Contract Report 567

Lake Sedimentation Survey of Siloam Springs State Park Lake, Adams County, Illinois

by Richard L. Allgire
Office of Sediment & Wetland Studies

Prepared for the
Illinois Department of Conservation

May 1992

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

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INTRODUCTION

The Illinois State Water Survey, in cooperation with the Illinois Department of Conservation, conducted a lake sedimentation survey of Siloam Springs State Park Lake in 1991. This report presents the results of that survey.

Reservoir Description

Siloam Springs State Park Lake is located in Adams County approximately 25 miles east of Quincy, Illinois in Sections 23 and 24, Township 2 S, Range 5 W, near the Adams-Brown County line (figure 1). Crabapple Creek was dammed to form the 63-acre lake in 1955. By 1991, sedimentation had reduced the surface area of the lake to 58 acres. The lake has a watershed area of 1,280 acres or 2.0 square miles.

Background

Prior to becoming a lake and a state park, the Siloam Springs were owned by an independent business executive. The springs were thought to have curative powers and were believed to have been named after the biblical pool of Siloam.

During the late 1800s a hotel and associated buildings were constructed for a resort including a thriving business of selling and distributing bottled spring water. After the resort began declining, the citizens of Adams and Brown Counties helped purchase the land for a state recreation area in 1940. The lake spillway was built in 1955, and Siloam Springs State Park was dedicated in 1956 (Illinois Department of Conservation, 1985).

Today, the lake is used primarily for recreational activities such as fishing, boating, and picnicking. Boats with internal combustion engines are prohibited on the lake.

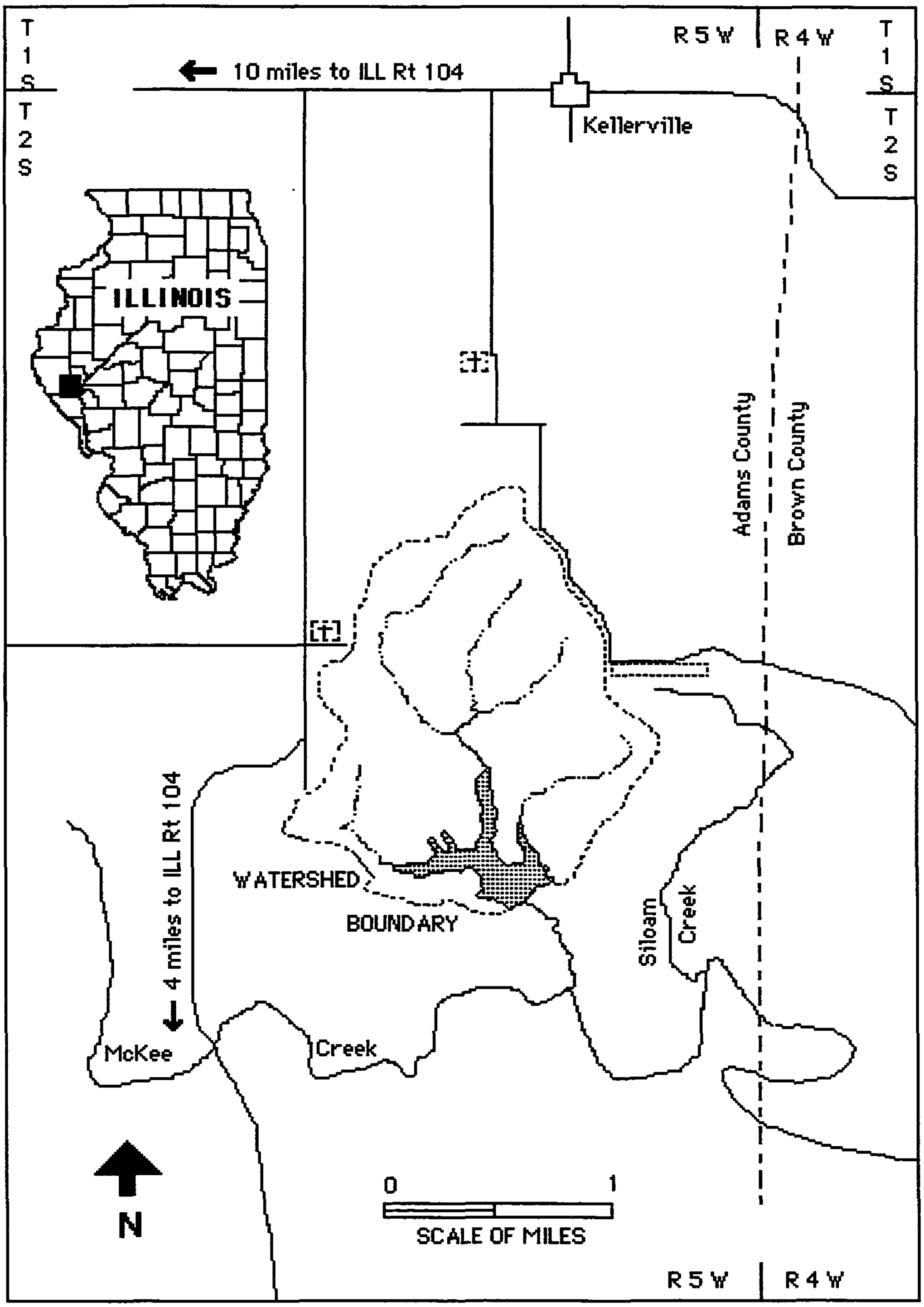


Figure 1. Location of Siloam Springs State Park Lake and its watershed

LAKE SEDIMENTATION SURVEY

Surveying Techniques

A sedimentation survey of Siloam Springs State Park Lake was begun in the fall of 1991 to determine: 1) the lake's present volume, 2) its original volume upon construction, 3) the volume of accumulated sediment since construction, 4) the characteristics of the accumulated sediment, 5) the total tonnage of sediment deposited, and 6) the stage-volume-area relationships within the lake.

The lake was divided into 14 lake segments by establishing 13 cross sections or range lines (figure 2). In this figure the lake segments are numbered beginning with the near-dam segment and continuing upstream on the primary creek. After reaching the uppermost end of the main stem of the lake, the numbering continues upstream on the secondary tributaries.

Concrete survey monuments at each end of the survey range lines (figure 2) permanently mark the locations for future surveys. A marked polypropylene cable was then stretched between the two survey monuments to measure linear distance along the survey line. The sounding boat was then maneuvered along the cable while taking measurements at 25-foot intervals.

The sounding measurements were made by using a 2-inch-diameter aluminum sounding pole marked at 0.1-foot intervals. To increase its sensitivity to the lakebed and obtain a more precise depth measurement, the sounding pole has an 8-inch diameter, free-sliding sediment shoe that "floats" on top of the lakebed surface. The pole was lowered through the water column to the lakebed to measure the present water depth relative to the spillway crest. It was then pushed downward through the softer accumulated sediment until the firmer original lakebed was reached. A second measurement was then read from the depth below the water surface to the original lakebed. The thickness of the accumulated sediment is the difference between the water depth and the original lakebed depth.

In addition to the soundings on the range lines, 12 sonar transects were run as a control check between soundings on selected range lines and between distinct range lines. The sonar transects were also used to assist in mapping the contours of the bathymetric map discussed in the section on stage-volume-area relationships of the lake.

Sediment Sample Collection

Lakebed sediment samples were collected at 11 locations throughout the lake (figure 2). The samples were analyzed for particle size distribution and unit weight. The

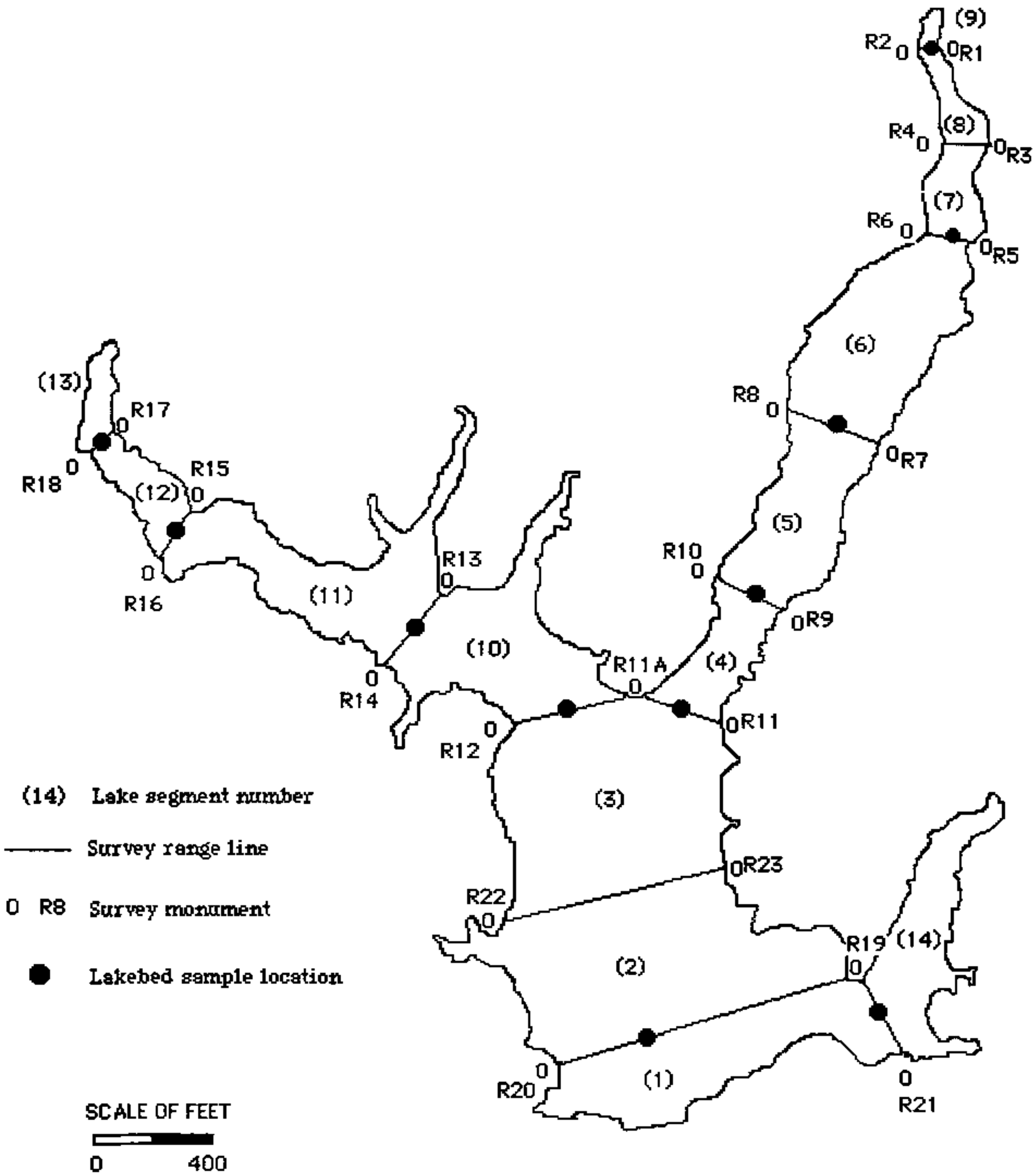


Figure 2. Siloam Springs State Park lake survey range lines, survey monuments, lake segments, and lakebed sample locations

