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STATE OF ILLINOIS
DWJGHT H. GREEN, *Governor*

THE CAUSES AND EFFECTS OF SEDIMENTATION IN LAKE DECATUR

CARL B. BROWN, J. B. STALL AND E. E. DETURK

ILLINOIS STATE WATER SURVEY, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND ILLINOIS AGRICULTURAL EXPERIMENT STATION, COOPERATING

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, Director

STATE WATER SURVEY DIVISION
A. M. BUSWELL, Chief

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SUMMARY

1. Lake Decatur, municipal water-supply reservoir of Decatur, Illinois, is located on the Sangamon River at the edge of the city. It has a drainage area of 906 square miles. When built in 1922, the reservoir had a surface area of 2,805 acres and a storage capacity of 19,738 acre-feet.

2. A sedimentation survey made in 1936 showed a capacity loss of 1.0 percent annually. A second survey made in 1946 showed a loss of 1.2 percent since 1936—a 20 percent increase. By 1946, the surface area of the lake had been reduced 201 acres and the capacity by 5,171 acre-feet, or 26.2 percent,

3. The consumption of lake water by the city and local industries has increased from an average of 340 million gallons per month in 1937 to an average of 428 million gallons per month in 1944. The future annual increase in the average monthly consumption is estimated to be at a rate of 8.7 million gallons.

4. In 36 years (1908-1945) there have been seven periods of six consecutive months in which the stream flow at Decatur has been less than the present or near-future demands on the lake (withdrawal for consumption plus estimated losses from evaporation and seepage). The lowest flow for six months, 3,573 acre-feet, which occurred in 1914-1915, is estimated to have a recurrence frequency of once in 35 years.

5. The increasing consumption and decreasing storage capacity of the lake will result in a water shortage by 1959 if a 6-months low flow equal to that of 1914-1915 should recur. The city, however, should guard against the probability of even smaller inflow. It is considered desirable to provide storage to offset a minimum flow of 2,500 acre-feet in six months, which is estimated to have a recurrence frequency of once in 50 to 100 years. To provide against this contingency will require additional storage by 1956. Thus, because of sedimentation, supplementary storage should be provided when the present lake is 34 years old. If no sedimentation had occurred, the present lake would have been adequate for 78 years.

6. The estimated average annual inflow to the lake from 1923 through 1935 was 68,000 acre-feet greater than that from 1936 through 1945. During the earlier period, stream flow exceeded 1,000 cubic feet per second for 44.6 days per year on an average; whereas during the later period, it exceeded this rate only 36.7 days per year. This indicates that hydrologic conditions were more favorable to erosion and sedimentation during the earlier period. Actually the sedimentation rate was 20 percent greater during the later period.

7. About three-quarters of the land in the drainage area above Lake Decatur has slopes of less than 2 percent. The remaining quarter, except for seven-tenths of 1 percent, has slopes ranging from 2 to 15 percent. The area is a broad, gently-rolling glacial drift plain in the heart of the Corn Belt. Its black prairie soils are intensively used for

agriculture. In a typical county—Piatt—in 1943, approximately 31 percent of the land was in corn; 331/2 percent in soybeans; 11 percent in small grain; 141/2 percent in hay and plowable pasture; 2 percent in woodland; and 8 percent in other uses. About 62 percent of the farms, embracing 72 percent of the land, are tenant-operated. Soil conservation practices had been planned on only 4.2 percent of the land to July 1, 1946, and only about one-half of the planned practices had been installed.

8. Turbidity and stream-flow records, analysis of lake sediments, and repeated observations and experiments on the land, show that the lake sediment is derived from all parts of the drainage area. It is estimated that at least 90 percent comes from sheet erosion, primarily from corn and soybean fields on slopes of 2 to 15 percent. Only 10 percent, or less, comes from gully, stream-channel, and shoreline erosion. Measurements in the lake show that shore-line erosion contributes between 1.6 and 6.6 percent of the total sediment.

9. From 1936 to 1946, 2,650,000 tons of sediment were deposited in the lake, while an estimated 750,000 tons passed over the spillway. This constitutes a loss of 3,400,000 tons of soil from farms of the drainage area during the 10 years. Although this is only part of the total soil loss, it is equivalent to complete removal of 7 inches—the plow depth—of fertile topsoil from 3,400 acres of land.

10. Analysis of plant nutrients in the reservoir sediment shows a loss from farmland during 24.3 years of 2,478,600 pounds of active nitrogen worth $223,560, and available organic phosphorus worth $85,050. Much larger losses are involved in some 12 million pounds of reserve nitrogen in organic matter and some 31/2 million pounds of total phosphorus included in the sediment inflow to the lake.

11. The 20-percent increase in the average rate of sedimentation during the 10 years, 1936-1946, as compared with the preceding 14.2 years, is attributed to progressive increase in the intensity of land use for intertilled row crops. In Piatt County, land in row crops increased from approximately 39 percent in 1924 to 641/2 percent in 1943. The increase was due mainly to soybeans. The present rate of sedimentation is estimated to be 30 percent above the average rate prior to 1936.

12. Possible remedial measures for maintaining the water supply and other values associated with Lake Decatur include (1) raising the present dam, (2) construction of several small reservoirs on tributary streams, (3) construction of one or more sizable reservoirs on the Sangamon River above Lake Decatur, and (4) soil conservation measures on the drainage area. Dredging is not considered economically feasible at present.

13. A complete program of soil conservation on the drainage area should include reduction in the acreage of land used for intertilled crops, crop rotations involving no more than two years in four of intertilled corn and soybeans, contour planting; and where required, terracing, diversions, grassed waterways, drainage and other practices. It is estimated that a complete conservation program would reduce sedimentation by 62 percent from its average rate during the 10-year

period, 1936-1946, or by 65 percent from the probable present rate. This conservation program would result in a higher level of farm income and maintain the soil resources of the area, as well as protect Lake Decatur. The Soil Conservation Districts organized in each of the six counties in the drainage area provide a means for accomplishing the needed soil conservation work.

14. It is estimated that past and future sedimentation will cause damage to Decatur's water storage facilities equivalent to $200 per acre-foot, or $47,200 annually at the 10-year average rate of 236 acre-feet of deposits. In addition, an estimated future loss of $4,375,000 in property values adjacent to the lake may result if the lake is permitted to become 80 percent filled with sediment. A further damage to the community estimated at $40,000 annually will result from loss of recreational facilities if the lake is allowed to become 80 percent silted. Probably the city would be justified in spending $100,000 annually over the next 100 years, or the equivalent present worth now, to effect a reduction of sedimentation to 38 percent of its 10-year average rate. Furthermore, the farmers of the area have a large stake in maintaining the industries and trading outlets in Decatur and can afford to protect their own soils in order to protect the water supply of the city.

15. This investigation, together with data on a few other reservoirs in Illinois, indicates that sedimentation is a critical problem in the utilization of impounding reservoirs. In 1944, 62 cities and towns in Illinois depended on impounding reservoirs subject to sedimentation. Widespread construction of additional municipal reservoirs appears probable.

THE CAUSES AND EFFECTS OF SEDIMENTATION IN LAKE DECATUR

BY

CARL B. BROWN,[1] J. B. STALL[2] AND E. E. DETURK[3]

INTRODUCTION

For more than a hundred years surface water has been impounded in reservoirs and purified for public and industrial uses in some sections of the United States. For that long, at least, sediment has been recognized as a major problem in utilizing surface water supplies. Chemists early found that minute sediment particles were the principal cause of turbidity—the cloudy or muddy quality that must be removed before water is acceptable on the dinner table, in the bath, or in the factory boiler. Moreover, engineers began to recognize some decades ago that sediment carried by flowing streams settles in impounding reservoirs built on these streams and, in some cases, rapidly reduces the capacity of the reservoirs to store water. As recently as 15 years ago, however, there was little quantitative data on the rates at which reservoirs were being filled with sediment. Moreover, there was little appreciation of the intimate relationship between the sources of sediment on the lands of the drainage basin and the increasing losses of reservoir capacity or the increased costs of water purification.

The need for more information on the effects of sediment on surface water supplies began to be recognized in Illinois as early as 1930. In 1931 and 1932 the State Water Survey Division undertook preliminary investigations of sedimentation in Lake Decatur in cooperation with the Decatur Water Supply Company, former owner of this municipal reservoir. Impetus was given to investigation of sedimentation problems with the spread of the movement to control soil erosion, which led to the creation of the Soil Conservation Service as a permanent agency of the U. S. Department of Agriculture in 1935. This agency undertook a systematic study of rates of reservoir sedimentation in all parts of the country in an effort to evaluate the effects of accelerated soil erosion on public water supply and other services rendered by storage reservoirs. Related studies were made of land use and erosion on the drainage areas. One of the early projects under this program was a survey of Lake Decatur and its watershed made in April-June, 1936, in cooperation with the State Water Survey Division, the State Agricultural Experiment Station, and the city of Decatur (See Figure 1).

