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STATE OF ILLINOIS

THE SILT PROBLEM AT SPRING LAKE

MACOMB, ILL.

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Agricultural Experiment Station, Cooperating

DEPARTMENT OF REGISTRATION AND EDUCATION

NOBLE J. PUFFER, Director

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(Printed by authority of the State of Illinois)

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CONTENTS

SUMMARY

1. Spring Lake, the municipal water supply reservoir at Macomb, Illinois was built in 1927 at a cost of about $138,000, The lake has a drainage area of 20.2 square miles; original surface area was 84,3 acres and original volume was 607 acre-feet.

2. The 1947 sedimentation survey shows a capacity loss of 2.32 per cent per year. In the 20.4 years that the reservoir has been in existence it has lost 47.3 per cent of its original capacity. At this rate the lake would be practically full of silt in another 20 to 25 years,

3. In the 20.4 years that the reservoir has been in use the most serious drawdown experienced removed a volume of water from the lake equal to approximately one-sixth of the lake's original capacity or one-third of its present capacity. Analysis shows that since the storage capacity is decreasing and the water demand in Macomb is increasing, the reservoir will be inadequate by 1953 to furnish the full needs of the city in the event of a severe drouth.

4. The present water consumption in Macomb is approximately 63 gallons per person per day; this is a lower average consumption than is found in several other representative cities in Illinois which utilize surface reservoirs for their source of supply.

5. The 14.23 acre-feet of sediment which has deposited in Spring Lake every year represents a destruction amounting to 33200 of the original cost of the construction of the reservoir. At 1948 price levels it would cost approximately $7500 annually to replace this storage capacity which is lost to sediment each year in Spring Lake,

6. As originally designed and built, Spring Lake had a ratio of capacity to watershed (C/W ratio) of 30 acre-feet per square mile. Sedimentation investigations in recent years in the United States and in Illinois indicate that a reservoir of this size in Illinois should have a C/W ratio of at least 150 acre-feet per square mile for a life of 100 years.

7. Records of the turbidity of the lake water and the water levels in the lake indicate that heavy rainfall on the watershed greatly increases turbidity in the lake water. Although some of this turbid water undoubtedly passes over the spillway, much of it remains in the lake for days after the rain occurred, permitting the silt to settle out.

8. The sediment deposited in Spring Lake during its 20.4-year life represents an average annual loss of 47.93 cubic feet or 1.44 tons of sediment per acre from the watershed.

9. Analyses were made of samples of sediment taken from representative parts of the lake. The samples can be grouped according to definite physical and chemical characteristics. The character of sediment differs according to location

in the reservoir. The finer, more fertile, and less compacted sediment is located in the main body of the lake.. Coarser, less fertile, more compacted, and to some extent less acid deposits are located in the delta and impounded channel sections of the lake.

10. The lake sediment contains an estimated 132,500 pounds of readily available potash, 14-1,000 pounds of phosphoric acid, and 22,700 pounds of nitrogen. At current market prices for fertilizer this has a potential value of $21,900.

11. A comparison of the texture of the sediment and watershed soils shows that the lake sediments are finer textured than tratershed soils, due in part at least to selective erosion and assorting effect of flowing water.

12. The two main classifications of soils occurring in the watershed are: (a) Dark-colored, more fertile, upland prairie soils which occupy 66.3 per cent of the watershed and (b) Lighter-colored upland timber soils which make up 28.4 per cent of the watershed area.

13. Of the total cropland in the watershed, 86.7 per cent is located on slopes of less than 4 per cent. Of the land in pasture, 47.1 per cent is located on slopes of less than 4 per cent.

14. A conservation survey shows that 82.7 per cent of the watershed is in land-capability classes I, II, and III, which are considered safe for continuous cultivation. At present about

97 per cent of the cultivated land falls within these capability classes.

15. In Emmett Township, in which most of the watershed lies, the 1938-1947 trend in cropping has been toward increasing acreages of intertilled crops - corn and soybeans.

16. In 1947 the average farm in Emmett Township consisted of 136 acres of which only 58 per cent was tillable. Of this tillable land, however, 63 per cent was in corn and soybeans which denotes overproduction of these intertilled crops. Such over-cropping is conducive to increased soil losses.

17. The conservation survey of the watershed indicates that more than 95 per cent of the sediment in Spring Lake comes from sheet erosion. Of the land area contributing to erosion, 54 per cent is now in cropland and 41 per cent is in pasture.

18. At present a small proportion of the farmers of the watershed participate in a soil conservation program. A great number of the farms are operated by tenants for absentee owners.

19. The conservation survey shows that major changes are needed in this watershed to make land use conform to land capability. In general, longer rotations are needed in addition to soil conservation measures.

20. It is estimated that a complete protective program on this watershed as outlined in this report would reduce soil losses by 80 per cent.

21. Possible remedial measures for maintaining a water supply for Macomb include (1) raising the present dam, (2) construction of another reservoir, possibly at a location Just downetream from the present Spring Lake, (3) adoption of an intensive soil and water conservation program on the watershed (4) development of a ground water supply. Dredging does not appear economically feasible.

22. The adoption of soil conservation practices means Increased net income to the farmer. For the 10-year period 1936-1946 high-conservation farms in a comparable area had net Incomes (after all costs of conservation were paid) of $3,46 per acre per year more than low conservation farms.

Recommendations

23. It is recommended

(a) That a qualified professional engineer be engaged to make a complete study of the Macomb water supply problem, and

(b) That the City of Macomb undertake immediately a soil and water conservation program on the Spring Lake watershed in cooperation with existing conservation agencies.

THE SILT PROBLEM AT SPRING LAKE MACOMB, ILLINOIS

by

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INTRODUCTION

Two of the Nation's most basic natural resources are soil and water. Depletion of either of these resources has a profound effect on the welfare of man. The investigation discussed in this report deals with problems arising from loss of soil from a watershed - with consequent reduction in the capacity of land to produce food and fiber - and deposition of the resulting sediment in a municipal reservoir, which reduces its capacity for the storage of water needed by the city of Macomb, Illinois,

A great many of the impounding reservoirs in Illinois have been constructed in the past two or three decades. Engineers commonly selected the most favorable site for these reservoirs considering such factors as distance from the city, dam-foundation conditions, water yield from the watershed, peak rates of runoff, population trends, and cost of storage furnished. The sedimentation factor was not considered because it was not generally recognized, or, if so, basic data on rates of sediment production necessary for design purposes was lacking.

After some twenty or thirty years it has become apparent that sediment is rapidly replacing reservoir space which was set aside for storing water during periods of high runoff to be used during periods of little or no runoff. As population and water consumption increase, the amount of reserve storage needed for a dependable supply during dry seasons also increases. An allowance for reserve storage for increased consumption is usually provided in the design of the reservoir, but the rapid loss of storage due to sedimentation, if not provided for, more than offsets this allowance. Thus, a number of cities are now facing water shortages although their reservoirs were designed to supply needs for many years to come.

The problem of developing a dependable water supply under limiting conditions of precipitation, runoff, evaporation, availability of natural sites, and prevailing rates of sediment production is not simple. If the reservoir capacity is too large in relation to the size of drainage area above, it may never fill to capacity, thus representing an economic loss to the owners. If it is too small, loss of capacity due to sedlmentation may be high and the reservoir may rapidly become useless.

The seriousness of erosion in Illinois and the conse-auent rapid reservoir sedimentation led the Illinois Water Survey Division, the Illinois Agricultural Experiment Station, and the Soil Conservation Service in 1936 to Join in a cooperative study to determine the effects of different watershed and climatic factors on the rate of sediment production and the rate of sedimentation of reservoirs. The sedimentation survey of Spring Lake was made under this program. Up to the present time, 13 reservoirs have been surveyed, 4 of which have been resurveyed after an elapsed period of 10 years.

SCOPE OF INVESTIGATIONS

This survey of Spring Lake was carried out at the request of officials of the City of Macomb when it became increasingly evident that the lake was losing considerable capacity and that possibly the sediment was reducing the storage in the lake to such an extent that it threatened the adequacy of the city water supply.

A detailed sedimentation survey of the reservoir was made from August 18 to September 6, 1947 by a field party of the State Water Survey Division, the Soil Conservation Service and the City of Macomb. The water depths and silt thicknesses in the reservoir were measured along twelve silt ranges. The survey determined the original capacity of the reservoir, the present capacity, and consequently the volume of silt in the reservoir. The loss of surface area was measured by mapping the original and present shorelines. In carrying out the survey a permanent marking system was installed so that in future years resurveys may be made to measure the sediment accumulation at that time.

An analysis of the past trend in water consumption of the City of Macomb has been made by the State Water Survey Division. It indicates the future water requirements of the city. A study of this future water need in conjunction with the present rate of reservoir storage depletion was made to show the approximate date at which the lake will no longer be adequate to furnish the entire water needs of the city in the case of a severe drouth.

In an effort to determine the watershed sources from which the sediment originates, the Soil Conservation Service in 1947 and 1948 conducted detailed conservation surveys of many farms in the watershed. This work was done on a sample basis; about one-half of the watershed area was surveyed and the data extended to represent the entire watershed. These data on soils, slopes, land use, erosion and conservation practices give a very complete picture of the agricultural use of the farm lands of the watershed. An analysis of these data has been made to show specific problem areas where the soil losses from erosion are great and where conservation measures would be particularly effective. By means of these data it is possible to point out definite soil and water conservation measures that would effectively reduce the soil losses.

An additional study has been made by the Soil Conservation Service of the land-use history of the watershed farms during the past twenty years while Spring Lake has been in existence. This analysis shows the trend in land use on the watershed for this period. Its interpretation in light of the measured rate of sedimentation aids in developing recommendations for land use changes which would be most effective in reducing soil losses.

During the course of the survey a series of ten sediment samples were taken from various parts of the reservoir by means of a special sampler. Chemical and physical analyses of these samples have been made by the Illinois Agricultural Experiment Station. An analysis of the texture, colloidal content, volume-weight and plant food constituents of the sediment gives significant indications of the watershed sources of the sediment deposited in the reservoir.

The final interpretation of the silting problem at Spring Lake has been made on the basis of the complete reservoir and watershed survey data by the three cooperating agencies. Results are presented so as to be most helpful to reservoir owners. Several remedial measures such as raising the present spillway, dredging, and application of a complete watershed protective program are discussed.

ACKNOWLEDG-MENT

The agencies conducting this survey wish to acknowledge the generous cooperation of the municipal authorities of Macomb, particularly the city water department, in expediting the reservoir survey. The city made available two men for the period of the survey to assist in the conduct of the work. Boats and oars were also furnished by the city. Mr. Bill Ward, Chairman of the City Water Committee, Mr. Wm. S. Newell, Waterworks Engineer and Mr. Jim Zircle, Lake Superintendent were helpful at all times. Mr. Newell supplied information on the construction and history of the reservoir and made available for study the data on local water consumption.

The survey of Spring Lake was made by a State Water Survey field party consisting of the following men: Bernt O. Larson, Chief of Party, John B. Stall, Assistant Engineer, Leslie Jones and Douglas Rucker, The Soil Conservation Service furnished most of the specialized survey equipment needed for this work. Mr. L. C. Gottschalk, Head, Sedimentation Section, Office of Research, Soil Conservation Service, gave technical assistance during two weeks spent with the survey party at the beginning of the summer's work and one day at Spring Lake. He also helped to compile the section of this report dealing with the watershed and reviewed the entire report.

In the conduct of the agricultural phases of this study Mr. Hampton Long, District Conservationist of the U. S.

Soil Conservation Service and Mr. Chae. J. Webb, Chairman, and the Directors of the McDonough County Soil Conservation District have been most helpful by authorizing the use of personnel assigned to the District for carrying out of the conservation survey of this watershed. The conservation survey was made during the summer of 1947 and 1948 by A. A. Agathen, Soil Scientist under supervision of A. A. Klingebiel, Soil Conservation Service. Mr. B. B. Clark, State Conservationist cooperated with the authors in the compilation of this report.

The study of the land use and conservation history of the watershed was made by Dr. E. L. Sauer, Project Supervisor, Research, Economics of Soil Conservation, Soil Conservation Service, and Illinois Agricultural Experiment Station Cooperating. This study entailed both field visits and study of public records and their interpretation. Dr. Sauer and Mr. Stall took the photographs used in the report.

The Illinois Soil Conservation Districts B8ard aided this study by financing the analyses of the sediment samples. This work was carried out in the laboratories of the Illinois Agricultural Experiment Station under the supervision of Dr. E.E. De Turk.

RESERVOIR

GENERAL INFORMATION

Spring Lake is located four miles northwest of the City of Macomb in Sections 15 and 16, Township 6 North, Range 3 West, McDonough County. As shown in Figure 1 the lake is impounded on Spring Creek and extends about one mile in a westerly direction from the dam which is located in Section 15. The dam is 600 feet long, lying in a general East-West direction with the spillway, 150 feet in length, at the east end. The top of the dam is 10 feet wide and is at elevation 649 feet above mean sea level. The upstream dam slope is 3 to 1 with a five foot berm at elevation 635 and a concrete 6lab facing from elevation 635 to 645. Downstream slope is 2 to 1. Design data specified a puddled clay core four feet thick at the bottom extending to "hard pan" or to a minimum depth of four feet below the valley floor. Material for the dam was excavated from the spillway location on the east bank of the original valley.

Spillway elevation is 641.0 which is 17 feet above the original stream bed and about 10 feet above the original valley floor. Wooden flashboards were permanently installed on the spillway in 1946 raising the effective crest 1.3 feet or to an elevation of 642.3.

