State Water Survey Division
SURFACE WATER SECTION
AT THE
UNIVERSITY OF ILLINOIS

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SEDIMENTATION SURVEY OF HIGHLAND SILVER LAKE HIGHLAND, ILLINOIS

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Prepared for
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SEDIMENTATION SURVEY OF HIGHLAND SILVER LAKE, HIGHLAND, ILLINOIS

Introduction

The Illinois State Water Survey has completed a sedimentation survey of Silver Lake, the water supply reservoir for the City of Highland, Illinois. The results of the July 1981 survey are presented in this report.

This project was completed as part of the regular work of the Water Survey under the administrative guidance of Stanley A. Changnon, Jr., Chief, and Michael L. Terstriep, Head of the Surface Water Section.

Field data were collected by a crew from the Water Survey consisting of the author; William Fitzpatrick, Technical Assistant; and Dale Goeke, student employee.

Samples were analyzed by the Water Survey's sediment laboratory under the direction of Michael V. Miller. Figures for the report were prepared under the direction of John W. Brother, Jr., and the report was edited by Gail Taylor. The camera copy of the report was prepared by Kathleen Brown, Pamela Lovett, and Lynn Weiss.

Reservoir Location

Silver Lake is located on Silver Creek, a tributary to the Kaskaskia River in Madison County. The dam for the reservoir is about one-half mile northwest of the City of Highland in Section 30, Township 4N., Range 5W. The lake lies entirely within Madison County. The spillway elevation of the reservoir is 500 ft above mean sea level.

Watershed

The watershed of the reservoir is primarily agricultural land with fairly low slopes. The watershed is currently the subject of an intensive monitoring program. More information will be available in the summary reports from this project. A map of the watershed is shown in figure 1.

Historical Background

In the early 1900s, water supply in the City of Highland was from private wells with a series of cisterns constructed for fire protection use.

In 1909, Harper Brother's Consulting Engineers of East St. Louis made recommendations for a public water supply (Harper, 1909). This water supply would be based on Silver Creek pumpage as well as on the use of a small impounding reservoir when Silver Creek was dry or muddy.

Because of voter disapproval, the city did not follow through on the plan suggested by the consultants. However, two industries in the city, a brewery and a condensed milk company, combined resources and built the reservoir in order to assure themselves of an adequate supply of water for their production. In about 1915, the city joined in the use of this supply.

The lake constructed was a 30 million gallon reservoir on the site of the city's old reservoir. The capacity of this reservoir was later increased to about 120 million gallons.

Following the severe drawdown of this reservoir during the period of the drought in the early 1950s, plans were developed by Backus and Pfieffer Consulting Engineers of Highland for construction of a reservoir on Silver

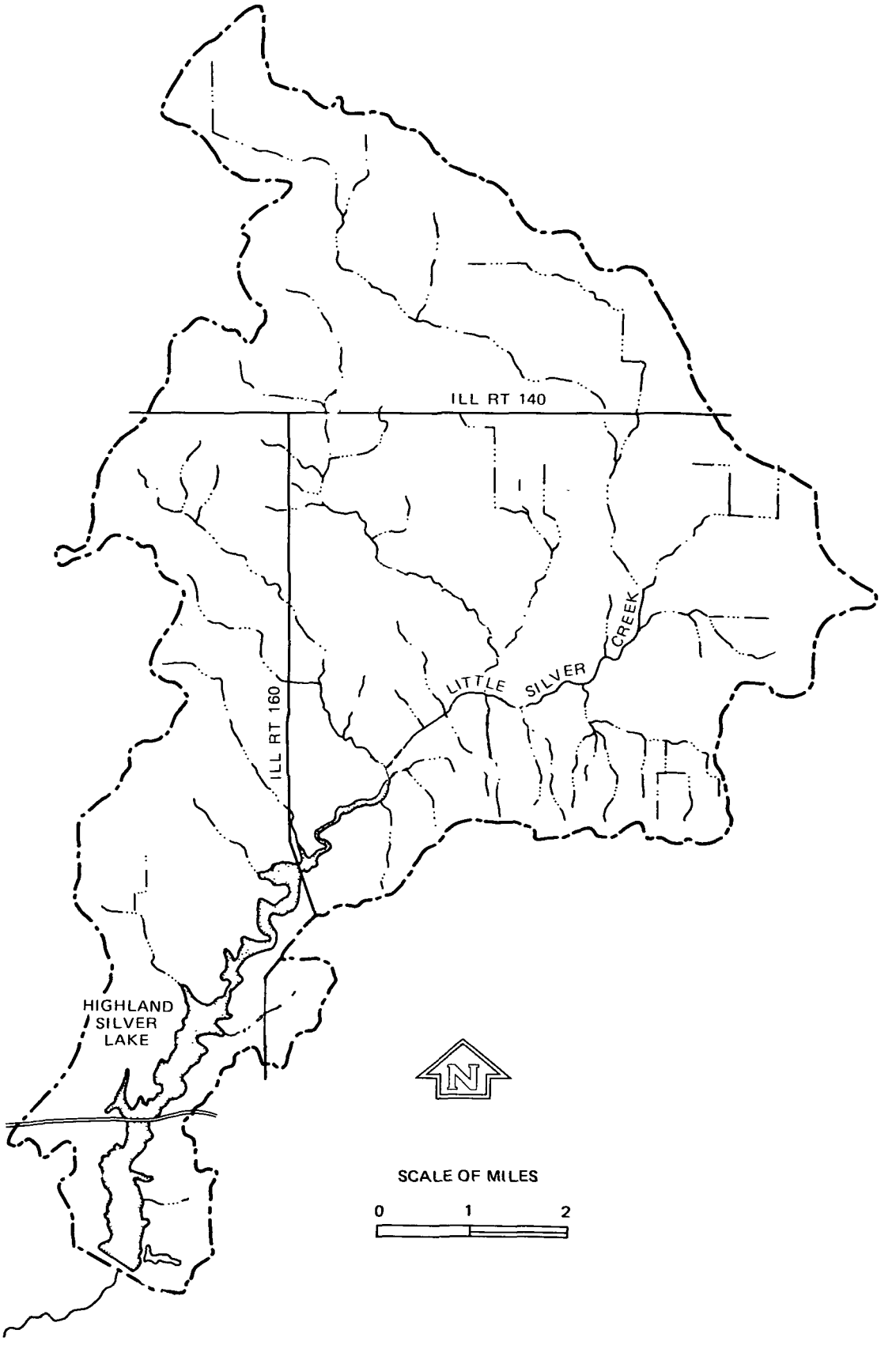


Figure 1. Watershed and location map of Highland Silver Lake

Creek. This reservoir (Silver Lake) was built, and storage was begun, in 1961.

The watershed is the subject of a cooperative study by the Water Survey, the Illinois Environmental Protection Agency, and Southwestern Illinois Planning Commission to evaluate the effects of applying erosion control technology to improve water quality in Silver Creek and Silver Lake.

Sediment Survey

During the survey, 15 primary range lines were laid out for determining the sedimentation rate of the lake as a whole. In addition, 8 secondary range lines were laid out for study of the small bay immediately upstream of the I-70 bridge. The watershed of this bay is the subject of an intensive evaluation.

The location of the primary range lines are shown in figure 2 and the location of the secondary range lines are shown in figure 3. Primary range lines were monumented using concrete markers, and secondary range lines were monumented by steel fence posts.

In the survey, sounding data were collected at regular intervals along each range line to determine both the original and current depths of the reservoir. All depth measurements were made with a 2-inch-diameter aluminum pole marked in tenths of feet. The pole was first lowered until it touched the current lake bottom, and a depth measurement was made. The pole was then pushed through the accumulated sediment until it hit the solid original lake bed, where another depth measurement was made. Horizontal control on each cross section was maintained either by a marked cable or by a cable with a meter.

