to-day based on the elevation of the water surface. In order to normalize all depth measurements to an absolute reference, water depths must be subtracted from an established value for the elevation of the water surface at the time of the bathymetric survey. Determination of water surface elevation has been described in an earlier section on establishment of lake levels.

To set depths relative to lake elevation, two additional fields are added to the attribute table of the point shapefile: LakeElevM, the reference surface elevation (the elevation of the water surface on the day that the aerial photography from which the lake perimeter polygon was digitized)and Elev_Ft, the elevation of the water surface in feet above sea level (Elev_ft), computed by converting ElevM to elevation in feet (ElevM * 3.28084).

Particularly for multi-day surveys, Adj_Depth and Depth_Ft should **NOT** be used for further analysis or interpolation. If water depth is desired, it should be produced by subtracting Elev_M or Elev_Ft from the reference elevation used for interpolation purposes (for federal reservoirs, the elevation of the water surface on the day that the aerial photography from which the lake perimeter polygon was digitized).

Post-processing *(ArcGIS):*

Ingest to ArcGIS is accomplished by using the Tools – Add XY Data option. The projection information is specified at this time (WGS84). Point files are displayed as Event files, and are then exported as a shapefile (filename convention: ALLPOINTS_WGS84.shp). The pointfile is then reprojected to the UTM coordinate system of the appropriate zone (14 or 15) (filename convention ALLPOINTS_UTM.shp).

Raster interpolation of the point data is performed using the same input data and the Topo to Raster option within the 3D Extension of ArcGIS. The elevation of the reservoir on the date of aerial photography used to create the perimeter/shoreline shapefile was used as the water surface elevation in all interpolations from point data to raster data.

Contour line files are derived from the raster interpolation files using the ArcGIS command under 3D Analyst – Raster Surface – Contour.

Area-elevation-volume tables are derived using an ArcGIS extension custom written for and available from the ASTRA Program. Summarized, the extension calculates the area and volume of the reservoir at 1/10-foot elevation increments from the raster data for a series of water surfaces beginning at the lowest elevation recorded and progressing upward in 1/10-foot elevation increments to the reference water surface. Cumulative volume is also computed in acre-feet.

