Contract Report 580

Sedimentation Survey of Stephen A. Forbes State Park Lake, Marion County, Illinois

by William C. Bogner
Office of Hydraulics & River Mechanics

Prepared for
Cochran & Wilken, Inc.

March 1995

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

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by

William C. Bogner
Illinois State Water Survey

INTRODUCTION

The Illinois State Water Survey (ISWS), in cooperation with the Illinois Department of Conservation and Cochran & Wilken, Inc., Consulting Engineers, conducted a sedimentation survey of Stephen A. Forbes State Park Lake (Forbes Lake) during the summer of 1993. This survey was undertaken in support of a U.S. Environmental Protection Agency Clean Lakes Program diagnostic/feasibility study of the lake being prepared by Cochran & Wilken, Inc., and the results are presented in this report.

Background

Sedimentation affects the use of any lake by reducing depth and volume, burying rooted plants and benthic organisms, and increasing the supply of nutrients to the lake. It is also a source of chemical contamination of the lake water. Additional impacts in a water supply reservoir include loss of reserve water supply capacity and burial of intake structures.

Sedimentation is a natural process that can be accelerated or slowed by human activities in the watershed. In general, sedimentation of a lake is accelerated unintentionally as a secondary impact of other watershed developments. For example, construction and agricultural activities are generally presumed to have negative impacts on lakes due to increased exposure of soil material to erosive forces.

Reductions of the sedimentation rate in a lake due to human impacts are almost always related to programs intentionally designed to reduce soil and streambank losses and often as plans for lake remediation. Such programs might include but are not limited to implementation of watershed erosion control practices, streambank and lakeshore stabilization, stream energy dissipaters, and lake dredging.

Sedimentation of a reservoir is the final stage in a three-step sediment transport process. The three steps are watershed erosion by sheet, rill, gully, or streambank erosion; sediment transport in a defined stream system; and finally, sediment deposition when stream energy is reduced and sediment can no longer be transported either in suspension or as bedload. This final step can occur throughout the stream system: from Illinois farmland to the Gulf of Mexico.

Lake sedimentation occurs when sediment-laden streamwater enters a lake. As the water velocity is reduced, suspended sediment is deposited in patterns related to particle size and fall velocity. Soil particles are partially sorted by size along the longitudinal axis of the lake during this process. Larger, heavier sand and coarse silt particles are deposited in the upper end of the lake, while finer silts and clay particles tend to be carried further into the lake.

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 to provide reasonable estimates within limits. A more precise measure of the sedimentation rate is provided by conducting a sedimentation survey of the reservoir that provides detailed information for each lake on distribution patterns within the lake and also defines temporal changes in overall sedimentation rates.

History of the Reservoir

Forbes Lake was built in 1962-1963 by the Illinois Department of Conservation with matching funds from the federal Dingell-Johnson Program. The lake is a central attraction to a 3,099-acre park development that includes facilities for boating, fishing, picnicking, hiking, swimming, camping, and hunting.

Forbes Lake (figure 1) is located in Marion County two miles east of the village of Omega, Illinois. The dam is at 38° 42' 45" north latitude and 88° 44' 45" west longitude in Section 10, Township 03N., Range 04E. in Marion County, Illinois. The dam impounds Lost Fork, a tributary to Skillet Fork, the Little Wabash River, and the Wabash River. The watershed is a portion of Hydrologic Unit No. 05120115 as defined by the U.S. Geological Survey (USGS, 1974).

Watershed and Climate

The watershed of Forbes Lake (figure 1) consists of the 21.1-square-mile area drained by Lost Fork Creek above the dam site. The highest point in the watershed is at an elevation of 656 feet above mean sea level (ft-msl), and the normal pool elevation of the lake is 512.9 ft-msl. Land use

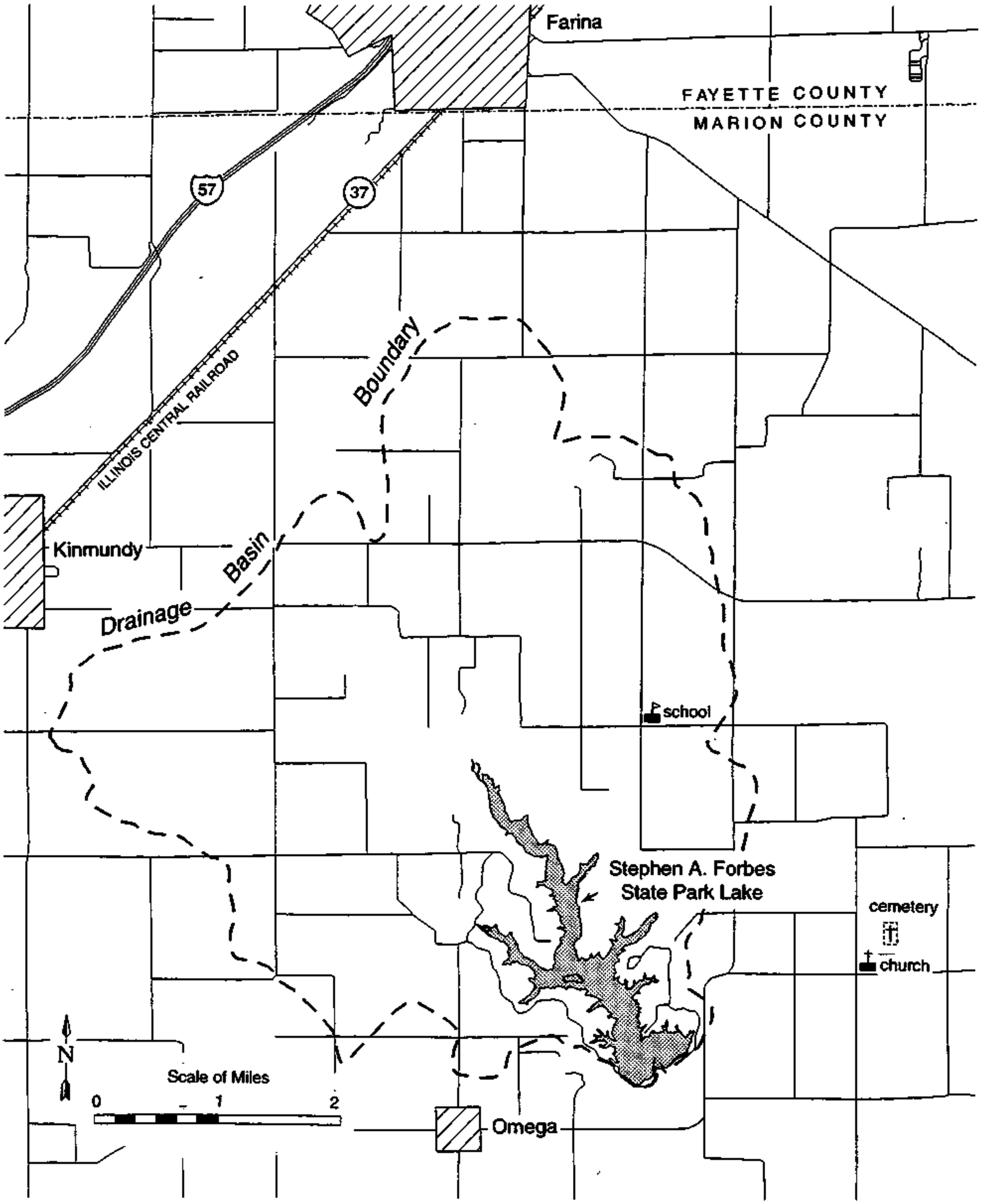

Figure 1. Location of Stephen A. Forbes State Park Lake and its watershed

in the watershed is mainly agricultural, and the majority of soils are upland prairie or timber soils formed in glacial till and silty loess deposits. These soils are underlain by an impervious clay layer developed by fines washed through the soil layer. This impervious clay layer inhibits infiltration of excess moisture during wet seasons and makes the soils droughty during dry seasons (Smith et al., 1926).

Average annual precipitation in the area is 40.45 inches as measured at Flora. Average runoff is 11.68 inches as measured in the Skillet Fork at Wayne City (1908-1992). The average annual lake evaporation rate is 36 inches per year (Roberts and Stall, 1967).

LAKE SEDIMENTATION SURVEYS

The 1993 survey is the only known sedimentation survey of Forbes Lake. Cross sections were laid out at 20 lines across the lake, surveyed, and monumented (figure 2). Survey transect lines were distributed longitudinally along the lake axis to define loss of depth within the pool area. The transects were permanently monumented by installing 40 4-inch by 4-inch concrete posts to mark the transect ends. Each odd-numbered post has a State Water Survey brass tablet embedded in the top and is stamped with an identification code.

Horizontal distance along the cross-section transects was measured by stretching a marked polyethylene cable between range-end monuments. Water depth (vertical control) was referenced to the water surface, and all depths were adjusted to the spillway crest elevation. Plots of all surveyed cross sections are presented in appendix I.

Lake Basin Volumes

Calculations of the lake capacities were made using methods described in the National Engineering Handbook of the U.S. Soil Conservation Service (USDA-SCS, 1968). This method basically requires surface area of the lake segments, cross-sectional area and widths of bounding segments, and a shape factor to determine the original, present, and sediment volume of each segment. These volumes are then summed to determine total lake volume. The reference elevation for the lake was the top of the spillway crest, 512.9 ft-msl.

Survey results are presented in table 1. The volumes presented in the table represent the capacity of the lake basin below the reference spillway elevation.

