OUT OF INVESTIGATION NO. 12 1951

STATE OF ILLINOIS

AOLAI E. STEVENSON, *Governor*

THE SILTING OF WEST FRANKFORT RESERVOIR

WEST FRANKFORT, ILLINOIS

J. B. Stall, A. A. Klingebiel, S. W. Melsted, and E. L. Sauer

A Cooperative Study by
Illinois State Water Survey Division, Soil Conservation Service
United States Department of Agriculture, and Illinois
Agricultural Experiment Station
With Local Help From
City of West Frankfort Water Department

DEPARTMENT OF REGISTRATION AND EDUCATION

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URBANA, ILLINOIS
(Printed By Authority of State of Illinois)

WEST FRANKFORT RESERVOIR

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SUMMARY

1. West Frankfort Reservoir was constructed as the water supply source for the city of West Frankfort in 1926 and served as the only supply until 1945 when the new Lake West Frankfort was completed. At present, both lakes furnish the supply.

2. Sedimentation surveys of the old lake, West Frankfort Reservoir, in 1936 and in 1949, showed that the reservoir lost 5.80 per cent of its capacity to sediment prior to 1936 and an additional 1.69 per cent since 1936.

3. Sediment deposited in the reservoir represents 6.12 tons per acre per year from the drainage area prior to 1936 and "2.32 tons after 1936.

4. In the year 1941, city pumpage completely drained the reservoir in spite of restrictions on water use. At the time a temporary pipeline was laid to Benton, eight miles distant, for water.

5. Future water demand on the water system is dependent on the economic development of the area, including the dominant industry, coal mining. The 1950 city population of 11,000 is estimated to increase to 15,800 by the year 1970.

6. It is estimated that total municipal pumpage will reach 1.55 million gallons per day by 1960 and 2.60 by the year 2000.

7. The drought of 1941 completely drained the reservoir and proved the reservoir inadequate to meet the city's needs at that time.

8. It is estimated that the present combined storage capacity of the old and new lakes is sufficient to withstand a 100-year drought. By 1957, sediment will have decreased storage capacity so that such a drought would cause a water shortage.

9. Similarly, the present reservoirs will be adequate till the year 1966, to furnish the total pumpage during a 50-year drought.

10. Samples of the sediment from various locations within the lake show considerable variation in chemical and physical characteristics.

11. There are three major soil groups in the watershed. 70.2% of the soils belong to the Ava group, 19.0% to the Bluford-Blair group and 10.8% to the Belknap group.

12. The topography in the watershed is dominantly rolling with 6.8% of the land greater than 12% slope. Thirty-six and one-tenth per cent of the watershed ranges from 7 to 12% slope, 53.6% varies from 1 1/2 to 7% and 3.5% is level.

13. The present land use in the watershed indicates that 37.9% of the land is in cultivation, 36.7% idle, 14.5% in pasture, 10.4% in woods and 0.5% in miscellaneous use.

14. According to the conservation survey, approximately 42% of the watershed is suitable for regular cultivation, 17% to hayland (occasional cultivation) and 41% to pasture and woodland.

15. Of the land now in cultivation in the watershed, 23.8% should be converted to pasture or woods. This land is too steep or too badly eroded to safely cultivate. Forty-four and five-tenths per cent of the idle land in the watershed is suitable for regular cultivation and 14.8% for very limited cultivation (largely hayland).

16. Forty-seven per cent of the watershed is severely or very severely eroded (largely subsoil in the plow layer), 22% moderately severely eroded and 31% none to slightly eroded.

17. Land use adjustments should be based on the soil conservation survey map as prepared for the watershed. Table 9 of the report shows the adjustments necessary.

18. It is estimated that if the proposed watershed program is applied to the land, the rate of siltation in the reservoir may be 80% less than the present rate. The major adjustments necessary to place the proposed watershed program into effect are (1) treat the land according to its capabilities (Tables 9 and 15); (2) treat the soils according to test; (3) in some cases supply economic assistance for the initial cost of the soil treatment program, and (4) use sound rotations and erosion control practices as suggested in Table 16.

19. Farm record studies in southern Illinois in areas comparable to this watershed show that a soil conservation program, such as recommended for the watershed resulted in crop yield increases of approximately 40 per cent.

20. Studies indicate that increased income from a conservation program will repay the cost of installing the program in three to six years in the West Frankfort area.

21. Pasture studies show that in this area the desirable forage was increased by proper soil treatment, from 1102 to 3448 pounds per acre while water runoff was reduced from 7.4 to 3.6 inches.

22. Proper soil treatment plus the use of improved varieties of legumes and grasses have produced 200 to 300 more pounds of meat per acre than untreated pastures. At present prices, the total treatment and seeding costs could be repaid in only one year by increased meat production.

23. It is estimated that a watershed treatment program on the drainage areas of both the old and new lakes would extend the total life of the reservoirs and the length of time they can be used, even after additional water storage has been provided.

24. The success of a sound and profitable watershed treatment program for West Frankfort watersheds depends greatly upon the proper application of the necessary plant nutrients such as limestone, phosphate and potash to cultivated and pasture land. It may be necessary to furnish economic assistance to some farmers in the watershed to purchase limestone, fertilizer and seed. These soils respond satisfactorily to fertilizer treatment.

25. Other cities in Illinois and the nation have found it economical, and even profitable, to invest

in the establishment of a watershed treatment program to reduce sedimentation in their reservoirs.

Recommendations

26. It is recommended that the City of West Frankfort undertake immediately the application of a watershed treatment program on the drainage areas of both West Frankfort Reservoir and the new Lake West Frankfort to reduce sedimentation and prolong the ultimate life of these lakes and the length of time they can be used for the public water supply. It is suggested that this program be carried out by: (1) Financial assistance from the city to the local soil conservation district for intensified conservation efforts on these watersheds, or (2) Purchase of the watersheds, or much of the critical erosion areas by the city for application of the needed conservation measures.

27. It is recommended that preliminary consideration be given to possible measures for increasing the raw water supply for the city. Such measures should be put into effect prior to the year 1966 in order to prevent a water shortage in event of a 50-year drought.

THE SILTING OF WEST FRANKFORT RESERVOIR
WEST FRANKFORT, ILLINOIS

by

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GENERAL

INTRODUCTION

Need for Data. Whenever a dam is built to store the waters of a muddy, flowing stream, a pool is formed behind the dam in which the rate of flow of the water is decreased. When this decrease of flow rate occurs, the particles of mud in the water immediately begin to settle to the bottom of the pool and come to rest there to decrease the storage capacity of that pool. Thus, upon the construction of a reservoir, destruction begins immediately.

In Illinois, reservoir storage is necessary on virtually all surface water supplies to insure an uninterrupted supply throughout the year or, through a cycle of years of low rainfall. Within Illinois, to date, there have been constructed approximately 500 artificial reservoirs. These have been built for municipal and industrial water supply, recreation, conservation, and flood control. Recent studies have shown that there are approximately 600 reservoir sites remaining within the state. It is imperative that these remaining reservoirs be utilized to the best possible advantage.

Early reservoir developments were of necessity carried out without adequate knowledge of factors involved in reservoir sedimentation. The need for more information on the effects of sedimentation on impounding reservoirs began to be recognized in Illinois as early as 1930, when the State Water Survey Divisron carried out a sedimentation survey of Lake Decatur in cooperation with the owners of the lake. Impetus was given the investigation of reservoir sedimentation problems with the spread of the movement to control soil erosion, which led to the creation of the Soil Conservation Service as a permanent agency of the U. S. Department of Agriculture in 1935. This agency undertook a systematic study of rates of reservoir siltation in all parts of the country. Related studies were made of land use and erosion on the drainage areas.

Illinois Program. Within Illinois, this investigational program has been carried out under a cooperative project agreement between the Illinois State Water Survey Division, the Office of Research of the Soil Conservation Service and the Illinois Agricultural Experiment Station. The objectives of this program are:

1. To establish information on factors involved in reservoir sedimentation in Illinois.
2. To establish a factual basis for future reservoir development in the state as affected by these sedimentation factors.
3. To show quantitatively the relationships between the problems of reservoir owners and problems of the watershed land owners.
4. To develop measures for sediment control.

One of the early surveys carried out under this program was a detailed survey of West Frankfort Reservoir. This survey was made in 1936 at which time the reservoir was ten years old. In 1949 an additional thirteen years had elapsed since the first survey and it was deemed advisable to resurvey this lake under this research program.

1. "Preliminary Data on Surface Water Resources," Illinois State Water Survey Division Bulletin No. 31, Urbana, Illinois, 1937.

SCOPE OF INVESTIGATIONS

Lake Survey. A detailed sedimentation survey of the reservoir was made in August-September 1936, by a field party of the Soil Conservation Service under the direction of L. M. Glymph. From this survey the original capacity of the reservoir was redetermined, and the capacity and sediment volume of the lake on that date were computed. A second survey, based on the 1936 survey system, was begun during June and July 1947 by a survey party of the State Water Survey Division and the City of West Frankfort. This survey was not completed satisfactorily until rechecks were made in 1949. The resurvey was thus completed in July, 1949.

Watershed Survey. In an effort to determine the watershed sources from which the sediment originates, the Soil Conservation Service in 1948 conducted a detailed conservation survey of this watershed. These data on soils, slopes, land use, erosion and conservation give a complete picture of the agricultural use of the farm lands of the watershed. An analysis of these data shows the problem areas where definite conservation measures are needed to reduce sedimentation in the lake. By means of these data it is possible to point out specific conservation practices that would effectively reduce soil losses and thus reduce the volume of sediment reaching the reservoir.

An additional study by the Soil Conservation Service of the land use history of the watershed farms during the life of the reservoir shows the trend in land use on the watershed during this period. The interpretation of these data in light of the measured rates of sedimentation for the two periods aids in developing recommendations for land use changes needed to reduce soil losses from the land and sedimentation in the lake.

Sediment Samples. During the course of the 1936 survey a series of 12 samples of the bottom sediment were taken by the field party. Pint samples were obtained by means of special tubular sampler. During the 1947 survey 15 similar sediment samples were taken. Chemical and physical analyses of both of these sets of sediment samples have been made by the Illinois Agricultural Experiment Station. The data on texture, colloidal content, volume weight and plant food constituents of the sediment give significant indications as to the watershed sources of the sediment deposited in the reservoir.

Interpretation of Results. The final interpretation of the silting problem at West Frankfort Reservoir 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 are discussed.