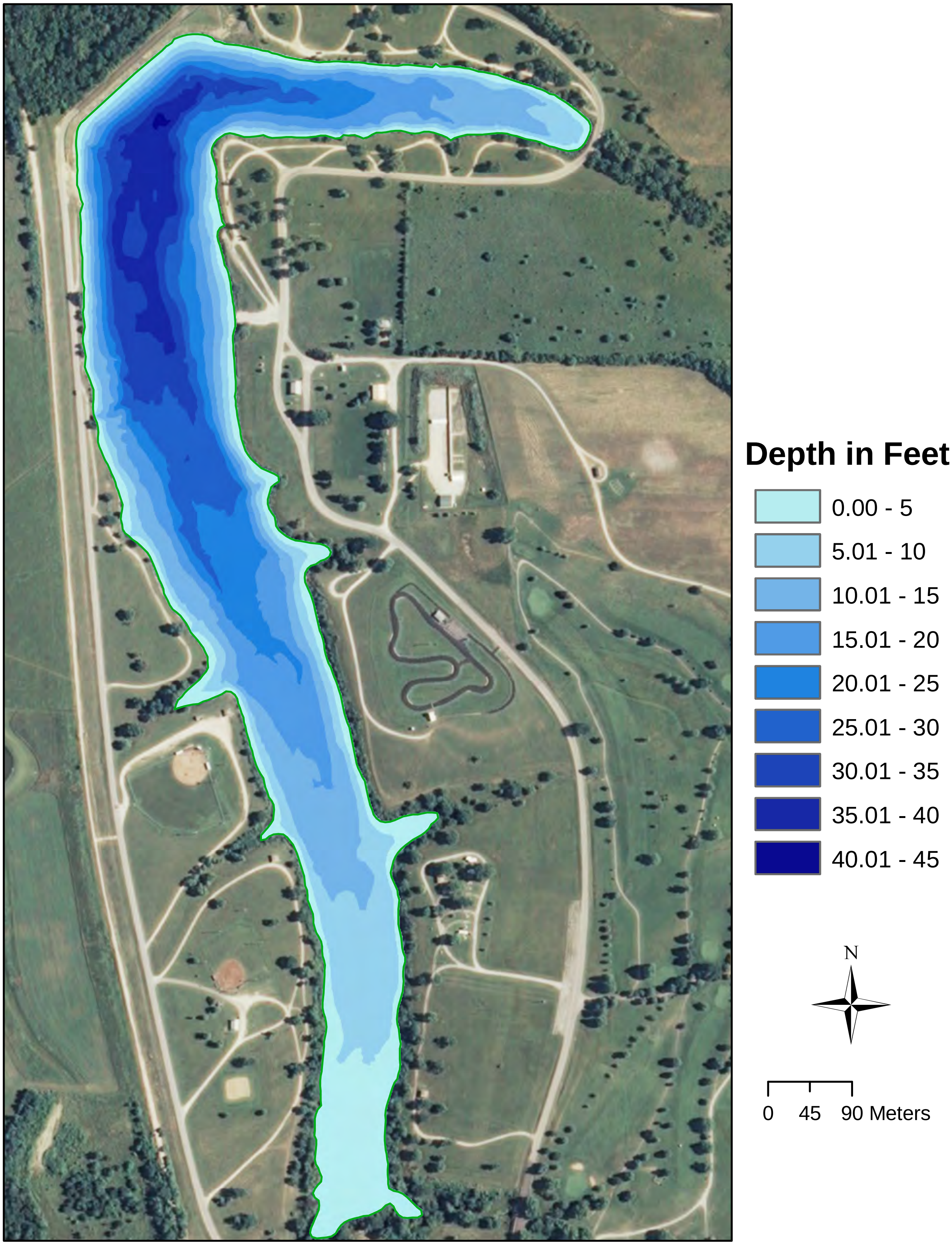

Figure 5. Lake depth map for Garnett City Lake.

Table 1
Cumulative area in acres by tenth foot elevation increments

Elevation (ft NGVD)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
960	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
961	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
962	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8
963	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.6	1.7
964	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
965	2.9	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6
966	3.7	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2
967	4.2	4.3	4.4	4.4	4.5	4.5	4.6	4.7	4.7	4.8
968	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.3	5.4
969	5.5	5.5	5.6	5.7	5.7	5.8	5.9	5.9	6.0	6.1
970	6.2	6.3	6.3	6.4	6.5	6.6	6.7	6.7	6.8	6.9
971	7.0	7.1	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.7
972	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.5
973	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3	9.4
974	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4
975	10.5	10.6	10.7	10.7	10.8	10.9	11.0	11.1	11.2	11.3
976	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.3	12.4	12.5
977	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5
978	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.6
979	14.7	14.8	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.7
980	15.8	15.9	16.0	16.2	16.3	16.4	16.5	16.7	16.8	16.9
981	17.1	17.2	17.3	17.5	17.6	17.7	17.9	18.0	18.1	18.3
982	18.4	18.6	18.7	18.8	19.0	19.1	19.2	19.4	19.5	19.6
983	19.8	19.9	20.0	20.1	20.3	20.4	20.5	20.7	20.8	20.9
984	21.1	21.2	21.3	21.5	21.6	21.7	21.9	22.0	22.2	22.3
985	22.5	22.6	22.8	22.9	23.1	23.2	23.4	23.5	23.7	23.8
986	23.9	24.1	24.2	24.4	24.5	24.7	24.8	25.0	25.1	25.3
987	25.4	25.5	25.7	25.8	26.0	26.1	26.3	26.4	26.6	26.8
988	27.0	27.1	27.3	27.5	27.7	27.9	28.1	28.2	28.4	28.6
989	28.7	28.9	29.0	29.2	29.3	29.5	29.7	29.8	30.0	30.1
990	30.3	30.5	30.6	30.8	31.0	31.2	31.4	31.6	31.7	31.9
991	32.1	32.3	32.4	32.6	32.7	32.9	33.1	33.2	33.3	33.5
992	33.6	33.8	33.9	34.0	34.2	34.3	34.5	34.6	34.7	34.9
993	35.0	35.1	35.3	35.4	35.6	35.7	35.8	35.9	36.1	36.2
994	36.4	36.5	36.6	36.7	36.9	37.0	37.2	37.3	37.5	37.6
995	37.8	38.0	38.1	38.3	38.4	38.6	38.7	38.9	39.1	39.2
996	39.4	39.5	39.7	39.8	40.0	40.1	40.3	40.5	40.6	40.8
997	41.0	41.1	41.3	41.4	41.5	41.7	41.8	41.9	42.1	42.2
998	42.3	42.5	42.6	42.8	43.0	43.1	43.3	43.5	43.7	43.9
999	44.1	44.3	44.5	44.7	45.0	45.3	45.6			