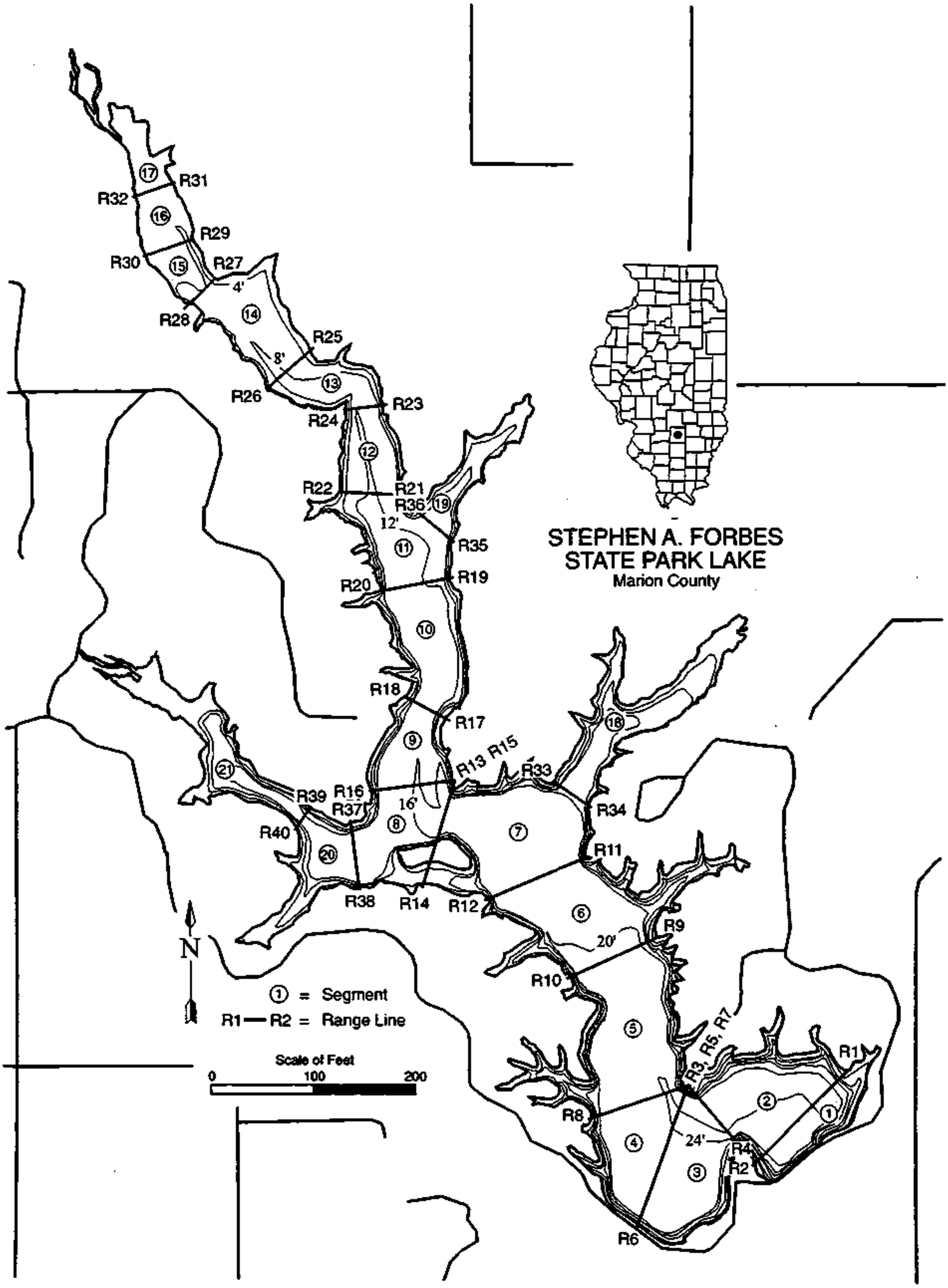

Figure 2. Forbes Lake survey plan with 1993 bathymetry

Table 1. Surveyed Capacities of Stephen A. Forbes Lake

Year of survey	*Interval since last survey (years)*	*Surface area (acres)*	*Reservoir storage capacity (ac-ft)*	*Reservoir storage capacity (mg)*	*Capacity per square mile of watershed (ac-ft)*	*Deposited sediment since last survey (ac-ft)*
1963	Constructed		7330	2390	347	
1993	30	509	6480	2110	307	5220

Note: Watershed area 21.1 square miles

The basin capacity was reduced from 7,330 acre-feet (ac-ft) when the lake was constructed in 1963 to 6,480 ac-ft in 1993. The 1993 basin capacity was 88 percent of the original 1963 capacity.

Water depths for the lake in 1993 were used to generate the bathymetric map in figure 2 and the water volume distribution curve data in figure 3. Figure 3 can be used to determine the portion of the capacity of the reservoir that is below a given reservoir depth. For example, the water volume below the 2-foot depth contour (shown by the dashed line in figure 3) is 85 percent of the total volume of the reservoir. As sedimentation continues over time, or if changes are made in the spillway elevation, or if a dredging program is implemented, the bathymetric map in figure 2 and the relationships shown in figure 3 will become less accurate.

Sediment Grain Size Distribution

A total of 29 lakebed sediment samples were collected for grain size distribution analysis. Field examination of these samples indicated little or no apparent sand size material in the samples collected, which is consistent with general observations concerning sediment distribution in Illinois lakes (Fitzpatrick et al., 1987; Bogner, 1986). These and other sources indicate that occurrence of sand exceeding 10 percent is unusual within sampled lake sediments.

Laboratory analyses of sediment particle size samples collected at Stephen A. Forbes Lake are presented (appendix IT). Particle size distribution graphs (figure 4a) show the distributions for the top surface of the lake sediments from the dam to cross section R15 to R16 (see figure 2). These samples show very similar particle size distributions in this wide, deep portion of the lake. Figure 4b concludes the presentation of plots of the surface sediment particle size distributions to the

