REPORT OF INVESTIGATION NO. 6 1951

STATE OF ILLINOIS

AOLAI E.STEVENSON, Governor

THE SILTING OF LAKE CHAUTAUQUA

Havana, Illinois

J. B. Stall and S. W. Melsted

In Cooperation With
Illinois Agricultural Experiment Station

DEPARTMENT OF REGISTRATION AND EDUCATION

NOBLE J. PUFFER, Director

STATE WATER SURVEY DIVISION

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THE SILTING OF LAKE CHAUTAUQUA HAVANA, ILLINOIS

by

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and

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SUMMARY

1. The Chautauqua Drainage and Levee District was organized in 1916 and constructed the levees which were later to form Lake Chautauqua. The levees were built along the flood plain of the Illinois River north of Havana, Illinois, in Mason County. After being farmed for several years, the area was permanently flooded in 1926.

2. In December, 1936 the federal Fish and Wildlife Service acquired the area and formed the present Lake Chautauqua for use as a refuge for migratory waterfowl. Spillways and control gates were constructed in the levees to allow control of the water level in this side-channel reservoir.

3. The water level in the lake is controlled as nearly as possible to provide good feeding conditions for waterfowl. The only water entering the lake comes from the flow of the Illinois River. The lake has no direct drainage area.

4. The 1950 sedimentation survey of this reservoir showed that in 23.8 years the storage capacity of the lake had been reduced from 14,290 acre feet to 11,680 acre feet, or 18.3 per cent.

5. The average annual sediment deposition in the lake has been 83,230 tons.

6. The average rate of rise of the bed of Lake Chautauqua is 1 foot in 32 years, which is approximately twice as great as the average for the entire unleviedarea of the Illinois River flood plain.

7. Sediment analyses show extremely high carbon and nitrogen contents far in excess of that to be expected from sediment derived from normal soil erosion. This is attributed to the presence of wildlife excreta.

8. The sediment deposited in the lake is quite high in total fertility.

INTRODUCTION

The removal of soil particles from the farm land, the transport of these particles through the gully, stream, and the deposition of these particles at some point along the course is a phenomenon which has a great influence on the economy of the State of Illinois. Investigation of the factors involved in this movement of soil by water is important in furnishing fundamental data. Such data are necessary to the preservation and orderly development of the soil and water resources of the state.

Illinois Program

Over the past twenty years a continuing cooperative study of reservoir sedimentation in Illinois has grown, involving the Illinois State Water Survey Division, the Office of Research of the Soil Conservation Service and the Illinois Agricultural Experiment Station. The objectives of this program are:

1. To establish information on factors affecting sedimentation.
2. To furnish factual data for future reservoir development.
3. To provide data for estimating sedimentation damages to existing and proposed reservoirs.
4. To develop methods of sedimentation control.

Need for This Report

This investigation of the sediment deposition in Lake Chautauqua was carried out to learn more about sedimentation in a side-channel reservoir. This lake has no direct watershed but is fed by water let into the lake from the Illinois River. The methods of operating this reservoir, the manipulation of the water level to the best advantage for wildlife propagation, provide conditions for sediment deposition which are com-

pletely different from conditions found in most artificial lakes studied to date within the state. General views of the lake are shown in Figure 1.

SCOPE OF INVESTIGATIONS

Lake Survey

A detailed survey of Lake Chautauqua was made from July 17 to 28, 1950 by a field party of the State Water Survey Division. In this survey a series of seven sediment cross-sections were taken on the lake. By this means the original and present capacity of the lake were determined as well as the volume of sediment deposited within the lake. In carrying out the survey a permanent monument system was installed so that in future years resurveys may be made to measure the sediment accumulation.

Sediment Samples

During the survey a series of seven sediment samples were taken from various parts of the reservoir by means of a special sampler. These samples were dried and weighed to determine the volume-weight of the sediment deposits in various portions of the lake. On four of these samples, chemical and physical analyses of this sediment have been made.

ACKNOWLEDGEMENT

State Natural History Survey Division

The State Natural History Survey Division was most helpful in the conduct of this survey. Dr. William C. Starrett, Director of the Survey's laboratory at the lake, furnished living quarters to the field party at the laboratory for the entire period of the field work. Dr. Starrett also furnished a boat and outboard engine for the period of field work and himself worked with the field party. Mr. William Nuess, Laboratory Assistant, worked with the party. Frank Bellrose, James Jordan, and Dr. George W. Bennett furnished background material on the past history and present operation of the lake.

Fish and Wildlife Service

The Fish and Wildlife Service of the U. S. Department of Interior owns and operates the lake as a wildlife refuge. Mr. Lyle Schoonover, Refuge Manager, furnished boats and outboard engines for the survey and himself worked with the field party. Mr. Schoonover also furnished water level records and past operational data on the lake. Mr. Ray Sarnes, Laborer-Patrolman, worked with the party for the entire period. Mr. J. Smith, employee of the Service, and a resident of the Chautauqua area for many years furnished much information on the early history of the drainage district and lake.

Department of Conservation

The State Department of Conservation, Leonard Schwartz, Director, contributed very materially to the conduct of this survey. Mr. Sam Parr, Superintendent, Division of Fisheries, was very much interested in the survey and furnished two-way radio equipment to the field party. Mr. William M. Bain, Aquatic Biologist stationed at the laboratory at the lake, worked with the field party.

