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Sedimentation Survey of Lake Paradise and Lake Mattoon, Mattoon, Illinois

by

William C. Bogner

Prepared for the
CMT Engineering Company
City of Mattoon and
Illinois Environmental Protection Agency

April 2003

Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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Abstract

The Illinois State Water Survey (ISWS) conducted sedimentation surveys of Lake Paradise and Lake Mattoon during 2001 in support of an Illinois Clean Lakes Program diagnostic/feasibility study to provide information on the storage and sedimentation conditions of the lakes. Both lakes are owned and operated by the City of Mattoon, which withdraws water from Lake Paradise as the raw water source for distribution of finished water and generally uses withdrawals from Lake Mattoon to maintain a more stable water level in Lake Paradise. The village of Neoga also withdraws water from Lake Mattoon for treatment and distribution. Since June 2001, Reliant Energy has operated a peaker power plant that has withdrawn water from Lake Mattoon for cooling systems.

Lake Paradise and Lake Mattoon are located on the main stem of the Little Wabash River, a tributary to the Wabash River. The watershed is a portion of Hydrologic Unit 05120114. The dam for Lake Paradise is about 4 miles southwest of the City of Mattoon at 39° 24' 47" north latitude and 88° 26' 23" west longitude in Section 8, Township 11N., Range 7E., Coles County. The dam for Lake Mattoon is about 12 miles southwest of the City of Mattoon at 39° 20' 00" north latitude and 88° 28' 56" west longitude in Section 1, Township 10N., Range 6E., Shelby County. Lake Paradise was surveyed in 1979 and Lake Mattoon in 1980 as part of a previous cooperative study by the ISWS, the Illinois Department of Transportation - Division of Water Resources (DoWR), the Illinois Water Resources Center, and several departments at the University of Illinois at Urbana-Champaign.

Lake Paradise lost 835 acre-feet (ac-ft) of its capacity as a result of sedimentation between 1908 and 2001. Approximately 481 ac-ft of this loss has occurred since 1931, which gives an annual sedimentation rate of 9.9 ac-ft since 1931. If this rate of sedimentation continues, the volume of Paradise Lake will be approximately half of the potential 1908 volume in the year 2013 and will be filled completely by sediment in the year 2118.

Lake Mattoon lost 1,705 ac-ft of its 1958 capacity as a result of sedimentation between 1958 and 2001, a sedimentation rate of 39.7 ac-ft per year since 1958. If this rate of sedimentation continues, the volume of Lake Mattoon will be approximately half of the 1958 capacity by 2124 and will be completely filled in the year 2291.

The sedimentation rates for Lake Paradise and its watershed for the periods 1931-1979, 1979-2001, and 1931-2001 were stable and ranged from 9.5 to 10 ac-ft. The long-term average annual sediment yield from 1931-2001 was 9.85 ac-ft. These sedimentation rates correspond to a rate of loss of lake capacity of 0.51 percent per year (1931-2001).

The sedimentation rates for Lake Mattoon and its watershed for the periods 1958-1980, 1980-2001, and 1958-2001 indicate a reduction in net sediment yield from 66.9 ac-ft per year for 1958-1980 to 10.7 ac-ft per year (1980-2001). The long-term average annual sediment yield was 39.5 ac-ft (1958-2001). These sedimentation rates correspond to rates of loss of lake capacity of 0.51 percent per year (1958-1980) and 0.08 percent per year (1980-2001). The long-term average sedimentation rate for the lake is 0.30 percent per year (1958-2001).

SEDIMENTATION SURVEY OF LAKE PARADISE AND LAKE MATTOON, MATTOON, ILLINOIS

Introduction

The Illinois State Water Survey (ISWS) conducted sedimentation surveys of Lake Paradise and Lake Mattoon during 2001 in support of an Illinois Clean Lakes Program diagnostic/feasibility study to provide information on the storage and sedimentation conditions of the lakes. Both lakes are owned and operated by the City of Mattoon, which withdraws water from Lake Paradise as the raw water source for distribution of finished water and generally uses withdrawals from Lake Mattoon to maintain a more stable water level in Lake Paradise. The village of Neoga also withdraws water from Lake Mattoon for treatment and distribution. Since June 2001, Reliant Energy has operated a peaker power plant that has withdrawn water from Lake Mattoon for cooling systems.

Sedimentation detracts from the use of any water-supply lake by reducing depth and volume, with an accompanying reduction of reserve water-supply capacity and burying of intake structures. Sedimentation of a reservoir is a natural process that can be accelerated or slowed by human activities in the watershed. In general, sedimentation of a lake is presumed to be accelerated unintentionally as a secondary impact of other developments within the watershed. For example, construction and agricultural activities generally are presumed to increase sediment delivery to the lake due to increased exposure of soil material to erosive forces.

Reductions of the sedimentation rate in a lake due to human impacts almost always are the result of programs intentionally designed to reduce soil and streambank erosion, and they are often the result of implementing lake remediation programs. These programs might include, but are not limited to, the implementation of watershed erosion control practices, streambank and lakeshore stabilization, and stream energy dissipaters. Lake dredging often is employed to remove previously accumulated sediments.

Sedimentation of a reservoir is the final stage of a three-step sediment transport process: watershed erosion by sheet, rill, gully, and/or streambank erosion; sediment transport in a defined stream system; and deposition of the sediment. In the latter process stream energy is reduced such that the sediment can no longer be transported either in suspension or as bed load. Sediment deposition can occur throughout the stream system.

Lake sedimentation occurs when sediment-laden water in a stream enters the reduced flow velocity regime of a lake. As water velocity is reduced, suspended sediment is deposited in patterns related to the size and fall velocity of each particle. During this process, soil particles are sorted partially by size along the longitudinal axis of the lake. Larger and heavier sand and coarse silt particles are deposited in the upper (inlet) end of the lake; finer silts and clay particles tend to be carried further into the lake (outlet).

Several empirical methods have been developed for estimating sedimentation rates in Illinois (ISWS, 1967; Upper Mississippi River Basin Commission, 1970; Singh and Durgunoglu, 1990). These methods use regionalized relationships between watershed size and lake sedimentation rates. As estimates, they serve well within limits. A more precise measure of the sedimentation rate is provided by conducting a sedimentation survey of the reservoir. The sedimentation survey provides detailed information on distribution patterns within the lake and defines temporal changes in overall sedimentation rates.

Acknowledgments

The project was funded by a grant from the Illinois Clean Lakes Program to the city of Mattoon. Cristie Crites of CMT Engineering was the project manager.

The views expressed in this report are those of the author and do not necessarily reflect the views of the sponsor or the Illinois State Water Survey.

This project was conducted by the authors as part of his regular duties at the Illinois State Water Survey under the administrative guidance of Derek Winstanley, Chief, and Mike Demissie, Head of the Watershed Science Section. Erin Bauer, Mark Johansen, and Richard Cahill (Illinois State Geological Survey) assisted with field data collection. Yi Han analyzed the sediment samples. Laura Keefer and Sally McConkey provided technical review. Eva Kingston edited the report, and Linda Hascall reviewed the graphics.

Lake and Watershed Information

Lake Locations

Lake Paradise and Lake Mattoon (figure 1) are located on the main stem of the Little Wabash River, a tributary to the Wabash River. The watershed is a portion of Hydrologic Unit 05120114 as defined by the U.S. Geological Survey (USGS, 1974).

The dam for Lake Paradise is about 4 miles southwest of the City of Mattoon at 39° 24’ 47” north latitude and 88° 26’ 23” west longitude in Section 8, Township 11N., Range 7E., Coles County. The lake lies entirely in Coles County.

The dam for Lake Mattoon is about 12 miles southwest of the City of Mattoon at 39° 20’ 00” north latitude and 88° 28’ 56” west longitude in Section 1, Township 10N., Range 6E., Shelby County. The lake lies in Shelby, Cumberland, and Coles Counties.

Watershed

The Lake Paradise watershed lies in Coles and Moultrie Counties. It is a sub-basin of the Lake Mattoon watershed, which consists of portions of Shelby, Cumberland, Coles, and Moultrie Counties. Agriculture is the principal land use in both watersheds. The topography of the area is dominated by low slopes with deeply incised, well-developed waterways.

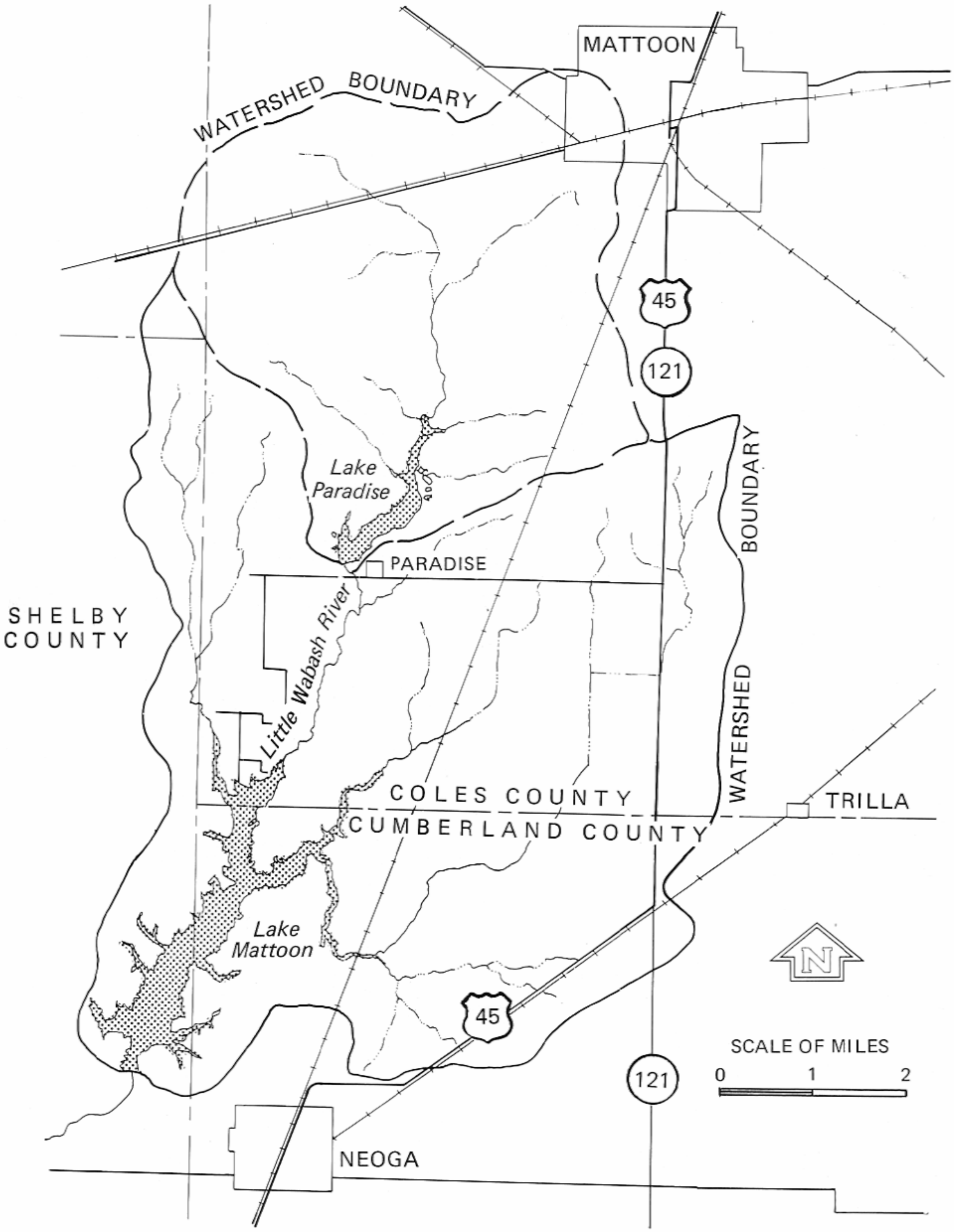

Figure 1. Watershed and location map of Lake Paradise and Lake Mattoon

Geologically, there is a striking difference in the history of the two watersheds. The Lake Mattoon watershed is bisected approximately east to west by the end moraine of the first advance of the Wisconsinan glacier. As a result, the northern half of the watershed, including the watershed of Lake Paradise, is primarily glacial till materials, while the southern portion is primarily glacial outwash and loess materials.

Historical Background

In the early 1900s, Mattoon, Illinois served as the terminal center for the "Big Four" Railroads. In 1908, the demands of the railroads for a reliable, high-quality source of water forced private interests from the city to construct a small reservoir southwest of town. The dam for this reservoir was just north of the current dam and spillway for Lake Paradise. The spillway of this reservoir was raised 2.5 feet in 1914 and 2.0 feet in 1922.

In 1931, the current dam and spillway were built with the spillway crest at an elevation of 684.5 feet above National Geodetic Vertical Datum (ft-NGVD). This spillway elevation resulted in almost total inundation of the original dam, the remnants of which can still be seen in segment 3 of the lake (figure 2). Prior to the construction of the present Lake Mattoon, Lake Paradise was known as Lake Mattoon.

The City of Mattoon bought Lake Paradise in the mid-1930s. In order to guarantee a reliable water source through the Twentieth Century, the city constructed Lake Mattoon in 1958 as a backup supply during periods of drought. Initially, the operating plan was to use Lake Paradise for the city's water supply and Lake Mattoon to maintain the level of Lake Paradise. However, facilities now exist for pumping Lake Mattoon water directly to the treatment plant. The spillway elevation of Lake Mattoon is 632.3 ft-NGVD.

Lake Sedimentation Surveys

Lake Paradise was surveyed in 1979 as part of a cooperative study by the ISWS, the Illinois Department of Transportation - Division of Water Resources (DoWR), the Illinois Water Resources Center, and several departments at the University of Illinois at Urbana-Champaign. The same agencies cooperated in a survey of Lake Mattoon in 1980. The DoWR is now the Illinois Department of Natural Resources Office of Water Resources. This report will refer to the 1979 survey of Lake Paradise and the 1980 survey of Lake Mattoon as the “initial” surveys of these lakes.

Survey plans for the initial surveys are shown for Lake Paradise (figure 2) and Lake Mattoon (figure 3). Endpoints for these transects were monumented with concrete posts embedded with either a DoWR cap or a railroad spike. Endpoint locations were determined by surveyed traverse.

Field data for the initial surveys were collected by the Division of Waterways using equipment provided by the ISWS. The ISWS also provided the survey plan, collected samples of accumulated sediments, analyzed survey data, and prepared a report summarizing findings of both surveys (Bogner, 1982).

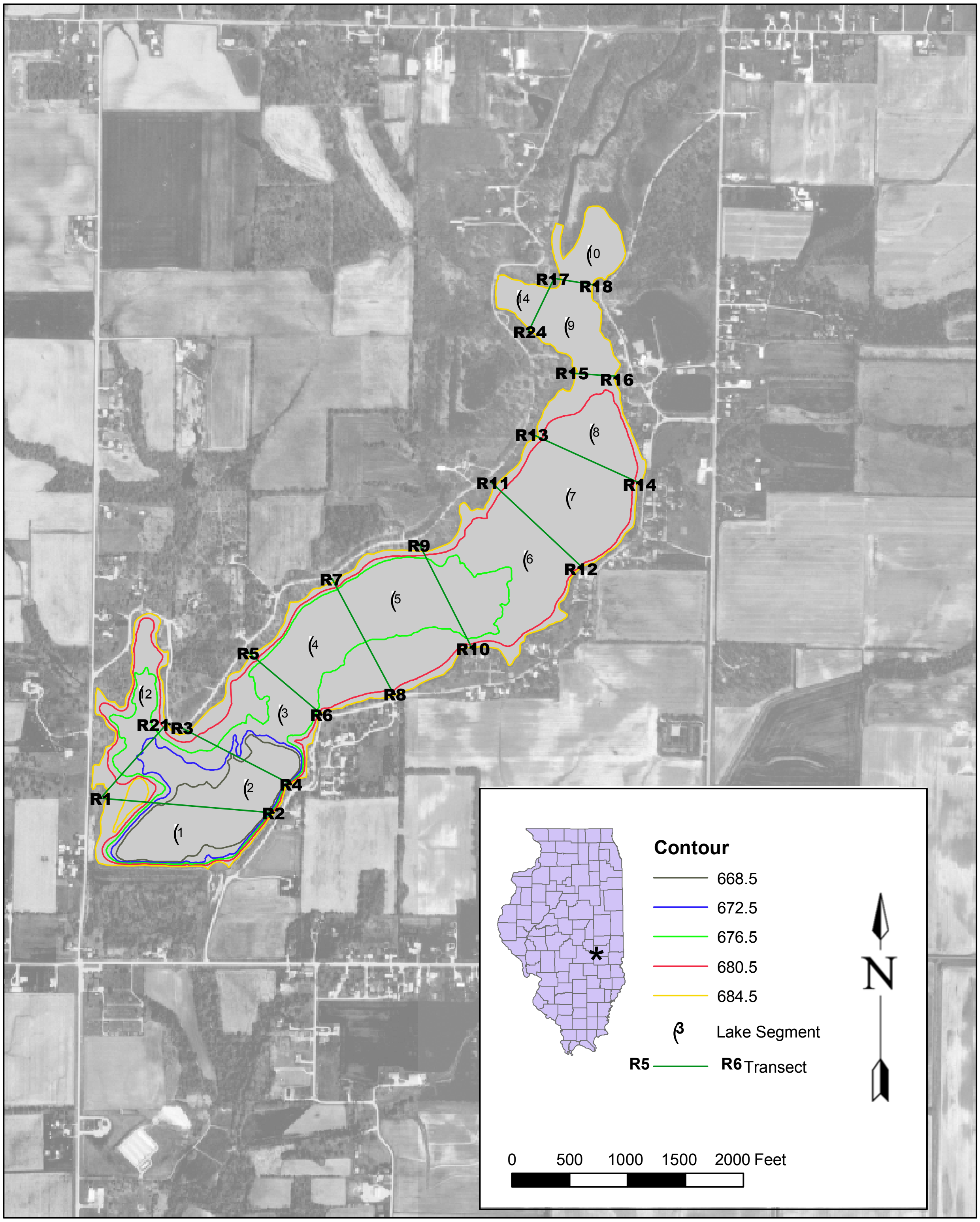

Figure 2. Lake Paradise survey plan and bathymetry

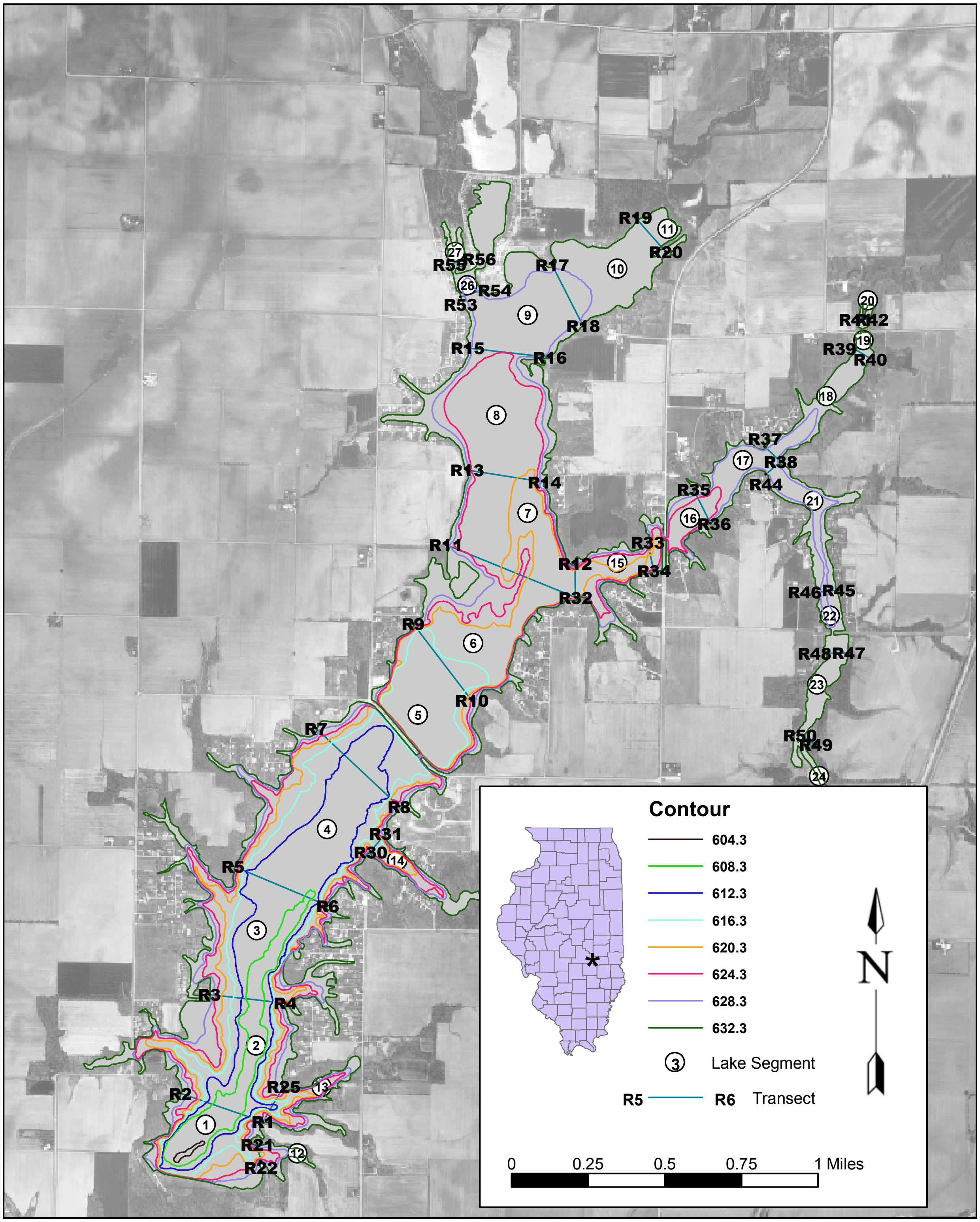

Figure 3. Lake Mattoon survey plan and bathymetry

For the initial surveys, sounding data were collected at 25-foot intervals on each cross section to measure both the original and time-of-survey depths of water in the lakes at the spillway elevations. All depth measurements were made with a 2-inch diameter aluminum pole marked in tenths of feet. The pole was lowered until it touched the current lake bottom, and a depth measurement was made. The pole then was pushed through the accumulated sediment to a point of refusal that was determined to be the solid original lakebed, and another depth measurement was made. Horizontal control on each cross section was maintained with a marked plastic cable between the transect endpoints.

For the 2001 survey, the survey plan of the initial surveys was followed as closely as possible. Selected survey monumentation established during the initial surveys was recovered, and the location coordinates were established using a Global Positioning System (GPS). Differential corrections for these GPS measurements were determined using U.S. Coast Guard correction signals (Radio Technical Commission for Maritime Services or RTCM). These selected location records were used with the survey traverse records collected in earlier surveys to determine GPS positions for all transect ends established for the lakes. These endpoint locations were verified in the field, and corrections to the original survey were made as needed. Several angular discrepancies were noted and corrected. Table 1 (Lake Paradise) and Table 2 (Lake Mattoon) list the endpoint coordinates used for the 2001 surveys.

The 2001 survey was conducted using an Odom Hydrographic Systems MK II fathometer for depth measurement and a differentially corrected GPS for horizontal control across the transect. The GPS system unit used was a Leica 9600 System. All navigation and data logging functions were controlled using HYPACK®, hydrographic survey software. The GPS positions were differentially corrected using RTCM correction signals broadcast by the U.S. Coast Guard from St. Louis, Missouri, or Rock Island, Illinois.

The fathometer was calibrated daily prior to initiating measurements. Calibration checks at the end of most work days showed daily variations of 0.1-0.2 feet for each reading in a profile at one-foot depth intervals. For each main lake cross section, up to five physical measurements of the water depth and sediment thickness were made with an aluminum sounding pole.