The reservoir is utilized for the city water supply. Water from the reservoir is conducted three and one-half miles

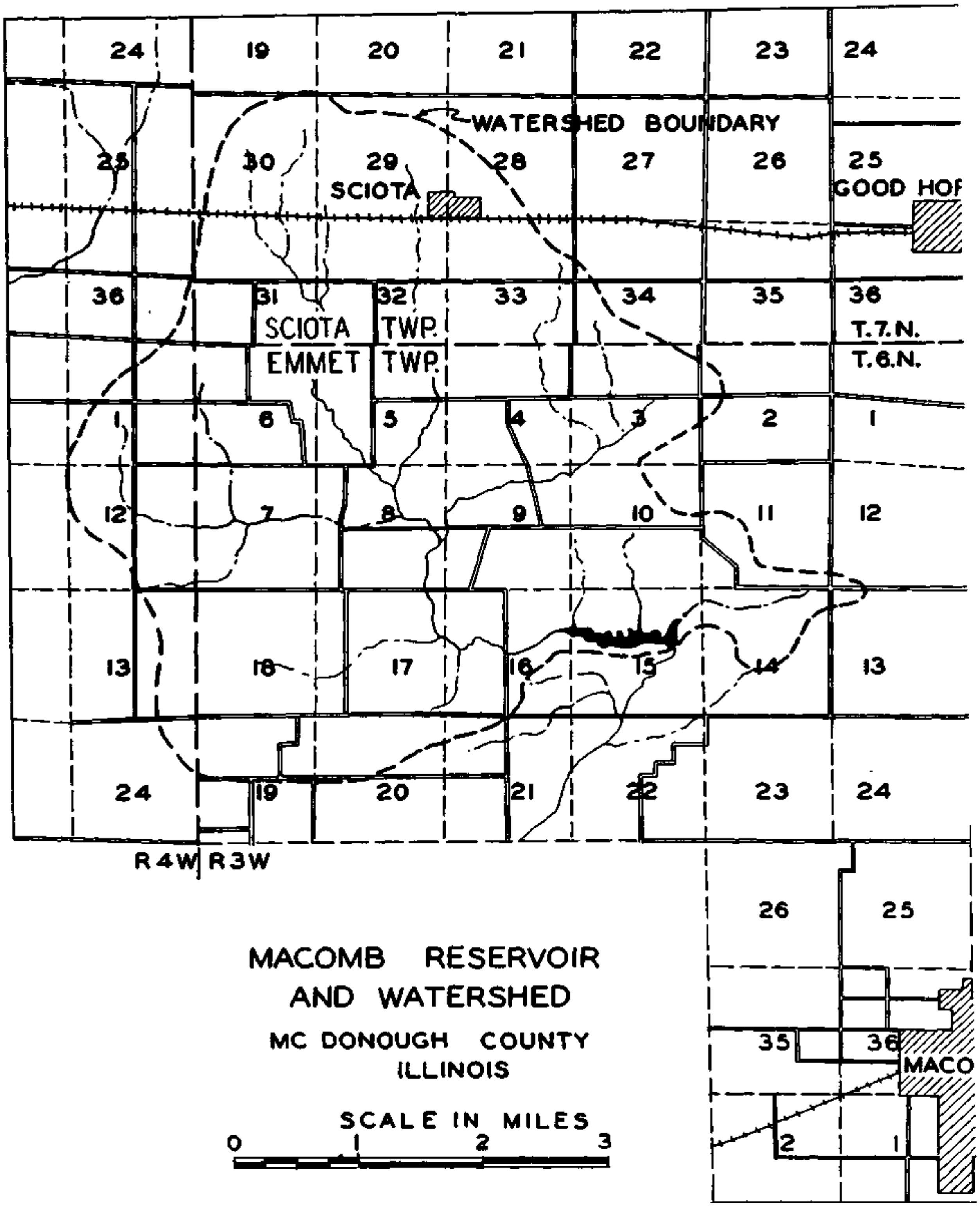
WATERSHED BOUNDARY
SCIOTA
GOOD HOP
SCIOTA TWP.
EMMET TWP.
T.7.N.
T.6.N.
R4W
R3W
MACO
MACOMB RESERVOIR AND WATERSHED
MC DONOUGH COUNTY
ILLINOIS
SCALE IN MILES
0
1
2
3

FIGURE 1

through a pipeline to the municipal filter plant located in the northern outskirts of the city on the Lamoine River.

Construction of the reservoir was completed and storage began in April 1927. Total cost of the development was reported to be $138,800.

At a water level elevation of 642.3 the lake proper is slightly more than one mile in length. The main body of the lake varies in width from about 700 feet at the dam to about 300 feet at the upper end. The lake was Impounded on the flood plain of Spring Creek which had a slope throughout the reservoir of 13.8 feet per mile. Original capacity of the reservoir was 607 acre-feet or 198 million gallons.

The watershed extends over an area of 20.2 square milos. Four main branches of Spring Creek unite about two miles above the head of the lake and the major inflow to the lake is through this channel. Several intermittent streams flow into this channel and into the reservoir proper. As the names Spring Creek and Spring Lake imply, a number of springs are located in the area.

METHODS OF SURVEY

The original and present water and sediment volumes of the reservoir were determined by the range method of survey developed by the Soil Conservation Service and described in their Bulletin 524*.

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*Eakln, H. M., Silting of Reservoirs, U. S. Dept. of Agriculture Technical Bulletin 524, Revised by C. B. Brown, 168 pp. illustrated. Washington, U, S. Gov't. Printing Office, 1939. Appendix.

A triangulation network consisting of 15 stations was expanded from a 650-foot base lino across the dam. This served as primary control for mapping shoreline and for the establishment of tho silt ranges. After mapping the 5.6 miles of shoreline, a system of 12 silt ranges was established as shown in Figure 2. The mapping was dons with plane table and telescopic alidade to a scale of 1-inch to 100 feet. Along each silt range, soundings of water depth were taken at approximately 25-foot intervals to locate the present elevation of the top of the sediment. Soundings were taken with a bell-shaped 5-pound aluminum sounding weight with base diameter of 5 inches and a height of 6 inches. At intervals of 50 feet, or with alternate soundings, the thickness of the sediment was measured with a "spud". This is a specially designed instrument developed for this work by the Soil Conservation Service. As shown in Figure 3 the spud consists of a steel rod made up of cupshaped grooves every one-tenth of a foot. The spud is thrown spear-like into the sediment. It passes completely through the sediment and penetrates the original bottom soil or pre-reservoir deposit. The total depth of penetration is determined by means of a calibrated lino attached to tho spud. The spud is then retrieved and tho actual thicknoss of the sediment is determined in the boat by inspecting the small soil or silt samples retained in the cups.

A total of 161 soundings and 70 spuddings were mado on the seven ranges on Spring Lake which could bo worked from

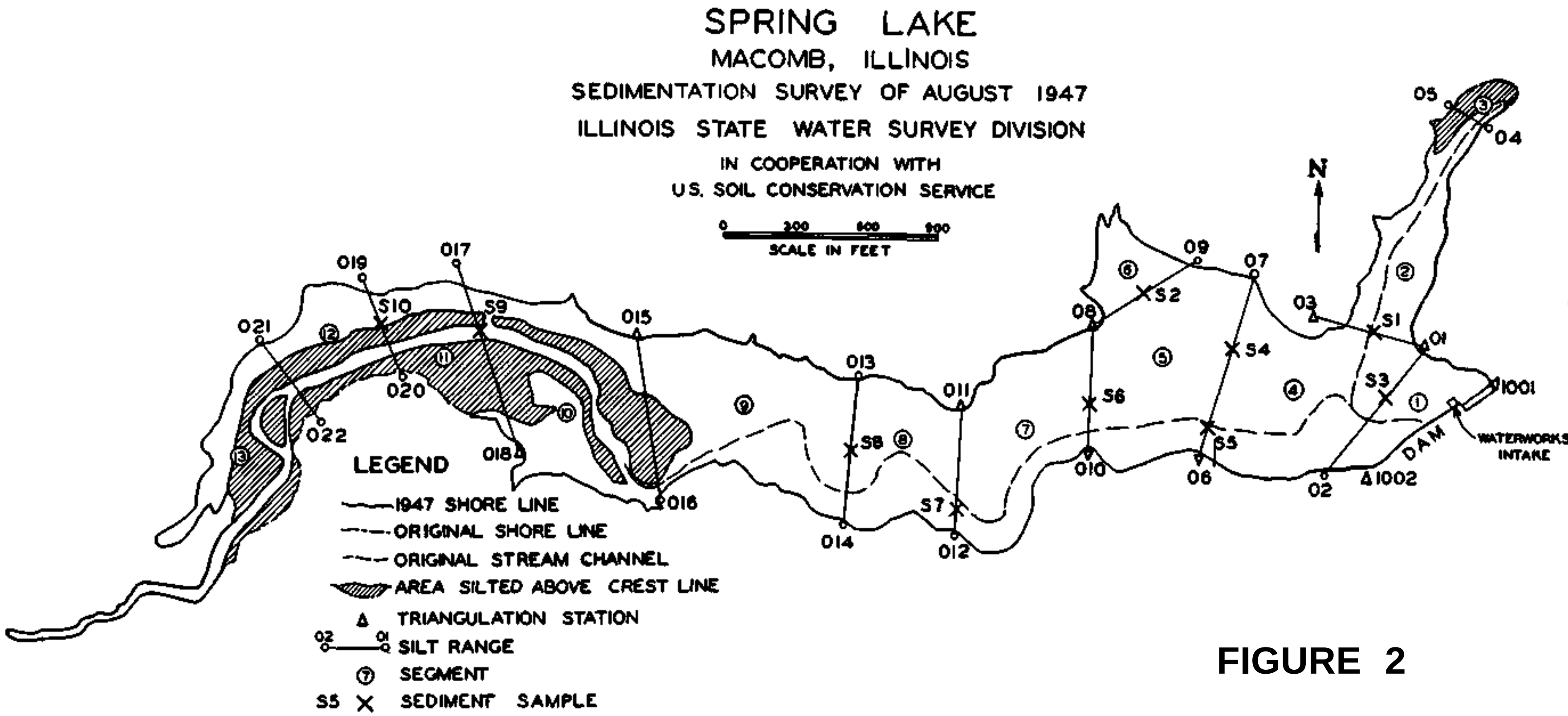
SPRING LAKE
MACOMB, ILLINOIS
SEDIMENTATION SURVEY OF AUGUST 1947
ILLINOIS STATE WATER SURVEY DIVISION
IN COOPERATION WITH
U.S. SOIL CONSERVATION SERVICE
0 200 600 900
SCALE IN FEET
N
LEGEND
1947 SHORE LINE
ORIGINAL SHORE LINE
ORIGINAL STREAM CHANNEL
AREA SILTED ABOVE CREST LINE
TRIANGULATION STATION
SILT RANGE
SEGMENT
S5 SEDIMENT SAMPLE
DAM
WATERWORKS INTAKE
1001
1002

FIGURE 2

a boat. On tho four uppermost ranges and on Range 04-05 wator dopthe were shallow and a considerable part of this area was above crest. Elevations of the top of the sediment on these ranges wero determined by Dumpy level at 25-foot intervals and sediment thicknesses were measured with a 1 l/2-lnch soil auger at 50-foot intervals. On these five ranges a total of 118 level shots and 57 borings were made.

At the beginning of the survey, water level in tho reservoir was at elevation 642.3, the top of the flashboards which have been permanently installed. The shoreline mapping was done at this elovation and survey results are based on this level of water in the reservoir. During the progress of the survey tho water level dropped to slightly below the former crest elevation of 641.0.

All triangulation stations and range ends were marked permanently with concrete posts 4 1/2 inches square and 4 1/2 feet long. As shown in Figure 4 these posts were set into the ground with about one foot exposed. Metal Identification plates wore attached to the top of each concrete marker.

SEDIMENTATION IN THE RESERVOIR

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

Figure 3. Use of the Spud in Measuring Silt Thicknesses.

Figure 4. Concrete Post Used to Mark Survey Stations.

shown in this summary arcs:

1. At the present spillway crost elevation, the 84.3 acre surfaco area of the reservoir has been reduced by 14 acres or 16.6 per cent in the 20,4 year life of the lako.

2. The capacity of the reservoir for water storage has been reduced from 607 acre-feet to 320 acre-feet or 47.3 per cent.

3. The sediment accumulation in the lako represents an average annual soil loss of 47.9 cubic feet of soil per acre from the watershed annually.

One of the outstanding facts to bo noted from Table 1 is relationship of the original capacity of the reservoir to the watershed area. The original capacity/watershed ratio (C/W ratio) was 30.05 acre-fect per square mile for Spring Lake. In other words the reservoir was designed and constructed to furnish about 30 acre-feot of storage space for every square mile of watershed. Sedimentation studies in Illinois and in other parts of the country* have shown that the original C/W ratio of a reservoir is significant in determining the rate at which it will collect sediment. A small-capacity reservoir which recoives the sediment from a big watershed area will of course loss capacity much faster than a high-capacity reservoir with a small watershed.

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* Brown, C. B. The Control of Roservoir Silting, U. S. Soil Conservation Service Misc. Publication 521, Wash. D.C. 1944.

Table 1, Summary of Sedimentation Data on Spring Lake, Macomb, Illinois.

	Quantity	Units
AGE 1/	20.4	Years
WATERSHED 2/		
Total Area	20.2	Square Miles
RESERVOIR 3/		
Area at spillway crest		
Original	84.3	Acres
Present	70.3	Acres
Storage Capacity 3/		
Original	607.	Acre-Feet
Present	320.	Acre-Feet
Storage per square mile of drainage area		
Original	30.05	Acre-Feet
Present	15.84	Acre-Feet
Storage per acre of drainage area		
Original	0.56	Acre-Inches
Present	0.30	Acre-Inches
SEDIMENTATION		
Reservoir sediment	287.0	Acre-Feet
Above crest deposits	3.2	Acre-Feet
Total sediment	290.2	Acre-Feet
Average annual sediment accumulation		
From entire watershed	14.23	Acre-Feet
Per square mile 4/	0.71	Acre-Feet
Per acre 4/	48.19	Cubic Feet
Tons per acree 5/	1.44	Tons
DEPLETION OF STORAGE		
Loss of original capacity per year	2.32	Per Cent
Loss of original capacity to date of survey	47.28	Per Cent

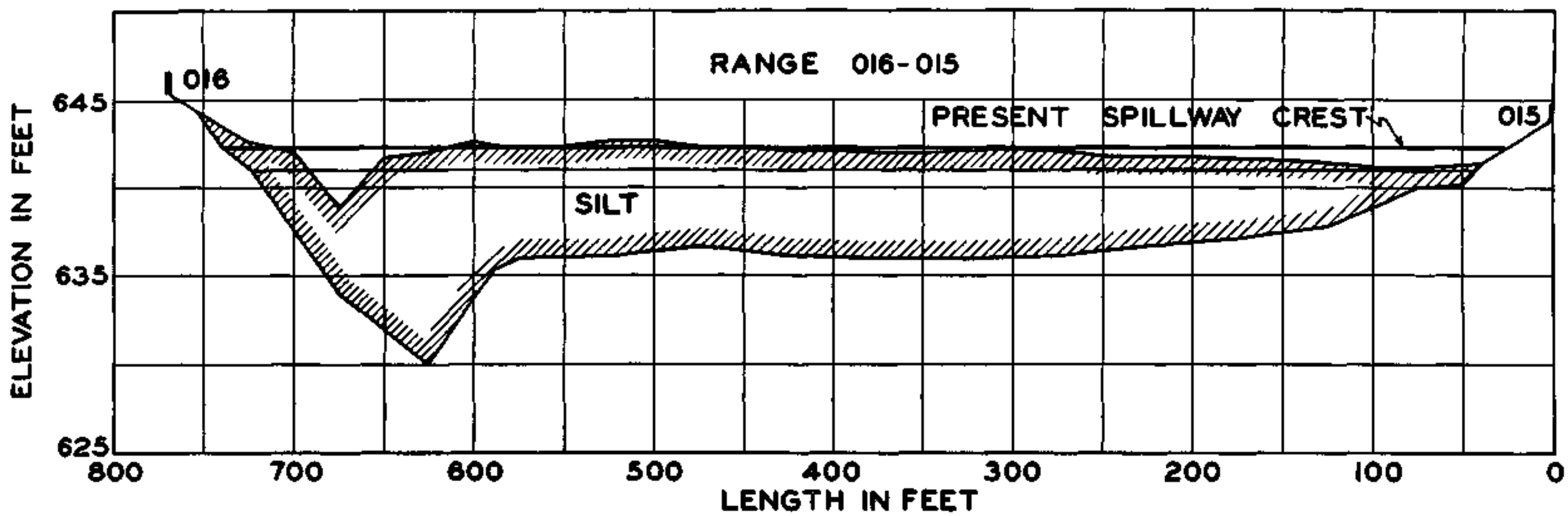
1/ Storage began April, 1927
Date of this survey - August-September 1947.
2/ Including area of lake.
3/ At present crest elevation 642.3 m.s.l.
4/ Excluding area of lake.
5/ Based on volume-weights of 10 sediment samples taken in 1947.

On the basis of present information it appears that in Illinois, under prevailing land use and agricultural practices, a C/W ratio of 150 or greater is desirable in order to assure a life of a century or more for a reservoir on a watershod of this size*. The C/W ratio of about 30 acre-feet per square mile for Spring Lake is undoubtedly one of the principal factors which explain the rapid rate at which Spring Lake is losing capacity.