State Water Survey Division

The survey of Lake Chautauqua was made by a field party of the State Water Survey Division consisting of the following men: J. B. Stall, Chief of Party, L. E. Roberts and B. J. Sayers, Engineering Assistants. This Division made the computations on the results of the reservoir survey including the water and sediment volumes. The report was prepared by J. B. Stall under the supervision of Mr. H. E. Hudson, Head of the Engineering Sub-Division.

Illinois Agricultural Experiment Station

The laboratory analyses of the sediment samples to determine chemical and physical characteristics were made by the Illinois Agricultural Experiment Station, Department of Agronomy, under the supervision of Dr. S. W. Melsted, who wrote the part of the report covering the sediment analyses.

Corps of Engineers

The Chicago District Office of the Corps of Engineers, U. S. Army, cooperated in this survey by furnishing copies of the base map needed for the survey. Maps used were compiled in 1931 by the Corps of Engineers. Maps were made of the Illinois River from the mouth to Lockport at that time.

RESERVOIR

GENERAL INFORMATION

Location

The lake is located on the former flood plain of the Illinois River, north of Havana in Mason County, Illinois, as shown in Figure 2. The southernmost end of the lake is about four miles north and slightly east of Havana. From here the lake extends about 6 miles in a northeasterly direction along the east side of the Illinois River. The lake is generally about one mile in width,

Figure la. View of Lake Chautauqua Looking North

Figure lb. View of Lake Chautauqua Looking South

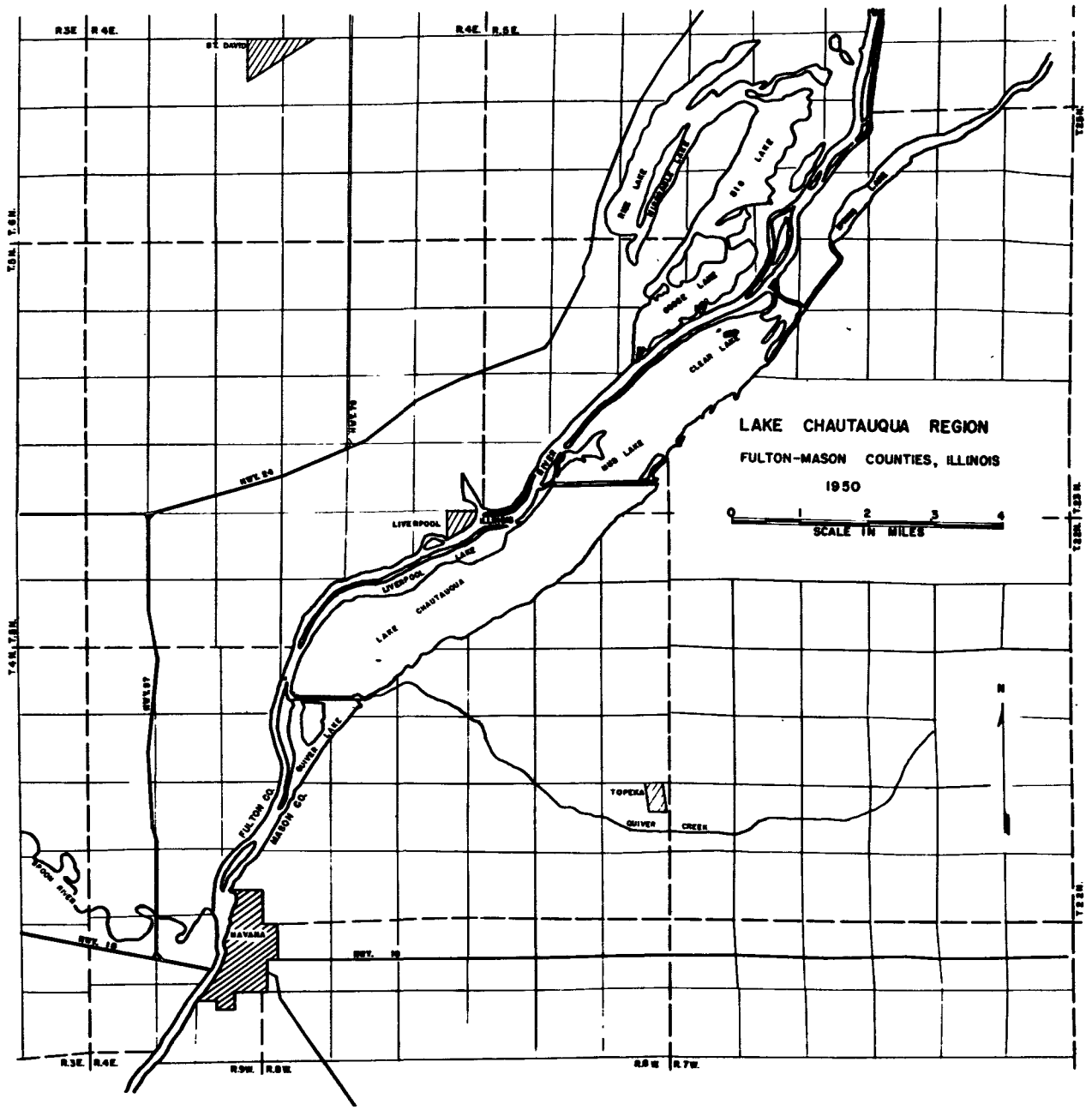

Figure 2. Lake Chautauqua Location Map

being nearly 1 1/2 miles in width at the lower end.