The GPS locations of the transect endpoints were entered into the HYPACK® software for the field survey. The depth sounder and the GPS unit were connected to a laptop computer operating HYPACK® software, which provided navigation guidance and data logging for the survey of each line. Plots of cross-section profiles of each transect appear in appendix I (Lake Paradise) and appendix II (Lake Mattoon).

Samples of the accumulated sediments were collected and analyzed for particle size distribution and unit weight. Results of the laboratory analyses for these samples appear in appendices III and IV (unit weight analysis) and appendices V and VI (particle size distribution). A detailed discussion of particle size distributions is presented in the section "Sediment Particle Size Distribution."

Table 1. Lake Paradise Range End Coordinates
1927 Illinois State Plane – East Projection (feet)

Traverse point	*East coordinate*	*North coordinate*
R1	468,959.2	1,000,471.0
R2	470,450.9	1,000,366.0
R3	469,649.0	1,001,092.0
R4	470,597.4	1,000,617.0
R5	470,212.1	1,001,747.0
R6	470,851.9	1,001,222.0
R7	470,919.7	1,002,395.0
R8	471,485.6	1,001,409.0
R9	471,672.6	1,002,700.0
R10	472,155.2	1,001,810.0
R11	472,308.9	1,003,251.0
R12	473,078.2	1,002,518.0
R13	472,636.0	1,003,673.0
R14	473,572.4	1,003,256.0
R15	472,974.0	1,004,210.0
R16	473,364.1	1,004,162.0
R17	472,797.0	1,005,023.0
R18	473,170.5	1,004,965.0
R21	469,539.9	1,001,119.0
R24	472,604.5	1,004,557.0

Table 2. Lake Mattoon Range End Coordinates
1927 Illinois State Plane – East Projection (feet)

Traverse point	*East coordinate*	*North coordinate*	*Traverse point*	*East coordinate*	*North coordinate*
R1	459319.6	972122.3	R33	465811.1	982218.2
R2	457884.8	972591.5	R34	465922.5	981730.3
R3	458359.1	974302.1	R35	466590.7	983141.4
R4	459667.4	974175.0	R36	466888.4	982557.5
R5	458736.7	976526.2	R37	467801.8	983897.2
R6	460377.4	975867.0	R38	468081.6	983644.5
R7	460135.3	978925.5	R39	469328.6	985610.8
R8	461584.0	977596.0	R40	469604.5	985447.5
R9	461779.9	980758.5	R41	469338.6	986134.4
R10	462813.5	979444.2	R42	469621.2	986140.2
R11	462327.4	982127.7	R44	467831.8	983417.8
R12	464559.8	981832.5	R45	469112.5	981445.7
R13	462676.0	983419.3	R46	468755.2	981401.1
R14	464010.8	983229.8	R47	469302.6	980359.6
R15	462653.6	985527.0	R48	468931.2	980346.7
R16	464070.9	985385.3	R49	468759.9	978771.6
R17	464090.9	986981.4	R50	468486.2	978930.9
R18	464640.5	985934.1	R51	469441.2	977199.5
R19	465513.1	987820.9	R52	469489.3	977258.9
R20	466050.8	987237.7	R53	462520.0	986404.0
R21	459223.8	971745.3	R54	462905.8	986525.8
R22	459293.0	971440.1	R55	462315.4	986961.6
R25	459667.7	972734.3	R56	462620.0	987059.0
R30	461107.5	976807.6			
R31	461363.8	977129.8			

Lake Basin Volumes

Depth to refusal sounding data from the initial surveys were used to calculate the original storage capacities in 1908 (Lake Paradise) and in 1958 (Lake Mattoon) at current spillway levels and also the 1931 lake surface area for Lake Paradise. Water depth soundings from the initial surveys, using the sounding pole, and the 2001 depth soundings from the depth sounder were used to calculate capacities for the date of construction and at the time of each survey. The difference between these storage capacities is the lake volume that has been lost to sedimentation since reservoir construction or between surveys.

Lake capacities were calculated using a method described in *the National Engineering Handbook* of the U.S. Soil Conservation Service (USDA-SCS, 1968). This method can determine the original and present volume of each segment by using the surface area of the lake segments, the cross-sectional area and widths of their bounding segments, and a shape factor. These volumes are then summed to determine the total lake volume. Reference elevations used were the top of the spillway for each lake, 684.5 ft-NGVD for Lake Paradise and 632.3 ft-NGVD for Lake Mattoon. These spillway elevations differ from values presented in the 1982 report (684.1 ft-NGVD for Lake Paradise and 632.0 ft-NGVD for Lake Mattoon) due to discrepancies discovered during the 2001 survey.

Volumes determined by the sedimentation survey were the 1979 water volume contained in the reservoir and the 1979 volume of sediment contained in the reservoir. The sum of these values is the potential water volume of the reservoir if the 1931 dam and spillway had been constructed in 1908.

However, when the dam and spillway were constructed in 1931, a portion of this volume already had been filled by sediment from the original (1908) dam and spillway. To develop a 1931-1979 sedimentation rate for Paradise Lake, it was necessary to estimate volume losses due to sedimentation from 1908 to 1931. This was accomplished by prorating sediment accumulations in segments 3-9 between 1908-1931 and 1931-1979.

The 1931 water volume in each segment was determined by using the formula:

Water volume (1931) = potential water volume (1908) – sediment volume (1908-1931)

By this method, the lake volume at the 1931 spillway elevation was reduced 6.7 percent due to sedimentation during the period 1908-1931. This approximate adjustment cannot be used to determine a 1908-1931 sedimentation rate.

Results and Analyses

Lake Paradise

Table 3 summarizes results of the 1979 and 2001 surveys of Lake Paradise. The lake lost 835 acre-feet (ac-ft) of its capacity as a result of sedimentation between 1908 and 2001. Approximately 481 ac-ft of this loss has occurred since 1931, which gives an annual sedimentation rate of 9.9 ac-ft since 1931.

If this rate of sedimentation continues, the volume of Paradise Lake will be approximately half of the potential 1908 volume in the year 2013 and will be filled completely by sediment in the year 2118. However, because of decreasing lake volume, trap efficiency of the lake will tend to decrease with age, which very likely will extend the life of the lake.

Table 3. Reservoir Capacity and Capacity Loss Analysis for Lake Paradise

Period	*Capacity*	*Capacity loss*	*Cumulative capacity loss*	*Period annual capacity loss rate*	*Cumulative annual capacity loss rate*
a) Analysis in units of acre-feet					
1908	2,087				
1931	1,942				
1931-1979	1,461	481	481	10.0	10.0
1979-2001	1,252	209	690	9.5	9.9
b) Analysis in units of million gallons					
1908	680				
1931	633				
1931-1979	476	156.6	156.6	3.3	3.3
1979-2001	408	68.1	224.7	3.1	3.2

Notes:
Lake surface area was 196 acres in 1931 (as determined for the 1979 survey).
Lake surface area was 166 acres in 1979.
Visual comparison of the 2001 shoreline with 1979 aerial photography did not indicate any significant change in surface area.
Capacity shown is for the sedimentation survey conducted at the end of the period.
Spillway elevation was 684.5 ft-NGVD.
See report text for details on the adjustment of segment volumes for 1908-1931 period sedimentation.
The 1931 volume is an interpolated value derived from 1908 and 1978 volumes.

Table 4 shows the variation in sediment accumulation in Paradise Lake by segments. Locations of these segments are shown in figure 2. In the computation of the weight of total sediment shown, the unit weights of samples of deposited sediments were used. The average dry unit weight of the deposited sediment was 33.2 pounds per cubic foot based on the samples collected in 2001.

A 1979 analysis of aerial photographic records for Paradise Lake indicated that sediment had completely filled 15 percent of the original area of the lake (30 acres out of 200 acres). Comparison of 1979 aerial photography and 1998 aerial photography indicates that this process has not continued.

Photographs were available from five different years: 1938, 1953, and 1966 (University of Illinois Map Library); 1979 (DoWR); and 1998 (Digital Orthophoto Quadrangles prepared by the USGS National Mapping Division). Changes in lake surface area are indicated in figure 2. Delta formations shown indicate that with periodic dry dredging it may be feasible to use the area upstream of transect R17-R18 as a sediment basin to reduce sedimentation in Lake Paradise.

Lake Mattoon

Table 5 summarizes results of the 1980 and 2001 surveys of Lake Mattoon. The lake has lost 1,705 ac-ft of its 1958 capacity as a result of sedimentation between 1958 and 2001, a sedimentation rate of 39.7 ac-ft per year since 1958.

If this rate of sedimentation continues, the volume of Lake Mattoon will be approximately half of the 1958 capacity by 2124 and will be completely filled in the year 2291. As with Paradise Lake, as lake volume decreases, the sedimentation rate also decreases, thus extending the life of the lake.

Table 6 shows the variation of sedimentation accumulations in Lake Mattoon by segments. Figure 3 shows segment locations. Dry unit weights of samples of deposited sediments were used to compute sediment weights shown in figure 6. The average unit weight of the deposited sediment was 27.4 pounds per cubic foot based on the samples collected in 2001.

Sedimentation Rates

Sedimentation rates for Lake Paradise and Lake Mattoon were analyzed in terms of delivery rates from the watershed and from accumulation rates in the reservoir. The in-lake accumulation rate provides a means of extrapolating future lake conditions from past and present lake conditions to evaluate the integrity of the lake as a water-supply source and as a recreational resource. Watershed delivery rates are the link between soil erosion processes in the watershed, sediment transport processes, and water-supply quantity impacts in the reservoir. These delivery rates measure the actual sediment yield from the watershed, including reduced sediment transport due to field and in-stream redeposition.

Table 4. Sediment Distribution in Paradise Lake

		Volume				*2001 sediment*			
Segment	*Area (acres)*	*1908 (ac-ft)*	*1931 (ac-ft)*	*1979 (ac-ft)*	*2001 (ac-ft)*	*Accumulation (ac-ft)*	*Weight (tons)*	*Thickness (feet)*	*Per segment acre (tons)*
1	13.8	246.4	246.4	206.3	184.8	61.7	28,606	4.5	2,073
2	14.2	250.9	250.9	207.0	187.6	63.2	29,339	4.5	2,066
3	15.3	234.0	212.1	166.3	145.9	88.1	56,979	5.8	3,724
4	16.6	221.3	198.6	151.3	134.6	86.7	56,107	5.2	3,380
5	19.9	251.2	224.2	168.0	153.6	97.5	54,371	4.9	2,732
6	25.4	315.6	279.0	202.4	183.5	132.2	73,684	5.2	2,901
7	18.4	182.6	164.1	125.5	109.6	73.1	64,150	4.0	3,486
8	11.3	89.4	80.0	60.4	48.2	41.1	36,095	3.6	3,194
9	9.1	54.5	45.3	26.1	20.1	34.4	41,171	3.8	4,524
10-11	30.5	89.6	89.6	29.2	24.0	65.6	78,630	2.2	2,578
12-13	20.2	131.3	131.3	111.1	55.1	76.2	66,906	3.8	3,312
14	5.7	20.5	20.5	7.7	5.4	15.2	18,154	2.7	3,185
Totals	196	2,087	1,942	1,461	1,252	835.0	604,193	4.3	3,089

Table 5. Reservoir Capacity and Capacity Loss Analysis for Lake Mattoon

Period	*Capacity*	*Capacity loss for period*	*Cumulative capacity loss*	*Period annual capacity loss rate*	*Cumulative annual capacity loss rate*
a) Analysis in units of acre-feet					
1958	13,293				
1958-1980	11,812	1,482	1,482	67.3	67.3
1980-2001	11,588	224	1,705	10.6	39.7
b) Analysis in units of million gallons					
1958	4,331				
1958-1980	3,849	482.7	482.7	21.9	21.9
1980-2001	3,776	72.8	555.6	3.5	12.9

Notes:
Lake surface area was 1,027 acres in 1958 (as determined for the 1980 survey).
Visual comparison of the 2001 shoreline and 1980 aerial photography did not indicate any significant change in 1980-2001 surface area.
Capacity shown is for the sedimentation survey conducted at the end of the period.
Spillway elevation was 632.3 ft-NGVD.

Lake Paradise

Changes in spillway elevation of Paradise Lake, and consequent changes in surface area and volume, considerably complicated the calculation of the sedimentation rate of the lake.

Increasing lake capacity improves lake efficiency as a sediment trap because the given inflow into the lake will be held longer, allowing more sediments to settle out of suspension. This increase in trap efficiency varies considerably, depending on the original and new volumes of the lake.

The most widely used method for determining trap efficiency is the graph developed by Brune (1953), shown in figure 4. This curve shows trap efficiency as a function of the Capacity/Inflow (C/I) ratio where capacity and annual inflow are in acre-feet.

For Lake Paradise, the variation in capacity has been from 460 ac-ft in 1908 to 2040 ac-ft in 1931. Average annual discharge for the Little Wabash River at Effingham is 11.6 inches (USGS, 1999). Assuming 12 inches of annual runoff from the 11,400-acre watershed of

Table 6. Sediment Distribution in Lake Mattoon

Segment	*Area (acres)*	*Volume* 1958 (ac-ft)	*Volume* 1980 (ac-ft)	*Volume* 2001 (ac-ft)	*2001 sediment* Accumulation (ac-ft)	*2001 sediment* Weight (tons)	*2001 sediment* Thickness (feet)	*2001 sediment* Per segment acre (tons)
1	52.1	885	816	825	59.8	28,135	1.1	540.0
2	88.3	1,445	1,342	1,360	84.4	40,591	1.0	459.7
3	105.8	1,902	1,769	1,767	134.7	66,154	1.3	625.3
4	123.0	2,322	2,180	2,175	147.1	73,781	1.2	599.8
5	99.4	1,777	1,630	1,630	147.0	75,235	1.5	756.9
6	92.9	1,382	1,205	1,168	213.5	109,983	2.3	1,183.9
7	45.2	581	508	488	93.6	48,498	2.1	1,073.0
8	87.2	806	695	699	107.0	62,209	1.2	713.4
9	58.5	342	280	287	54.5	35,133	0.9	600.6
10	40.9	172	128	121	51.2	59,766	1.3	1,461.3
11	12.0	18	10	8	10.4	17,579	0.9	1,464.9
12	5.9	31	27	26	5.2	3,493	0.9	592.0
13	16.4	112	101	97	14.9	9,927	0.9	605.3
14	14.2	129	118	113	15.7	10,472	1.1	737.5
15	26.1	322	273	257	64.9	43,276	2.5	1,658.1
16	21.6	234	190	169	65.1	43,404	3.0	2,009.5
17	22.6	218	162	135	83.3	55,508	3.7	2,456.1
18	19.1	128	80	62	65.6	43,717	3.4	2,288.8
19	3.9	12	6	4	8.3	5,553	2.1	1,423.8
20	3.7	3	1	1	2.2	1,489	0.6	402.5
21	23.8	174	126	99	75.0	49,998	3.2	2,100.7
22	9.3	62	39	25	36.6	24,424	3.9	2,626.2
23	12.9	69	33	14	55.8	37,217	4.3	2,885.0
24	10.8	41	19	1	39.4	26,260	3.6	2,431.5
25	0.5	2	1	0	1.6	1,058	3.1	2,033.9
26	22.7	102	63	50	52.3	34,835	2.3	1,534.6
27	8.4	23	11	7	15.7	10,494	1.9	1,249.3
Total	1,027	13,293	11,812	11,588	1,705.1	1,018,188	1.7	991.2

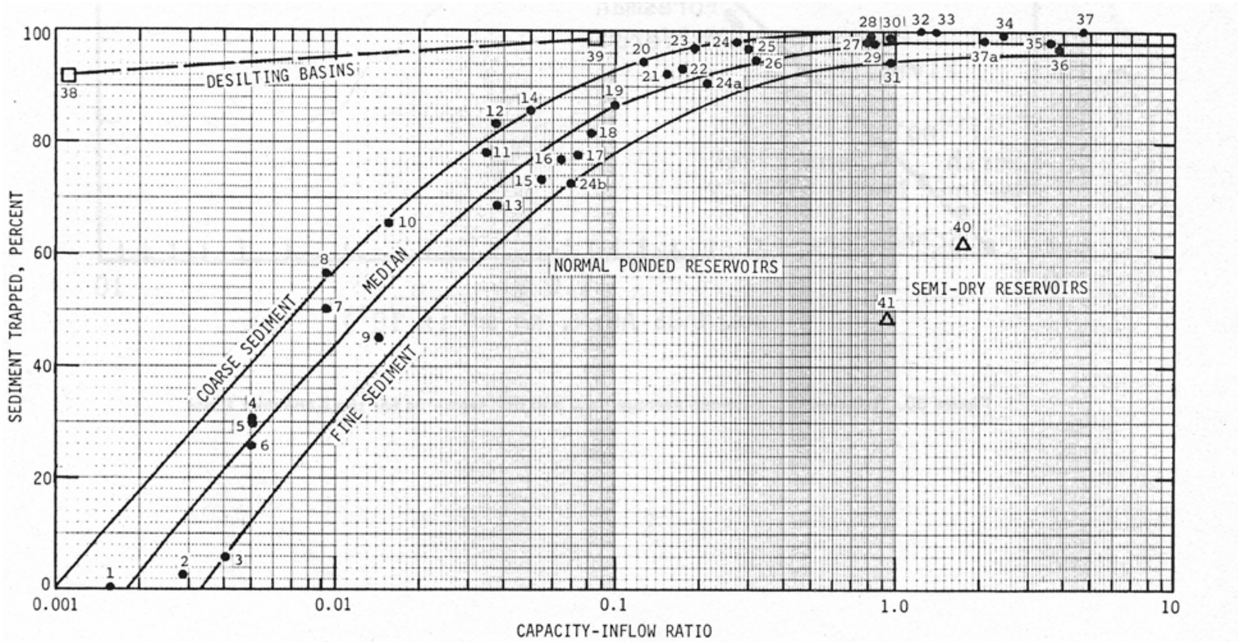

Figure 4. Trap efficiency of a man-made lake (after Brune, 1953).

Lake Paradise, inflow becomes 11,400 ac-ft/year with a C/I ratio of 0.04 for 1908 and 0.18 for 1931. For these C/I ratios, the trap efficiencies are 69 percent for 1908 and 87 percent for 1931, based on the graph in figure 4. This analysis indicates that the trap efficiency of the lake increased approximately 25 percent from 1908 to 1931, when the existing dam was constructed.

To reduce the effects of these variations in the trap efficiency on calculations, the sedimentation rate of Lake Paradise was determined by adjusting the calculated results to a 1931-1979 sedimentation period, as previously discussed.

Tables 7 and 8 give the sedimentation rates for Lake Paradise and its watershed for the periods 1931-1979, 1979-2001, and 1931-2001. These rates indicate a stable 1931-2001 net sediment yield of 9.5 to 10 ac-ft. The long-term average annual sediment yield from 1931-2001 was 9.85 ac-ft.

These sedimentation rates correspond to a rate of loss of lake capacity of 0.51 percent per year (1931-2001).

Table 7. Computed Sediment Delivery Rates from Watershed for Lake Paradise

	Annual deposition rates			
Period	*Acre-feet*	*Acre-feet per square mile*	*Cubic feet per acre*	*Tons per acre*
1931-1979	10.02	0.55	37.7	
1979-2001	9.50	0.52	35.7	
1931-2001	9.85	0.54	37.0	0.56

Note:
Total watershed area is 18.1 square miles.

Table 8. Capacity Loss Rates (percent) for Lake Paradise Relative to 1931 Lake Capacity

Period	*Per period*	*Period annual loss*
1931-1979	24.8	0.52
1979-2001	10.8	0.49
1931-2001	35.5	0.51
(Relative to potential 1908 capacity)		
1908-2001	40.0	

Lake Mattoon

Tables 9 and 10 give the sedimentation rates for Lake Mattoon and its watershed for the periods 1958-1980, 1980-2001, and 1958-2001. These rates indicate a reduction in net sediment yield from 66.9 ac-ft per year for 1958-1980 to 10.7 ac-ft per year (1980-2001). The long-term average annual sediment yield was 39.5 ac-ft (1958-2001).

These sedimentation rates correspond to rates of loss of lake capacity of 0.51 percent per year (1958-1980) and 0.08 percent per year (1980-2001). The long-term average sedimentation rate for the lake is 0.30 percent per year (1958-2001).

Table 9. Computed Sediment Delivery Rates from Watershed for Lake Mattoon

	Annual deposition rates			
Period	*Acre-feet*	*Acre-feet per square mile*	*Cubic feet per acre*	*Tons per acre*
1958-1980	66.9	1.19	81.3	
1980-2001	10.7	0.19	13.0	
1958-2001	39.5	0.70	48.0	0.66

Note:
Total watershed area is 56 square miles.

Table 10. Capacity Loss Rates (percent) for Lake Mattoon Relative to the 1958 Lake Capacity

Period	*Per period*	*Period annual loss*
1958-1980	11.2	0.51
1980-2001	1.7	0.08
1958-2001	12.9	0.30

Bathymetric Surveys

The 2001 water depths for the lakes were used to generate the bathymetric maps in figure 2 (Lake Paradise) and figure 3 (Lake Mattoon). Lakebed elevation contours were used to develop the volume distribution curve data (figures 5 and 6). These plots can be used to determine reservoir capacity below a given elevation. For example, the water volume below the 4-foot depth contour in Lake Paradise (dashed line in figure 5) is 671 ac-ft. With time and continued sedimentation, relationships shown in figures 5 and 6 will become obsolete. Alteration of the spillway elevation or implementation of a dredging program likewise would alter these relationships.