sampling locations were selected to gather representative samples of lakebed sediments from different lake segments.

Three types of samplers were used: a 3-foot-long, 2-inch-diameter piston core sampler; an Eckman Dredge surface sampler; and a 1.6-foot-long, 2-inch-diameter tube sampler. The core sampler and the tube sampler were used to obtain sediment cores. The core sampler was used for coring submerged lake sediments while the tube sampler was used for sampling on the transects that have accumulated sediment above the normal lake level, such as R5-R6 in the upper end of the lake.

The core samples were placed on a sample board to record their length and physical descriptions. Based on field observations, two to six subsamples were then cut from the core and sent to the laboratory for particle size and unit weight analysis. The Eckman Dredge was used to sample the top 2 to 4 inches of the lakebed surface for particle size.

LAKE SEDIMENTATION ANALYSIS

Depth Analysis

The sounding pole measurements along the survey range lines were used to create cross-sectional plots showing the present and original lakebed profiles and water depths. The original lake area, present lake area, and the sediment area contained within each range line were calculated and can be used to compare the original and present lake depths.

Siloam Springs Lake in 1955 had a maximum depth of approximately 45.3 feet, with an average lake depth of 20.1 feet. The 1991 lake survey showed a maximum depth of approximately 42.4 feet, with an average lake depth of 17.3 feet. This shows that on average the lake lost 2.8 feet of depth from sedimentation since it was built. This loss of depth, however, is not constant throughout the lake. The upper end of the lake has lost a larger percentage of its average depth compared to the lower sections near the dam.

Figure 3 plots cross section R22- R23 near the midpoint of the lake. This plot is fairly typical of cross sections in the lower end of a reservoir. The 1955 average water depth for this survey line was 29.6 feet compared to the 1991 average water depth of 27.7 feet, an average water depth loss of 1.9 feet.

Figure 4 depicts the plot for survey line R5-R6 in the upper end of the lake. The average depth for this survey line in 1955 was 5.8 feet, while it was 0.0 feet in 1991 with an accumulation of 6 feet of sediment. This plot also illustrates the amount of sediment

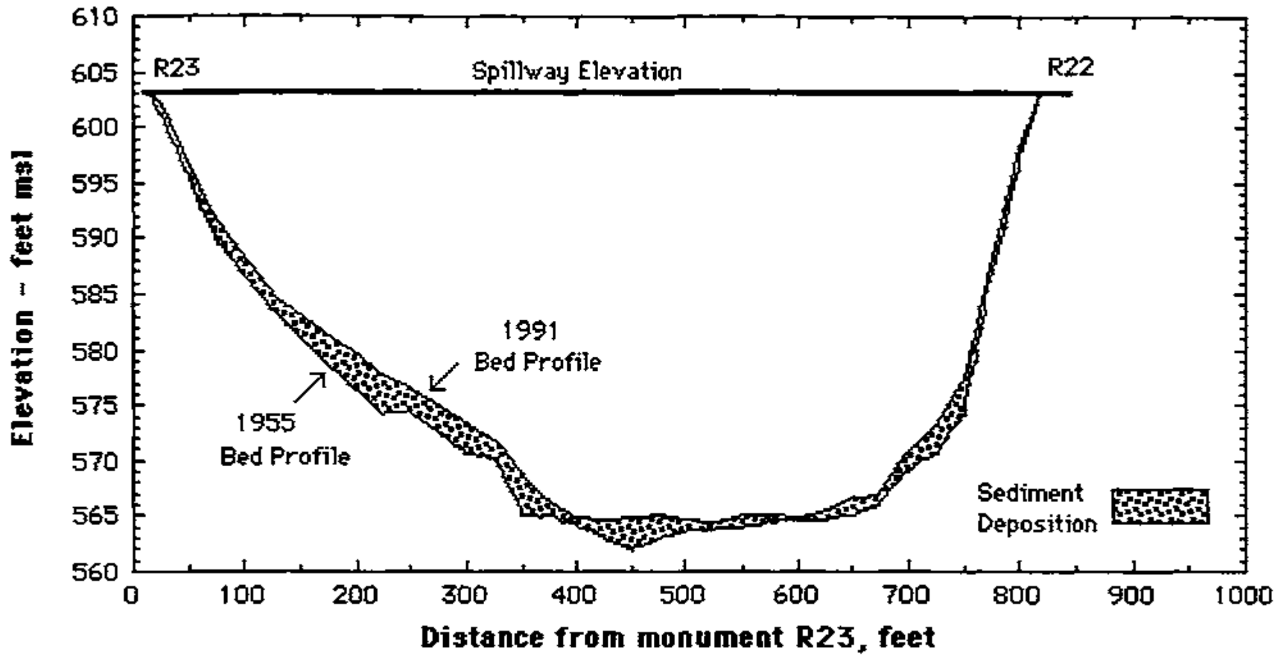


Figure 3. Typical cross section of Siloam Springs Lake near the dam

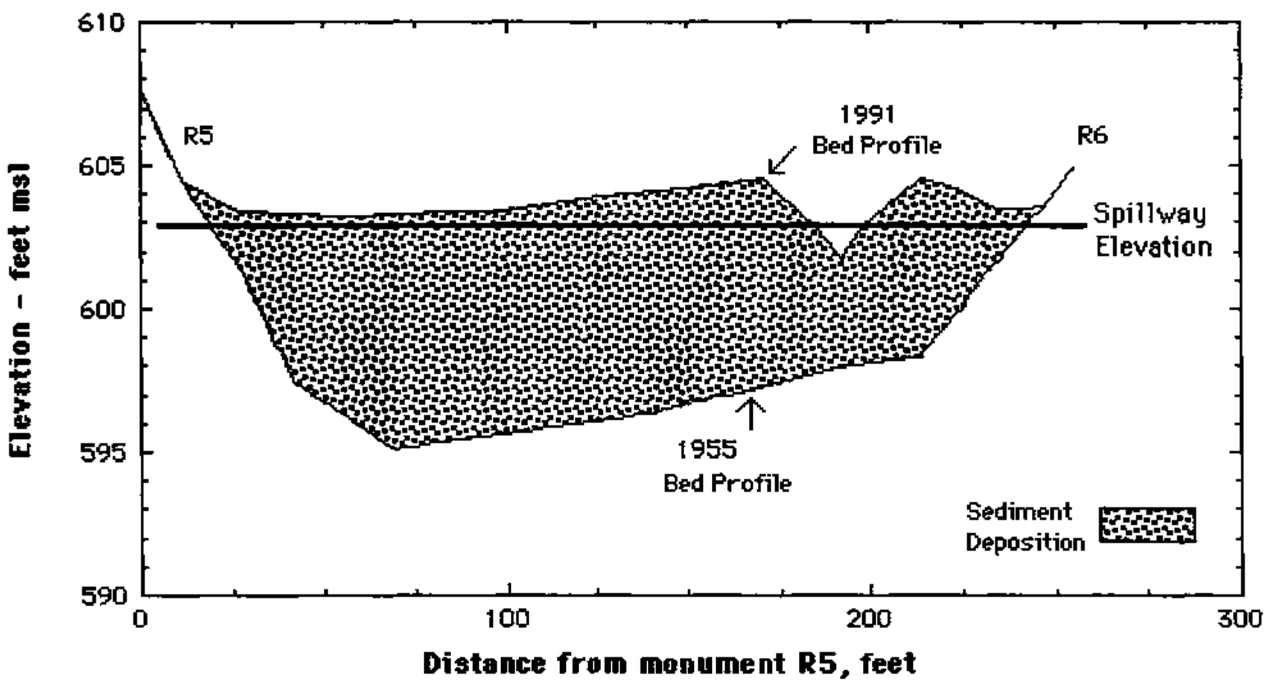


Figure 4. Typical cross section of Siloam Springs Lake illustrating sediment deposition above the spillway elevation

deposition that has occurred above spillway elevation in the upper reaches of the lake. Survey lines R1-R2 and R3-R4 exhibited similar deposition trends.

Plots of all the lake survey range lines comparing the original bed profile and the 1991 bed profile in relation to the spillway elevation are shown in appendix **I.**

Volume Analysis

Lake sedimentation rates can be expressed as the sediment volume or as the mass of sediment accumulated. Lake volume loss, the amount of lake storage that has been displaced by sediments, is useful in discussing the available storage capacity of the lake. The mass is the weight of sediment usually measured in tons or kilotons and allows comparison of sedimentation rates between lakes and sediment yields from different watersheds.