Levees

The lake is formed by levees which confine the waters of the lake on the north, west, and south. The eastern edge of the lake is formed by the east bluff of the Illinois River Valley. The levees were constructed during 1917-1922 by the Chautauqua Drainage and Levee District. Design specifications called for a 12-foot crown on the levee top at elevation 440 mean sea level. Side slopes were to have a 3 to 1 slope. Through the years the levees have been overtopped, washed out, and repaired many times. At the present time it is believed that there are low points in the south and west levees at elevation approximately 436.

Spillways

Improvements carried out by the U. S. Biological Survey, the predecessor of the present Fish and Wildlife Service, included construction of two spillways as shown in Figure 3. The west spillway was constructed to have a total length of 1500 feet; A 350-foot length was at elevation 437.5, and the remaining 1150 feet at elevation 440. 0. The south spillway had a total length of 1000 feet, consisting of a 300-foot length at elevation 437.5 and the remaining 700 feet at elevation 440. 0.

Inlet Control Structures

Improvements carried out by the federal owners of the lake during the period 1936-1939 included construction of two control gate structures. The largest control structure is located at the extreme east end of the north levee. This structure, as shown in Figure 4, consists of four, 12-foot taintor gates. These gates are manipulated throughout the year to maintain the desired water level in the lake.

A smaller control structure is located on the southeast levee. This consists of a concrete conduit 3 feet square with a gate valve enclosed. The location of this conduit is shown in Figure 3. This control valve is utilized on occasion to aid in the maintenance of the desired lake level, but has a much smaller capacity than the taintor gates.

HISTORY

1916

The Chautauqua Drainage and Levee District was organized in 1916 in Mason County covering an area of 3,608 acres. In 1917 a construction assessment was levied in the amount of $236,000 and bonds were issued for an additional $169,920. Construction was begun on the levees and pumping station but was not entirely completed by 1922 when three breaks occurred in the levees. Repair and further construction work continued after the water had receded. In 1924 the first corn was planted in the area but the crop was unsuccessful. In 1924 a fair corn crop was produced in the higher spots of the area.

1926

During heavy rains in October 1926 the west levee broke in two places. One break was near the pumping station and waters practically destroyed the pumping station. At the same time, two breaks occurred in the north levee and two in the south levee. When the water receded the levees were eroded to such a low level that a minor rise in the Illinois River would submerge the south, west and part of the north levee.

The 1926 levee breaks were not repaired immediately. For about 10 years the water level in the lake area would rise and fall with the river and no particular use was made of the area. During this period the lake existed only as a backwater or side-channel reservoir. During high stages the flood waters, heavily laden with sediment would completely inundate the lake area. During this period, sedimentation conditions in the Lake Chautauqua area were very similar to the present adjacent backwater areas of Quiver Lake and Mud Lake. (See Figure 2.)

1936

In December, 1936 arrangements were completed by the U. S. Biological Survey (predecessor of the U. S. Fish and Wildlife Service) for the acquisition of the lake and surrounding dikes for use as a refuge for migratory waterfowl. The total land acquired by the government was 4471 acres. At this time the levee breaks were repaired and much of the levee was rebuilt. Spillways and control gates as described earlier, were constructed to allow the control of the water level within the lake. This improvement work was completed in 1940.

1943

On May 25 to 27, 1943, flood waters broke across and damaged the north levee. The damage was repaired. In Figure 5 is shown the south levee during high water in 1950.

PRESENT OPERATION

Since the improvement of the levees and the completion of the control structures the water level within the lake has been controlled throughout the year, as nearly as possible, in accordance with a "water management plan." This plan is devised at the beginning of each year, and is planned to provide the most desirable feeding conditions during the duck migration seasons.