ACKNOWLEDGEMENT

City of West Frankfort. The agencies conducting this survey wish to acknowledge the generous cooperation of the municipal authorities of West Frankfort, particularly the city water department, in authorizing and expediting the two surveys. In 1936, former waterworks superintendent John Misker supplied information on the construction of the lake and furnished materials for the survey monuments.

In the conduct of the 1947 survey, Mayor Luther Burpo, City Clerk George I. Cotter, and Maintenance Foreman "Buck" Wells were most helpful at all times. The city furnished two boats and two helpers to the survey party for the entire three-week period of the survey.

State Water Survey Division. The 1947 resurvey of this reservoir was carried out by a field crew of the State Water Survey Division consisting of B. O. Larson, Chief of the Party, J. B. Stall, Assistant Engineer, Leslie Jones and Douglas Rucker, Assistants; The replotting of the cross-sections, planimetering of cross-sectional and surface areas of the lake, and the computation of the 1949 volume of water and sediment in the lake were carried out under the supervision of J. B. Stall. The compilation of the engineering sections of this report plus the preparation of the report for publication has been done by Mr. Stall under the supervision of H. E. Hudson, Jr., Head, Engineering Subdivision.

Soil Conservation Service. Various officials of the U. S. Department of Agriculture, Soil Conservation Service have contributed to this study in many ways. The 1936 survey of this reservoir was made by the Central Reservoir Party, Section of Sedimentation Studies, Division of Research. The personnel of the party was as follows: Louis M. Glymph, Jr., Chief of Party; Victor H. Jones, Assistant Chief; William G. Shannon, Oscar D. Price and Harry L. Fischer. The advance report[2] on this reservoir was prepared by Dr. Jones and forms the base upon which the present report is written.

The Sedimentation Section of the Office of Research in Washington furnished the specialized field equipment for the survey work. Mr. L. C. Gottschalk, Head of the Sedimentation Section, gave technical assistance to the field party during the conduct of the survey and to the authors in the compilation of this report.

Mr. B. B. Clark, State Conservationist, cooperated by authorizing the conservation survey of this watershed by Soil Conservation Service

2. Jones, V. H., "Advance Report on the Sedimentation Survey of West Frankfort Reservoir." U. S. Soil Conservation Service SCS-SS-15, 9 pp., illus., processed, Washington, D. C., 1937.

personnel and was helpful in many ways to the authors in the compilation of the report. The field work of the watershed soil conservation survey was carried out by Mr. George Walker, Soil Surveyor, during 1947. Mr. A. A. Klingebiel, State Soil Scientist, analyzed the survey data on the watershed and compiled the watershed section of this report. Mr. H. M. Smith, Soil Scientist, assisted in the preparation of the proposed conservation program needed on the watershed.

Dr. E. L. Sauer, Project Supervisor, Research, Economics of Soil Conservation, Soil Conservation Service and Illinois Agricultural Experiment Station cooperating, carried out the study of land use and conservation history of the watershed. This study entailed both field visits and study of public records and their interpretation. Dr. Sauer also prepared the data in this report concerning the costs and benefits of conservation.

Illinois Agricultural Experiment Station. The 1936 samples of the sediment in the lake were procured by the field party under the supervision of Professor F. H. Crane. The interpretation of the 1936 and 1947 sediment analyses and their comparison to watershed soils has been carried out by S. W. Melsted, Associate Professor of Soil Analysis.

Franklin County Soil Conservation District. The directors of the Franklin County Soil Conservation District have aided this study by authorizing the use of personnel assigned to the District for carrying out the conservation survey of this watershed. The Illinois State Soil Conservation Districts Board cooperated in this study by financing the laboratory work in making the sediment analyses. This work was carried out in the laboratories of the Illinois Agricultural Experiment Station.

RESERVOIR

GENERAL INFORMATION

Reservoir. West Frankfort Reservoir, known locally as the "Old Reservoir", is located six miles east of the city of West Frankfort in Sections 19 and 30, Township 7 South, Range 4 East, Franklin County. As shown in Figure 1 the lake is impounded on Tilley Creek, a small intermittent stream.

At the present spillway crest elevation of 441. 77 M. S. L. the lake proper is slightly more than one mile in length. The main body of the lake varies in width from about 1,200 feet near the dam to 350 feet at the upper end. The basin is comparatively shallow and has a flat bottom broken only by stream channels cut 5 to 10 feet below the valley flat.

Dam. The dam, located in the southwest corner of Section 19, is an earth-fill structure 850 feet long, 27 feet in maximum height above the valley bottom, 100 feet wide at the base and 4 feet wide at the top. The upstream face has a 2:1 slope. The concrete spillway extends across a small tributary channel which joins Tilley Creek below the dam.

Spillway. The spillway is separated from the northeast end of the main dam by a shoulder of glacial till 175 feet wide. The spillway crest has a net length of 90 feet and, when constructed in 1926, the crest elevation was 439 feet above mean sea level. Five concrete posts four feet in height were constructed as part of the original spillway for the purpose of holding flashboards. In August, 1941 the spillway crest was raised one foot and in April, 1943 about two additional feet, making the crest elevation 441. 77 feet after this date. The spillway structure is shown in Figure 2.

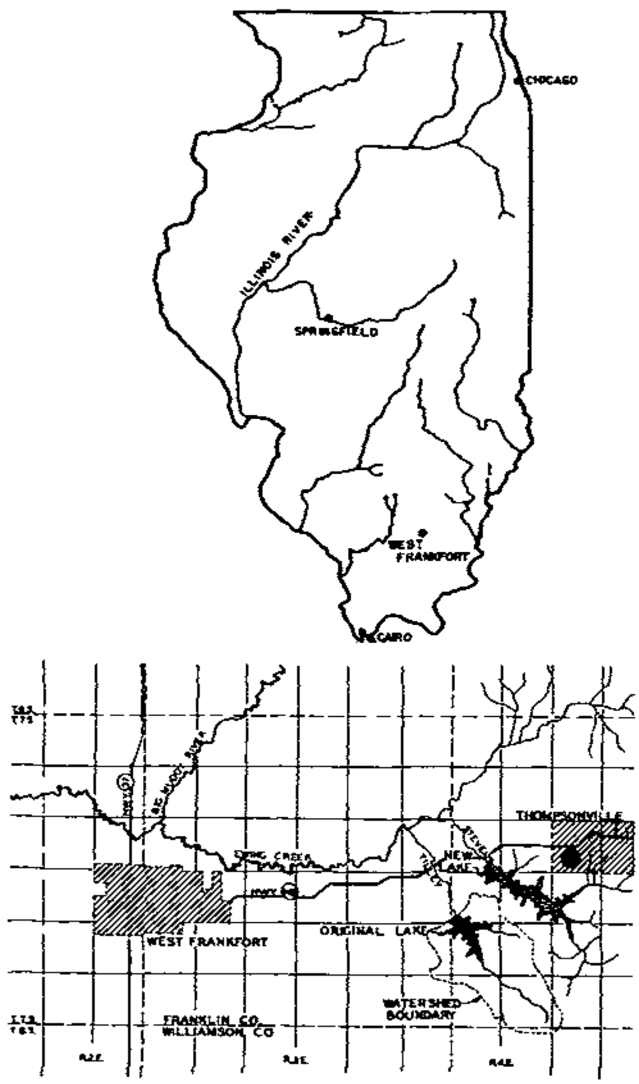

FIG. 1. WEST FRANKFORT RESERVOIR LOCATION.

FIG. 2. WEST FRANKFORT RESERVOIR SPILLWAY - 1951.

METHODS OF SURVEY

Range System. The record of sedimentation in West Frankfort Reservoir is based on the survey system established in 1936 by the field party of the Soil Conservation Service. At that time a complete sedimentation survey of the reservoir was made cooperatively by the same three agencies conducting the present studies. A triangulation net of 12 stations was expanded from a 1075 foot base line across the dam; it served as control for mapping the shore line and the establishment of the system of 14 silt ranges on the lake. Range ends and triangulation stations were marked with iron pipes set in concrete and stamped with station numbers. Mapping was done with plane table and telescopic alidade to a scale of one inch equal to 200 feet.

All values of storage capacity and silt volume for the reservoir were determined by the range method of survey developed by the Soil Conservation Service and described in its Bulletin No. 524, "Silting of Reservoirs".[3]

1936 Survey. In 1936, along each silt range, soundings of water depth were taken every 25 feet to locate the elevation of the top of the silt at that time. Soundings were taken with a bell-shaped 5-pound aluminum sounding weight with a 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, this consists of a steel rod made up of cup-shaped grooves every

FIG. 3. USE OF SPUD IN MEASURING SEDIMENT.

one-tenth of a foot. On the range line this spud is thrown spearlike into the sediment on the end of a calibrated line. It penetrates the soft sediment and goes into the original soil or prereservoir deposit. The bar is then retrieved and in the boat the actual thickness of the sediment is measured by inspecting the small soil or sediment samples retained in the cups.

1947 Survey. In 1947 a detailed resurvey of the reservoir was carried out by a field crew of the State Water Survey Division under Bernt O. Larson, Chief of Party. In making the resurvey it was necessary to remap completely the shoreline because the spillway crest had been raised since the 1936 survey. As a result of this raise in water level many of the original survey stations were submerged or washed out. In such cases the stations were re-established or alternate stations were located above the present crest line. All stations re-established were marked with concrete posts as shown in Figure 4. Since the 1936 cross-sections showed the original soil profile

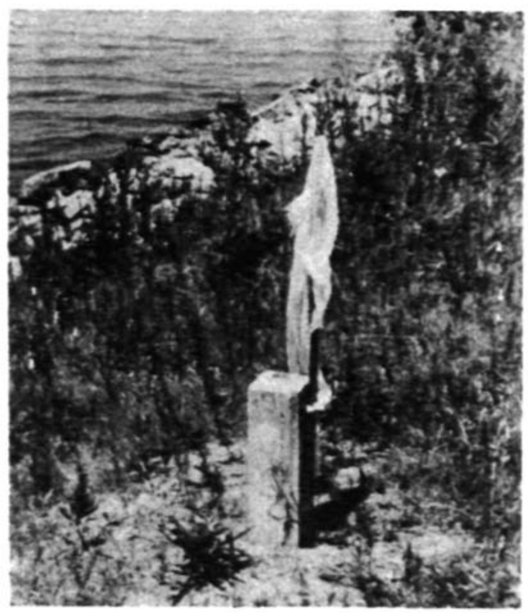

FIG. 4. CONCRETE POST USED AS PERMANENT MARKER.

3. Eakin, H. M., "Silting of Reservoirs," U. S. Department of Agriculture Technical Bulletin 524, Revised by C. B. Brown, 168 pp. illustrated. Washington, U. S. Government Printing Office, 1939. Appendix.