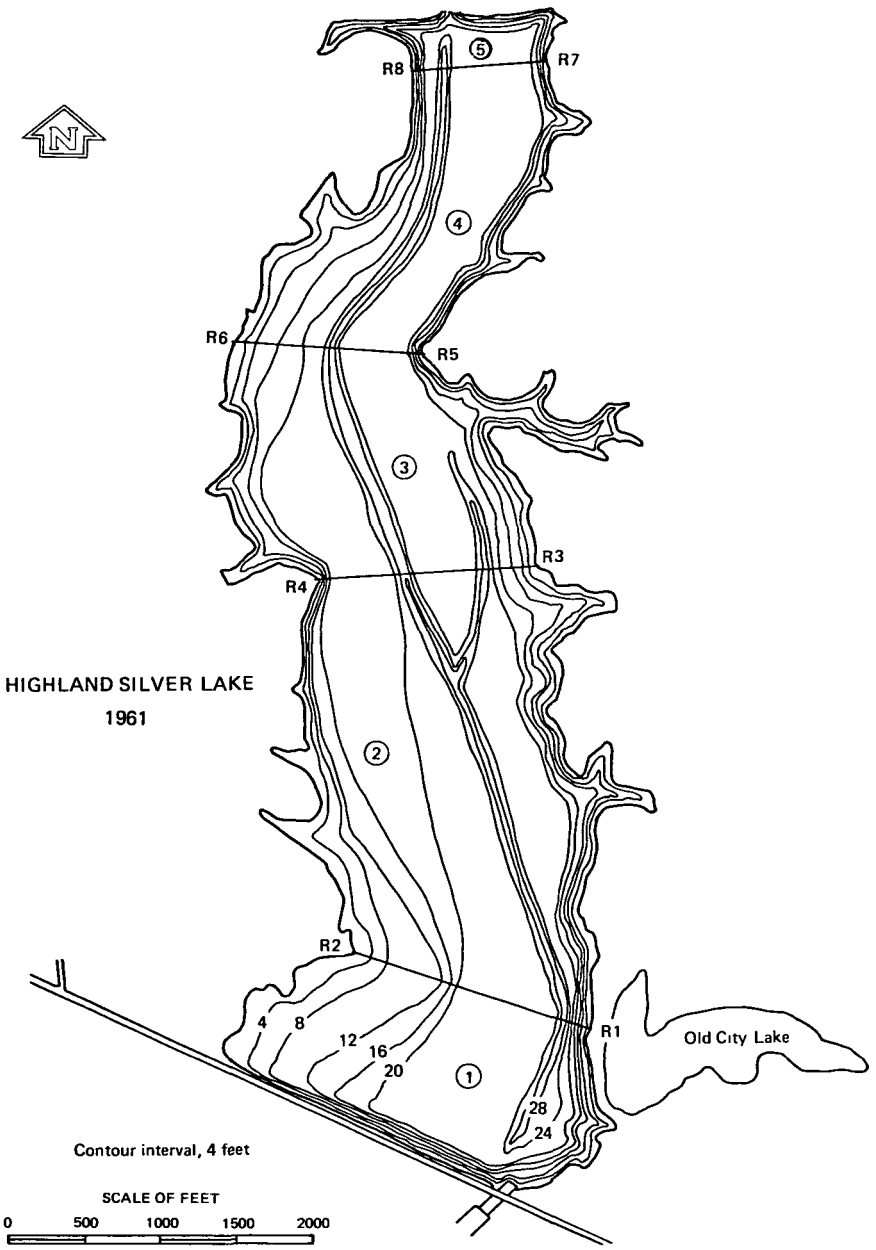
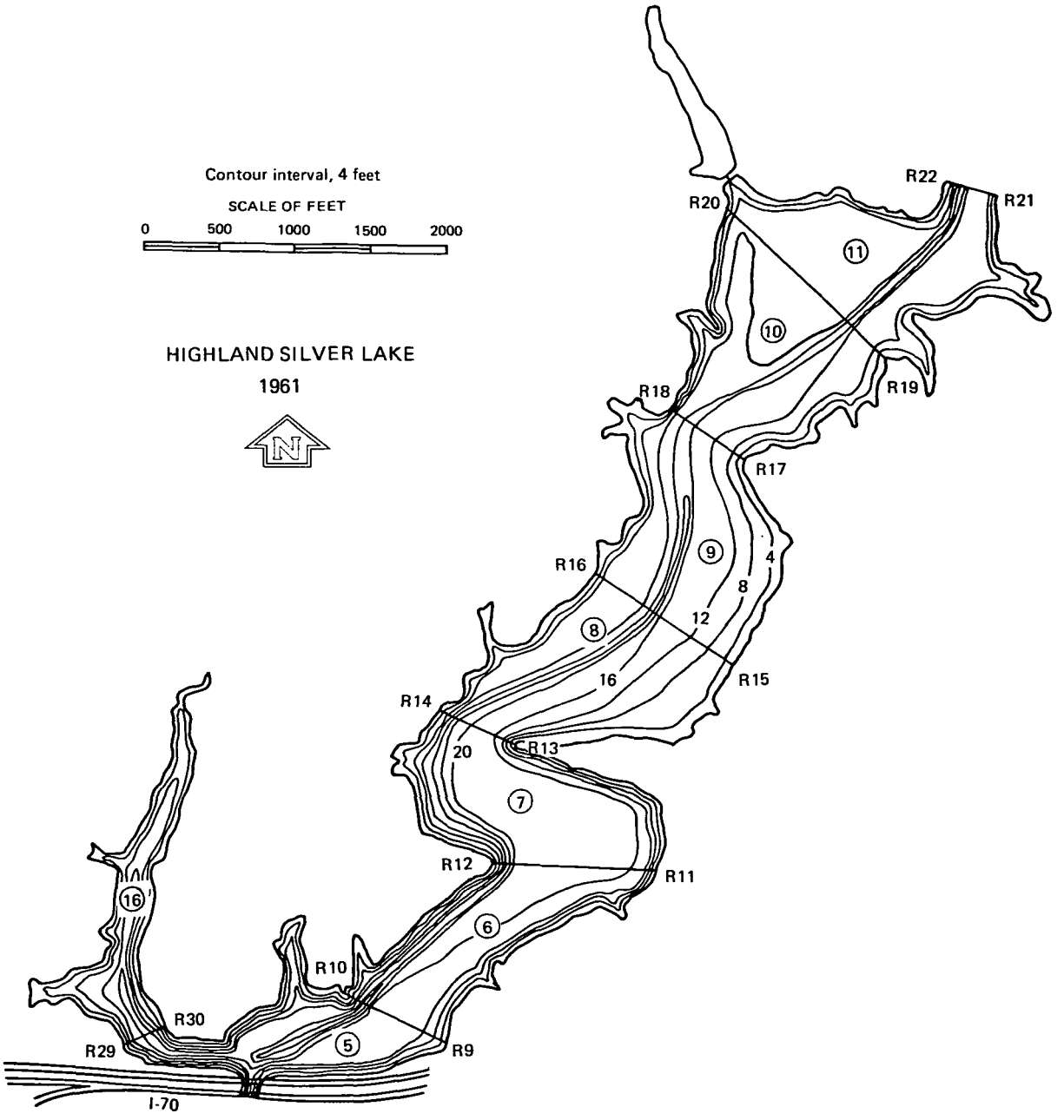


Figure 2. Highland Silver Lake original depth contours and cross section locations