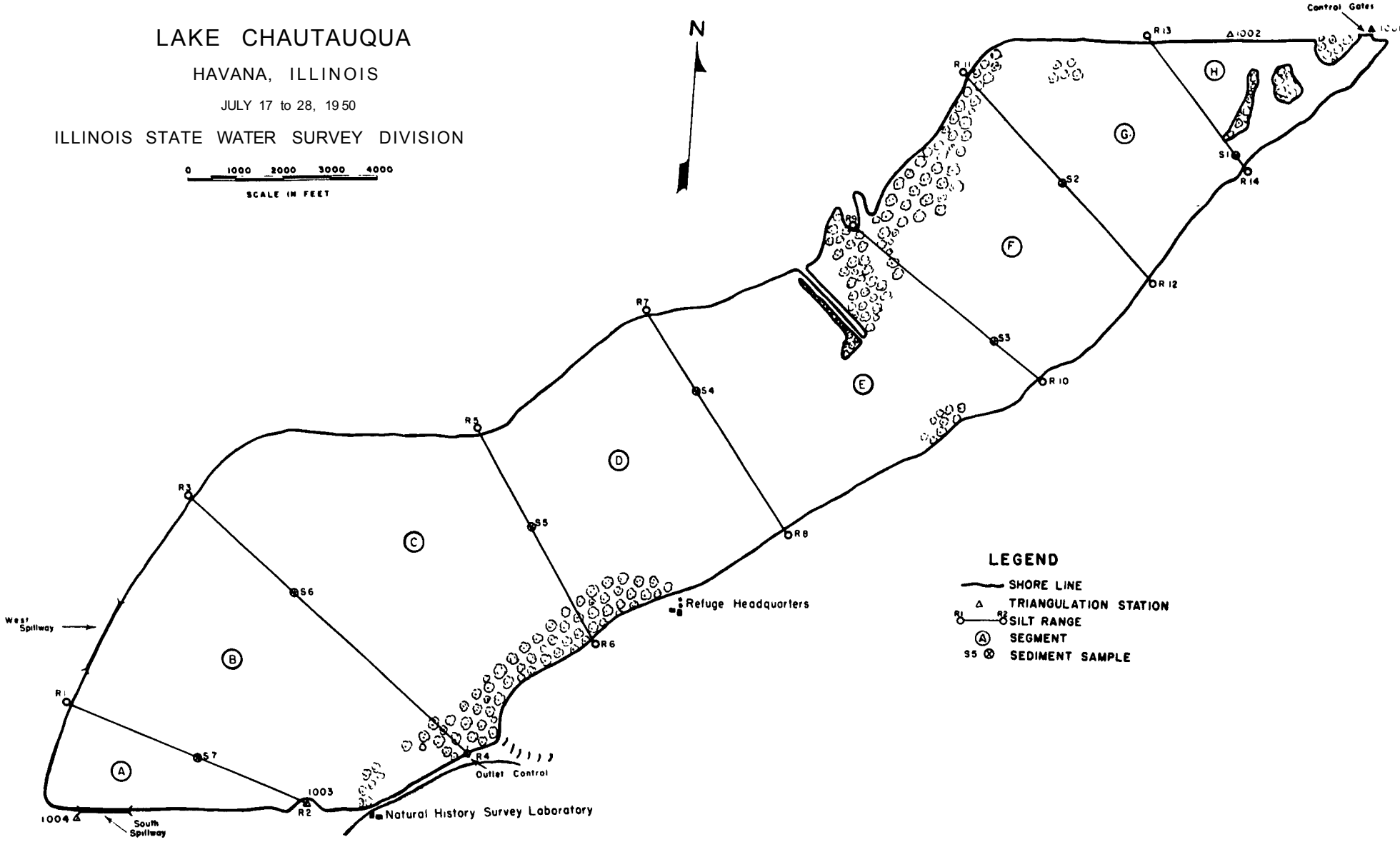

Figure 3. Base Map of Lake Chautauqua

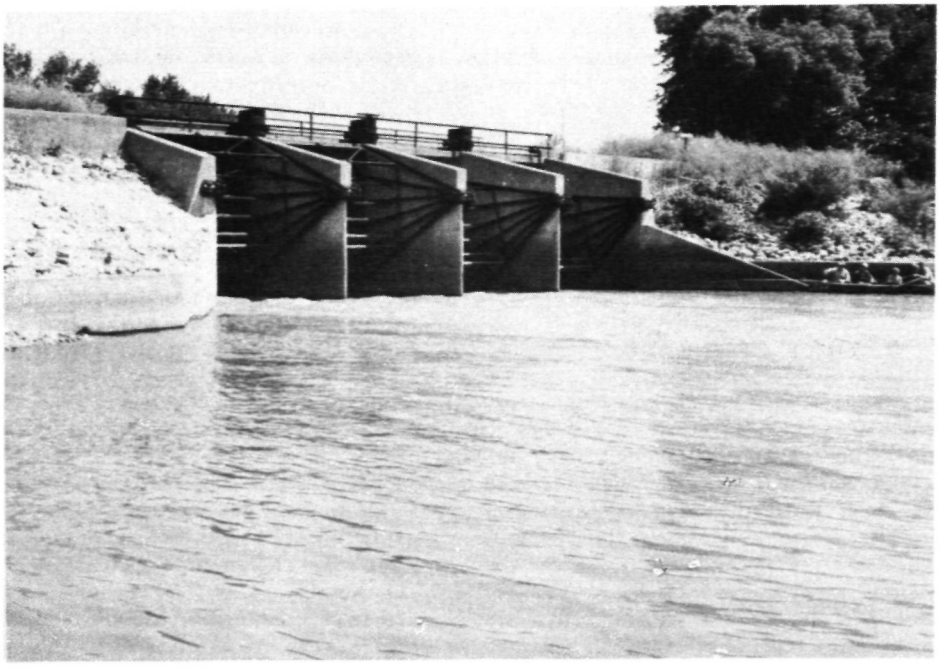

Figure 4. Inlet Gates Located in the North Levee

Figure 5. View Along the Top of the South Levee Looking Westward on July 20, 1950
Note flow into Lake Chautauqua from Quiver Lake (at left).
Water level 439. 1 Mean Sea Level

During the years 1944 to 1949 the water management plan was as follows: from May 1 to September 15 the lake level was maintained as nearly as possible at elevation 434. 5 mean sea level; from September 15 to May 1 the lake level was maintained as nearly as possible at 435. 0. In 1950 the plan was changed and the lake level was maintained at elevation 435.0, as nearly as possible, for the entire year. The only sources of water to. the lake are rainfall directly in the lake and water admitted from the river through the gates.

METHODS OF SURVEY

The original and present storage capacities and the volume of sediment in the reservoir were determined by the range method of survey developed by the Soil Conservation Service and described in their Bulletin No. 524, "Silting of Reservoirs."[1]

Range System

The base maps used for the survey consisted of sheets No. 20 and 22 of the Corps of Engineers 1933 map of the Illinois River from Grafton to Lockport. These had 'a scale of 1 inch to 1000 feet. The water level contour line at "normal pool elevation" (435. 0 M. S. L.) was taken from these maps. A baseline, 3,000 feet in length was chained along the north levee extending west from the control gates. On the south levee, triangulation stations were established at points identifiable from the map. From these control points seven silt ranges were established on the lake as shown in Figure 3. The water depth and sediment thickness were measured along each range.