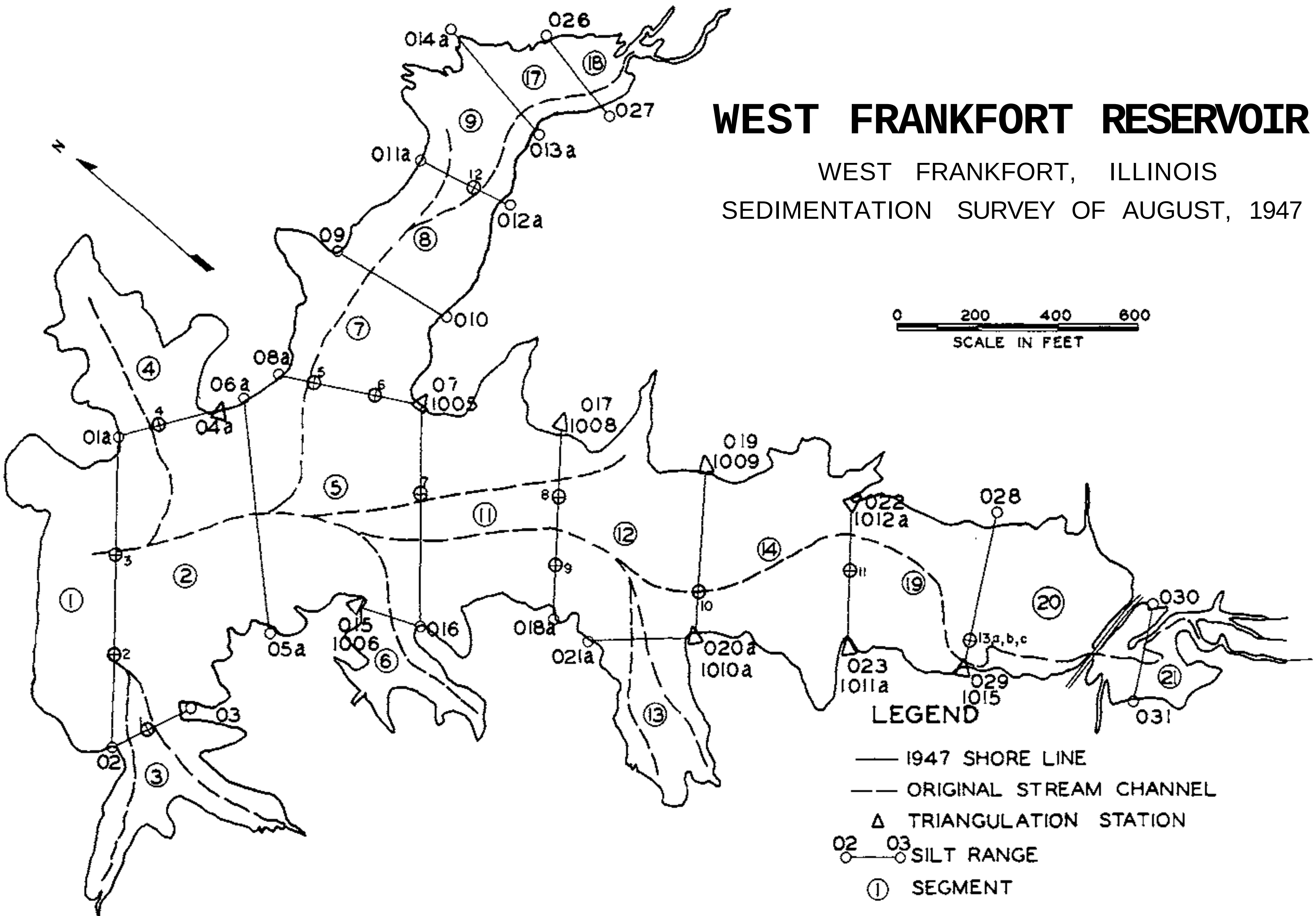
WEST FRANKFORT RESERVOIR
WEST FRANKFORT, ILLINOIS
SEDIMENTATION SURVEY OF AUGUST, 1947
N
0 200 400 600
SCALE IN FEET
LEGEND
1947 SHORE LINE
ORIGINAL STREAM CHANNEL
TRIANGULATION STATION
02 03 SILT RANGE
SEGMENT
SEDIMENT SAMPLE
014a
026
027
013a
011a
012a
09
010
08a
06a
04a
01a
07
1005
017
1008
019
1009
022
1012a
028
030
031
02
03
05a
015
1006
016
018a
021a
020a
1010a
023
1011a
029
1015
13a,b,c

FIG. 5.

and the silt thickness in 1936, these ranges were not respudded but were resounded to locate the 1947 top of the silt. The raise in spillway crest caused the extension of the upper limit of backwater considerably above the uppermost silt range established in 1936. Because of this it was necessary to establish two additional silt ranges on the upper end of the main body of the reservoir and one additional range at the head of the large east arm of the reservoir. On these new ranges the silt thickness was measured with the spud. The entire survey network and reservoir are shown in Figure 5.

FIG. 6. USE OF SOUNDING POLE IN MEASURING SEDIMENT.

Measurement of Silt. The 1947 survey revealed that sediment deposition since the 1936 survey had been relatively small. Because of this, the resounding of the sediment ranges gave a 1947 sediment cross section very little different than the 1936 cross section. It was thus believed desirable to resurvey all cross sections to measure the actual sediment thickness at each point along the cross section. In June-July 1949 such a resurvey was made. At this time the spud was not used entirely but the sediment thickness was measured with a sounding pole as shown in Figure 6.

Along each silt range at intervals of 25 feet the water depth and sediment thickness were measured with a sounding pole. This consists of a 1 1/2-inch diameter calibrated aluminum pole constructed in sections to give a total length of 30 feet. The pole is lowered in the water until it rests on the top of the sediment deposit and the present water depth is measured. The pole is then thrust on down through the soft sediment until it strikes the hard soil of the original reservoir bottom. In this manner sediment thickness is measured. As the boat is rowed across the range a cross section of water depth and sediment thickness is obtained. A total of 366 sediment measurements were made on the 16 ranges on the lake which were resurveyed in 1949.

SEDIMENTATION IN THE RESERVOIR

Summary of Data. Table 1 is a summary of the sedimentation data obtained from the two surveys of West Frankfort Reservoir, together with data derived therefrom which are pertinent to the sedimentation problem. Since the spillway had not been raised at the time of the 1936 survey, the results of that survey have been converted to the 1949 elevation so that the results of the two surveys would be comparable. All results shown in Table 1 are based on the 1949 spillway crest elevation.

It is important to note from Table 1 that the original storage capacity of the reservoir of 1608. 4 acre-feet had been reduced to 1515.0 acre-feet by 1936 and has been further reduced to 1487.8 acre-feet by 1949. This means that during the earlier silting period the reservoir lost a total of 5. 80 per cent of its original capacity to silt. During the later period (since 1936), an additional 1. 69 per cent has been lost. The rate of sediment production and the rate of loss of capacity have thus decreased radically since the 1936 survey.

Compaction of Sediment. The decrease in storage loss during the later period is due in part to exposure of the sediment deposits to air which allows shrinkage. In late years (after 1936) the reservoir has been subject to severe drawdowns, as explained in a later section of this report. The prolonged exposure of the lake bed to air and sunlight allows the sediment deposits to dry out and compact, becoming much more dense. Consequently, they occupy less space in the reservoir. At the location of sediment sample No. 13 (Figure 5) it was possible to procure three samples of the sediment representing the three feet of sediment thickness at this point. The volume-weights of these samples indicated that the lower deposits had compacted to a density of about 90 pounds per cubic foot while the upper layer of more recent sediment had a density of only 73 pounds per cubic foot. These density values were used to calculate for the reservoir the amount of compaction which had taken place. These samples were the only quantitative values available for compaction. The use of the sounding pole revealed the higher density of the lower sediment deposits as did also the use of the spud in 1947 and in 1949 in making periodic checks on the sounding pole in various parts of the reservoir.

On the basis of such data it is shown in Table 1 that a total volume of 93. 3 acre-feet of sediment deposited in the reservoir prior to 1936. By 1949 this had compacted to 75. 7 acre-feet and an additional 44. 8 acre-feet of sediment had entered the

Table 1

Summary of Sedimentation Data
West Frankfort Reservoir, West Frankfort, Illinois

		Quantity	Units
Age:[1]	1926-1936	10.1	Years
	1936-1949	12.8	Years
	1926-1949	22.9	Years
Watershed, total area:[2]		4. 03	Square miles
		2581	Acres
Reservoir			
Area at crest leve l:[3]	1926	182.6	Acres
	1936	182.6	Acres
	1949	182.6	Acres
Storage capacity at crest level:[3]	1926	1608.4	Acre-feet
	1936	1515.0	Acre-feet
	1949	1487.8	Acre-feet
Storage per square mile of drainage area:	1926	399.	Acre-feet
	1936	376.	Acre-feet
	1949	369.	Acre-feet
Sedimentation			
Total sediment accumulation:	1926-1936	93.3	Acre-feet
	1936-1949	44. 8[4]	Acre-feet
	1926-1949	120.5	Acre-feet
Average annual rate of accumulation			
From entire drainage area:	1926-1936	9.26	Acre-feet
	1936-1949	3.49	Acre-feet
	1926-1949	6.02	Acre-feet
Per square mile:[5]	1926-1936	2.45	Acre-feet
	1936-1949	0.93	Acre-feet
	1926-1949	1.61	Acre-feet
Per acre:	1926-1936	168.2	Cubic feet
	1936-1949	63.4	Cubic feet
	1926-1949	109.4	Cubic feet
Tons per acre:[6]	1926-1936	6.12	Tons
	1936-1949	2.32	Tons
	1926-1949	4.00	Tons
Depletion of Storage			
Loss of original capacity per year:	1926-1936	0.58	Per cent
	1936-1949	0.13	Per cent
	1926-1949	0.33	Per cent
Total loss of original capacity:	1926-1936	5.80	Per cent
	1936-1949	1.69	Per cent
	1926-1949	7.45	Per cent

1. Storage began August, 1926. Date of first survey was August 19 to September 12, 1936. Date of second survey was June 28 to July 7, 1949.
2. Including area of lake.
3. Original elevation of spillway crest was 439. 00 m. s. 1. In April 1943 crest was raised to 441. 77 m. s. 1. Survey results are calculated using the latter (present) elevation.
4. Net increase in sediment volume, 1936-1949 was 27.2 acre-feet. In 1949, however, the 93. 3 acre-feet of sediment deposited prior to 1936 had compacted, due to exposure to air, to 75. 7 acre-feet. Thus the actual volume of sediment deposited 1936-1949 was 44. 8 acre-feet.
5. Excluding area of lake.
6. Average specific weight of sediment in 1936: 73 pounds per cubic foot.
Average specific weight of sediment in 1949: 83. 7 pounds per cubic foot.

reservoir, making a total 1949 deposit of 120. 5 acre-feet. The significant values for comparison of the earlier and later sedimentation period show that the annual rate of sediment deposition has decreased from 9. 26 acre-feet to 3. 49 acre-feet. Likewise the annual sediment reaching the reservoir has decreased from an average of 6. 12 tons per acre to 2. 32 tons per acre since 1936.