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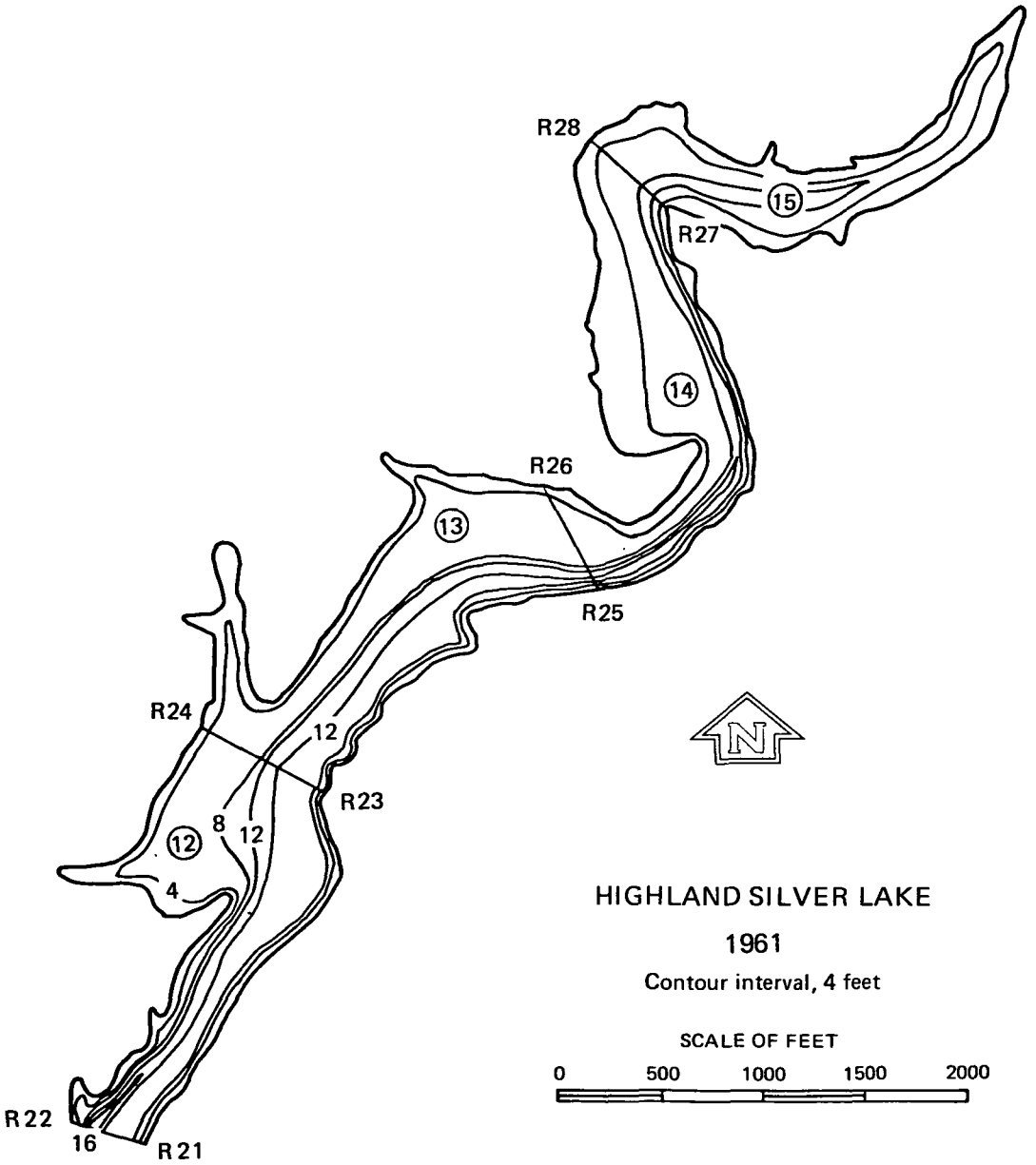

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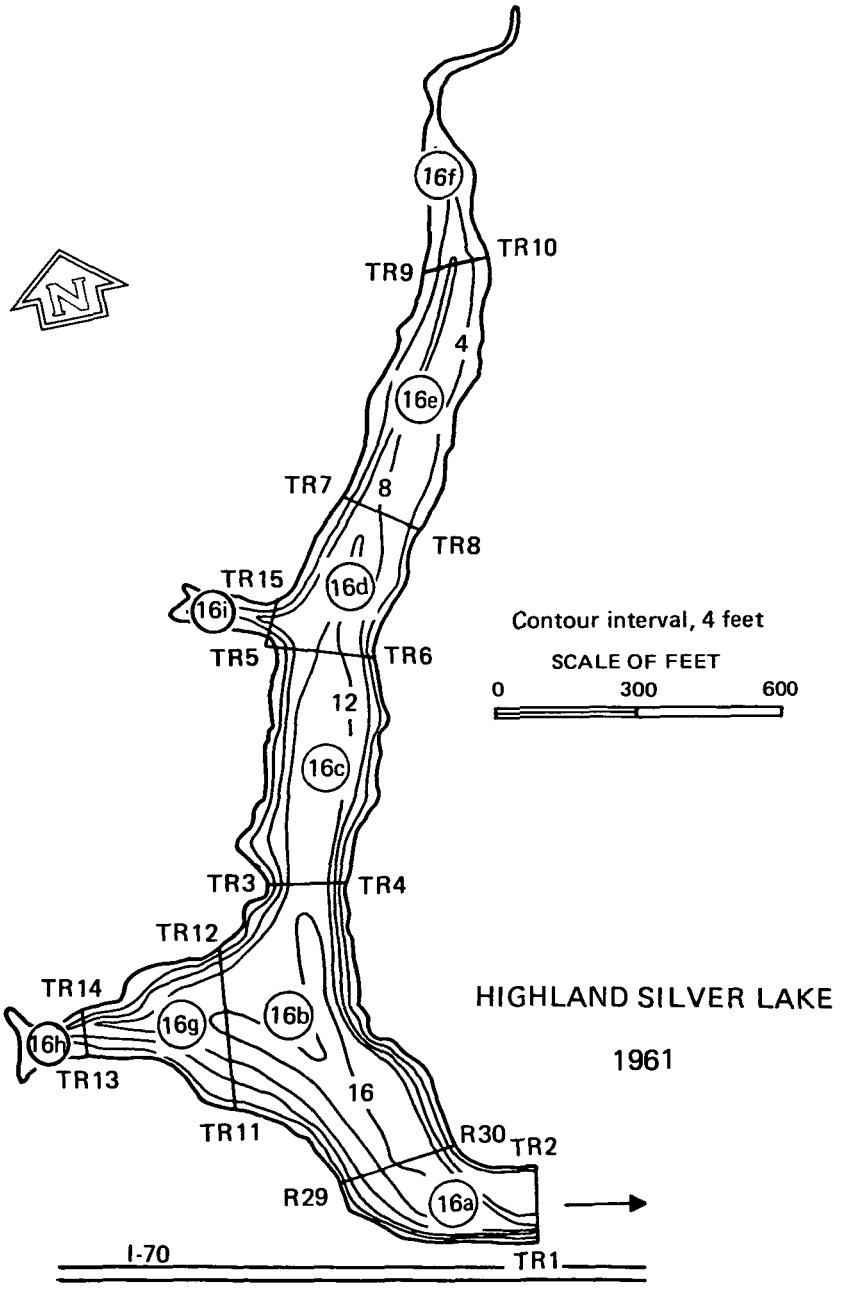


Figure 3. Segment 16 bay original depth contours and cross section locations

Samples of the accumulated sediments were collected during the survey for determining particle size distribution and unit weight of the sediments.