Measurement of Sediment

Along each range at intervals of 200 feet the water depth and sediment thickness were measured with a sounding pole. This consists of a 1 1/2 inch diameter calibrated aluminum pole as shown in Figure 6. The pole is lowered in the water until it rests lightly on the top of the sediment deposit and thus the present water depth is measured. The pole is then thrust on down through the soft sediment until it strikes the hard soil of the original reservoir bottom. In this manner sediment thickness is measured. As the boat is rowed across the range, and measurements are made, a cross-section is obtained of water depth and sediment thickness. A total of 187 measurements were made on the seven ranges on Lake Chautauqua.

1. Silting of Reservoirs, U. S. Department of Agriculture, Technical Bulletin No. 524, Washington, D. C., U. S. Government Printing Office, 1939.

The accuracy of this method of sediment measurement is dependent upon the presence of a highly compacted original soil layer or pre-reservoir deposit. In Lake Chautauqua no difficulty was experienced in measuring the sediment with the sounding pole. The lake bed had been tilled and was very compact. The sediment in the lake was loosely compacted, having never been exposed to drying of the sun. It had an average density of about 36 pounds per cubic foot. The use of the sounding pole under these conditions was almost ideal. In preliminary soundings the values obtained checked closely with values obtained by use of the "spud" bar, a standard device which obtains samples of sediment at various depths.

Survey Markers

All triangulation stations and range ends were marked permanently in the field with concrete posts 4 1/2 inches square and 4 1/2 feet long. As shown in Figure 7 these posts were set into the ground with about one foot exposed. These permanent markers will be of value in the future when it becomes desirable to make a re-survey of Lake Chautauqua along these same silt ranges.

SEDIMENTATION IN THE RESERVOIR

Summary of Data

Table 1 is a summary of the sedimentation data obtained from this survey of Lake Chautauqua together with data derived therefrom which are pertinent to the sedimentation problem in this lake. Several of the significant findings shown in this summary are:

1. The capacity of the lake for water storage has been reduced from 14,290 acre feet to 11,680 acre feet or 18. 3 per cent in 23. 75 years.
2. Average annual sediment deposition in the lake has been 84, 230 tons.

Distribution of Sediment

The distribution of the storage capacity and the storage loss within the lake are shown in Table 2. For the location of the segments see Figure 3. From the table it is seen that segments E, and F, in the middle portion of the lake have suffered the greatest while the end segments, particularly segment H, have lost capacity at a lesser rate.

Figure 8 shows three typical cross-sections of water and sediment. From these cross-sections it is seen that the deposits in all parts of the reservoir are relatively uniform in thickness across the range. On Range R5-R6 it is noticed that the minor variations in the elevation of the original lake bottom have been concealed by the sediment and the present top of the

Figure 6. Use of the Sounding Pole in Measuring Sediment

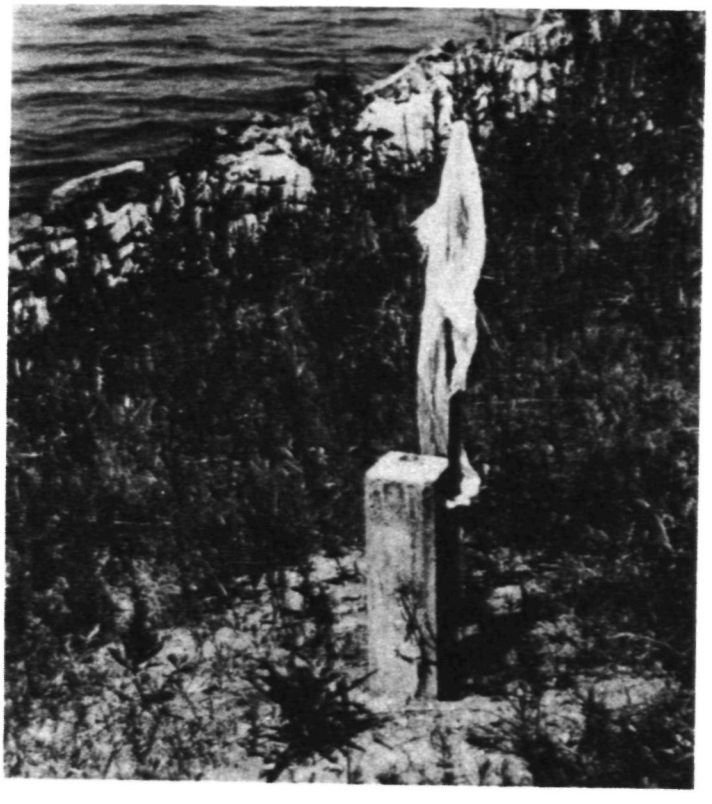

Figure 7. Concrete Post Installed as a Permanent Survey Marker

Table 1

Summary of Sedimentation Data on
Lake Chautauqua
Havana, Illinois

	Quantity	Units
Age[1]	23.75	Years
Reservoir		
Area[2]	3,562.	Acres
Storage Capacity[2]		
Original	14,290.	Acre feet
	4,674.	Mil. Gal.
Present	11,680.	Acre feet
	3,819.	Mil. Gal.
Sedimentation		
Total Sediment	2,614.	Acre feet
	2,000,500.	Tons
Average Annual Sediment Accumulation		
By Volume	110.	Acre feet
By Weight[3]	84,230.	Tons
Depletion of Storage		
Loss of Original Capacity		
Per Year	0.77	Per cent
To Date of Survey	18.3	Per cent