A lake with high volume loss could have a low sediment mass and vice versa. Various factors influence the volume-weight relationship of sediments, such as drying and compaction, particle sizes, amount of sediment accumulated, and where the sediments are deposited in the lake. Lakebed sediments that have been exposed to drying due to drawdowns of the lake level compact and shrink in volume and thus increase in weight per unit of measure. Sediments are also compacted by the pressure of overlying sediments. Therefore, sediments that are lower in the sediment column could be denser than those recently deposited near the lakebed surface. This reduction in sediment volume and subsequent increase in unit weight does not affect the total mass or weight of sediment measured in a lake.

The range line data were used to calculate the cross-sectional areas of the original lakebed and the accumulated sediments for each transect. These areas are combined with surface areas of the lake segments to determine the original, the 1991, and the sediment volumes in the lake. This procedure was developed by the U.S. Soil Conservation Service and described in their *National Engineering Handbook* (U.S. Department of Agriculture, Soil Conservation Service, 1968).

Table 1 lists by lake segment the original, present, and sediment volumes, and the percent of original volume lost to sedimentation. The original lake volume was 1,176 acre-feet. The 1991 lake volume was measured at 1,022 acre-feet for a total lake volume loss of 13 percent or an average annual volume loss of 0.36 percent. Figure 5 illustrates the total percent loss of original lake volume by lake segment.

As listed in table 1 and seen in figure 5, lake segments 7-9 have lost 100 percent of their original capacity. Also shown in figure 5 are the changes in shoreline since 1955 due to sedimentation in lake segments 6, 13, and 14. This sedimentation has reduced the

Table 1. 1955 Original Lake Volume, 1991 Current Lake and Sediment Volumes, and Percent Volume Loss by Lake Segment

Lake segment	*Segment surface area (acres)*	*1955 original lake volume (acre-ft)*	*1991 current lake Volume (acre-ft)*	*1991 sediment volume (acre-ft)*	*Percent volume loss*
1	7.0	202.2	186.5	15.7	7.8
2	11.2	342.5	318.3	24.2	7.1
3	11.4	271.0	248.4	22.6	8.4
4	2.1	39.4	32.3	7.1	18.0
5	4.2	52.6	38.6	14.0	26.6
6	6.7	47.0	19.7	27.3	58.1
7	1.2	5.8	0	6.6	100.0
8	0.9	3.2	0	4.6	100.0
9	0.2	0.4	0	0.6	100.0
10	5.9	95.1	84.1	11.0	11.6
11	6.1	74.5	61.4	13.1	17.6
12	1.5	8.9	4.6	4.3	48.3
13	0.8	1.8	0.2	1.6	88.9
14	3.9	31.5	27.9	3.6	11.4
TOTAL	**63.1**	**1176**	**1022**	156	**13.1***

* Average percent loss for entire lake

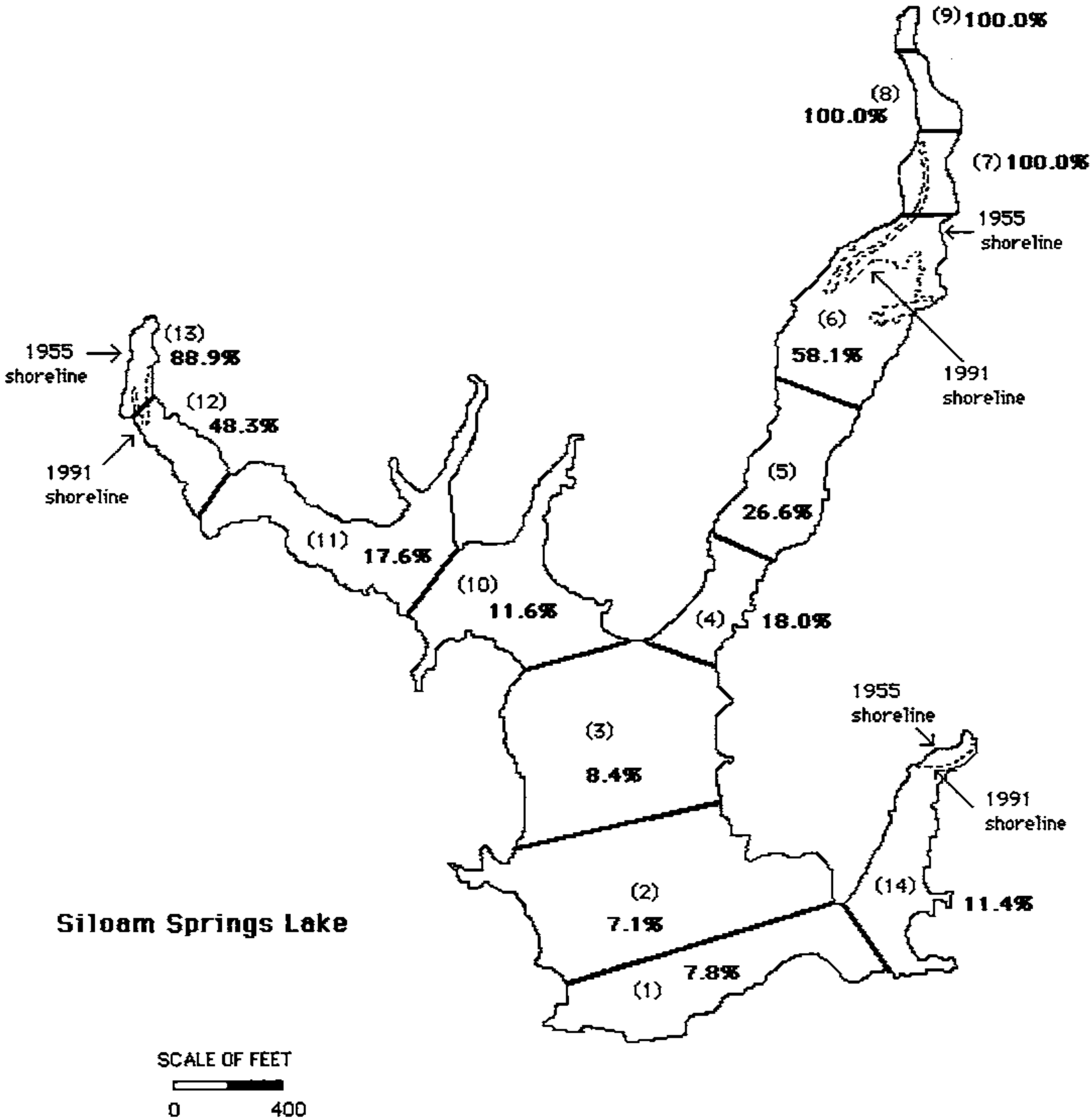


Figure 5. Percent loss of original lake volume by lake segment and changes in shoreline for Siloam Springs Lake

original lake surface area from 63 acres in 1955 to 58 acres in 1991. Lake segments 7-9 have accumulated a total of 2.4 acre-feet of additional sediment beyond their original volumes. This accumulation of sediment in and above the original lake segment capacity for range line R5-R6 in the upper region of the lake was previously illustrated in figure 4.

Stage-Volume-Area

The range line depth data in conjunction with the sonar transects were used to create a bathymetric map of the lake (figure 6). The areas and stages from this map were used to develop the stage-volume-area curves shown in figure 7. These curves give the water volume remaining in the lake and the water surface area for given elevations based on the spillway crest.

To use the stage-volume-area curves in figure 7, follow the desired elevation across to either the surface area or volume curve and then read the corresponding area across the top of the graph or the volume across the bottom of the graph.

Lake Sediment Characteristics

A total of 22 particle size and 22 unit weight samples were taken from 11 locations. All samples were taken near the midpoint of their respective range lines. The unit weight samples were analyzed at the Water Survey's sediment lab, and the particle size samples were analyzed at the Illinois Geological Survey's Geotechnical Laboratory.

The sediments deposited in Siloam Springs Lake are typical of those found in Illinois lakes. They are usually fine-grained with little or no sand and gravel. The weighted average of all particle size samples consists of 6 percent sand, 54 percent silt, and 40 percent clay, respectively. The particle size samples from the upper reaches of the lake exhibited a higher percentage of sand with sand content decreasing nearer the spillway. This longitudinal stratification of particle size is typical of sediment-trapping properties of lakes.

Particle size samples from range line R5-R6 exhibited a higher percentage of sand than did the rest of the sample sites. This higher percentage of sand was caused by a distinct deposit 0.2 feet thick composed of greater than 90 percent sand. This was the only location that exhibited a distinct sand layer. The weighted averages for each of the particle size sampling locations are listed in appendix II.