Sedimentation Calculations

The sounding data from the survey were used to determine the original storage capacity of the reservoir and the capacity at the time of the survey. The difference between these storage capacities is the volume of sediment that has accumulated since construction of the reservoir in 1961.

The volume calculations were made for both the reservoir and the bay using two methods, the Dobson Prismoidal Formula and the contour method calculation as described in the National Engineering Handbook of the Soil Conservation Service, Section 3 (SCS, 1968).

Results and Analysis

The results of the survey indicate that 995 acre-ft of sediment weighing 866 thousand tons accumulated in the reservoir between 1961 and 1981. This has resulted in a 13.6% reduction in the capacity of the reservoir.

Table 1 summarizes the results of the survey for the lake as a whole and indicates that sediment input to the lake averages 72.5 cubic feet per year from each acre of land in the watershed. On the basis of the average unit weight (40 pounds per cubic foot) of 22 samples collected at the time of the survey, this amounts to 1.45 tons per acre per year by weight. The annual rate of capacity loss in the lake has been 0.69% per year. This is close to the average of sedimentation rates in other Illinois reservoirs.

Table 2 summarizes the results of the survey by segments as indicated in figure 2. These values indicate the amount of sediment that has

Table 1. Summary of Sedimentation Data
Highland Silver Lake

Age	**Years**		
Built November, 1961			
Survey July, 1981	19.7		
Watershed	**Sq mi**	**Acres**	
Total area	48.4	30,946	
Area excluding lake	47.4	30,348	
Reservoir			
	Sq mi	**Acres**	
Surface area at spillway level	0.94	598.4	
Storage capacity at spillway level	**Acre-feet**	**Mil gal**	
1961	7,331	2389	
1981	6,336	2064	
Capacity per square mile of drainage area*	**Acre-feet**		
1961	151		
1981	131		
Sedimentation	**Acre-feet**		
1961-1981	995		
Average annual accumulation of sediment**			
	Acre-feet from entire watershed		
1961-1981	50.5		
	Acre-feet per square mile		
1961-1981	1.07		
	Cubic feet per acre		
1961-1981	72.5		
	Tons per acre		
1961-1981	1.45		
	Percent of original storage	**Percent per year**	
Depletion of original storage			
1961-1981	13.6	0.69	

* Includes area of lake
** Excludes area of lake

Table 2. Summary of Sedimentation Data for Highland Silver Lake

Segment*	Volume (ac-ft) 1948	1980	Loss of original capacity % of total	%/yr	Weight of sediment (tons
1	863	792	8.2	0.42	46,546
2	1,767	1,618	8.4	0.43	102,873
3	932	846	9.2	0.47	62,748
4	759	678	10.7	0.54	61,570
5	353	310	12.2	0.62	36,244
6	323	283	12.4	0.63	34,325
7	357	300	16.0	0.81	46,803
8	366	302	17.5	0.89	54,363
9	300	253	15.7	0.80	42,891
10	309	254	17.8	0.90	48,515
11	316	251	20.6	1.04	52,947
12	213	155	27.2	1.38	65,562
13	194	127	34.5	1.75	77,487
14	136	73	46.3	2.35	77,800
15	55.1	25.7	58.4	2.71	37,780
16	87.9	68.4	22.2	1.13	17,583
Total	7,331	6,336			866,000
Percentage of total volume lost			13.6	0.69	

*Refer to figure 2 for locations of segments

accumulated in each segment by volume, percent of original capacity lost, and weight. The rate of capacity loss in percent per year shows a generally increasing trend from the dam to the headwaters of the reservoir. This results from initial release of sediment load as the moving creek water enters the reservoir and releases the coarser portion of its sediment load. The sediment load is released faster near the headwaters of the reservoir and more slowly near the dam where only finer materials will remain in suspension.

Table 3 summarizes the results of the survey of the segment 16 bay by sub-segments as indicated in figure 3. A comparison of the sedimentation rate in this bay with the sediment delivery from the watershed has not been made at. this time because of the backwater influence of the main body of the reservoir on sedimentation in the bay.

Figures 2 and 3 show the 1961 contours of the bottoms of the lake and bay, respectively. Figures 4 and 5 show the July 1981 contours of the reservoir and bay. These contour maps were used to develop the stage-volume-area relationships for the reservoir and bay shown in figures 6 and 7. On these graphs the horizontal distance between the volume or area curves indicates the volume or area change of the reservoir or bay at a particular stage.

The 1981 curves on these graphs can be used, with some adjustment for continuing sedimentation, to determine the volume and area of the reservoir given a stage below the spillway elevation.

As an example of the use of figures 6 and 7, in figure 6 the 1981 volume and area when the water level is 10 feet below the spillway level were 1850 acre-ft and 310 acres, respectively. The corresponding values for 1961 were 2600 acre-feet and 355 acres. In 1981, there were 750

Table 3. Segmental Summary of Sediment Data for Highland Silver Lake, Segment 16

Sub-segment*	Volume 1962	Volume 1981	% Lost Total	% Lost Average amount
a	12.7	10.3	18.9	0.96
b	45.9	36.6	20.3	1.03
c	23.4	18.7	20.1	1.02
d	11.6	8.9	23.3	1.18
e	10.2	6.6	35.3	1.79
f	2.2	1.1	50.0	2.54
g	10.5	8.1	22.9	1.16
h	0.7	0.4	42.9	2.18
i	1.1	0.8	27.3	1.38
Totals	118.3	91.5		13.24
Percentage of total volume lost			22.6	1.15

