Bathymetric and Sediment Survey of Miola Lake, Miami County, Kansas

Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2009-01 (April 2009)

Revised Area-Elevation-Capacity Tables and Figures, January 2010

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SUMMARY

On June 25, 2008, the Kansas Biological Survey (KBS) performed a bathymetric survey of Miola Lake in Miami 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:		
	Date of survey:	June 10, 2008
Reservoir Statistics:		
	Elevation on survey date	904.6 ft
	Area on survey date (acres):	189
	Volume on survey date (acre-feet):	2724
	Maximum depth (feet):	28.8
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	339370.7, 4272124.8
	UTM Zone:	15N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	913.92
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	June 10, 2008

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LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Miola Lake near the City of Paola in Miami County, Kansas.

Location: Miola Lake is located adjacent to the City of Paola at 295th Street and Hedge Lane Road. The reservoir is formed by Miola Dam on Dorsey Branch Creek. It is owned by the City of Paola.

Purpose: Water supply, recreation, and flood control.

Structure and Spillway Type: The reservoir was constructed in 1957. Dam is of earthen construction. Its length is 2100 feet. Maximum discharge is 1600 cubic feet per second.

Miami County, Kansas

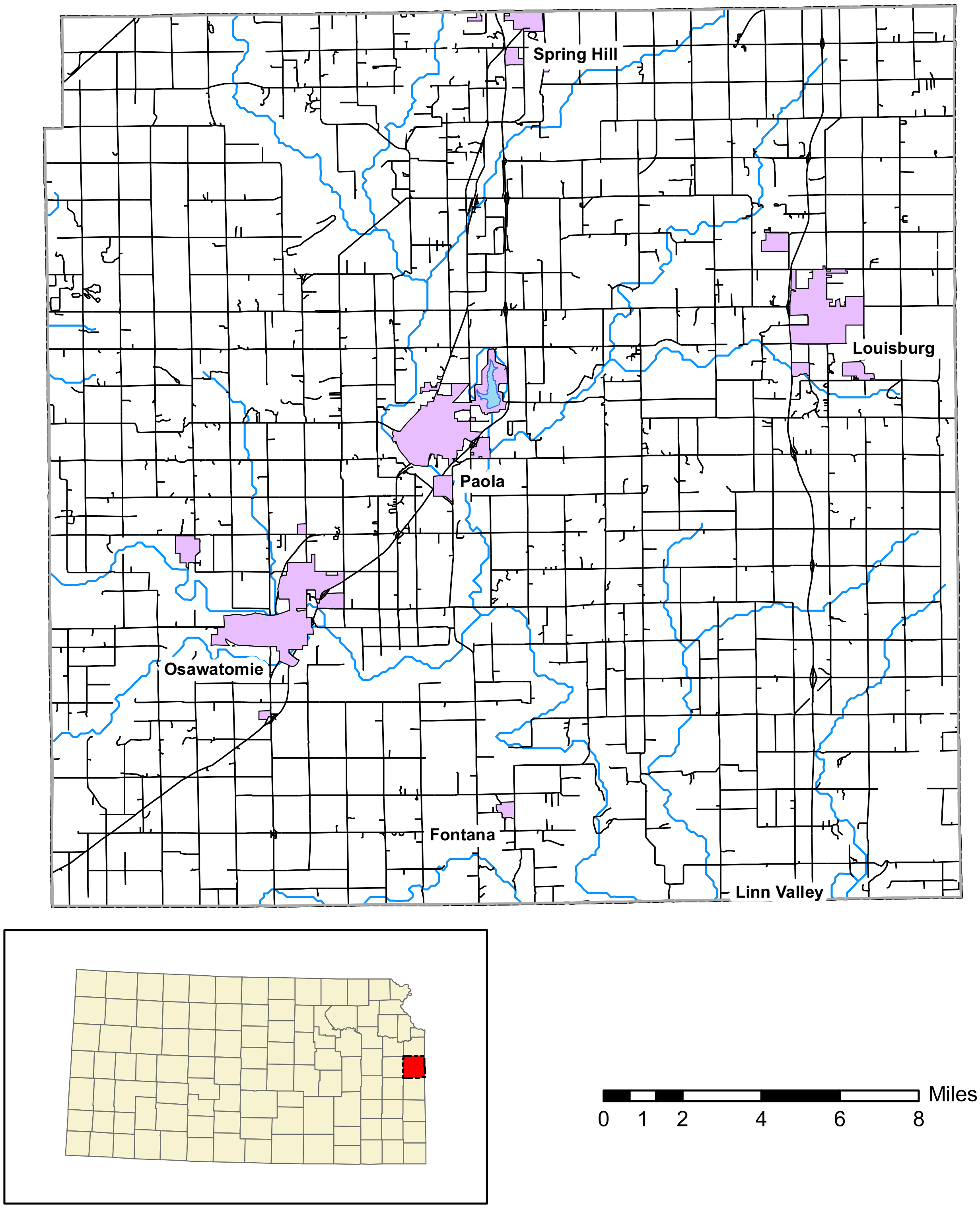

Figure 2. Location of Miola Lake in Miami County, Kansas.