DISTRIBUTION OF SEDIMENT

The thickest sodiment deposits in the reservoir are in the upper end, segments 9 and 10 (see Figure 2), and consequently in this part of the lake the greatest loss of capacity has occurred. In this part of the lake the sediment is about 6 feet thick and thins down to a thickness of about 3 feet on ranges near tho dam. On the uppermost ranges of the lake the sediment is about one foot thick.. Figure 5 shows the cross-sections of Ranges 015-016 and 06-07. It is seen that on Rango 015-016 the lake has silted practically to tho crest elevation; on this range and on ranges above there remains very little storage capacity. Range 06-07 is typical of the ranges noarer the dam. In this portion of the lake approximately one-third of the original storage capacity has been lost.

*Brown, C. B., Stall, J. B., De Turk, E. E., "Causes and Effects of Sedimentation in Lake Decatur", Illinois State Water Survey Division, Bulletin No. 37, 62 pp. illus., March 1947.


RANGE 016-015
016
015
PRESENT SPILLWAY CREST
SILT
ELEVATION IN FEET
645
635
625
800
700
600
500
400
300
200
100
0
LENGTH IN FEET

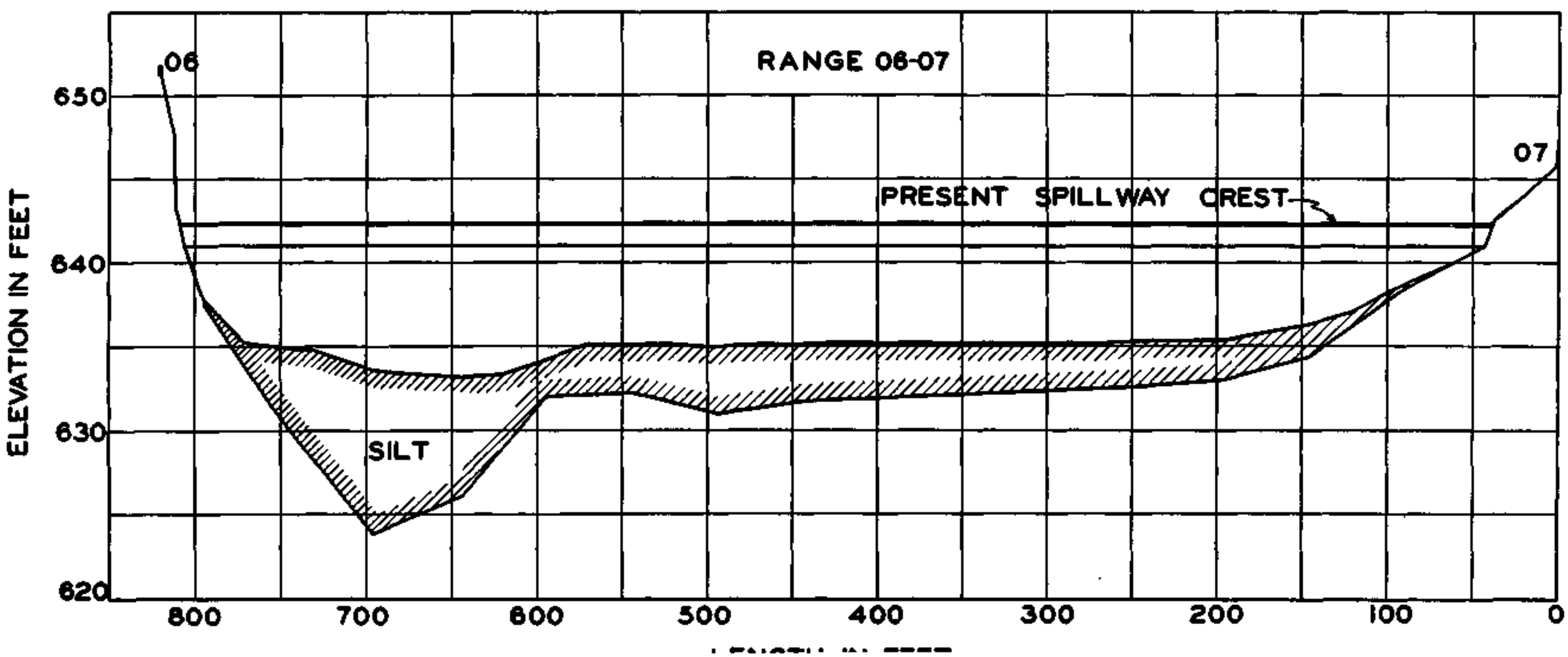

RANGE 06-07
06
07
PRESENT SPILLWAY CREST
SILT
ELEVATION IN FEET
650
640
630
620
800
700
600
500
400
300
200
100
0

Figure 6 shows the sediment deposits in Segment 9 when the water level was slightly more than 1-foot below crest. This is an eastward view from a point near the middle of Range 015-016; the sediment in the foreground is about 6 feet thick.

In the upper end of the lake, above Range 015-016 there has been some deposition of sediment above the spillway crest. This area is shown in Figure 2 and at present is covered with vegetation and willow growths. In several places above Range 017-018 there are willow trees of such a large size as to indicate that these areas have supported growth from 15 to 20 years - practically the life of the lake. Hence this uppermost part of this reservoir probably has never furnished a very great storage capacity. Original water depths here were shallow and this portion of the lake has probably been swampy and frequently exposed and dried since the construction of the lake.

HISTORY OF THE MACOMB WATER SUPPLY

Period 1893 to 1926.

A public water supply was first installed at Macomb about the year 1893 when a single well was drilled 1630 feet deep entering sandstone at 1135 feet below the surface. This well was near the center of town and in spite of the fact that this water was very hard and highly mineralized, it was the only source of supply for 10 years. About 1903 the city put down several sand and gravel wells in the southeast part of the city; the reported yield of this system was 50,000 gallons per day.

Figure 6. Sediment Deposit In Survey Segment No. 9.

figure 7. Lamoine River Reservoir. Used from 1911 till 1927 for the Macomb Water Supply.

In 1911 a channel dam was constructed on the Lamoine River near the northern city limits and the present filter plant was built and put into operation. The impounding capacity of this small dam was not great (See Figure 7); it raised the water level about 5 1/2 feet above the stream bed. This watershed covered 180 square miles. Stream flow was extremely variable in quality and volume and during the protracted dry period of 1913, flow practically ceased and a serious water shortage resulted. Some spring water is present in this stream since, at low stages, a clear, more highly-mineralized water was observed than when more surface runoff is entering the stream at higher stages. The base flow of spring water from this 180 square mile watershed was not adequate for dry weather needs.

<u>Period 1926-1947.</u>

In 1926 because of the inadequacy of the Lamoine River reservoir, Mayor C. E. Asher and city officials undertook the construction of a larger Impounding reservoir of sufficient size to meet the entire needs of the growing city. At that time six different reservoir sites in the vicinity were investigated and with the aid of the Caldwell Engineering Company it was decided that the reservoir on Spring Creek would be the best investment. Spring Lake was then constructed and was put into use in 1927. Since that time this lake has been utilized as the main source of supply, the Lamoine River reservoir being used only for very short periods as a standby source.

INCREASE IN WATER CONSUMPTION

Filter plant records of the daily raw water pumpage from the Spring Lake reservoir are available since 1934. The monthly and yearly averages of pumpage have been plotted in Figure 8. In 1935 the average daily pumpage for the year was 318,000 gallons; by 1947 this demand had increased to 555,000 gallons. The future trend in water consumption is dependent on many factors such as the rate of growth of population in the city, the presence and possible expansion or reduction of industry in the city, the possibility of new industries locating in the city, the use of water for new purposes by present users, and the availability of an adequate supply. The future demand will consequently be predicted most accurately on a basis of full acquaintance with these matters. The extrapolation shown in Figure 8 is merely a straight-line extension of the trend line or "best fit" curve as calculated from the past record, 1934 to 1947. A continued increase at this rate would mean that by 1960 the average pumpage would be 780,000 gallons per day.

PRESENT WATER CONSUMPTION PER CAPITA

Macomb's normal water consumption in gallons per day per capita is shown in Table 2 as compared to eight other Illinois communities which depend upon surface reservoirs for their source of water. From this table it is seen that a water consumer in Macomb uses 63 gallons per day while consumers

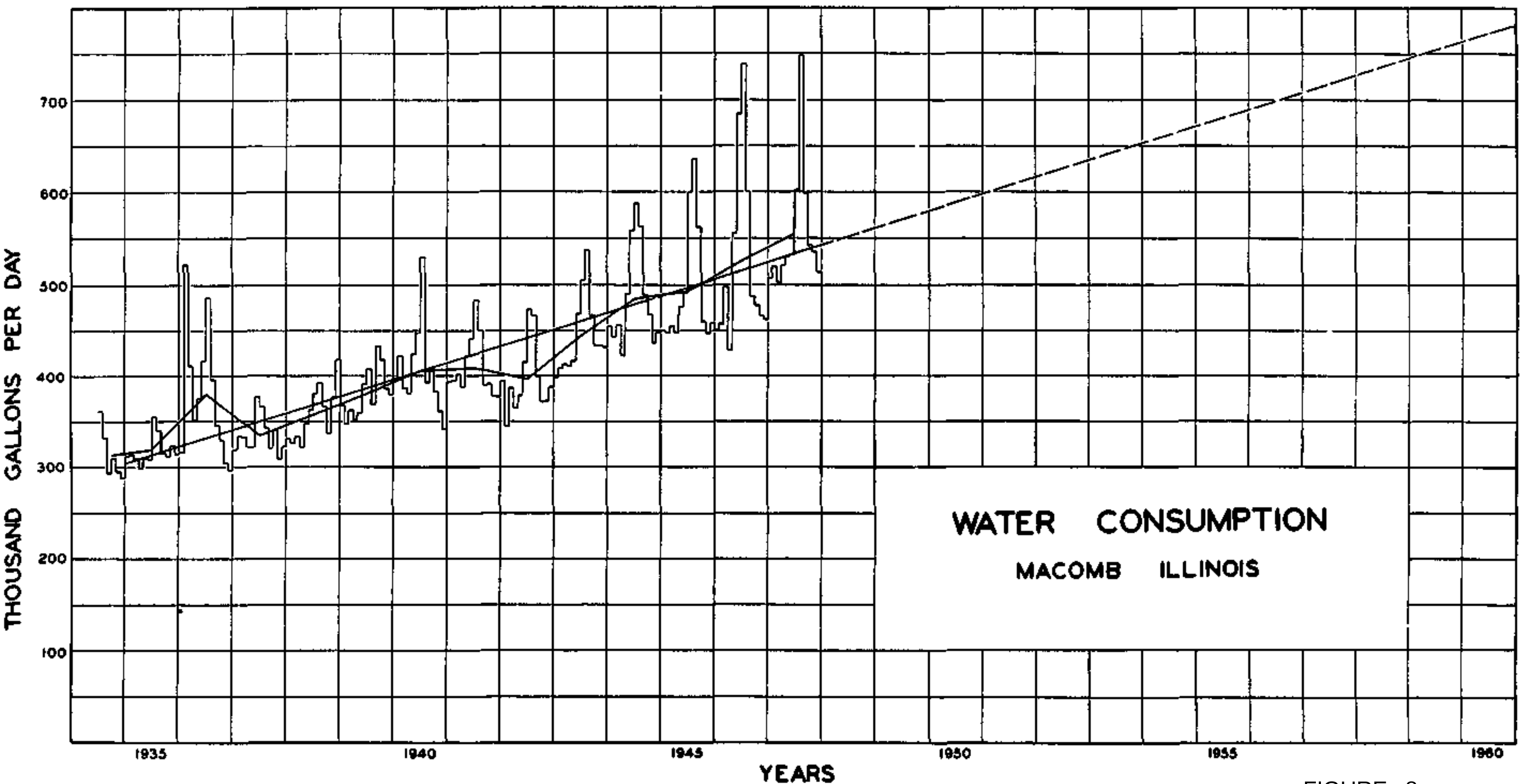

WATER CONSUMPTION
MACOMB ILLINOIS
THOUSAND GALLONS PER DAY
700
600
500
400
300
200
100
1935
1940
1945
1950
1955
1960
YEARS

FIGURE 8

Water Consumption in Several Representative Illinois Communities Utilizing Surface Reservoirs.

Name	Population 1940	Water Consumption Gallons ppr Dey Per Capita	Water Rate - $/1000 Gal. Maximum	Minimum
Bunker Hill	1082	111	1.00	0.20
Carthage	2575	31	0.57	0.15
Pittsfield	2884	61	0.60	0.15
Hillsboro	4514	47	0.50	0.10
Pana	5966	84	0.50	0.14
Litchfield	7048	71	0.50	0.12
Macomb	8764	63	0.50	0.35
Paris	9281	102	0.42	0.10
Canton	11577	60	0.50	0.20
Centralia	16343	122	0.45	0.15
Jacksonville	19844	97	0.60	0.12
Decatur	59305	148	0.33	0.05
Springfield	75503	106	0.23	0.09.

Consumption data from State Water Survey files and Dep't. of Public Health Circular No. 136 "Data on Public. Water Supplies". Water rate data from (Circular No. 136.

in other communities use as much as two or three times this amount. This situation could be influenced by several things such as water rates, absence in the city of large industrial water users or by a limited supply of water. Only a comprehensive study of the city's supply and demand for water would give the answer to this. The possibility of increasing per capita water consumption is an additional factor however which would tend to further raise the future water requirements of the city. The future need as shown in Figure 8 does not include any such increase. The possibility however of the increased development of the city water supply so as to bring about a greater water use by all consumers will of course put a correspondingly greater demand on Spring Lake.

RESERVOIR OPERATION AND NEED

General

The function of any water supply impounding reservoir is to store runoff from the watershed during wet periods when the stream flow exceeds the consumption. The water thus stored is available for use during dry periods when the flow of water in the stream is insufficient to furnish the users need. Consequently to obtain the full value from a reservoir it should be designed so that the runoff coming into the reservoir is. great enough to overbalance the consumption plus the losses. The storage volume of the reservoir should be great enough that it can fulfill all needs during the driest season for which It is designed.

The best indication of the usefulness and the need of a water-supply reservoir is the fluctuation of the water level in the lake. Every time the water level is drawn down in the reservoir, demand is exceeding the inflow. This means there would be a water shortage if the lake were not present. Likewise the best indication of the impending inadequacy of a reservoir is the occurrence of serious drawdowns during dry periods when inflow is small and consumption is great. Sediment deposits steal needed storage space. This loss of water storage capacity causes increasingly heavy drawdowns during dry periods.

Drawdown Data

Water level measurements based on the permanent spillway crest are available at Spring Lake from 1940 to date. Prior to 1940, lake levels were recorded merely as high, low or medium. During the seven year period for which accurate levels are available the two largest drawdowns occurred in August 1941 when lake level reached 17 inches below crest and March 1942 when it reached 18 inches below crest. At only one other time, in July 1940, did the level recede more than one foot below crest. Mr. Wm. S. Newell, Waterworks Engineer, who has been associated with the waterworks during the entire life of Spring Lake, reports that the lowest level to which the lake ever dropped was 22 inches below the permanent concrete crest.