1. Area was permanently flooded in October, 1926. Date of this survey, July, 1950.

2. At "normal pool elevation," 435. 0 mean sea level.

3. Based on seven volume-weight samples.

Table 2

Distribution of Storage Loss in Lake Chautauqua

Segment	Storage Capacity		Storage Loss	
	Original	Present		
	Acre feet	Acre feet	Acre feet	Per cent
A	742.2	602.6	139.6	18.8
B	2695.0	2286.4	408.6	15.2
C	2902. 3	2482. 7	419.6	14. 5
D	2385.6	1912.5	473. 1	19. 8
E	2449. 0	1914.9	534. 1	21.8
F	1560. 6	1192.0	368.6	23.6
G	1141.4	918.4	223.0	19.5
H	416. 7	369.6	47. 1	11.3
Total	14,292.8	11,679. 1	2613.7	18. 3

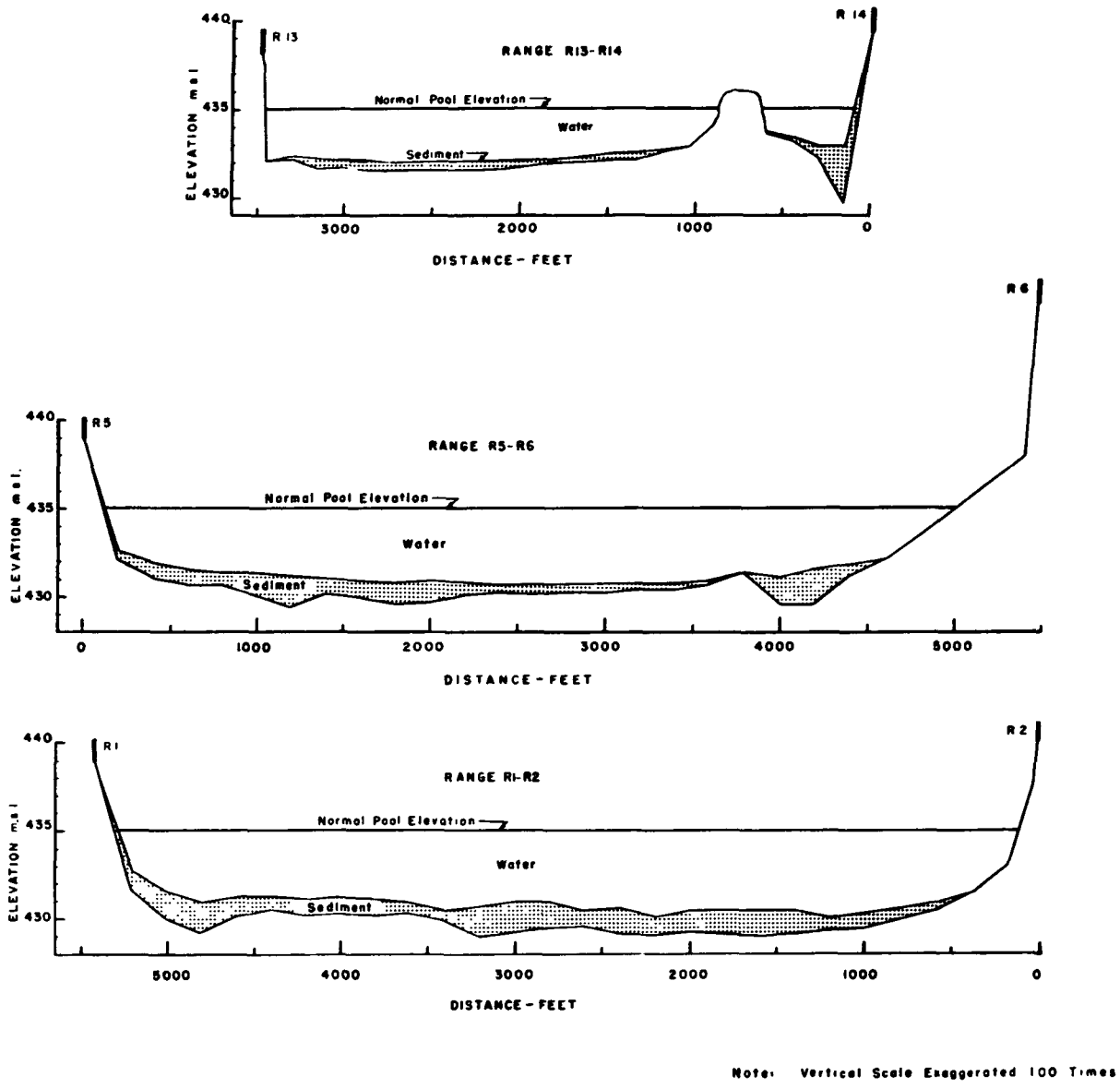

Figure 8. Typical Cross-sections, Lake Chautauqua

sediment has an almost level surface. The sediment deposits in the lower part of the reservoir are thicker, the sediment thickness being generally proportionate to the original water depth.

Near station R 14 in the inflow channel below the control gates it is seen that a thick deposit has accumulated. The elevation of the top of this deposit in the inflow channel is seen to be slightly higher than that along the remainder of Range R 13-R 14.