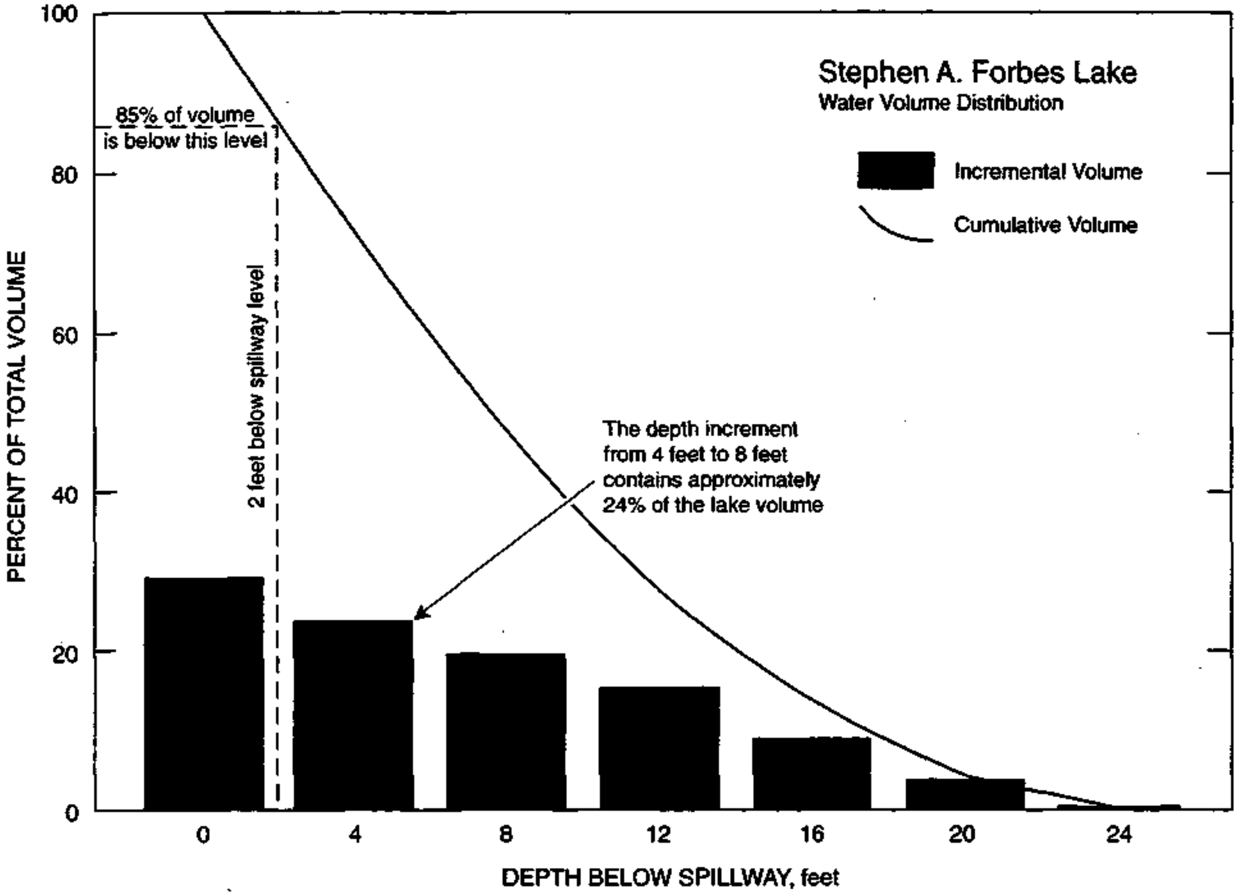

Figure 3. Water volume distribution curve for Forbes Lake

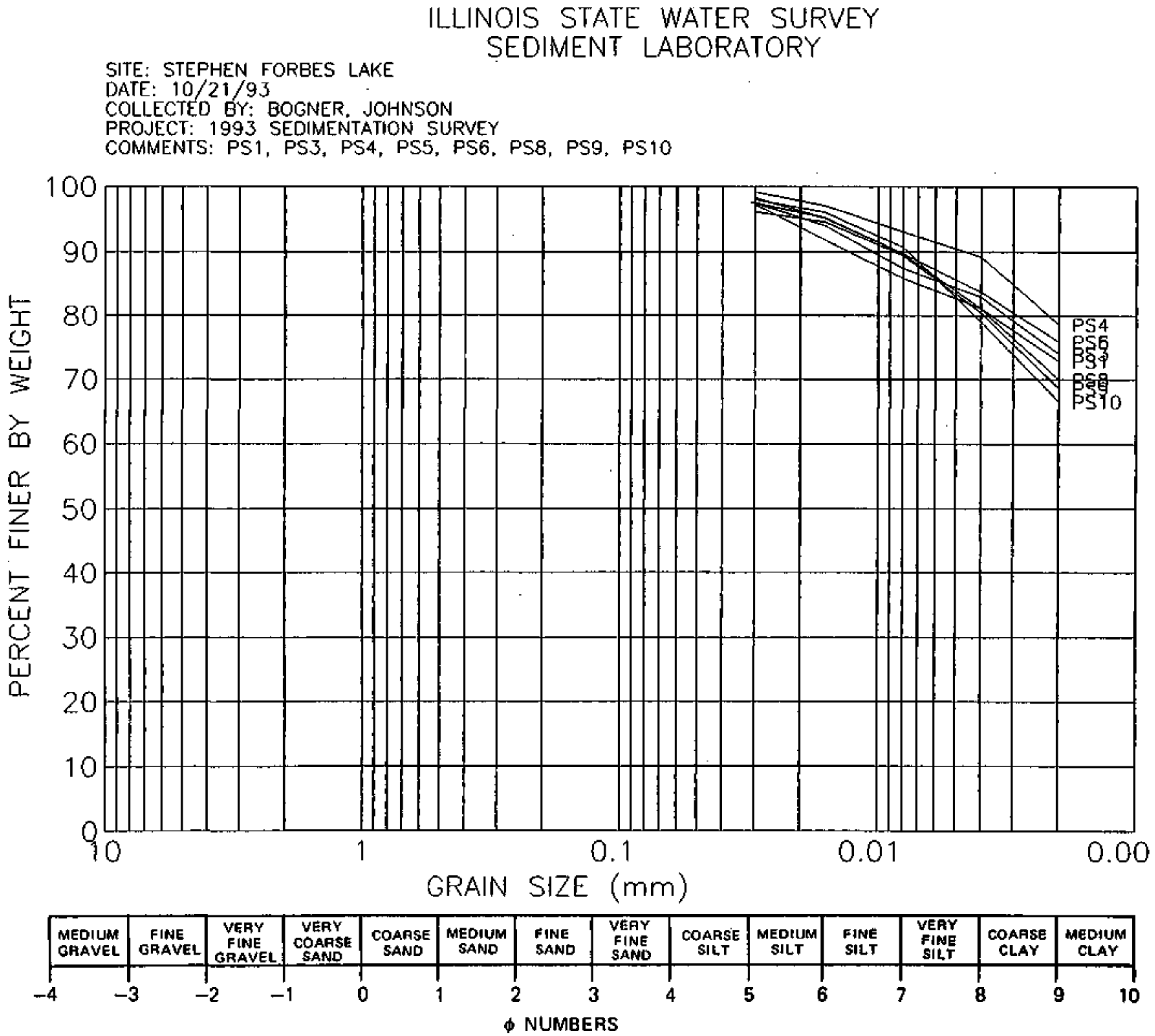

Figure 4a. Grain size distribution plots for lower Forbes Lake

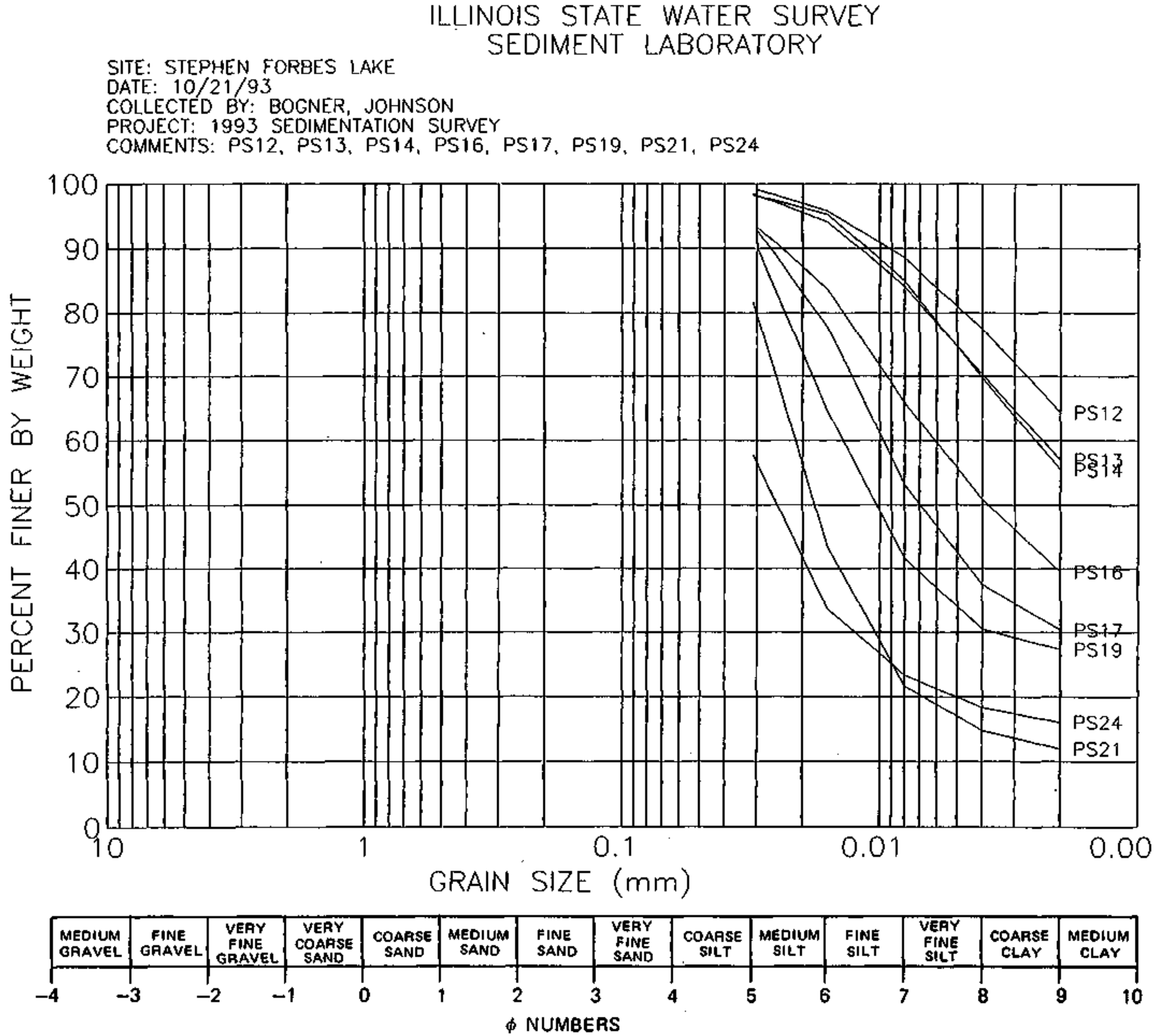

Figure 4b. Grain size distribution plots for upper Forbes Lake

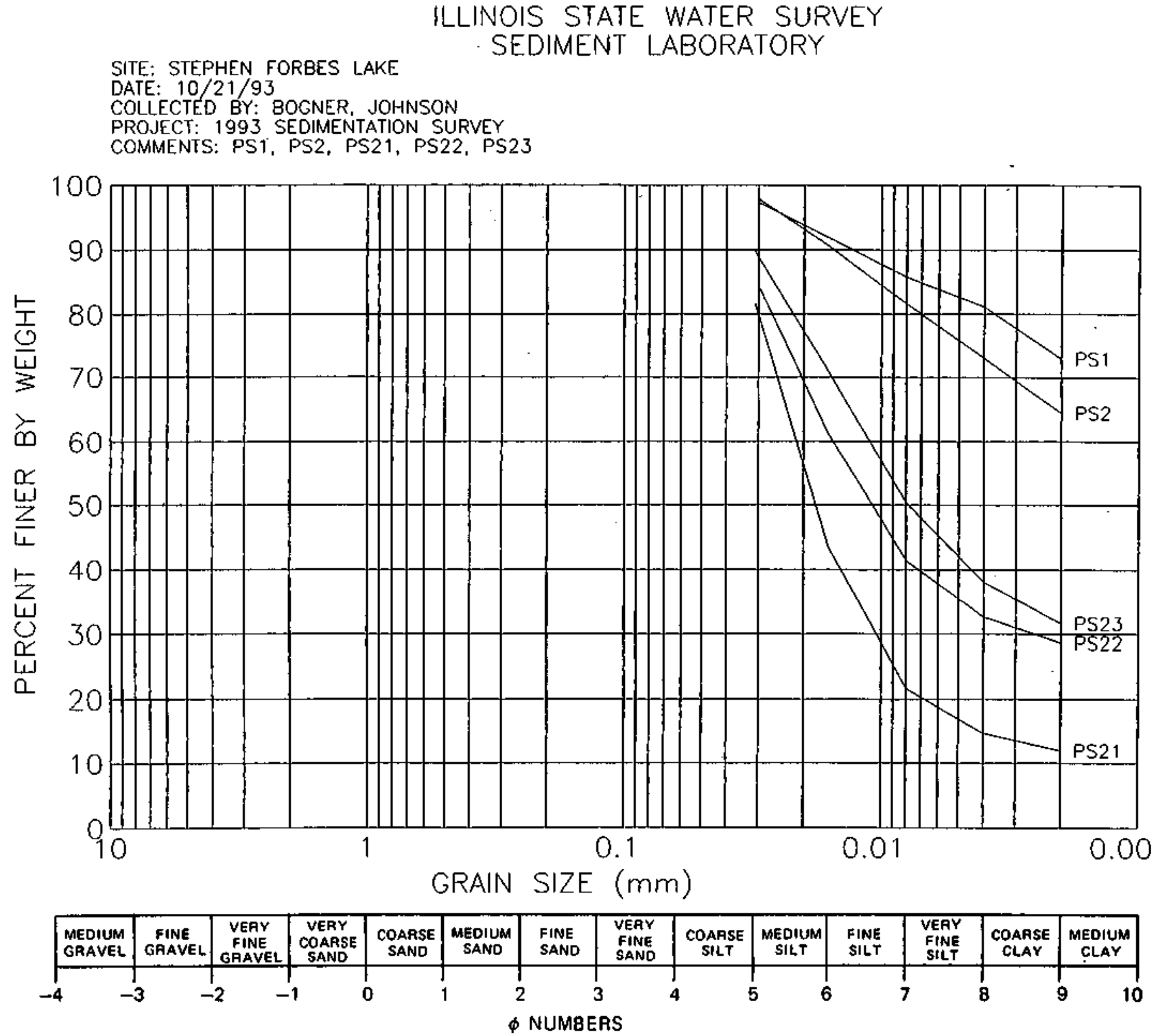

Figure 4c. Grain size distribution plots for sediment core samples from Forbes Lake

upper end of the lake. These distributions show decreasing particle sizes for the deposited sediments from the inflow point of Lost Fork Creek to cross section R17 to R18.