The present capacity of the lake at the top of the wood flashboarde is shown earlier in this report to be 320 acre-feet as compared to the original capacity of 607 acre-feet at this elevation. Approximately 85 acre-feet of this volume is contained in the upper 1.3 feet of the lake which has been added by the installation of the flashboards in the spillway. The original volume of the lake at its former level thus was 5 2 2 acre-feet. A drop in lake stage of 22 inches below the former crest removes approximately 100 additional acre-feet of water from the reservoir. This 100 acre-feet of withdrawal represents approximately one-sixth of the original lake capacity and approximately one-third of the present lake capacity as shown in Tablo 1. In other words the greatest demand on the reservoir experienced to date removed a volume of water equal to approximately one-third of the present reservoir capacity. This does not necessarily mean however that the reservoir now has three times the storage capacity needed. A drouth of greater severity than any recently experienced would put a much greater demand on the reservoir.

The storage capacity of Spring Lake is being reduced by 2.32 per cent per year and the pumpage from the reservoir has in past dry seasons amounted to about one-third of the present storage capacity. With the demand increasing and storage diminishing the storage will become inadequate at some future date and a water shortage will occur. The first signs of such a shortage will be the occurrence of heavy drawdowns on the reservoir during the dry seasons of the year.

Remaining Useful Life of Reservoir

The lack of records of the seasonal variations of the flow in Spring Creek makes it difficult to determine the actual performance of the reservoir and the exact length of period for which the storage in the lake is utilized. The springs in the watershed and in the lake area which contribute to the inflow of the lake make this problem more complicated.

In order to determine the minimum inflow to be expected during dry periods a study was made of six isolated periods during which precipitation in the area was zero or negligible and the water level was below crest. For these periods, varying from 14 to 31 days in length, it was discovered that the total volume of pumpage plus the evaporation loss was greater than the volume of water removed from the lake as signified by the recorded lowering of the lake stage. This indicated that inflow amounted to from 351,000 to 439,000 gallons of water per day, and averaged 391,000 gallons per day. This average has been used as a minimum daily inflow in the analysis of possible drouths and their effect on the reservoir.

The occurrence of a drouth of such severity as to furnish only this minimum inflow of 391,000 gallons per day for a period of three months (90 days) is believed to be possible on this watershed. Such a period is on record for a watershed of ten square miles near Galesburg. From this and other stream flow recorde in this area it appears that such a drouth is by no means improbable at Macomb, The lack of any actual records of the dry season flow in Spring Creek prevents any estimate of the frequency of occurrence of such a drouth,

A study has been made of the three months of the year when demand is greatest (June, July and August) and the results are shown in Figure 9» In this diagram the reservoir capacity is plotted against time in years. The remaining storage capacity at the present rate of silting is shown below the descending line. Along the bottom is shown the three-month evaporation loss as estimated from measurements in this region of the state. This loss is completely unavoidable and must be taken into consideration in this reservoir usage analysis. Plotted upward from this is the storage needed for the three-month consumption as given in the records of the city and shown on Figure 8 of this report, (summer demand minus the calculated inflow). It is seen that the need for storage is increasing at such a rate that, in the event of a severe drouth in 1953, the remaining reservoir capacity would be Just adequate to furnish the city's water need for the three summer months. In subsequent years the demand is seen to be greater than the available storage which means a definite water deficiency should be expected in the event of an extreme drouth.

The reservoir now appears adequate to furnish the full supply in the event of an extreme drouth. The demand is

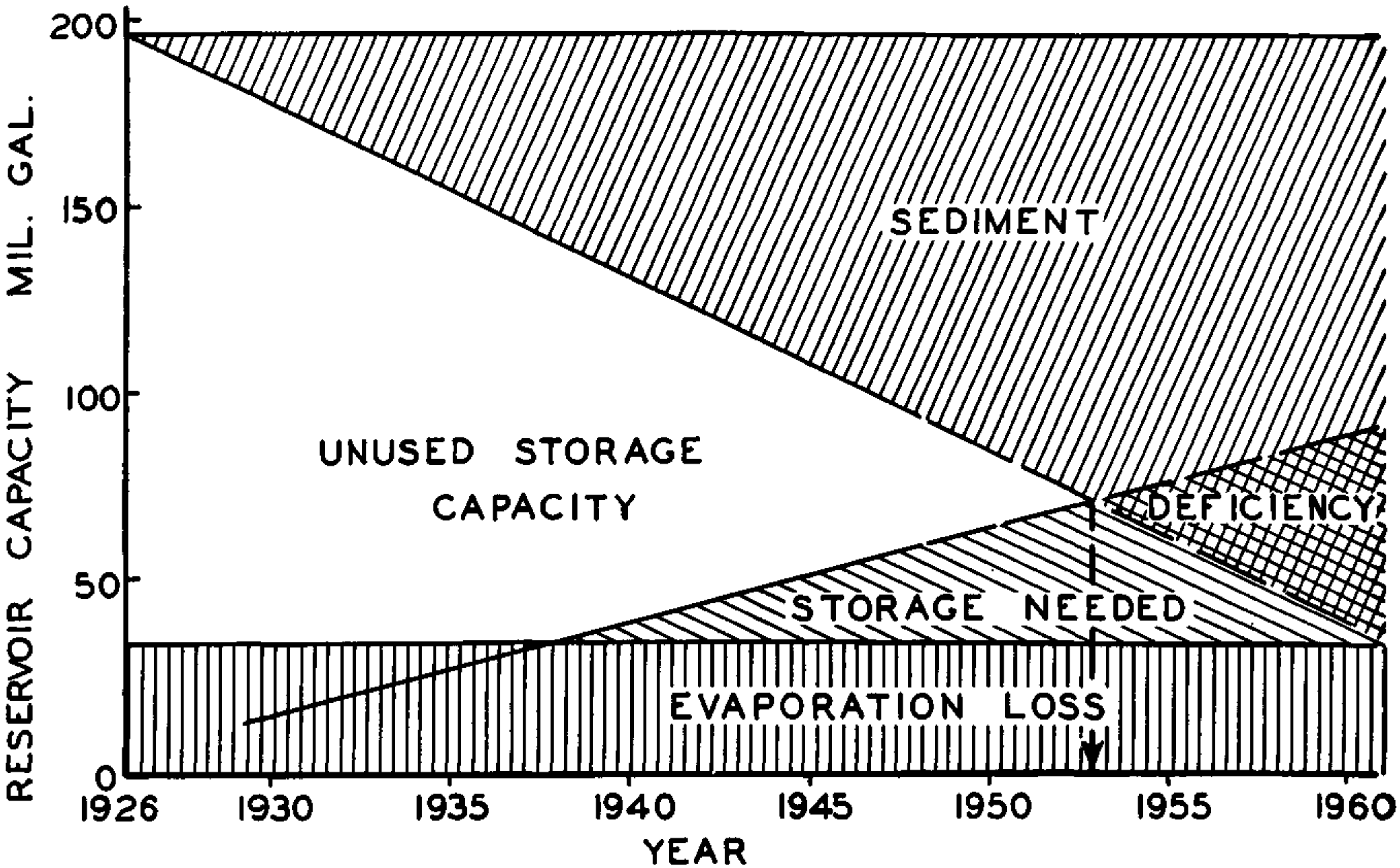


FIG.9 USEFUL LIFE OF SPRING LAKE , MACOMB

JUNE - JULY - AUGUST   BASED ON MINIMUM INFLOW increasing and the storage is decreasing as shown in Figure 9, hence if an extreme drouth occurs after 1953 a water shortage may be expected.

ECONOMIC LOSS FROM SEDIMENTATION

From the taxpayers standpoint the sediment accumulation in Spring Lake has caused a definite loss of their investment in this storage reservoir. The Spring Lake development is reported to have cost a total of $138,000 in 1927. Since this survey shows the original capacity of the reservoir to be 607 acre-feet it is seen that this storage thus cost originally $227 per acre-foot. The present survey also shows that 14.23 acre-feet of storage capacity are being lost per year to sediment. At this rate, the loss amounts to $3230 of the original investment lost per year.

Replacement of this lost storage capacity at present day prices would be expensive. In 1927 when Spring Lake was constructed the general cost of such work was much lower than at present. One of the most widely-used indices of such construction cost is the Engineering News-Record Construction Cost Index which is computed monthly and considers current prices of certain basic construction commodities such as cement, steel, labor, etc. In 1927 the Construction Cost Index was 208* (based on the year 1913 = 100) and in October

*Engineerlng News-Record, October 28, 1949, Vol. 141, No. 18, p. 69, McGraw Hill Pub. Co., New York, N.Y.

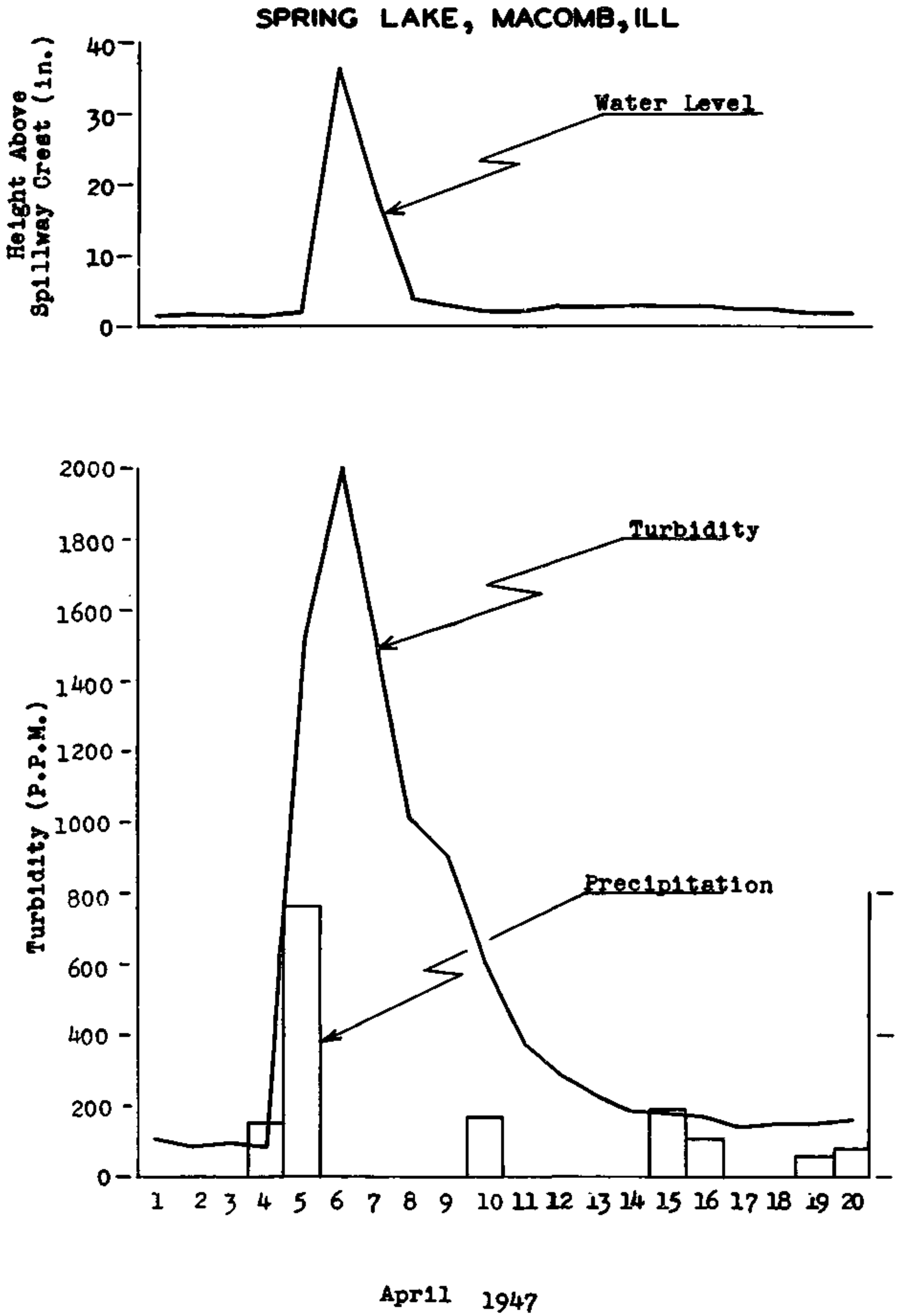
1948 this index had risen to 480. In consideration of this increase in cost the 14.23 acre-feet of Spring Lake storage capacity which are lost to sediment every year would cost $7457 to replace at the present time.

TURBIDITY AND SEDIMENT MOVEMENT

From records of the precipitation on the watershed, water levels in the reservoir, and the turbidity of the lake water it was possible to confirm the movement of sediment into the reservoir during and after heavy rains on the watershed. Figure 10 presents such a period in April, 1947. At the bottom is plotted the daily rainfall in the area as reported by the U. S, Weather Bureau station at Macomb. Also plotted is the turbidity (in parts per million) of the water taken from the lake each day into the water treatment plant. Turbidity is a measurement of the light transmission of water and hence is an indication of the presence of silt and clay particles. At the top of Figure 10 is shown the water level in the lake in inches above the crest of the spillway.

It is seen that the two-inch rain occurring on the watershed on April 5 caused a large increase in the turbidity of the water in Spring Lake both that day and the next, April 6. The lake level reached a maximum of about 36 inches above the crest on April 6. Some of this sediment which came into the lake undoubtedly passed over the spillway during this heavy runoff. It should be noted however that although the

FIG. 10 PRECIPITATION, WATER LEVEL AND TURBIDI RELATIONSHIP



water level was back to normal by April 8 the turbidity remained relatively high for about six more days, or until about April 14. It was during these six days that much of the lesser runoff of the April 5 heavy rain came down into the lake and brought its load of sediment. It can also be noticed from this figure that the lighter rains of less than one-half inch on the watershed occurring in later April did not appreciably raise the water level or turbidity in Spring Lake.

These Macomb data clearly show the relation between muddiness of the lake water and rainfall on the watershed. In running off the land and down into Spring Creek and Spring Lake this water picks up the soil from the farmland and carries it along to the reservoir where much of it stops.

SEDIMENT CHARACTERISTICS

CHEMICAL AND PHYSICAL PROPERTIES OF THE SEDIMENT

Sediment samples were taken at 10 representative locations in the reservoir (see Figure 2), in order to determine the physical and chemical characteristics of the sediment in Spring Lake, These were chemically analyzed for base-exchange properties, hydrogen-ion concentration (pH), total nitrogen and carbon, which indicate the organic matter, and for available potassium and phosphorus. Physical measurements were made of the apparent specific weight and the relative fineness, as shown by the proportions of the different sized particles. The detailed results of these analyses are given in Tables 3A and 3B,

An examination of these data indicates that the samples may be divided into three groups, in each of which most of the physical and chemical properties, including base-exchange capacity, organic carbon and particle-size distribution are similar, although the groups differ from each other in these respects. The largest group, samples 1, 3, 4, 5, 6, and 7, represents the sediment distributed over the main body of the lake. The second group consists of samples 2, 8, and 10, which represents deposits in the delta areas. The third group consists of sample 9, which was taken from the impounded channel.