Distribution of Sediment. Both the 1936 and 1949 surveys indicated a high rate of storage loss at the heads of the two main arms of the reservoir. In 1936 the percentages of storage loss in segments 8, 9, 17, and 18 near the head of the east arm of the lake were two to three times the average for the entire lake of 5. 80 per cent. In segments 12, 13, 14, 19, and 20 losses were nearly twice the average for the lake. The 1949 survey also indicated this tendency. The highest storage losses after 1936 have occurred in segments 17, 18, 19, 20, and 2 1 at the heads of the two arms of the reservoir.

Precipitation. Studies indicate that there is little if any correlation between the mean annual rainfall or number of occurrences of 2-inch, 1-inch and 0. 5-inch precipitation and rate of sedimentation for West Frankfort Reservoir. For the period 1926-1936, the average annual rate of precipitation at West Frankfort was 42. 82 inches. During the latter period, 1936-1949, the average annual rate of precipitation was 40. 91 inches. For the first period considered, an average of 2. 50 days out of the year were accompanied by rainfalls greater than 2 inches as compared to 2. 55 days for the latter period. Rainfalls measuring greater than 1 inch for these two periods occurred on an average of 11.6 and 10. 9 days per year respectively. The average number of days per year in which rainfall was greater than 1/2 inch for the first period was 30. 0 as compared to 27. 0 days for the latter period.

The data show some variation in all cases that would indicate that some of the change in rate of sedimentation might be attributed to slightly higher rainfall rates and intensities of rainfall in the first period. Such a statement would not be completely justified, however, since the variations in rainfall on a 4-square mile area such as the West Frankfort watershed could well be of greater magnitude than the above variations.

HISTORY OF THE WEST FRANKFORT WATER SUPPLY

1913. The city of West Frankfort was incorporated in 1906 and as early as 1913 discussion was being given to the installation of a public water supply. After some investigation of possible ground water and surface water supplies, a contract was let in 1916 for two wells. A series of 25 test holes put down by the well contractor led to the drilling of two wells north of town near the Big Muddy River. This water was highly mineralized and was not completely satisfactory. By 1921 the wells had been dismantled and a concrete channel dam on Big Muddy River had been constructed. This channel reservoir was utilized for about five years until a more satisfactory surface reservoir could be planned and built.

1926. The present West Frankfort Reservoir was completed on Tilley Creek and storage began in August 1926. For more than 10 years this reservoir furnished the complete public supply. During the later 1930's, however, the increasing water consumption began to cause large drawdowns on the reservoir during the summer dry season until in 1941 the reservoir was practically emptied. During the drought it was necessary to lay eight miles of pipeline to Benton to secure water. At this time the spillway crest was raised one foot and in 1943 the crest was raised about two additional feet to its present level. Subsequent to this, drawdowns were not so great.

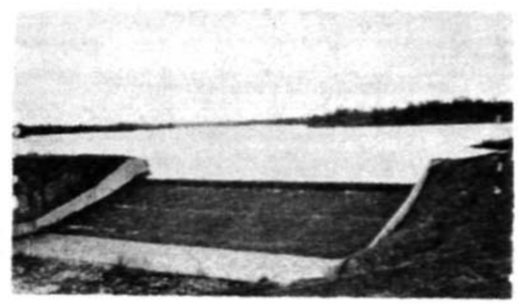

FIG. 7. NEW LAKE WEST FRANKFORT AND SPILLWAY.

1945. In spite of the increased capacity of the old reservoir, additional storage capacity was needed in view of the increasing demand for water. An additional impounding reservoir was planned on Stevens Creek just east of the old reservoir, as shown in Figure 1. The new Lake West Frankfort was completed and put in operation in 1945. The new reservoir has a reported capacity of 495 million gallons (or 1, 514 acre-feet) and has a drainage area of 4800 acres. The lake is shown in Figure 7. At present the old and new reservoirs are used in combination to furnish the supply. The raw water is pumped from the reservoirs to the water treatment plant located in the northeast part of the city.

INCREASE IN WATER CONSUMPTION

General Considerations. The future demand for water in the West Frankfort area is dependent upon many factors such as the presence and possible expansion of water-using industries, the location of new industries in the area, the increase in population, the water rates, the water quality, and the adequacy of the water supply. A city of

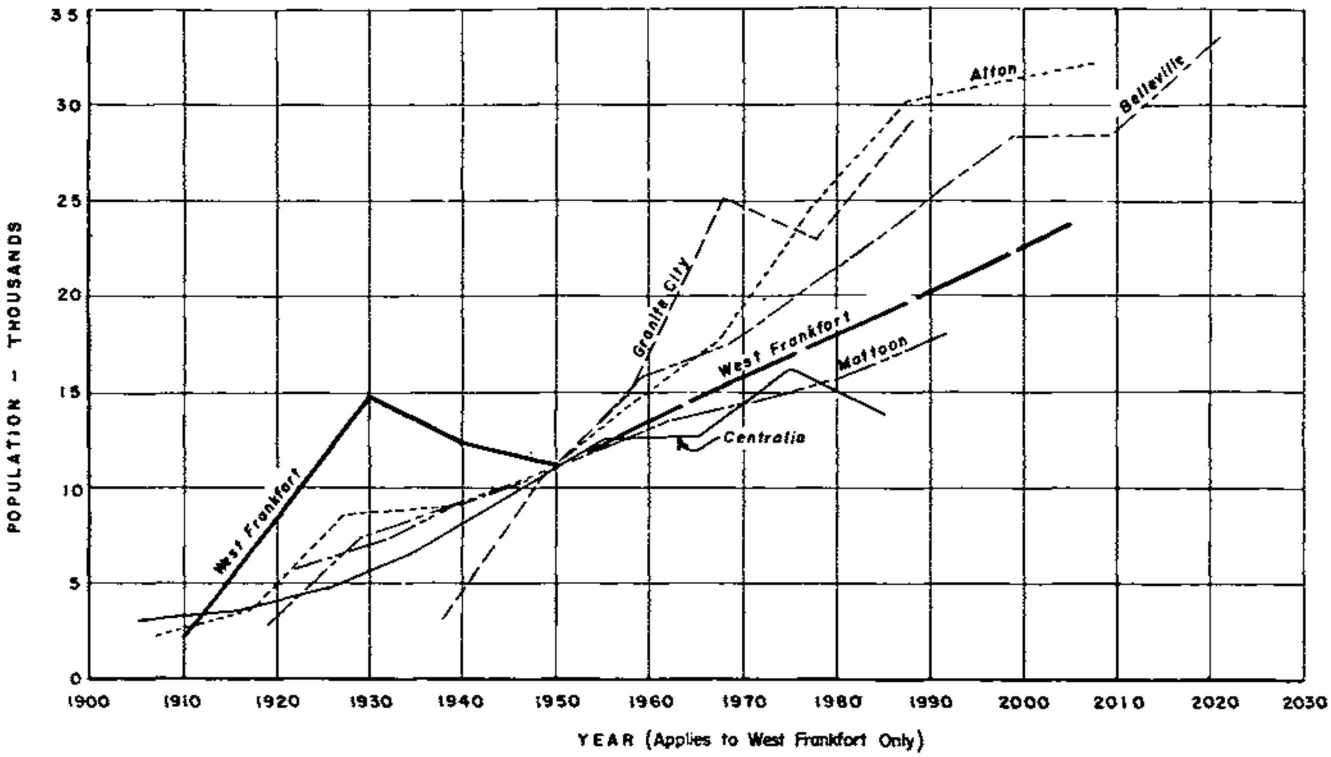

FIG. 8. WEST FRANKFORT POPULATION INCREASE.

limited water supply is a city of limited growth and likewise the early development of the water resources of an area stimulates the economic growth of the area.

Future of Coal Mining Industry. The entire economy of the city of West Frankfort is closely tied to the economic picture of Franklin County as a whole and to the coal mining industry. Future population is thus much affected by the future of coal mining in the area. Franklin County is the largest coal producer in southern Illinois. Coal production rose from 2 million tons in 1908 to 12 million tons in 1920, and remained at this rate until about 1930 when it dropped to about 8 million tons. Later, in 1939, it began a sharp rise to its highest production in history. In 1944, 18 million tons were produced.

The total number of coal mine employees in Franklin County rose steadily from 2 thousand in 1908 to 16 thousand in 1923. Then the trend reversed and by 1940 only about 6, 500 people were employed. By 1946 this had increased again to about 7, 500 (fewer workers than in 1915). The low employment level is due in part to mechanization of the mining industry. This got well under way in the late '20's and led to much greater production of coal per man-day.

A recent economic study of the area by the Executive Committee on Southern Illinois stated, "It appears that the Illinois coal industry has experienced its greatest change due to mechanization, but another cycle appears to be in the making, the effects of which cannot be predicted; that the market for coal will be less affected in the immediate future by further progress in efficient utilization than in the past; that the competition of petroleum products will increase somewhat in railroad fuel and decrease in domestic heating and in manufacturing; and that some new markets for Illinois coal are developing."[4] It is estimated that the Franklin County coal reserve has been depleted by only 26 per cent up to the present.

For the stability of the economy of the area new industrial expansion must be realized. This is necessary to raise the general income level and to eliminate chronic unemployment. West Frankfort, among other cities of the area, has made recent efforts to attract new manufacturing plants to aid in diversifying employment in the area. With its favorable attributes, including labor supply, transportation services, power supply and water supply the prospects are considered good for such industrial expansion.

Population Trend. The expected future population rise of West Frankfort is shown in Figure 8. Although the population has decreased over the last two decades, it is believed that future planning for water supply needs should be on the basis of a population increase in future years. This estimate anticipates a steady (though not sharp) rise in mining activities in the area, and the loca-

4. "Southern Illinois," University of Illinois Press, Urbana, 1949.

tion of new water-using industries in the area. The population growth shown in Figure 8 is based on past population trends in other cities in the state. The graph shows West Frankfort's future compared to past growth of the cities of Granite City, Alton, Bellville, Mattoon and Centralia. Of these, Centralia best represents the growth of a city under the major influence of the mining industry. The other cities shown are more diversified and the West Frankfort estimate is based on all the curves shown.