Twenty-two samples were collected from the lake for unit weight analysis. The average sediment density for each lake segment is included in table 2. The average density for the lake was 47 pounds per cubic foot. The highest densities occurred in the upper

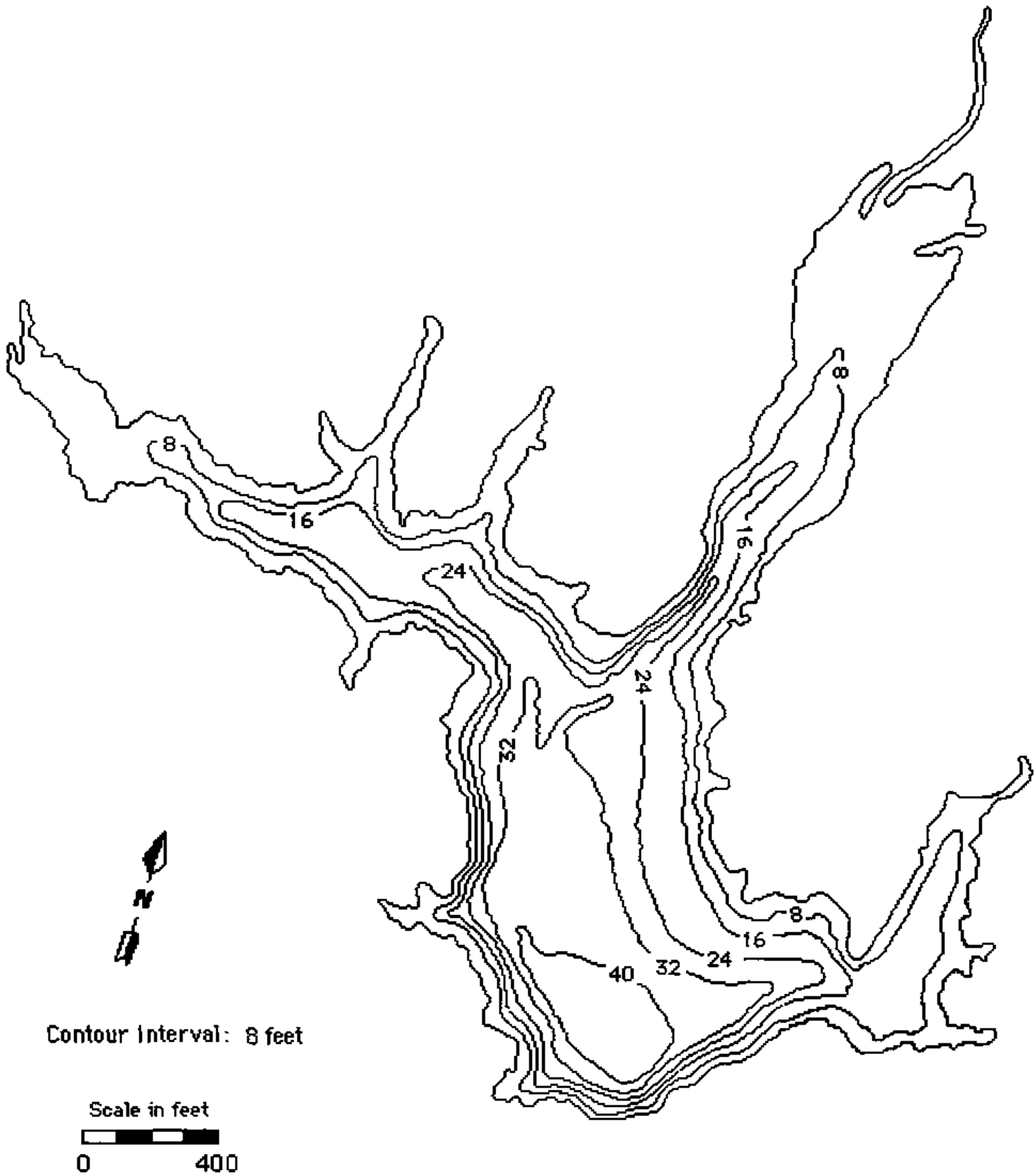


Figure 6. Bathymetric map of Siloam Springs Lake

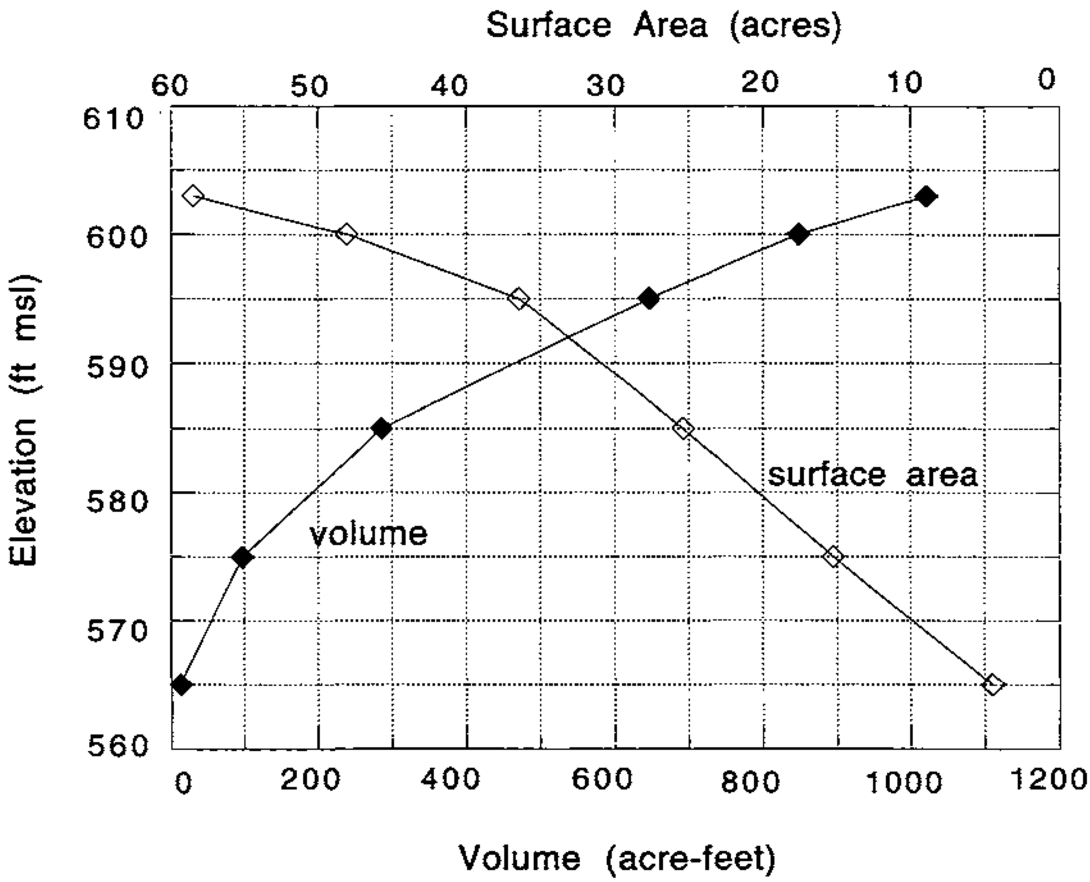


Figure 7. Stage-volume-area relationships for Siloam Springs Lake, 1991

Table 2. Lake Sediment Volume, Average Sediment Density, and Sediment Tonnage by Lake Segment

Lake segment	*Sediment volume (acre-feet)*	*Average density (lbs. per cubic foot)*	*Sediment (kilotons)*
1	15.7	22.8	7.8
2	24.2	27.5	14.5
3	22.6	37.2	18.3
4	7.1	39.7	6.1
5	14.0	49.2	15.0
6	27.3	63.4	37.8
7	6.6	62.5	9.0
8	4.6	65.0	6.3
9	0.6	52.1	0.7
10	11.0	55.1	13.2
11	13.1	59.2	16.9
12	4.3	77.6	7.3
13	1.6	88.4	3.0
14	3.6	66.5	5.2
TOTAL	**156**	**47.3***	**161**

* Average sediment density for entire lake

reaches of the lake. Lake segment 13 contained the highest density with an average of 88 pounds per cubic foot.

Sedimentation Rates

The sedimentation rate is measured as mass or weight of sediment deposited in the lake in tons or kilotons. The tons of sediment in each lake segment are calculated by using the average sediment density and the sediment volume for each lake segment together with a constant of 21.78 to give the total weight for each lake segment. The total sediment tonnage accumulated in the lake is the sum of all of the segment weights.

The 156 acre-feet of sediment that has been deposited in the lake since 1955 weighs 161,000 tons or 161 kilotons. Table 2 lists the sediment volume, density, and kilotons of sediment accumulated by lake segment. This accumulation of sediment amounts to an average annual deposition of 4,470 tons or 3.5 tons per acre of watershed. Table 3 summarizes the sedimentation data for Siloam Springs Lake.

SUMMARY

Siloam Springs Lake was built in 1955. The lake was surveyed in 1991 to determine its volume, sedimentation rate, and volume loss rate since construction. The original lake volume was 1,176 acre-feet. The 1991 survey measured the lake at 58 surface acres with a volume of 1,022 acre-feet. This represents a volume loss of 13 percent since construction or 0.36 percent loss per year.

The lake has accumulated 156 acre-feet of sediment with an average density of 47 pounds per cubic foot for a total mass of 161,000 tons. This is an average of 4,470 tons per year or 3.5 tons per year per watershed acre.

ACKNOWLEDGMENTS

This project was conducted by the author as part of his regular duties at the State Water Survey under the administrative guidance of Richard G. Semonin, Chief; and Misganaw Demissie, Director of the Office of Sediment and Wetland Studies.

The figures were computer generated by the author with valuable assistance provided by Laura Keefer. Eva Kingston edited the report, and Becky Howard prepared the camera-ready text.