The tabular presentations of volumes for this report were prepared using the results of an average end area type of calculation for volumes, while the stage-volume-area graphs (figures 5 and 6) were developed on the basis of the contour method of calculation. The two calculation methods process the same basic data but result in different values for the lake volume. The range method calculation is a detailed methodology that results in a consistent set of lake volume calculations for the series of lake volumes (original, initial survey, and 2001). The contour volume method includes a larger data set and yields a more accurate estimate of the volume but is not as

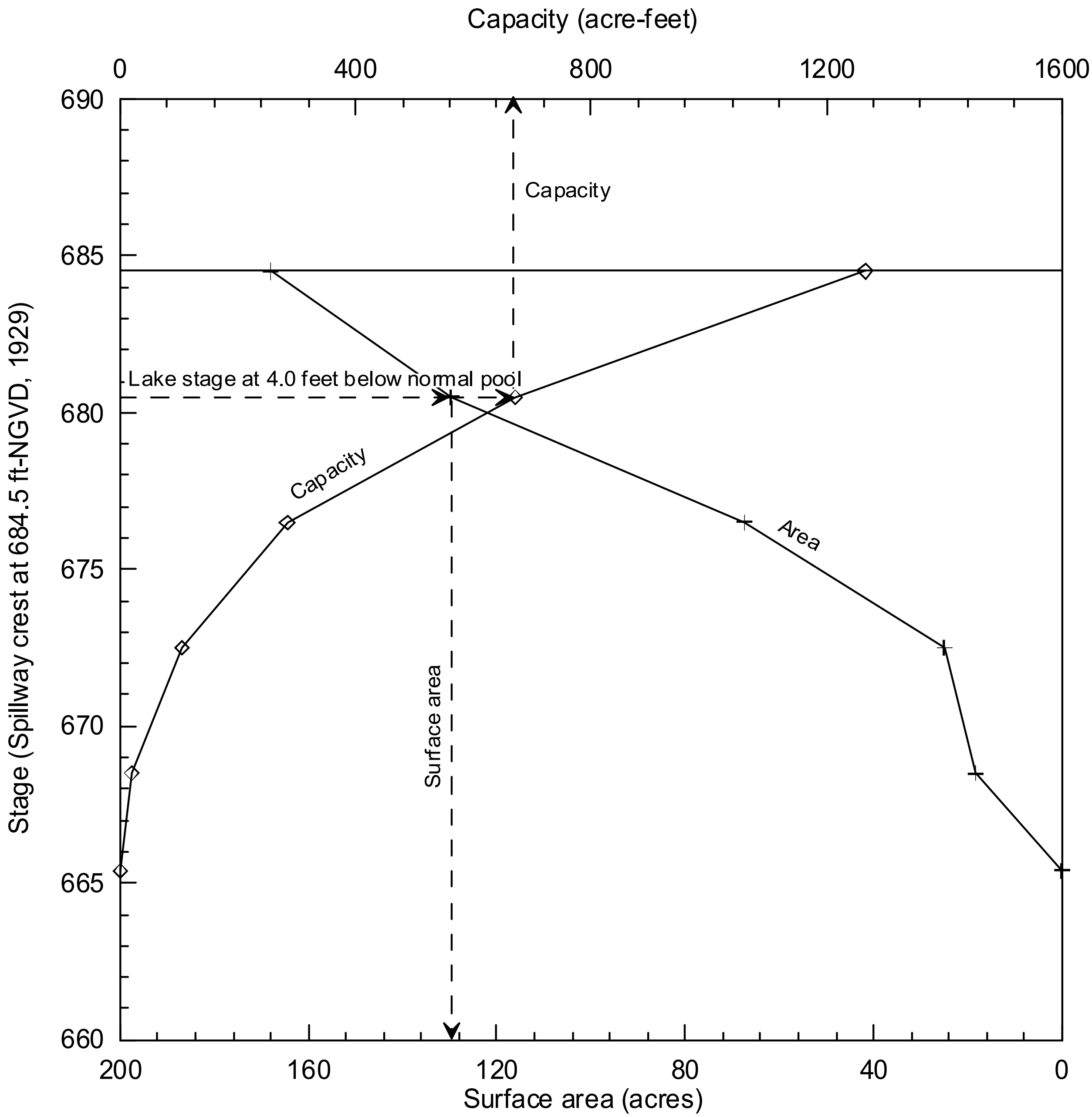

Figure 5. Stage-volume-area relationship for Lake Paradise

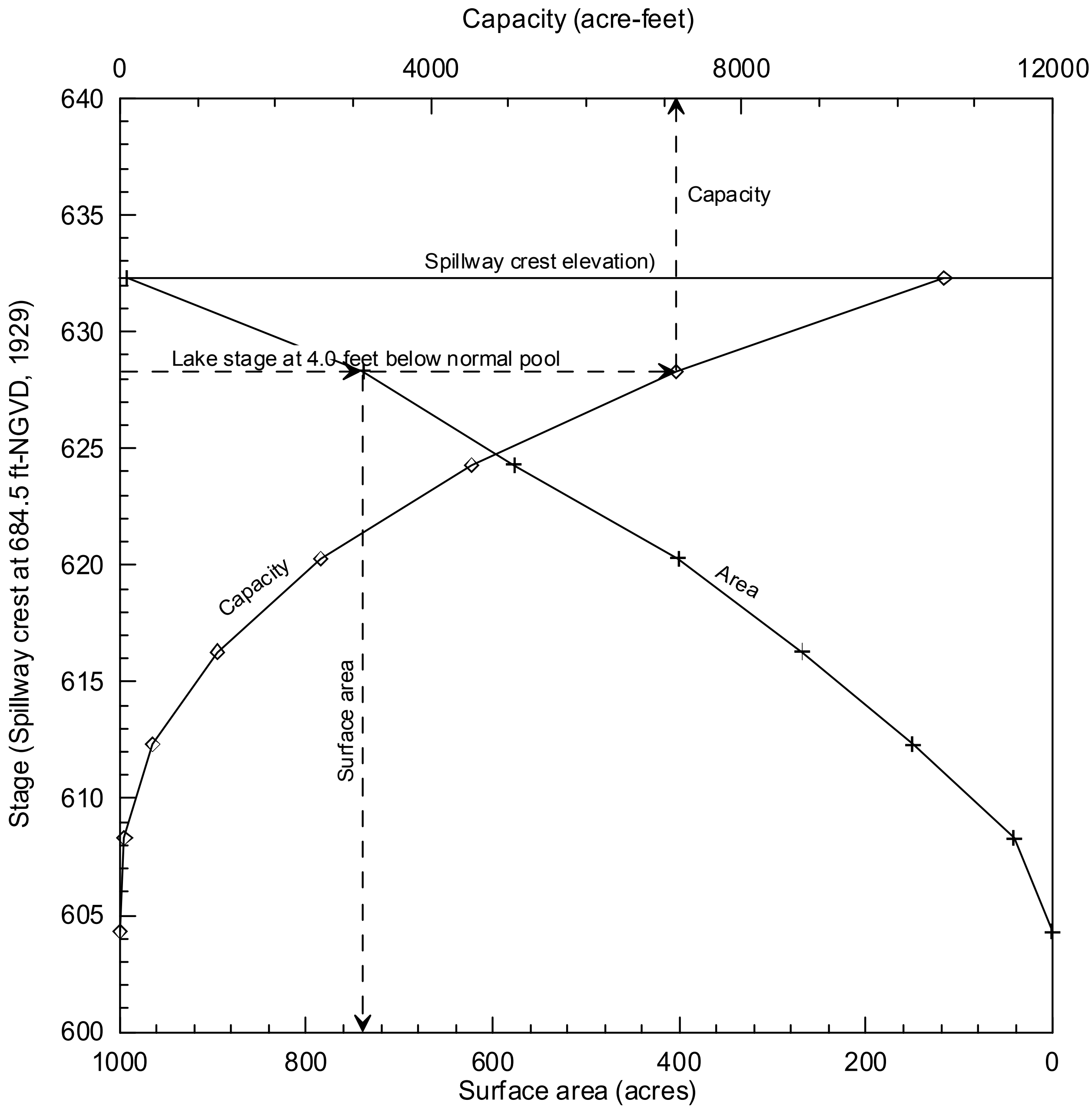

Figure 6. Stage-volume-area relationship for Lake Mattoon

reproducible. The calculation difference for Lake Paradise was 1.0 percent and the difference for Lake Mattoon was 9.5 percent.

Comparison of Results

The long-term sedimentation rates are 0.51 percent per year for Lake Paradise and 0.30 percent per year for Lake Mattoon. These rates are similar to the general trend of sedimentation rates for other Illinois reservoirs determined in the ISWS lake sedimentation program.

Lake Paradise sedimentation rates show a very stable sedimentation condition (0.5 percent per year) over the two sedimentation periods available. The Lake Mattoon sedimentation record shows a significant reduction in the rate of sediment accumulation from 0.08 percent for the most recent sedimentation period (1980-2001) to 0.51 percent for the initial period (1958-1980).

Sediment Particle Size Distribution

Particle size distribution of the samples can show the variability of sedimentation patterns in the lake both longitudinally and with depth. Longitudinally, it is common to see coarse materials deposited in the upstream areas of the lake and increasingly finer materials further into the lake. With depth (core samples), comparison of older sediments collected from the bottom of a core to the more recent surface sediments often shows that the more recent materials are coarser. This trend reflects the lost trap efficiency of the upper end of the lake and the gradual transition of the inflow area of the lake to downstream areas.

Ten lakebed sediment samples were collected from Lake Paradise for particle size distribution analysis. Figure 7 and appendix V present the laboratory analyses for these samples. Samples plotted in black were collected from the lake sediment surface; samples plotted in red were collected from core samples. A shift down or to the left would indicate coarser sediments. These samples do show both the smaller particle sizes with distance into the lake and the shift of the coarser materials downstream with time.

Thirteen lakebed sediment samples were collected from Lake Mattoon for particle size distribution analysis. Figure 8 and appendix VI present the laboratory analyses for these samples. Samples plotted in black were collected from the lake sediment surface; samples plotted in red were collected from core samples. A shift down or to the left would indicate coarser sediments.

Figure 8a shows particle size distribution plots for samples collected from the main body of the lake between the dam and the Bush Creek confluence (cross section R11-R12). These samples show very little variability with either location or over time.

Figure 8b shows particle size distribution plots for main lake areas upstream of R11-R12 and at the confluence of Bush and Brush Creeks. These plots show distinct changes both longitudinally and with time. Shifts in size distributions show the general trend of sediments deposited at a point in the lake becoming coarser with time. Similarly, the combination of the two plots would show the general trend of finer sediment accumulating in downstream areas of the lake.

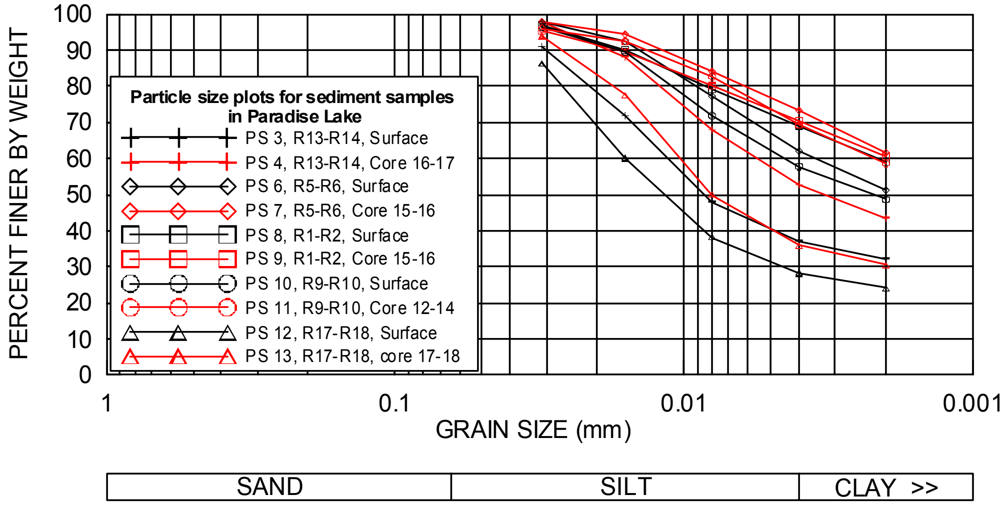

Figure 7. Particle size distributions for Lake Paradise sediment samples

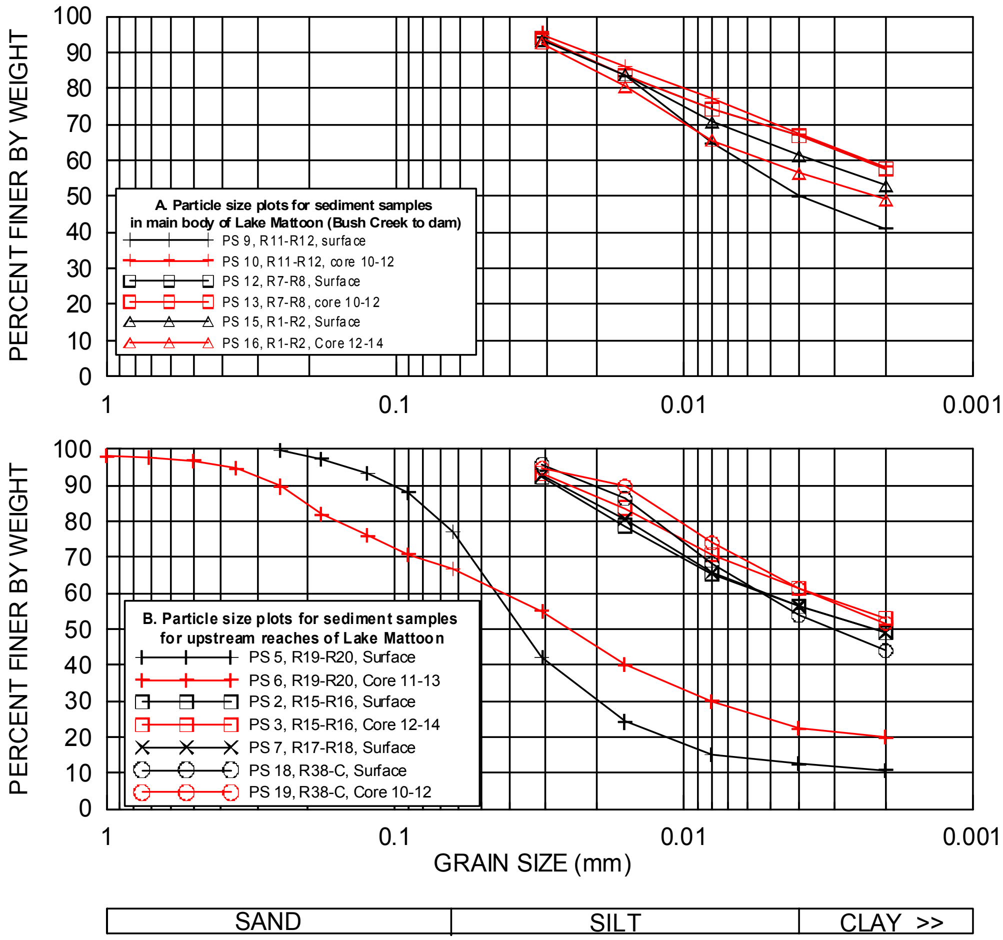

Figure 8. Particle size distributions for Lake Mattoon sediment samples

Summary

The Illinois State Water Survey has conducted sedimentation surveys of Lake Paradise and Lake Mattoon near Mattoon, Illinois. Lake Paradise originally was constructed in 1908, and Lake Mattoon was constructed in 1958. Together, the lakes serve as the raw water source for the Mattoon water supply. The village of Neoga also takes raw water from Lake Mattoon. Previous lake sedimentation surveys were conducted in 1979 for Lake Paradise and 1980 for Lake Mattoon.

Spillway levels for the lakes are 584.4 ft-NGVD, 1927 for Lake Paradise and 532.3 ft-NGVD, 1927 for Lake Mattoon. Lake Paradise has been modified several times in terms of spillway level, and the original dam, constructed in 1908, has been inundated by the existing impoundment.

Sedimentation has reduced the potential capacity of Lake Paradise from 2,087 ac-ft (680 million gallons) in 1908 to 1,252 ac-ft (408 million gallons) in 2001. The sediment accumulation rates in the lake have averaged 9.9 ac-ft per year from 1931 to 2001. Annual sedimentation rates for two separate periods, 1931-1979 and 1979-2001, were 10.0 and 9.5 ac-ft, respectively.

The 1908 structure (the old dam) impounded water in what is now part of the present lake. This structure caused an undocumented amount of sedimentation in the affected lake segments. The volume of the lake was adjusted to account for this pre-1931 sedimentation.

Sedimentation has reduced the potential capacity of Lake Mattoon from 13,293 ac-ft (4,331 million gallons) in 1958 to 11,588 ac-ft (3,776 million gallons) in 2001. Sediment accumulation rates in the lake have averaged 39.7 ac-ft per year (1958-2001). Annual sedimentation rates for two separate periods, 1958-1980 and 1980-2001, were 67.3 and 10.6 ac-ft, respectively. The results of the 2001 sedimentation survey indicate a significant reduction in the sedimentation rate between the two survey periods.

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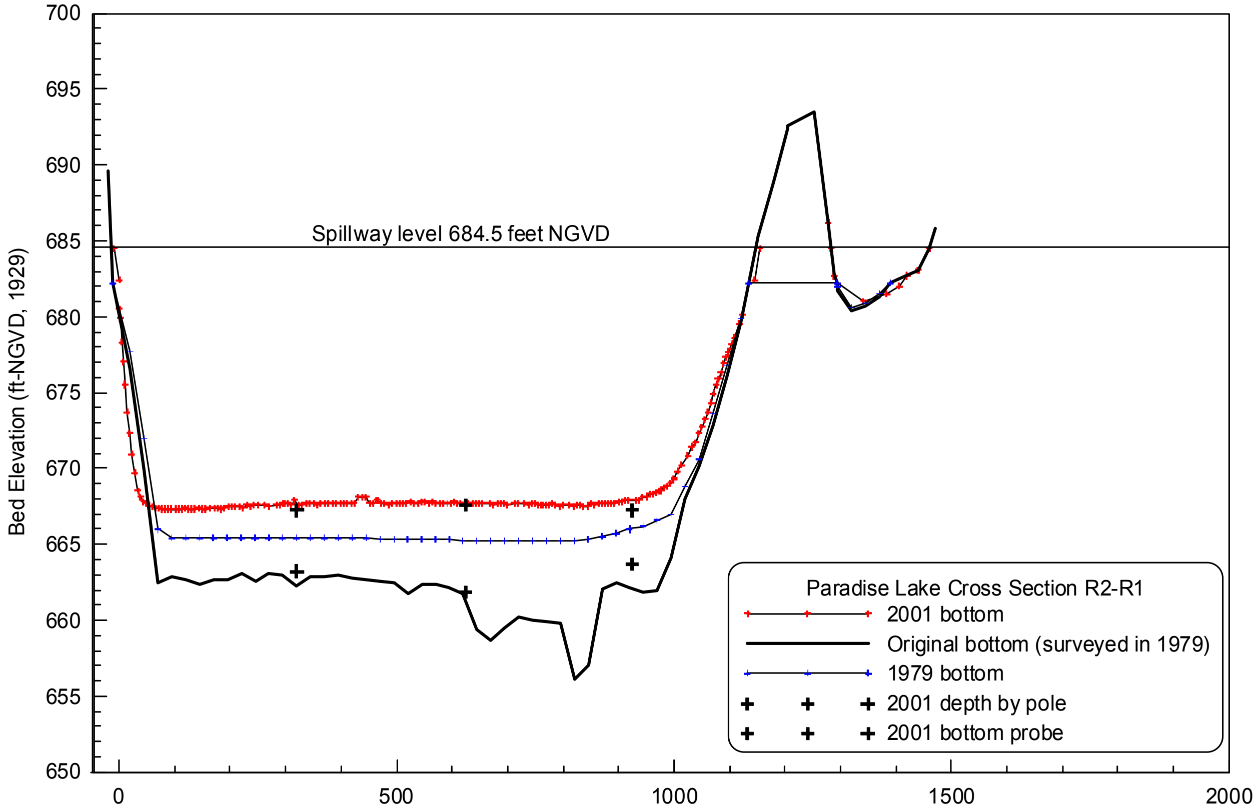
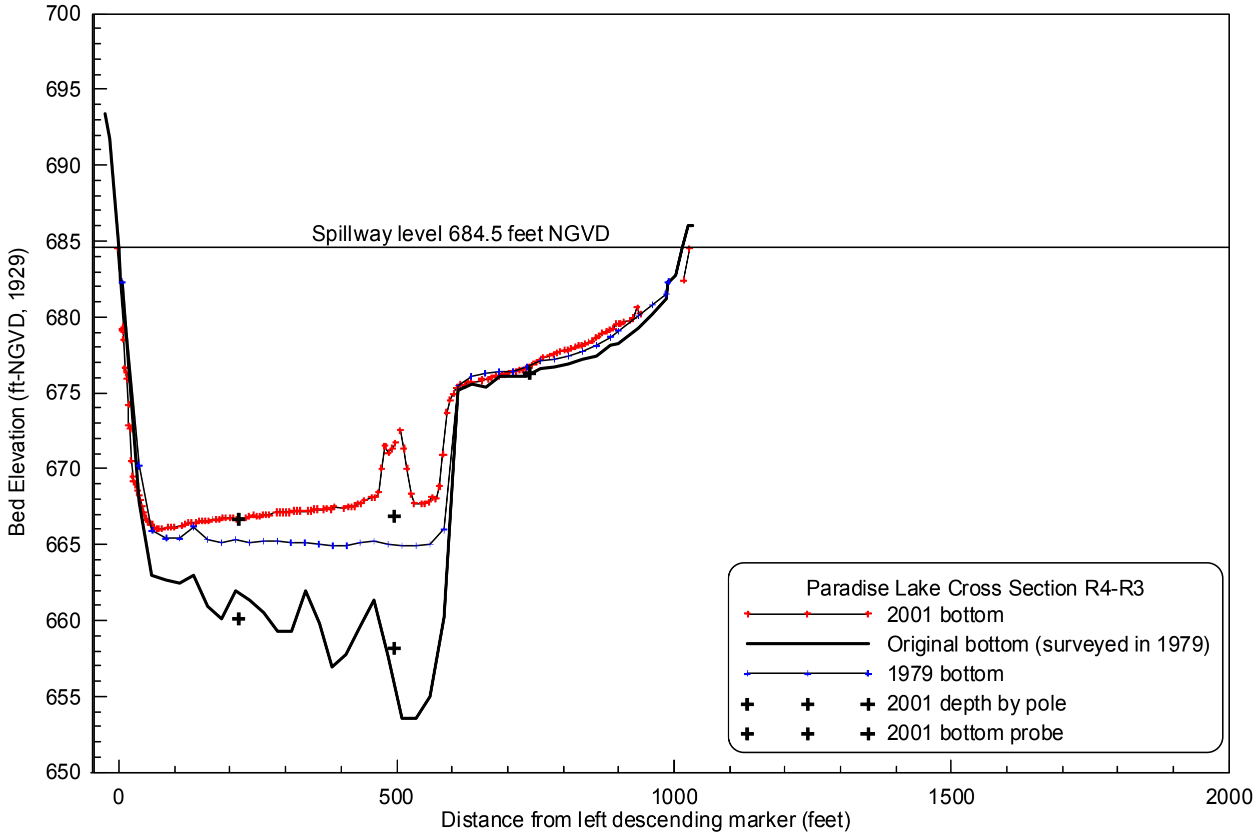
Appendix I. Cross-Section Plots of the Lake Paradise Transects



Spillway level 684.5 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Paradise Lake Cross Section R2-R1
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe



Spillway level 684.5 feet NGVD
Bed Elevation (ft-NGVD, 1929)
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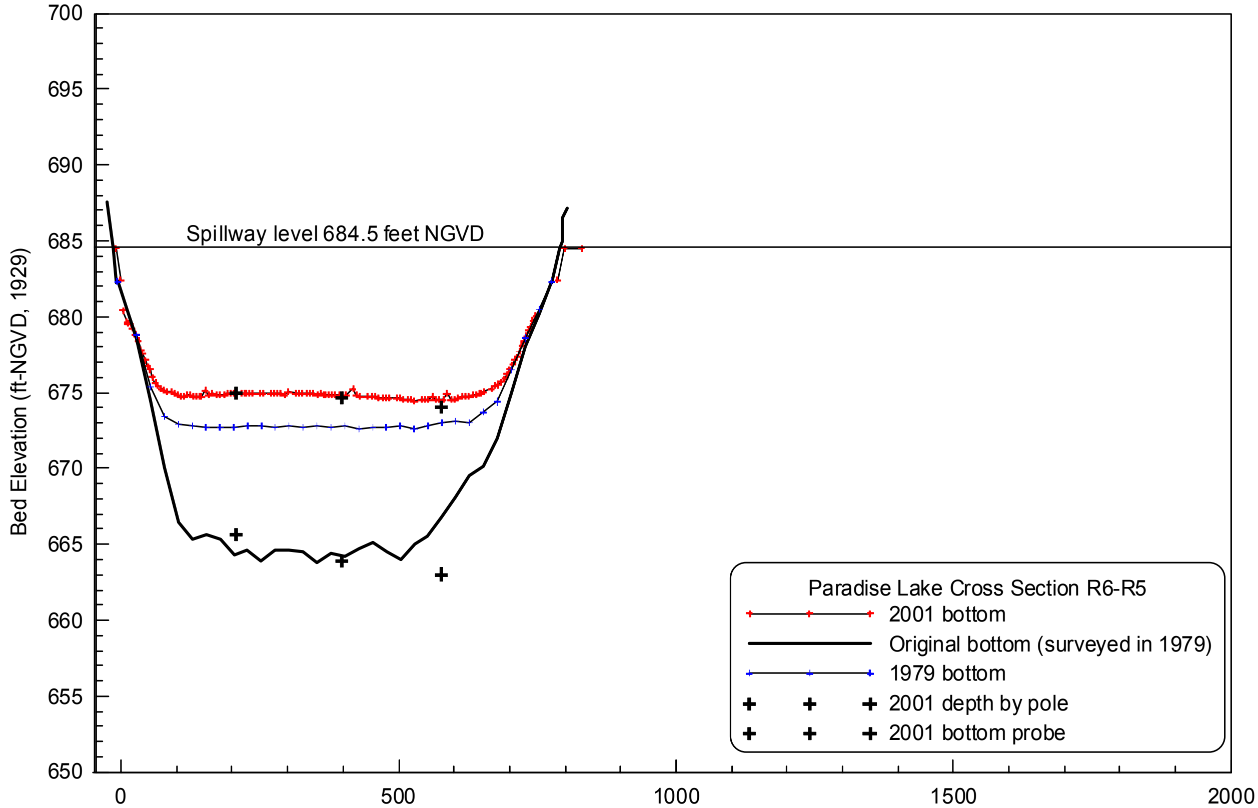
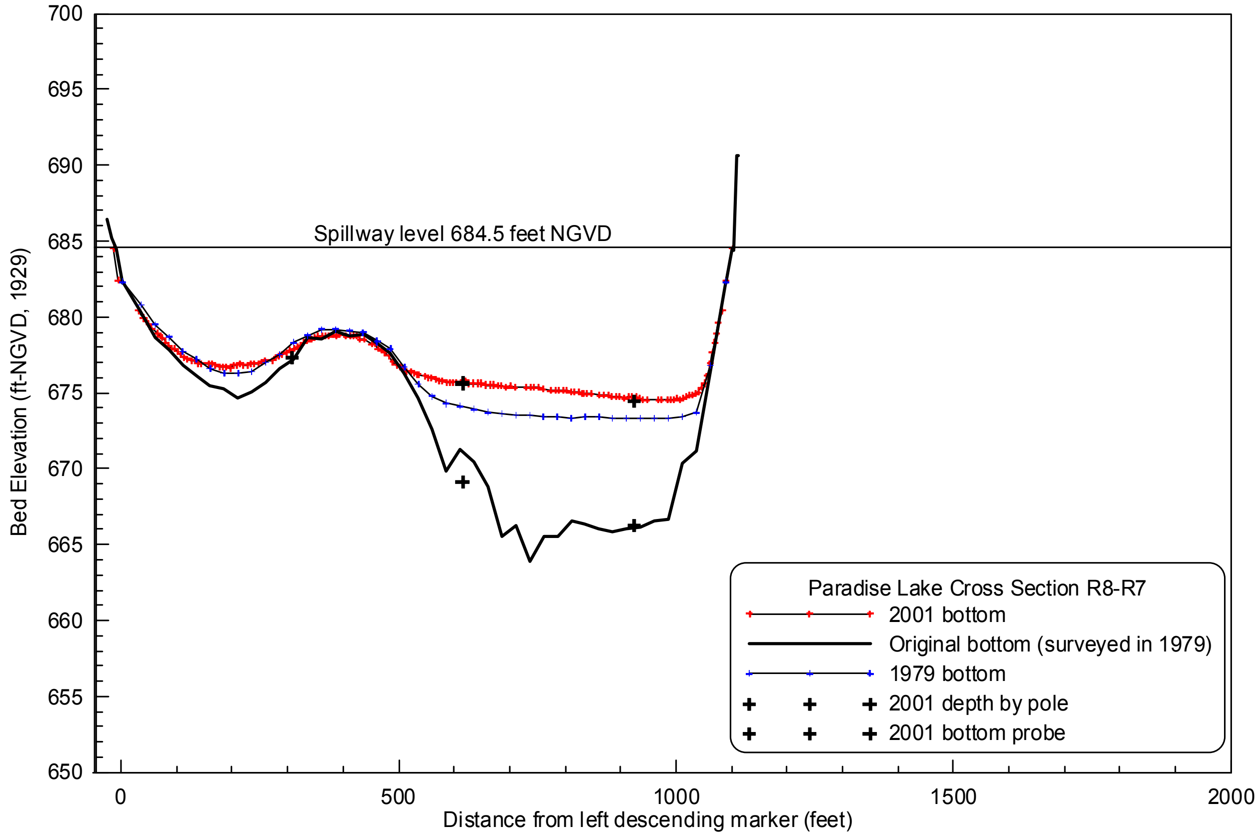
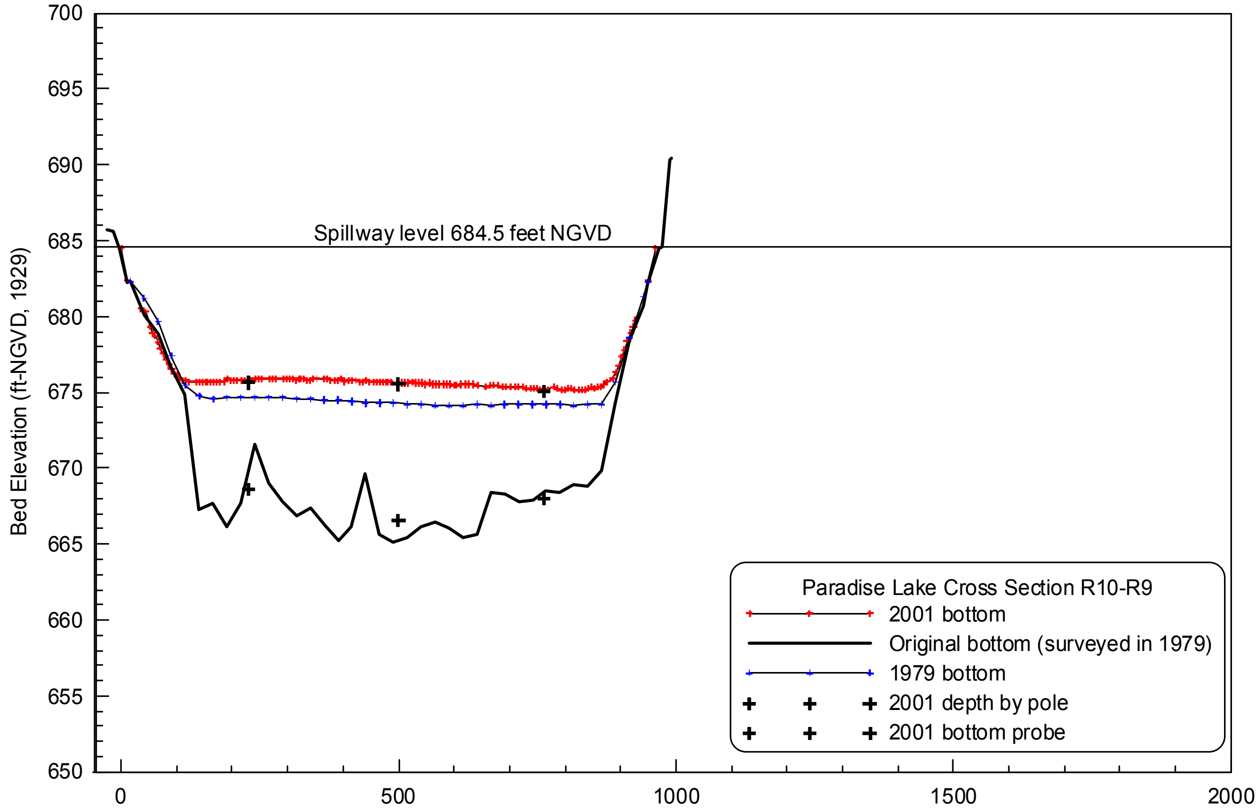
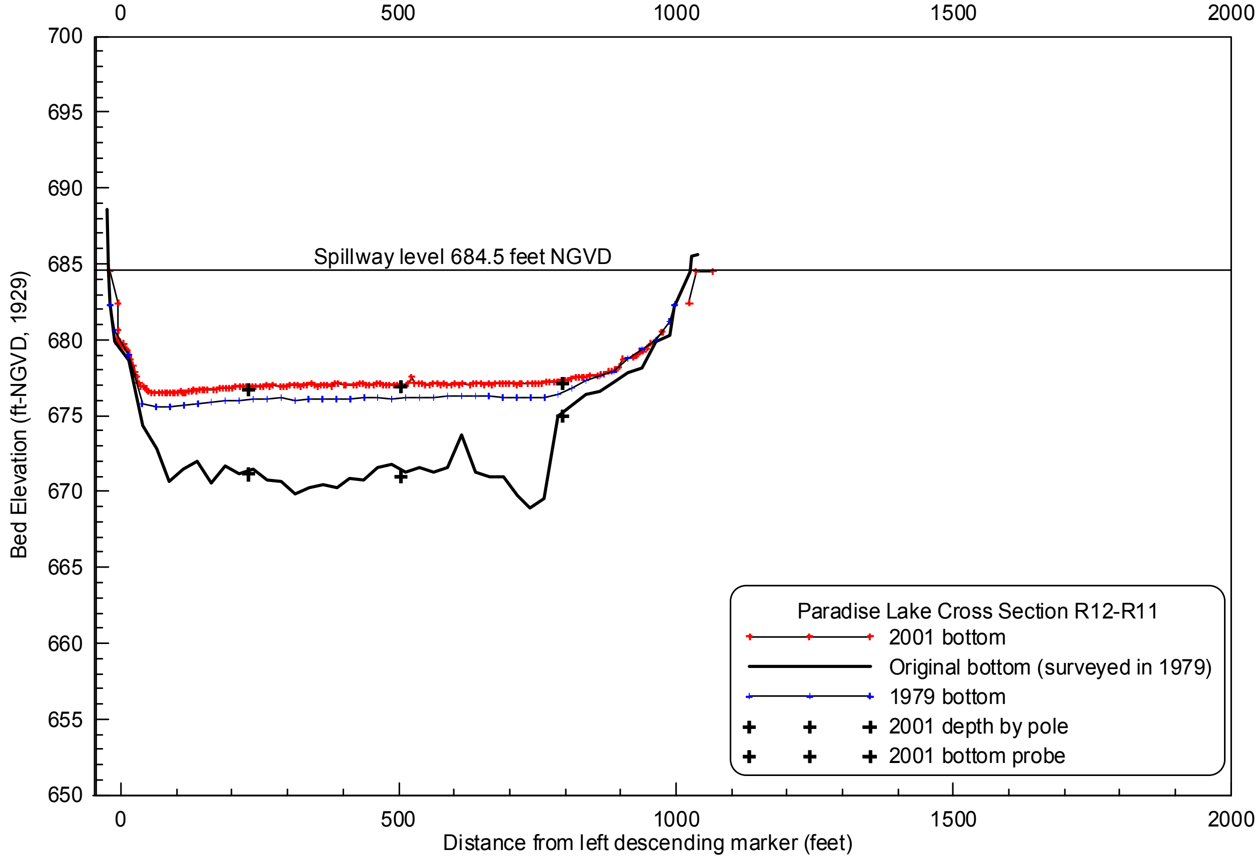
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe
Distance from left descending marker (feet)


Bed Elevation (ft-NGVD, 1929)
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R6-R5
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000

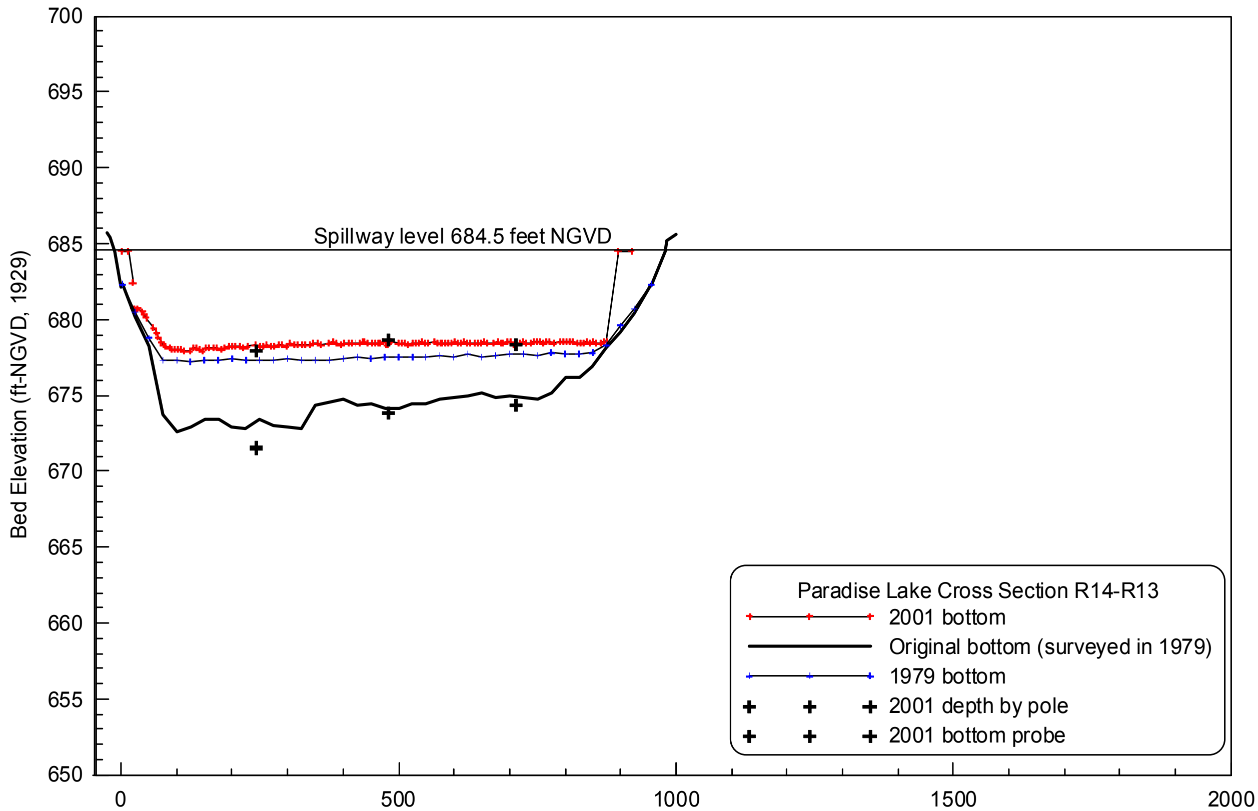

Bed Elevation (ft-NGVD, 1929)
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R8-R7
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000
Distance from left descending marker (feet)



Bed Elevation (ft-NGVD, 1929)
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R10-R9
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe



Bed Elevation (ft-NGVD, 1929)
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000
Distance from left descending marker (feet)
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R12-R11
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe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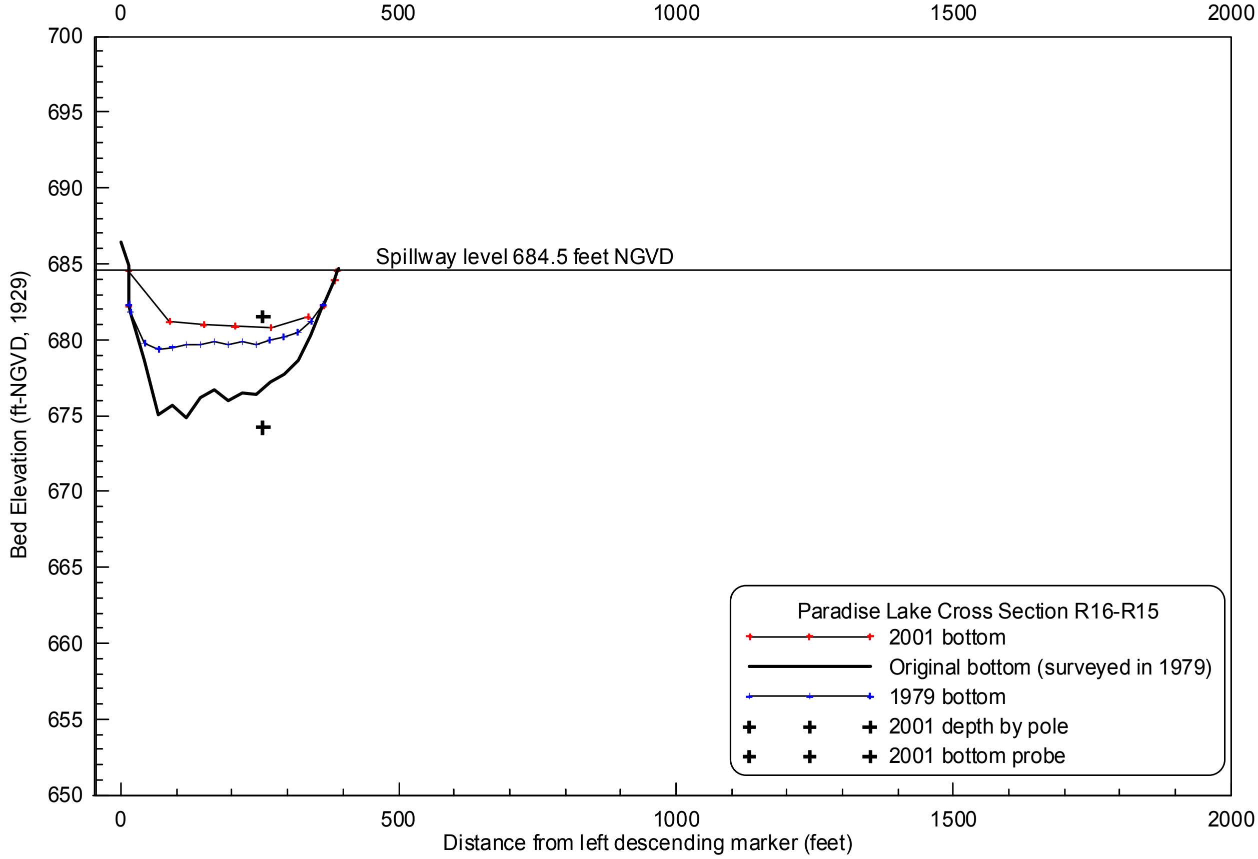
Bed Elevation (ft-NGVD, 1929)
Paradise Lake Cross Section R14-R13
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe


Spillway level 684.5 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Paradise Lake Cross Section R16-R15
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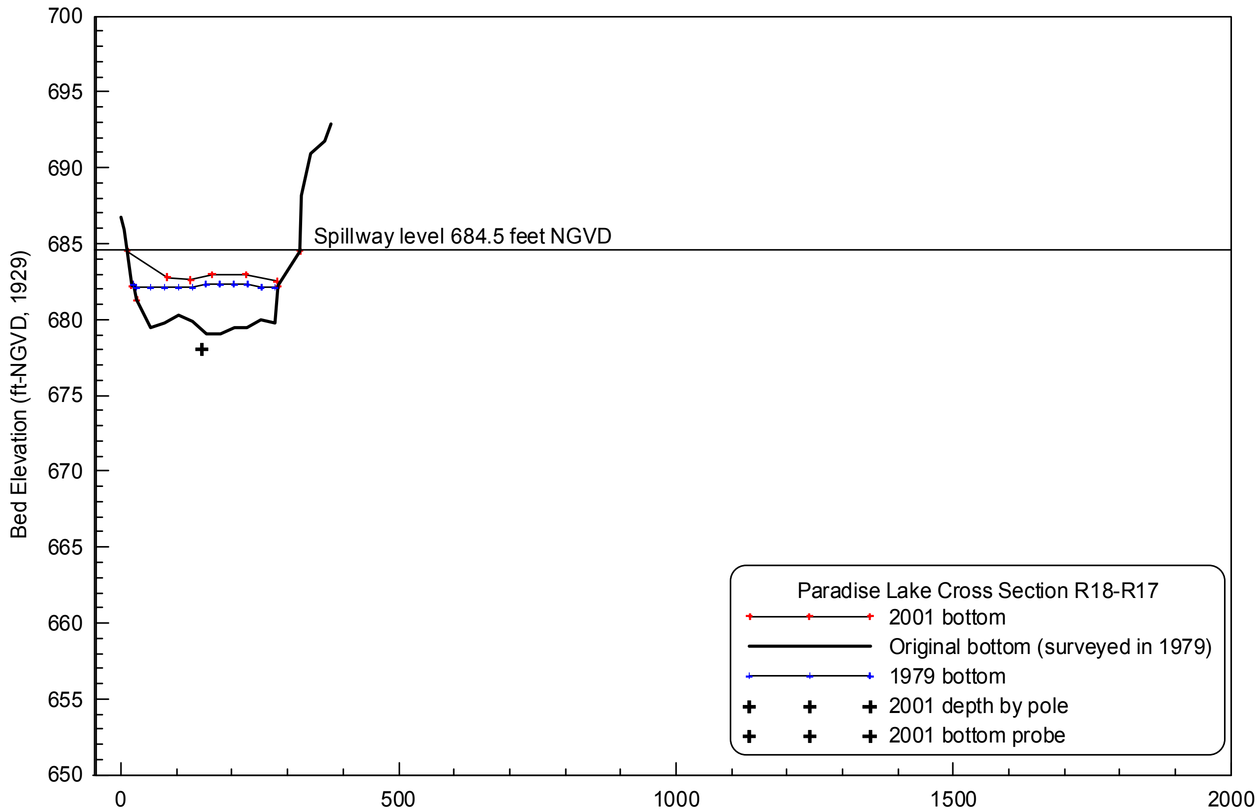
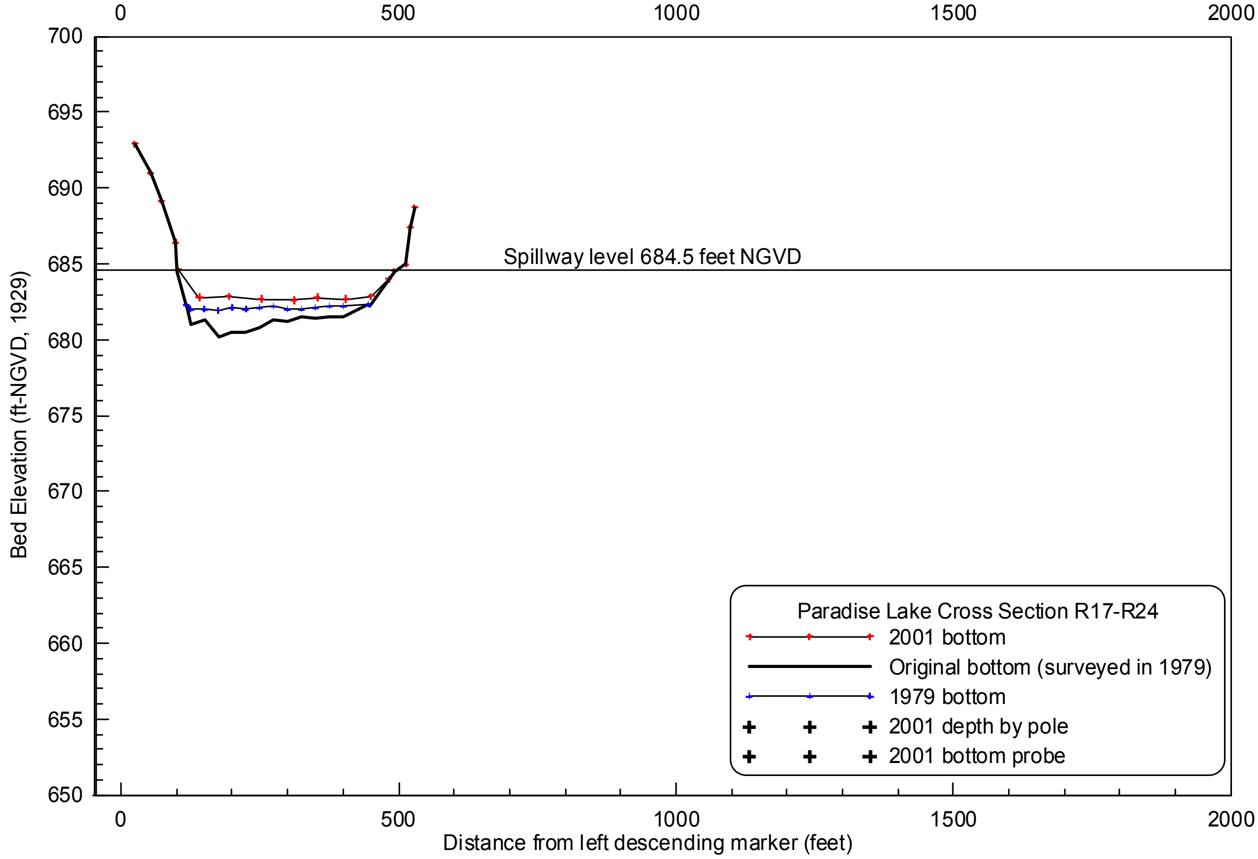
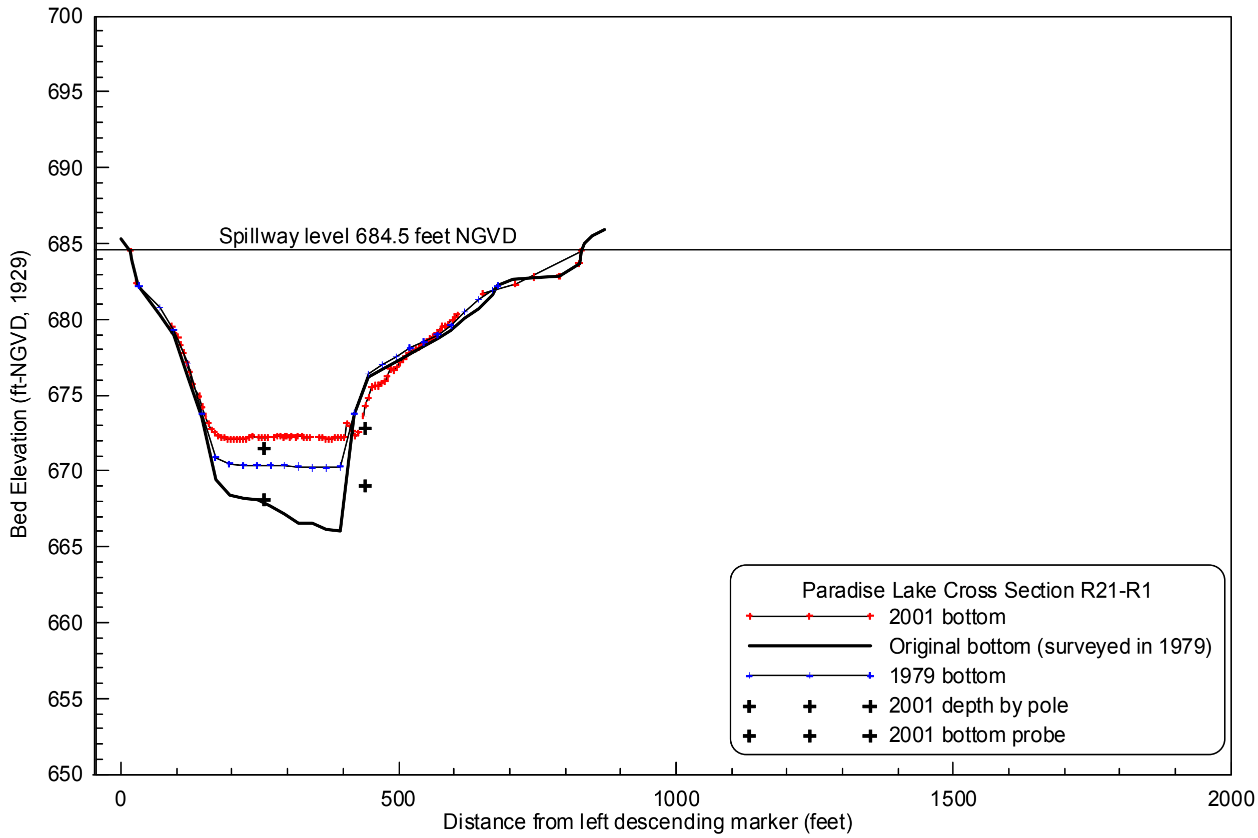
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe
Distance from left descending marker (feet)