Water Consumption per Capita. The total municipal pumpage in any particular year divided by the population gives the rate of water consumption per capita. Factors affecting per capita consumption are the same as those affecting the total water demand. In the past, repeated studies have been made correlating the per capita consumption and the total population. A recent study in Illinois[5] has shown that the population of a community is not necessarily correlated with the per capita consumption. As the population increases the per capita consumption does not always increase. The per capita consumption is most closely correlated with the net effective family buying income of the area. If the economic development of the area increases this average purchasing power, then the per capita water consumption can be expected to increase, otherwise not.

Table 2 shows the variations in consumption per capita at West Frankfort in past years. This has varied from a low of 29. 0 gallons per person per day in 1935 to 100.5 in 1950. For estimating future demands a value of 115 was used. The estimates of future population from the graph in Figure 8 multiplied by the average daily consumption of 115 gallons gives the average annual pumpage to be expected in future years. Calculated in this manner, the total municipal pumpage may reach 1. 55 million gallons per day by I960 and 2. 60 million gallons per day by the year 2000.

The city water treatment plant is shown in Figure 9.

FIG. 9. WEST FRANKFORT WATER TREATMENT PLANT.

Table 2

Water Consumption Per Capita at West Frankfort

Year	Gallons per Day per Capita
1926	42.0
1930	38.0
1935	29.0
1940	43.8
1945	66.2
1950	100.5

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' needs. 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 large enough to 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. Continuous water level measurements are available at West Frankfort Reservoir from 1935 to date.[6] Only intermittent records are available prior to 1935. The water-level fluctuations are shown graphically in Figure 10. During the 14-year period for which accurate levels are available, the largest drawdown occurred in June 1941 when the lake was dry, and as previously mentioned, water was pumped from Benton. The second largest drawdown occurred in February

5. Larson, B. O. , and Hudson, H. E. . Jr. , "Residential Water Use and Family Income." Journal American Waterworks Assn. , August, 1951, Vol. 43, No. 8.

6. Roberts, W. J. , "Hydrology of Five Illinois Water Supply Reservoirs," Bulletin No. 38, State Water Survey Division, Urbana, Illinois. 1948.

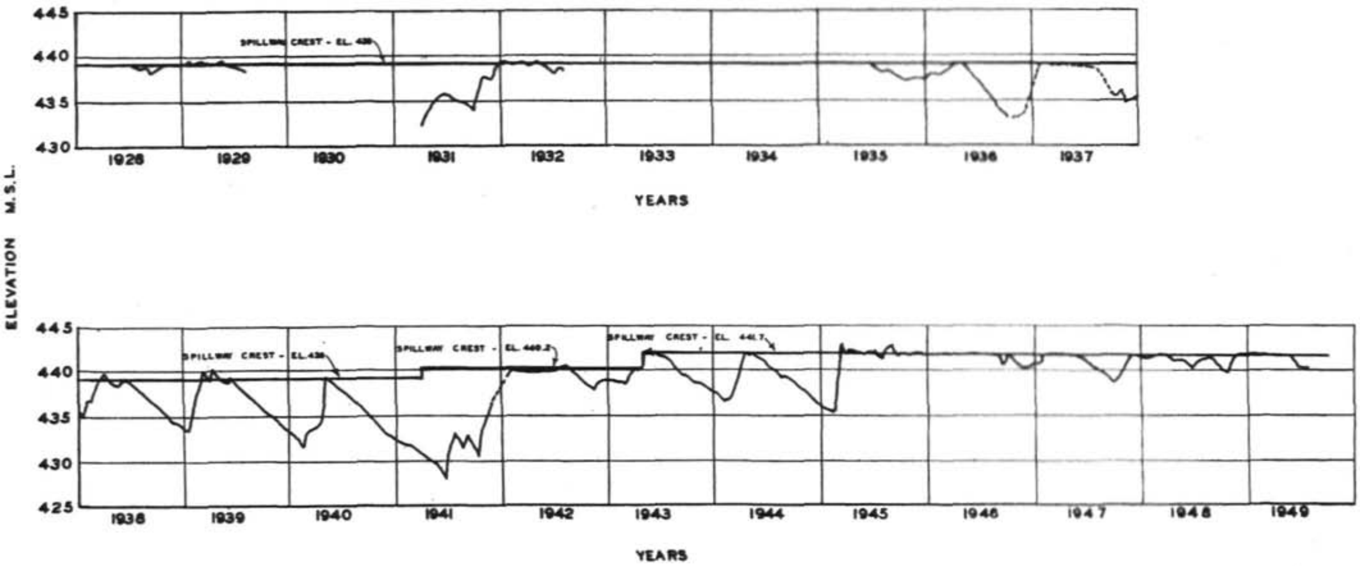

FIG. 10. WEST FRANKFORT RESERVOIR WATER LEVEL FLUCTUATIONS.

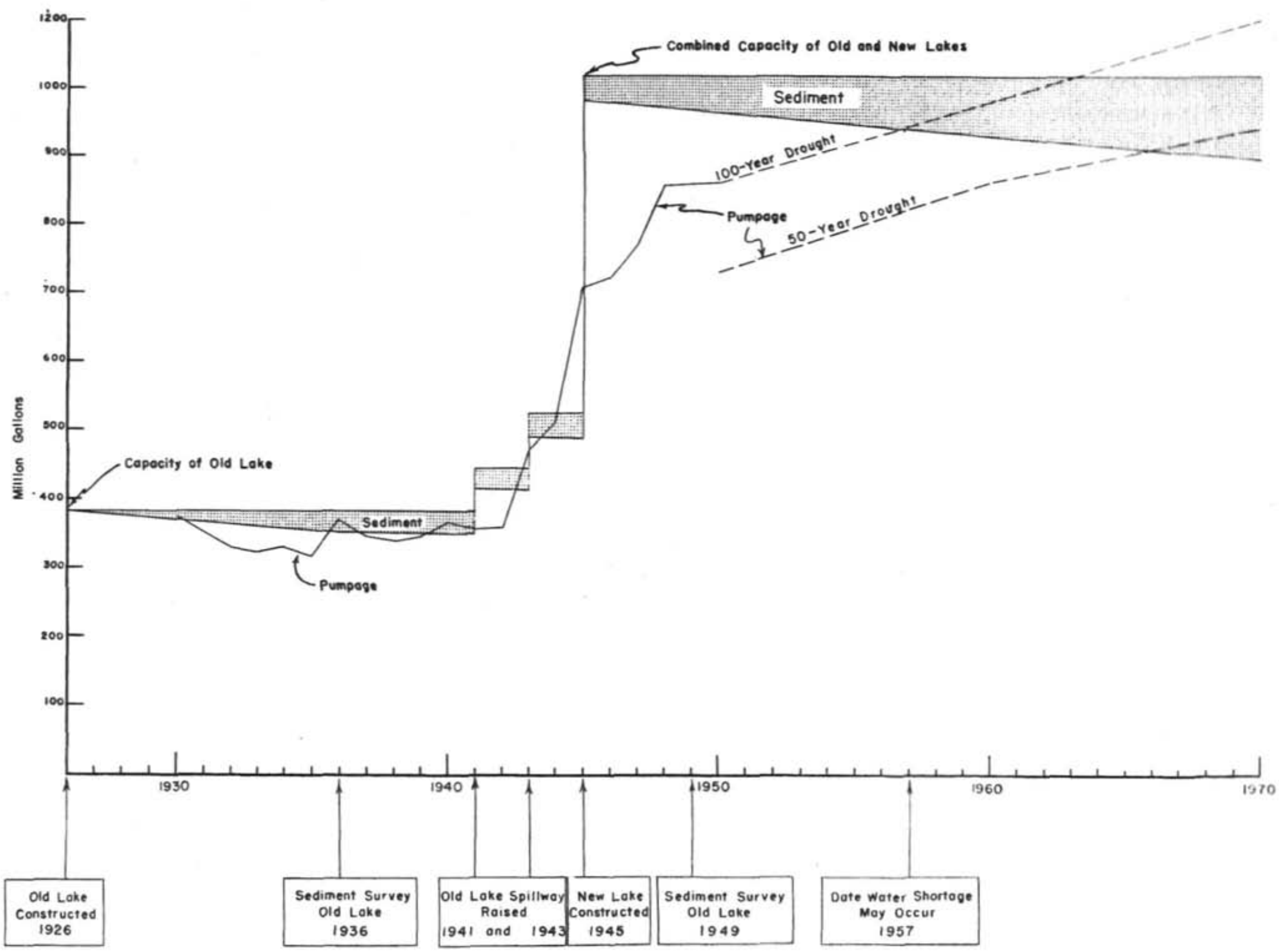

FIG. 11. REMAINING USEFUL LIFE OF WEST FRANKFORT LAKES.

1940 when the water level receded 8.0 feet below crest. From early in 1945 to the latter part of 1946 there was a period of 19 months in which there was no drawdown greater than one foot. During this period, however, the precipitation was approximately 33 per cent greater than the average for that section of Illinois.

Remaining Useful Life of the Reservoir. The storage capacity of West Frankfort Reservoir is now being reduced by 0.33 per cent per year. While this is a relatively low rate of depletion, increasing demand and decreasing storage volume could only result in another serious water shortage at some future date if the city were entirely dependent on this reservoir. The completion of the new Lake West Frankfort has decreased the possibility of such a city water shortage, however. The total supply of water available to the city is limited at present only by the total storage capacity of the old and new lakes combined.

The 1941 water shortage., which completely drained the old reservoir, emphasized the fact that the reservoir was inadequate in size to furnish the city's needs. Thus its "useful life" or the period for which it could be depended upon as the only source of water, terminated in 1941. The "ultimate life" of the reservoir, however, is much longer and will not be terminated until the reservoir is completely filled with sediment or until, for other reasons, the lake can no longer be used.