Table 3. Sedimentation Data Summary of Siloam Springs Lake

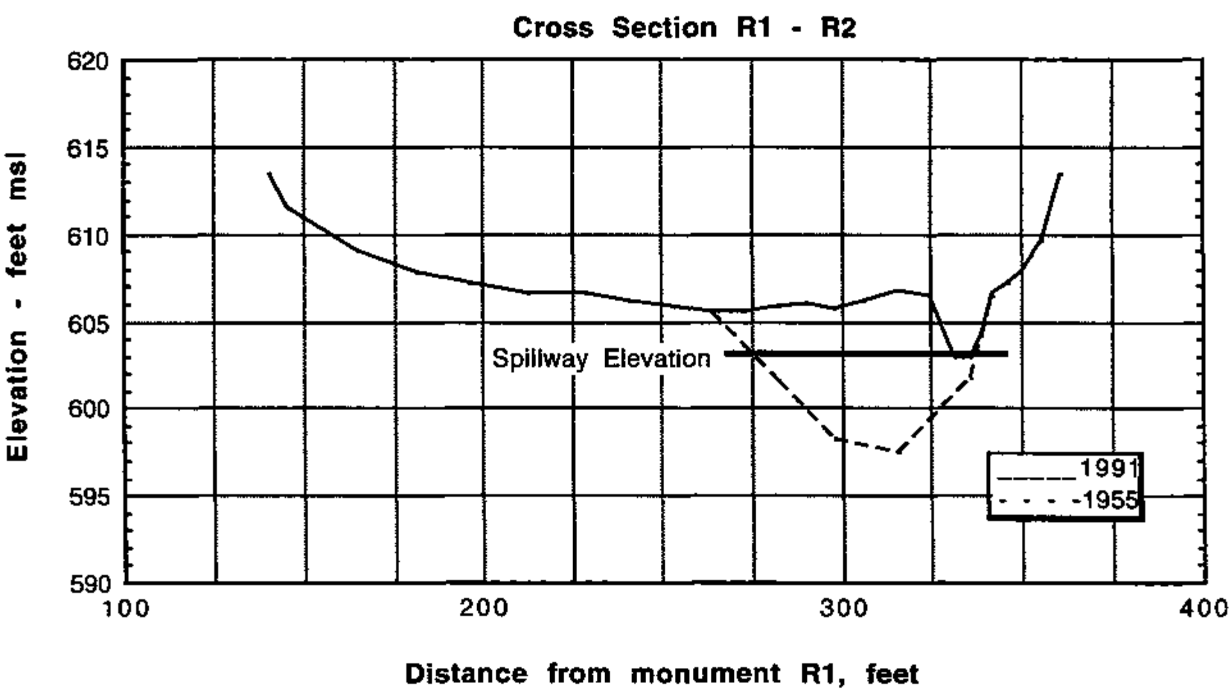
Age	36 years (built in 1955)
Sedimentation survey	1991
Watershed area	1,280 acres (2.0 square miles)
Reservoir data	
Surface area	58 acres
1955 storage capacity	1,176 acre-feet (383 million gallons)
1991 storage capacity	1,022 acre-feet (333 million gallons)
1991 sediment volume	156 acre-feet (51 million gallons)
Volume loss (percent)	
1955 to 1991	13.1
Average annual	0.36
Sediment accumulated (tons)	
1955 to 1991	161,000
Average annual	4,470
Average per watershed acre	126
Average annual per watershed acre	3.5

REFERENCES

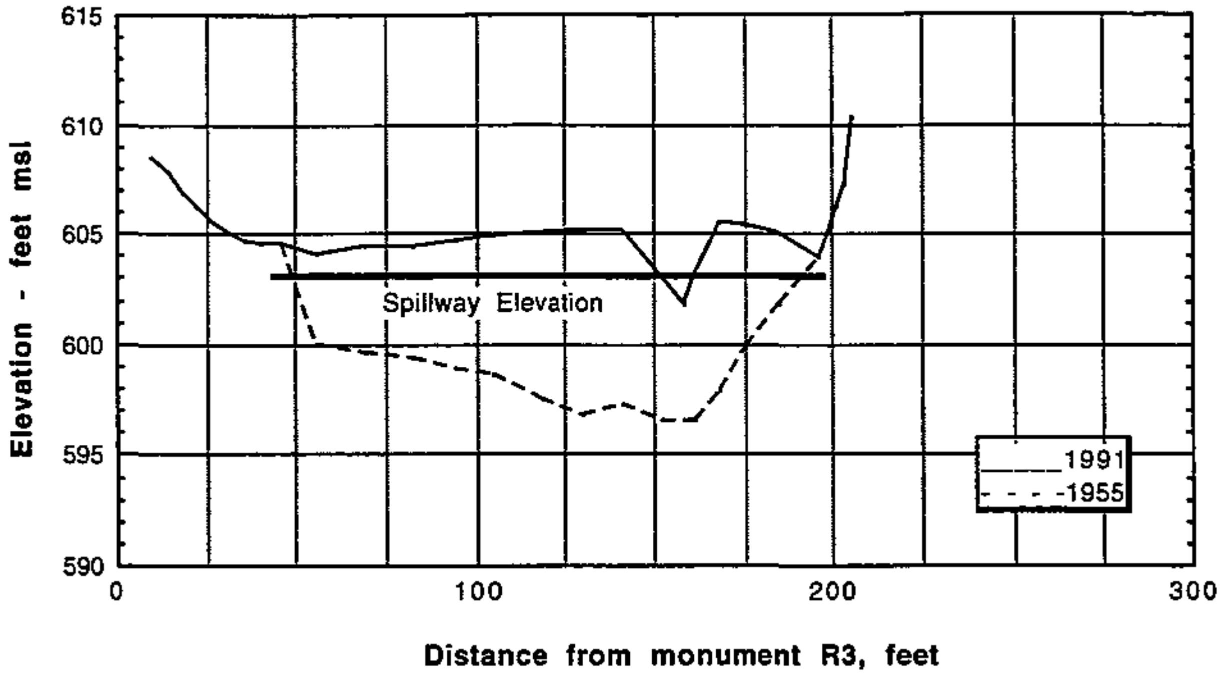
Illinois Department of Conservation, Land and Historic Sites. 1985. *Siloam Springs State Park* (brochure).

U.S. Department of Agriculture, Soil Conservation Service. 1968. *National Engineering Handbook,* Section 3, "Sedimentation," chapters 1, 2, and 7.

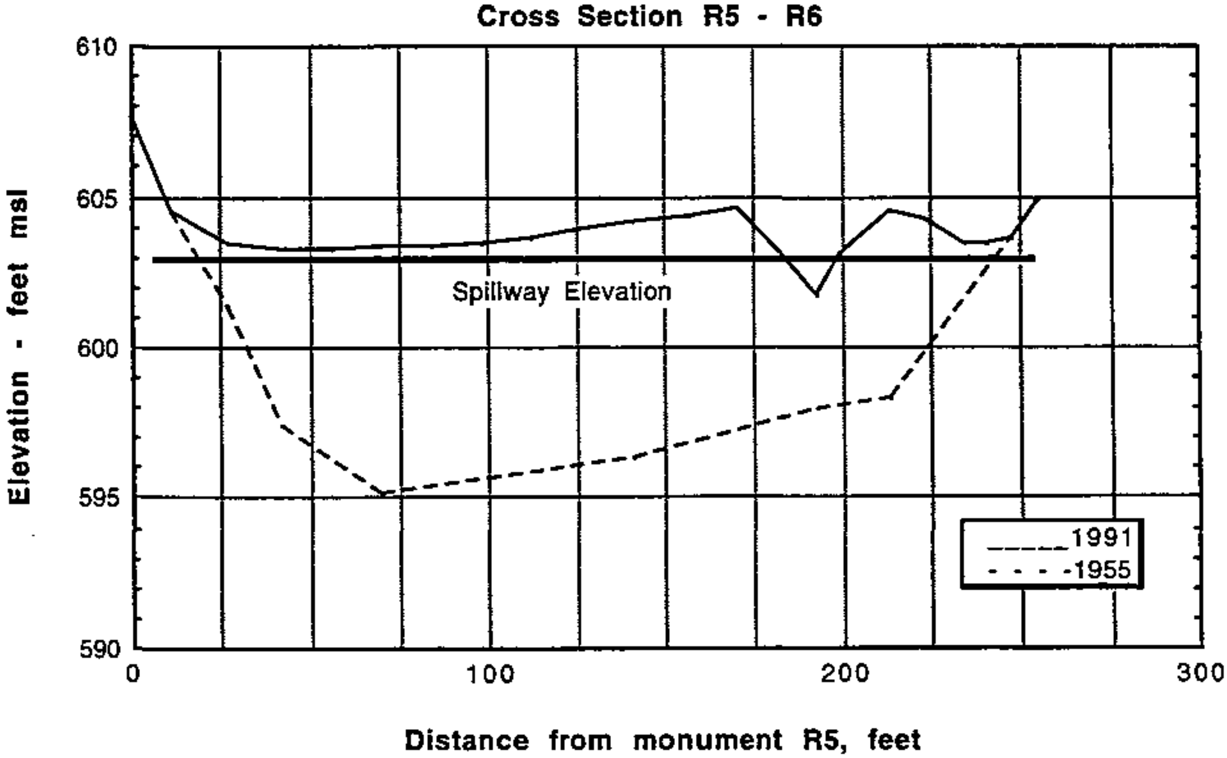
Appendix I. Cross-sectional Plots of Survey Range Lines for Siloam Springs State Park Lake