Reservoir Bathymetric (Depth) Surveying Procedures

KBS operates a Biosonics DT-X acoustic echosounding system (www.biosonicsinc.com) with a 200 kHz split-beam transducer and a 38-kHz single-beam transducer. In addition to providing basic information on reservoir depth profiles, the Biosonics system also permits the assessment of bottom sediment composition. Latitude-longitude information is provided by a JRC 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, geospatial data of the target lake is acquired, including georeferenced National Agricultural Imagery Project (NAIP) photography. The lake boundary is digitized as a polygon shapefile from the FSA NAIP georeferenced aerial photography obtained online from the Data Access and Service Center (DASC) at the Kansas Geological Survey. Prior to the lake survey, a series of transect lines are created as a shapefile in ArcGIS for guiding the boat during the survey. Transect lines are spaced more closely (25-50 meters separation) on smaller state/local lakes, while a spacing of 100-150 meters is used for federal reservoirs.

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. To assist the boat operator in navigation, an auxiliary LCD monitor is connected to the computer and placed within the easy view of the boat operator. Transducer face depth on all dates is 0.5 meters below the water surface. 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 Miola Lake is the top of the east end of the concrete wall of the spillway on the lake side of the dam (Figure 3a, Figure 3b).

The water surface elevation of Miola Lake on June 10, 2008 was 904.68 feet AMSL.

Location of Lake Elevation Benchmark:

Miola Lake: Eastern end of concrete wall of intake structure on dam.

UTM (NAD83, Zone 15): Easting (X) [meters] 339370.7, Northing (Y) [meters] 4272124.8

Figure 3a. View west along dam.

Figure 3b. Close-up view. Lake level was measured from the water surface to the top of the concrete wall at the eastern (right side in picture) side.

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 FILE: log1309r.08O 000464895  (Miola Lake)

 2005   NOTE:  The IGS precise and IGS rapid orbits were not available
 2005   at processing time.  The IGS ultra-rapid orbit was/will be used to
 2005   process the data.
 2005
 1008   NOTE:  Antenna offsets supplied by the user were zero.  Coordinates
 1008   returned will be for the antenna reference point (ARP).
 1008
                              NGS OPUS SOLUTION REPORT
                              ========================

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

      USER: mjakub@ku.edu                            DATE: November 05, 2008
RINEX FILE: log1309r.08o                             TIME: 16:13:09 UTC

  SOFTWARE: page5  0810.20 master24.pl 081023      START: 2008/11/04  17:00:00
 EPHEMERIS: igu15042.eph [ultra-rapid]              STOP: 2008/11/04  19:31:30
  NAV FILE: brdc3090.08n                        OBS USED:  5136 /  5214   :  99%
  ANT NAME: TPSHIPER_PLUS   NONE               # FIXED AMB:    31 /    34   :  91%
ARP HEIGHT: 0.0                                OVERALL RMS: 0.011(m)

 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)           ITRF00 (EPOCH:2008.8436)

         X:      -421598.311(m)   0.045(m)          -421599.029(m)   0.045(m)
         Y:     -4974682.660(m)   0.017(m)         -4974681.289(m)   0.017(m)
         Z:      3956396.751(m)   0.032(m)          3956396.625(m)   0.032(m)

       LAT:   38 34 59.09444      0.038(m)        38 34 59.11765      0.038(m)
     E LON:  265  9 20.97971      0.043(m)       265  9 20.94537      0.043(m)
     W LON:   94 50 39.02029      0.043(m)        94 50 39.05463      0.043(m)
    EL HGT:          246.628(m)   0.004(m)                245.529(m)   0.004(m)
 ORTHO HGT:          278.564(m)   0.062(m) [NAVD88 (Computed using GEOID03)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 15)         SPC (1502 KS S)
Northing (Y) [meters]     4272124.869           618945.101
Easting (X)  [meters]      339370.757           718460.731
Convergence  [degrees]    -1.15036159           2.24660889
Point Scale                0.99991775           1.00000329
Combined Factor            0.99987905           0.99996459

US NATIONAL GRID DESIGNATOR: 15SUC3937172125(NAD 83)

                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DI3428 KSU1 KSU1_KSUN_KS2006 CORS ARP      N390602.677 W0963634.093  163680.1
DJ3673 KST6 TOPEKA 6 CORS ARP              N390239.667 W0960220.831  115731.9
AJ1832 NDS1 NEODESHA (2) CORS ARP          N371805.504 W0953605.332  157052.5