*Refer to figure 3 for locations of sub-segments

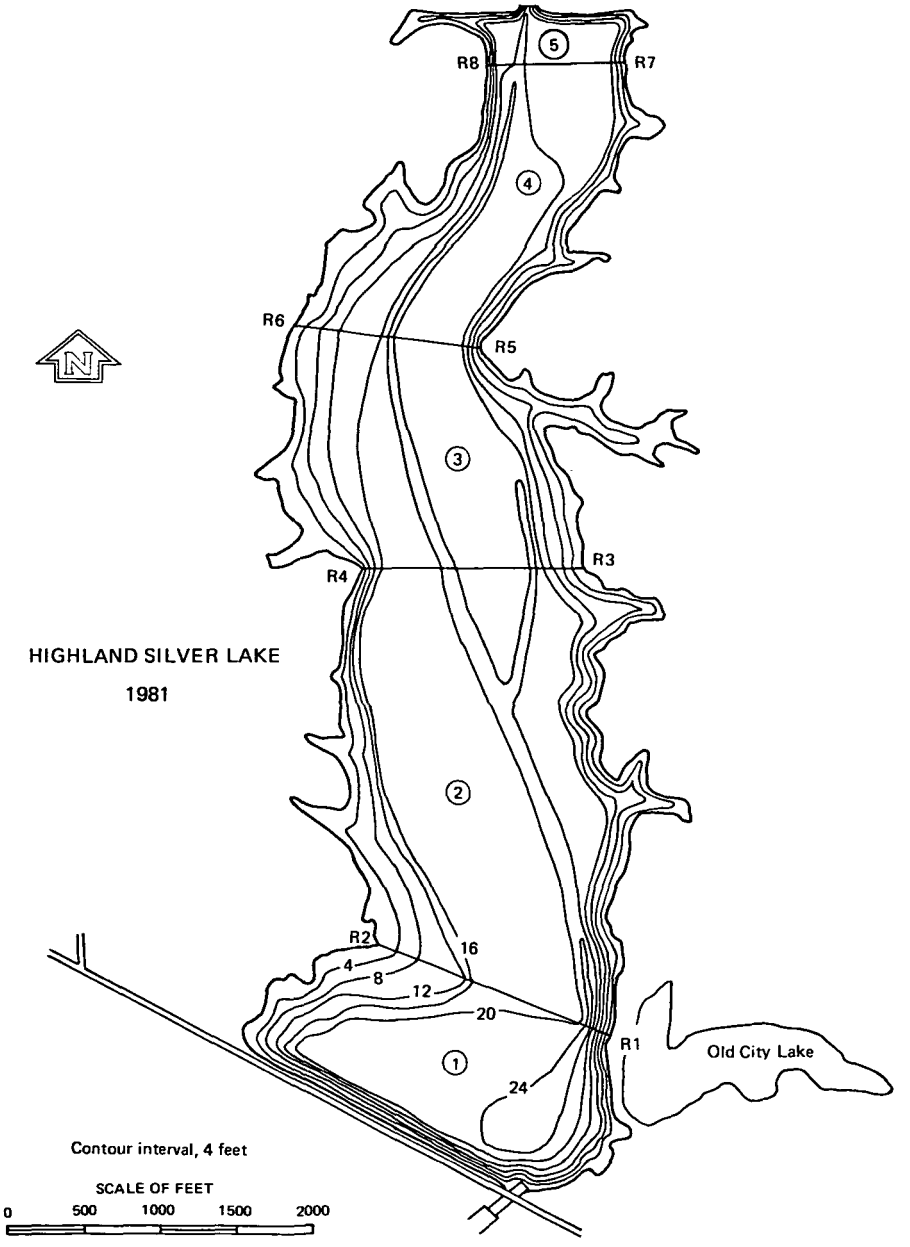
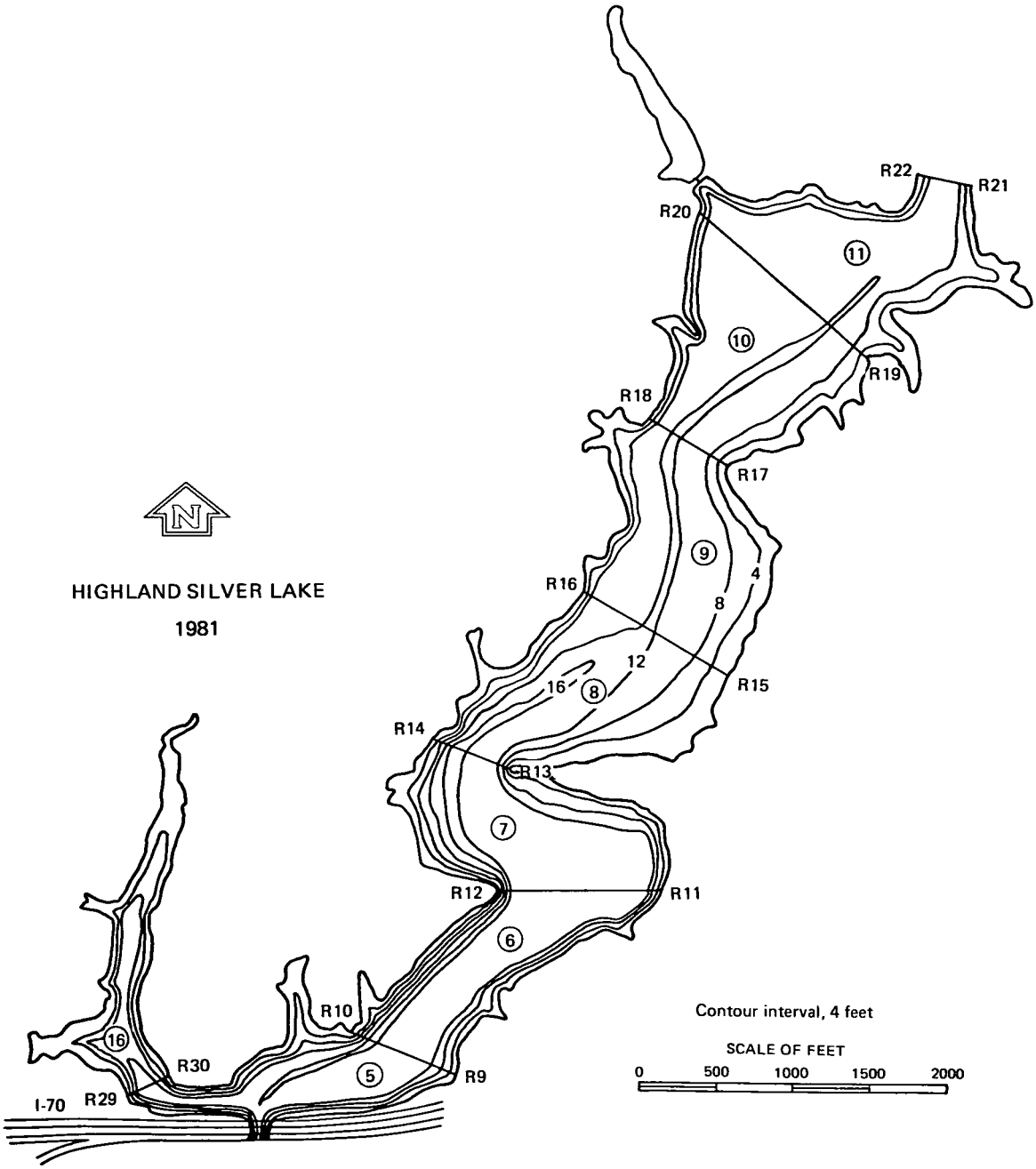


Figure 4. Highland Silver Lake 1981 depth contours and cross section locations



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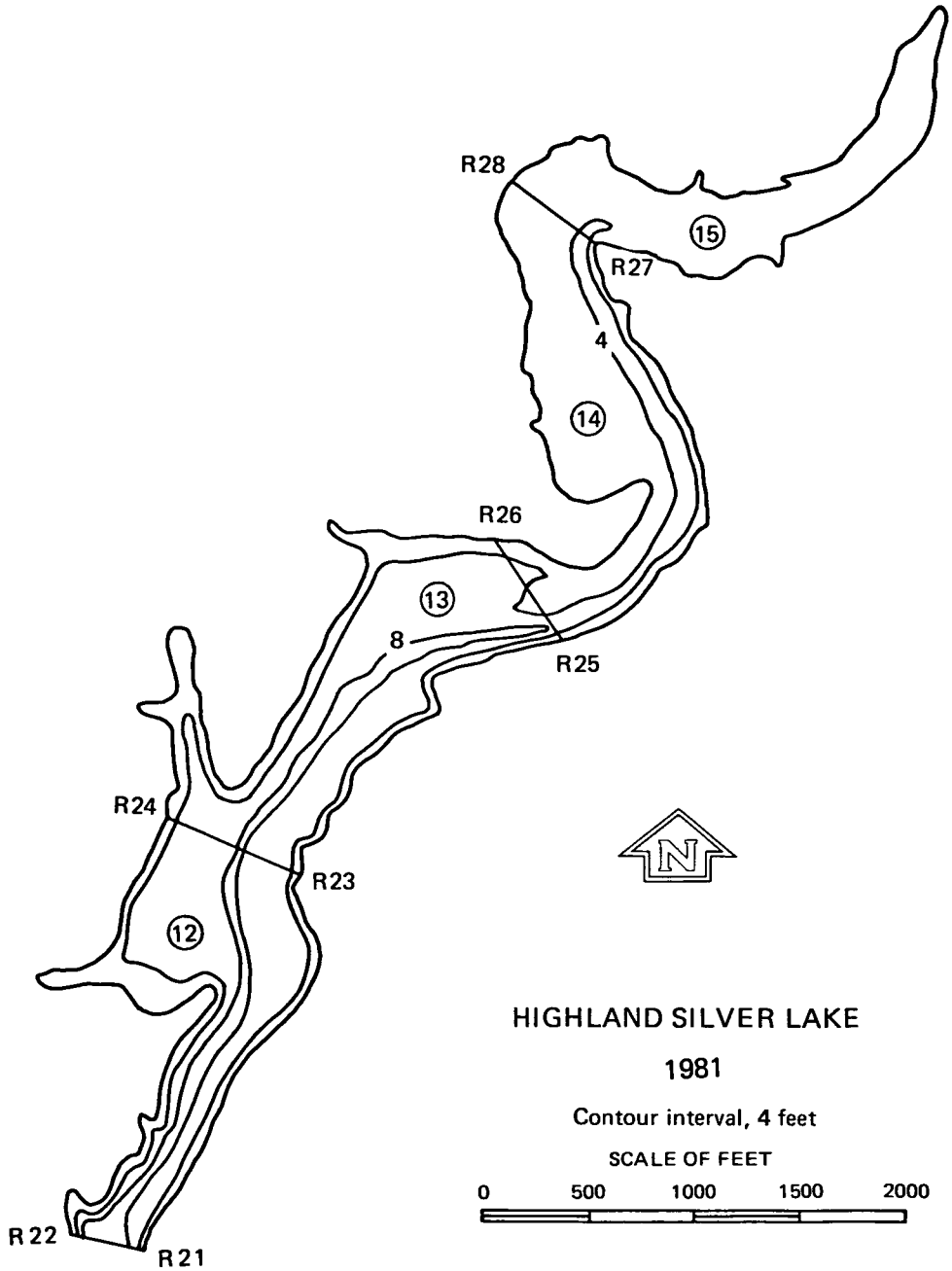