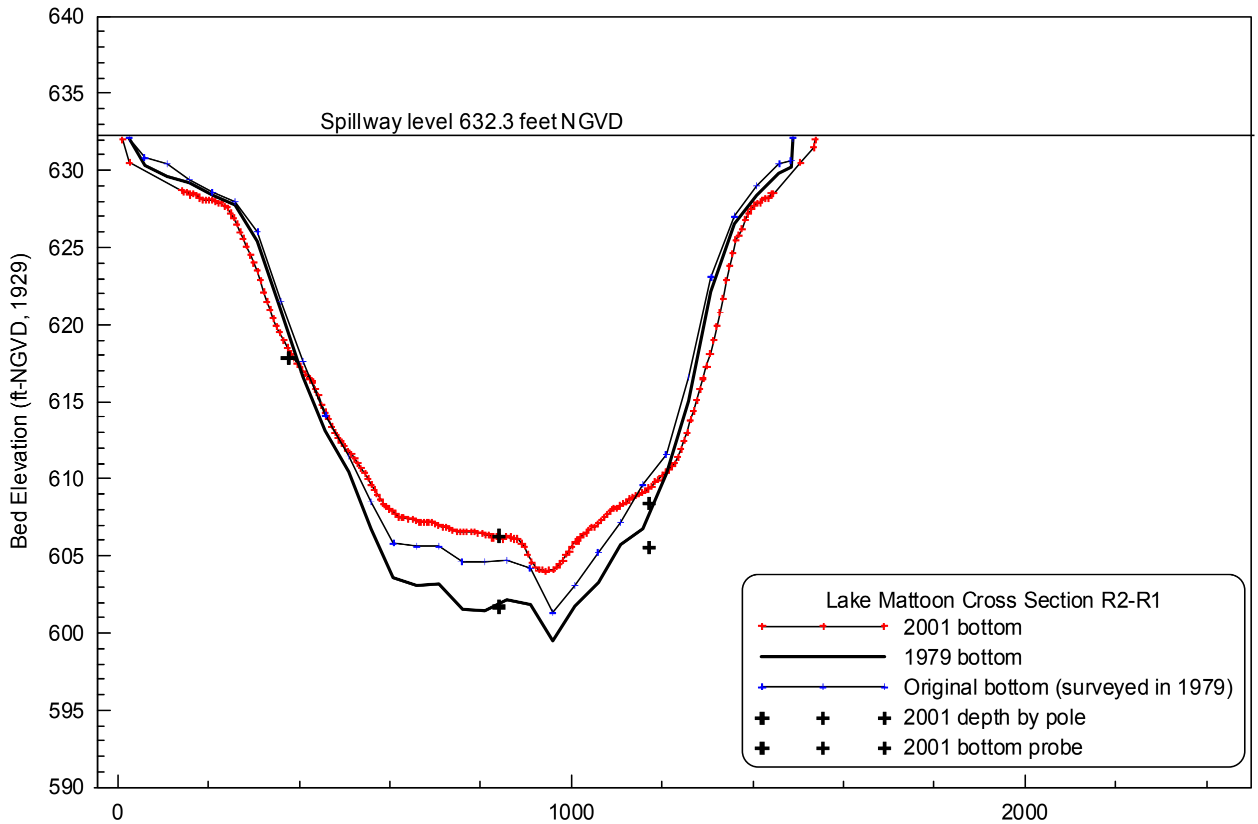

Bed Elevation (ft-NGVD, 1929)
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R18-R17
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe


Bed Elevation (ft-NGVD, 1929)
700
695
690
685
680
675
670
665
660
655
650
0
500
1000
1500
2000
Distance from left descending marker (feet)
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R17-R24
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe

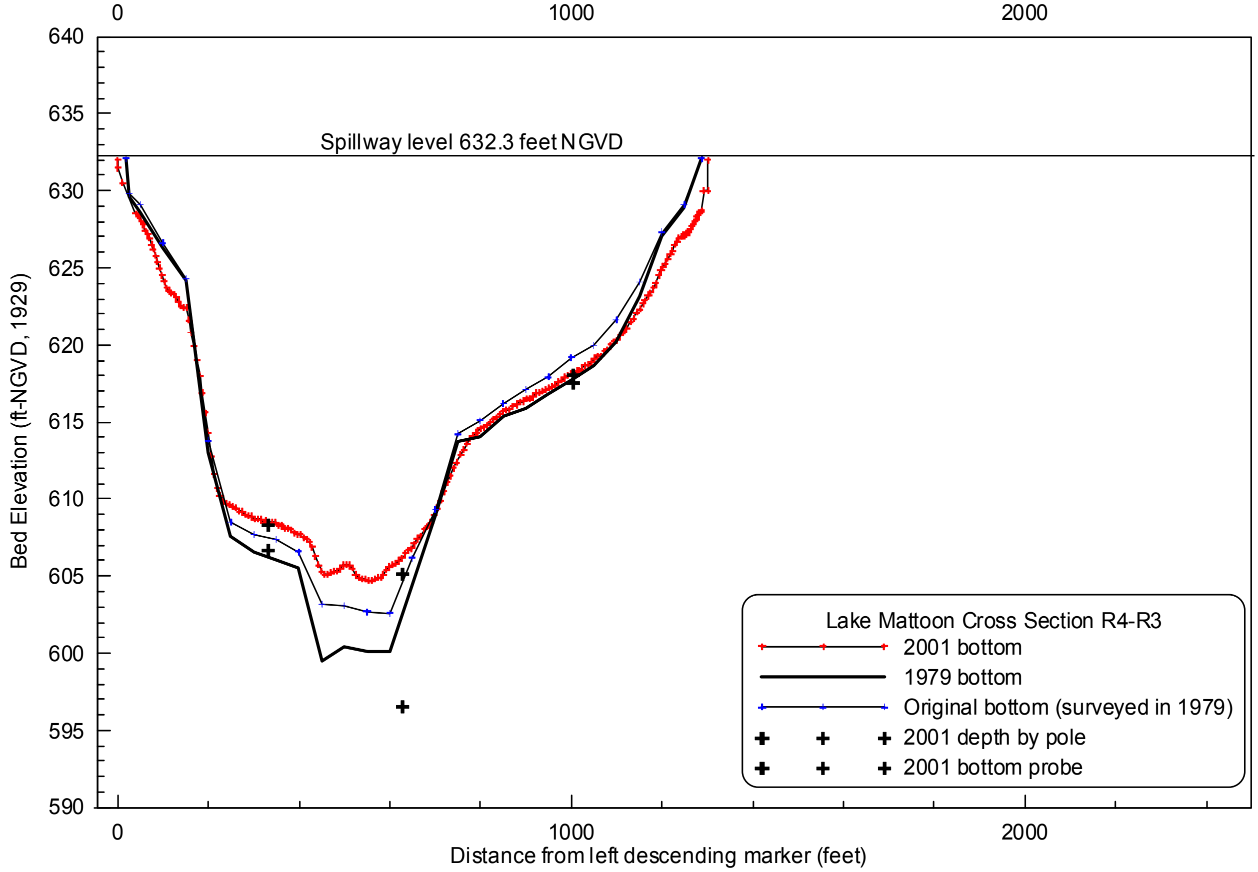


700
695
690
685
680
675
670
665
660
655
650
Bed Elevation (ft-NGVD, 1929)
Spillway level 684.5 feet NGVD
Paradise Lake Cross Section R21-R1
2001 bottom
Original bottom (surveyed in 1979)
1979 bottom
2001 depth by pole
2001 bottom probe
0
500
1000
1500
2000
Distance from left descending marker (feet)

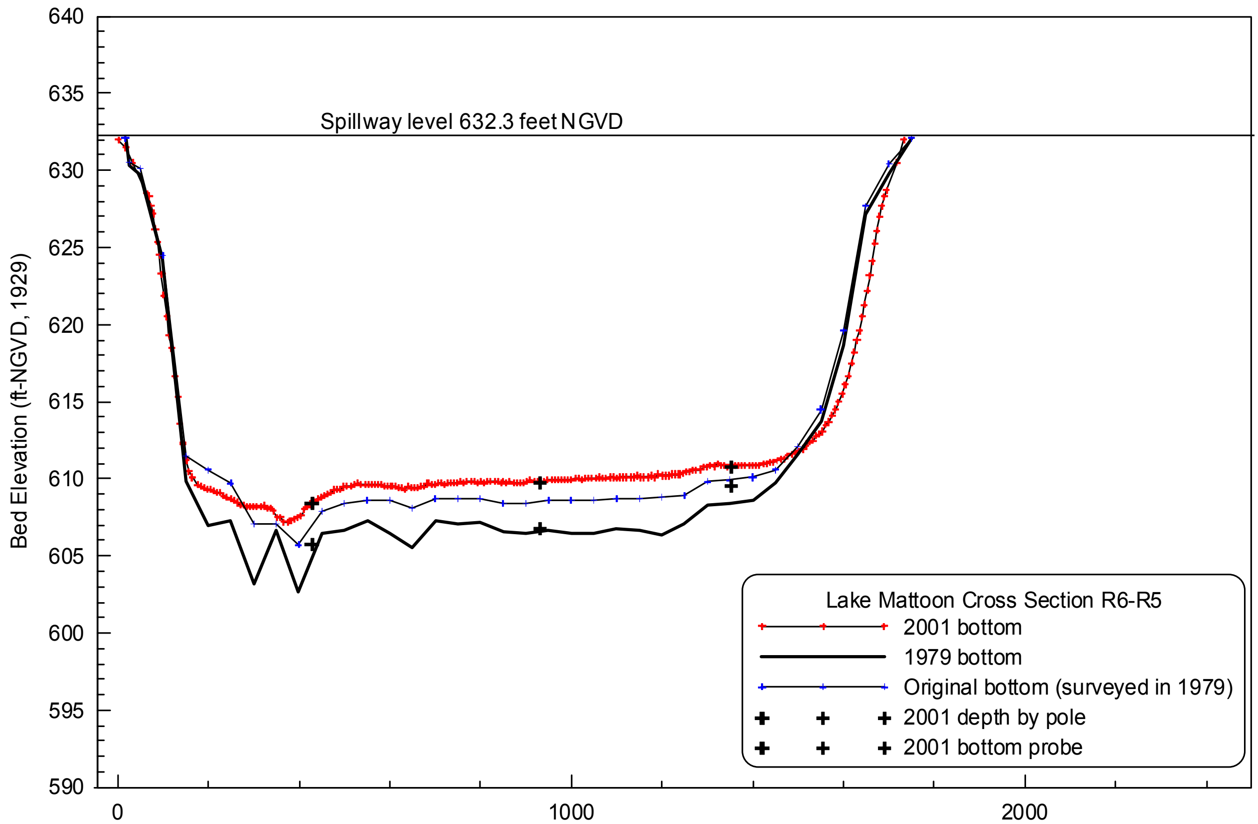
Appendix II. Cross-Section Plots of the Lake Mattoon Transects



Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Lake Mattoon Cross Section R2-R1
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe



Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R4-R3
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R6-R5
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
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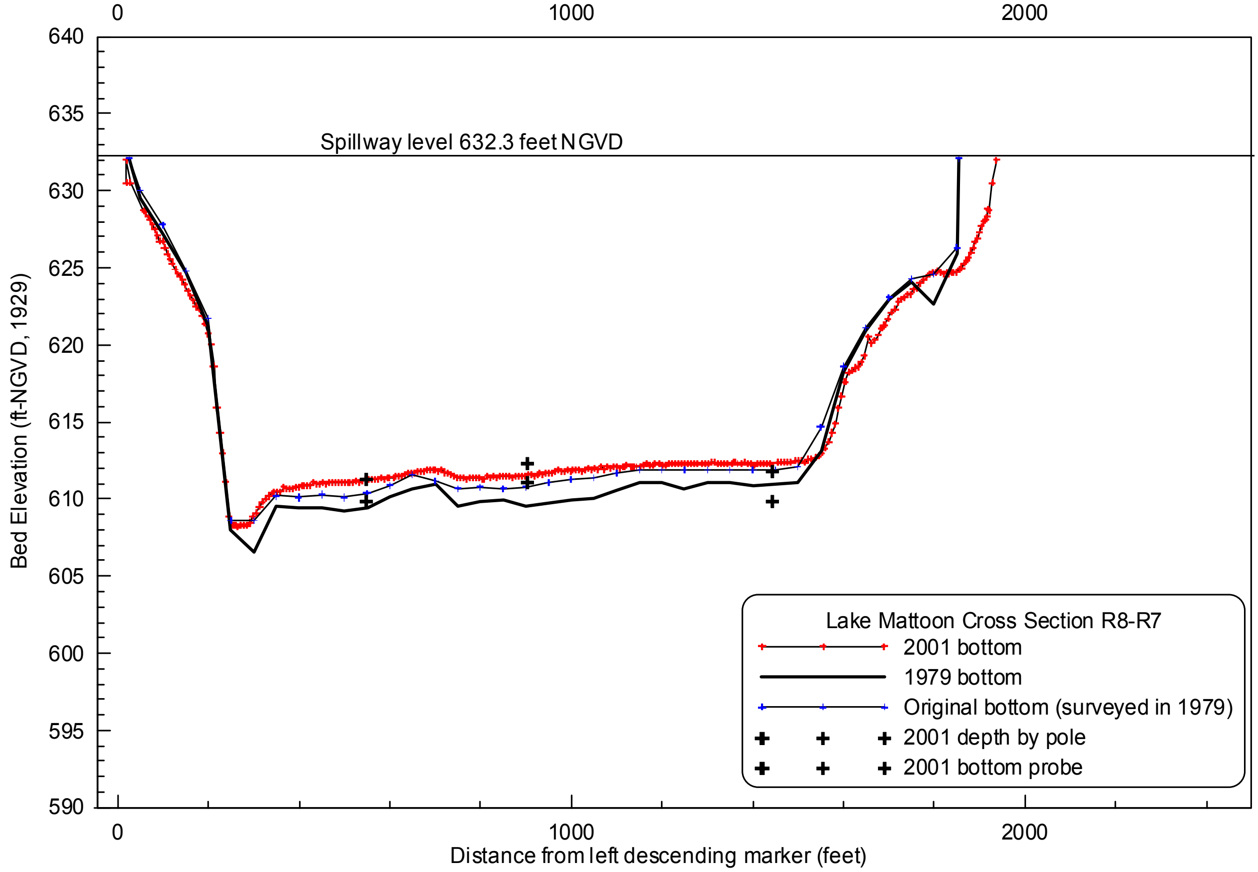
610
605
600
595
590
0
1000
2000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Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R8-R7
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
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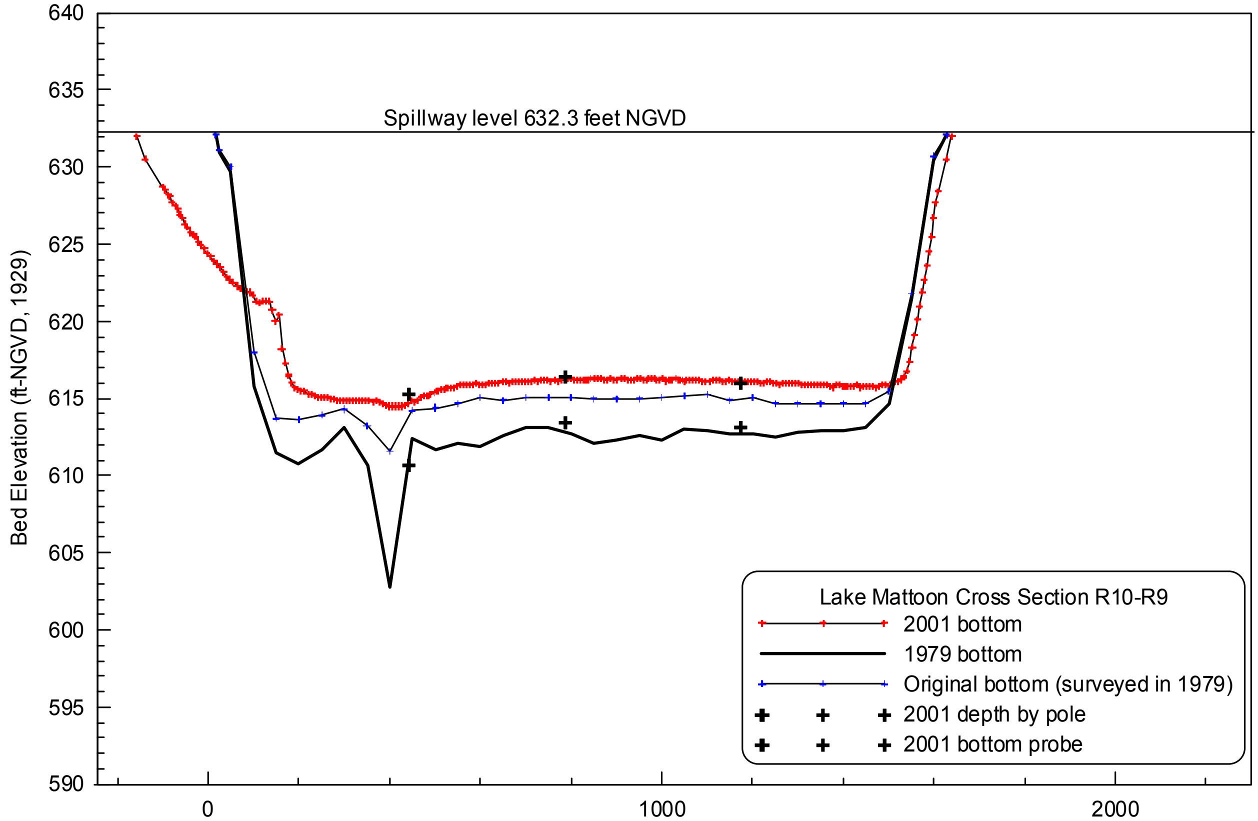
595
590
0
1000
2000
Distance from left descending marker (feet)


Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
640
635
630
625
620
615
610
605
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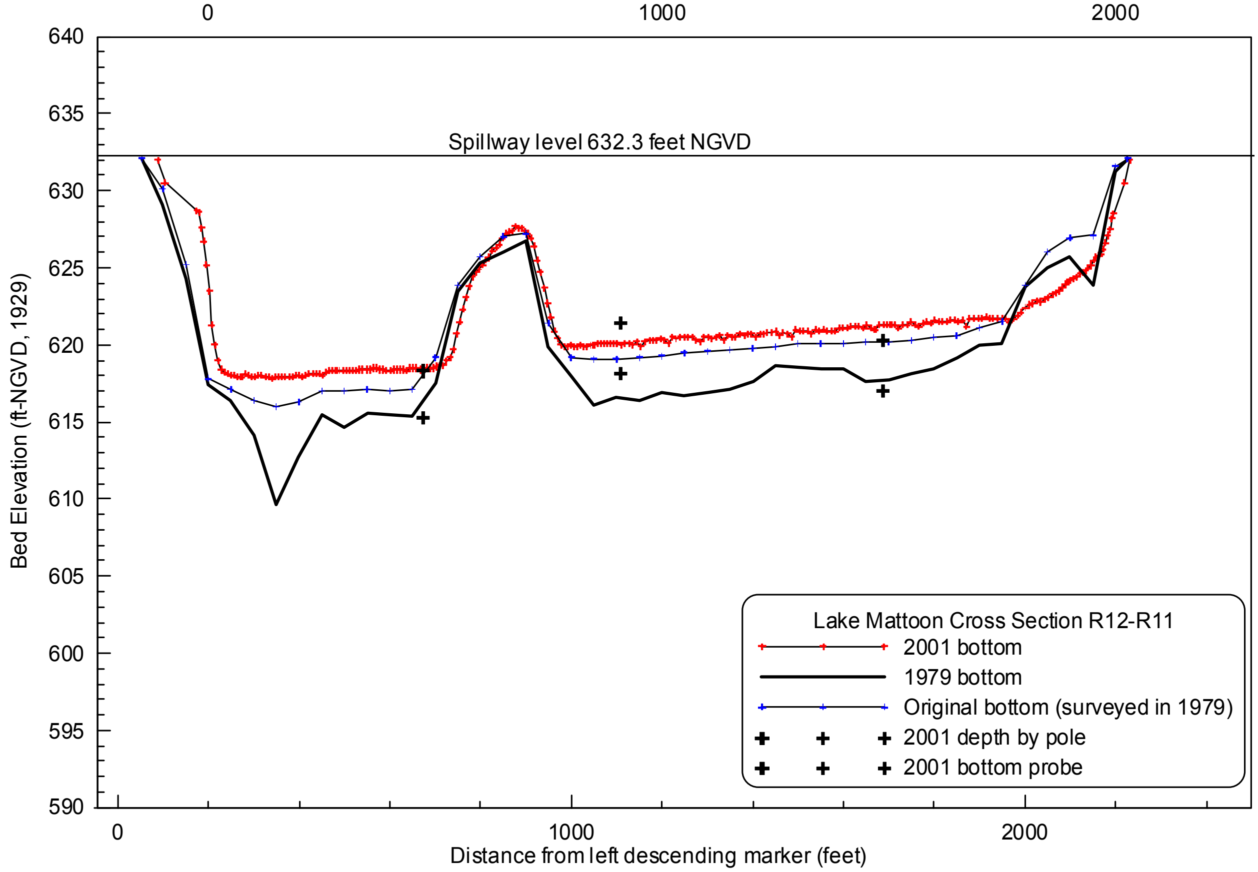
1000
2000
Lake Mattoon Cross Section R10-R9
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
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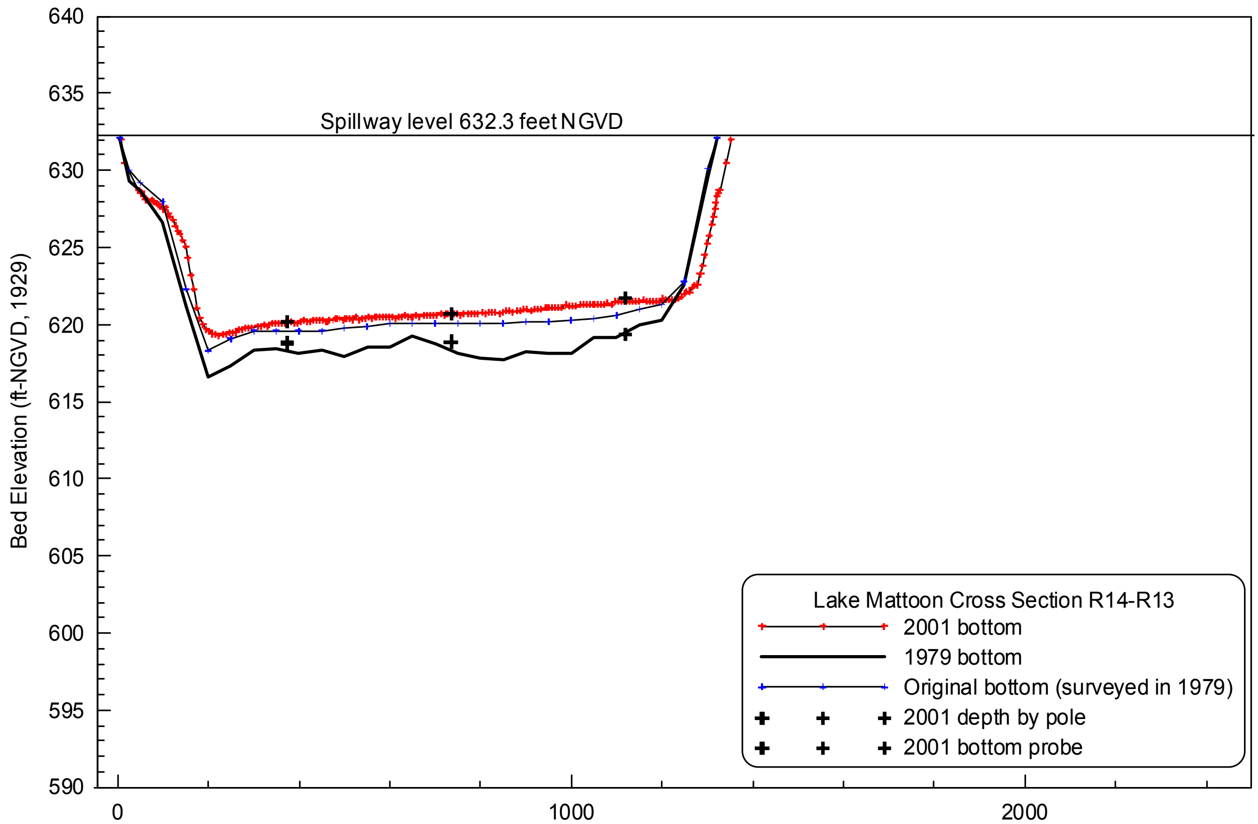
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R12-R11
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe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Bed Elevation (ft-NGVD, 1929)
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2000
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R14-R13
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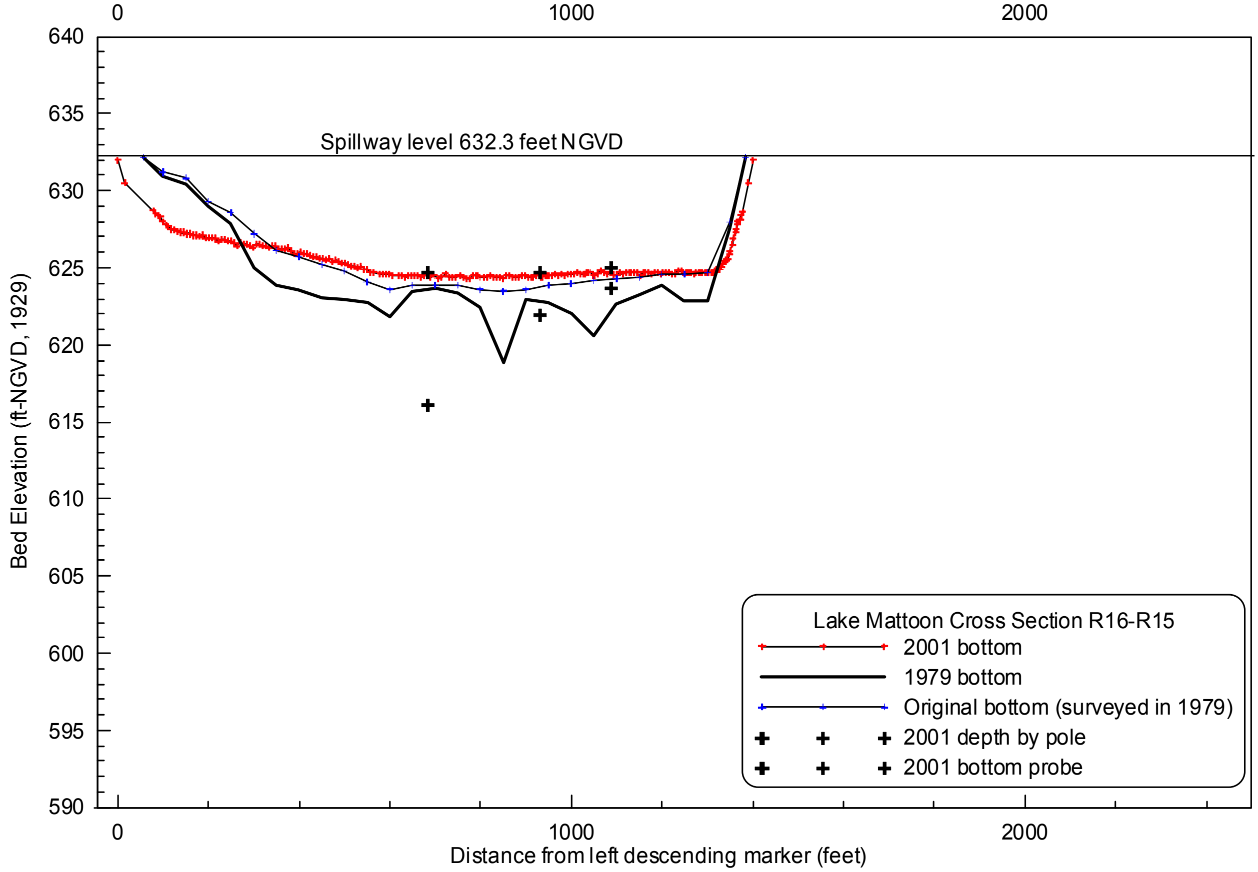
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe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600
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590
Bed Elevation (ft-NGVD, 1929)
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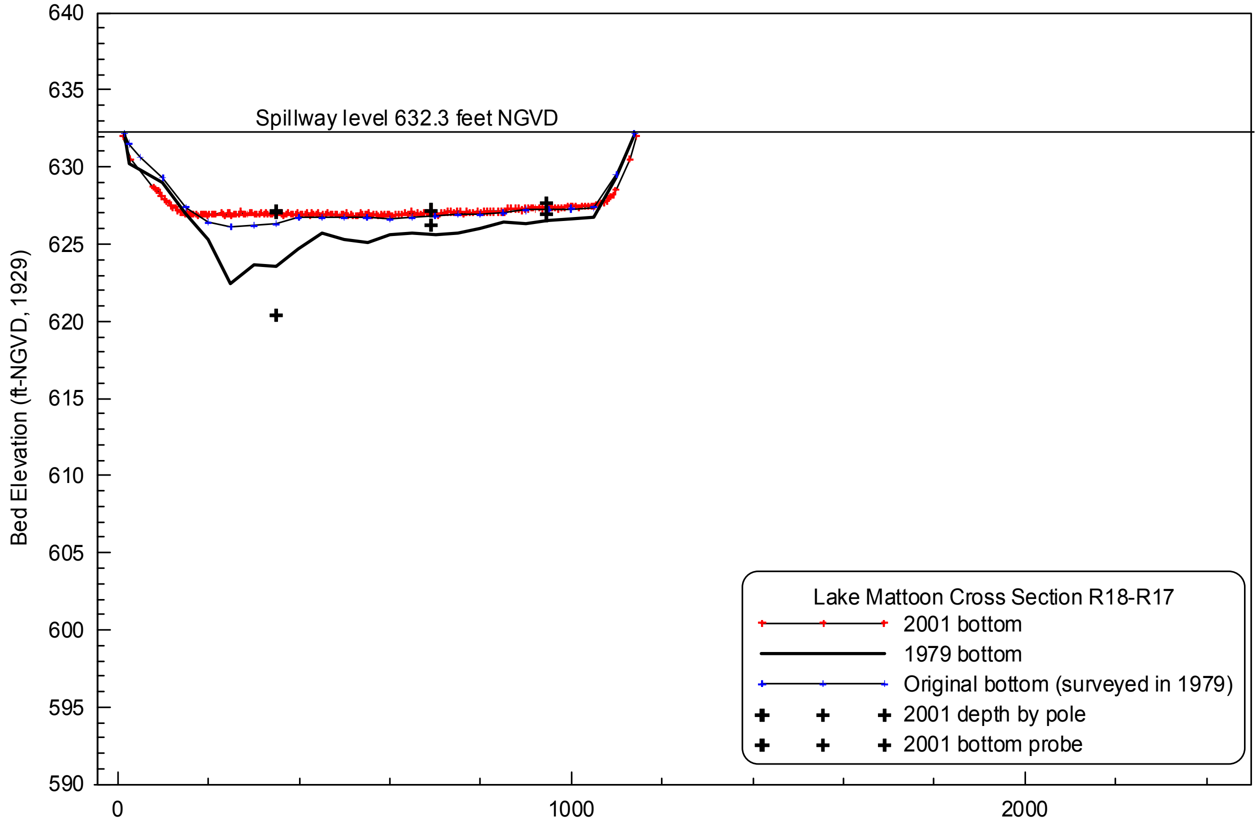
1000
2000
Distance from left descending marker (feet)
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R16-R15
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe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Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
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1000
2000
Lake Mattoon Cross Section R18-R17
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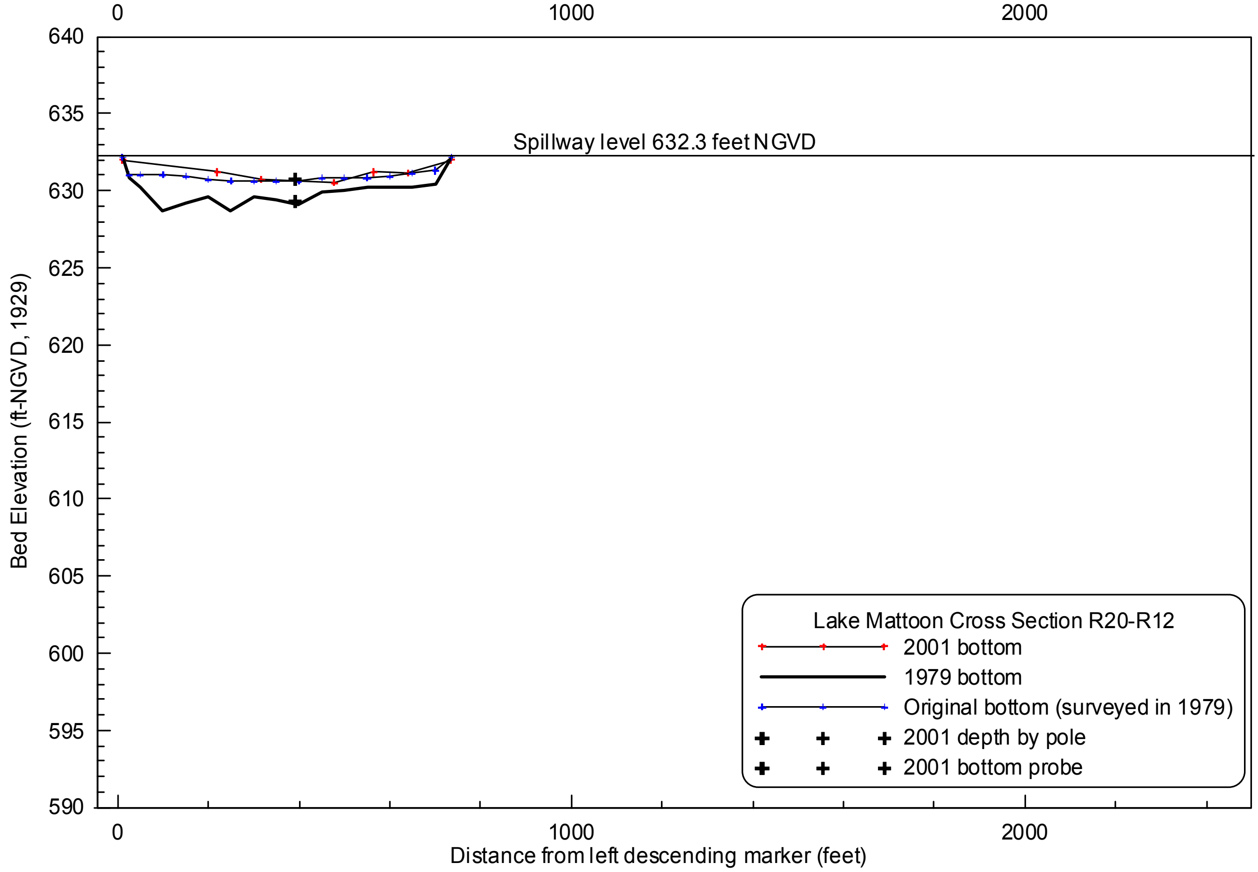
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe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610
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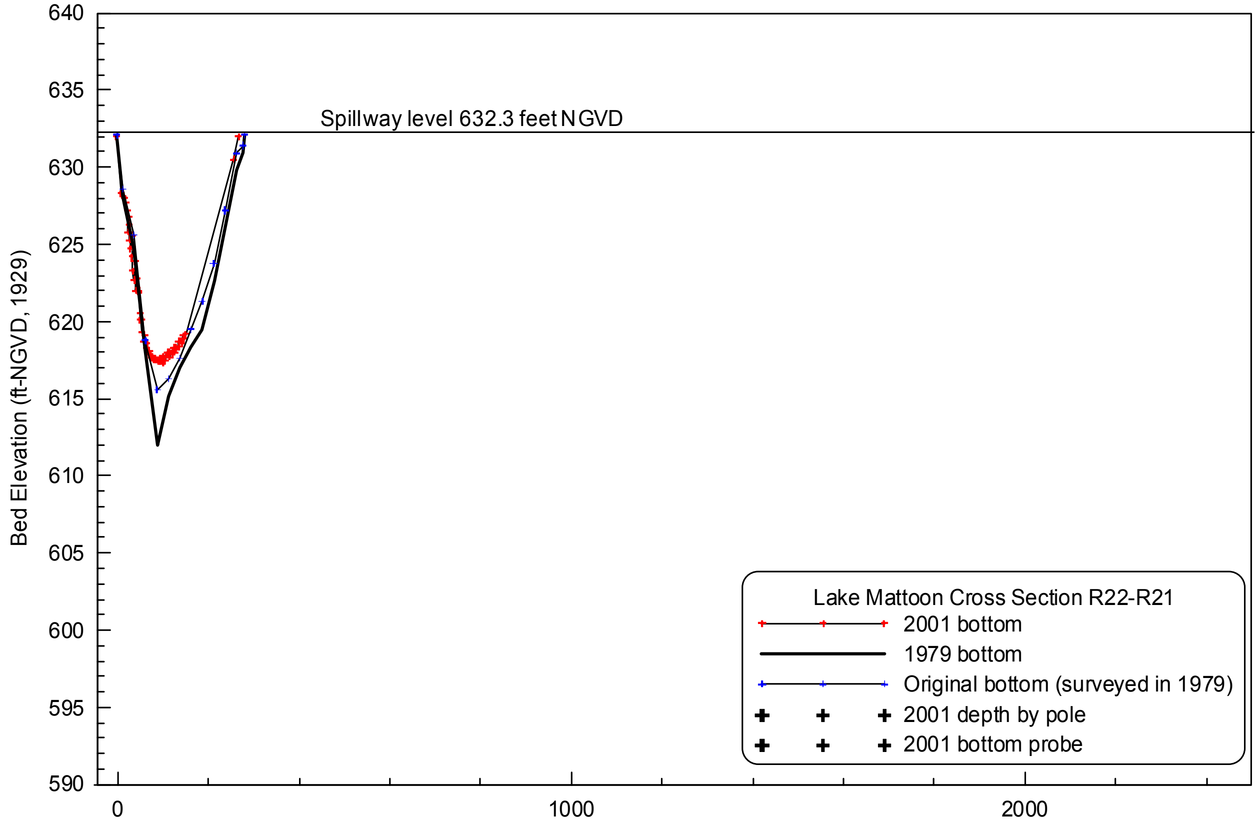
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R20-R12
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R22-R21
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
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620
615
610
605
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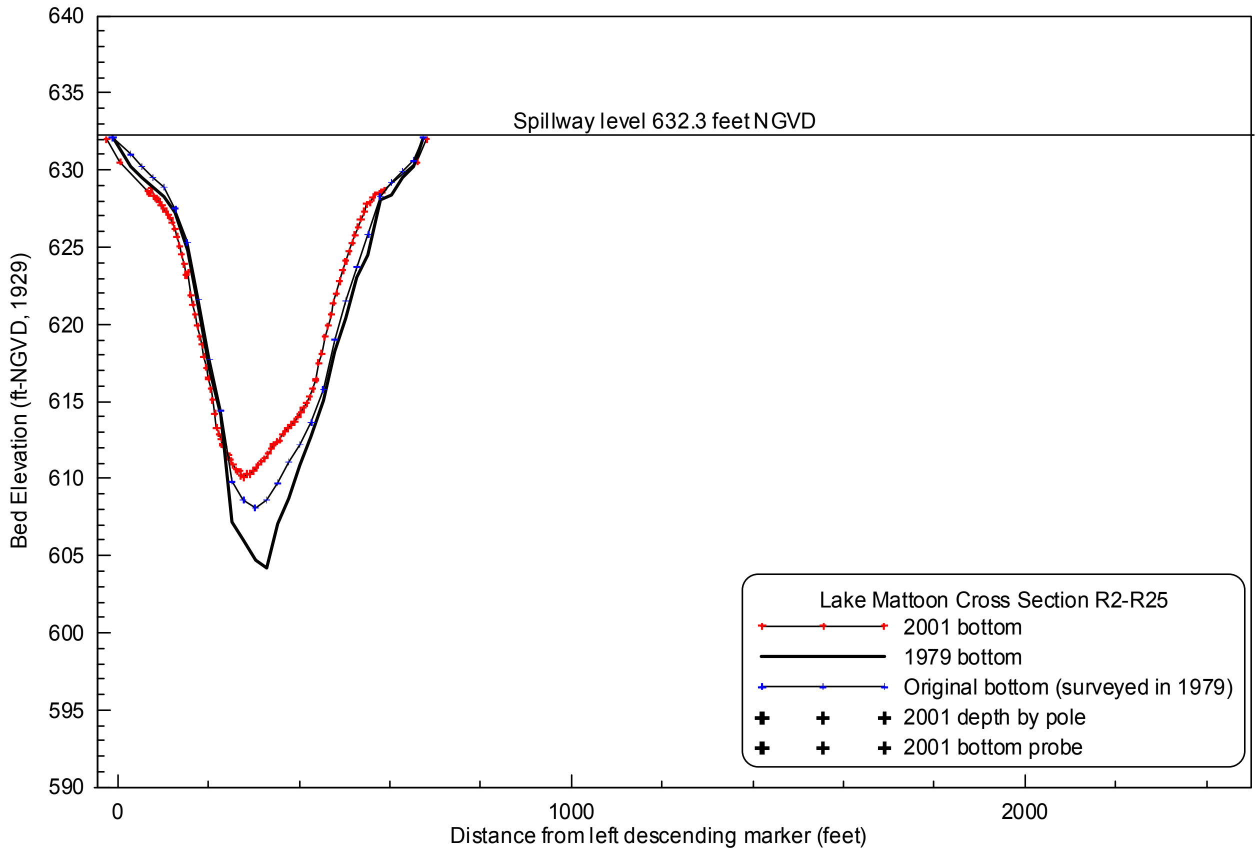
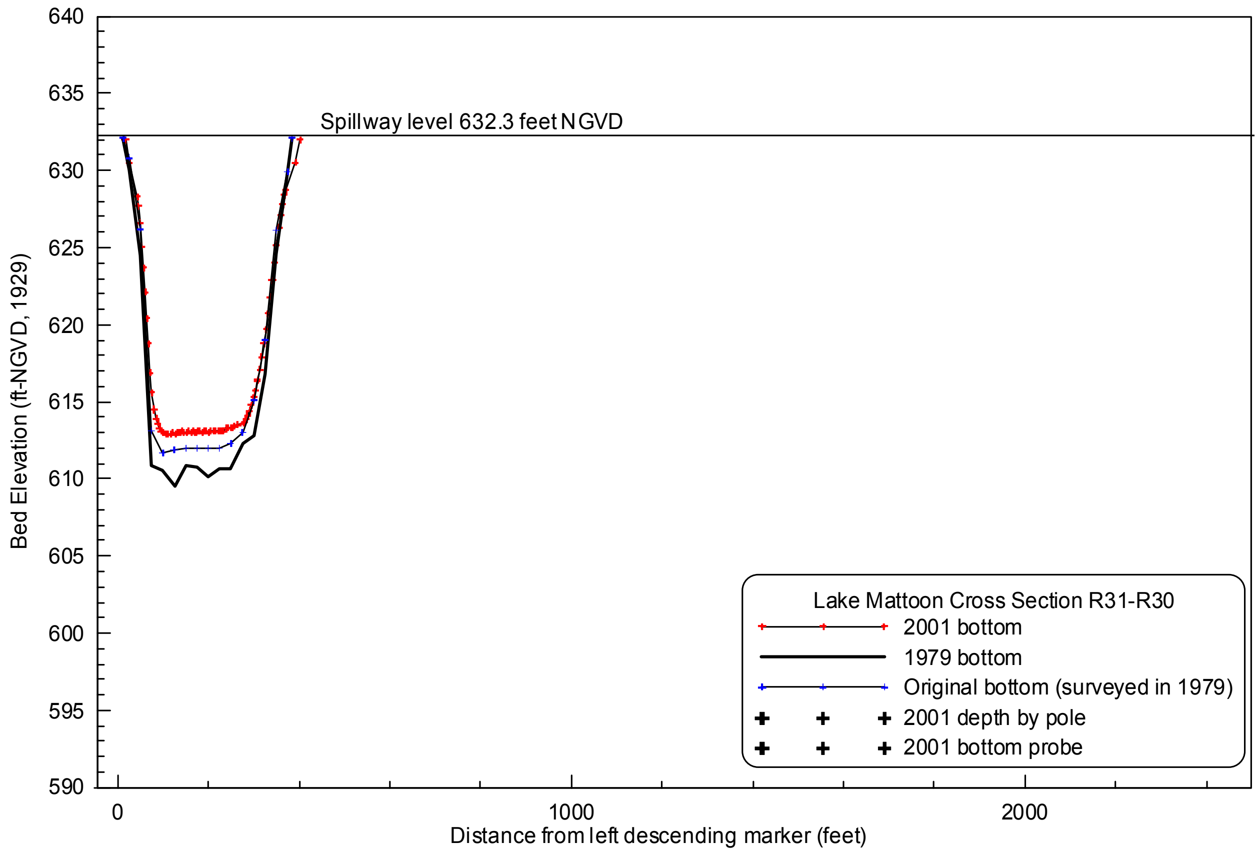
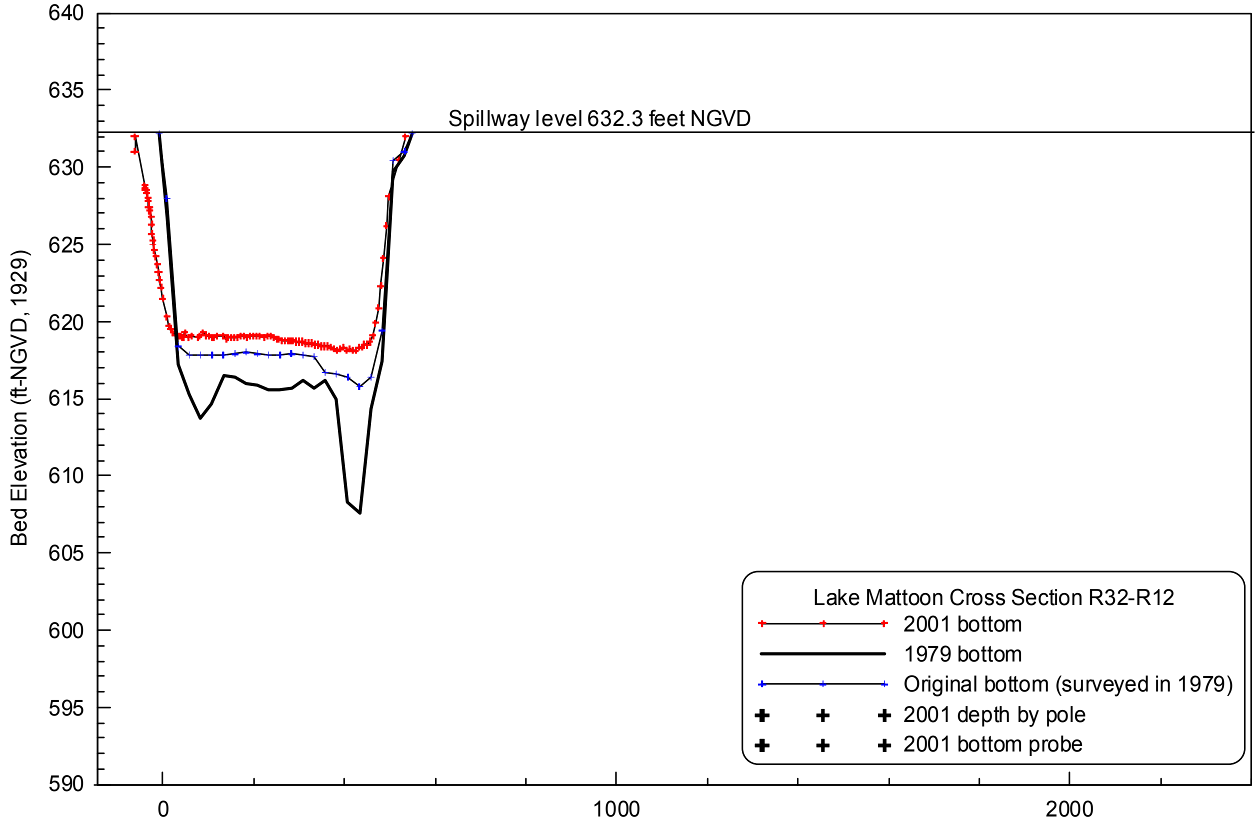
595
590
0
1000
2000