The organic-carbon content of the sediment is highest in the main body of the reservoir (see Figure 11) ranging from 1.74 to 2,27 per cent. Lowest organic-carbon content, amounting

Table 3A. Chemical Data on Spring Lake Sediments

Sample No.	Miles above Dam	Range	Total N	Total C	Base Ex.cap. m. e.	Total Bases m. e.	Base Saturation %	pH	Avail. K lb/A	Avail. P lb/A
1	0.1	01-03	0.175	1.74	27.5	27.4	99.6	6.91	300+	170
2	0.3	09-08	0.106	1.29	18.5	19.2	103.8	6.88	300+	139
3	0.1	01-02	0.175	2.09	34.3	31.5	91.3	6.29	300+	149
4	0.22	07-06	0.200	2.12	35.2	30.9	87.8	6.63	300+	1.77
5	0.25	07-06	0.226	2.27	38.4	33.0	86.0	6.60	300+	154
6	0.33	010-08	0.201	2.14	35.2	29.9	85.1	6.54	300+	159
7	0.4	011-012	0.189	1.91	28.9	25.6	88.5	6.82	300+	177
8	0.53	013-014	0.149	1.64	21.8	19.8	90.8	6.94	300+	170
9	0.83	017-018	0.095	1.09	15.1	14.5	95.8	6.99	300+	159
10	0.9	019-020	0.156	1.88	22.4	20.7	92.3	6.74	300+	190
								Means	300+	162

Table 3B Physical Data on Spring Lake Sediments

Sample No.	Miles above Dam	Range	Apparent Vo'l. Wt.	% Sand >50 Microns	Silts Microns 50-20	Silts Microns 20-2	Clay Microns 2-0.2	Clay Microns <0.2
1	0.1	01-03	0.824	0.38	14.228	42.390	11.107	28.080
2	0.3	09-08	0.986	0.98	29.387	40.837	4.515	21.547
3	0.1	01-02	0.749	0.38	5.387	43.466	19.207	27.767
4	0.22	07-06	0.712	0.06	6.385	43.358	11.101	34.010
5	0.25	07-06	0.708	0,11	1.214	37.972	20.682	35.375
6	0.33	010-08	0.795	0.07	5.203	42.743	12.235	36.209
7	0.4	011-012	0.859	0.07	10.105	49.197	7.661	28.150
8	0.53	013-014	1.010	1.58	27.718	40.838	5.058	20.357
9	0.83	017-018	1.050	11.40	39.604	27.992	2.445	14.464
10	0.9	019-020	0.846	0.4l	23.165	46.042	5.843	20.161

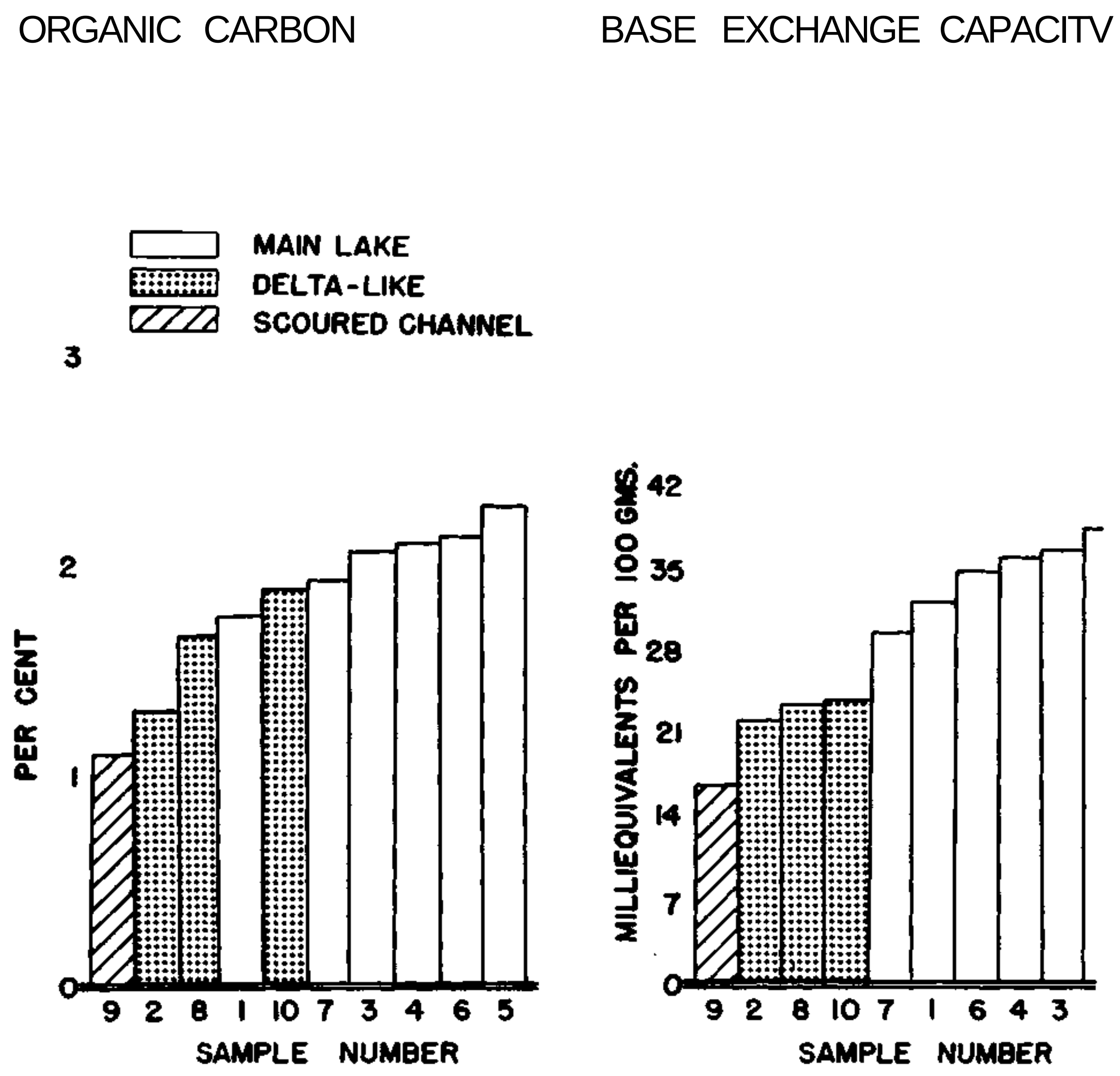


FIGURE 11. ORGANIC CARBON AND BASE EXCHANGE CAPACITY OF SPRING LAKE SEDIMENT.

to 1.09 per cent was found in the impounded channel. The organic-carbon content of samples from delta areas ranged from 1.29 to 1,88 per cent. Similar variations were found for the base-exchange capacity of the sediment. Thus the base-exchange capacity of sediment in the main body of the reservoir ranged from 27.5 to 38.4 milliequivalents, as compared with 18.5 to 22.4 in the delta sediments and 15.1 in the impounded channel. On the average, the sediment in the delta areas and in the impounded channel is less acid than that in the main body of the lake.

An analysis of available nutriont elements in the sediment indicates that there are an estimated 132,500 pounds of available potash (K_a0), 141,000 pounds of phosphoric acid (P_aO_5), and 22,700 pounds of nitrogen in the 378,000 tons of sediment in the lake. At current market prices of 5.7 cents per pound for potash, 8.5 cents per pound for phosphoric acid, and 10 cents per pound for nitrogen, this has a potential value of $21,900. This, of course, represents only the readily available plant nutrients which came to rest within the reservoir area. The gross loss of nutrient elements from watershed lands may be many times that retained in the reservoir. It includes the nutrient elements which came to rest in the watershed above the reservoir, those which passed through the reservoir and over the dam both in suspension and in solution, and those contained in the sediment which eventually would become available for plant assimilation in the next few decades.

The specific weight of sediment in Spring Lake varies depending on the location of deposits in the reservoir and the extent to which deposits have been subjected to aeration. Tho sediment in the main body of the reservoir varies from a specific dry weight of 44.18 pounds per cubic foot to 53.60 pounds per cubic foot with a mean dry weight of 48.33 pounds per. cubic foot. The dry weight in delta areas varies from 52.79 to 63.02 with a mean of 59.11 pounds per cubic foot. Sediment in the impounded channel has a dry weight of 65.52 pounds per cubic foot. The arithmetical average of all samples is 53.28 pounds per cubic foot.

The distribution of texture of sediment presents an interesting picture of the inter-relationship of incoming load, settling velocities, and detention time in the reservoir. In general the texture of sediment bears little relationship to the texture of soils in the watershed, because of selective erosion processes and assorting action of water. The sediment in the main body of the lake is about half silt and half clay. That in the delta area averages about three-fourths silt and one-fourth clay. The silt fraction of sediment in the main body of the iake is essentially fine silt with very little coarse silt present. In the delta areas the silt fraction is about half fine silt and half coarse silt. The clay fraction of sediment in both the main body of the reservoir and in the delta areas consists primarily of the superfine fraction, having diameters of less than 0.2 micron with only small amounts of coarse clay present.

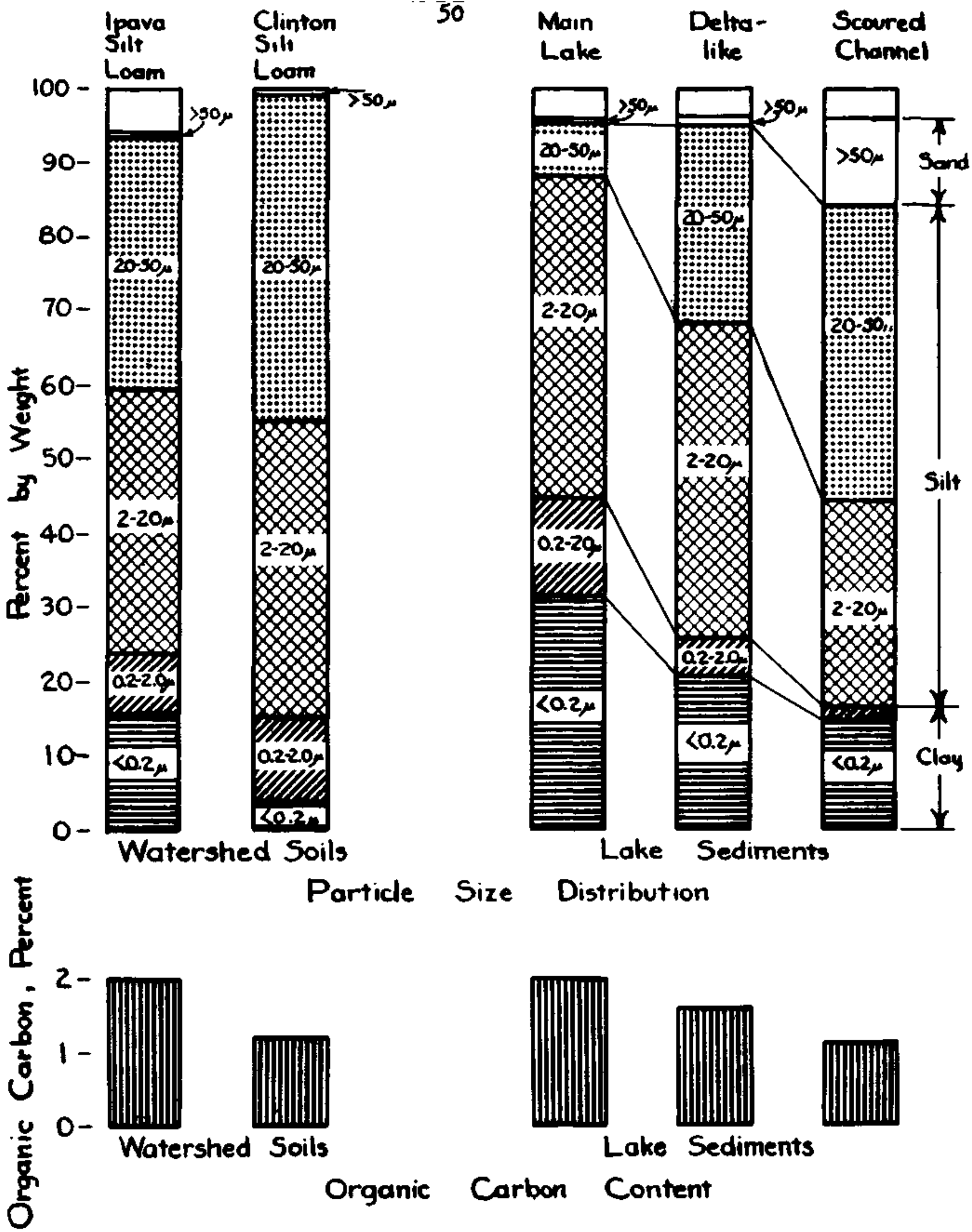
There are two possible explanations of this anomaly. The high pH value of the sediment and the most complete saturation of the exchange complex with bases may have caused the finest grained clays to become flocculated, thus causing them to settle out along with the larger particles; or the predominant grain 6ize of material in runoff from numerous small storms may have been superfine material, and if these storms occurred primarily while the reservoir was below crest all of these fines would settle out in the reservoir,

SIMILARITY OF SEDIMENT TO WATERSHED SOILS

Erosion is a selective process. Runoff removes mostly the finer particles from soil leaving the coarser particles in the field or enroute as colluvial material below slopes and as alluvium in channels and on flood plains. Sorting of sediment by water is developed to even a finer degree when sediment-laden water spreads out in a reservoir. The mechanical composition of sediment in different parts of the reservoir is a function of the nature of the incoming load and the detention storage time in the reservoir. The chemical nature of sediment is also ro-lated to erosion processes and the assorting effect of water. Plot studies show that the organic content of sediment may be as much as 4 to 6 times as great as that in the original soil from which it was derived. Also, the finer sediment fractions contain greater amounts of available nutrient elements so that the effect of water on sorting also affects the amount of available nutrients in sediment.

3ecause of the heterogeneous nature of soils, selective erosion, and the assorting effect of water, it is difficult to relate sediment in a single reservoir either physically or chemically with any group of soils In the watershed. A comparison of the two prominent soils in the watershed, Ipava and Clinton silt loams, and the sediment in representative parts of the lake are shown in Figure 12. The particle-size distribution and organic content in typical surface soils of the watershed are shown in Table 4. It may be seen that the sediments have considerably higher percentages of clay in them than the original soils. The averago per cent of clay in the sediment in the main body of the lake exceeds that of the finest-grained soil of the watershed, namely Sable silty clay loam.

The organic-carbon content of sediment is probably more nearly like that of the original soil then any other single physical or chemical factor. However, whether or not this can be used as a basis for determining sediment sources is problematical. In addition to the organic-matter content derived from soils in the watershed, sediment in a lake receives contributions from decaying aqueous and subaqueous vegetation in the lake and from periodic flushing of accumulations of leaves and other vegetal debris in upstream channels and waterways. In addition, an unknown quantity of organic mattor, with its low specific gravity, has been washed over the spillway and out of tho lake.



PARTICLE SIZE DISTRIBUTION AND ORGANIC CARBON CONTENT

SPRING LAKE SEDIMENT AND WATERSHED SOILS

FIGURE 12

Table 4

Particle size distribution and organic ce.rbon content in surface soils typical of i3pring Lake watershed

	Sable silty clay loam	Muscatine silt loam	Ipava silt loam	Clinton silt loam
	per cent	per cent	per cent	per cent
Sand, over 50 microns	1.9	0.7	0.7	0,9
Coarse silt, 50 to 20 microns	5/	38.7	35.5	44.8
Fine silt, 20 to 2 microns	5/	32.2	35.6	40,2
Total silt, 50 to 2 microns	65.7	70.9	71.1	85.0
Coarse clay, 2 to 0.2 microns	5/	9.3	8.5	11,2
Fine clay, less than 0.2 microns	5/	13.3	15.4	3,7
Total clay, less than 2 microns	32.4	22.6	23.9	14.9
Total Organic Carbon	3.6 1/	3.0 2/	2.0 3/	1.21 4/

1 Black clay loam and black silt loam.

2 Brown silt loam.

3 Brown-gray silt loam on tight clay.

4 Yellow-gray silt loam.

Organic carbon values are taken from Illinois Soil Report 7, Table 2, page 5. These soil type names are the ones in uso when the report was written. They represent the same soils as indicated by the type names heading the above columns, tho the type borders do not exactly coincide.