[1]Sedimentation Specialist, Office of Research, Soil Conservation Service, Washington, D. C.
[2]Assistant Engineer, State Water Survey Division, Department of Registration and Education, Urbana, Illinois.
[3]Professor, Soil Fertility, Department of Agronomy, College of Agriculture and Agricultural Experiment Station, University of Illinois, Urbana, Illinois.

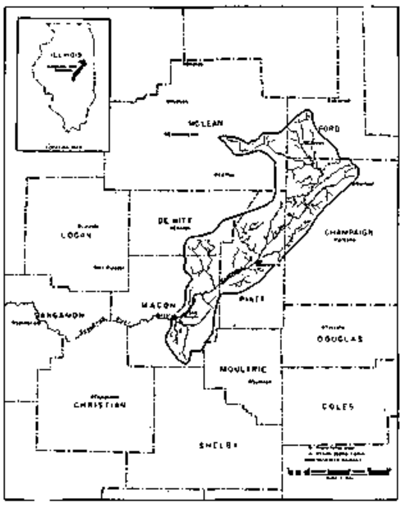

FIG. 1.—Index Map of Lake Decatur Watershed.

A second survey of Lake Decatur was made by these agencies in May and June, 1946. Additional investigations designed to cover all of the important relationships between reservoir capacity, water needs, effects of sediment on treatment problems, water supply from the Sangamon River, and effects of land use and agricultural practices in this drainage basin have been made during 1946. The results of these studies are reported in this publication. The findings have led to a prediction of the remaining useful life of Lake Decatur. They show the nature of the problem confronting the city. They give a basis for long-range planning for the protection and maintenance of the city's water supply. Furthermore, these investigations have shown for the first time in this section of the country the intimate relationship between public water supply and problems of the land. They give a measure of the effects of land use and treatment on the quality of water and the maintenance of storage reservoirs. The results are useful not only in solving the problem of the city of Decatur; they also indicate the general nature of the problems confronting other cities and towns in Illinois that now depend on surface water supplies and many more that will be developing surface supplies in the future as ground-water supplies become more and more fully developed or overdeveloped.

SCOPE OF INVESTIGATIONS

In the summer of 1930, F. L. Washburn, Engineer for Macon County, made an investigation for the Decatur Water Supply Company, former owner of Lake Decatur, to determine the extent of erosion around the shores of the lake and its effects on sedimentation on the lake bottom. He found that some shore lines had eroded back 25 to 35 feet since the reservoir was impounded in 1922. Several small bays and inlets had been filled with sediment. A resurvey of a line of levels taken in 1920 for the road across the south Sand Creek arm showed deposits of from 1 to 2 feet entirely across the valley below this road. Sounding along the line of a proposedfroad one-fourth mile south of Rhea's Bridge showed that the lake had filled from 1 to 2 feet across half the width of the lake basin. Soundings in the borrow pit near the Nelson Park Bridge showed deposits up to 4 feet thick.

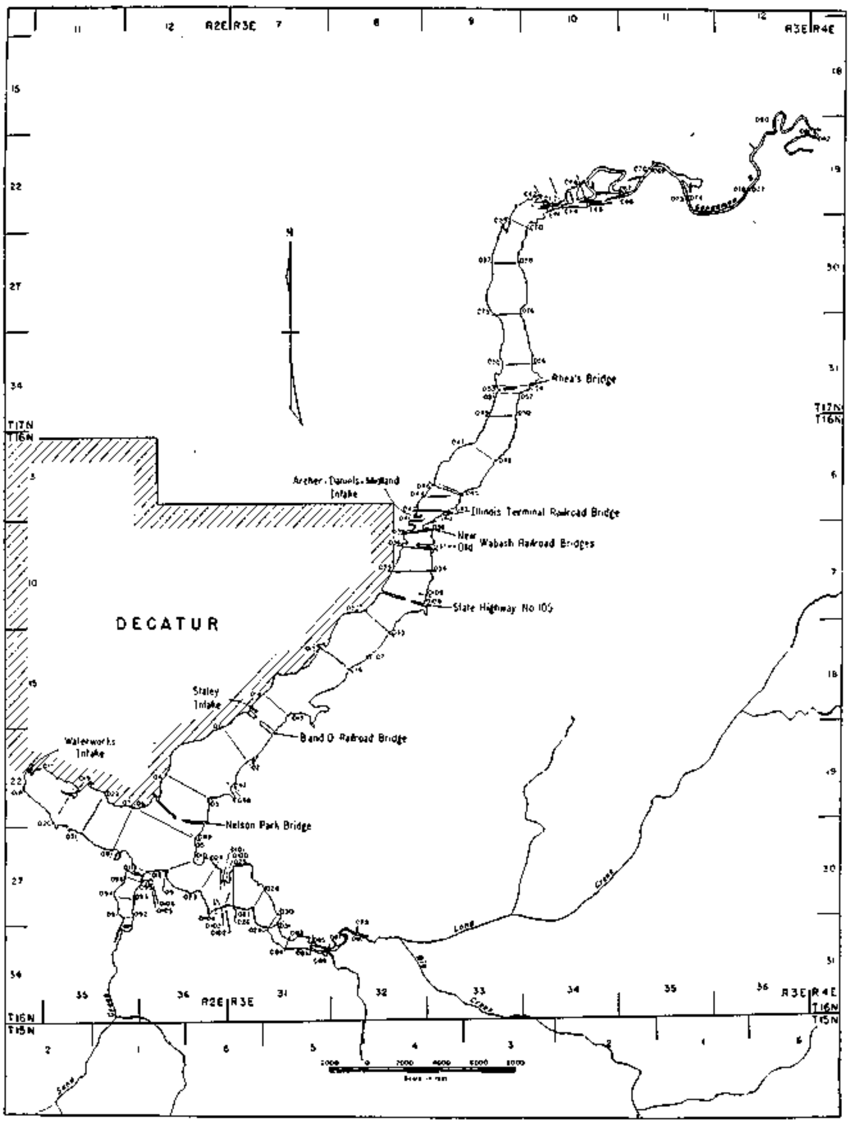

FIG. 2.—Map of Lake Decatur.

These findings by Mr. Washburn led the State Water Survey Division, in cooperation with the Decatur Water Supply Company, to establish a system of *55* ranges for sedimentation measurements throughout the reservoir between September, 1931 and January, 1932. The range ends were accurately located from transit traverses and elevations were determined by levels from convenient bench marks. Concrete monuments or iron pipes were placed to mark the range ends. The ranges were closely spaced near the principal bridges crossing the lake in order to determine the effects of these constrictions on sedimentation. Over the greater part of the lake, away from the bridges, ranges were spaced at intervals of ¾ to 1½ miles. Soundings were taken along these ranges, and profiles of the then-existing lake bottom were plotted. Sediment thicknesses were also determined along ranges in the upper part of the lake above State Highway No. 105 bridge and near the heads of the Sand Creek and Big Creek arms. No measurements were made in the lower part of the lake, and hence the total volume of sediment could not be computed. The survey was made for the primary purpose of establishing a basis for future measments of sedimentation.

A complete sedimentation survey of the reservoir was made between April 8 and July 3, 1936, by a field party of the Soil Conservation Service with the cooperation of the State Water Survey Division, the State Agricultural Experient Station, and the city of Decatur.[4] The methods used in making this survey are described in a subsequent section (See pp.000). From this survey the original capacity of the reservoir was redetermined, and the capacity and sediment volume of the lake on the date of the survey were computed. A second survey, based on the system of ranges used in 1936, was made between May 1 and June 12, 1946, by a party composed of personnel supplied by the Soil Conservation Service, the State Water Survey Division, and the city of Decatur. From this survey the additional loss of capacity in the reservoir was determined. The data permit comparison of the rate of sedimentation during the period 1922-1936 with the period 1936-1946.

In addition to determining the volume of sediment in the lake, ranges were established in 1936 for measuring the extent and rate of shore-line erosion due to wave action around the lake. These ranges were resurveyed in 1946. The resulting data make it possible to estimate within limits the volume of sediment contributed by wave erosion to the lake.