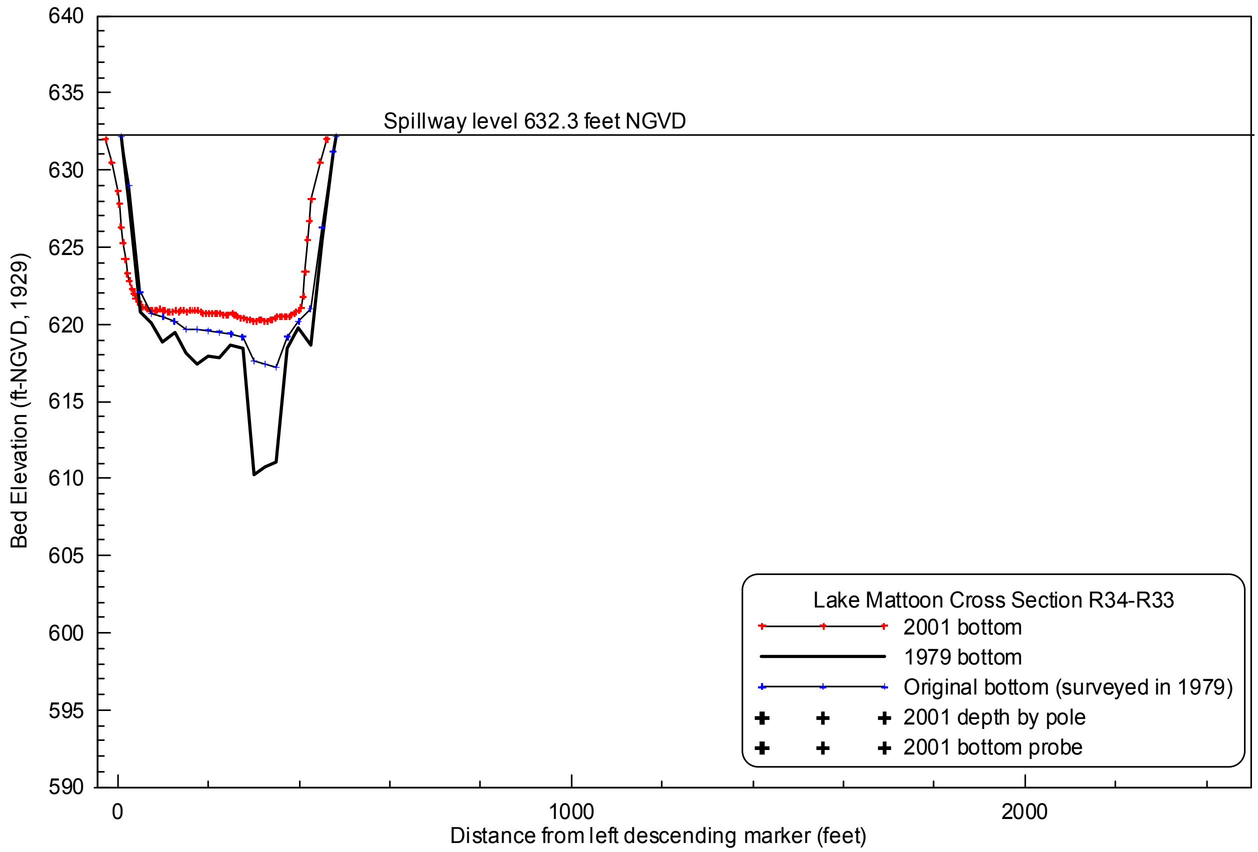

Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R2-R25
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)



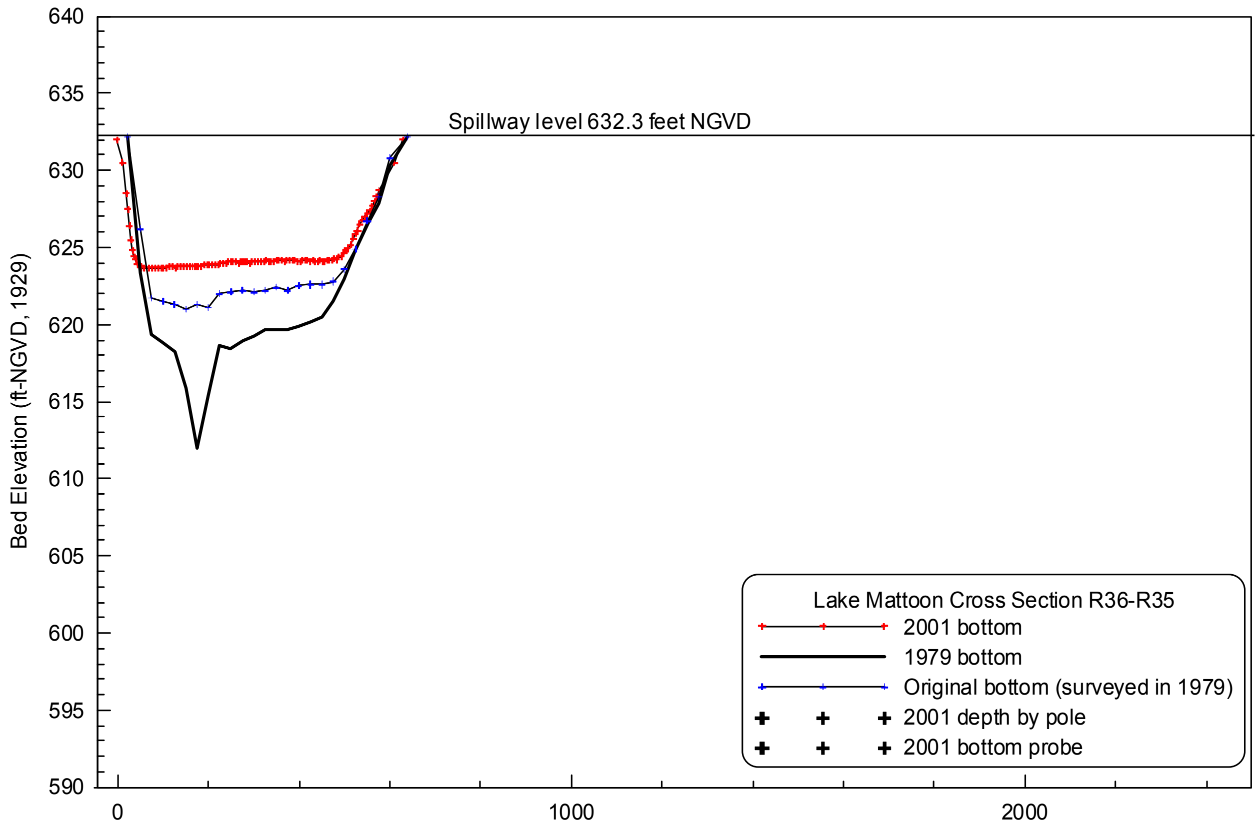
640
635
630
625
620
615
610
605
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R31-R30
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe



Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R32-R12
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000



Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R34-R33
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)


640
635
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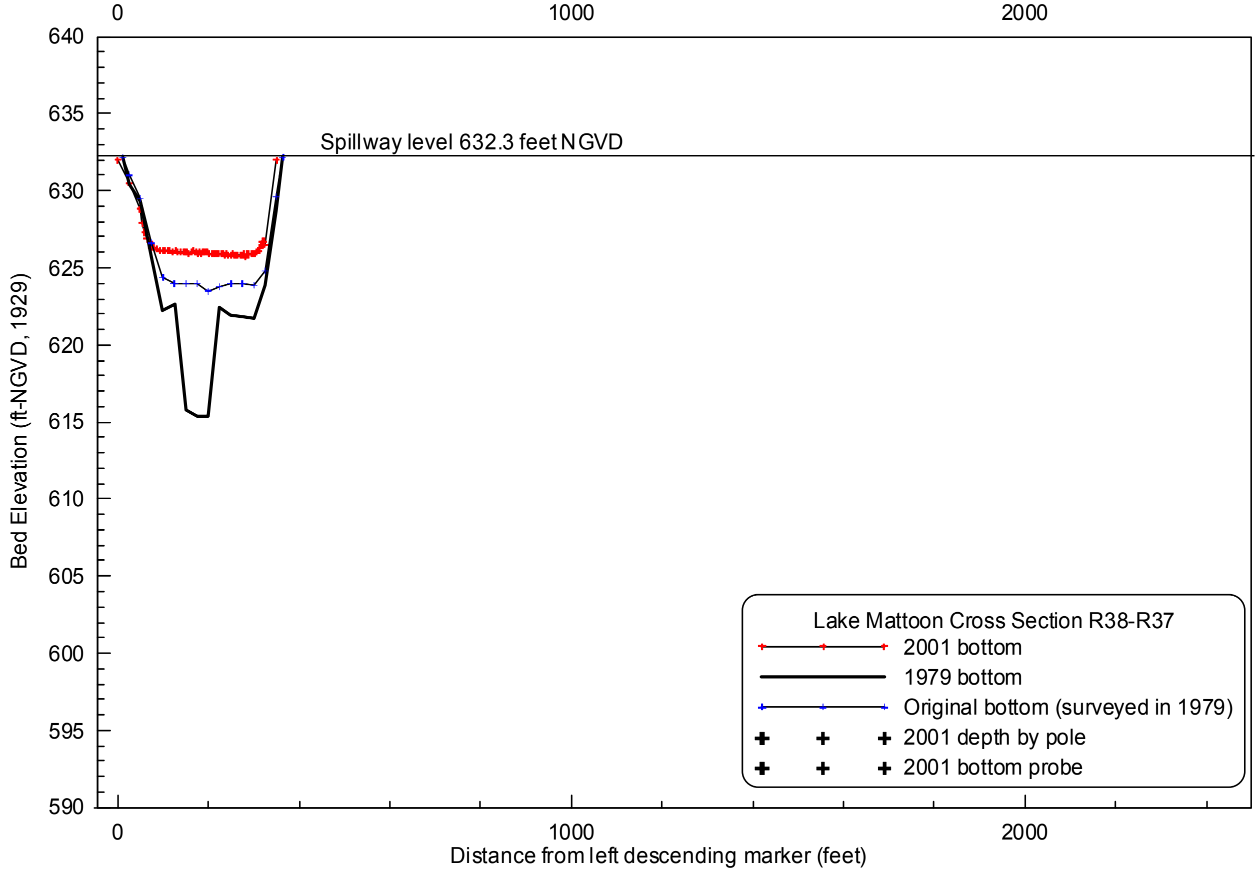
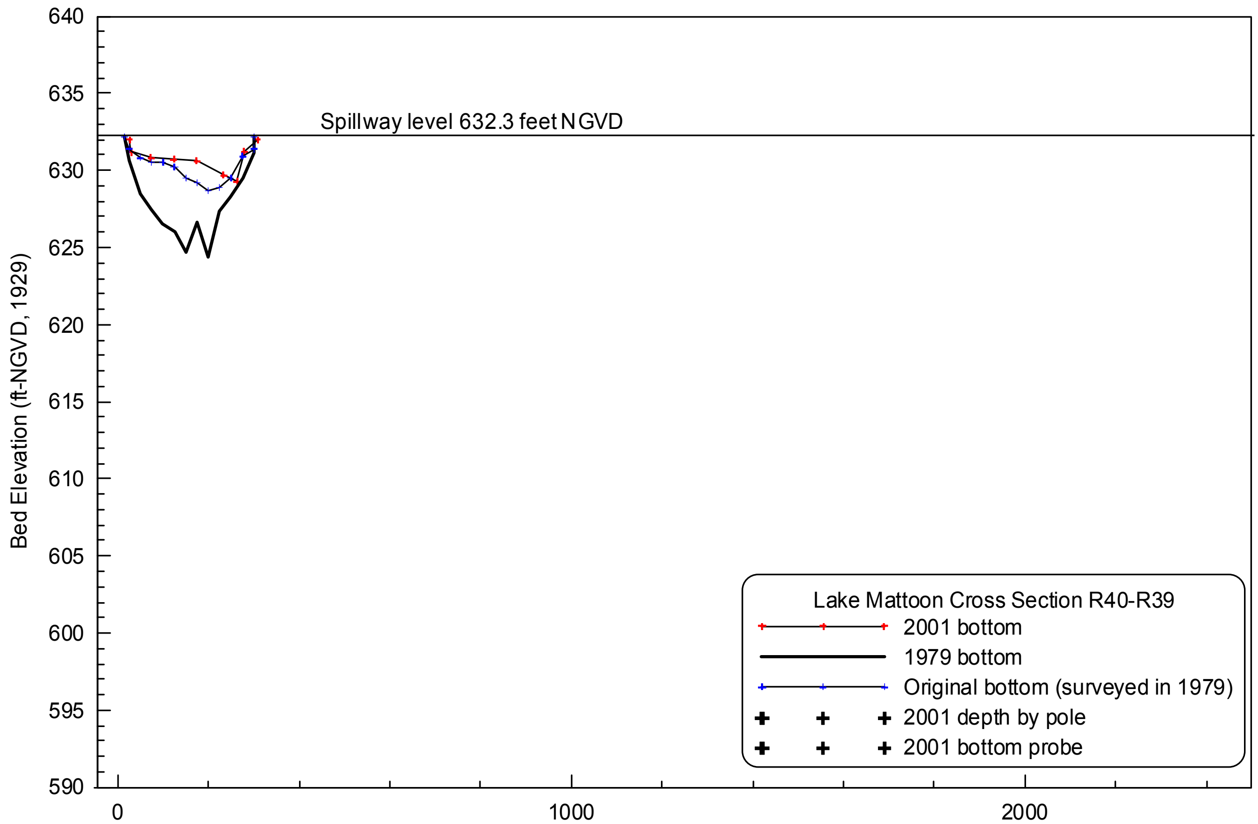
625
620
615
610
605
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
0
1000
2000
Lake Mattoon Cross Section R36-R35
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


640
635
630
625
620
615
610
605
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R38-R37
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