5 Silt and clay were not subdivided into two size grades for this sample.

Table 5

Particle size distribution and organic carbon content of sediment in Spring Lake.

	Main Body of Lake; Samples 1, 3.4.5.6.7	(Levee) Delta-like Samples 2, 8, 10	Scoured channel; Sample 9
	per cent	per cent	per cent
Sand, over 50 microns	0.2	1.0	11.4
Coarse silt , 50 to 20 microns	7.1	26.8	39,6
Fine silt, 20 to 2 microns	43.2	42.6	28.0
Total silt, 50 to 2 microns	50.3	69.4	67,6
Coarse clay,2 to 0.2 microns	13.7	5.1	2.4
Fine cley,less than 0.2 microns	31.6	20.7	14.5
Total clay, less than 2 microns	45.3	25.8	16.9
Total organic carbon	2.0	1.6	1.1

Figure 13 Sediment - As it Appears in Spring Lake.

Figure 14 Soil - From the Original Reservoir Bottom.

WATERSHED

INTRODUCTION

Many watershed factors affeet the rate of sedimontation of reservoirs. They include size of drainage area, topography, soil types, slopes, and land use. The relative importance of these factors must bo examined in order to develop reservoir design data. Furthermore, the sources of sediment must be determined if an effective sediment control program is to be developed for the reduction of reservoir damages. AS a part of this study the Soil Conservation Service has made a conservation survey of Spring Lake watershed and a special study of farming conditions. The conservation survey consisted of field mapping of soil groups, slopes, degree of erosion, and present land use on aerial photographs having a scale of four inches to a mile, A sample system of mapping alternate 320-acre blocks was used. In addition to mapping erosion and deposition by the usual standard methods, the survey was modified to include mapping of channel erosion and deposition.

PHYSIOGRAPHY

Spring Creek watershed lies entirely within McDonough County, Illinois. Most of the watershed is in Emmett Township, although the upper part extends into Sciota Township. Spring Creek rises in Sec. 30, T. 7 N., R. 3 V., 2 miles west of Sciota, Illinois, and flows generally southeastward to a point 4 miles northwest of Macomb, Illinois, where it changes its direction in a sharp bend to flow southwestward Joining East Fork of Crooked Creek at a point 5 miles west of Macomb. East Fork of Crooked Creek is a tributary of Lamoine River which empties into the Illinois River below Beardstown, Illinois. Spring Lako is formed by a dam located Just above the sharp bend near Macomb, Illinois. The watershed above the dam including the lake extends over an area of 20.2 square miles as determined by planimetering from U. S. Geological Survey topographic sheets.

The watershed of Spring Crock is located in the south central portion of the Galesburg Plain*, a minor division of the Central Lowland Province. It consists of a level to undulatory till plain formed by a thick mantle of Illinoian drift capped with loess.

SOIL GROUPS

Three main classes of soils occur in the watershed - upland prairie soils which extend over 66.3 per cent of the area; upland timber soils which extend over 28.4 per cent of the area; and bottomland soils which occupy 5.3 per cent of the area. Figure 15 shows the general location of these three main groups of soils in the watershed. Dominant soils are those of the

*Leighton, M. M., Ekblaw, George E., and Horberg, Lcland, "Physiographic Divisions of Illinois," Illinois Geological Survey, Report of Investigations No. 129, 33 pp., illus. Urbana, Illinois. 1948.

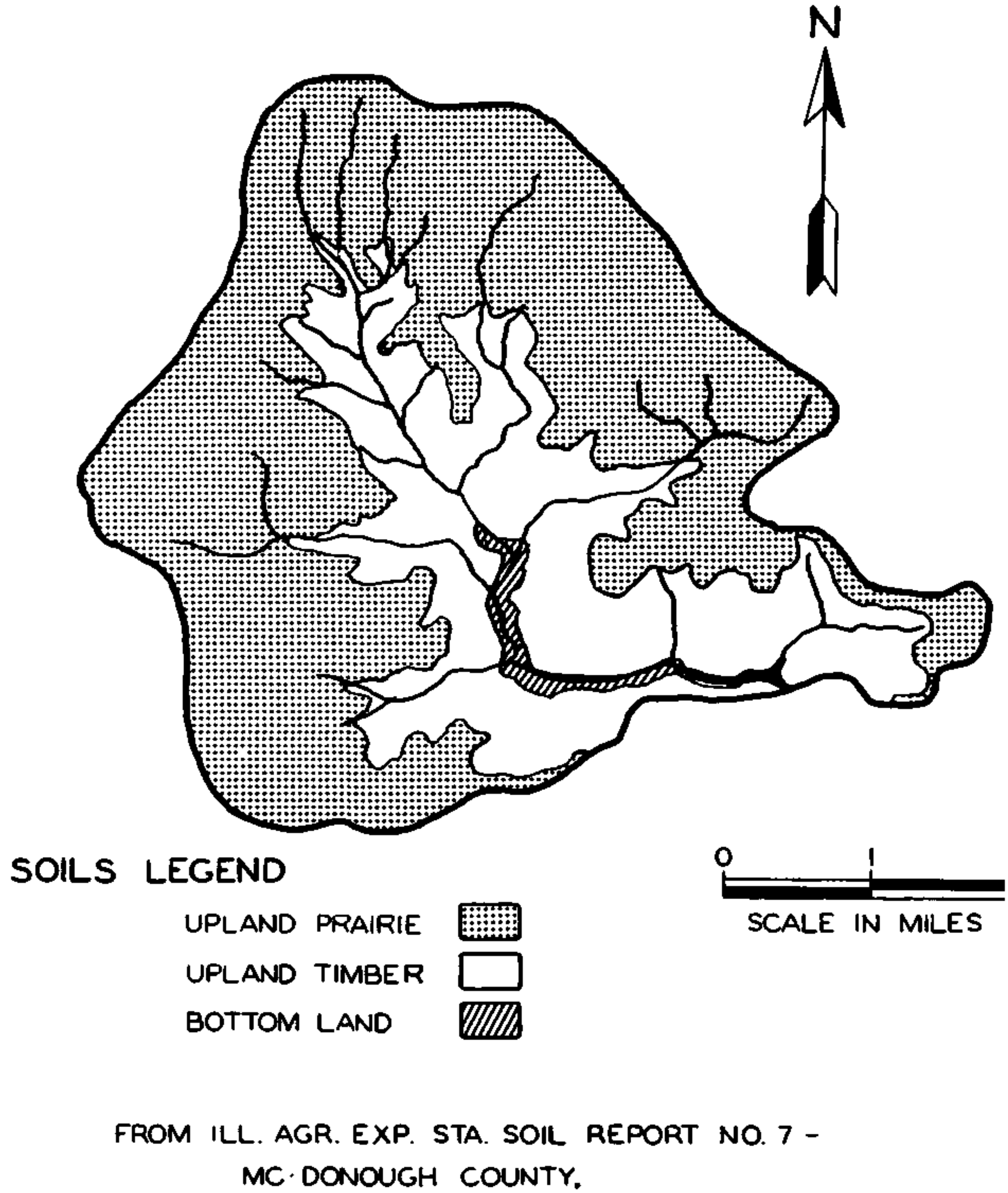


FIGURE 15 GENERALIZED SOIL MAP OF

SPRING LAKE WATERSHED

Bolivia Silt Loam group which occupy 36.1 per cent of the aroa and those of the Ipava Silt Loam group which occupy 23.8 per cent of the area. Both are dark-colored, medium- textured, upland prairie soils of moderate permeability. The Ipava Silt Loam group occupies the level to gently sloping upland having slopes rarely exceeding 1 l/2 per cent, whereas the Bolivia Silt Loam group occurs on areas of more undulating topography.

The Alma-Clinton Silt Loam group of soils, occurring on 10.1 per cent of the area, and the Blair Silt Loam group of soils, occurring on 13.0 per cent of the area, represent the dominant upland timber soils. They are light-colored, medium-textured soils with moderately slow to slow permeability. The Alma-Clinton Silt Loam group occurs on rolling topography, while the Blair Silt Loam group occurs on strongly rolling topography. The acreage and percentage of the various soil groups in the watershed are shown inTable 6.

In general the derk prairie soils are more fertilo than the light-colored timber soils, The relative productivity of soils in the Spring Lake watershed may be found in Table 7.

SLOPES

Slopes influence the velocity of runoff and its ability to erode soil. In general, slopes arc low in the Spring Lake watershed in comparison with watersheds of similar size in other parts of the country. From Table 8, it is calculated that 73.4 per cent of the total watershed area has less than 4 per cent slope. The degree of slope in any part of the

Table 6

Acreages and Percentages of Various Soil Groups in
Spring Lake Watershed
Macomb, Illinois

Soil Group	Area	
Upland Prairie Soils	Acres	Per Cent
1. Dark-colored, medium-textured, moderately permeable soils:		
Ipava silt loam group	3065	23.8
Bolivia silt loam group	4647	36.1
Total	7712	59.9
2. Dark-colored, heavy-textured, moderately permeable soils:		
Illiopolis silty clay loam group	462	3.6
3. Dark-colored, medium-textured, moderately slowly permeable soils:		
Edinburg silty clay loam group	136	1.1
Assumption silt loam group	108	0.8
Total	244	1.9
4. Moderately dark, medium-textured, slow to very slowly permeable soils:		
Denny silt loam group	34	0.3
Velma silt loam group	80	0.6
Total	114	0.9
Upland Timber Soils		
5. Light-colored, medium-textured, slowly permeablo soils:		
Alma-Clinton silt loam group	1299	10.1
Berwick silt loam group	402	3.1
Blair silt loam group	1668	13.0
Hickory gravelly loam group	277	2.2
Total	3646	28.4
Bottomland Soils		
6. Light and dark colored medium textured-moderately permeable soils group:		
Huntsville loam group	589	4.6
Belknap silt loam group*	36	0,3
Imperfectly drained Huntsville group	55	0.4
Total	680	5.3
Entire watershed	12,858	100.0

*Includes 14 acrns of sediment deposits within the original lake area.

Table 7

Estimated Crop Yields in Spring Lake Watershed
on Soils under Good and Fair Management*

Soils**	Per Cent Watershed	Soil Mgt. Systems	Average Yields Bushels per Acre Corn	Beans	Oats
1. Dark colored, medium to heavy textured, moderately permeable soils	63.5	good		27	46
		fair	60	25	43
3. Dark colored, medium textured, moderately slowly permeable soils	1,9	good	52	23	39
		fair	48	23	37
4. Moderately dark colored, medium textured, very slowly permeable soils	0.9	good	47	20	34
		fair	41	19	31
5. Light colored, medium textured, slowly permeable soils	28.4	good	45	19	36
		fair	40	16	33
6. Bottomland soils	5.3	Variable depending on overflow.			

*Crop yields were estimated from data in Illinois Agricultural Exp. Station Bull, No, 522 entitled "Productivity of Central Illinois Soils" by R. T. 0'Dell.

+The yield estimates for this group apply only to the more level soils which are adapted to cultivation.

**Soil group 2 from Table 6 was combined with Soil group 1 in this table.

Table 8 — Distribution of Slope Classes in Each Soil Group

Soil Group	A slopes 0-1 1/2%		B slopes 1 1/2-4%		C slopes 4-7%		D slopes 7-12%		E slope 12-18%		F slopes 18-30%		G slopes over 30%		Total
	Acres	Per-cent	Acres	Per-cent	Acres	Per-cent	Acres	Per-cent	Acres	Per-cent	Acres	Per-cent	Acres	Per-cent	Acres
1. Dark-colored, medium-textured, moderately permeable soils	4,642	74.6	2,226	69.2	720	62.8	124	15.2	-----	-----	---	-----	--	-----	7,712
2. Dark-colored, heavy-textured, moderately permeable soils	462	7.4	-----	----	---	----	---	---	-----	-----	---	-----	--	-----	462
3. Dark-colored, medium-textured, moderately slow permeable soils	192	3.1	8	0.3	32	2.8	12	1.5	-----	-----	---	-----	--	-----	244
4. Moderately dark, medium-textured, very slowly permeable soils	34	0.6	-----	----	12	1.1	68	8.3	-----	-----	---	-----	--	-----	114
5. Light-colored, medium-textured, slowly permeable soils	276	4.4	921	28.6	382	33.3	611	75.0	1,013	100.0	422	100.0	21	100.0	3,646
6. Bottomland soils	618	9.9	62	1.9	---	----	---	----	-----	-----	---	-----	--	-----	680
Total	6,224	100.0	3,217	100.0	1,146	100.0	815	100.0	1,013	100.0	422	100.0	21	100.0	12,868

Spring Lake watershed is related to the extent of development of the drainage system. The upland areas are level to gently sloping. The slope of the upland area drops off gently into the waterways, but the side slopes of the waterways become progressively steeper downstream. Maximum steepness occurs along the main stream and entranched tributary valleys. Nearly 90 per cent of the upland prairie soils occur on slopes of less than 4 per cent, whereas only 34 per cent of the upland timber soils occur on similar slopes. Of the total cropland in the area, 86.7 per cent is located on slopes of less than 4 per cent. About 47.1 per cent of land in pasture is located on slopes of less than 4 per cent.

PRESENT LAND USE

One of the more important factors that affect the rate of sediment production is land use. Five classes of land use were mapped in the conservation survey. Cropland is all land on which crops were grown at the time the survey was made. It includes land in row crops, small grains, and hay. Pasture land is land in perennial grasses, and woodland is land which is at least 40 per cent covered by the spread of trees. Miscellaneous land consists of land used for farmsteads, roads, or other purposes, while idle land consists of land not used for cultivation or any purpose for economic return.

Land use in general follows soil groups. Thus 80.1 per cent of the cropland in the watershed is located on dark-colored, medium-textured, moderately permeable soils, while most of the pasture and practically all of the woodland is located in light-colored, medium-textured, slowly permeable soils. (See Table 9). Cropland is confined primarily to A and B slopes while pasture is fairly well distributed on all slopes. Over half the woodland is located on F slopes with the balance fairly well distributed on lesser slopes. (See Table 10).

Table 11 presents a general summary of the capability of the lands of the watershed as compared to the present use of these lands. This shows that 82.7 per cent of the watershed is in land-capability classes I, II, and III which is considered safe for continuous cultivation. At the time of the survey 97 per cent of the cultivated land falls within these classes.

Table 11 also shows that 17.3 per cent of the watershed area is in land-capability classes VI and VII (not recommended for cultivation) and Class IV (can be cultivated only 1 year in 6). Three per cent of the land now being cropped in the watershed is on this type of land.

The major problem of land use adjustment in the watershed appears to be one of reducing the percentage of corn and soybeans on the land now being farmed and increasing the percentage of grasses and legumes. In addition, 1.3 per cent of the land now being farmed is best suited to woodland or pasture and should be taken out of cultivation. This is land that is too stcop or eroded to be safely cultivated without serious erosion losses.