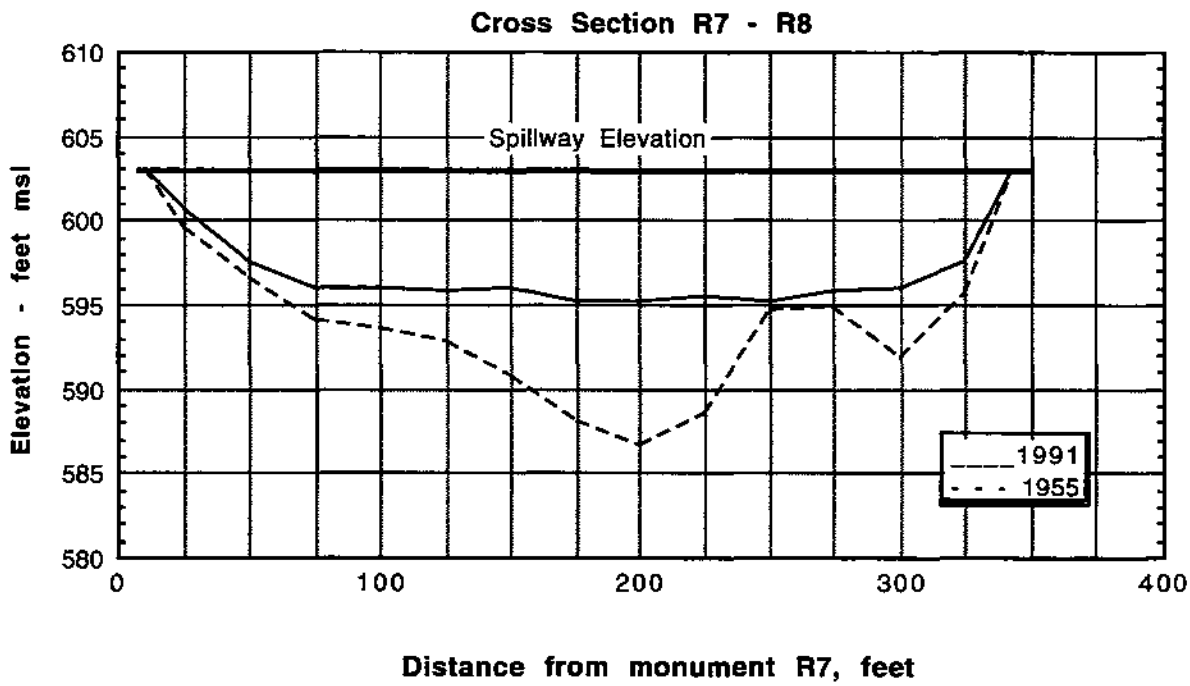


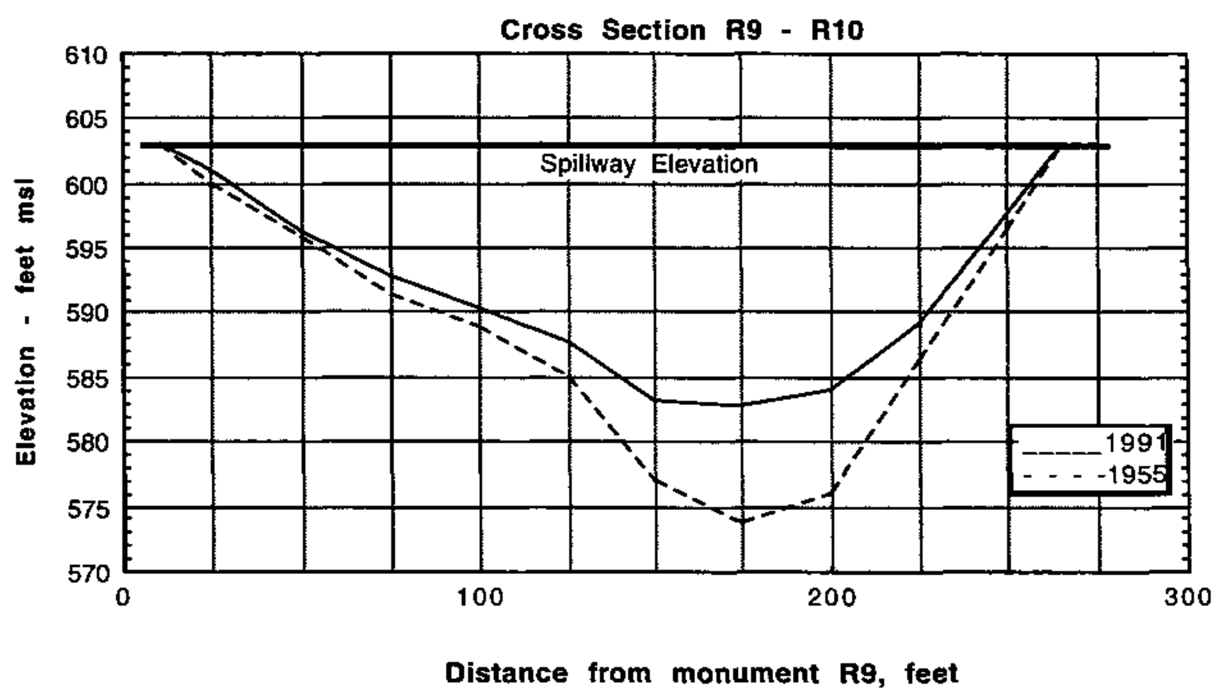
Cross Section R3 - R4

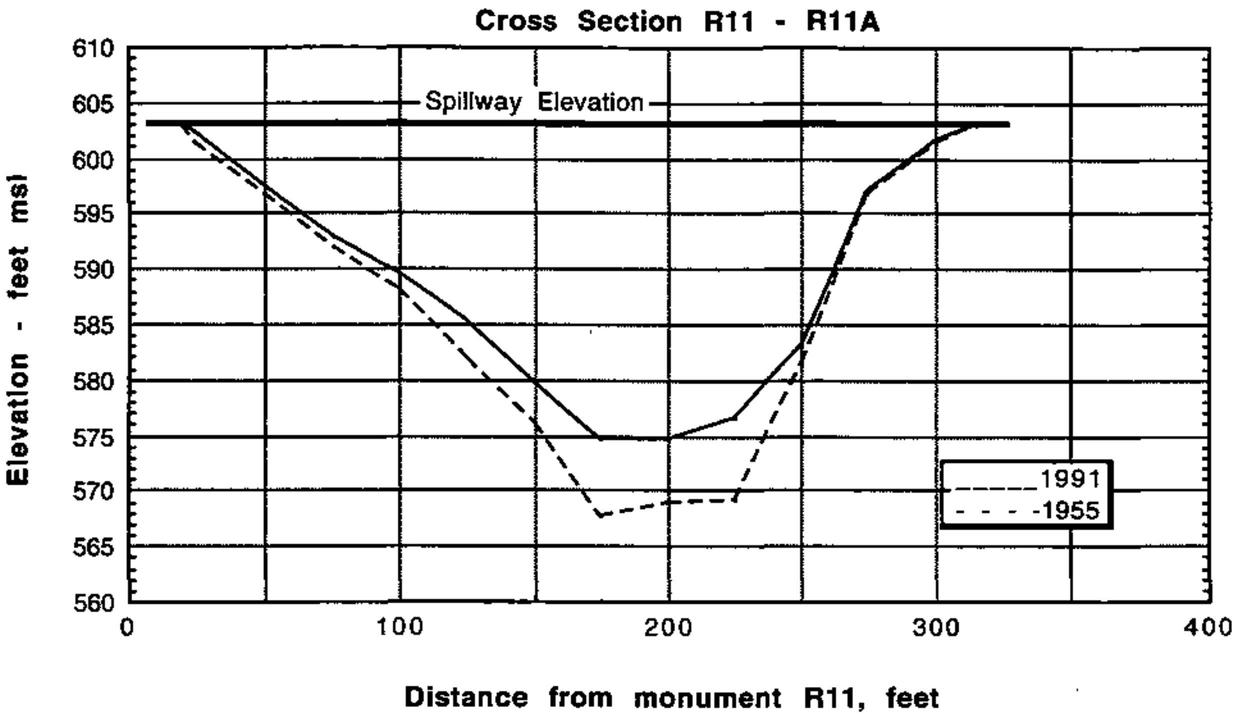


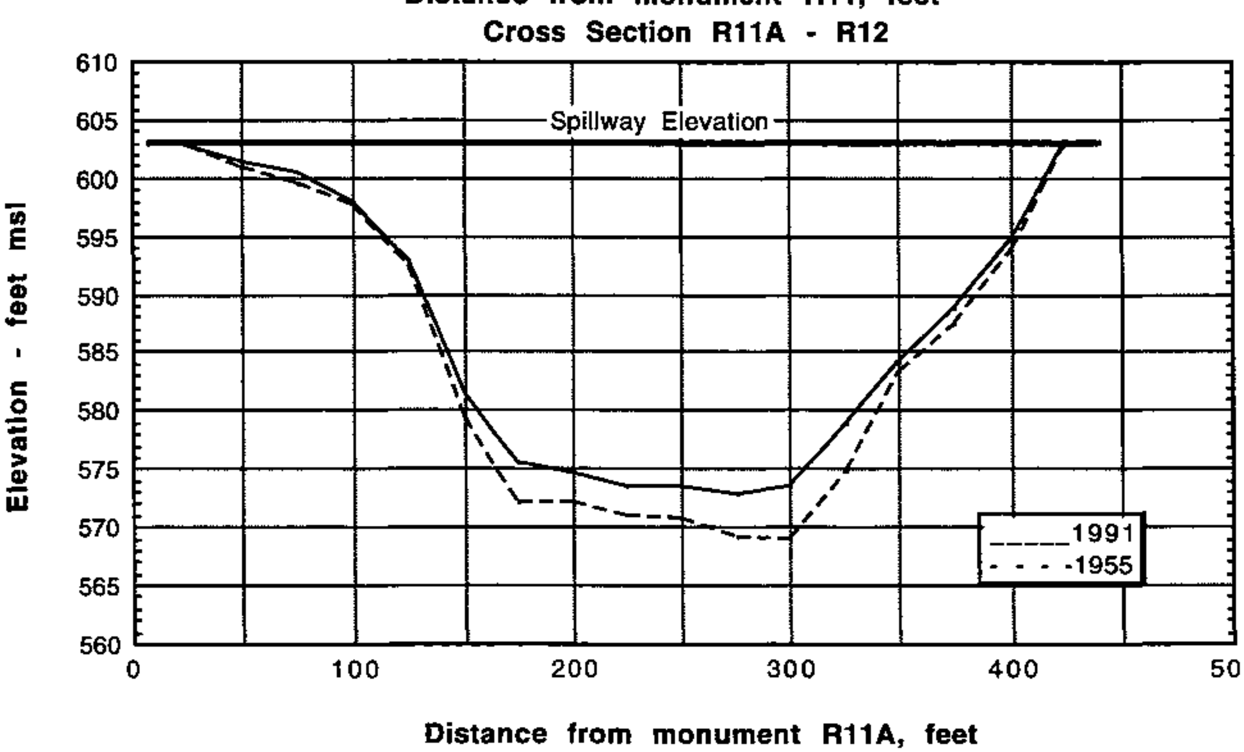
Cross Section R5 - R6

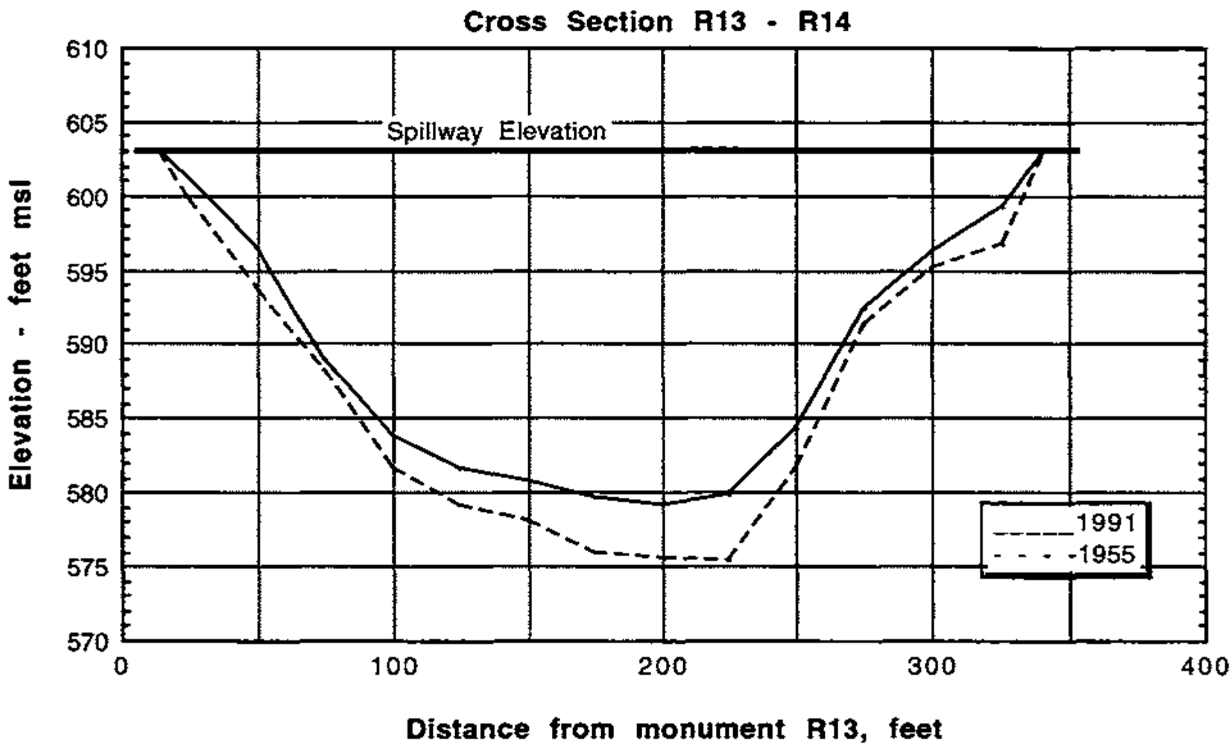


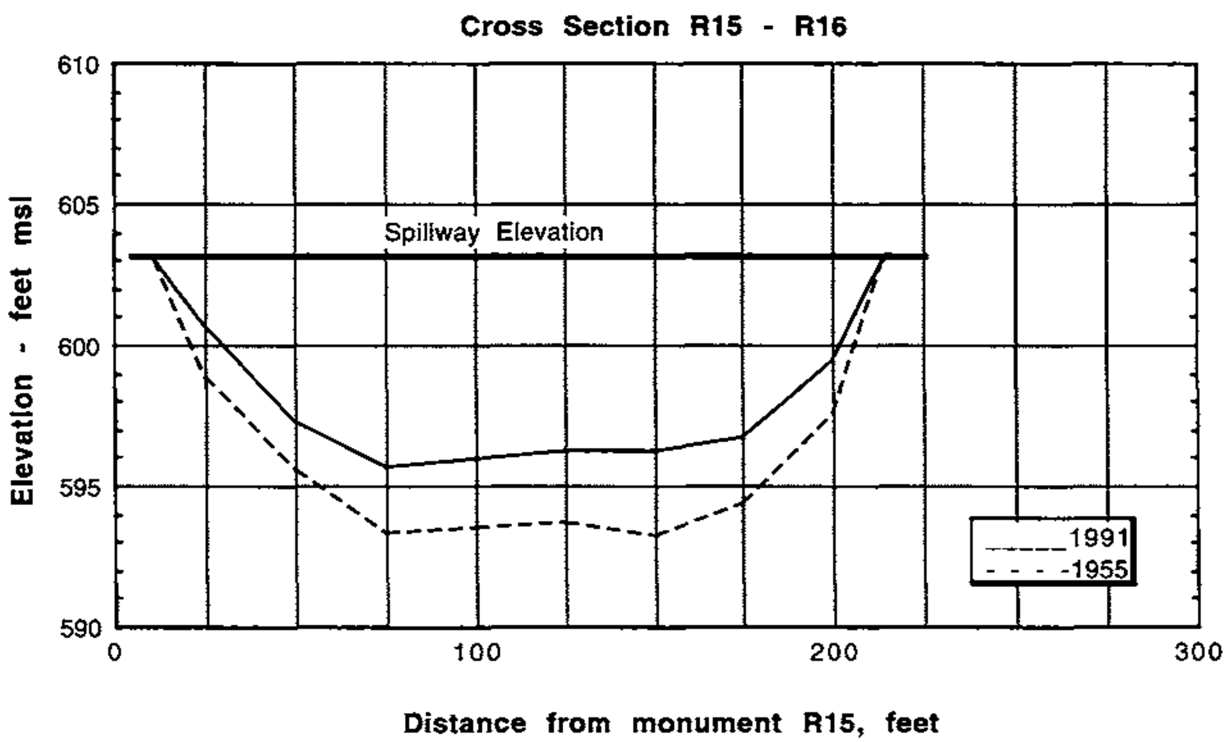

Cross Section R7 - R8
Spillway Elevation
Elevation - feet msl
610
605
600
595