                 NEAREST NGS PUBLISHED CONTROL POINT
JE0882      W 221                          N383435.    W0944935.       1717.6

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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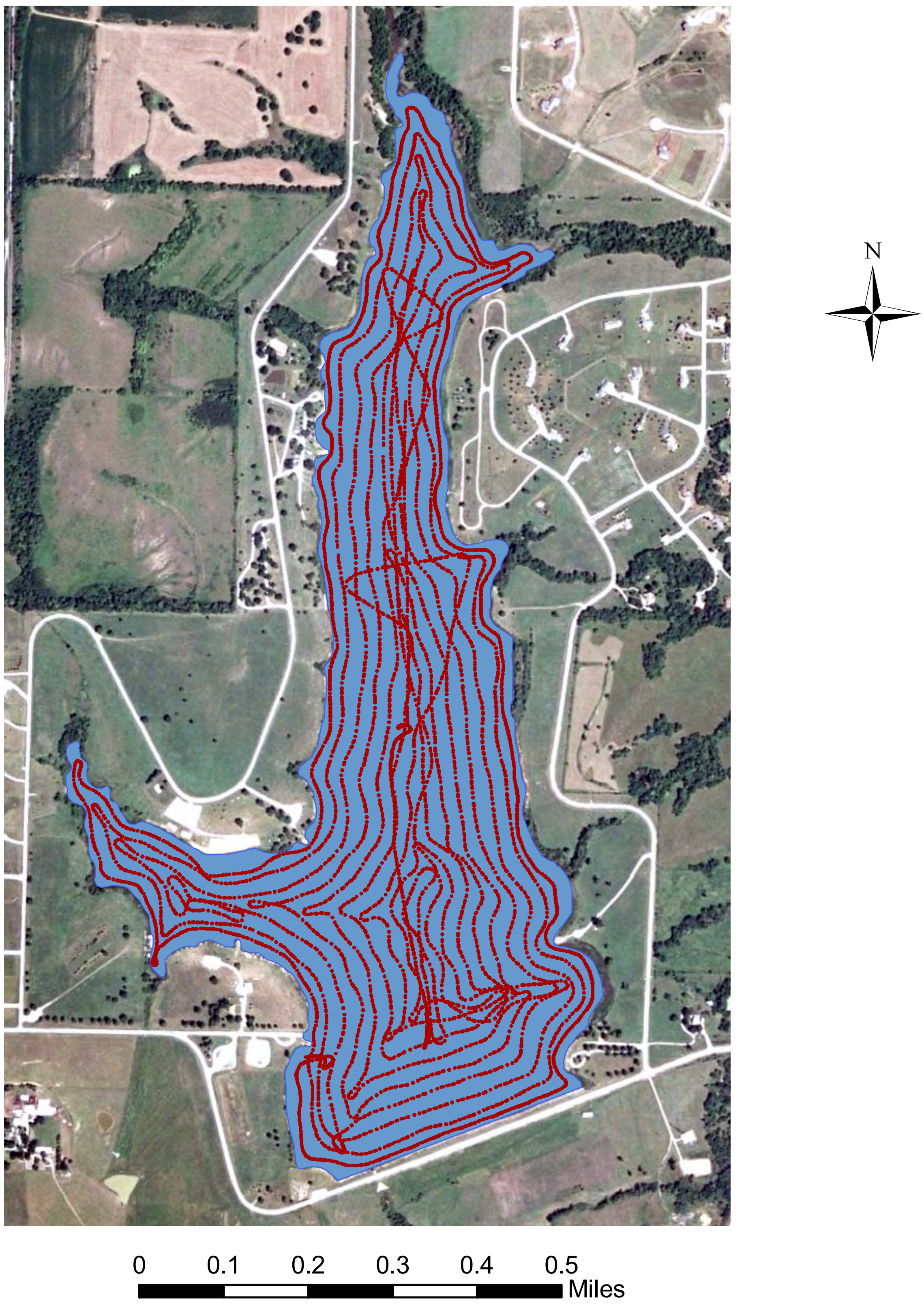

Figure 4. Bathymetric survey transects for Miola Lake

<u>Post-processing</u> *(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 7 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).

<u>Post-processing</u> (*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 (typically 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 0.5 meters). Four values are computed in Excel: DepthM, DepthFt, ElevM and ElevFt, where:

DepthM = Adj_Depth
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, another field is added to the attribute table of the point shapefile, ElevM. The value for this attribute is then computed as Depth_ElevM = (Elevation of the Water Surface in meters above sea level) - Adj_Depth. Elevation of the water surface in feet above sea level is also computed by converting ElevM to elevation in feet (ElevM * 3.28084).

Particularly for multi-day surveys, ADJ_DEPTH, Depth_M, 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.