On May 4 and 6, 1936, following heavy rains, sets of water samples were taken by engineers of the State Water Survey Division as a basis for estimating the rate of movement of turbid water through the lake, and the characteristics of the sediment. After the survey of 1946, the State Water Survey Division undertook a detailed analysis of the turbidity records obtained by the city's filtration plant and similar records obtained by the A. E. Staley Manufacturing Company. Correlative studies were made of rainfall distribution over the drainage

[4]Glymph, L. M., Jr., and Jones. V. H. Advance Report on the Sedimentation Survey of Lake Decatur, Decatur, Illinois. U. S. Soil Conserv. Serv. SCS-SS-12. 23 pp., illus., processed. Washington, D. C, Apr., 1937.

basin and stream discharge into the lake during selected periods in which high turbidity occurred. These studies have given a further basis for estimating the rate of movement of turbid water out of the watershed, into and through the reservoir, and to indicate the sources of sediment which are responsible for loss of storage capacity and for increase in the costs of water purification.

During the 1936 survey, Dr. E. E. DeTurk of the State Agricultural Experiment Station collected and analyzed samples of sediment from various locations in the lake to determine the texture, colloidal content, volume-weight, and plant-food constituents. Another series of samples was collected for the same purpose during the 1946 survey. These data give significant indications of the sources of sediment deposited in the reservoir, the extent of soil and plant-food losses from the drainage area, and the average weight of sediment per unit volume of deposit.

Subsequent to the 1946 survey, the State Water Survey Division has made an analysis of trends in water consumption by the city of Decatur and the A. E. Staley Manufacturing Company as a means of predicting future water requirements. The history of use and drawdown of the lake since 1930 has been studied. An analysis has been made from stream-flow records of the average water yields, or runoff from the drainage area, the frequency and duration of flood flows of various magnitudes, and the low-water or drought expectancy. From the study of low-flow expectancy in relation to the expected trends in consumption and the measured rate of storage loss resulting from sedimentation, it has been possible to predict the dates at which Decatur may face a water shortage if low flows comparable to those experienced in the past as well as those theoretically possible are experienced.

In an effort to determine the causes of increase in the rate of sedimentation of the lake, the Soil Conservation Service with the cooperation of the State Agricultural Experiment Station has made a study of trends in land use, crop production, and application of conservation practices in the drainage area of Lake Decatur from the time it was built until 1946. These data, together with the analysis of hydrologic conditions made by the State Water Survey Division, have led to an interpretation of the cause of increased sedimentation, and to a forecast of what may be expected in the future under present or various possible future conditions of land use and agriculture.

A preliminary study of the effects of sediment, or turbidity, on the city water-treatment costs showed that the latter was influenced to a large extent by modernization and improved techniques which prevented any direct comparison. Consideration was also given to the economic effects of sedimentation on water supply, the recreational value of the lake for boating and fishing, and on the value of property adjacent to the lake.

ACKNOWLEDGMENT

Many individuals have contributed materially to the investigations reported in this publication. Credit is due in particular to the following local, State, and Federal officials and other persons who have supplied data or cooperated in making possible the several surveys and investigations: Mr. Henry H. Bolz, Secretary of the Decatur Association of Commerce; Mr. John Rehfelt, Superintendent of the Municipal Water Department; Mr. L. A. Nalefski, former chemist, and Mr. Gerald Davis, present chemist, of the city; Mr. Earl Cooper formerly superintendent of the Lake Decatur Water Supply Company; and other officials of the city of Decatur who were instrumental in supplying boats, equipment, and various items of information pertaining to the reservoir; Dr. R. E. Greenfield, chemist of the A. E. Staley Manufacturing Company of Decatur; the directors of the soil conservation districts of Macon, Dewitt, Piatt, Champaign, Ford, and McLean Counties, who have urged the undertaking of the latter phases of these investigations; Mr. Harry R. Beeson, secretary of the Upper Sangamon Valley Association of the Soil Conservation Districts, and conservationist of the Upper Sangamon Valley Conservation Service, an organization supported by the city of Decatur; Mr. Pete E. Cooley, former secretary of the Association; Dr. Roger H. Bray of the Department of Agronomy, Dr. John E. Wills of the Department of Agricultural Economics, Mr. Ralph C. Hay, Associate Professor in Agricultural Engineering Extension of the University of Illinois and of the staff of the State Agricultural Experiment Station; Mr. Bruce Clark, State Conservationist, Mr. W. W. Russell, District Conservationist, of the Soil Conservation Service; Mr. Louis M. Glymph, Jr., and Dr. Victor H. Jones who were in charge of the sedimentation investigations made by the Soil Conservation Service in 1936; Mr. Gunnar M. Brune who was in charge of the SCS Survey in 1946; Mr. Louis C. Gottschalk of the Sedimentation Section, SCS; and members of the staff of the State Water Survey Division who have participated in these investigations, including Mr. W. D. Gerber, retired, Dr. Max Suter, Mr. C. O. Reinhardt, and Mr. H. F. Smith.

THE DAM AND RESERVOIR

Lake Decatur is located on the Sangamon River in Macon County, T. 16 and 17 N., R. 2 and 3E. The lake borders the city of Decatur on the south and east and extends about 8 miles upstream from the northeastern city limits. It is impounded on the main stem of the Sangamon River, and backwater extends into two principal tributaries, Sand Creek and Big Creek. The reservoir is used primarily for municipal and industrial water supply but has an important value for recreation, including boating, fishing, and swimming.

The reservoir is created by a dam which has a total length of approximately 1,900 feet, extending nearly north and south across the Sangamon River Valley (See Figure 2). The dam consists of three segments—the concrete-spillway segment in the middle, which is 480 feet long, 28 feet in height above the bottom of the original channel, 4 feet thick at the top, and 14 feet thick at the base; and two earth-fill sections on either end each having a length of about 675 feet and providing a freeboard of approximately 22 feet between its top and the crest of the spillway. The upstream faces of the end segments have

FIG. 3.—Lake Decatur Dam.

slopes of 2.5 to 1 and are faced with concrete slabs. The upstream face of the spillway section is vertical. Both end segments meet the spillway at oblique angles, giving the dam a zigzag pattern. The spillway-crest elevation is 610 feet above mean sea level (USGS datum). Provision was made in construction for 21/2-foot flash boards along the entire length of the spillway, but they have never been used. Two flood gates 9 feet high and 14 feet wide, with tops at spillway-crest level, adjoin the north end of the spillway segment. In addition, one 3 x 4 foot flushing conduit in the middle of the spillway provides an outlet at a depth of 15 feet below spillway crest.

When storage began on April 16, 1922, the surface area of the reservoir was 2,805 acres, and the storage capacity was 19,738 acre-feet, or approximately 6,432,000,000 gallons (as determined by the survey of 1936). The dam was constructed in 1921-1922 by the Decatur Water Supply Company, an Illinois corporation, which furnished water to the city for 10 years under contract. During this period an extensive program of shore-line stabilization by riprapping was carried out. In 1932, the control and administration of the lake was acquired by the city of Decatur. The cost of the Lake Decatur development, according to city officials, was as follows: Dam, $940,000; land, $547,897.13; clearing of land, $119,295.02; roads and bridges, $309,-091.97; riprapping, $97,555.81. The total original cost was $2,013,-839.93. Subsequent improvements, including the cost of the filtration plant, have brought the total investment to more than $2,500,000.

Lake Decatur occupies a relatively long, somewhat winding stretch of the Sangamon River Valley, through which the stream formerly followed a tortuous, meandering course over a well-developed floodplain. The floodplain is slightly less than one-half mile in width, on the average, and is bordered mainly by bluffs and steep slopes. The lake ranges in width from about 1/4 to 3/4 mile. Just upstream from the dam, the maximum depth of water over the original floodplain was 16 feet, and the maximum depth in the original channel was about 28 feet. The average gradient of the floodplain through the reservoir basin is about 1.5 feet per mile. Throughout the lake proper, the impounded water covers the entire floodplain and encroaches slightly upon the adjacent bluffs and slopes; thus, much of the lake shore is steep or even precipitous. The submerged channel ranges in width from 100 to 200 feet and in depth from 5 to 10 feet below the level of the floodplain. The only important tributary arms are Big Creek and Sand Creek which join the main lake about 2 miles above the dam.

SEDIMENTATION IN THE RESERVOIR

Methods of Survey

The record of sedimentation in Lake Decatur is based on the survey system established in 1936, which incorporated a substantial part of the range system laid out by the State Water Survey Division in 1931—1932 (See Figure 2). The 1936 survey was tied to a chained 2,000-foot base line across the lake along the south side of the Baltimore & Ohio Railway fill. From this line 72 triangulation stations were established by plane table and telescopic alidade. An auxiliary base line, also 2,000 feet in length, was chained across the lake along the north shoulder of State Highway 105 fill between triangulation stations 1038 and 1039. Using the triangulation stations as control points, the spillway-crest contour, elevation 610, was mapped on a scale of 500 feet to the inch around the entire reservoir, a distance of approximately 70 miles. In the delta areas of the main lake and tributary arms, both the original and 1936 crest lines were mapped.