A future water shortage will occur only during a dry period of such severity that the minimum inflow to both reservoirs is insufficient to furnish the entire pumpage for the city during a period of critical usage. In Figure 11 is shown graphically the remaining useful life of the combined lakes at West Frankfort. The uppermost line on the graph shows that when the old lake was constructed in 1926 it had a capacity of 383 million gallons; this was increased in 1941 and again in 1943 when the spillway was raised. During this period the lake was collecting sediment as shown in the graph, so that the capacity available for storage was decreasing. In 1945 the new lake was put into operation, greatly increasing the storage volume available for use, as shown. Immediately upon construction, however, this lake also began collecting sediment. No measurements of sediment have been made in the new lake, but the present rate of sediment accumulation has been estimated from that measured in the old lake. Table 1 of this report shows that present rate of sediment production from the watershed of the old lake was 0.93 acre-feet per square mile per year. This value was used to estimate the present and expected future deposition in both the old and new lakes. This assumes that the two adjoining drainage areas have similar soil losses, which is believed to be a reasonable assumption in the absence of more reliable data. Figure 11 shows graphically the total combined capacity of the old and new lakes and the rate at which sediment is collecting in the lakes as well as the expected future deposition to the year 1970. In 1970, about 899 million gallons of storage will be available in the two lakes.

The demand on the lakes is also shown in Figure 11, including pumpage and evaporation. The volume of water evaporated in any one year cannot be overcome and must be taken into account. In addition to evaporation, the lakes must furnish the city pumpage, which is on the increase. The 12 months' pumpage in past and future years is plotted in Figure 11. This shows that in years prior to 1945 the pumpage was practically equal to the storage available during a drought and in some cases more.

The entire Figure 11 is based upon a drought of such severity as to furnish practically zero inflow to the reservoirs for a 12-month period. In such a case, the city would have to pump from the lakes for an entire 12-month period without any inflow to the lakes. The occurrence of such a drought is estimated to take place one time per 100 years. This drought period was selected for analysis since modern water-supply planning suggests that an adequate supply be provided against such a drought.

The drought of 1941 was sufficient to cause a water shortage since the new lake was not completed at that time. With the completion of the new lake, pumpage increased greatly, and it would seem that water consumption in earlier years was somewhat restricted due to the inadequate supply. This trend substantiates the belief that an increased source of water leads to greater use of water.

No water shortage or near shortage has occurred in the years 1945 to date, and as shown in Figure 11, no shortage would have occurred even if a severe drought had occurred since the available storage capacity was greater than the total demand on the lakes. In some future year, however, with pumpage increasing and available storage capacity in the lakes decreasing, a shortage can be expected. This is shown also in Figure 11. In the year 1957 the total demand will reach 940 million gallons, at which time the reservoirs will have 940 million gallons of storage space available. If a "100 year" drought should occur in 1957, both reservoirs would be empty at the end of the drought. In subsequent years the reservoirs would not have available the needed storage space and a water shortage would occur. For example, in the year 1962, pumpage would demand about 1.01 billion gallons and the lakes could furnish only 0.925 billion gallons. It can be concluded that in any year after 1957 a water shortage can be expected in event of a 100 year drought.

Also shown in Figure 11 is the performance of the reservoirs in the event of a "50 year" drought. Such a drought would cause zero inflow to the lakes for a 9-month period. For such a case the present reservoirs will be adequate until the year 1966.

Chemical and Physical Data. The sediments being deposited in the reservoir show considerable variation in their physical and chemical characteristics. The chemical and physical data are presented in Tables 3 and 4. Locations of samples are shown in Figure 5. Texturally, the sediments appear fairly uniform, and little sorting action by water is indicated. Chemically, the sediments are quite variable, but these variations do not appear to be related to, or characteristic of, the relative location of the samples within the reservoir. Both total carbon and total nitrogen vary by more than 100 per cent, yet these variations cannot be explained on the basis of the location of the sample within the reservoir or the source of the sediment. In general, the carbon values are high, indicating a concentration of the finer sediments before the reservoir is reached. The variability of the carbon-nitrogen ratio of the various samples is suggestive of organic debris, such as leaves, mixed in with the sediments.

Soil samples taken within the watershed area are not available for direct comparison with the reservoir sediments. However, the nature of the sediment indicates that the major source of sediment is probably due to sheet erosion within the watershed. There is also some indication, through the lower nitrogen and carbon values obtained in 1947, that most of the sediment now entering the reservoir comes from erosion of the subsoil. This is the type of sediment which one would expect from the "moderately severe" and the "severe" classes of erosion. (See Figure 16.)

Again it must be emphasized that the sediments appear to be very heterogeneous and that they fail to conform to the usual distribution patterns found in most lakes and reservoirs.

Table 3

Chemical Data - West Frankfort Reservoir Sediment

		1936		1947					
Sample No.	Range	Total N (%)	Total C (%)	Total N (%)	Total C (%)	Vol. Wt. (apparent)	Available K (lb. /acre)	Available P (lb./acre)	pH
1	02-03	0.145	1.79	0.093	0.98		300+	77	4.81
2	01-02	0.124	1.12	0.077	0.87		292	79	4.60
3	02-01	0.106	0.97	0.071	0.81	1.17	300+	59	5.65
4	01-04	0.179	1.68	0.091	1.10	0.99	208	61	4.50
5	08-07	0.208	0.61	0.090	0.99	1.08	300+	75	5.18
6	08-07	0.116	1.22	0.059	0.65		192	67	4.66
7	017-016	0.207	2.23	0.075	0.83	1.10	300+	71	5.44
8	018-017	0.156	1.51	0.078	0.78	1.16	300+	83	5.10
9	018-017	0.092	1.00	0.063	0.77		260	51	5.60
10	019-020	0.146	1.38	0.131	1.25	1.03	300+	79	5.62
11	022-023	0.105	1.02	0.078	0.75	1.19	300+	73	5.48
12	011-012	0.099	1.13	0.155	1.05	1.22	300+	65	5.15
13a	028-029			0.075	0.75	1.19	300+	65	5.22
13b	028-029			0.047	0.51	1.38	101	17	6.20
13c	028-029			0.069	0.78	1.42	68	79	6.78

Table 4

Physical Data - West Frankfort Reservoir Sediment

Sample No.	Base Capacity (m. e. /100 gm.)	Total Bases (m. e. /100 gm.)	Sand (%)	Silt (%)	Clay (%)
7	15.5	6.6	3.9	78.2	16.8
11	12.0	6.9	1.5	76.7	21.4

WATERSHED

INTRODUCTION

The rate and amount of siltation in a reservoir may be affected by a number of reservoir, climatic and watershed factors. The major factors are the age and size of the reservoir, the size of the drainage area, the general topography, the length and steepness of the slopes, the kind of soil, rainfall characteristics, and the land use pattern. These factors vary in importance from one watershed to another, and from one year to the next, and must be carefully evaluated at each site. Some of these factors can be corrected to reduce siltation in the reservoir whereas others are permanent physical conditions.

The source of sediment must be determined if an effective sediment control program for the reservoir is to be established. As a part of this study, the Soil Conservation Service made a detailed soil conservation survey map of the entire West Frankfort reservoir watershed, as well as a special study of the farming conditions. The conservation survey consisted of identifying and recording on 4-inch aerial photographs the kinds of soil, steepness of slope, kinds and degree of erosion, and present land use. In addition to this physical information, the mapping of channel erosion and deposition was also recorded. Standard soil conservation survey procedures were followed in the preparation of the field maps.

PHYSIOGRAPHY

West Frankfort Reservoir is located almost entirely in Franklin County, Illinois. The drainage area is 2, 398 acres in size and is located in the Tilley Creek watershed five miles southeast of West Frankfort. Although most of the reservoir watershed lies in Cave township, a small acreage occurs in Franklin township and in Williamson County.

The topography in this watershed is quite rolling with narrow ridge tops occupying the area between the drainageways. The general land formation consists of weathered Illinoian till plain with a thin covering of loess. The loess mantle is usually 30 inches or less in thickness.

SOIL GROUPS

Three main groups of soil occur in the watershed: the Ava silt loam soil group, the Bluford-Blair silt-loam soil group, and the Belknap silt loam group. The acreages and percentages of

Table 5

Acreages and Percentages of Various Soil Groups
in West Frankfort Reservoir Watershed

Soil Group	Area	
	Acres	Per cent
Upland Soils		
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam group	1682	70.2
2. Light-colored, medium-textured, very slowly permeable, imperfectly drained soils. Bluford-Blair silt loam group[1]	455	19.0
Bottomland Soils		
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam group[2]	261	10.8
Total Watershed	2398	100.0

1. Four acres of Wynoose included with Bluford group.
2. Sixteen per cent of this group is Sharon silt loam soil group.

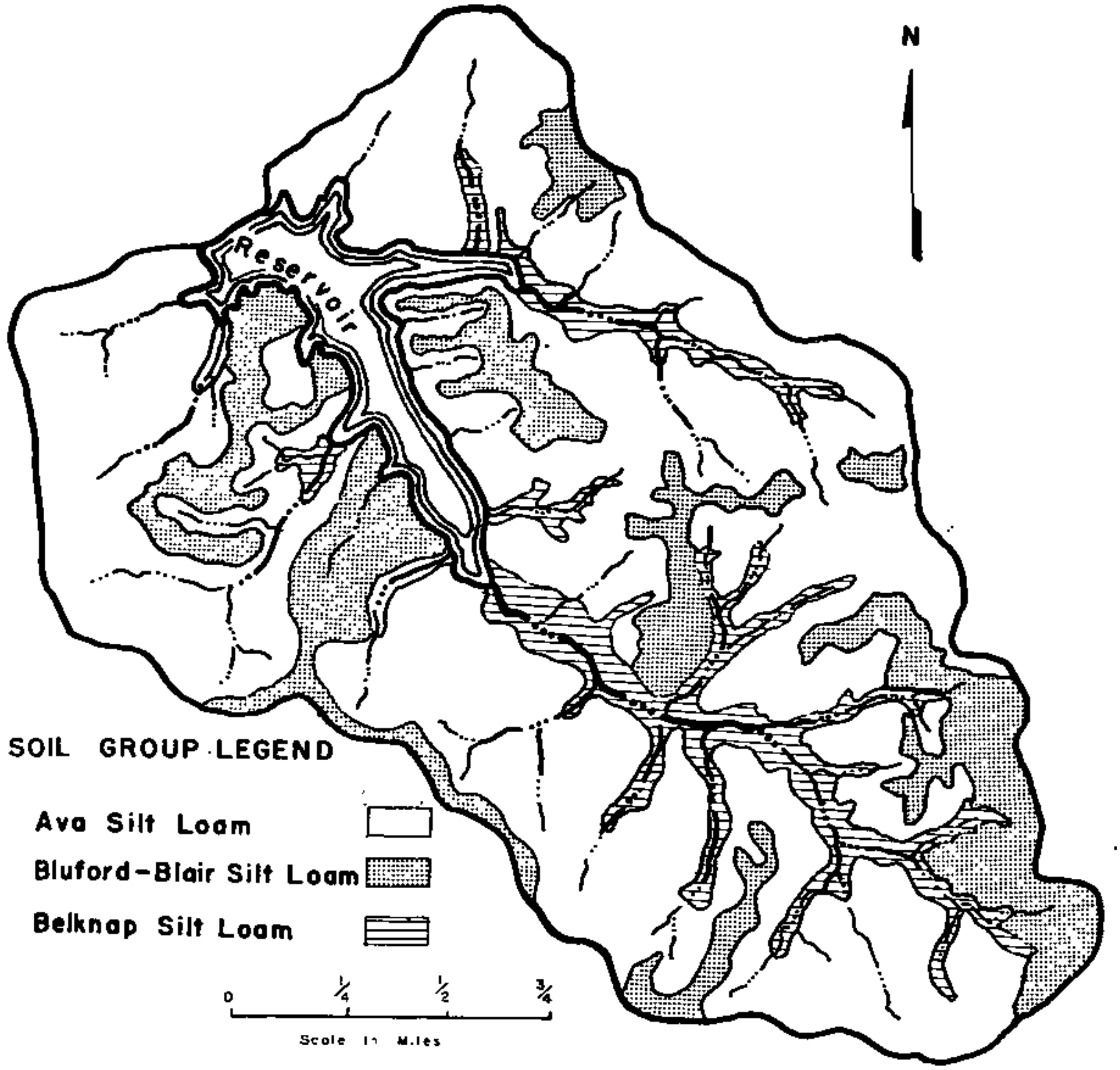

FIG. 12. GENERALIZED SOILS MAP OF WATERSHED.