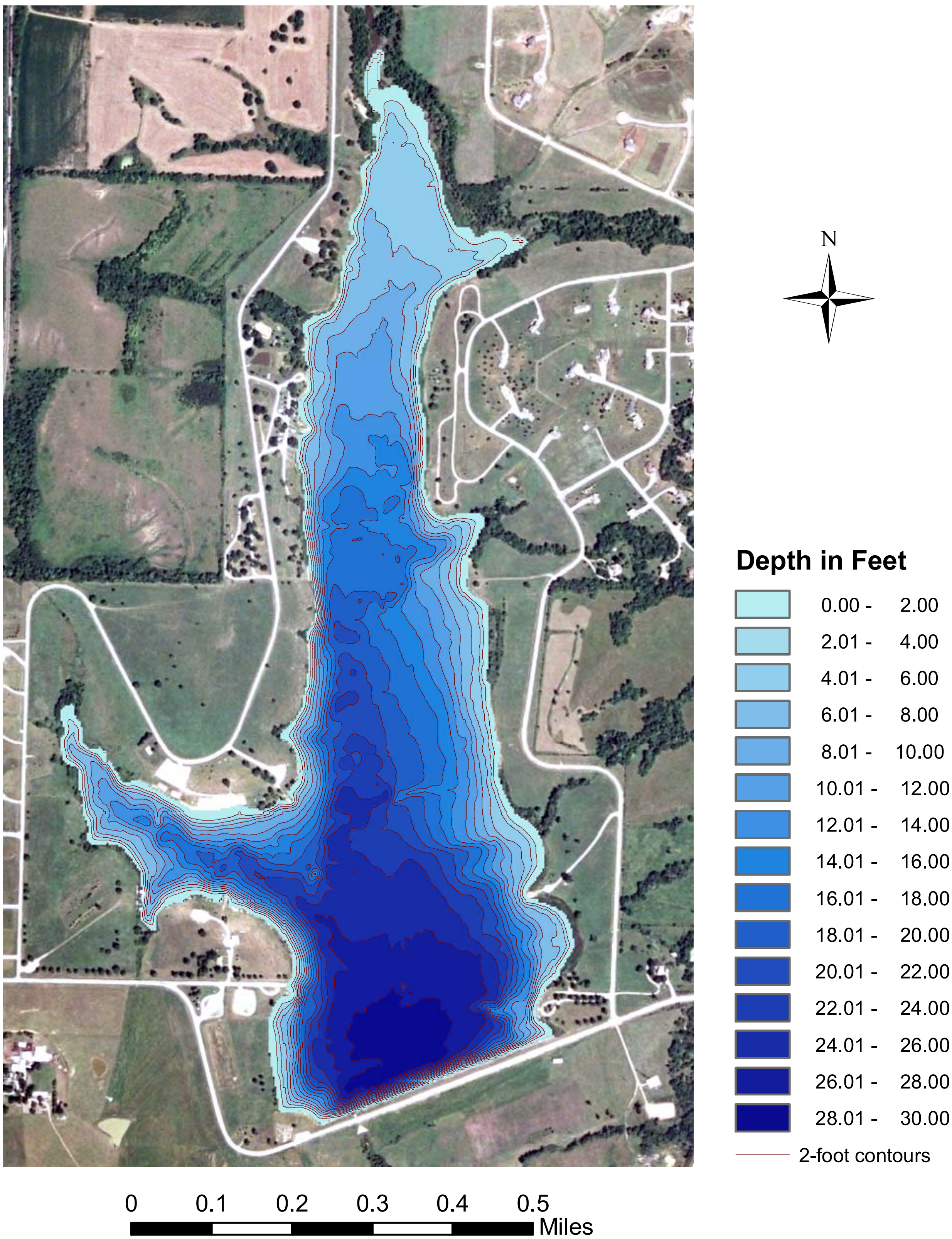

Figure 5. Water depth based on June 2008 bathymetric survey.for Miola Lake. Depths are based on a pool elevation of 904.68 feet.

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
875	0	0	0	0	0	0	0	0	0	1
876	1	1	2	4	5	6	7	7	8	9
877	9	10	10	11	12	12	13	13	14	15
878	16	16	17	17	18	18	19	20	21	21
879	22	23	24	24	25	26	27	28	29	29
880	30	31	32	32	33	33	34	34	35	35
881	36	36	37	37	38	38	39	39	40	40
882	41	42	42	43	43	44	44	45	45	46
883	46	47	47	48	48	49	49	50	50	51
884	51	52	52	53	53	54	54	55	55	56
885	56	57	57	58	59	59	60	60	61	62
886	62	63	63	64	65	65	66	67	67	68
887	69	70	70	71	72	72	73	74	75	76
888	77	78	79	80	81	82	82	83	84	85
889	85	86	87	87	88	89	89	90	90	91
890	92	92	93	94	95	95	96	97	98	98
891	99	99	100	101	101	102	102	103	104	104
892	105	106	106	107	107	108	109	109	110	111
893	111	112	113	114	114	115	116	117	117	118
894	119	119	120	121	121	122	123	123	124	125
895	125	126	127	127	128	128	129	130	130	131
896	132	132	133	134	134	135	136	136	137	138
897	139	139	140	141	142	142	143	144	145	145
898	146	147	148	149	150	151	152	153	154	155
899	156	157	157	158	159	160	161	162	163	164
900	165	166	167	168	168	169	169	170	170	171
901	171	172	172	173	173	173	174	174	175	175
902	176	176	177	177	177	178	178	179	179	180
903	180	181	181	181	182	182	183	183	184	185
904	185	186	186	187	187	188	189			