To determine the capacity and sediment volume, 49 ranges crossing the lake and tributaries were established and tied into the triangulation net. Twenty-four of these ranges had been previously laid out and sounded by the State Water Survey Division in 1931-1932. The 1936 range system included most of the older ranges, except the closely-spaced ranges near Rhea's Bridge and the old and new Wabash Railroad bridges. Ranges had been concentrated in these areas in anticipation of an exceptionally large amount of sedimentation here. Preliminary spudding in 1936 indicated that this was not the case. Soundings were taken along the ranges at intervals of 25 feet or less, and spuddings at intervals of 100 feet or less. On most ranges the boat was kept on line by a signalman on shore, while the position of the sounding or spudding was cut in by intersection from a plane table located on an adjacent range end or suitably-located cut-in station. On several ranges, however, a marked cable was stretched from shore to shore, and the position of soundings was determined by this means.

In addition to the sedimentation ranges, 14 special shore-line ranges were established for future determination of the extent of wave erosion as a factor in reservoir silting. Furthermore, surveys of 14 end sections of regular ranges were extended for the same purpose. On these ranges and the range ends, levels were run from a point well back from the expected maximum limit of erosion down to the water's edge, and by closely-spaced soundings out into the lake to the limit of coarse, wave-erosion debris.

Soundings were taken with a bell-shaped, cast-aluminum sounding weight, approximately 5 inches in diameter at the base, and weighing about 5 pounds. Direct measurements of sediment thickness were obtained with a spud, which consists of a well-tempered steel rod, similar to axle shafting, into which encircling triangular grooves have been machined at intervals of 0.1 foot along its length. The spud, when dropped in the water, goes through the sediment deposits and into the underlying old soil. Each groove retains a sample of the deposit at the point at which it comes to rest. Clear distinctions could be made almost everywhere in Lake Decatur between sediment and old soil. That positive identifications were obtained was verified in the 1946 survey in which spuddings at the 1936 points of measurement, but through greater thickness of sediment, showed consistent elevations of the old soil, seldom differing from the 1936 measurements by more than 0.1 to 0.2 foot.

In the 1946 survey, both soundings and spuddings were repeated on a number of ranges. The results were so consistent that spudding was largely abandoned, except as an occasional check, and the larger number of ranges were simply sounded to obtain the surface of the sediment. Profiles on the shallow water ranges were obtained by leveling. In the 1946 survey, 39 of the 49 sedimentation ranges were resurveyed. The ranges not remeasured are those crossing the channel only in the extreme upper end of the lake and the tributary arms. Examination of these ranges indicated no significant change since 1936 because of the scouring action of stream inflow. All 28 wave-erosion ranges were resurveyed and the amount of erosion was determined.

In 1936, samples of bottom sediment were obtained from 39 selected sites by means of two types of sediment samplers. For the thinner deposits on the submerged floodplain, the iron tube sampler developed by the State Water Survey Division was used. The samples from the channel, where the sediment was more than 3 feet deep, were obtained with the spud. In 1946, samples were obtained with a pipe sampler to the end of which 2-inch nipples were attached below a check valve.

In both surveys the plotted cross-sections along the ranges were planimetered to determine the cross-sectional area of the range prior to sedimentation and in 1936 and 1946. The difference in cross-sectional area represented the area of sediment deposited to these dates. The surface area of each segment bounded by one, two or more ranges, and the intervening shore line was planimetered. From these data the capacity and sediment volume of the reservoir was determined by the SCS range survey formula.[5]

Rates of Sedimentation

The following is a summary of sedimentation data obtained from the surveys of Lake Decatur, together with data derived therefrom which are pertinent to the interpretation of the record.

[5]Eakin, H. M. Silting of Reservoirs. *V.* S. Dept. Agr. Tech. Bul. 524. Rev. by C. B. Brown, 168 pp., illus. Washington. U. S. Govt. Print. Off., 1939. Appendix.

SUMMARY OF SEDIMENTATION DATA ON LAKE DECATUR, DECATUR, ILL.

	Quantity	Unit
1922-1936	14.2	Years
1936-1946	10.0	Years
1922-1946	24.2	Years
Watershed:		
Total area:[2]	906	Square miles
Reservoir:		
Area at spillway stage:		
1922	2,805	Acres
1936	2,746	Acres
1946	2,604	Acres
Storage capacity at spillway level:		
1922	19,738	Acre-feet
1936	16,930	Acre-feet
1946	14,567	Acre-feet
Capacity per square mile of drainage area:		
1922	21.79	Acre-feet
1936	18.69	Acre-feet
1946	16.08	Acre-feet
Sedimentation:		
Total sediment:		
1922-1936	2,808	Acre-feet
1936-1946	2,363	Acre-feet
1922-1946	5,171	Acre-feet
Average annual accumulation:		
From entire drainage area:		
1922-1936	198	Acre-feet
1936-1946	236	Acre-feet
1922-1946	214	Acre-feet
Per 100 square miles of drainage area:[3]		
1922-1936	22.0	Acre-feet
1936-1946	26.2	Acre-feet
1922-1946	23.7	Acre-feet
Per acre of drainage area:[3]		
By volume:		
1922-1936	15.0	Cubic feet
1936-1946	17.8	Cubic feet
1922-1946	16.1	Cubic feet
By weight:[4]		
1922-1936	0.39	Tons
1936-1946	0.46	Tons
1922-1946	0.42	Tons
Depletion of Storage:		
Loss of original capacity:		
Per year:		
1922-1936	1.00	Percent
1936-1946	1.20	Percent
1922-1946	1.08	Percent
Total:		
1922-1936	14.23	Percent
1936-1946	11.97	Percent
1922-1946	26.20	Percent

[1]Storage began April 16, 1922. Date of first survey was April 8, 1936, to July 3, 1936. Date of second survey was May 1, 1946, to June 15, 1946.

[2]Including area of lake.

[3]Excluding area of lake.

[4]Average dry weight of 1 cubic foot of sediment is 51.7 pounds, based on weighted average of 21 samples.

The more significant findings shown by this summary are as follows:

1. The surface area of the lake has been reduced 201 acres in 24.2 years by deposits in the upper end of the lake and in the two principal tributary arms, Sand Creek and Big Creek.
2. The capacity of the reservoir for water storage has been decreased by 5,171 acre-feet, or 26.2 percent in the 24.2 years from the date of its completion in 1922 to the date of the 1946 survey.
3. The loss of original storage capacity has increased from an average of 1.0 percent annually during the period 1922-1936 to 1.2 percent annually during the succeeding 10 years, 1936-1946. For the entire period the average annual loss has been 1.08 percent.
4. The sediment accumulated in the lake represents an average annual loss of 16.1 cubic feet per acre from the drainage area of 577,000 acres (excluding the lake area). The rate of loss has increased, however, from 15.0 cubic feet per acre annually before 1936, to 17.8 cubic feet per acre annually since 1936.

Distribution of Sediment

An outstanding characteristic of sedimentation in Lake Decatur is the relative uniformity in thickness and in type of deposits over the lake basin. The average thickness of sediment in the main body of the lake increases gradually from slightly less than 2 feet near the dam to slightly more than 3 feet in the upper part of the reservoir. There is a notable absence of thick delta deposits near the head of the lake. This is interpreted as being due to the uniformly fine texture of the incoming sediment, which is carried in suspension to all parts of the reservoir.

Throughout the reservoir, the thickest deposits of sediment are in the submerged channel. Deposits in the channel increase from about 5 feet near the dam to about 9 feet near Range 55-56. Above this point they decrease until near the head of the lake the main channel is practically free of sediment as a result of scour by inflowing flood discharge. The most completely silted portions of the lake are above Range 57-58. In this area, deposits have been built up to above spillway level, and for a stretch of more than. one mile the original lake area now consists of swampy vegetation such as willows, cattails, and grasses, cut by meandering overflow channels (See Figure 4). Small areas of above-crest deposits have accumulated also at the heads of Sand Creek and Big Creek arms. On submerged valley slopes and other areas above the general level of the floodplain, little or no sediment has accumulated. Adjacent to the areas of wave erosion, however, there are comparatively narrow wave-built benches of coarser material, generally extending 20 to 100 feet from shore. In percentage, the greatest concentration of capacity loss occurs between Ranges 36-37 and 65-66.

FIG. 4.—Upper Section of Lake Decatur showing area almost completely filled by sediment.