Table 2
Cumulative volume in acre-feet by tenth foot elevation increments

Elevation (ft NGVD)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
960	0	0	0	0	0	0	0	0	0	0
961	0	0	0	0	0	0	0	0	0	1
962	1	1	1	1	1	1	1	1	1	1
963	1	1	1	2	2	2	2	2	2	2
964	3	3	3	3	3	4	4	4	4	5
965	5	5	5	6	6	6	7	7	7	8
966	8	9	9	9	10	10	10	11	11	12
967	12	13	13	13	14	14	15	15	16	16
968	17	17	18	18	19	19	20	20	21	21
969	22	22	23	23	24	25	25	26	26	27
970	28	28	29	29	30	31	31	32	33	33
971	34	35	36	36	37	38	39	39	40	41
972	42	42	43	44	45	46	46	47	48	49
973	50	51	52	52	53	54	55	56	57	58
974	59	60	61	62	63	64	65	66	67	68
975	69	70	71	72	73	74	75	76	78	79
976	80	81	82	83	84	86	87	88	89	91
977	92	93	94	96	97	98	100	101	102	104
978	105	106	108	109	110	112	113	115	116	118
979	119	121	122	123	125	127	128	130	131	133
980	134	136	137	139	141	142	144	146	147	149
981	151	152	154	156	158	159	161	163	165	167
982	168	170	172	174	176	178	180	182	184	186
983	188	190	192	194	196	198	200	202	204	206
984	208	210	212	214	217	219	221	223	225	227
985	230	232	234	237	239	241	244	246	248	251
986	253	255	258	260	263	265	268	270	273	275
987	278	280	283	285	288	291	293	296	298	301
988	304	307	309	312	315	318	320	323	326	329
989	332	335	337	340	343	346	349	352	355	358
990	361	364	367	370	373	377	380	383	386	389
991	392	396	399	402	405	409	412	415	419	422
992	425	429	432	436	439	442	446	449	453	456
993	460	463	467	470	474	477	481	485	488	492
994	495	499	503	506	510	514	517	521	525	529
995	532	536	540	544	548	552	555	559	563	567
996	571	575	579	583	587	591	595	599	603	607
997	611	615	620	624	628	632	636	640	645	649
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999	696	701	705	710	714	719	723			