640
635
630
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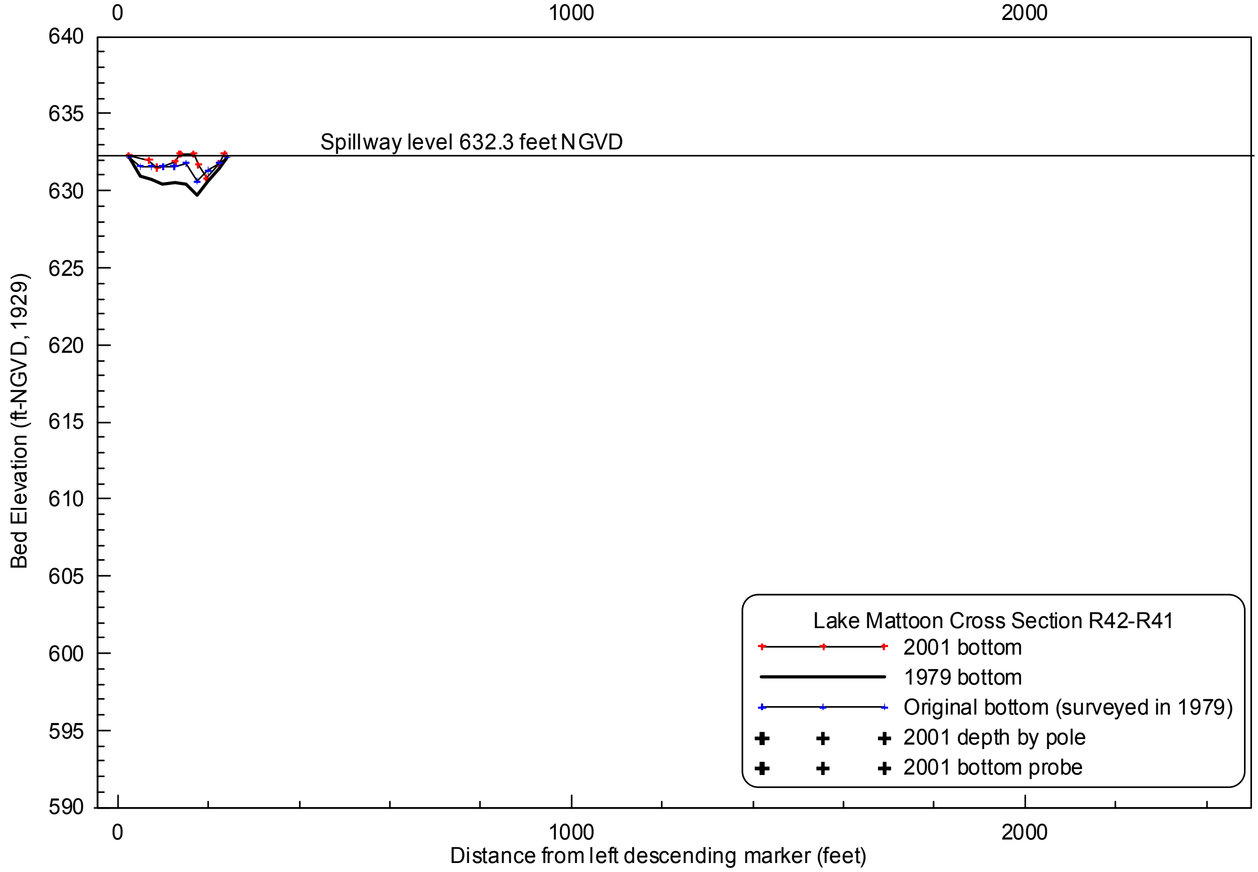
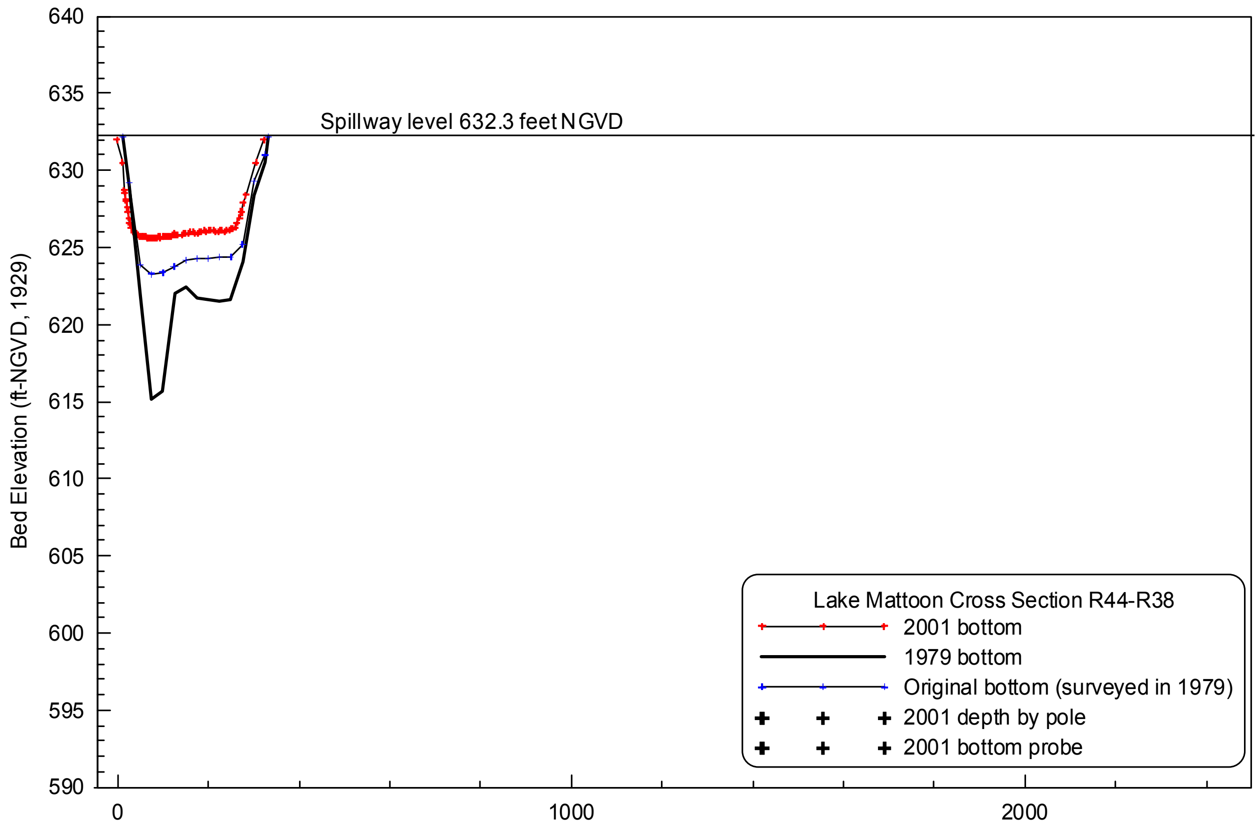
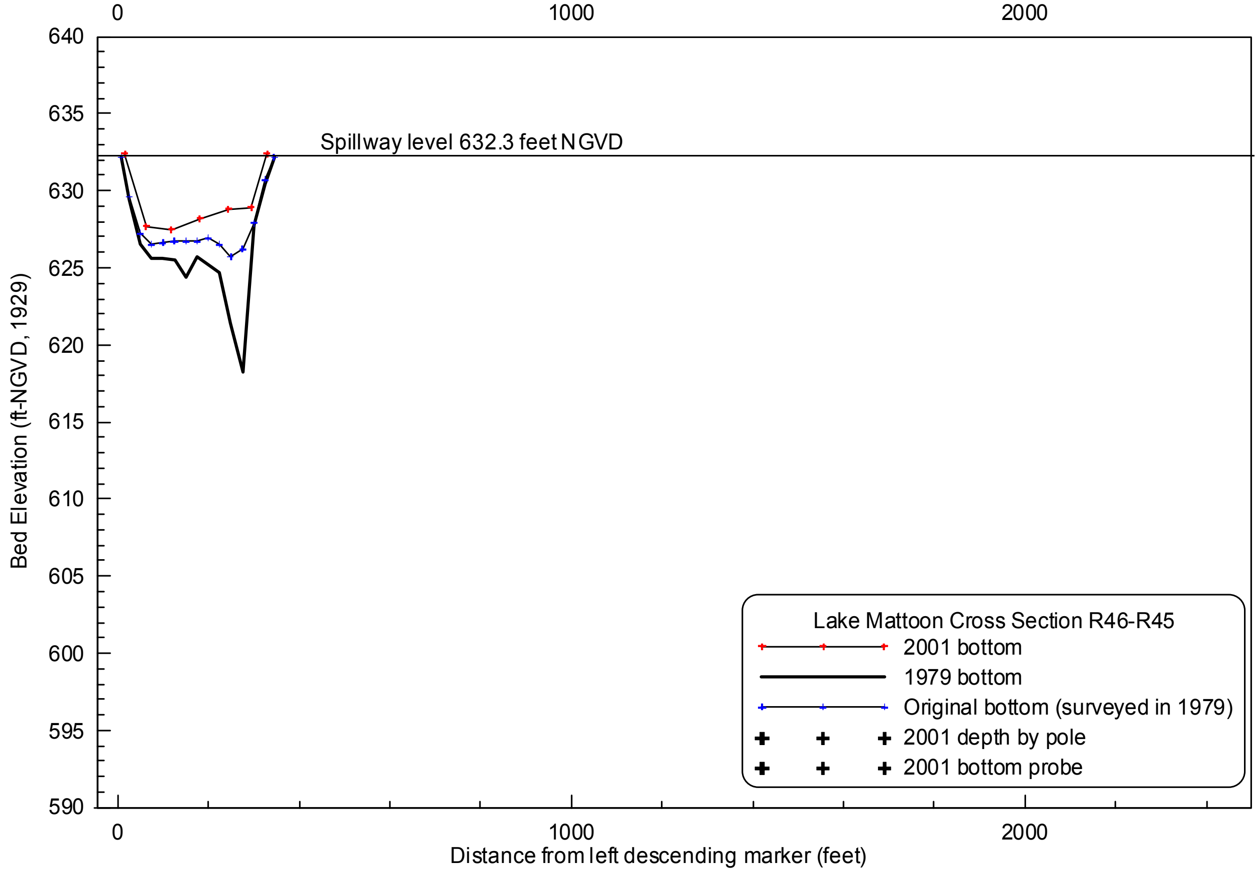
620
615
610
605
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R40-R39
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
0
1000
2000

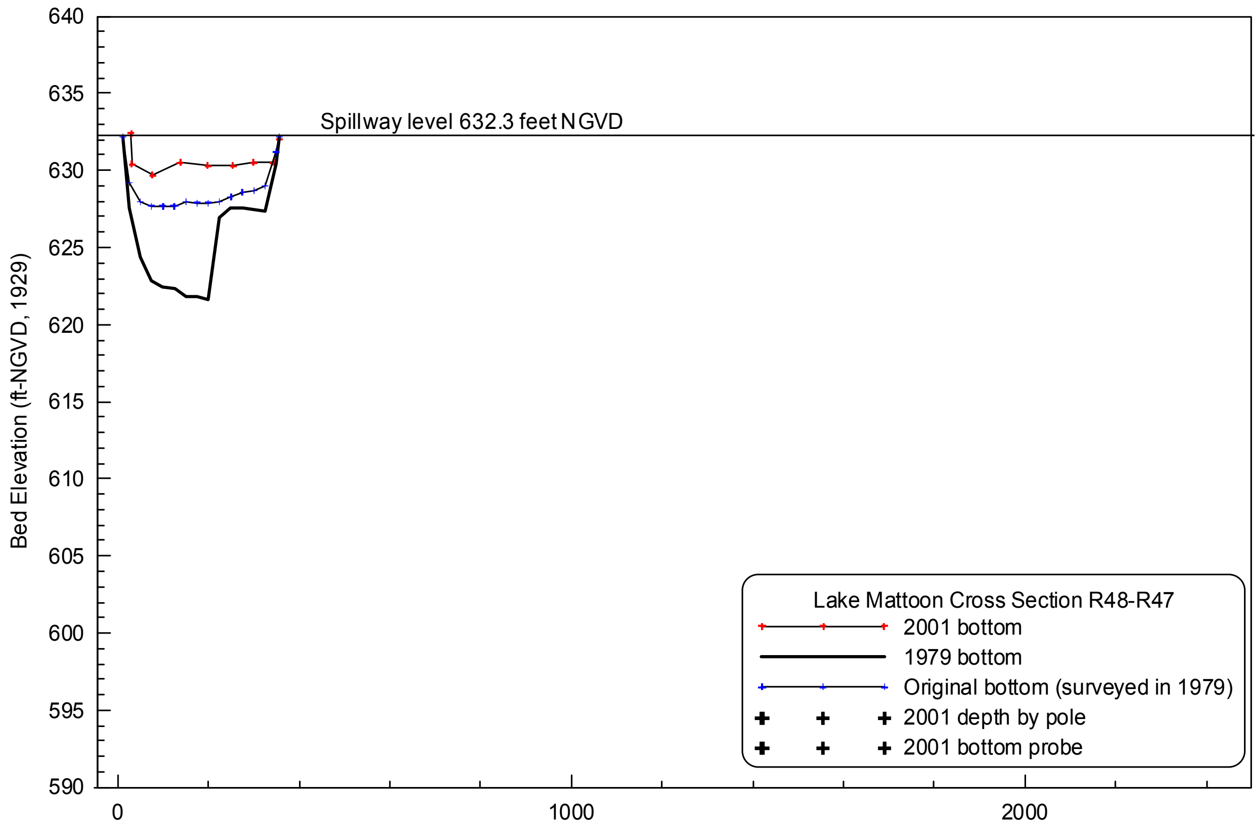

640
635
630
625
620
615
610
605
600
595
590
Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R42-R41
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
0
1000
2000
Distance from left descending marker (feet)



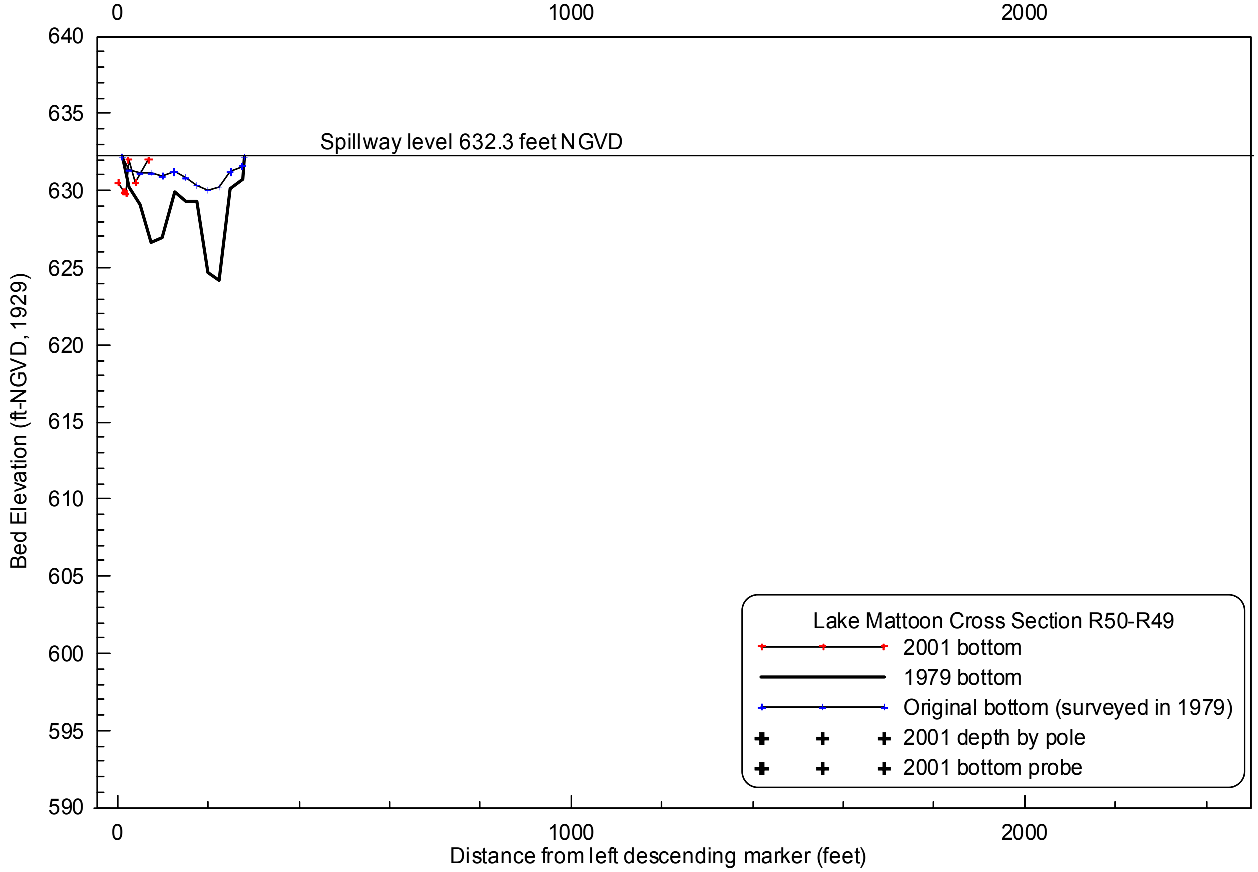
Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R44-R38
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000



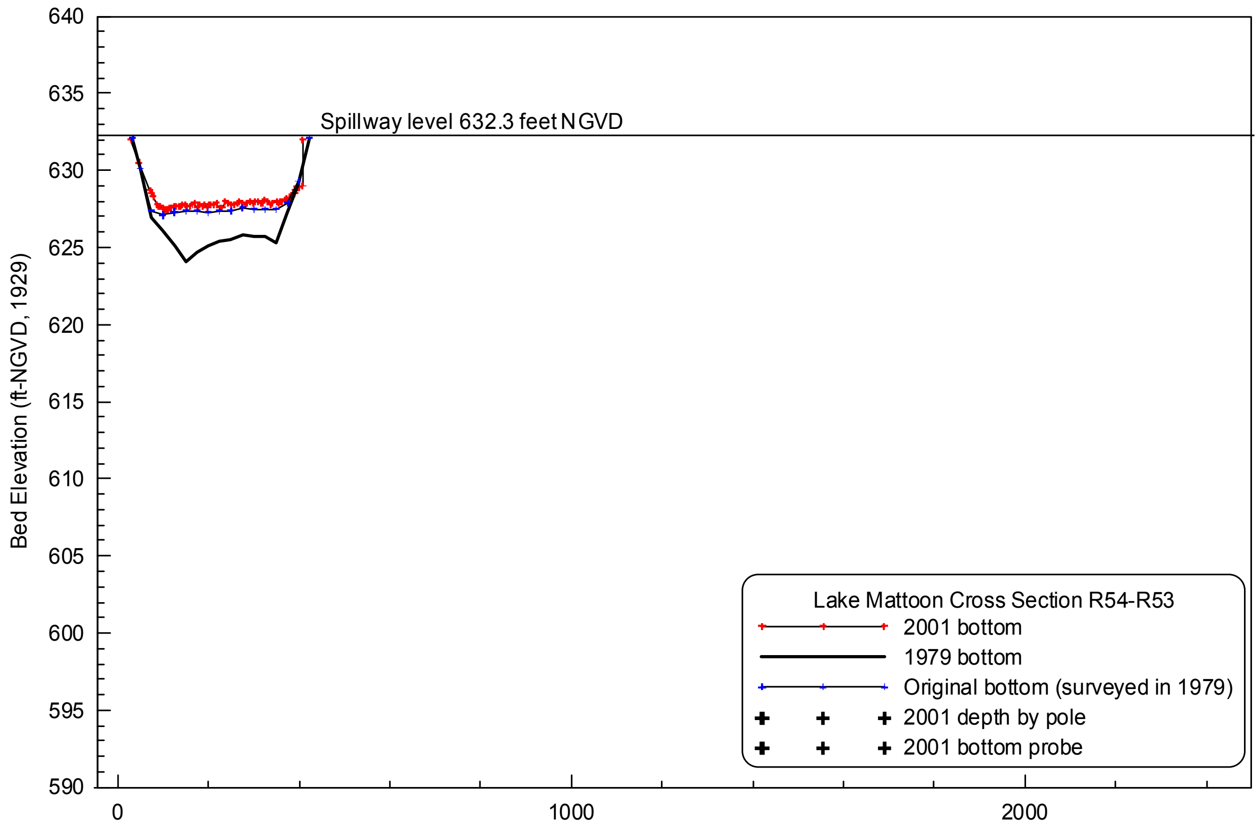
Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
Lake Mattoon Cross Section R46-R45
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)

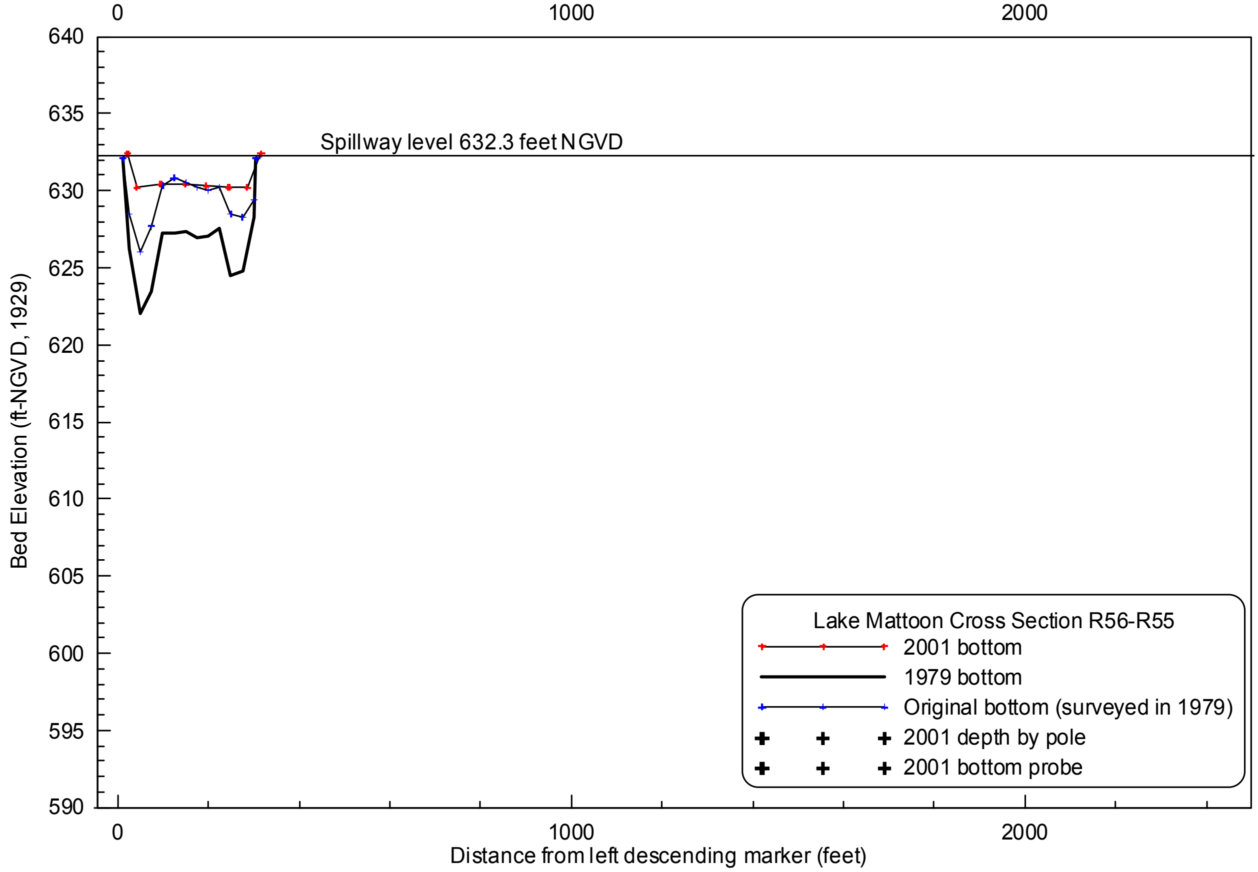


Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Lake Mattoon Cross Section R48-R47
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe



Spillway level 632.3 feet NGVD
Bed Elevation (ft-NGVD, 1929)
640
635
630
625
620
615
610
605
600
595
590
0
1000
2000
Distance from left descending marker (feet)
Lake Mattoon Cross Section R50-R49
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R54-R53
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe


Bed Elevation (ft-NGVD, 1929)
Spillway level 632.3 feet NGVD
Lake Mattoon Cross Section R56-R55
2001 bottom
1979 bottom
Original bottom (surveyed in 1979)
2001 depth by pole
2001 bottom probe
Distance from left descending marker (feet)

Appendix III. Lake Paradise Sediment Core Sample Unit Weight Results

Sample number	*Location*	*Sediment layers*	*Unit weight (pounds per cubic foot)*
1	R14-R13	0-3	34.5
2	R14-R13	13-16	48.1
5	R6-R5	12-15	29.7
6	R2-R1	4-7	19.1
7	R2-R1	12-15	23.5
8	R10-R9	7-10	25.6
9	R18-R17	3-6	48.1
10	R18-R17	14-17	61.9

Appendix IV. Lake Mattoon Sediment Core Sample Unit Weight Results

Sample number	*Location*	*Sediment layers*	*Unit weight (pounds per cubic foot)*
1	R16-R15	6-9	29.6
4	R20-R19	5-8	77.5
8	R12-R11	5-8	23.8
11	R8-R7	5-8	23.5
14	R2-R1	6-9	21.6
17	R38	5-8	30.6

Appendix V. Lake Paradise Sediment Particle Size Distribution Sample Results

	Sample number									
Particle size (millimeters)	*PS 3 R13-R14 Surface*	*PS4 R13-R14 Section 16-17*	*PS 6 R5-R6 Surface*	*PS 7 R5-R6 Section 15-16*	*PS 8 R1-R2 Surface*	*PS 9 R1-R2 Section 15-16*	*PS 10 R9-R10 Surface*	*PS 11 R9-R10 Section 12-14*	*PS 12 R17-R18 Surface*	*PS 13 R17-R18 Section 17-18*
0.031	91.1	97.8	97.6	97.8	96.9	95.5	96.4	95.8	86.4	94.0
0.016	71.8	88.2	92.4	94.3	90.0	89.3	89.4	92.3	60.1	77.6
0.008	48.0	68.0	77.3	84.0	79.0	80.0	71.8	82.7	38.2	50.0
0.004	37.2	52.8	62.1	73.1	69.1	70.5	57.8	69.2	28.3	35.8
0.002	32.3	43.6	51.1	61.7	59.2	60.6	48.6	58.6	24.1	30.5

Appendix VI. Lake Mattoon Sediment Particle Size Distribution Sample Results

	Sample number												
Particle size (millimeters)	*PS 5 R19-R20 Surface*	*PS 6 R19-R20 Section 11-13*	*PS2 R15-R16 Surface*	*PS 3 R15-R16 Section 12-14*	*PS 7 R18-R17 Surface*	*PS 9 R11-R12 Surface*	*PS 10 R11-R12 Section 10-12*	*PS-12 R7-R8 Surface*	*PS-13 R7-R8 Section 10-12*	*PS 15 R1-R2 Surface*	*PS 16 R1-R2 Section 12-14*	*PS 18 R38 Surface*	*PS 19 R38 Section 10-12*
2		98.6											
1		97.9											
0.710		97.6											
0.5		96.7											
0.355		94.5											
0.25	99.6	89.5											
0.18	97.2	81.8											
0.125	93.2	75.9											
0.09	87.9	70.7											
0.063	77.0	66.7											
0.031	42.1	55.0	93.5	94.0	78.0	94.3	95.1	93.7	92.2	93.2	92.6	95.8	94.6
0.016	24.2	40.0	76.7	83.4	69.4	86.9	86.0	83.4	78.7	83.6	80.5	86.2	89.6
0.008	15.1	30.0	53.1	64.7	49.1	76.3	77.2	74.1	65.4	70.7	65.6	68.1	73.9
0.004	12.6	22.3	40.6	50.0	38.0	65.7	67.3	66.7	56.3	61.3	56.4	53.7	61.2
0.002	10.8	19.9	34.4	41.0	33.0	56.6	58.2	57.6	48.8	53.0	49.0	44.0	51.6