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
875	0	0	0	0	0	0	0	0	0	0
876	0	0	0	1	1	2	2	3	4	5
877	6	7	8	9	10	11	12	13	15	16
878	18	19	21	23	25	26	28	30	32	34
879	37	39	41	43	46	49	51	54	57	60
880	63	66	69	72	75	79	82	85	89	92
881	96	100	103	107	111	115	119	122	126	130
882	134	139	143	147	151	156	160	165	169	174
883	178	183	188	192	197	202	207	212	217	222
884	227	232	237	243	248	253	259	264	270	275
885	281	286	292	298	304	310	315	321	328	334
886	340	346	352	359	365	372	378	385	392	398
887	405	412	419	426	433	441	448	455	463	470
888	478	486	494	501	510	518	526	534	543	551
889	559	568	577	585	594	603	612	621	630	639
890	648	657	667	676	685	695	704	714	724	734
891	744	753	763	773	784	794	804	814	825	835
892	845	856	867	877	888	899	910	920	931	942
893	954	965	976	987	999	1010	1022	1033	1045	1057
894	1069	1081	1093	1105	1117	1129	1141	1154	1166	1178
895	1191	1203	1216	1229	1242	1254	1267	1280	1293	1306
896	1319	1333	1346	1359	1373	1386	1400	1413	1427	1441
897	1455	1469	1483	1497	1511	1525	1539	1554	1568	1583
898	1597	1612	1627	1641	1656	1671	1686	1702	1717	1732
899	1748	1764	1779	1795	1811	1827	1843	1859	1875	1892
900	1908	1925	1942	1958	1975	1992	2009	2026	2043	2060
901	2077	2094	2111	2129	2146	2163	2180	2198	2215	2233
902	2250	2268	2286	2303	2321	2339	2357	2375	2393	2411
903	2429	2447	2465	2483	2501	2519	2538	2556	2574	2593
904	2611	2630	2648	2667	2686	2705	2724			