Character of Sediment

The sediment in Lake Decatur consists chiefly of poorly compacted silt and clay, ranging in color from gray or bluish-gray in submerged areas, to brown or rust where recently exposed to the air. Coarse sand, grit, and gravel occur in narrow areas along several sections of the lake shore at the foot of wave-cut bluffs. No typical delta deposits have formed at the head of the main reservoir, but small deltas in the two major tributaries, Sand Creek and Big Creek, have filled the original stream channels for some distance. In the channel above the head of the open lake, the sediment differs little from that normally present in free-flowing streams in this region. The bulk of the channel sediment is silt and fine sand, with occasional gravel bars, all of which are subject to seasonal scour and fill.

Chemical and physical measurements were made on a number of samples of sediments from Lake Decatur in order to secure information that would aid in determining the volume-weight relations and in estimating the nature, amount, and value of the erosional losses from the land in the watershed.

Roughly 10 percent of the watershed land is covered by light-colored soils, formerly timbered, bordering the Sangamon River, as against 90 percent in dark-colored, grassland soils. The analyses, Tables 1 and 2, indicate that the lake sediment is similar to the surface soil (plowed depth) of this area. The content of organic carbon and nitrogen in the sediments is nearly twice as great as in the surface of the predominant timber soils and slightly lower than the prairie soils. The physical analysis further shows the similarity in proportion of the different particle sizes of a typical sample of sediment shown in

TABLE 1.—ANALYTICAL DATA ON SAMPLES OF SEDIMENT FROM MAIN BODY OF LAKE DECATUR TAKEN IN 1936 AND 1946

Range	Miles above dam	1936 Samples			1946 Samples			Water in air-dry Samples
		Thickness	Organic Carbon	Total Nitrogen	Thick-ness	Total Nitrogen	Apparent Vol. Wt.[1]	
		Feet	*Percent*	*Percent*	*Feet*	*Percent*		*Percent*
		0.5	2.69	0.230				
017-018	0.1	4.3c[4]	3.06c[4]	0.303c[4]				
		1.4	2.92	0.259				
		2.7	2.90	0.269		0.264c	0.64c	4.54c
06-05	1.8	2.3c	2.91c	0.261c		0.238c	0.70c	3.03c
		0.7	2.80	0.252		0.194	1.04	2.90
		0.6	2.53	0.214		N.S.	N.S.	N.S.
01-02	2.8	1.9c	2.68c	0.252c		0.141c	1.06c	3.12c
		0.4	2.67	0.237		0.188	0.95	2.27
013-014	3.4	3.1	2.67	0.261				
		0.7	2.82	0.253				
		1.8c	1.97c	0.174c		0.229c	0.74c	4.29
032-033	4.8	0.2	N.S.	N.S.		0.234	0.72	4.18
		1.2	2.64	0.256		N.S.	N.S.	N.S.
035-034	5.4	1.9[5]	2.23[5]	0.205[5]				
		3.1	2.87	0.269				
		0.7	2.79	0.243				
038-039	5.8	3.5c	2.85c	0.266c				
		0.6	2.35	0.206				
042-043	6.0					0.217	0.82	4.41
						0.272c	0.78c	4.57c
		1.1	2.85	0.258				
045-046	6.3	0.5	2.82	0.255				
		3.7c	2.88c	0.269c				
		5.2c	2.57c	0.241c				
049-050	7.3	0.6	2.74	0.240				
		1.6	2.59	0.234				
		1.3	2.57	0.232		N.S.[6]	N.S.[6]	
055-056	7.8	0.6	2.71	0.254		0.191	0.70	2.85
		6.3c	2.58c	0.252c		0.219c	0.67c	3.00c
		1.0	2.76	0.193				
057-058	8.7	0.4	2.37	0.204				
		6.0c	2.29c	0.198c				
						0.184[2]	1.20[2]	3.18[2]
065-066	10.0					0.283[3]	0.85[3]	3.65[3]
						0.197c	0.71c	2.31c
073-074	11.4		2.17c	0.180c				
Mean			2.65	0.239		0.218	0.827	3.45

[1]Apparent volume weight calculated as W=a/b where a is net dry weight of sample (gm) and b is volume (ml) of wet sample as packed into sampling cylinder in process of taking sample. Dry weight in pounds per cubic foot can be obtained by multiplying this value by 62.5.

[2]Delta samples, surface is 2.2 ft. above original crest line.

[3]Delta sample, surface 2.9 ft. above original crest line.

[4]The designation "c" represents samples taken from original river channel.

[5]Particle size distribution on this sample in Table 4.

[6]N.S. = No sample.

TABLE 2.—ANALYTICAL DATA ON SAMPLES OF SEDIMENT FROM SIDE ARMS OF LAKE DECATUR AND ON WAVE EROSION SEDIMENTS TAKEN IN 1936 AND 1946

1936 Samples

Range	Description	Thickness	Organic Carbon	Total Nitrogen
		Feet	*Percent*	*Percent*
024–023	Big Creek arm at mouth	0.8	2.43	0.230
		0.6	2.46	0.227
		0.7	2.01	0.187
027–028	Big Creek arm 0.5 mile above mouth	1.2	2.18	0.206
		...	2.26	0.193
		1.4c	2.20c	0.200c
		5.6	2.18	0.216
095–096	Sand Creek arm 0.14 mile above mouth	4.1	2.35	0.219
		1.8c	2.29c	0.210c
		2.0	2.35	0.223

1946 Samples

Range	Description	Total Nitrogen	Apparent Vol. Wt	Water in air-dry Samples
		Percent		*Percent*
093–094	Sand Creek arm 0.3 mile above mouth	0.181	1.06	2.46
		0.119	1.34	4.11
025–026	Big Creek arm 0.3 mile above mouth	0.200	1.04	3.42
		0.210	0.75	3.80
0109	Main lake, 5.2 miles above dam, 18 feet from S.E. shore	0.064	1.54	1.41
0102	Big Creek arm S. shore, 0.3 mile above dam	0.017	1.66	0.22
0104	Big Creek arm S. shore, 0.2 mile above dam	0.067	1.43	1.48

TABLE 3.—BASE EXCHANGE PROPERTIES OF LAKE DECATUR SEDIMENT, 1946 SELECTED SAMPLES

Range	Description	Base exchange capacity m.e.[1]	Total bases m.e.[1]	Base saturation percent	pH
06–05	1.8 mi. above dam, in channel	35.3	74.7	212	7.4
06–05	1.8 mi. above dam, S.E. of channel	26.4	28.3	107	6.9
032–033	4.8 mi. above dam, toward N.E. shore	35.8	56.8	159	7.3
032–033	4.8 mi. above dam, toward S.E. shore near or at channel	33.5	49.2	147	7.4
065–066	10.0 mi. above dam, delta, surface	32.1	39.0	121	7.5

[1]m.e. = milligram equivalents per 100 grams of soil.

TURBIDITY AND SEDIMENT MOVEMENT

The rate of movement of sediment into and through the lake was estimated by analysis of turbidity records of the lake water and of stream-flow data. Daily turbidities of the raw lake water at the dam were available from the Decatur waterworks for the period 1934-1946. Daily readings of the lake level at the dam were available for the period 1927-1946. Daily turbidities of raw lake water for the period 1934-1946 were also available from the A. E. Staley Manufacturing Company, which has an intake about three miles above the dam, as shown in Figure 2.

Turbidity is an approximation of the suspended matter present in water determined by optical methods.[7] A turbidity value expressed in parts per million is not equivalent to the suspended matter content, also expressed in parts per million, but the two often have a sufficiently constant relationship that turbidity values can be used as a rough approximation of suspended-sediment content.

A Jackson candle turbidimeter was used for all determinations at Staley's except for very low values. The city waterworks uses the same type of instrument for values above 100 parts per million, and a Hellige turbidimeter for values below 100. Staley's values represent the turbidity of a 24-hour composite sample prepared from intake samples collected every two hours. At the waterworks the turbidity measurements are made on one sample daily taken between 8 A.M. **and** 10 A.M.

The relation between turbidity fluctuations and the movement of sediment-laden water through the lake was investigated after heavy rains in early May, 1936, by Dr. Max Suter of the State Water Survey Division[6]. In order to compare the suspended matter actually present with recorded turbidity, a series of water samples covering the entire length of the lake was collected on May 4 and again on May 6. Filtration of these samples showed the suspended solids present at each point throughout the length of the lake on these two days. These data showed that the suspended sediment load maintained a rather sharp front during its movement down the lake; definite turbidity peaks substantiate this interpretation. This study showed that from May 4 to May 6 the turbid inflow moved nearly 3½ miles, from a point about 9.6 miles to a point about 6.2 miles above the dam. On May 7 and 8 a turbidity peak occurred at the dam. During this period the lake level remained practically constant at 0.70 foot above spillway crest.