This reduction in deposited sediment particle sizes is consistent with all other Illinois impoundment lakes for which such data are available. The reduction is caused by the natural sorting of the inflowing sediments in the lake environment. Coarser sediments are deposited as the inflowing streamwater is first slowed by entering the lake. As water moves through the lake, the sediments suspended in the water column become finer as all coarser size fractions come out of suspension. At the dam, the suspended sediments are predominantly colloidal and organic materials.

Figure 4c shows two examples of the vertical variation of sediment particle size. These comparisons show the variability of sediment particle size distribution with time.

Samples 21-23 were collected from a single vertical core sample near the upper end of the lake. In this area of the lake, the particle size distribution of the accumulated sediments becomes coarser over time. This is due to the downlake shift in the initial depositional environment of the lake as a result of decreased trap efficiency at the upper end of the lake. Over time, the initial depositional zone in the lake will move further down the lake because of water volume loss to sedimentation.

Samples 1 and 2 in figure 4c were a vertical core sample adjacent to the dam. In this area, the sediment particle size distribution is more stable over time.

Sediment Distribution

Table 2 shows the distribution of sediment in the lake. Figure 5 presents the 1993 average sediment thickness and mass distribution for the lake as well as for each segment. Sediment thicknesses range from 2 to 4 feet.

The sediment mass distribution presented in figure 5 indicates the variation of sediment characteristics within the lakes. In general, sediment mass distribution in Forbes Lake follows normal patterns of lake deposition. Coarser sediments are deposited in the upstream portion of the lake where the entrainment velocities of the inflowing stream are reduced to much slower velocities in the lake environment. These coarser sediments tend to be denser when settled and are subject to drying and higher compaction rates due to more frequent drawdown exposure in the shallow water environment.

Table 2. Volume by Segment for Stephen A. Forbes Lake

Segment number	*Volume (ac-ft)* Water 1963	Water 1993	Sediment 1993	Annual loss rate (percent)
1	333	307	25	0.26
2	672	620	52	0.26
3	581	533	47	0.27
4	509	467	42	0.28
5	1101	1008	93	0.28
6	831	760	71	0.28
7	749	676	73	0.33
8	354	312	42	0.39
9	251	223	28	0.37
10	343	299	43	0.42
11	297	251	46	0.51
12	171	143	28	0.55
13	130	102	28	0.72
14	176	122	54	1.02
15	49	25	24	1.63
16	52	16	36	2.29
17	27	5	22	2.67
18	245	221	23	0.32
19	97	82	15	0.51
20	218	190	28	0.43
21	143	121	22	0.52
Totals	7328	6485	843	0.38

Table 3. Annual Sediment Accumulation Rates from Watershed of Stephen A. Forbes Lake

Period	Sediment deposited (ac-ft)	*Sediment deposited* Per square mile of watershed (ac-ft)	Per acre of watershed (cubic ft)	Per acre of watershed (tons)
1963-1993	174	8.2	560	1.42

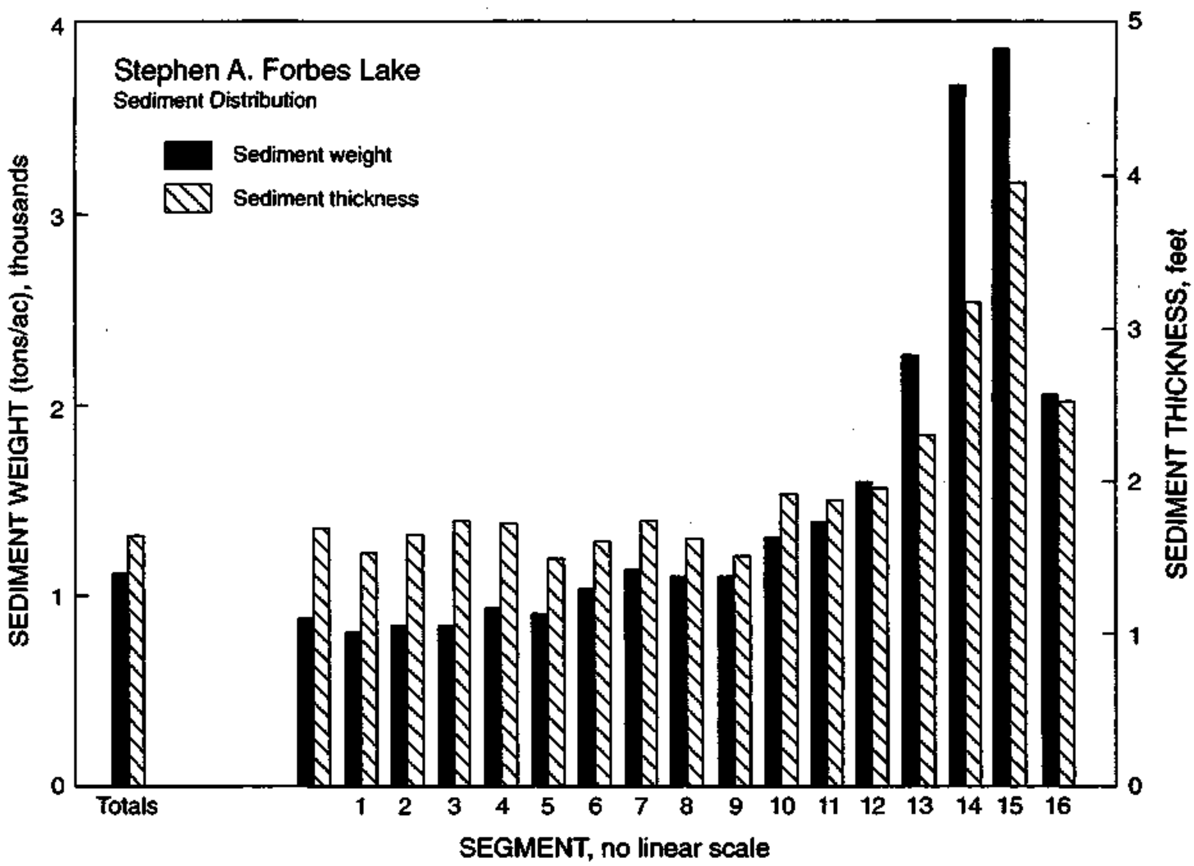

Figure 5. Sediment mass distribution in Forbes Lake

As the remaining sediment load of the stream is transported through the lake, increasingly finer particle sizes and decreasing unit weight are observed. The distribution of sediment mass in the lake is not proportional to the distribution of sediment thickness. More frequent dewatering and coarser grain sizes as shown in appendix II combine to increase compaction of sediments in the upper end of the lake. This is also indicated by the variation in dry unit weight of lake sediments, increasing from 22 pounds per cubic foot near the dam to more than 50 pounds per cubic foot in the upper end of the lake. Average unit weight of the sediments in the lake was 31.3 pounds per cubic foot.

Sedimentation Rates

Sedimentation rates for Forbes Lake are presented in terms of delivery rates from the watershed as well as accumulation rates in the reservoir. The in-lake accumulation rate provides a means of extrapolating from past and present lake conditions to future lake conditions in order to evaluate the integrity of the lake as a recreational resource. The watershed delivery rates are the link between soil erosion processes in the watershed, sediment transport processes, and water supply quantity and quality impacts in the reservoir. These delivery rates measure the actual sediment yield from the watershed, including the reduced sediment transport due to field and in-stream redeposition. Delivery rates show the need for continuing efforts to control watershed erosion as a major factor in reducing reservoir sedimentation.

The sedimentation rates for Forbes Lake and its watershed are given in tables 2 and 3 for the period 1963 - 1993. The lake has lost an average of 0.38 percent of its original capacity annually since 1963. Distribution of this loss in the lake ranges from 0.26 percent per year near the dam to more than 2.5 percent per year in the upper end of the lake (segment 17). As the upper reaches of the lake fill with sediment, higher rates of volume loss should be expected downstream due to lost storage capacity and reduced trap efficiency. Thus, with more than 75 percent of the volume of segment 17 filled with sediment, segment 16 will probably lose capacity at a higher rate.

Annual sediment input to the lake (1.42 tons per acre of watershed) indicates possible problems with high erosion rates in the watershed. Assuming a 25 percent delivery ratio between sediment delivery to the lake and soil erosion in the watershed, more than 5.5 tons of soil is eroded annually from each acre of watershed area.

Factors Affecting Forbes Lake Sedimentation Rates

Sedimentation rates in a lake vary over time due to changes in watershed and in-lake conditions. Altered watershed conditions can affect sediment delivery rates to the lake, which can vary over time due to changes in precipitation and land use patterns, and streamflow variability. In-lake conditions that might affect the sedimentation rate are reduced trap efficiency (due to reduced storage capacity) and sediment consolidation.

In the case of Forbes Lake, representative streamflow for Skillet Fork at Wayne City since the construction of the lake in 1963 (395 cubic feet per second or cfs) has been virtually the same as the long-term average discharge at that station (399 cfs for 75 years of record). This suggests that the sediment input rates to the lake that are closely related to runoff rates have been representative of a long-term average rate over the life span of the lake. No detailed statistical analysis of streamflow distribution was made to evaluate the influence of extreme events or seasonal variability of storms on the sedimentation rate. In general, sediment transport rates in the streams flowing into Forbes Lake can be anticipated to be disproportionately higher for larger discharges and for winter or spring storms when soil is poorly protected due to lack of ground cover.