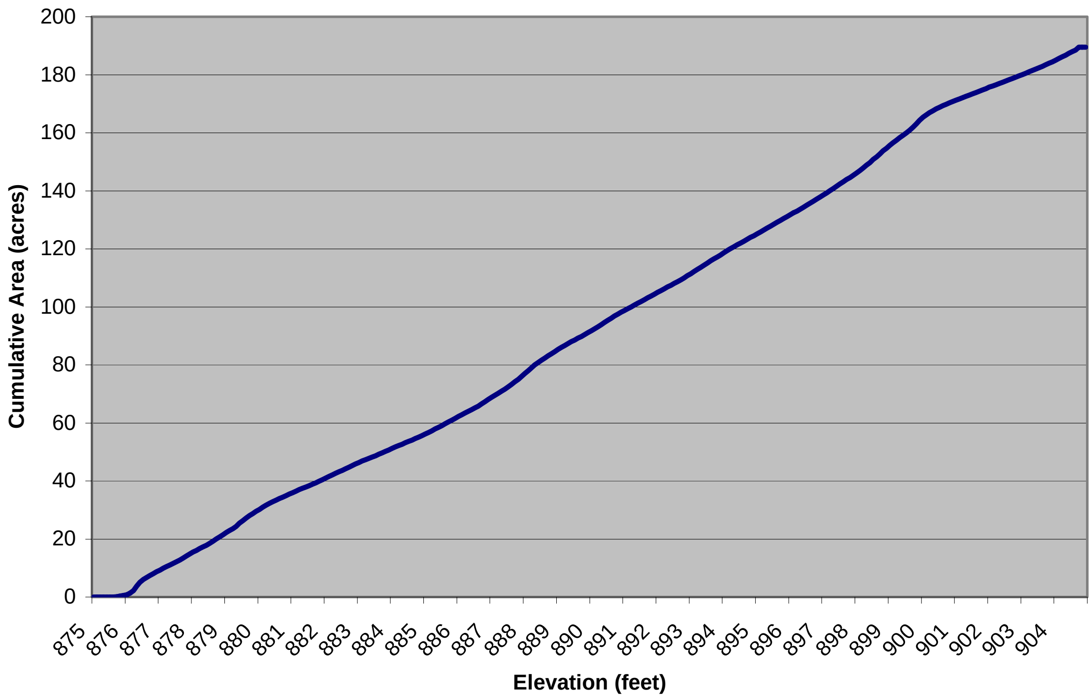

Figure 6. Cumulative area-elevation curve

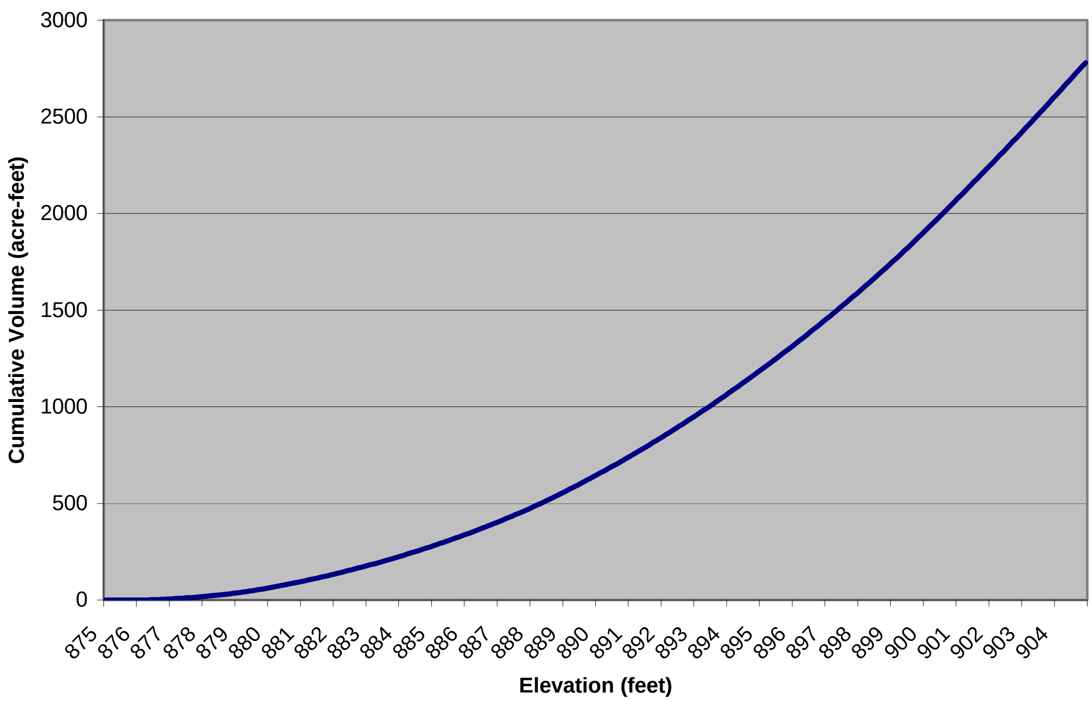

Figure 7. Cumulative volume-elevation curve

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. Samples are then shipped to MidWest Laboratories (Omaha, NE), for texture, bulk density, and other analyses.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed across the length of the reservoir (Figure 8). Silt percentages decreased from 68% at the inflow end (MIOLA#1) to 30% near the dam (MIOLA#3). Conversely, the clay fraction increased from the inflow end to the dam (Table 3; Figure 9; Figure 10).

Table 3
Miola Lake Sediment Sampling Site Data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
MIOLA#1	339443.5	4273831.4	10	68	22
MIOLA#2	339424.5	4272964.6	10	40	50
MIOLA#3	339468.0	4272375.1	20	30	50