As part of this study, numerous gravimetric determinations of sediment content were made by the Gooch filter method on samples from which turbidity readings had been previously taken. These data give a basis for estimating the average coefficient of fineness or ratio of turbidity readings to gravimetric determination of sediment content in the water. This correlation of suspended-sediment content

[6]Suter, Max. Report on Sedimentation Studies of Lake Decatur, Decatur, Illinois. Illinois State Water Survey (1936). (Unpublished)

[7]Standard Methods for the Examination of Water and Sewage. American Public Health Association and American Water Works Association, Ninth Edition, (1946).

TABLE 7.—FLOW OF SANGAMON RIVER AT DECATUR, ILLINOIS[1]

	1908–09	1914–15	1916–17	1920	1930–31	1940–41	1944–45
	Ac.-ft.	*Ac.-ft.*	*Ac.-ft.*	*Ac.-ft.*	*Ac.-ft.*	*Ac.-ft.*	*Ac.-ft.*
July		807		4,362		3,054	
August	1,339	363	1,248	1,025	362	1,329	1,268
September	651	641	746	1.060	353	242	1,119
October	740	446	1,177	782	561	342	953
November	1,266	540	1,482	1,227	855	1,001	1,129
December	1,441	812	1,593	1,786	1,178	1,836	1,065
January	1,704	771	1,887		887	3,084	1,025
February			1,869		916		
March					1,983		
Total 6 months[2]	7,141 (4)	3,573 (1)	8,133 (6)	10,242 (7)	4,197 (2)	7,804 (5)	6,559 (3)
Total 7 months		4,380 (1)	10,002 (3)		5,113 (2)	10,888 (4)	
Total 8 months					7,096 (1)		

[1]U. S. Geological Survey stream flow records from Sangamon River at Monticello, Illinois, in mean c.f.s. for each month converted to monthly flow at Decatui in acre-feet on the basis of proportional watershed areas (x 1.65).

[2]Number in parenthesis shows rank in series.

water supply to meet all requirements. This deficiency will occur after months of low stream flow when the lake has been drawn down to the fullest extent possible to maintain the normal water supply. Figure 9 shows the predicted future effects of increasing water consumption and decreasing storage capacity with the recurrence of low-flow periods comparable to those of 1914-1915, 1930-1931, and 1944-1945, as well as an estimated minimum inflow against which it would seem prudent to provide a storage "reserve."

The uppermost horizontal line is at the level of the original reservoir capacity, 19,738 acre-feet. The volume of sediment line, based dn the surveys previously described, shows that 2,808 acre-feet of sediment had been deposited in 1936 and 5,171 acre-feet in 1946. The sediment curve is extended on the assumption of a continuing rate of storage loss of 1.2 percent annually.

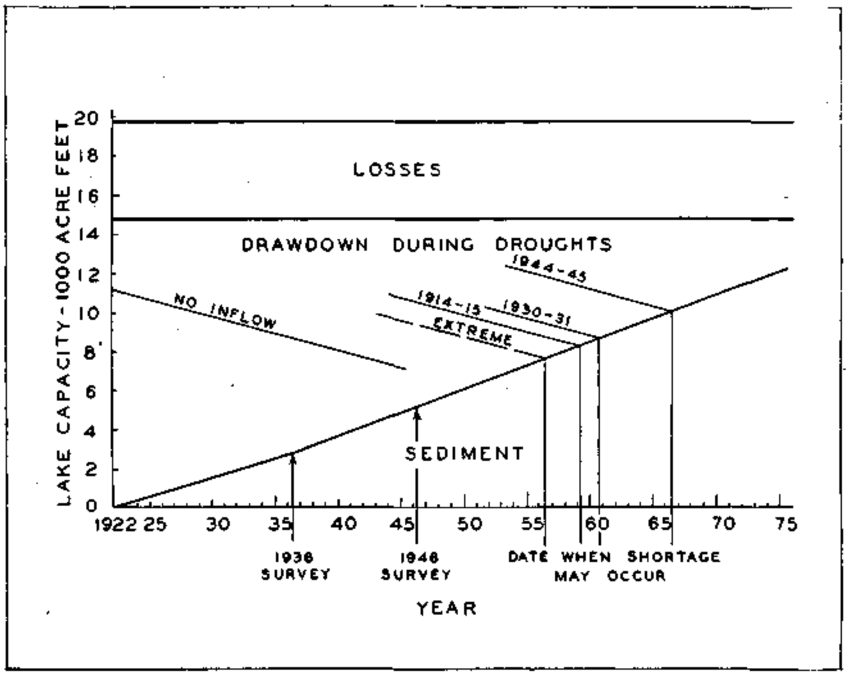

FIG. 9.—Effect of sedimentation on the useful life of the reservoir.

From records of stream flow, water use from the lake and draw-down the unaccounted water losses by evaporation and seepage were computed to be approximately 7,500 acre-feet and 3,200 acre-feet, respectively, for the 6-month low-flow periods in 1940-1941 and 1944-1945. Based on these data, a near-average value of 5,000 acre-feet was chosen for the purpose of this analysis as the average unaccounted loss during a

ECONOMIC LOSSES FROM SEDIMENTATION

Sedimentation in Lake Decatur is causing three types of direct damage. These are: (1) premature loss of the reservoir's capacity to provide adequate water supply; (2) potential reduction in property values surrounding the lake; and (3) gradual reduction in recreational value for boating, fishing, etc. In the absence of corrective measures, other indirect losses will occur, such as loss of business and higher costs of production to industry in the city and to the agriculture of the surrounding trading zone.

The city can maintain its water supply by developing additional reservoir storage and by reducing the rate of loss of the present or future storage through assistance in the soil conservation program on the watershed area. There appear to be three economically feasible alternatives for developing additional storage (See pp. 52): (1) raising the present dam; (2) building several small reservoirs on tributaries to the present lake; and (3) building one or more larger reservoirs on the Sangamon River above Lake Decatur. If the 1936-1946 average rate of sediment production from the watershed continues, all three alternatives probably will have to be used within the next 100 years. Only a detailed engineering investigation of potential dam sites and a study of the financial aspects of future storage developments could determine the sequence in which these alternatives should be used.

Certain economic considerations should be recognized at this time. First, the construction of a sizable reservoir upstream from the present lake would be effective in shutting off probably 80 percent of the sediment now coming into Lake Decatur. Smaller reservoirs on the tributaries would shut off only 20 percent or less of the total sediment inflow. On the other hand, a complete soil conservation program on the watershed would reduce sedimentation by an estimated 62 percent (Seepp. 57). Because of the nature of the conservation job, however, probably 10 years of aggressive effort would be required to complete the application of conservation practices and needed conversions in land use and farm economy. As additional storage should be provided by 1956, before a conservation program could be fully effective, the protection of the present lake by an upstream reservoir should be given proper weight in considering the over-all practicability of the three alternatives for providing additional storage.

A second important consideration is the advancing cost of construction. Louis R. Howson has recently shown[8] that permanently higher construction costs may be expected. He presents construction-cost indices that show permanently higher costs result after every major war. For example, following the Civil War, construction costs never receded to less than 40 percent above those prevailing in 1860. Following the first World War, construction costs never receded to as much as 50 percent above those of 1913. Except for slightly more than a year, about 1922, and for a little more than 4 years, between 1930

[8]Howson, L. R. Permanently Higher Costs Here—Rate Increase Necessary. Water Works Engineering, Vol. 99, No. 12, pp. 684-687, 704-708, 1946.

belt of more rolling topography one to one and one-half miles wide on each side of the Sangamon River floodplain in Piatt County contains only 38.9 percent nearly level land; whereas 18.5 percent of the land has 2 to 5 percent slopes, 35.9 percent has 5 to 15 percent slopes, and 6.7 percent has slopes of more than 15 percent.

Geologically,[9,10] the drainage area is comparatively uniform and homogeneous. It is almost entirely covered by the Shelbyville till, a glacial formation that resulted from the advance of the southwestern salient of the Michigan glacial lobe in early Wisconsin (Pleistocene) time. Nearly everywhere the till is covered by wind-deposited loess, which attains thicknesses of as much as 4 feet in this area. Beneath the Wisconsin till are deposits of two earlier glacial periods, but their surface outcrop is limited. The Iowan-Peorian loess zone and the Sangamon gumbotil outcrop around the lake, and the older Illinoian till is exposed in steep banks near the State Highway 105 bridge and near the Decatur Country Club. No outcrops of still older formations are known in the watershed. Some fluvio-glacial sands and gravels in the form of valley-train and terrace deposits occur along the Sangamon River Valley.