Land use patterns in Marion County have changed very little over the 31-year life span of the lake. Agricultural statistics for 1963 and 1991 indicate that total acreage in cultivation increased by 15 percent from 1963 to 1991 from 170,000 to 205,000 acres (Illinois Department of Agriculture, 1965, 1991). During this period, corn and soybean acreage in production remained stable at about 130,000 acres; wheat acreage increased from 29,000 acres to 48,000 acres; sorghum acreage increased from 0 to 14,000 acres; and hay acreage dropped from 17,000 acres to 12,000 acres.

The trap efficiency (percentage portion of inflowing sediment captured by the reservoir) of Forbes Lake was determined using a predictive equation developed by Dendy (1974) based on the relationship between the annual capacity to inflow ratio and sediment holding capacity. Using the 1963 and 1993 water volumes, the trap efficiency of Forbes Lake since its construction has been 95 percent.

Consolidation of lake sediments over time would affect the sedimentation rate of the lake by reducing the volume of accumulated sediments. Sediments accumulate on the bottom of the lake in a very loose, fluid mass. As these sediments are covered by continued sedimentation or if they are exposed by occasional lake drawdown, they would be subject to compaction. This process has probably not been a significant factor at Forbes Lake. Relatively thin sediment deposits and the absence of a water supply draft on the lake suggests a limited potential for consolidation of the sediments.

EVALUATION

Because the lake is an integral part of many park activities, maintaining the health of Forbes Lake is an important management goal for park officials. The sedimentation loss rates and sediment yield rates of the lake and its watershed are about average for Illinois impoundment lakes. Table 4 presents comparative data for some other recently surveyed Illinois lakes.

Table 4. Comparison of Stephen A. Forbes State Park Lake and Other Illinois Lakes

Lake	*County*	*Capacity drainage area ratio (ac-ft/sq mi)*	*Annual rate of volume loss (percent)*	*Annual watershed sediment yield (tons/acre)*
Stephen Forbes Lake	Marion	347	0.38	1.4
Lake Centralia	Marion	452	0.24	1.5
Raccoon Lake	Marion	115	0.53	1.0
Paris West Lake	Edgar	13.6	0.74	0.28
Lake Springfield	Sangamon	197	0.26	0.79
Lake Decatur	Macon	20.3	0.58	0.27
Lake Pittsfield	Pike	249	0.90	5.6
Pinckneyville City Lake	Perry	382	0.44	3.0
Lake Carlinville	Macoupin	65	0.73	1.2

Note: Information from Allgire and Bogner (1990), Bogner (1986, 1987, 1992, 1995), and Fitzpatrick et al. (1985, 1987)

Barring significant changes in land use practices, watershed development, or stream hydraulics, future sedimentation rates in Forbes Lake should be consistent with past rates.

Sedimentation patterns in the downstream segments of the lake will also change very little. Rates of sedimentation in the upper segments of the lake (at least segments 14 - 16) will increase due to sedimentation capacity lost in higher numbered segments.

SUMMARY

The Illinois State Water Survey has conducted a sedimentation survey of Stephen A. Forbes State Park Lake, which was originally constructed in 1963 and serves as a central component of the park facilities. Sedimentation has reduced lake capacity from 7,330 ac-ft (2,340 milligrams or mg) in 1963 to 6,480 ac-ft (2,110 mg) in 1993. Sediment accumulation rates in the lake averaged 168 ac-ft per year over the period 1963 - 1993. Based on a review of long-term historical trends and conditions since the lake was constructed, these sedimentation rates accurately reflect the long-term average condition.

ACKNOWLEDGMENTS

This project was conducted by the author as part of his regular duties at the Illinois State Water Survey under the administrative guidance of Mark E. Peden, Acting Chief; Nani G. Bhowmik, Head of the Hydrology Division; and Ta Wei David Soong, Director of the Office of Hydraulics & River Mechanics. Timothy Nathan, Nancy Johnson, and James Slowikowski assisted with the field data collection and monumentation. Mr. Nathan also assisted with the data analysis and generation of computer graphics.

Linda Hascall prepared the final illustrations for the report. Eva Kingston edited the report, and Kathleen J. Brown prepared all camera-ready copy.