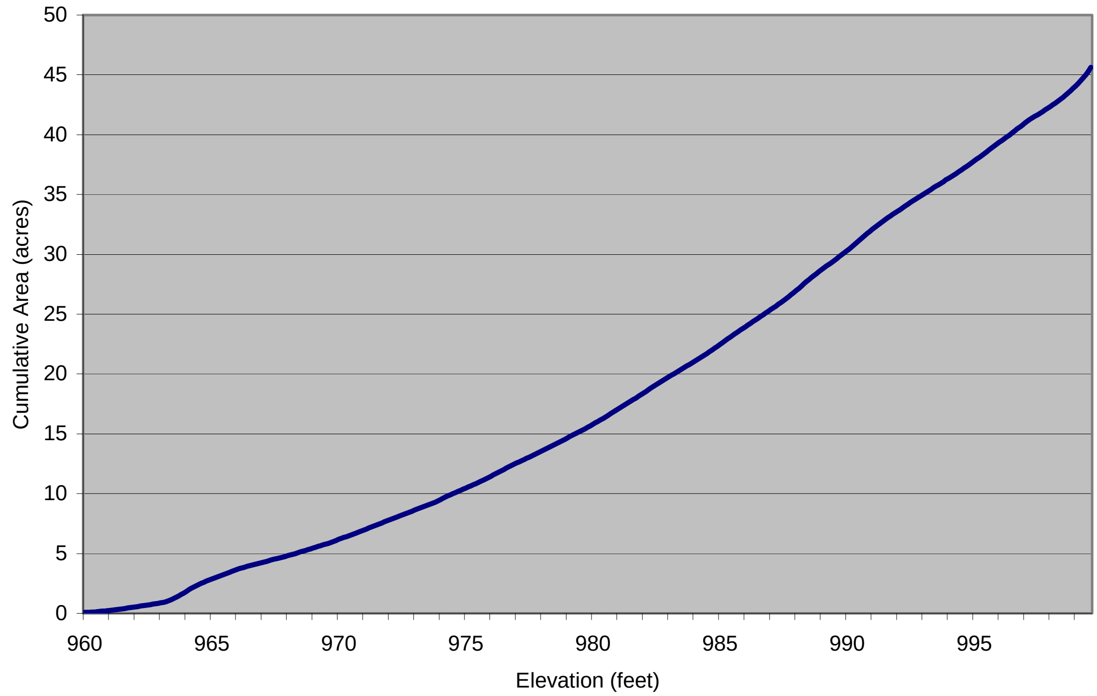

Figure 6. Cumulative area-elevation curve

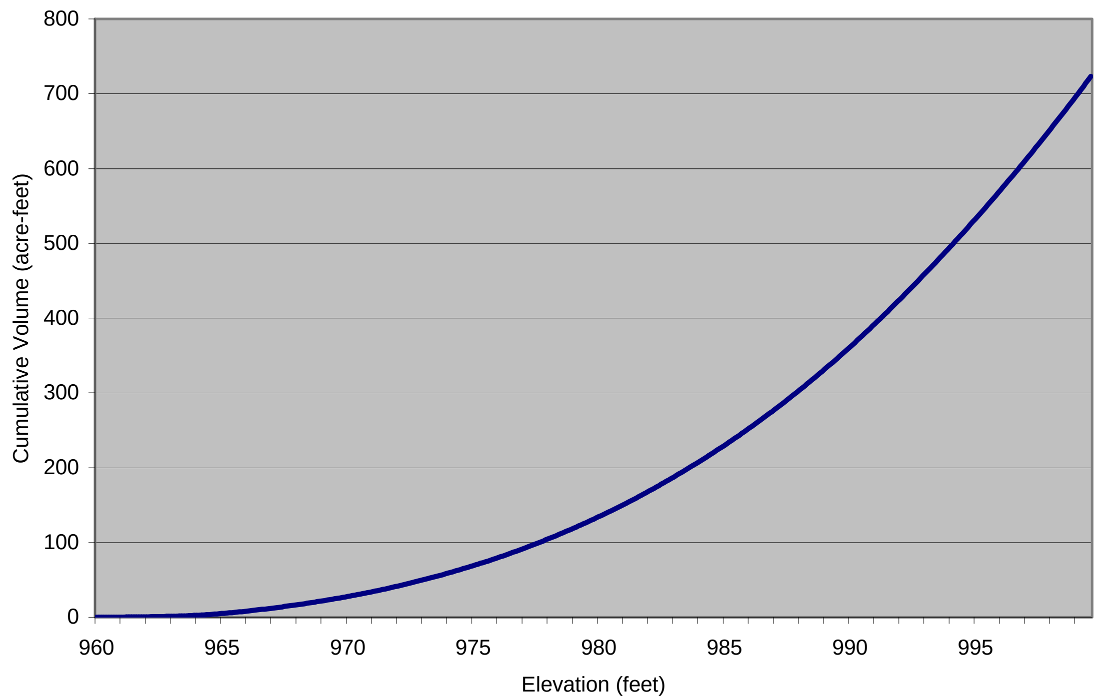

Figure 7. Cumulative volume-elevation curve

SEDIMENT SAMPLING PROCEDURES

Sediment samples were collected from three sites within the reservoir using a Wildco drop-corer (Wildlife Supply Company, Buffalo, NY). One sample is taken near the dam; a second at mid-lake; and a third in the upper end/transitional area. Sampling is typically performed on the same day as the bathymetric survey, following completion of the survey. As the drop-corer samples only the upper sediment, the entire sample in each case is collected and sealed in a sampling container. The samples are then shipped to the Kansas State University Soil Testing Laboratory (Manhattan, KS), for texture and other analyses.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed along the reservoir (Figure 8). Sand was a minor fraction in all three samples, with particle size distributions dominated by silt and clay (Table 3; Figure 9; Figure 10).

Table 3
Sediment sampling site data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
GCL-1	303900	4242059	6	46	48
GCL-2	304026	4241224	10	44	46
GCL-3	303865	4241626	2	66	32