Soils and Erosion

Erosion as related to soils has not been mapped over the entire drainage area of Lake Decatur. The Soil Conservation Service has mapped much of Piatt County, however, and this is believed to give a good representation of conditions in the watershed as a whole. Piatt County is about one-half as large as the drainage area above Lake Decatur. Although only about 58 percent of the county is within the drainage area, physical land conditions in the rest of the county are typical of the watershed, of which about 27 percent is within Piatt County (See Figure 1).

Soil conservation survey maps have been prepared on more than 100,000 acres in Piatt County. These maps give a physical inventory, showing soil types, percent of slope, degree of erosion, and present land use. Maps representing 15 percent of the entire county were selected at random from each of the so-called problem areas of the county, and the acreage of the various Land-Capability Classes was tabulated. This information was then projected to the entire county and is summarized in Table 8. This table shows that nearly three-quarters of the entire county consists of nearly level, highly productive soils, requiring no special erosion-control practices to maintain the soil for general agricultural purposes. Although these soils are not considered a problem for general farming in so far as erosion is concerned, it is probable that the relatively small loss per acre of soil removed in runoff and drainage water is an important part of the total sediment production of the drainage area. More than one-fourth of the land is in Classes II, **III,** and IV, on slopes ranging from 2 to 15 percent. Here a major sheet-

[9]Leighton, M. M. The Glacial History of the Sangamon River Valley at Decatur and its Bearing on the Reservoir Project: Illinois State Acad. Sci. Trans., Vol. 14, pp. 213-218, 1922.
[10]Leighton, M. M. and Ekblaw, G. E. The Glaciology of the Decatur Region (abstract): Illinois Acad. Sci. Trans., Vol. 27, No. 2, p. 111, 1934.

erosion problem exists. Land in these classes is widely distributed, and it probably produces most of the sediment reaching Lake Decatur.

TABLE 8.—CLASSES OF LAND IN PIATT COUNTY

Land-Capability Classes	Entire County	Rolling Area adjacent to Sangamon River
	percent	*percent*
Class I Land		
Nearly level, less than 2% slope; dark colored, highly productive soil. Land suitable for cultivation, requiring no erosion-control practices to maintain soil for general agricultural purposes.	73.9	38.9
Class II Land		
Gently sloping, less than 5%; productive soil. Good land that can be cultivated safely with easily applied practices.	19.4	18.5
Class III Land		
Sloping, less than 10%; moderately productive soil. Moderately good land that can be cultivated safely with such intensive treatments as terracing and strip cropping.	4.8	29.1
Class IV Land		
Strongly sloping or eroded land. Slopes up to 15%. Best suited to hay or pasture, but can be cultivated occasionally, usually not more than 1 year in 6.	1.2	6.8
Class VI Land		
Steep or eroded land, not recommended for cultivation. Best suited for permanent pasture land.	0.5	3.8
Class VII Land		
Very steep or eroded land. Suited for woodland or pasture with major restrictions in use; needs extreme care to prevent erosion.	0.2	2.9
Total	100.0	100.0

A separate analysis was made of the more rolling part of Piatt County, which occurs in a belt about one to one and one-half miles wide adjacent to the Sangamon River (See Table 8). In this belt slightly less than two-fifths of the land is nearly level, whereas three-fifths is on slopes of 2 to 15 percent and is eroding moderately to severely.

Land Use and Conservation

The Sangamon River watershed lies in a rich and productive agricultural area in the heart of the Corn Belt. Except for urban areas, roads, railroad rights-of-way, etc., practically all of the land in the drainage area is in farms, and a high proportion of farm land is in cul-

FIG. 10.—Sheet erosion in cornfield near Monticello, Illinois. June 13, 1946.

FIG. 11.—Sheet erosion and deposition above fence near Parnell, Illinois. June 13, 1946.

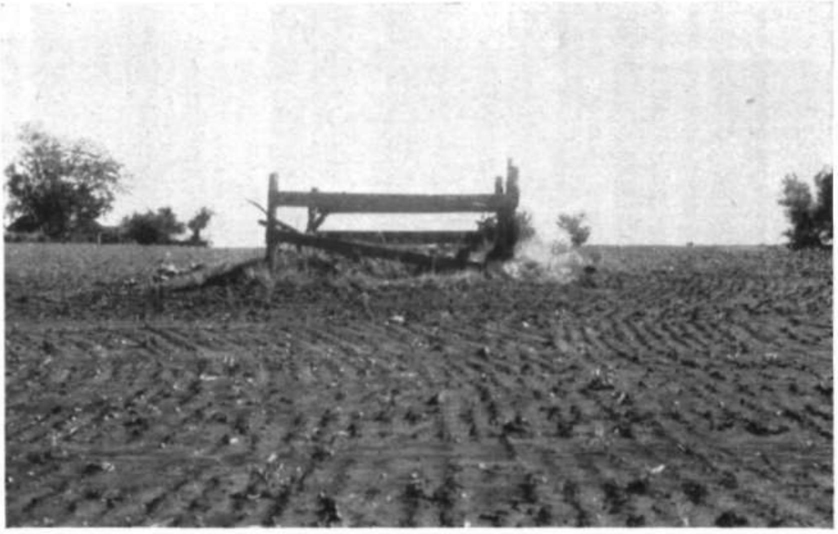

FIG. 12.—Sheet erosion in field surrounding abandoned well showing depth of soil removal near LeRoy, Illinois. June 13, 1946.

FIG. 13.—Gully erosion on strongly rolling land near Sangamon River.

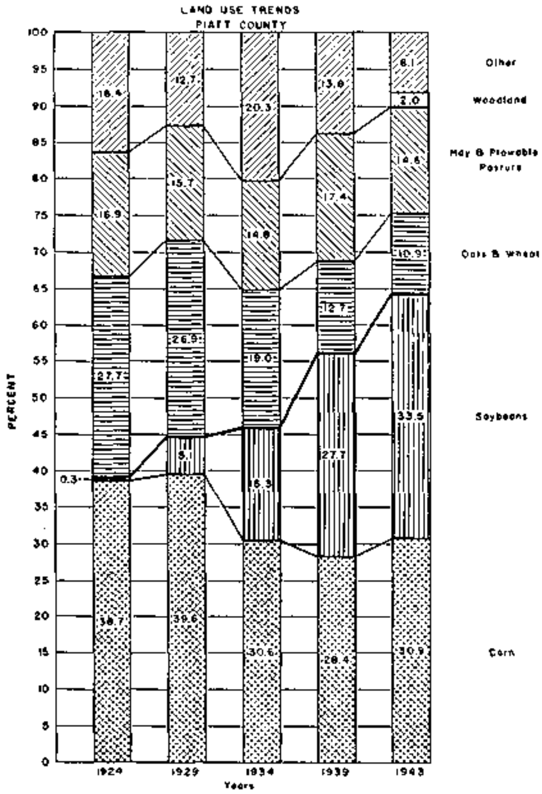

FIG. 14.—Land use trends in Piatt County.

Land use data for each of the six counties in which the watershed lies show the same trend. The acreage planted to corn and soybeans in these counties has increased from 41 percent of their combined area in 1922 to 60 percent of their area in 1945. In every county the increase has been due to expansion of acreage in soybeans. In 1922 only 30,365 acres in all six counties was planted in this crop; in 1945, 614,700 acres was in soybeans, a net gain of 584,335 acres. Corn acreage declined from 1,043,800 acres in 1922 to 951,800 acres in 1945, a net loss of 92,000 acres. If it is assumed that all of the net loss in corn acreage was replaced by soybeans, there remains 492,335 acres now in soybeans (19 percent of the total land area in the six counties) which was used in 1922 for small grain, hay, pasture, and other purposes engendering far less soil erosion.

Although only meager experimental data on soil erosion are available for this area, the results of plot studies at the University of Illinois are indicative of the effects of land use.[11] Four plots on a 2-percent

[11]Van Doren, C. A., and Stauffer, R. S. Summary of Contour Farming Study. Ill. Agr. Exp. Sta. and Soil Conserv. Serv. June 1946 (mimeographed).

month "extreme" drought, period should be experienced. By 1970 the city will need about 14,500 acre-feet under the same conditions. At that date Lake Decatur could supply only 4,000 acre-feet after deducting losses. Thus, the combined storage of the three small reservoirs and of Lake Decatur would barely cover the estimated water-storage requirements.

Several possible reservoir sites exist on the Sangamon River above Lake Decatur. A feasible site may exist just above the present lake, but no investigation of this site has been made. A reservoir at this location would have the same general characteristics as Lake Decatur. Several sites farther up the Sangamon River were investigated in 1934[12] in connection with possible additional water supply for Champaign, Urbana and the University of Illinois. Feasible storage capacities at these sites range from less than half the original capacity of Lake Decatur to more than one and one-half times its capacity. A site in Section 15, T.20 N, R. 7 E., Champaign County, where the largest amount of storage could be developed, was found, however, to be geologically unfavorable.