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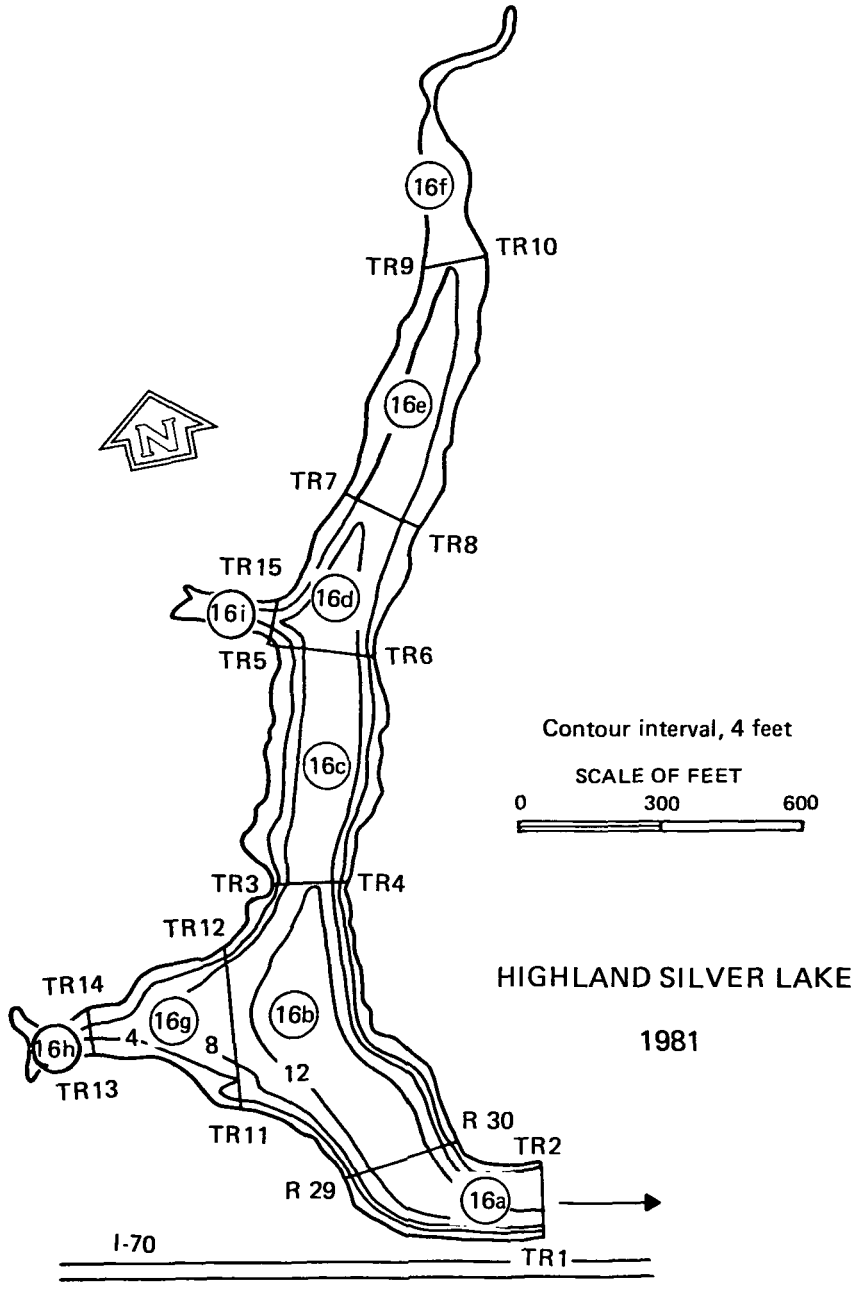