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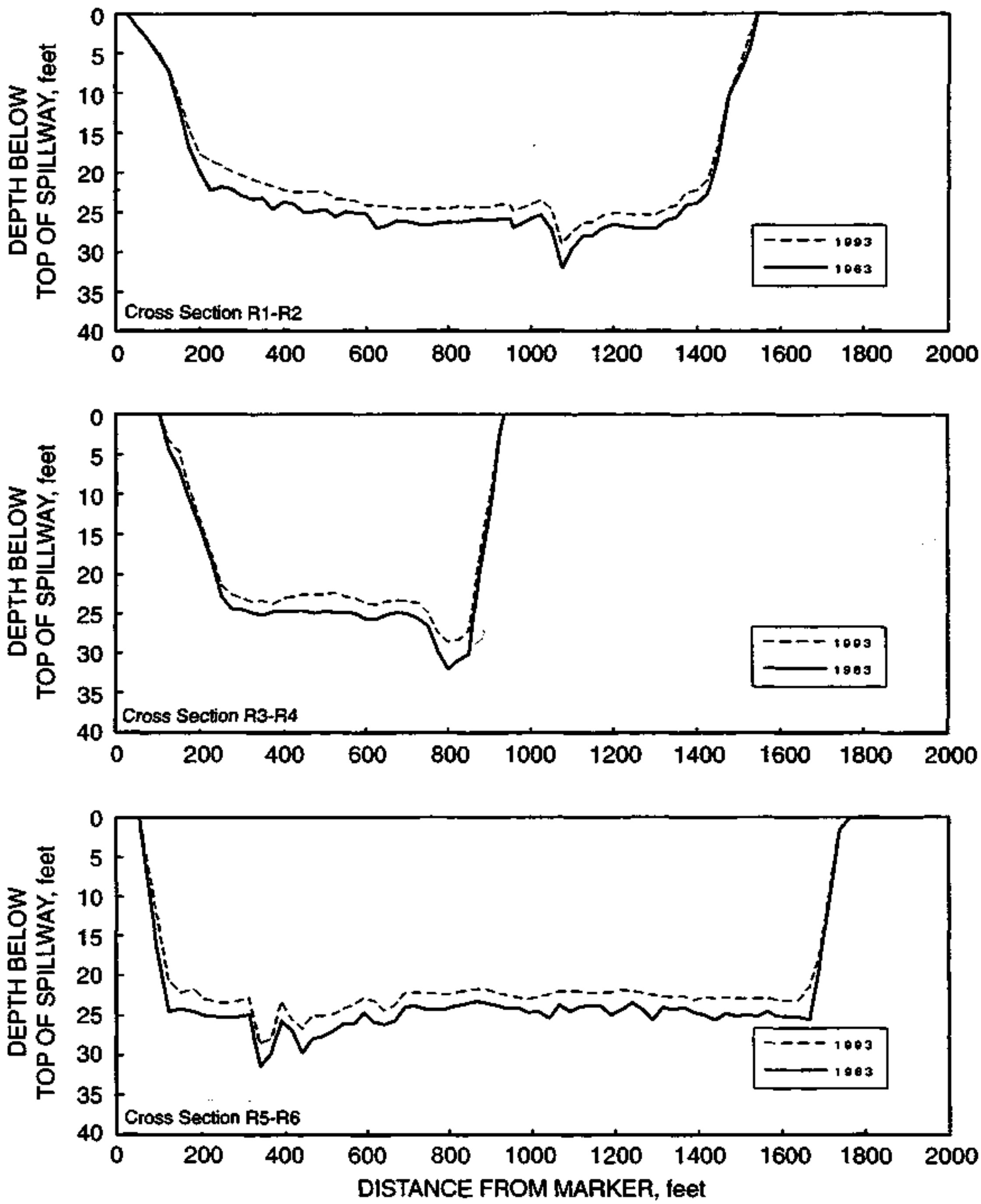
APPENDIX I. SURVEYED CROSS-SECTIONAL PLOTS FOR STEPHEN A. FORBES LAKE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1963
Cross Section R3-R4
Cross Section R5-R6
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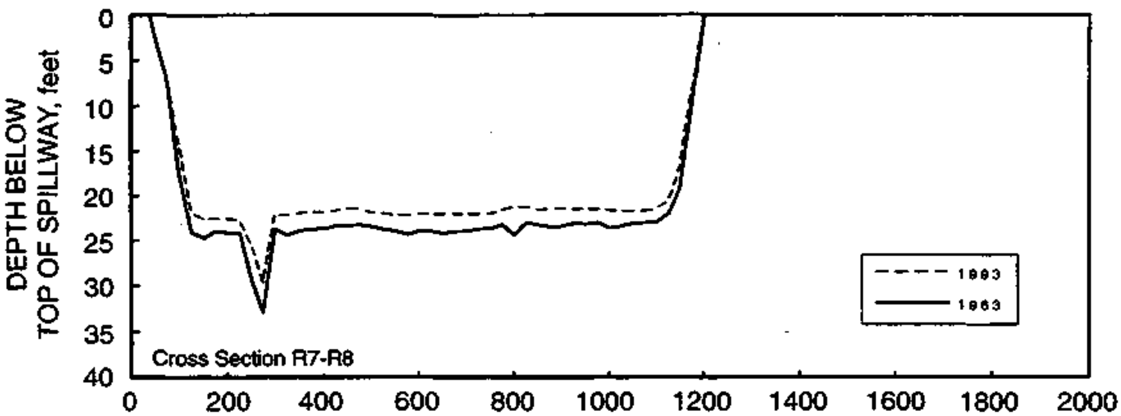
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Cross Section R7-R8
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1400
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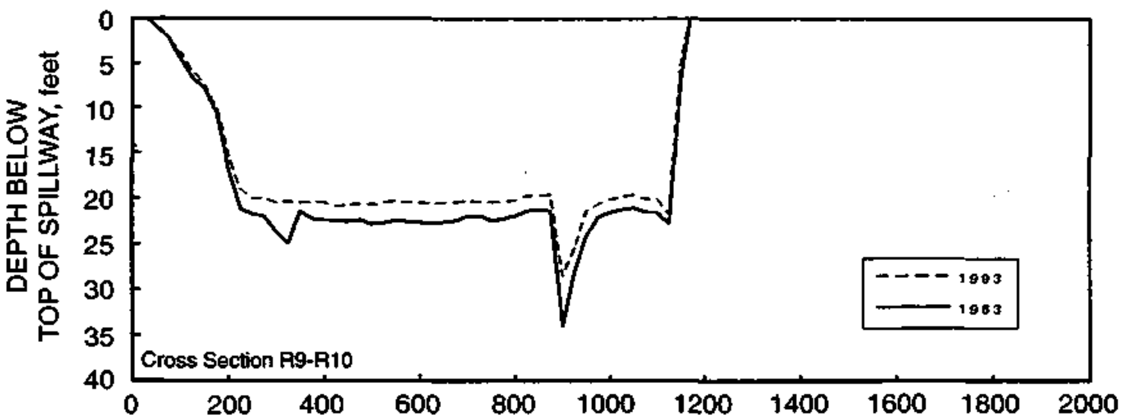
1800
2000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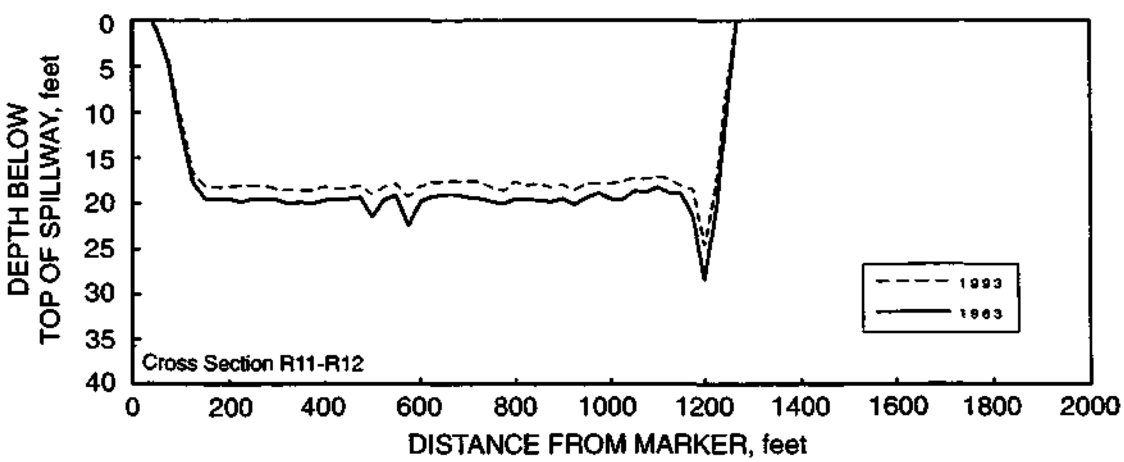
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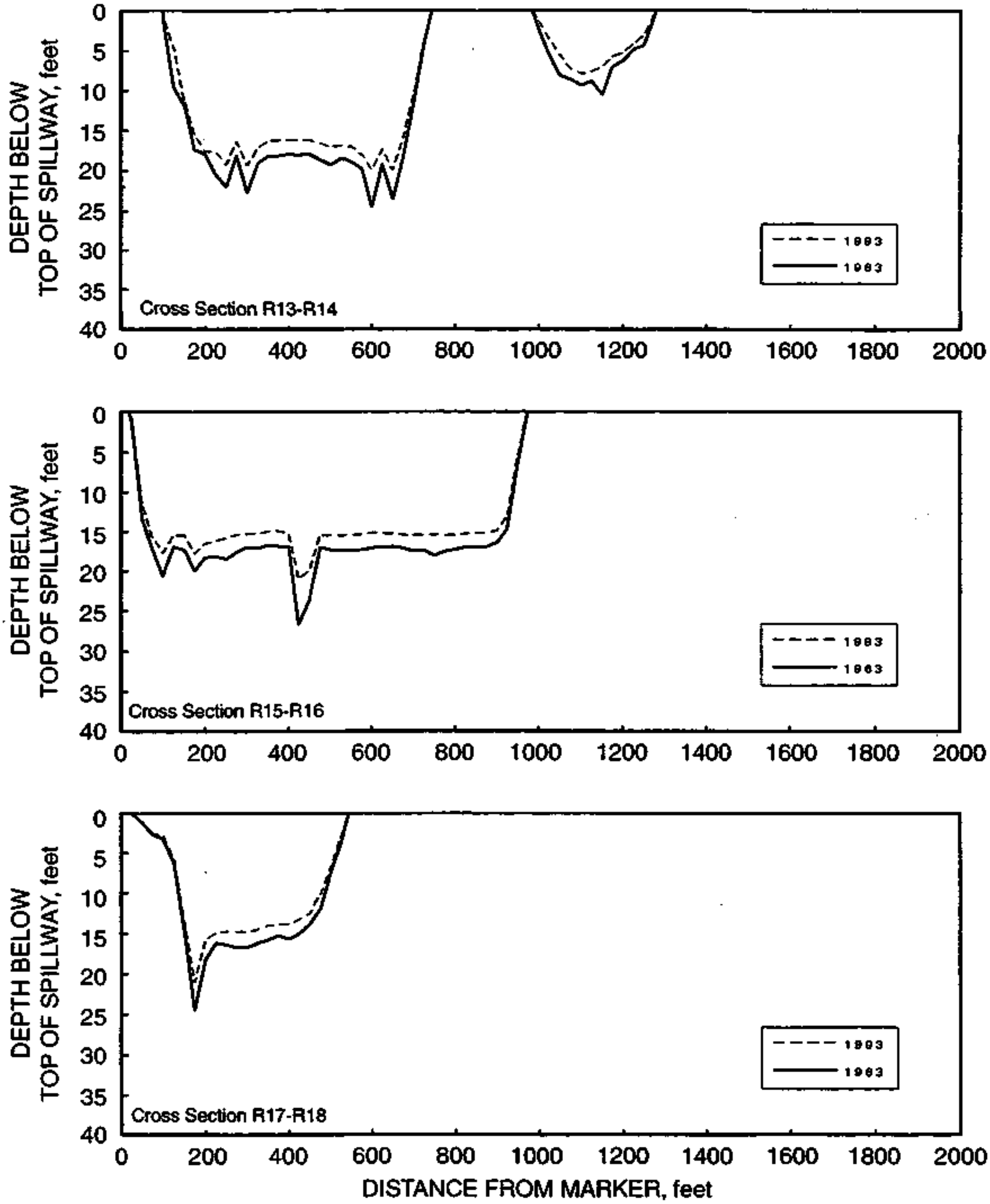
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Cross Section R15-R16
Cross Section R17-R18
1993
1963
DISTANCE FROM MARKER, feet
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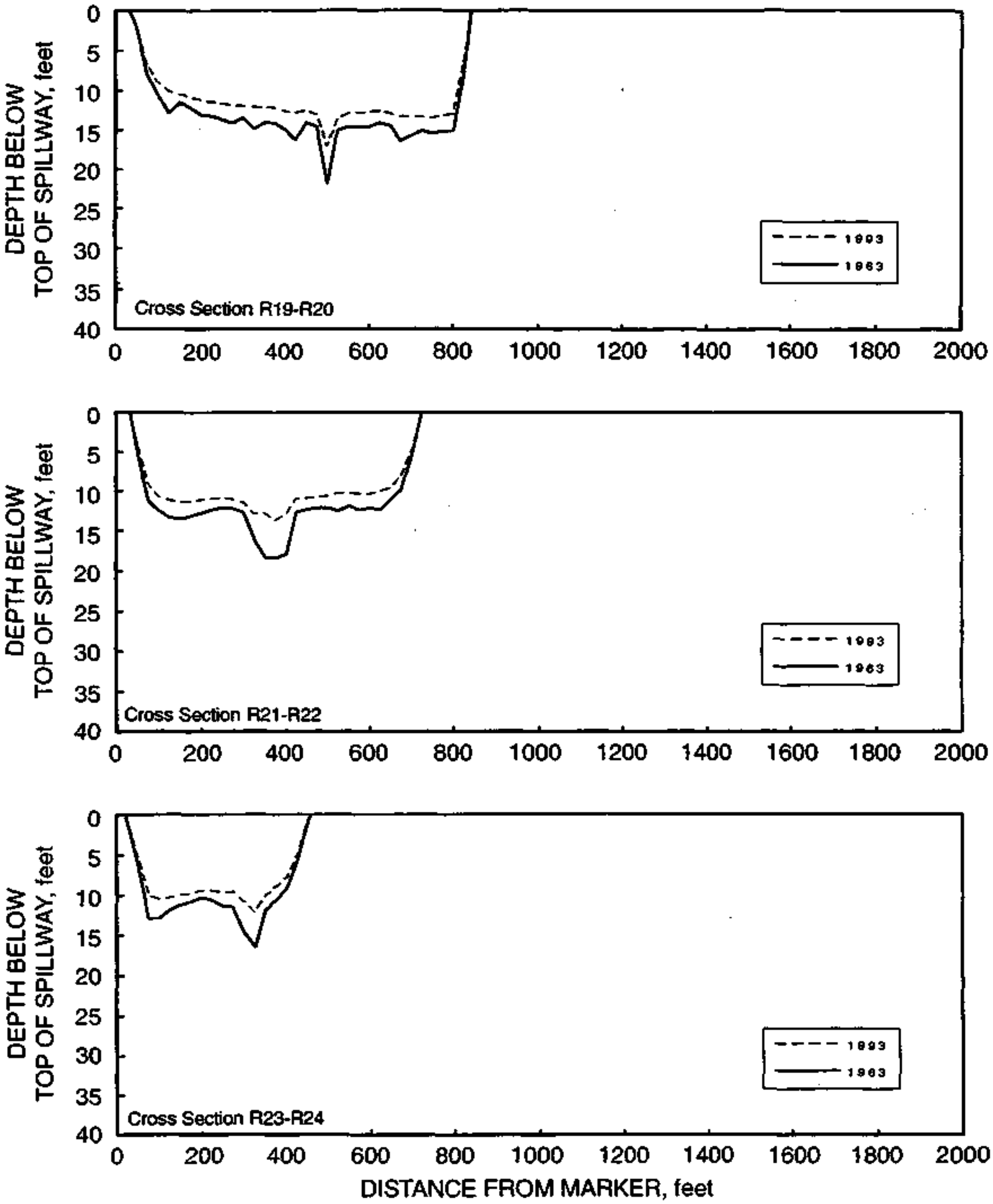