The total volume of sediment deposited in the lake represents an average rate of rise of the lake bed of one foot every 32 years. It has been estimated in earlier studies[2] that the average rate of rise of the entire unlevied flood plain of the Illinois River is approximately one foot every 70 years. Thus, Lake Chautauqua is losing capacity at a rate about twice as great as the average for other similar flood-plain areas along the Illinois River. The operation of the lake is such as to verify this. The retention in the lake of the sediment-laden flood water after the river stage has subsided provides a chance for the sediment to settle out. In adjacent backwater areas such as Mud Lake or Quiver Lake, undoubtedly much of the sediment is carried on downstream with the subsiding flood waters. Much of the sediment in Lake Chautauqua is of such a small particle size that a retention time of 7 to 12 days is necessary for deposition.

SEDIMENT SAMPLES

Procurement of Samples

During the course of the survey a series of seven samples of the deposited material were obtained at locations shown in Figure 3. These samples were taken with a pipe-nipple sampler as shown in Figure 9. This sampler consists of a 3-foot section of galvanized iron pipe, 2 inches in diameter with a check valve at the top. Above the check valve is an additional 2-foot section of 1-inch pipe with an open "T" fitting at the top for securing the sampler to a line. A 2-inch nipple 4 inches in length is attached on the bottom of the sampler. The entire sampler, with the nipple in position, is shown in Figure 9a. From a boat the sampler is lowered into the water on a line and sinks into the sediment deposit of its own weight. As the sampler is retrieved, the 2-foot column of water above the check valve holds the sample of sediment in the nipple and in the 3-foot length of pipe. In the boat the excess sediment on the extreme lower end of the pipe nipple is struck off at the edge of the nipple and a pipe cap is attached. The nipple is then removed from the sampler and the upper edge is struck off and capped. Usually the sample is immediately transferred to a glass jar as is shown in Figure 9b, and hand-sealed for later laboratory analysis.

Sediment Characteristics

The chemical and physical characteristics of four of the sediment samples were determined in the laboratories of the Illinois Agricultural Experiment Station. The sediments that are accumulating in Lake Chautauqua are, in general, quite fine in texture. Apparently, much of the coarser sediment being carried by the water of the Illinois River has settled out before the water enters the lake, largely because the river does not flow directly into the lake proper. Within the lake further separation of sediment has occurred.

Detailed chemical and physical analysis of the sediment samples indicates a wide variation in sediment characteristics. The data are presented in Tables 3 and 4. Samples No. 1 and 2 are quite similar and they come from the same general area of the lake. (See Figure 3.) The extremely fine nature of this sediment, over 50 per cent clay, indicates a high degree of sorting of sediments and quiet water. The total carbon and total nitrogen values are extremely high, indicating an accumulation of organic matter in the lake far in excess of any amounts that could be accounted for through soil erosion. These large accumulations of nitrogen and carbon must, therefore, be attributed to wildlife excreta.

The sediment in the area of sample No. 4 is quite coarse when compared with the sediment of other areas of the lake. This definitely indicates a channel area where sediment-laden incoming water meets still water. In this area the sediments are sandy and silty with much less clay in them. They are much lower in total nitrogen and total carbon, and the sediments are similar in characteristics to the sediments one would expect to find being carried directly in the Illinois River. In all probability most of this sediment was deposited in this area during a levee break at this point.

The area represented by sample No. 6 has sediments quite similar to the sediments in the area represented by samples No. 1 and 2. The sediments are somewhat higher in the silt fraction and it may be inferred that there is somewhat more water movement at this point in the lake than at the points indicated by samples 1 or 2. The particle-size distribution of the sediment samples is shown in Figure 10. The size distribution is shown in comparison to similar data on several smaller lakes within Illinois. Comparing the Lake Chautauqua samples it is

2. "Soil Pollution in the Illinois River." Testimony presented to the Illinois River Pollution Commission by the Illinois State Water Survey Division, March 30, 1950, Urbana, Ill.