Coordinates are Universal Transverse Mercator (UTM), NAD83, Zone 15 North

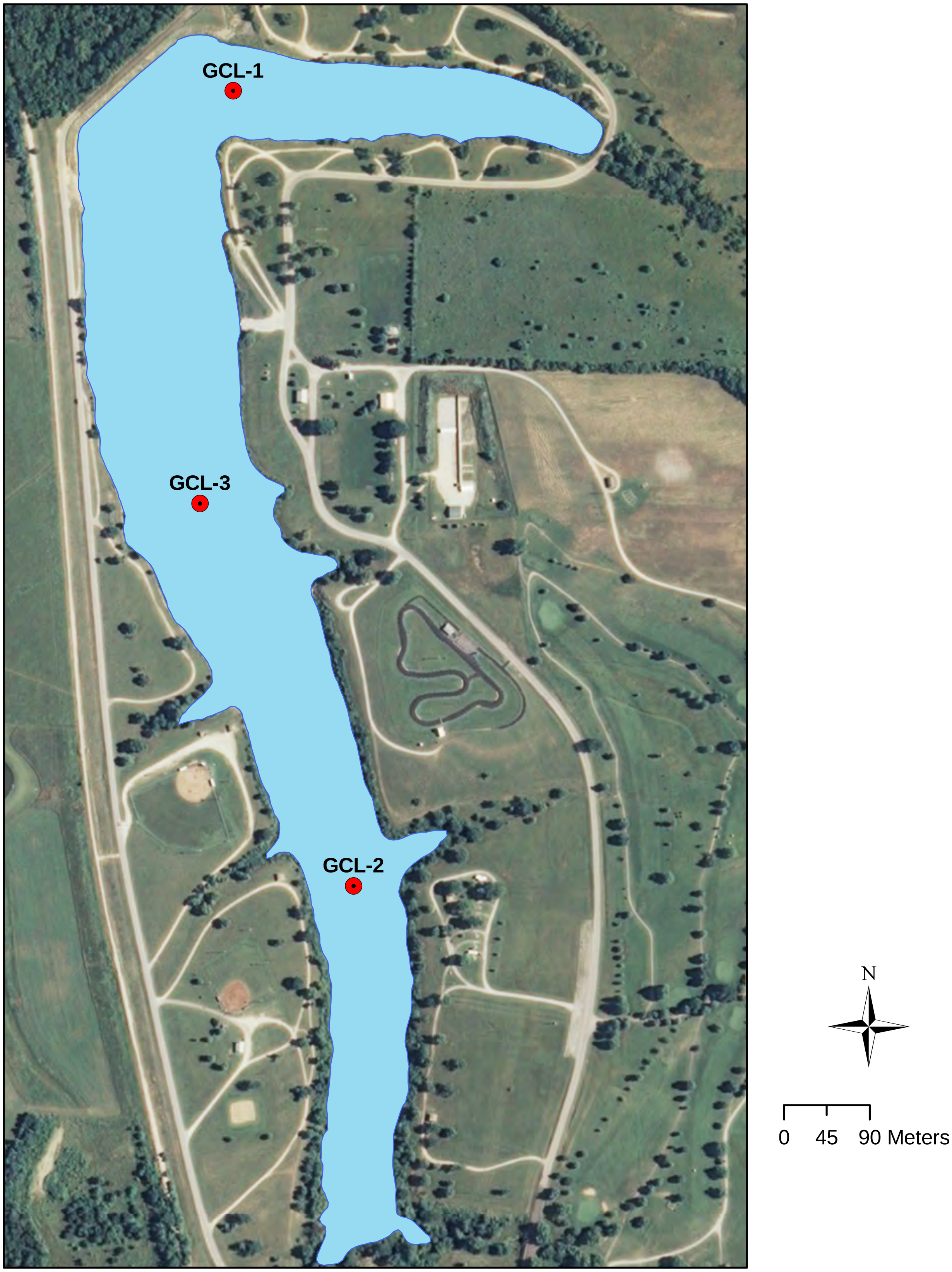