The land-use history of Emmett Township, in which most of the watershed lies, for the period 1938-1947 is shown in

Table 9 Distribution of Present Land use in each Soil Group

Soil Group	Cropland		Pasture		Woodland		Miscellaneous		
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
1. Dark-colored, medium textured, moderately permeable soils	6,904	80.1	589	16.6	4	1.0	215	75.7	7,712
2. Dark-colored, heavy textured, mod.permeable soils	462	5.4	---	----	-	---	---	----	462
3. Dark-colored, medium-textured, med. slowly permeable soils	214	2.5	28	0.8	-	---	2	0.7	244
4. Moderately dark, medium textured, very slowly permeable soils	54	0.6	60	1.7	-	---	---	---	114
5. Light-colored, medium-textured slowly permeable soils	905	10.4	2,268	64.1	406	99.0	67	23.6	3,646
6. Bottomland soils	84	1.0	596	16.8	-	---	---	---	680
Total	8,623	100.0	3,541	100.0	410	100.0	284	100.0	12,858

Table 10 Distribution of Present Land use in each Slope Class

Slope Class	Cropland		Pasture		Woodland		Miscellaneous		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	
A(0-1 1/2 percent)	5,275	61.2	783	22.1	20	4.9	145	51.1	6,223	48.4
B(1 1/2-4 percent)	2,19?	25.5	884	25.0	62	15.1	74	26.0	3,217	25.0
C(4-7 percent)	825	9.5	266	7.5	12	2.9	44	15.5	1,147	8.9
D(7-12 percent)	282	3.3	480	13.6	36	8.8	17	6.0	815	6.3
E(12-18 percent)	38	0.4	919	25.9	52	12.7	4	1.4	1,013	7.9
F(18-30 percent)	6	0.1	194	5.5	222	54.1	----	----	422	3.3
G(over 30 percent)	------	----	15	0.4	6	1.5	---	----	21	0.2
Total	8,623	100.0	3,541	100.0	410	100.0	284	100.0	12,858	100.0

Table 11 Land Use Capability Classes compared with existing Land Use.

	Cropland		Pasture		Woodland		Miscellaneous		Entire Watershed	
	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent
Class I Land Suitable for cultivation, requiring no erosion control practices to maintain soil for general agricultural practices	5,092	59.0	537	15.2	---	---	143	50.4	5,772	44.9
Class II Land Good land that can be cultivated safely with easily applied practices	2,568	29.8	899	25.4	82	20.0	82	28.9	3,631	28.2
Class III Land Moderately good land that can be cultivated safely with such intensive treatments as terracing and strip-cropping	705	8.2	490	13.8	12	2.9	30	10.6	1,237	9.6
Class IV Land Best suited to hay or pasture, but can be cultivated occasionally, usually not more than 1 year in 6	144	1.7	456	12.9	18	4.4	23	8.1	641	5.0
Class VI Land Not recommended for" cultivation. Best suited for permanent pasture	94	1.1	970	27.4	292	71.2	6	2.1	1,362	10.6
Class VII Land Not recommended for cultivation. Suited for woodland or pasture with major restrictions in use	20	0.2	189	5.3	6	1.5	---	---	215	1.7
Entire Watershed	8,623	100.0	3,541	100.0	410	100.0	284	100.0	12,858	100.0

Table 12. Corn is the predominant crop followed in order of importance by soybeans, small grains and hay. Up to 1947 the acreage of intertilled crops, corn and soybeans has increased slightly while the acreage of small grains had decreased. In 1947 the average farm in Emmett Township consisted of 136 acres of which only 58 per cent was being cultivated. Of this tillable land, however, 63 per cent was in corn and soybeans, indicating too intensive production of these intertilled crops. Such emphasis on these cash crops is significant in that intertilled cropland, particularly with rows running up and down the slope, is subject to accelerated soil erosion which accounts for a large portion of sediment transported by runoff to Spring Lake.

Comparison of land use data for Emmett Township with that of McDonough County indicates that tillable land is being cropped more intensively in Emmett Township than it is in the county as a whole. The upper end of Spring Lake watershed, which is located in Sclota Township, is cropped still more intensively than the land in Emmett Township. Sciota Township is reforred to by many in the area as the "mud flats" and during heavy rains considerable soil is eroded from this land.

Table 12

Per Cent of Tillable Land in Various Crops, Emmett Township
McDonough County, Illinois, 1938-1947a/

Crops	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Corn	41	38	39	37	37	43	47	43	46	41
Soybeans	14	18	16	15	22	19	21	21	17	22
Small grains	28	27	22	25	17	20	10	19	20	17
Hay & pasture	14	15	20	21	23	15	21	14	16	15
Other & idle	3	2	3	2	1	3	1	3	1	5

a/Based on assessor's acreage census.

EROSION

Two kinds of water erosion occur in the watershed: sheet erosion and channel erosion. In developing any type of watershed-treatment program for protection of a reservoir, it is of primary importance to know where sediment is coming from and how much of the sediment is actually getting down to the reservoir.

The degree of erosion that has taken place in the watershed was mapped by comparing the thickness of different soil layers with that of similar soils and slopes in locations protected from erosion. The following erosion groups were mapped:

No apparent erosion: Approximate original depth of topsoil still remains.

Slight to moderate erosion: Over six inches of original topsoil remaining, no subsoil exposed by plow.

Moderately severe erosion: Occasional to frequent exposure of subsoil by plow, two inches to six inches of topsoil remaining.

Severe erosion: Erosion of the subsoil, less than two inches of surface soil remaining.

Very severe erosion: Frequent gullies, too deep to cross with farm implements and very severe erosion that has penetrated into parent material.

Erosion by sheet wash and erosion by channel flow were mapped separately during the course of the conservation survey, as was deposition on flood plains and in channels. Based on the estimated average original depth of virgin soil profiles, it is estimated from the results of the survey that over 95 per cent of the eroded material comes from sheet erosion. It follows that watershed treatment for reduction of the rate of sedimentation of this reservoir must be concentrated on areas where sheet erosion is most severe.

No apparent erosion is occurring over 40.2 per cent of the watershed. Slight to moderate erosion is occurring on 46.2 per cent and moderately severe erosion on 11.8 per cent of the watershed. Severe erosion is occurring on 1.7 per cent of the watershed and very severe erosion on 0.1 per cent of the watershed. Severe and very severe erosion is occurring on soils of group 5, while moderately severe erosion is occurring on soils of groups 1 and 5.

The distribution of erosion in relation to slopes is shown in Table 14. Slight to moderate erosion is occurring on all slopes with the largest percentage on B slopes. Moderate severe and severe erosion is occurring on C, D, and E slopes, while very severe erosion is confined to D and E slopes.

Table 13.--Distribution of the Erosion Group in each Soil Group

Soil Group	No apparent erosion		Slight to moderate erosion		Moderately severe erosion		Severe erosion		Very severe erosion		Total
	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres
1. Dark-colored, medium textured, moderately permeable soils	3506	67.8	3517	59.2	641	42.4	48	21.9	---	-----	7712
2. Dark-colored, heavy textured, slowly permeable soils	462	8.9	----	----	---	----	--	----	---	----	462
3. Dark-colored, medium textured, slowly permeable soils	136	2.6	70	1.2	38	2.5	--	----	---	----	244
4. Moderately dark, medium textured, slowly permeable soils	34	0.7	80	1.3	---	----	--	----	---	----	114
5. Light-colored, medium textured, slowly permeable soils	354	6.8	2278	38.3	833	55.1	171	78.1	10	100.0	3646
6. Bottomland soils	680	13.2	----	----	---	----	---	----	---	-----	680
Total	5172	100.0	5945	100.0	1512	100.0	219	100.0	10	100.0	12858

Table 14.—-Distribution of Erosion Groups in Each Slope Class

Slope Group	No apparent erosion		Slight to moderate erosion		Moderately severe erosion		Severe erosion		Very severe erosion		Total
	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres
A (0-1 1/2 percent)	4900	94.7	1323	22.2	---	----	---	----	----	---	6223
B (1 1/2-4 percent)	239	4.6	2946	49.6	32	2.1	---	----	----	---	3217
C (4-7 percent)	4	0.1	307	5.2	812	53.7	24	11.0	----	---	1147
D (7-12 percent)	4	0.1	234	3.9	432	28.6	139	63.5	6	60.0	815
E (12-18 percent)	25	0.5	732	12.3	206	13.6	46	21.0	4	40.0	1013
F (18-30 percent)	----	----	390	6.6	22	1.5	10	4.5	----	----	422
G (over 30 percent)	----	----	13	0.2	8	0.5	--	----	----	----	21
Total	5172	100.0	5945	100.0	1512	100.0	219	100.0	10	100.0	12858

Most of the erosion in this watershed is occurring on land which at present is used for cropland. Of the land area contributing to erosion in the watershed, 54 per cent is now in cropland and 41 per cent is in pasture. Although a high degree of erosion was found on land that is now used for pasture, some of this may have occurred earlier in the history of this watershed when the present pasture land was used for cropland. However, the present deteriorated conditions of the p?sture land in this watershed indicates that it is suffering from above-normal erosion.

CONSERVATION

Land use adjustments and conservation practices are needed in the watershed both to develop a more permanent and profitable agriculture and to reduce the rate of sedimentation of Spring Lake. Only a relatively small proportion of the farmers in the watershed have participated in soil conservation programs. A high proportion of the farmland is operated by tenants, with considerable acreage owned by absentee owners. This tenure has contributed to a high rate of continuous corn and soybean cultivation on these farms.

Observations and farmers[1] statements indicate that most of the permanent pastures in the watershed are unproductive. They have been depleted of soil fertility and over-grazed, and many of them are eroding. The number of livestock has increased in this area over the past 10 years, while acreages of both

Table 15.--Distribution of Erosion Groups in Each Land Use Class

Land Use Classes	No apparent erosion		Slight to moderate erosion		Moderately severe erosion		Severe erosion		Very severe erosion		Total
	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres	Per Cent	Acres
Cropland	4050	78.3	3626	61.0	828	54.8	115	52.5	4	40.0	8623
Idle Land	----	----	2	1/	31	2.1	8	3.7	—	----	41
Pasture	1015	19.6	1819	30.6	609	40.3	94	42.9	4	40.0	3541
Woodland	----	----	386	6.5	22	1.4	---	----	2	20.0	410
Miscellaneous	107	2.1	112	1.9	22	1.4	2	0.9	--	----	243
Total	5172	100.0	5945	100.0	1512	100.0	219	100.0	10	100.0	12858

1/Less than 0.1 of 1 per cent.

rotation hay and pasture and permanent pasture have decreased. Cropland in the watershed needs better management, including reduction in acreage of corn and soybeans, with corresponding increase of small grains, hay, and rotating pasture. In addition to better land use, supporting soil conservation and erosion control practices are needed in the watershed. A study of existing farm conservation plans in the watershed and opinions based on farmer interviews shows that the soils should be tested and limestone, phosphate, and in some cases potash applied according to tests, in order to secure adequate stands of legumes and grasses. Many waterways need to be shaped, fertilized and seeded. Existing waterways need to be shaped, seeded, widened and properly maintained. Sloping land should be farmed on the contour and terraces are needed on many of the fields to control runoff and erosion. Rotational grazing should be practiced on both permanent and rotation pastures. Permanent pastures should be cleared of brush, renovated, treated, seeded, and mowed to prevent weed growth. In a few instances, earth and concrete dams or flumes are needed. For the most part, sod flumes and adequate vegetation in the waterways should be sufficient. Timber should be protected and livestock kept out in order to secure an economical growth of timber.

RESULTS

CAUSE OF HIGH RATE OF STORAGE LOSS OF SPRING LAKE

The rate of sedimentation of Spring Lake has been high. In only twenty years the lake has lost nearly half of its original storage capacity. By 1953 the remaining capacity will not be adequate to furnish requirements of the city in the event of a severe drouth. This condition is due primarily to lack of sufficient original storage capacity to allow for the rate of sediment inflow, or conversely the lack of adequate control of soil erosion on the watershed.

In comparison with rates of sediment production found by surveys elsewhere in Illinois, the rate of sediment production from the watershed above Spring Lake (1.44 tons per acre per year is not considered high for a watershed of this size under prevailing farming practices. The rate of sediment production per unit of drainage area is related in part to the size of watershed. The larger the watershed the lower the rate of sediment production per unit of drainage area, other conditions being equal. On the basis of present information it appears that in Illinois, under prevailing farming practices, at least 150 acre-feet of storage capacity per square mile should be developed on a 20-square mile watershed to assure a rate of storage loss of less than 1.0 per cent annually. For watersheds of smaller size, a larger capacity-watershed ratio is needed while for larger watersheds a smaller capacity-watershed ratio may be used. An allowance of only 30 acre-feet of storage per square mile of drainage, in the design of Spring Lake, is much too small. This factor primarily accounts for the high rate of storage loss even though the rate of sediment production from this watershed is not considered high under prevailing farming practices,

REMEDIAL MEASURES

Development of Additional Supply

Analysis of water-consumption records for Macomb indicates that sediment in Spring Lake is encroaching upon the dependable capacity of the reservoir and that a water shortage can be expected during a prolonged drouth occurring in any year after 1953, Therefore, the need for enlarging the present storage facilities or finding a new source of water suppry is of immediate concern to the city. To accomplish this, consideration should be given to raising the dam, dredging the present deposits from the reservoir, or developing a new surface water or ground water supply. The relative feasibility of these measures can be determined only by a thorough engineering investigation.

Surface Water

Many cities have found it economical to develop additional storage by raising the dam of an existing reservoir. At Spring Lake the spillway has already been effectively raised 1.3 feet by the installation of permanent flashboards. This added approximately 85 acre-feet to the capacity of the reservoir. In developing still more storage capacity the possibility of raising both the present spillway and the dam should be given consideration.

The present reservoir is estimated to have trapped about 75 Per cent of the incoming sediment load, the remainder having gone over the spillway. By increasing the capacity of the present reservoir a higher percentage of incoming sediment will be deposited because of increased detention time of water in the reservoir. On the basis of the measured rate of sediment production from this watershed and the increased trap efficiency of a larger reservoir it is estimated that a capacity of 3 to 4 times the present capacity is needed to assure a future rate of sedimentation of less than 1.0 per cent annually under prevailing farming practices in the watershed. There are definite physical limitations on raising the dam and spillway which need further study to determine the amount of additional storage that could be developed by this method.

Some reservoir operators have resorted to dredging to restore capacity lost by sedimentation. The two limiting factors in this method are cost and disposal of dredged material. Dredging costs have increased steadily in the last decade and dredging usually cannot be Justified in projects of this size because of the high initial cost of equipment. The operating cost alone for dredging Spring Lake to restore the project to its original capacity probably would exceed the original cost of the dam and reser voir.

A possible reservoir site exists on Spring Creek Just below Spring Lake, but its exact characteristics have not been determined. If feasible from an engineering standpoint, a reservoir at this location would be desirable for several reasons. First, it probably would allow the continued use of most of the present pipeline into the city, thereby eliminating the necessity of a new line if a source of water supply was developed at some other location. Secondly, Spring Lake above would serve as a sedimentation basin, thus reducing the rate of storage loss in the new reservoir to a negligible amount for many years. The effectiveness of Spring Lake in reducing the sediment load to the downstream reservoir could be further increased by developing vegetative screens at the head of the lake which would promote sediment storage above the present crest level of Spring Lake, thus reducing the amount deposited in both Spring Lake and the new reservoir below.*

Groundwater

The history of the Macomb water supply shows that only in the very earliest stages of development was a ground water supply utilized. The subsequent construction of the Lamoine River channel dam and Spring Lake signify that ground water sources have been considered generally inadequate to furnish the

*For further measures to reduce sedimentation, see "The Control of Reservoir Silting", Misc. Publ. No. 521, U. S. Dept. of Agriculture, Wash. D. C. 1944.

public supply. This is concluded chiefly because experience has shown that in cases where adequate ground water is available this source is usually found more economical to develop than a surface supply. In searching for the most economical auxiliary water supply the ground water resources of the area should be subjected to a complete investigation and should be considered in the light of the known surface water resources. Such an investigation is properly in the realm of activity of a professional engineering firm.