Figure 9a. Sediment Sampler Ready for Use

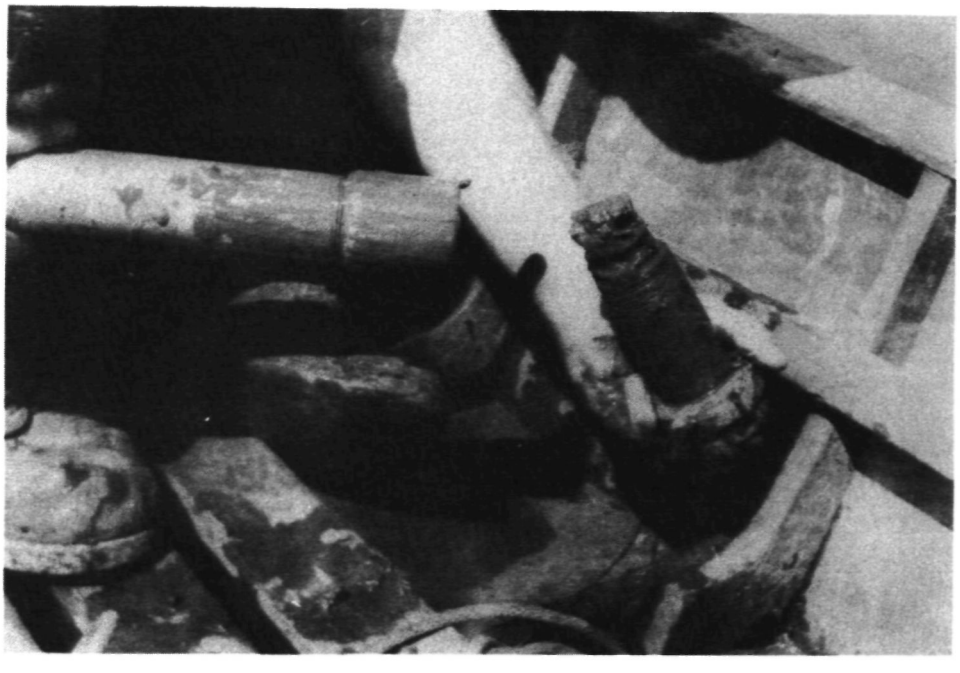

Figure 9b. Sediment Sampler in Position for Removal of Sample

Table 3

Volume-Weights of Sediment Samples, Lake Chautauqua, 1950

Sediment Sample	Range	Density, Pounds/Cubic Foot
1	R 13-R 14	24.9
2	R 11-R 12	27.5
3	R 9-R 10	34. 1
4	R 7-R 8	46.2
5	R 5-R 6	35.2
6	R 3-R 4	36.2
7	R 1-R 2	32.8

Table 4

Chemical and Physical Data - Lake Chautauqua Sediment

Sample No.	Volume Weight (gm./c.c.)	Total Nitrogen (%)	Total Carbon (%)	C/N Ratio	Base Capacity (m.e./100 g.)	Total Bases (m.e./100 g.)	P^H	Sand (%)	Silt (%)	Clay (%)
1	0.40	0.470	>4. 14	>9.0	34.5	48.8	6.5	1.6	30.7	52.5
2	0.44	0. 365	3.30	9.0	32.9	49.5	6.7	1.5	31.0	56.2
4	0.74	0. 163	1.89	11.5	19.5	34.3	6.7	4. 1	54.5	29.4
6	0.58	0.220	2.66	12.0	29.5	34.7	6.6	0.7	37.6	47. 1

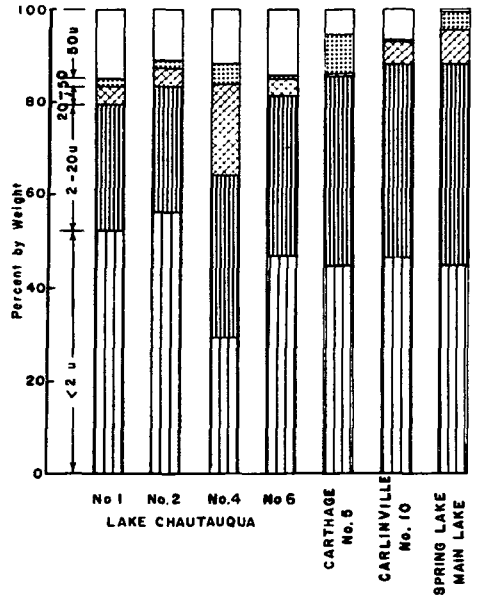

Figure 10. Size Distribution of Sediment Samples

seen that samples 1, 2, and 6 are very similar, containing about 80% particles less than 20 microns and a total of less than 4% particles greater than 20 microns. Sample 4 is considerably different, containing only 64% particles less than 20 microns and about 44% greater than 20 microns.

The sediment deposits in Lake Chautauqua are quite high in fertility. In terms of fertilizer equivalents this fertility would represent approximately 50,000 tons of ammonium nitrate, 2,000 tons of muriate of potash, and 5, 000 tons of superphosphate. Much of this fertility comes from the excreta of the wildlife living in the area. Certainly the area should be ideal, from a fertility point of view, for the growth of swamp or forest cover.

Water Sample

On July 28, 1950 a sample of the lake water was taken on Range R 5-R 6 at the location of sediment sample No. 5. The mineral analysis of this sample is shown in Table 5.

Table 5

Mineral Analysis
August 11, 1950

Sample of water collected July 28, 1950, from Lake Chautauqua, owned by U. S. Department of Interior, Fish and Wildlife Service. Location: Center of Section. Section 9, Twp. No. 22 N., Range 8 W.

Laboratory No. 122, 500

		ppm.	epm.			ppm.	epm.
Iron (total)	Fe	0.7		Silica	SiO_2	2.0	
Manganese	Mn	0.0		Fluoride	F	0.5	
Calcium	Ca	35.5	1.78	Chloride	Cl	13.0	0.37
Magnesium	Mg	18.6	1.53	Nitrate	NO_3	0.2	Tr.
Ammonium	NH_4	0.6	0.03	Sulfate	SO_4	71.8	1.49
Sodium	Na	12.0	0.52	Alkalinity (as $CaCO_3$)		100.	2.00
Turbidity		Tr.		Hardness (as $CaCO_3$)		166.	3.31
Color		0		Residue		229.	
Odor		0					

ppm. = parts per million
epm. = equivalents per million
ppm. x .0583 = grains per gallon

STATE WATER SURVEY DIVISION

R. M. King, Assistant Chemist

REPORTS OF INVESTIGATIONS

ISSUED BY THE STATE WATER SURVEY

No. 1. Temperature and Turbidity of Some River Waters in Illinois. 1948.

No. 2. Groundwater Resources in Winnebago County, with Specific Reference to Conditions at Rockford. 1948.

No. 3. Radar and Rainfall. 1949.

No. 4. The Silt Problem at Spring Lake, Macomb, Illinois. 1949.

No. 5. Infiltration of Soils in the Peoria Area. 1949.

No. 6. Groundwater Resources in Champaign County. 1950.

No. 7. The Silting of Ridge Lake, Fox Ridge State Park, Charleston, Illinois. 1951.