Figure 5. Segment 16 bay current depth contours and cross section locations

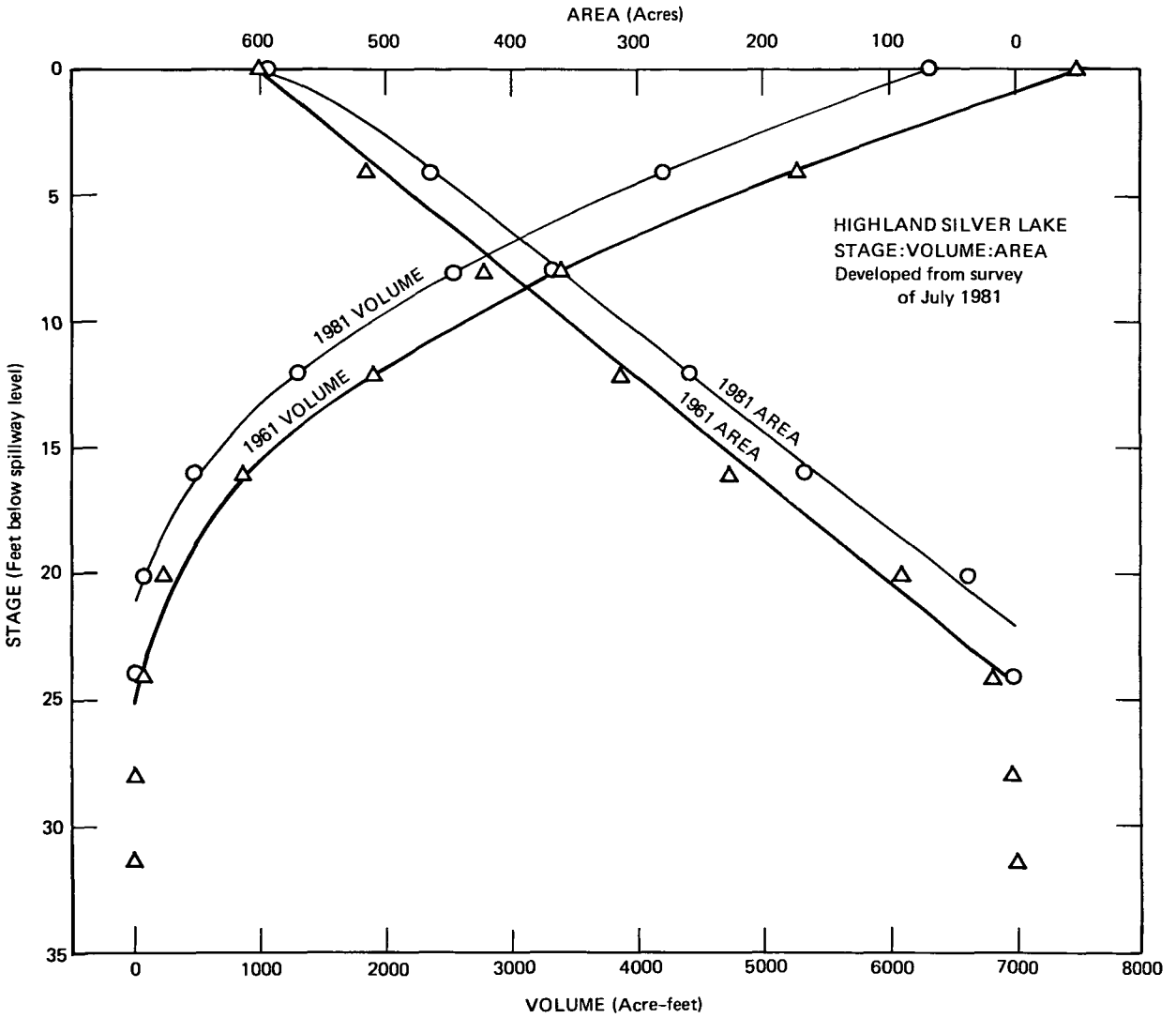

Figure 6. Highland Silver Lake stage-volume-area curves, original and 1981

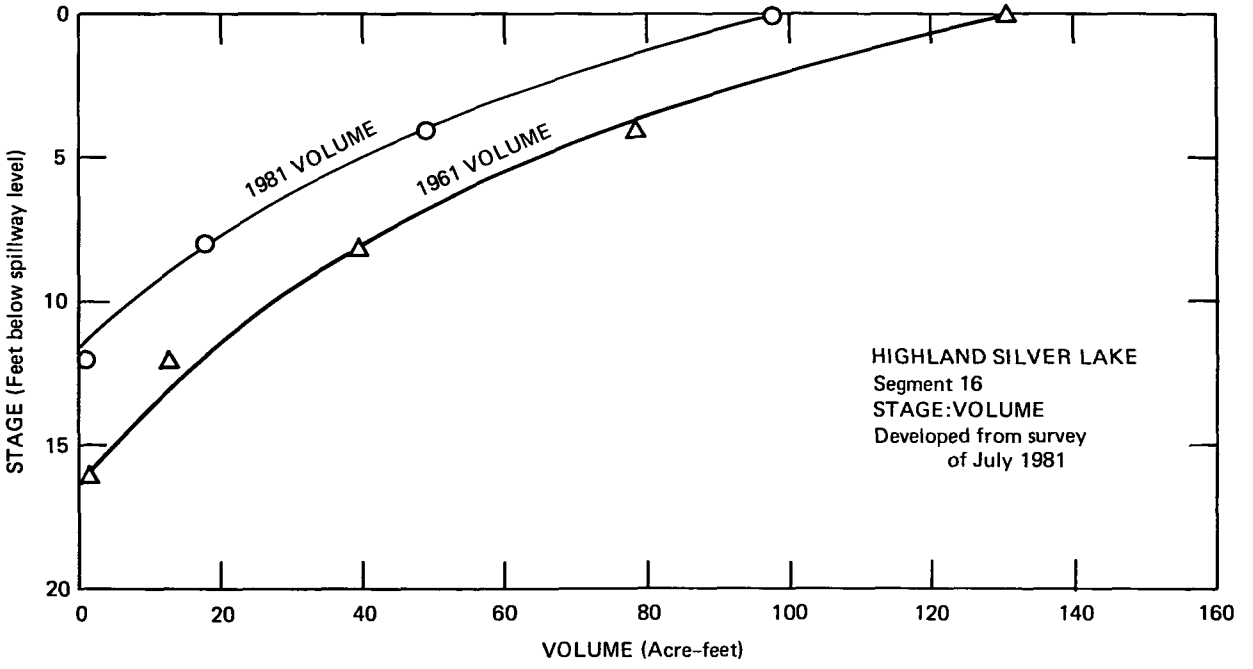

Figure 7. Segment 16 stage-volume curves, original and 1981

acre-feet of sediment below the 10 foot mark. To estimate the capacity of the lake at this water level in the year 2000 when the age of the lake will be 39 years, the following equation can be used:

$$V_{10,2000} = 2600 - [(750 \div 20) \times 39] = 1138$$

$V_{10,2000}$ = the volume of the reservoir in the year 2000 with the water level 10 feet below the spillway elevation. This will be a rough estimate of the future volume of the reservoir at this level. Several factors could seriously affect the accuracy of this value. Among these factors are:

- Changes in agricultural practices in the watershed
- Changes in land use
- Changes in the hydraulics of the watershed, such as channelization of the creek or construction of sedimentation basins
- Changes in precipitation patterns
- Exposure of accumulated sediments to drying and compaction as a result of water level drawdown

Changes in land use and agricultural practices are the most likely of these factors to experience change in the Silver Lake watershed and should be well defined. However, changes in precipitation patterns such as a period of unusually high discharge might result in considerably altered sedimentation patterns.

The particle size distributions of four sediment samples collected at the time of the survey are given in figures 8 and 9. Figure 8 shows the particle size distributions for three samples from the main lake and indicates gradations in sediment sizes from the headwaters of the lake to the dam.

Distribution A in figure 8 is from R27-R28 and represents materials in the headwaters of the lake. Distribution A shows that these materials are