Reservoirs at any of the upstream sites would be broad, shallow lakes similar to Lake Decatur. They would have large water losses from evaporation. Their rate of silting under present watershed conditions probably would range from about one-third to about equal that of Lake Decatur, depending on the ratio of capacity to watershed area. Upstream reservoirs would decrease the rate of silting in Lake Decatur but would themselves be subject to fairly rapid depletion of storage. Thus, in effect, sedimentation would be reduced in the present lake where it has proved to be very costly, and would be partially transferred to another site where, presumably, the expense to water-supply, property, and recreation would not be so great.

Soil Conservation

In preceding sections it has been pointed out that the city's water storage may be increased by raising the present dam or by constructing one or more additional reservoirs in the drainage basin above the present reservoir. This additional storage will be necessary some 44 years earlier than if no sedimentation had occurred in the present reservoir. Even though it will alleviate the threat of deficient water supply for a few decades, this storage too will be rapidly lost by sedimentation unless measures are taken on the land to control and reduce the rate of soil erosion. The ultimate solution of the water supply problem can be achieved only by proper coordination of the needs of the city and the needs of the land, that is, by planning the use, treatment and management of the land in such a way as to achieve lasting agricultural prosperity with the minimum of soil erosion. Already enough is known of the science of soil conservation to point the direction toward what can be and must be done to maintain the soil resources of this great agricultural area as well as the water resources of its streams.

[12]Preliminary Data on Surface Water Supplies. Illinois State Water Survey Division Bull. No. 31, 157 pp., 1937.

Upper Sangamon Valley Conservation Service. As a result of the findings of the 1936 investigation of sedimentation in Lake Decatur, the Decatur City Council came to recognize that a long-range farm-city program of conservation of natural resources in the Upper Sangamon Valley could benefit all of the people in the watershed and at the same time prolong the usefulness of Lake Decatur for water supply.

In June 1941 the city council employed two conservationists and established the Upper Sangamon Valley Conservation Service in the city's Public Property Department. The purpose of this service is to determine what the problems are, to assist farmers and land-owners to establish conservation on their farms, and to secure the assistance and cooperation of local, State, and Federal agencies to work with districts in carrying out a land use and conservation program in the watershed.

The city has been providing funds for advancing this program to the extent of approximately $12,000 a year.

The main assistance at first was helping all the counties to organize Soil Conservation Districts. After the counties had organized Districts, the Upper Sangamon Valley Conservation Service entered into co-operative agreements with each of the Soil Conservation District boards, under which the Service furnishes (1) assistance in preparation of district programs and work plans, (2) assistance with educational meetings, tours, publicity, and demonstrations, (3) assistance in making available educational materials which will help farm people to solve their erosion problems, and (4) assistance in helping farmers lay out conservation practices.

RELATION OF FINDINGS TO SURFACE WATER SUPPLY IN ILLINOIS

Out of 249 treated public water supplies in Illinois in 1940,[13] 107 were surface water supplies and 142 were ground water supplies. Of the 2,581,253 persons[14] in Illinois that rely on sources other than Lake Michigan, nearly half depend on surface water. The increasing need for use of impounding reservoirs for public water supply is shown by the 15-percent growth in number of these reservoirs from 1937 to 1944. In addition, a large number of surface water supplies are used by rail-roads and industries. As of 1944,[14] 62 cities and towns had impounding reservoirs. Most towns dependent on surface water supplies that are not located on Lake Michigan or the largest rivers, such as the Ohio, Mississippi, or Illinois, have found it necessary to provide storage for use during recurrent periods of low stream flow or drought.

It has been recognized for some years in Illinois and throughout the North Central States that ground water supplies were being rapidly developed to the limits of their capacity. The decline of ground water levels over a long period of years has been a common experience in many industrial areas from Ohio westward into Iowa. Investigations of several areas with declining water tables have pointed to over-

[13]Weibel, S. R. A Summary of Census Data on Water Treatment Plants in the United States. U. S. Public Health Service Public Health Reports, Vol. 57, No. 45, pp. 1679-1694. Nov. 6, 1942.
"Data on Illinois Public Water Supplies. Illinois Department of Public Health, Division of Sanitary Engineering, June, 1944.

of sediment production from the drainage area was equivalent to 200 ac.-ft./l00 sq. mi., as compared with 22 ac.-ft./l00 sq. mi. during the same period from the area above Lake Decatur.

A survey of West Frankfort Municipal Reservoir[18] located on Tilley Creek in Franklin County showed an annual storage loss of 0.81 percent from 1926 to 1936. This reservoir had an original capacity of 1,175 acre-feet and a drainage area of 3.54 square miles, which gives it a large C/W ratio of 332 ac.-ft./sq. mi. Its indicated rate of sediment production, however, is equivalent to 268 ac.-ft./lOO sq. mi. of drainage area, or twelve times as great as that of the Lake Decatur watershed.

In the development of surface water supplies, engineers commonly select the most favorable natural site for an impounding reservoir. The choice is usually dependent on proximity to the city, desirable geological conditions, adequate water yield from the drainage area and lowest cost per acre-foot of storage for development. Almost never in the past has the factor of sedimentation been given weight in either the selection of a site or the design of a reservoir. Yet, this factor may overweigh various other factors in the long-term economics of the project. Failure to consider sedimentation has been due largely to lack of quantitative information on its effects. More studies of the general type reported herein are urgently needed as a guide to sound planning for the most economical and efficient utilization of surface water supplies.

In planning new reservoir developments, three factors relating to sedimentation should be considered in addition to the usual site and water-supply factors. These factors are: (1) the ratio of the capacity of the proposed reservoir to the size of the drainage area, not only with respect to adequacy of water yield to meet all demands but also with regard to rate of capacity loss in the light of estimated sediment inflow; (2) the possibilities of protecting the reservoir through watershed treatment and soil conservation measures; and (3) the possible applicability of other measures of sedimentation control such as venting density currents.[19]

The data cited above indicate that reservoirs with relatively low C/VV ratios in agricultural sections of Illinois will have high rates of storage depletion. The smaller the total drainage area, the higher will be the rate of storage loss for a given C/W ratio, other factors being equal. The rate of sediment production from drainage areas of a few square miles may be six to twelve times as high as from drainage areas of a few hundred square miles, as shown by comparison of the measurements in Lake Bracken, Lake Calhoun, West Frankfort and Pittsfield Reservoirs with the data from Lake Decatur.

Under prevailing land use and agricultural practices, it would appear, on the basis of present information, that reservoirs with large drainage areas must have an original storage capacity of not less than 50 ac.-ft./sq.mi., and reservoirs with small drainage areas must have a storage capacity of several hundred acre-feet per square mile in order

[18]Jones, V. H. Advance Report on the Sedimentation Survey of West Frankfort Reservoir, West Frankfort, Illinois. U. S. Soil Conserv. Serv. SCS-SS-15. 9 pp., illus., processed. Washington, D. C., May, 1937.

[19]Brown, C. B. The Control of Reservoir Silting. U. S. Dept. Agr. Misc. Pub. 521. 166 pp., illus. Washington, U. S. Govt. Print. Off., 1943.

to assure a reasonably long and economic life.[17] With sedimentation surveys of a considerable number of additional reservoirs in the state, it would be possible to set up a definite scale of values as a guide to reservoir planning and design.

On the other hand, it should be recognized that the provision of a large amount of excess storage, over and above that needed to meet anticipated demands on the reservoir during its period of amortization, is a form of insurance against premature loss by sedimentation. It may be that this excess investment could be better spent in another way, namely, in reducing the rate of sediment production from the drainage area through aid to the soil conservation program.-[0] Expenditures for furthering soil conservation rather than for large excess storage capacity would have the double value of assuring much greater longevity of the water supply, and at the same time maintaining the agricultural productivity of the surrounding area on which the urban population is dependent in many ways.

Furthermore, expenditures for conservation of watershed lands tend to increase the purity and stability of water supply, enhance the esthetic appeal and protect property values of the lake area, and maintain the usefulness of the lake for recreational purposes by reducing the turbidity and deposition of silt bars which interfere with swimming, boating and fishing. To the fullest extent possible, therefore, the control of erosion on watershed areas should be planned and promoted by water users in this state in lieu of developing a great excess of storage.

[20]Brown, C. B. Erosion Control on Watershed Lands. Jour. Amer. Water Works Assoc, Vol. 38, No. 10, pp. 1127-1137. October, 1946.