Figure 8. Sediment sample sites on Garnett City Lake.

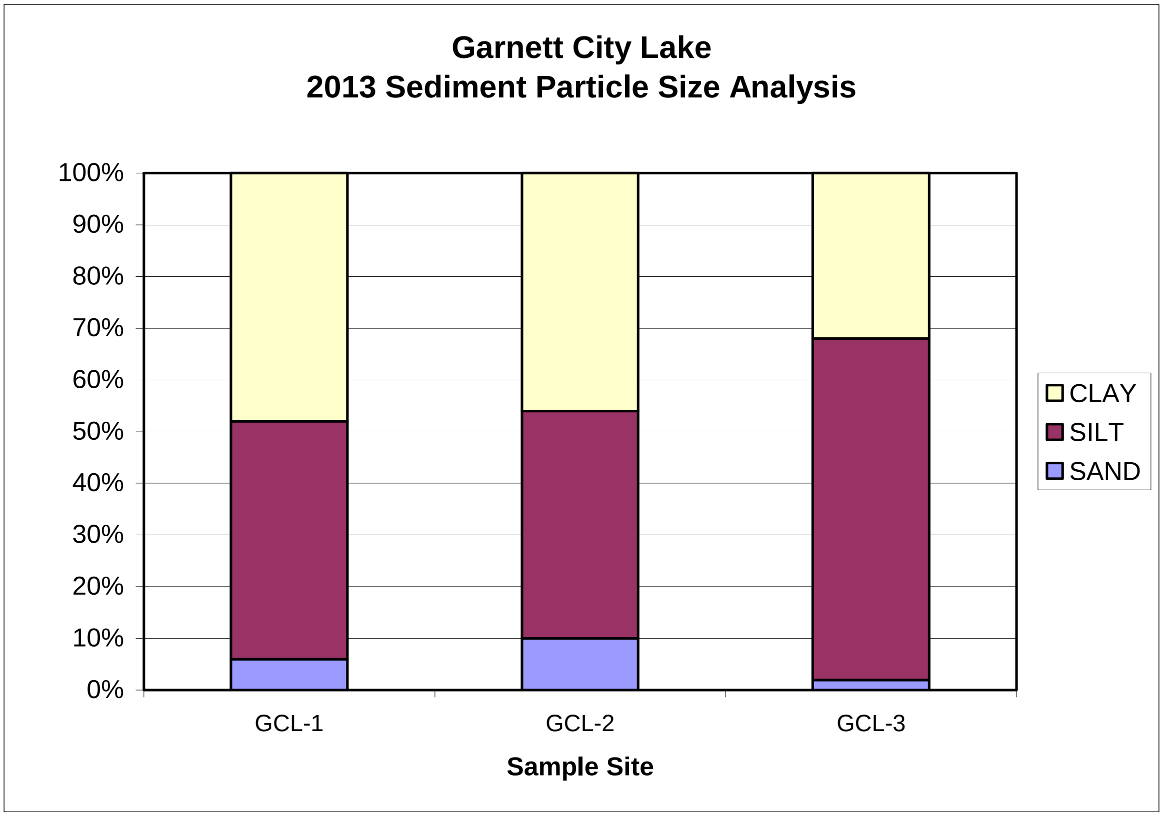

Figure 9. Sediment particle size analysis.