the various soil groups in the watershed may be found in Table 5. Figure 12 shows the general location of these three main soil groups.

The Ava silt loam group consists of soils that have light colored, medium textured surface soils. The upper portion of the soil to a depth of 18 to 25 inches is a bright yellow brown in color. This upper material is high in silt content and moderately slow in permeability. The soil immediately below this silt cap is highly mottled with gray and is relatively high in clay content. This mottled layer usually is derived from leached Illinoian drift and is slow to very slow in permeability. The Ava silt loam group occurs on sloping land and the major problem in farming this soil is to control erosion and to supply the necessary plant nutrients. These soils are moderately productive if they are treated according to soil tests and protected from excessive erosion. They are especially well adapted to the growth of grasses and legumes.

The Bluford-Blair silt loam group is comprised of soils that are light in color and a medium texture in the surface soil. They differ from the Ava soil group largely in that they are not well drained and the mottled layer occurs immediately below the surface. In general these soils occur on less rolling topography. In some instances the problem in farming the land may be a wetness factor; however, the dominant problem is erosion. Very small areas of level claypan soils may be found on several of the more level ridge tops. The Bluford-Blair soils are moderately productive when they are treated according to soil tests, protected from erosion and excess water removed from the level areas. For greatest production these soils should be in grasses and legumen at least one-half of the time.

The Belknap silt loam group is a light colored, medium textured, imperfectly drained soil. There soils are often wet and subject to overflow. They

Table 6

Distribution of Soil Groups in Each Slope Class
West Frankfort Reservoir Watershed

Soil Group	A Slopes (0 - 1-1/2%) Acres	Pct.	B Slopes (1-1/2 - 4%) Acres	Pct.	C Slopes (4- 7%) Acres	Pct.	D Slopes (7 - 12%) Acres	Pet.	E Slopes (12 - 18%) Acres	Pct.	F Slopes (18- 30%) Acres	Pet.	G Slopes (over 30%) Acres	Pct.
Upland Soils														
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam group	---	----	175	30.0	506	72.4	837	96.8	161	100.0	2	100.0	2	100.0
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soils. Bluford-Blair silt loam group	4	4. 7	230	39.4	192	27.6	28	3.2	---	----	---	----	---	----
Bottomland Soils														
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam group	82	95.3	179	30.6	---	----	---	----	---	----	---	----	---	----
Total	86	100. 0	584	100. 0	698	100.0	865	100. 0	161	100.0	2	100. 0	2	100.0
Percent of Total Watershed		3. 5		24.4		29.2		36. 1		6.8				

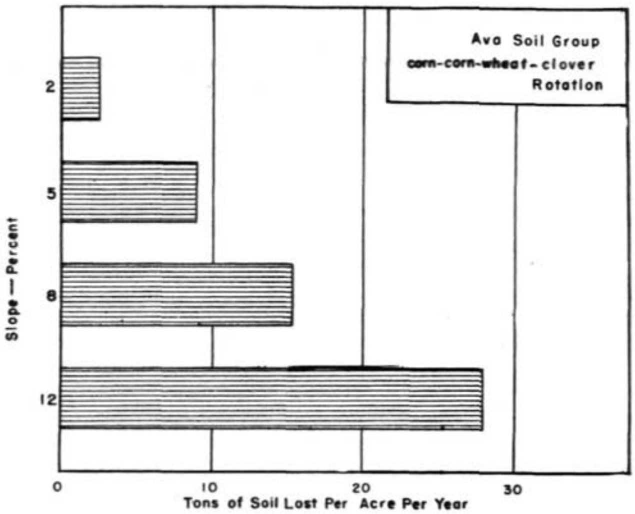

FIG. 13. EFFECT OF SLOPE ON EROSION. (BASED ON SLOPE AND PRACTICE DATA.)

are moderately productive after the wetness and overflow factors have been overcome. Some of these soils near the reservoir have a permanent high water table. They are best suited to pasture-land or woodland. Likewise, some of these soils occur in small upland drainageways that are not practical to farm. They too are best suited to pasture or woods.

SLOPES

The results of studies at many Soil Conservation Erosion Experiment Stations' definitely show that steepness of slope is one of the more important factors influencing soil losses. In general, each time the steepness of slope is doubled the soil loss increases two and one-half times. Figure 13 shows this relationship. It can generally be assumed that there is a close relationship between the amount of soil lost from the watershed and that deposited in the reservoir. The slopes in West Frankfort watershed range from level to steep. The steepest slopes occur adjacent to the drainageways. Table 6 indicates that 3. 5 per cent of the watershed is level, 24. 4 per cent ranges from 1 1/2 to 4 per cent slopes, 65. 3 per cent ranges from 4 to 12 per cent, and 6. 8 per cent of the watershed is more than a 12 per cent slope. Ninety-five per cent of the level land in the watershed occurs along the drainageways. Ninety-seven per cent of the slopes over 7 per cent belong to the Ava silt loam soil group, whereas practically all of the Bluford-Blair soil group occurs on slopes less than 7 per cent.

7. Van Doren, C. A. & Card, L. E., "Protecting Your Soil," Circular 667 (1950), and Hays, O. E., & Clark, Noble, "Cropping Systems That Help Control Erosion," Bulletin No. 452 (1941). University of Illinois in cooperation with Soil Conservation Service, Urbana, 111.

PRESENT LAND USE

Land use is another very important factor affecting soil loss and sediment production in lakes and reservoirs. Fields in cultivation may produce one hundred times more soil loss than the same land with good grass cover or woods. Five different kinds of land use were classified in the soil conservation survey. Cropland is all land on which crops were grown at the time of the survey. This includes such crops as corn, beans, small grains and rotation hay. Pasture land is land in perennial grasses, and woodland is land on which the tree canopy covers at least 40 per cent of the area. Miscellaneous land consists of land used for farmsteads, roads, etc., and idle land refers to those areas not used for cultivation or any purpose that would furnish an economic return. The idle land in West Frankfort watershed is land that has been in cultivation and is now grown up in broom sedge and briars as viewed in Figure 14.

Table 7 presents the distribution of soil groups in each land use class. Of the 1,682 acres in the Ava silt loam group, 545 acres are in cropland and 664 acres in idle land. Likewise, of the 455 acres in the Bluford-Blair silt loam group, 209 acres are in cultivation and 160 acres in idle land. On the bottomland soil totaling 261 acres, 154 acres are in cropland and 55 acres are idle land. Of the entire watershed 37. 9 per cent is in cropland, 36. 7 per cent in idle land, 14. 5 per cent in pasture, 10. 4 per cent in woodland and 0. 5 per cent in miscellaneous land use.

Cropland in the watershed ranges from level land up to 18 per cent slope. Twenty-six and seven-tenths per cent of it occurs on slopes over 7 per cent (Table 8). In contrast, fifty-two per cent of the idle land occurs on land with slopes of less than 7 per cent.

Present land use and land capability in West Frankfort watershed are shown in Table 9. The three general categories divide the land into areas suitable for regular cropping, those suited

FIG. 14. IDLE LAND IN THE WATERSHED. NOTE BRIARS AND BROOM SEDGE.

for limited cropping, and those suited for permanent vegetation. The six specific classes break these three general categories into classes of land according to the hazards involved in using the land. This table shows that approximately 42 per cent of the watershed is suitable for continuous cultivation, 17 per cent suitable for limited cultivation and 41 per cent is best suited to pasture or woods. Although only 42 per cent of the watershed is suitable for continuous cultivation, approximately 75 per cent of the watershed has been under cultivation at one time or another.

Table 9 also shows that 23. 8 per cent of the land being farmed is not suitable for cultivation. This land is best suited for permanent pasture or woods (see Figure 15). When class VI and VII land is farmed, the result is excessive erosion from the fields and more silt becomes available for deposition in the reservoir.