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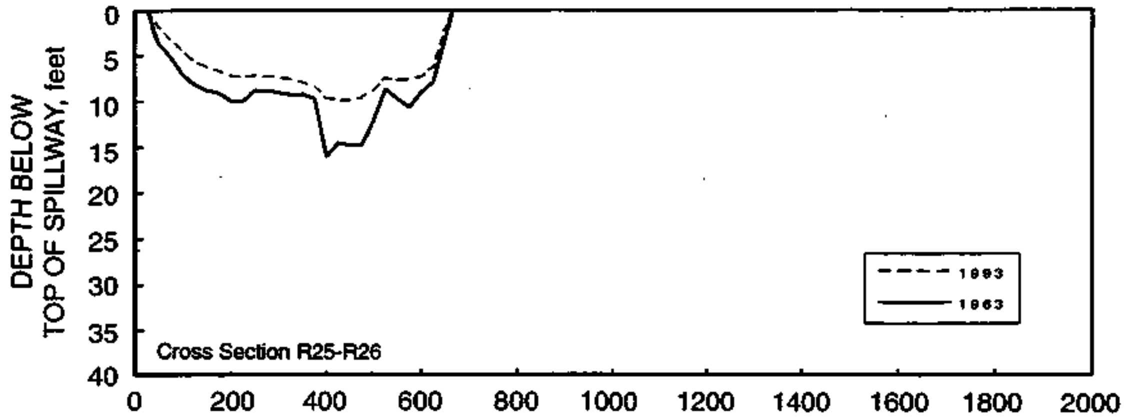
Cross Section R19-R20
Cross Section R21-R22
Cross Section R23-R24
DISTANCE FROM MARKER, feet



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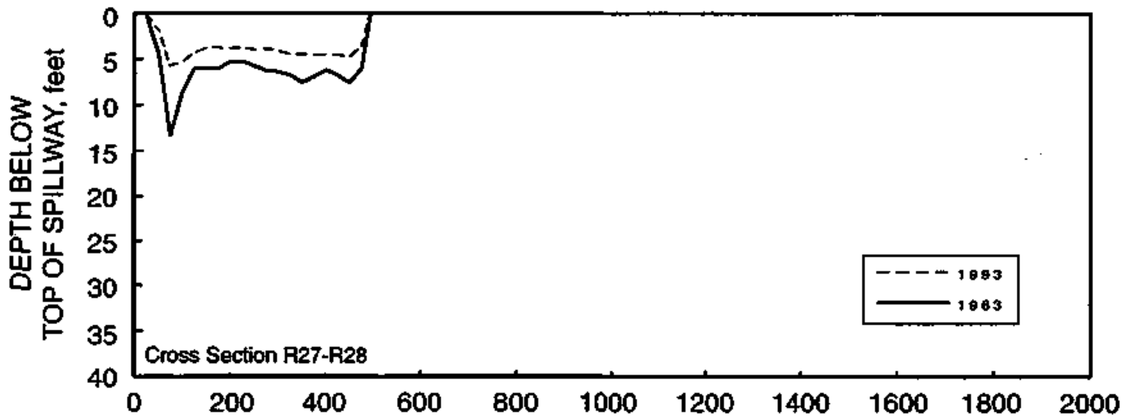

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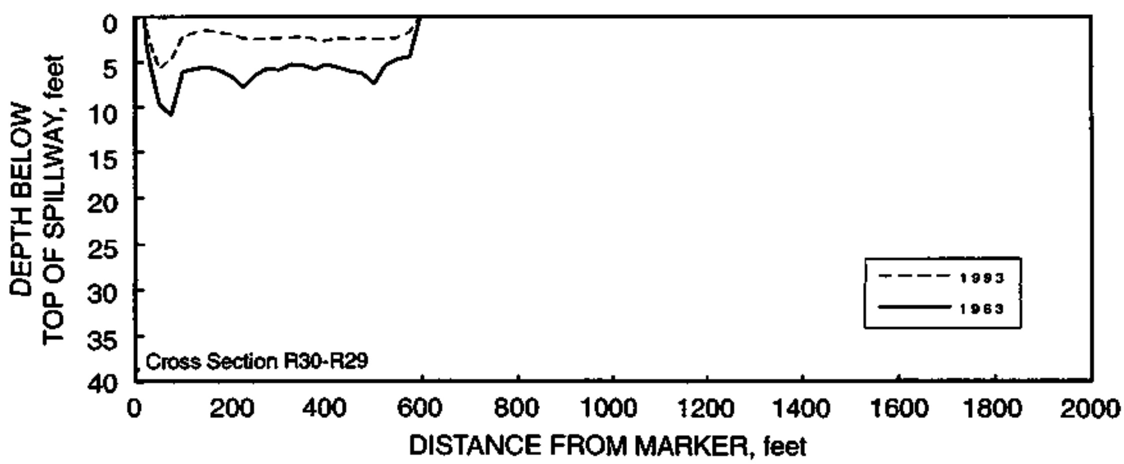

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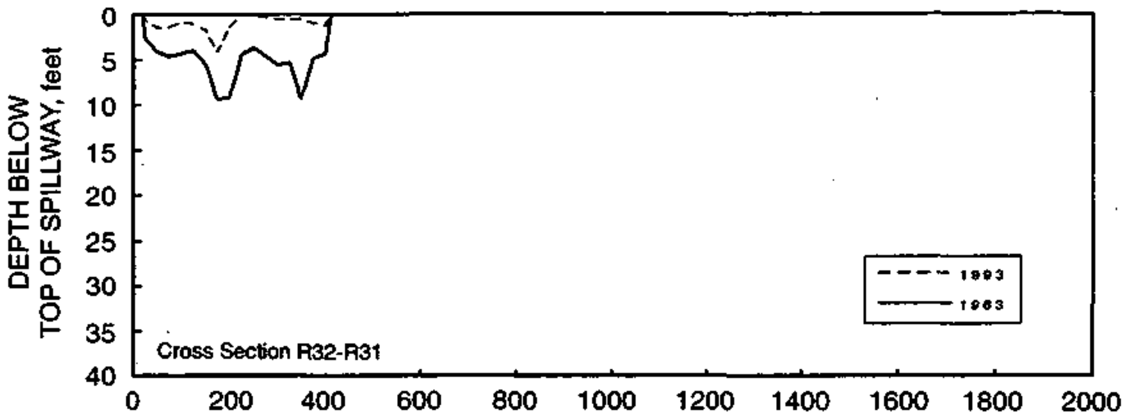