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

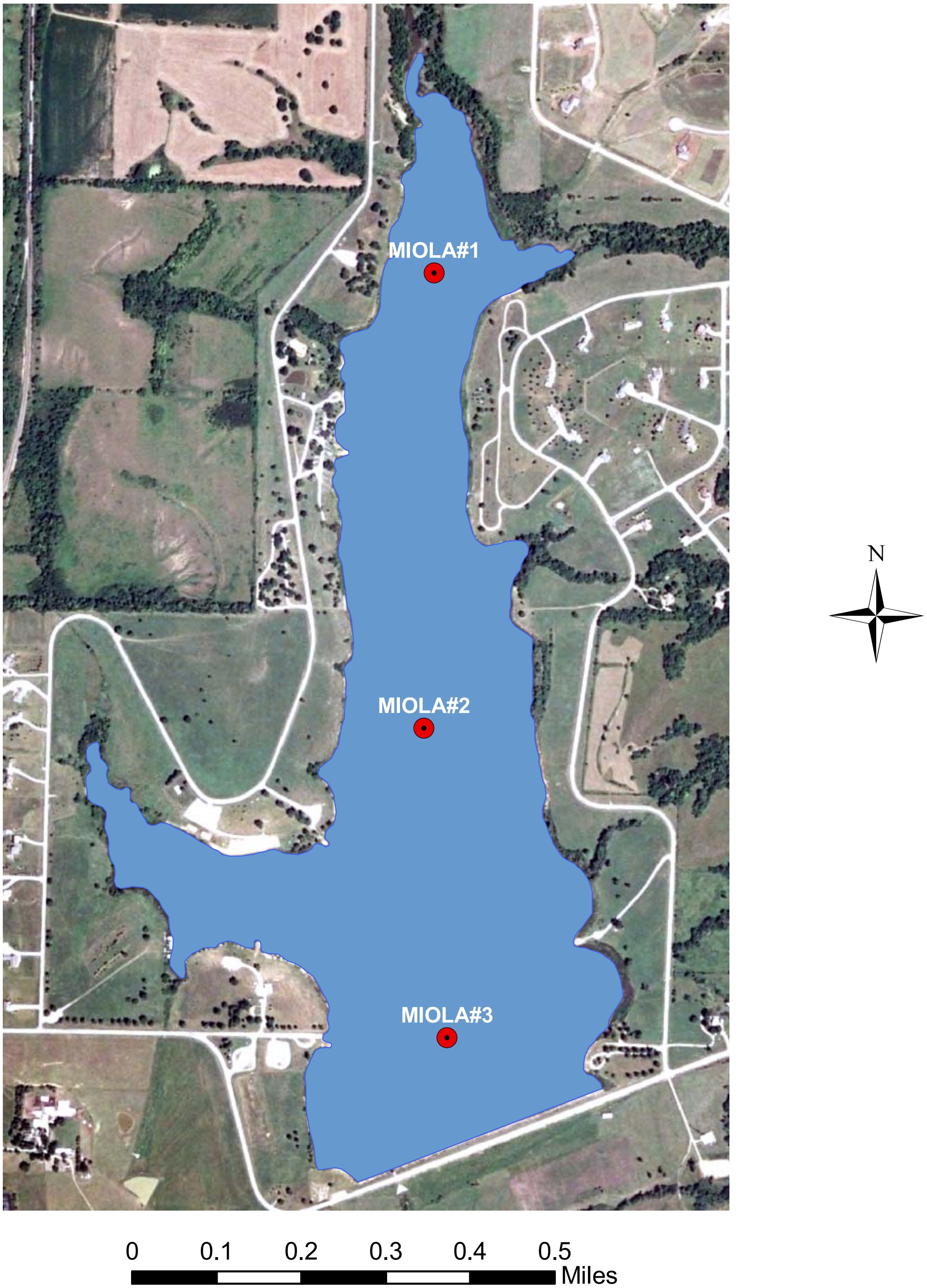

Figure 8. Location of sediment samples in Miola Lake

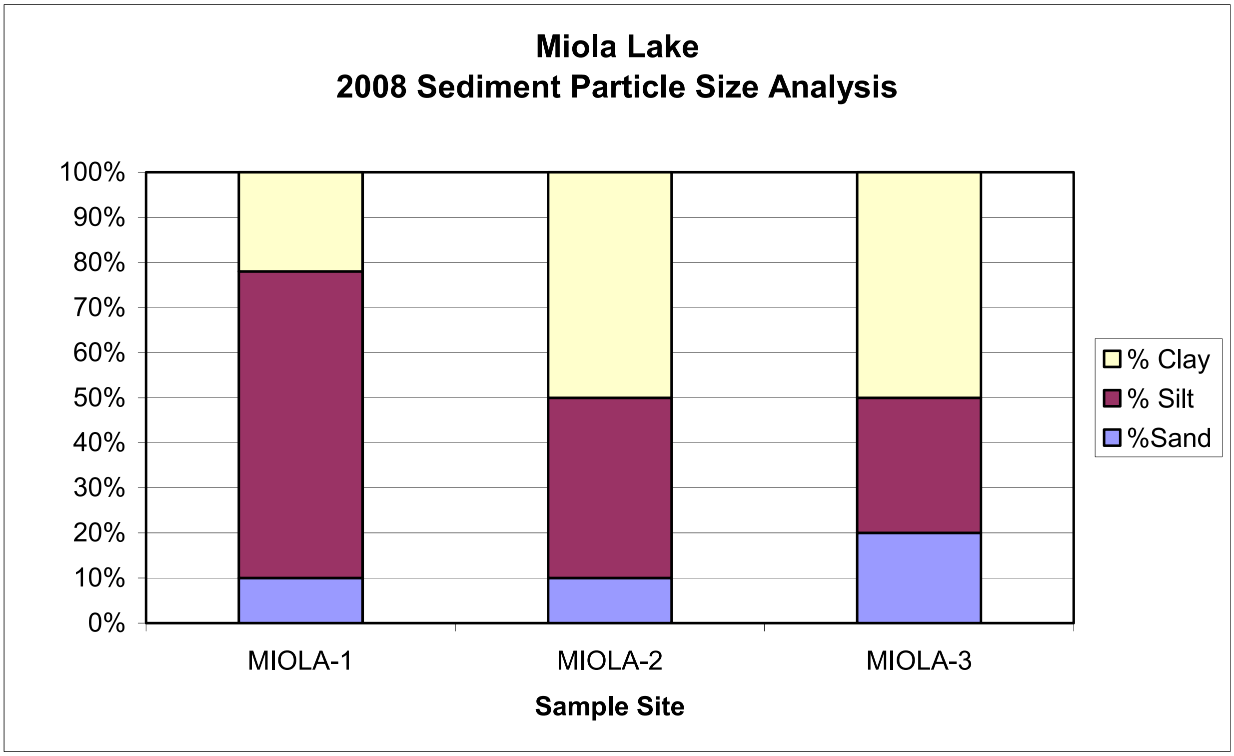