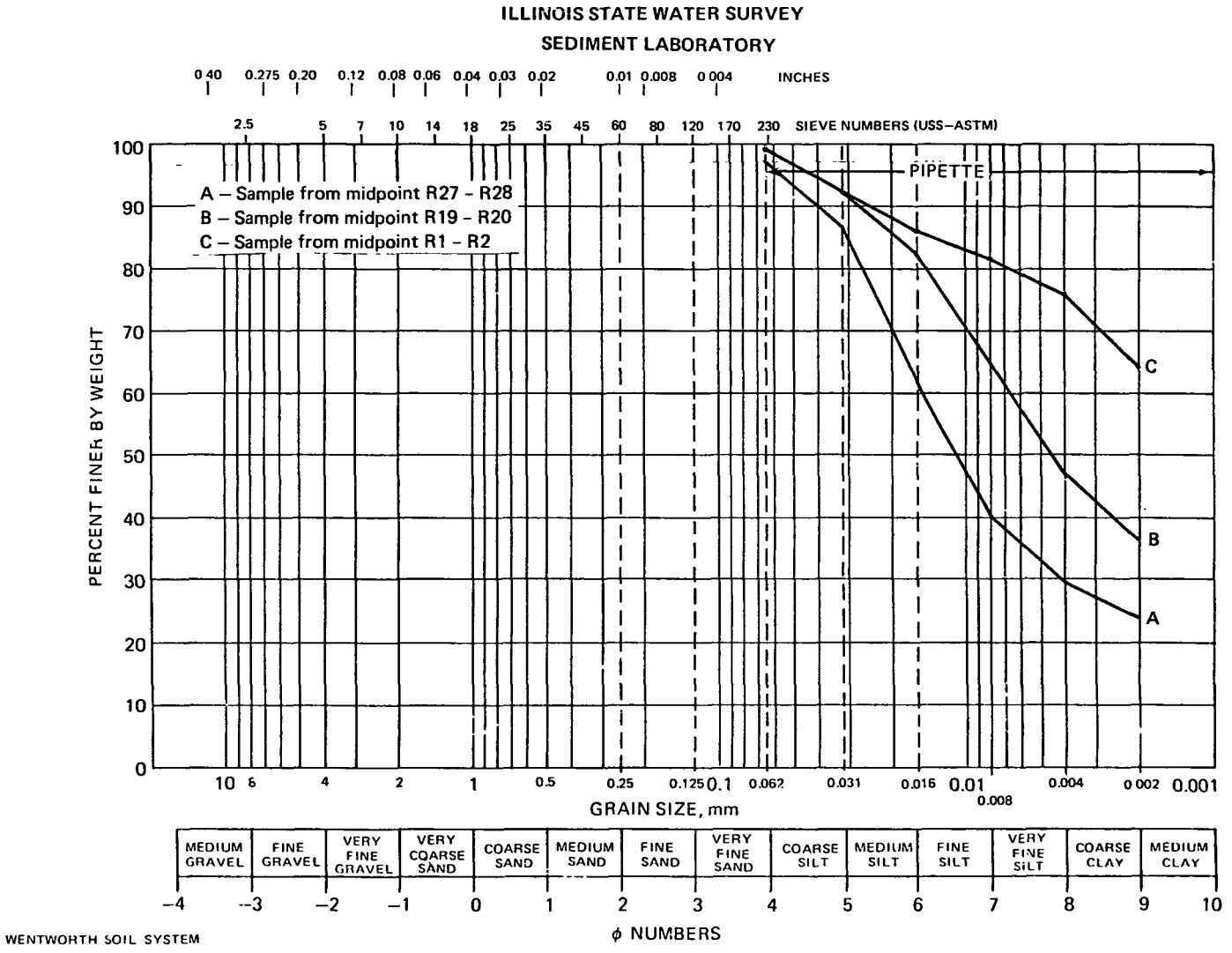

Figure 8. Particle size distribution for sediment samples taken from Highland Silver Lake at R27-R28, R19-R20, and R1-R2 (see figure 2)

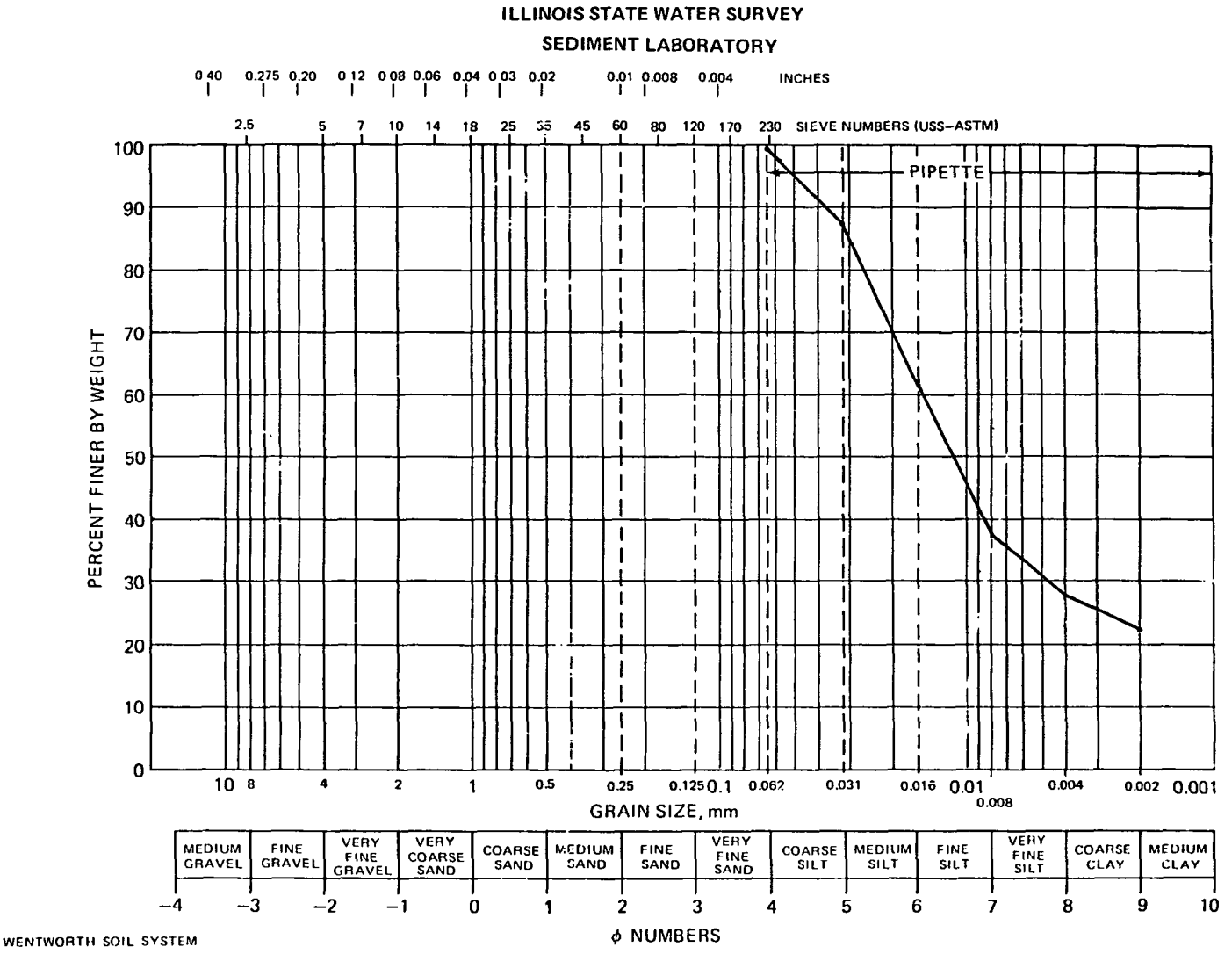

Figure 9. Particle size distribution for sediment sample taken at the midpoint of TR7-TR8 (see figure 3)

principally silt size materials with about 3% sand and about 30% clay. Distribution B shows the sample analysis for sediments in the vicinity of R19-R20 and distribution C shows the sample analysis in the vicinity of R1-R2, which is at the dam. Distribution B shows that the sample was composed of 48% clay and 52% silt while distribution C shows that more than 75% of the sediment accumulated near the dam is clay size material.

These distributions show graphically that as the water moves through the reservoir, the sediment carried in suspension becomes finer and finer as coarser materials settle out in the upper reaches of the lake.

Figure 9 shows the sample analysis for a sample in the bay at segment 16. Note that the size distribution is very similar to the distribution at R27-R28 (distribution A in figure 8) since this bay has its own source of coarser-size materials.

Summary

A sedimentation survey was made of Highland Silver Lake in Madison County, Illinois. The results of the survey indicate that sediments are accumulating in the reservoir at the rate of 50.5 acre-feet per year, reducing the capacity by 0.69% per year. This amounts to 72.5 cubic feet per acre of watershed or 1.45 tons per acre. The lake volume has decreased by 13.6% since its construction in 1961.

References

Soil Conservation Service, 1968. National Engineering Handbook, Section 3, "Sedimentation," Chapters 1, 2, and 7.

Harper, E. F., 1909. Engineer's Report on a Proposed System of Water Works for Highland, Illinois, June 30.