Several industries in Macomb have private wells, and an inspection of such data is indicative of the general ground water situation. The files of the State Water Survey Division show that practically all of the industrial wells at Macomb secure their ground water from wells penetrating bedrock and have depths from about 350 to 430 feet that are reported to produce from 25 to 35 gallons per minute. There is little uniformity in the non-pumping water levels in the different wells.

An industry located Just north of the center of town has two wells reported to be 429 feet deep. In 1940 it was reported that they produced about 3C to 35 gallons per minute each. The non-pumping water level was reported as 190 feet and the pumping level at 340 feet. The water temperature was 57.5°F. This water was found to have a total mineral content of 426 parts per million, a low iron content and 304 ppm. hardness.

In August 1948 an electrical earth resistivity survey. was conducted by the State Geological Survey in the Macomb area.

This survey was made in an effort to locate areas of high electrical resistivity indicative of sand and gravel deposits in the glacial drift, The most favorable area of high resistivity was along the present course of Troublesome Creek about three miles south of Macomb. The second area for consideration was found to be that of a sand and gravel terrace which parallels and is south of the Lamoine River Just north of Macomb.

Watershed Treatment Program

The rate of sedimentation of Spring Lake can be materially reduced by a watershed treatment program consisting of the measures outlined briefly in a preceding section and shown in Table 16. The installation of watershed treatment measures at this time, however, will not materially reduce the hazard of a water shortage at Macomb since the watershed program could hardly be completed before the year 1953 when the storage capacity of Spring Lake will become insufficient to furnish a dependable suppl; during a prolonged drouth. Although a complete watershed treatmenl program will not greatly alleviate the water supply problem at Macomb it is highly important from the standpoint of protecting a new and additional surface water supply from rapid loss if the present reservoir should be enlarged or if a new reservoir should be constructed.

It is far more economical to stop sediment at its source than to dredge it from a reservoir or to develop replacement storage which becomes progressively more costly as the best sites are used first.

From the conservation survey data of the Spring Lake watershed it is possible to estimate the soil losses under prevailing land use and the soil losses if a conservation program were installed on the watershed. In Table 16 is shown the present land use in the watershed together with estimated and soil losses compared to the recommended land use and the consequent lower soil losses. It will be noticed that 623 acres of land currently used for pasture and timber could be included in the crop rotatior

Table 16 shows that the establishment of a watershed treatment program can be expected to reduce the annual soil loss from about 58,000 tons to about 11,000 tons. This is an 81 per cent reduction of soil leaving the fields. The significant change in land use in this program is in the length of rotations. As hat been brought out previously the present average rotation for the watershed has been a 3-1-1 (3 years corn, 1 year oats, 1 year hay)• The proposed rotations vary from 2-1-1 to 1-1-4. A complete breakdown of the acreages of the watershed recommended for these rotations is shown in Table 17. In addition to the longer rotations needed on this watershed, such additional conservation measures as contouring, terracing, and strip cropping are recommended on 42.6 per cent of the cultivated land. This will further reduce soil losses. Table 17 shows the actual acreages of the cultivated land on which these various conservation measures are needed.

It is estimated that the rate of sediment production from Spring Lake watershed could be reduced about 81 per cent by

Table 16

Estimated Reduction in Sheet Erosion from a Watershed Treatment Program
Spring Lake Watershed, Macomb, Illinois

	Without Program							With Conservation Program						
	Acre's in Culti- vation	Esti- mated Soil Loss, Tone	Acres in Pasture woods	Esti- mated Soil Loss, Tons	Acres in Misc. land use	Esti- mated Soil Loss, Tons	Total Annual Soil Loss, Tons	Acres in Culti- vation	Esti- mated Soil Loss, Tons	Acres in Pasture- woods	Esti- mated Soil Lose, Tons	Acres in Misc. land use	Esti- mated Soil Loss, Tons	Total Annual Soil Loss, Tons
1. Dark colored, medium textured moderately per- meable soils	6904	24872	593	356	215	129	25357	7205	8279	292	59	215	129	8467
2. Dark colored, heavy textured moderately per- meable soils	462	0	0	0	0	0	0	462	0	0	0	0	0	0
3. Dark colored, medium textured moderately slow- ly permeable soils	214	772	28	17	2	1	790	224	104	18	4	2	1	109
4. Moderately dark, medium textured very slowly per- meable soils	54	248	60	36	0	0	284	54	24	60	12	0	0	36
6. Light colored, medium textured slowly permeable soils	905 '	30479	2674	1604	67	40.0	32123	1213	2144	2366	473	67	40.0	2657
6. Bottomland soils	84	0	596	0	0	0	0	88	0	592	0	0	0	0
	8623	56371	3951	2013	284	170	58554	9246	10551	3328	548	284	170	11269

General Notes.

(1) Under this conservation program 623 acres would be converted from pasture to cultivation.
(2) A soil loss factor of 0.2 ton per acre per year was assumed on pasture and woods under conservation program and 0.6 under present management. Ho loss was assumed on level pasture and woods.
(3) notation used as a basis for land use without program based on assessors acreapre figures for Emmett Twp. 1947 (See Table 9).

Table 17

Estimated Conservation Practices and Rotations Needed
on Cropland in Spring Lake Watershed, Macomb, Ill.

Soil Groups	Total Culti-vated land. Acres.	No Prac-tices needed. Acres.	*Contour Culti-vation. Acres.	Terraces. Acres.	Strip Crop-ping. Acres.	Corn-Beans Oats-Clover. Acres.	Suggested Rotations: Corn-Oats-Clover or Corn-Beans-Oats. 2 Yrs. Alf., Brome. Acres.	Suggested Rotations: Corn-Oats 2 Yrs. Alf., Brome. Acres.	Suggested Rotations: Corn-Oats 4 Yrs. Alf., Brome. Acres.
1. Dark-colored, moderately permeable soils	7205	4307	2252	617	29	6246	857	73	29
2. Dark-colored, heavy textured, moderately permeable soils	462	462	----	---	--	462	---	--	--
3. Dark-colored, medium textured, moderately slowly permeable soils	224	186	8	26	4	183	37	--	4
4. Moderately dark, medium textured, very slowly permeable soils	54	34	----	12	8	----	34	12	8
5. Light-colored, medium textured, slowly permeable soils	1212	225	634	260	94	----	999	143	71
6. Bottomland soils	88	88	----	---	--	88	---	--	--
Totals	9245	5302	2894	915	135	6979	1927	228	112

*In order to obtain a greater reduction in soil loss, a large percentage of this contoured acreage could be terraced. It would be possible to have more acres of corn or soybeans if more terraces were used.

a complete watershed treatment program. Table 16 is based on an analysis of existing erosion conditions and conservation needs in the watershed. Although the measures shown in this table are designed primarily to control sheet erosion, it is estimated that 95 per cent of the total sediment load entering Spring Lake is derived from this source. Therefore such a program should effect a reduction of approximately 77 per cent of the total sediment load brought into the reservoir.

Calculations show that the establishment of such a watershed program now would not be sufficient to extend the useful life of the reservoir beyond 1955. it would require a minimum of five years to complete a conservation program on the watershed. In this period the consumption needs would continue to increase to such an extent that the reservoir would be inadequate by 1955. Such a program would, however, reduce the sedimentation in the lake and extend its ultimate life and hence extend the length of time Spring Lake could continue to be used in connection with other supply.

For illustration of the usefulness of a watershed protective program it has been calculated that if such a program had been Initiated in 1936 sedimentation could have been reduced so as to extend the useful life of the reservoir to approximately 1970. This extension of the life of the lake from 1948 to 1970 would have meant a stay of 17 years in the necessity of providing additional storage. In view of the expensive replacement of storage space It would seem that such a program could have been economically Justified at that time had the sedimentation program been real-

Figure 16 Erosion **Between** Corn **Rows** Planted Downhill
Spring Lake Watershed

Figure 17 Large Gully in a Permanent Pasture
Spring Lake Watershed

ized then.

A program of watershed protection including land use changes, conservation measures and channel improvement could possibly be justified at present for the purpose of extending the period that Spring Lake can continue to be used in conjunction with other storage.

COSTS AND BENEFITS OF CONSERVATION

The adoption of a soil conservation program by farmers in the watershed would be a definite benefit to the city of Macomt by reducing the volume of sediment coming into the reservoir. Studies of actual farms in the state show that the application of soil conservation measures can be justified economically by the farmer himself because increased crop yields from conservation-farmed land mean increased farm income.

The long-time benefits of conservation are certain. However, considerable effort and money must usually be expended before positive results are achieved. Conservation benefits are demonstrated by studies comparing matched high- and low- conservation farms in McLean County for the period 1936-1945. The farms compared had similar land-use capabilities and were similar in size but used different amounts of soil and water conservation practices. Figures 18 and 19 show the benefits of conservation in terms of income changes and crop yield changes.

Conservation costs amounted to approximately $35 per acre on the high-conservation-score farms. This was about twice the amount spent for conservation on the low-conservation-score

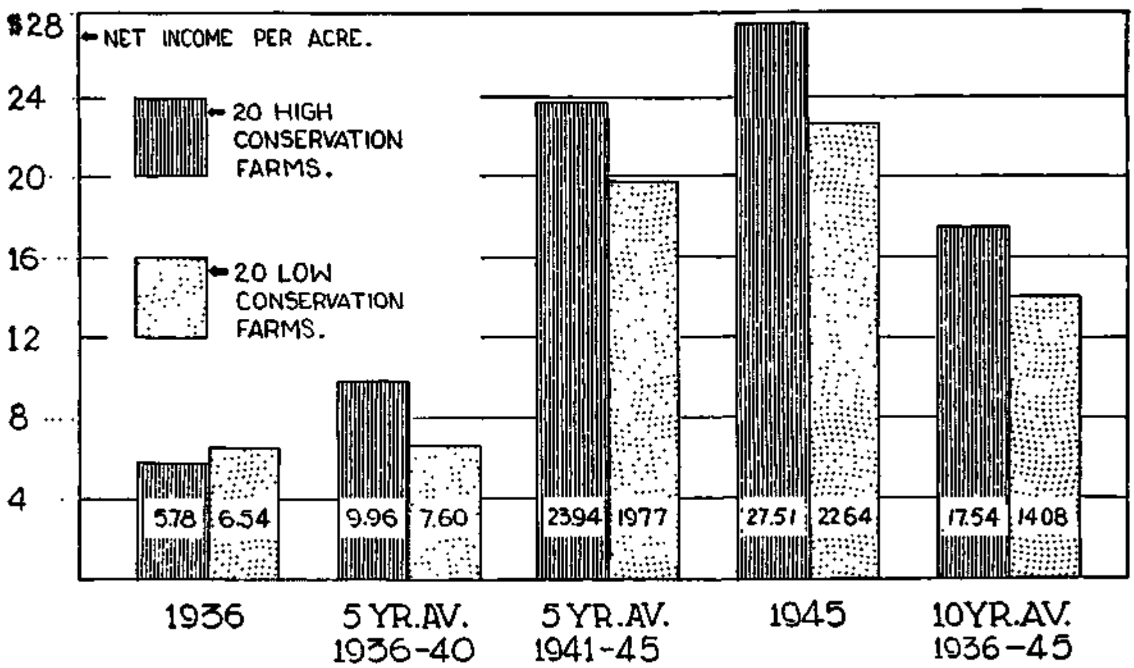


FIGURE 18 NET INCOME PER ACRE. IDENTICAL FARMS WITH HIGH AND LOW CONSERVATION SCORES, M^c^LEAN COUNTY, 1956 — 1945.

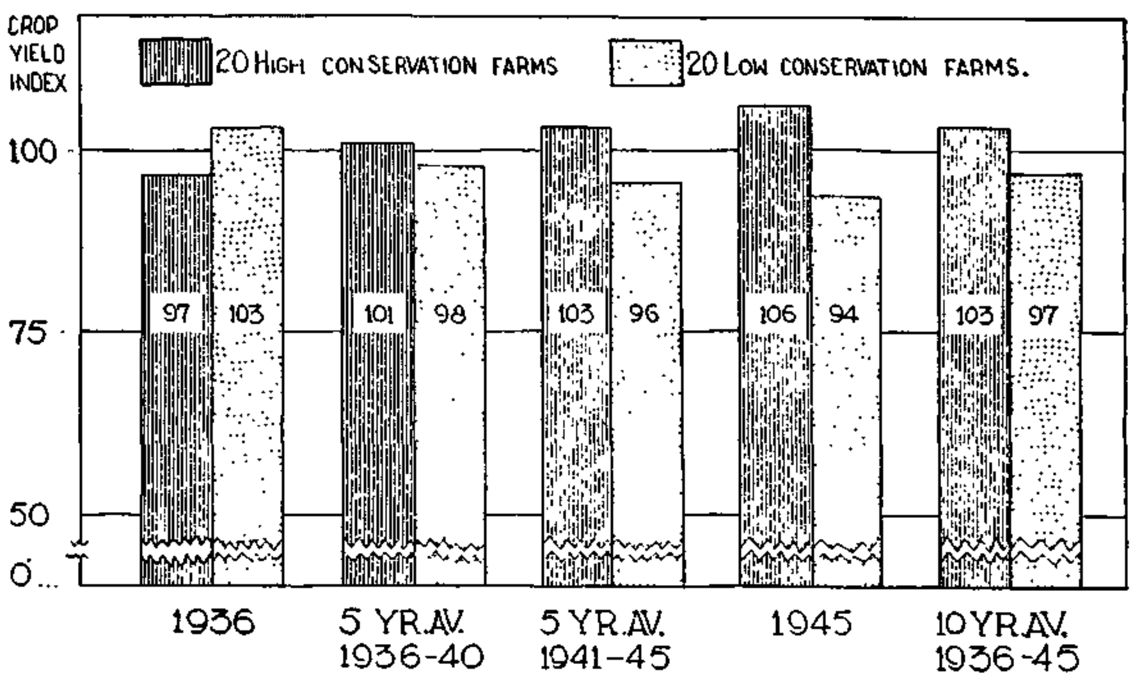


FIGURE 19 CROP YIELD INDEX, IDENTICAL FARMS WITH HIGH AND LOW CONSERVATION — SCORES, McLEAN CO. 1936-45 (AVERAGE YIELDS OF ALL CROPS FOR ALL FARMS EQUALS 100).

farms.

The high-conservation farms had average net incomes of $3.46 per acre per year more for the 10-year period. (This was after accounting for all expenses, Including costs of conservation). This increased Income amounted to $5,536 for a l6o-acre farm for the 10-year period.

Conservation costs and benefits in the Soring Lake watershed would probably be comparable to those in the McLean County study, While the McLean County farms studied have a higher proportion of tillable land, this would be offset by the higher proportion of present unproductive pastureland in the Spring Lake watershed which would be brought into profitable production by application of a comploto conservation plan.

RECOMMENDATIONS

It is recommended that a complete study of the water supply problem at Macomb be made by a qualified professional engineer and that the sediment problem be included as a part of this study.

It is recommended that the City of Macomb undertake immediately the development of a soil and water conservation program on this watershed. Such a program should be organized in cooperation with the McDonough County Soil Conservation agencies. Insofar as possible the program should be carried out in accordance with the recommendations of local officers of these agencies and in accordance with the findings of the foregoing report.