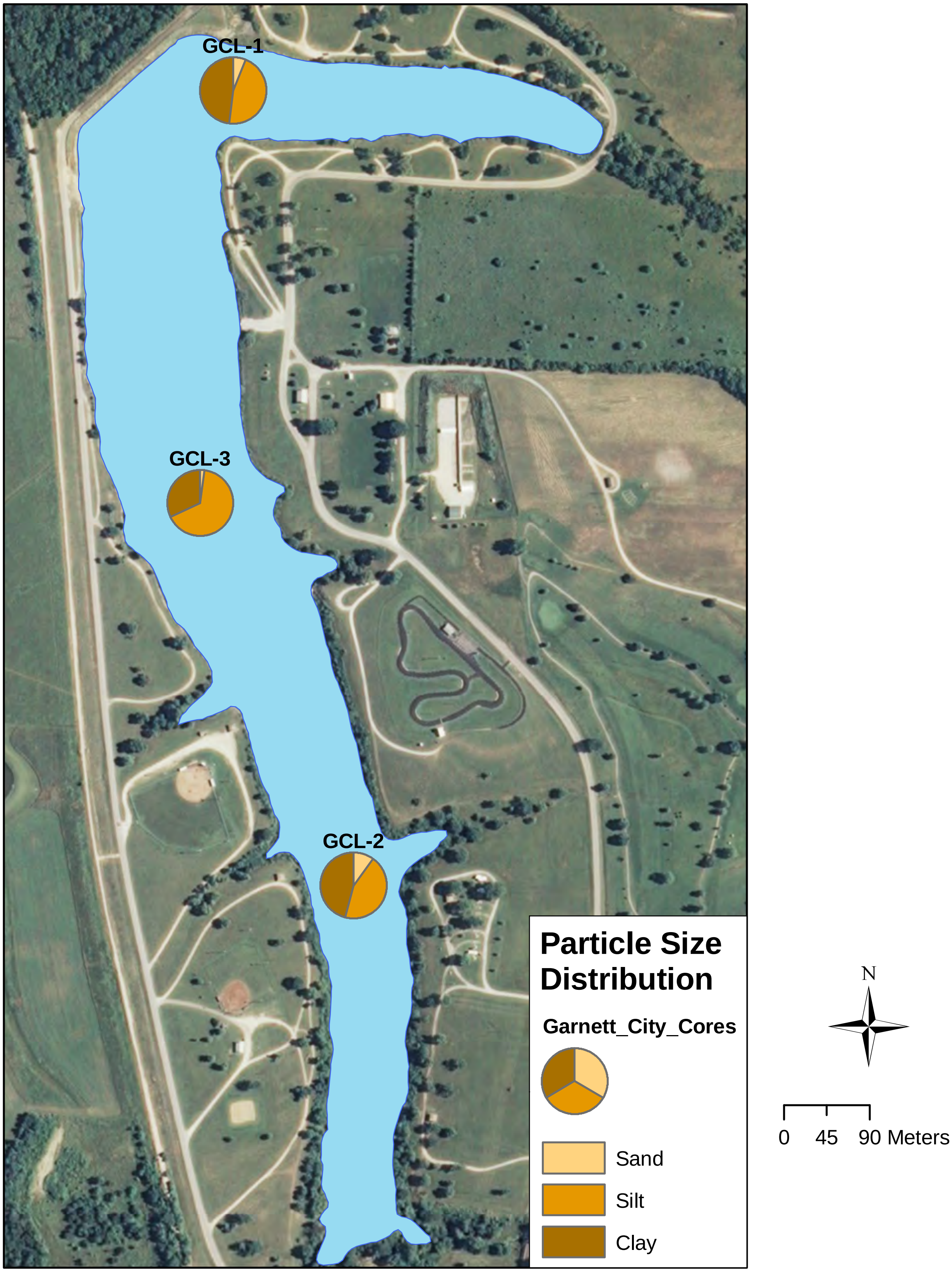

Figure 10. Particle size distribution of sediment in Garnett City Lake.