Figure 9. Sediment particle size analysis.

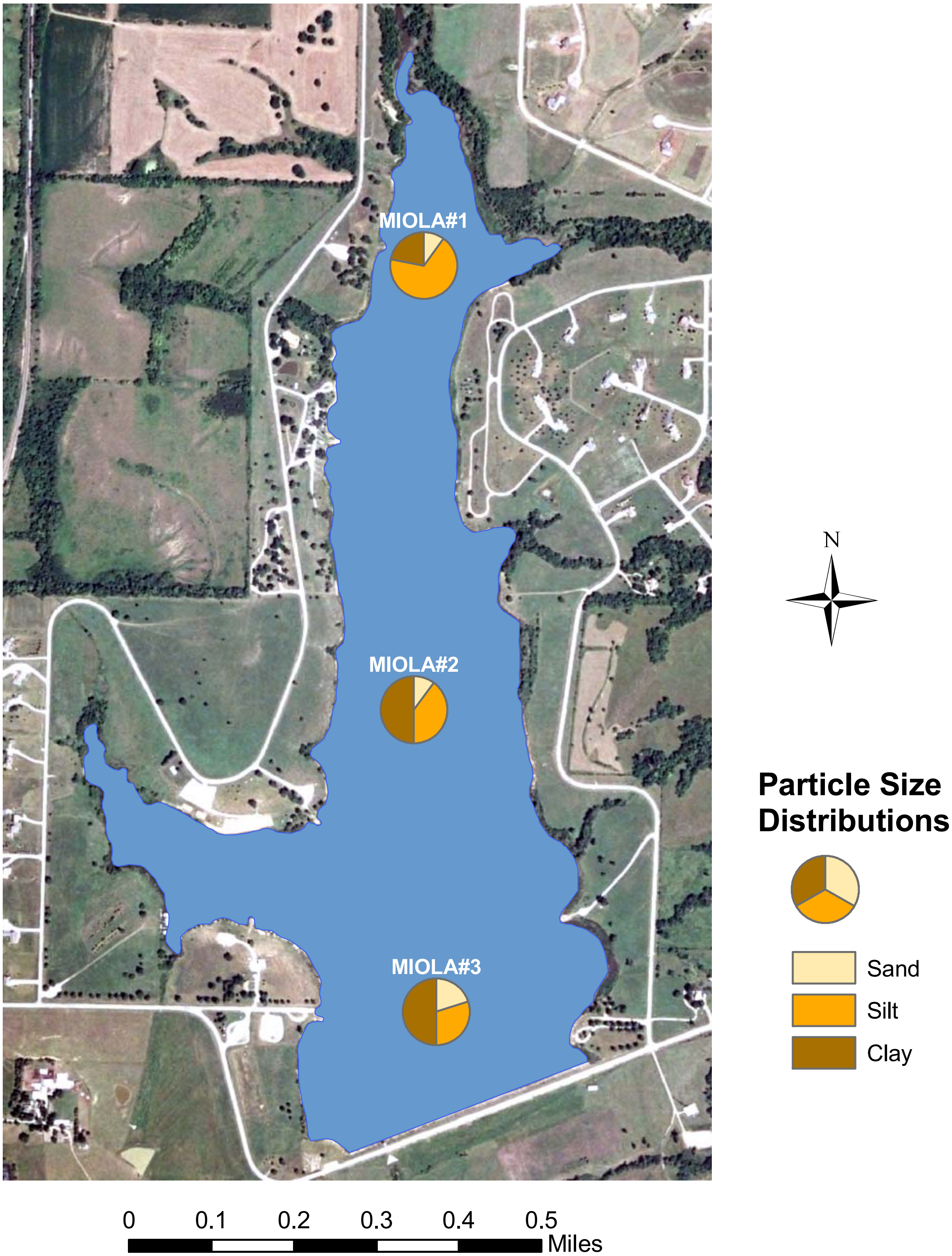

Figure 10. Particle size distribution of sediment samples in Miola Lake