590
585
580
0
100
200
300
400
1991
1955
Distance from monument R7, feet

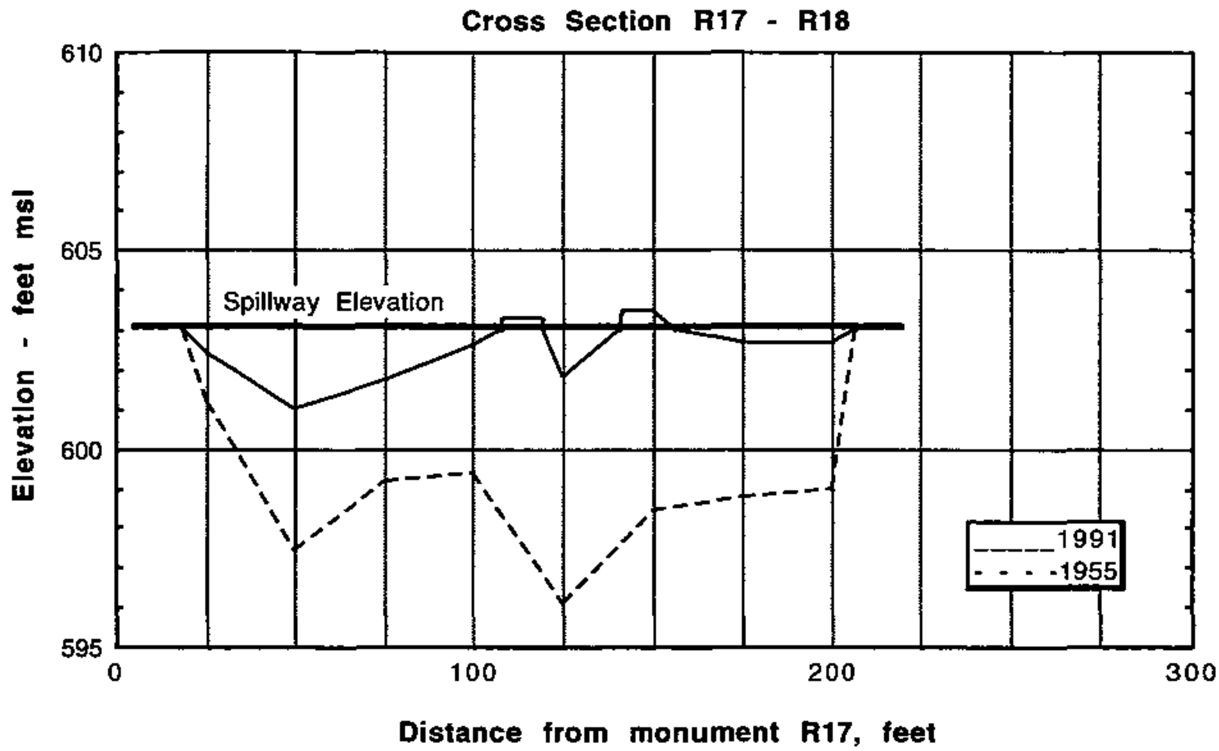

Cross Section R9 - R10
Spillway Elevation
Elevation - feet msl
610
605
600
595
590
585
580
575
570
0
100
200
300
1991
1955
Distance from monument R9, feet


Cross Section R11 - R11A
Spillway Elevation
1991
1955
Elevation - feet msl
Distance from monument R11, feet