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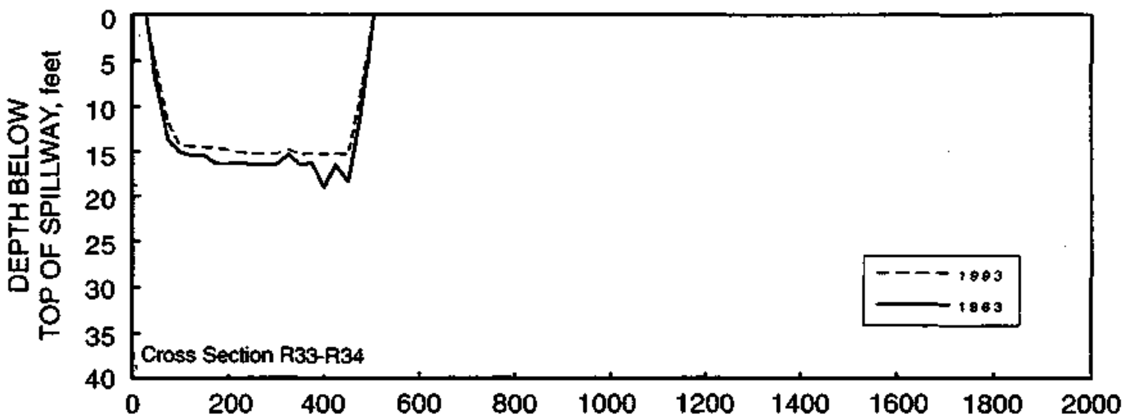
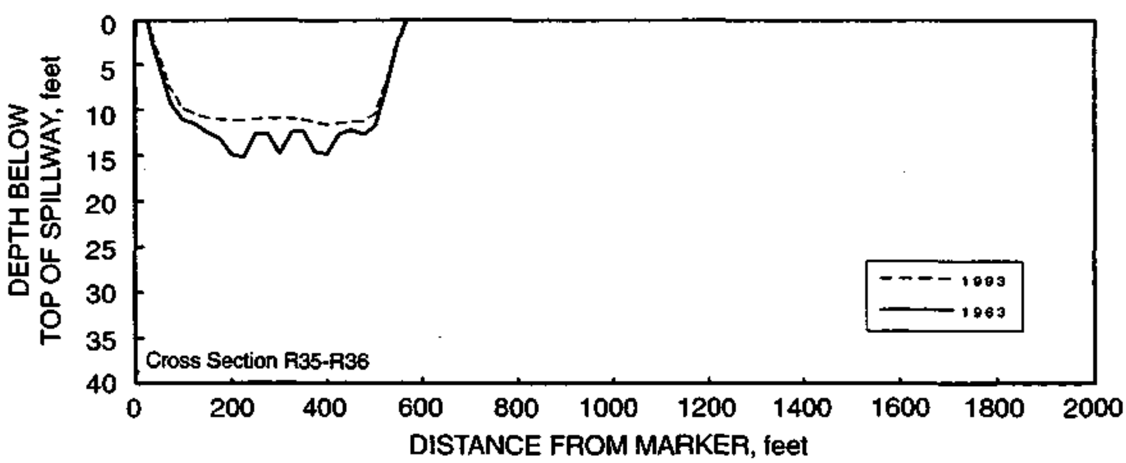
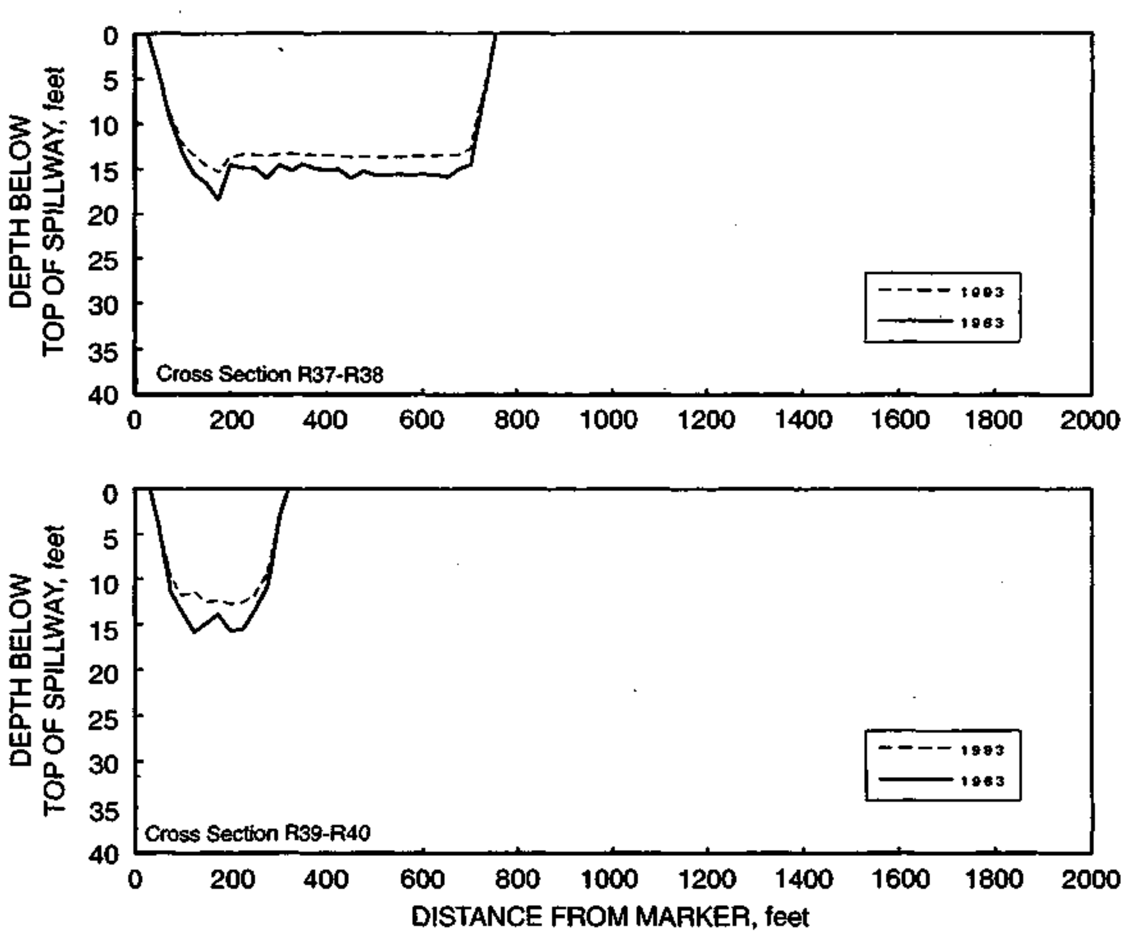
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
1800
2000



DEPTH BELOW TOP OF SPILLWAY, feet
Cross Section R33-R34
1993
1963



DEPTH BELOW TOP OF SPILLWAY, feet
Cross Section R35-R36
1993
1963
DISTANCE FROM MARKER, feet



DEPTH BELOW TOP OF SPILLWAY, feet
1993
1963
Cross Section R37-R38
Cross Section R39-R40
DISTANCE FROM MARKER, feet

APPENDIX II. GRAIN SIZE DISTRIBUTIONS

Core section depths refer to the depth below the sediment surface. Samples were collected at the midpoint of the transect.

PS1: R1 to R2
Surface sediments

Grain size	*Percent finer*
0.031	97.33
0.016	91.85
0.008	85.85
0.004	81.13
0.002	72.84

PS2: R1 to R2
Core section 0.6 to 0.8 feet

Grain size	*Percent finer*
0.031	97.84
0.016	90.57
0.008	81.64
0.004	72.97
0.002	64.55

PS3: R3 to R4
Surface sediments

Grain size	*Percent finer*
0.031	97.69
0.016	94.05
0.008	87.42
0.004	82.86
0.002	74.02

PS4: R5 to R6
Surface sediments

Grain size	*Percent finer*
0.031	99.26
0.016	97.08
0.008	93.1
0.004	89.25
0.002	78.61

PS5: R7 to R8
Surface sediments

Grain size	*Percent finer*
0.031	97.59
0.016	95.27
0.008	89.72
0.004	83.67
0.002	75.93

PS6: R9 to R10
Surface sediments

Grain size	*Percent finer*
0.031	97.59
0.016	95.27
0.008	89.72
0.004	83.67
0.002	75.93

Appendix II. Continued

PS7: R9 to R10
Core section 1.2 to 1.4 fee

Grain size	*Percent finer*
0.031	100
0.016	97.08
0.008	93.48
0.004	86.56
0.002	76.05

PS8: R11 to R12
Surface sediments

Grain size	*Percent finer*
0.031	98.35
0.016	95.17
0.008	89.7
0.004	81.05
0.002	69.98

PS9: R13 to R14
Surface sediments

Grain size	*Percent finer*
0.031	96.17
0.016	94.62
0.008	89.47
0.004	80.44
0.002	68.58

PS10: R15 to R16
Surface sediments

Grain size	*Percent finer*
0.031	98.09
0.016	96.07
0.008	90.73
0.004	79.06
0.002	66.48

PS11: R15 to R16
Core section 2.0 to 2.1 feet

Grain size	*Percent finer*
0.031	56.59
0.016	41.12
0.008	29.21
0.004	21.23
0.002	17.18

PS12: R17 to R18
Surface sediments

Grain size	*Percent finer*
0.031	99.1
0.016	95.82
0.008	88.5
0.004	77.51
0.002	64.38

Appendix II. Continued

PS13: R19 to R20
Surface sediments

Grain size	*Percent finer*
0.031	98.47
0.016	94.1
0.008	84.19
0.004	70.24
0.002	56.97

PS14: R21 to R22
Surface sediments

Grain size	*Percent finer*
0.031	98.3
0.016	95.28
0.008	85.03
0.004	69.73
0.002	55.45

PS15: R21 to R22
Core section 1.5 to 1.7 feet

Grain size	*Percent finer*
0.031	73.94
0.016	68.56
0.008	60.32
0.004	49.57
0.002	37.64

PS16: R23 to R24
Surface sediments

Grain size	*Percent finer*
0.031	93.33
0.016	83.75
0.008	65.91
0.004	50.88
0.002	39.48

PS17: R25 to R26
Surface sediments

Grain size	*Percent finer*
0.031	92.83
0.016	77.8
0.008	53.19
0.004	37.5
0.002	30.39

PS18: R25 to R26
Core section 0.8 to 0.9 feet

Grain size	*Percent finer*
0.031	95.13
0.016	79.21
0.008	60.12
0.004	44.71
0.002	36.17

Appendix II. Continued

PS19: R27 to R28
Surface sediments

Grain size	*Percent finer*
0.031	90.17
0.016	64.64
0.008	41.6
0.004	30.5
0.002	27.35

PS20: R27 to R28
Core section 1.5 to 1.6 feet

Grain size	*Percent finer*
0.031	94.27
0.016	84.36
0.008	65.54
0.004	49.91
0.002	41.00

PS21: R29 to R30
Surface sediments

Grain size	*Percent finer*
0.031	81.71
0.016	43.43
0.008	21.71
0.004	14.75
0.002	11.94

PS22: R29 to R30
Core section 1.3 to 1.5 feet

Grain size	*Percent finer*
0.031	84.37
0.016	61.16
0.008	41.44
0.004	32.65
0.002	28.67

PS23: R29 to R30
Core section 2.5 to 2.6 feet

Grain size	*Percent finer*
0.031	89.81
0.016	70.85
0.008	50.39
0.004	38.09
0.002	31.6

PS24: R31 to R32
Surface sediments

Grain size	*Percent finer*
0.031	57.73
0.016	33.69
0.008	23.38
0.004	18.32
0.002	16.03

Appendix II. Concluded

PS25: R31 to R32
Core section 1.0 to 1.2 feet

Grain size	*Percent finer*
0.031	66.47
0.016	39.95
0.008	29.83
0.004	24.7
0.002	22.21

FS26: R31 to R32
Core section 2.2 to 2.4 feet

Grain size	*Percent finer*
0.031	39.41
0.016	27.96
0.008	20.44
0.004	17.5
0.002	15.04

PS27: R35 to R36
Surface sediments

Grain size	*Percent finer*
0.031	91.02
0.016	63.43
0.008	34.36
0.004	24.61
0.002	22.14

PS28: R33 to R34
Surface sediments

Grain size	*Percent finer*
0.031	94.96
0.016	82.77
0.008	64.75
0.004	50.07
0.002	42.22

PS29: R39 to R40
Surface sediments

Grain size	*Percent finer*
0.031	97.63
0.016	92.44
0.008	80.38
0.004	66.15
0.002	55.43