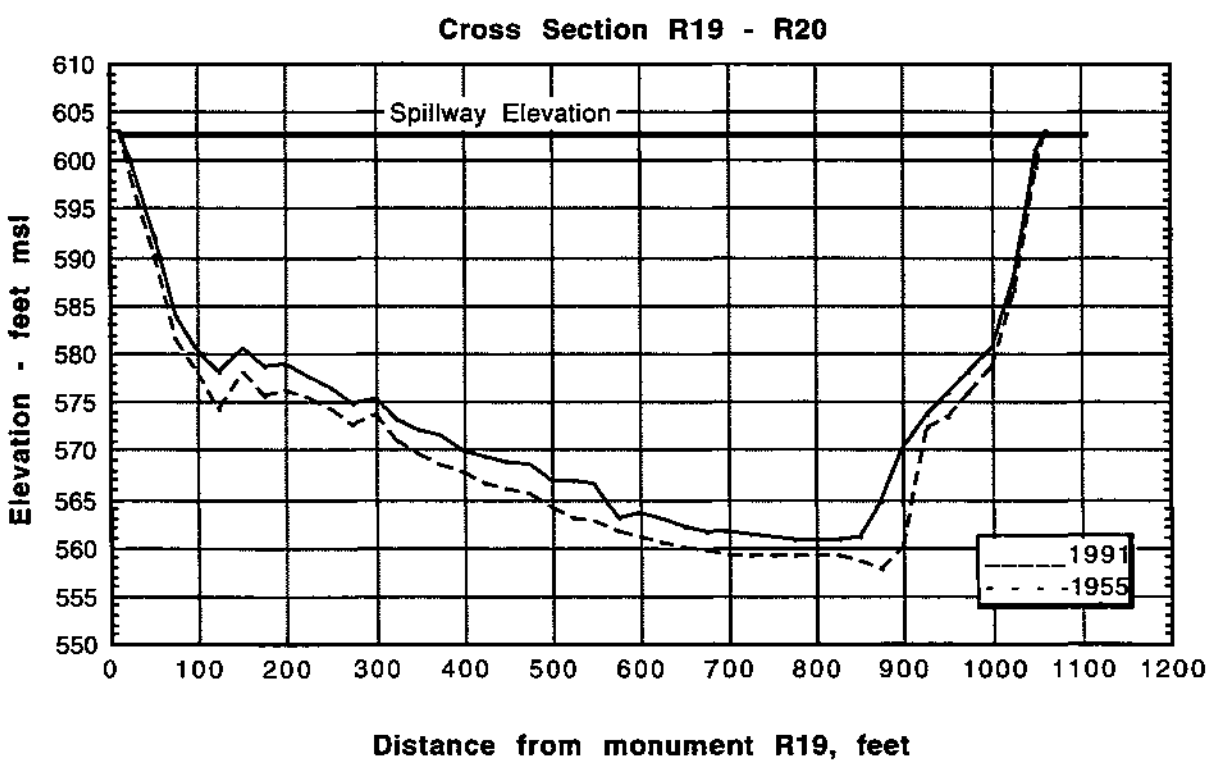

Cross Section R11A - R12
Spillway Elevation
1991
1955
Elevation - feet msl
Distance from monument R11A, feet


Cross Section R13 - R14
Spillway Elevation
Elevation - feet msl
610
605
600
595
590
585
580
575
570
0
100
200
300
400
1991
1955
Distance from monument R13, feet

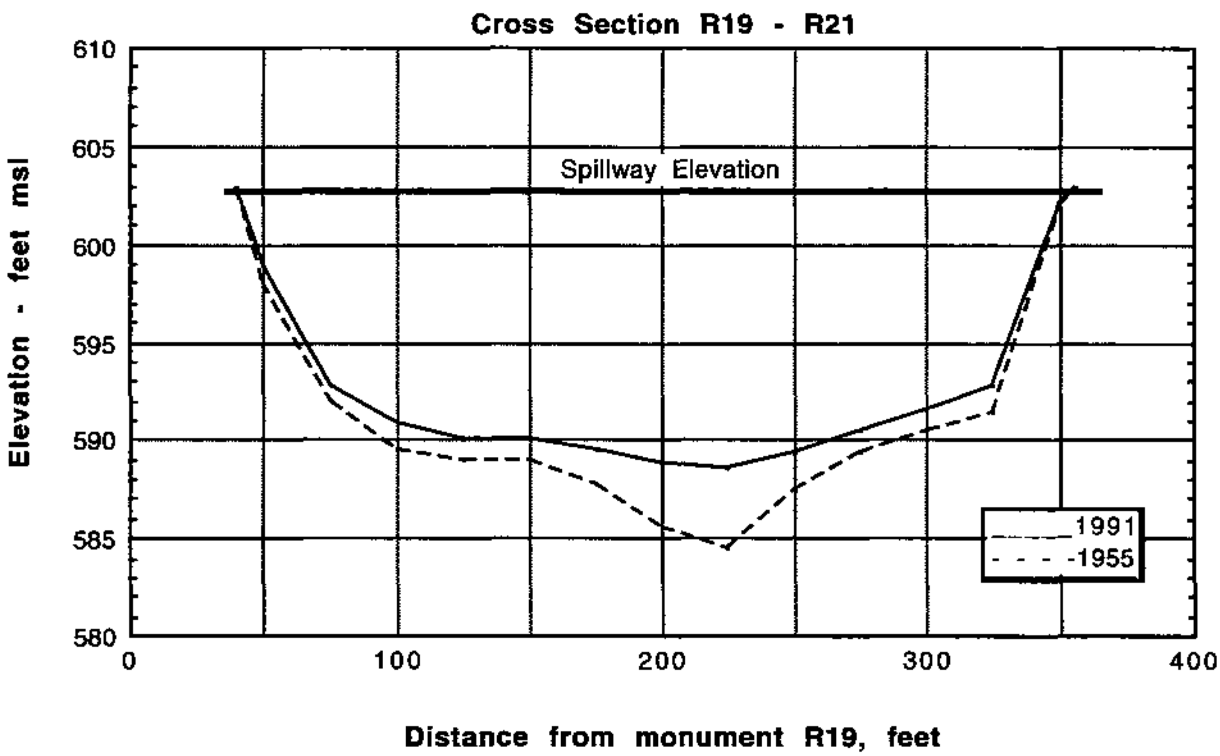

Cross Section R15 - R16
Spillway Elevation
Elevation - feet msl
610
605
600
595
590
0
100
200
300
1991
1955
Distance from monument R15, feet

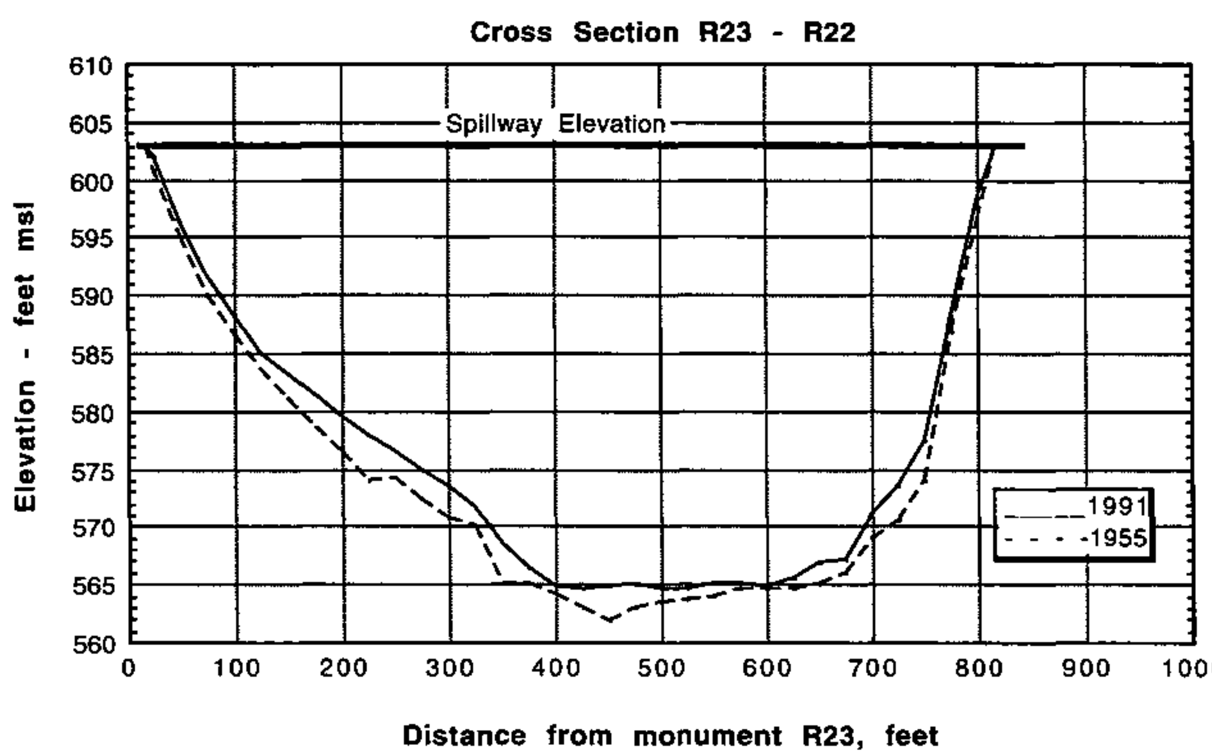


Cross Section R17 - R18
Spillway Elevation
Elevation - feet msl
610
605
600
595
0
100
200
300
1991
1955
Distance from monument R17, feet



Cross Section R19 - R20
Spillway Elevation
Elevation - feet msl
610
605
600
595
590
585
580
575
570
565
560
555
550
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1991
1955
Distance from monument R19, feet


Cross Section R19 - R21
Spillway Elevation
1991
1955
Elevation - feet msl
610
605
600
595
590
585
580
0
100
200
300
400
Distance from monument R19, feet


Cross Section R23 - R22
Spillway Elevation
1991
1955
Elevation - feet msl
610
605
600
595
590
585
580
575
570
565
560
0
100
200
300
400
500
600
700
800
900
1000
Distance from monument R23, feet

Appendix II.. Particle Size Analysis (Weighted Averages)

Survey range line	*Sand (percent)*	*Silt (percent)*	*Clay (percent)*
R1-R2	3.8	68.0	28.2
R5-R6	23.6	59.8	16.6
R7-R8	1.5	68.5	30.0
R9-R10	0.2	56.8	43.0
R11-R11A	0.6	52.6	46.8
R11A-R12	10.4	44.7	44.9
R13-R14	0.3	36.3	63.4
R15-R16	5.0	71.7	23.3
R17-R18	3.8	68.0	28.2
R19-R20	1.6	42.3	56.0
R19-R21	21.4	59.5	19.1