Table 9 also indicates that 44. 5 per cent of the idle land in the watershed is the type of land that is suitable for continuous cultivation and 14. 8 per cent is suitable for limited cultivation. If the land surface is entirely covered with broom

Table 7

Distribution of Soil Groups in Each Land Use Class
West Frankfort Reservoir Watershed

Soil Group	Cropland		Idle Land		Pasture		Woodland		Miscellaneous		Total
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres
Upland Soil											
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam group . . .	545	60.0	664	75.5	273	78.6	193	76.8	7	53.8	1682
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soils. Bluford-Blair silt loam group	209	23.0	160	18.2	31	9.0	50	20.0	5	38.5	455
Bottomland Soil											
3. Light-colored, moderately slow permeability, imperfectly drained soils. Belknap silt loam group .	154	17.0	55	6.3	43	12.4	8	3.2	1	7.7	261
Total	908	100.0	879	100.0	347	100.0	251	100.0	13	100.0	2398
Percent of Watershed .		37.9		36.7		14. 5		10.4		0.5	100.0

Table 8

Distribution of Slope Classes in Each Land Use Class
West Frankfort Reservoir Watershed

Slope Class	Cropland		Idle Land		Pasture		Woodland		Miscellaneous		Total	
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.
A (0 - 1-1/2 per cent)	75	8.3	7	0.8	---	----	4	1.6	---	----	86	3.6
B (1-1/2 - 4 per cent)	285	31.4	194	22. 1	69	19.9	32	12.8	4	30.8	584	24.3
C (4 - 7 per cent)	305	33.6	257	29.2	80	23.0	53	21. 1	3	23. 1	698	29.1
D (7 - 12 per cent)	228	25. 1	372	42.3	161	46.4	98	39.0	6	46. 1	865	36. 1
E (12 - 18 per cent)	15	1.6	47	5.4	35	10. 1	64	25.5	---	----	161	6.7
F (18 - 30 per cent)	---	----	---	---	2	0.6	---	----	---	----	2	0. 1
G (over 30 per cent)	---	----	2	0.2	---	----	---	----	---	----	2	0. 1
Total	908	100.0	879	100.0	347	100.0	251	100.0	13	100.0	2398	100.0

Table 9

Land Use Capability as Compared with Existing Land Use at Time of Survey
West Frankfort Reservoir Watershed

Land Use Capability Classes	Cropland		Idle Land		Pasture		Woodland		Miscellaneous		Entire Watershed	
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pet.	Acres	Pet.	Acres	Pct.
Land Suited for Regular Cultivation												
Class I Land												
Suitable for cultivation, requiring no erosion control practices to maintain soil for general agricultural practices	18	2.0	---	----	3	0.9	---	----	---	----	21	0.9
Class II Land												
Good land that can be cultivated safely with easily applied practices	202	22.2	122	13.9	30	8.6	12	4.8	---	----	366	15.3*
Class III Land												
Moderately good land that can be cultivated safely with such intensive treatments as terracing and strip-cropping	321	35.4	269	30.6	72	20.7	53	21.1	5	38.5	720	30.0
Land Suited for Limited Cultivation												
Class IV Land												
Best suited to hay or pasture, but can be cultivated occasionally, usually not more than 1 year in 6	151	16.6	130	14.8	47	13.6	81	32.3	2	15.4	411	17.1
Land Suited Only for Permanent Vegetation												
Class VI Land												
Not recommended for cultivation. Best suited for permanent pasture	206	22.7	324	36.8	156	45.0	99	39.4	6	46.1	791	33.0
Class VII Land												
Not recommended for cultivation. Suited for woodland or pasture with major restrictions in use	10	1.1	34	3.9	39	11.2	6	2.4	---	----	89	3.7
Entire Watershed	908	100.0	879	100.0	347	100.0	251	100.0	13	100.0	2398	100.0

*Approximately one-fourth of the Class II land occurs in narrow bottoms which are too small to farm and in areas adjacent to the reservoir that cannot be drained satisfactorily. These areas are best suited to pasture land.

sedge and weeds, idle land does not present a problem from an erosion or siltation standpoint. Cropping the idle land best suited for cultivation is very important from an economic and proper land-use adjustment viewpoint.

The land-use history of Cave township, in which most of the watershed lies, is shown in Table 10. Similar information for Franklin County may be found in Table 11.

In Cave township the per cent of farm tillable increased from 75 per cent in 1938 to 96 per cent in 1946, whereas in Franklin County the per cent of farm tillable decreased from 79 per cent in 1939 to 73 per cent in 1946. A ten-year average (1938-1947) in Cave township indicates that 21 per cent of the cropland was in corn and beans, 6 per cent in small grains, 44 per cent in hay and pasture and 29 per cent miscellaneous and idle land. Analysis of the census data does not indicate that in the township as a whole the land has been cropped too heavily to clean-tilled crops or small grain. The major land-use adjustment does not appear to be one of reducing acreages of crop land or percentage of clean-tilled crops for the watershed but one of using land for cultivation that is suitable for cultivation and using land best adapted to pasture for pasture. This deduction of course would not be true on specific fields on some farms in the watershed. Proper soil treatment according to soil tests is essential for the establishment of proper land use in the watershed.

EROSION

Both sheet and gully erosion occur in the watershed. In developing a watershed treatment program for protection of a reservoir it is necessary to know where the sediment is coming from and how much of it is actually being deposited in the reservoir.

Erosion was determined by measuring the depth of topsoil and comparing it to an uneroded or virgin area under a similar land condition. The following erosion groups were mapped:

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

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

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

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

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

Erosion by sheet wash and by channel flow were mapped separately in the soil conservation survey. It is estimated from the results of the survey that over 90 per cent of the eroded material comes from sheet erosion. A program to reduce

Table 10

Land Use, Cave Township, Franklin County, Illinois. 1938-1947[a]

Items	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947[b]	Ten-year Average
Acres per farm	74	70	73	68	69	73	73	74	79	--	73
Per cent of farm tillable	75	74	74	78	84	93	93	95	96	--	85
Per cent tillable land in:											
Corn	16	14	14	17	13	12	12	7	13	13	13
Soybeans	6	8	9	11	8	10	6	6	7	8	8
Small grains	9	9	6	11	7	5	6	5	4	2	6
Hay and pasture	38	38	35	34	43	51	49	49	50	53	44
Other and idle	31	31	36	27	29	22	27	33	26	24	29

[a] Based on assessor's acreage census.
[b] Preliminary data.

Table 11

Land Use, Franklin County, Illinois. 1938-1947[a]

Items	1938	1939	1.940	1941	1942	1943	1944	1945	1946	1947[b]	Ten-year Average
Acres per farm	..	77	77	80	76	77	79	79	84	- -	79
Per cent of farm tillable	--	79	77	74	79	80	74	72	73	--	76
Per cent tillable land in:											
Corn	18	18	19	18	18	15	17	9	16	15	16
Soybeans and cowpeas	8	9	11	11	10	10	8	8	8	10	9
Small grains	14	14	12	15	13	13	16	14	14	12	13
Hay and pasture	36	37	36	35	37	36	34	38	38	41	37
Other and idle	24	22	22	21	22	26	25	31	24	22	24

[a] Basedonassessor'sacreagecensus.
[b] Preliminary data.

FIG. 1 5. APPROXIMATELY ONE-FOURTH OF THE LAND NOW BEING FARMED SHOULD BE IN PASTURE OR WOODS.

siltation in the reservoir would necessarily require conservation measures and practices that would greatly reduce sheet erosion in the watershed Figure 16 indicates the amount of the various erosion classes in the watershed. The high percentage of the watershed classified as severe erosion indicates the amount of soil that has been washed from the fields. It is very difficult to determine how much of this soil was lost prior to the building of the reservoir and the amount lost after the reservoir was built. The fact that 47 per cent of the watershed is severely or very severely eroded presents a very definite land use and management problem.

Ninety-two per cent of the land in the watershed having no apparent erosion was classified as the Belknap silt loam group, whereas 89 per cent of the severely eroded land and 100 per cent of the very severely eroded land was classified as the Ava silt loam soil group (Table 12). A major portion of the Bluford-Blair soil group was mapped as slight to moderately severe erosion.

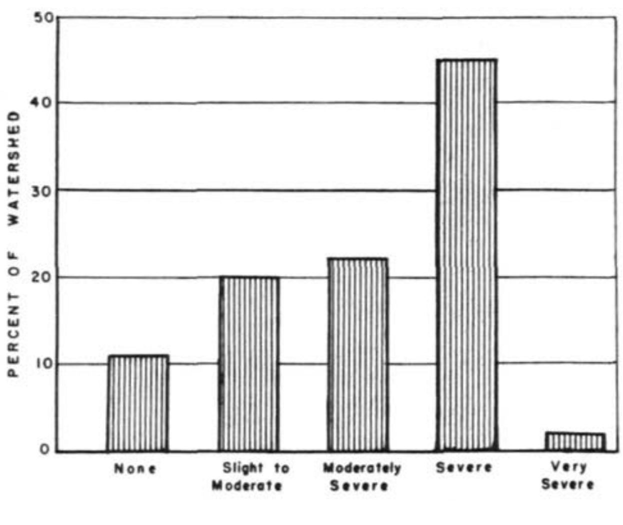

FIG. 16. DISTRIBUTION OF EROSION CLASSES IN WEST FRANKFORT RESERVOIR WATERSHED (LEGEND PAGE 20).

FIG. 17. SLOPING LAND IN REGULAR CULTIVATION REQUIRES CONSERVATION TO REDUCE EROSION.

It can be generally concluded from Table 13 that the steeper the slope the greater the erosion. Practically all of the no apparent erosion and slight erosion occurred on slopes less than 4 per cent. Most of the moderately severe erosion occurred on slopes of from 4 to 7 per cent and the severe and very severe erosion was found on slopes of 7 to 12 per cent.

Table 14 shows that 54. 5 per cent of the very severely eroded land and 40 per cent of the severely eroded land is idle. Thirty-one and five-tenths per cent of the land classed as severe erosion and 9.0 per cent of the land classed as very severe erosion is in cultivation. The major portion of the severely and very severely eroded land is now being used as cropland, pasture or as idle land.

CONSERVATION

The land in this watershed has been farmed with little consideration given to conservation, soil fertility maintenance or improvement. It has' been farmed without thought to the steepness of slope or the erosion that has taken place. For the

FIG. 18. MOST PASTURES IN THE AREA ARE OF POOR QUALITY AND IN NEED OF RENOVATION.

Table 12

Distribution of the Soil Groups in Each Erosion Group
West Frankfort Reservoir Watershed

Soil Group	No apparent Erosion		Slight to Moderate Erosion		Moderately Severe Erosion		Severe Erosion		Very Severe Erosion		Total
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pet.	Acres
Upland Soil											
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam. . .	---	----	354	74.4	331	63.2	953	89.0	44	100.0	1682
2. Light-colored, textured, very slow permeability, imperfectly drained soils. Bluford-Blair silt loam.	22	7.8	122	25.6	193	36.8	118	11.0	---	----	455
Bottomland Soil											
3. Light-colored. medium-textured. moderately slow permeability, imperfectly drained soils. Belknap silt loam .	261	92.2	---	----	---	----	---	----	---	----	261
Total	283	100.0	476	100.0	524	100.0	1071	100.0	44	100.0	2398

Table 13

Distribution of Slope Classes in Each Erosion Group
West Frankfort Reservoir Watershed

Slope Class	No apparent Erosion		Slight to Moderate Erosion		Moderately Severe Erosion		Severe Erosion		Very Severe Erosion		Total
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres
A (0 - 1-1/2 per cent)	86	30.4	---	----	---	----	---	----	---	----	86
B (1-1/2 - 4 per cent)	191	67.5	256	53.8	137	26. 1	---	----	---	----	584
C (4 - 7 per cent)	6	2. 1	62	13. 0	309	59.0	308	28.8	13	29.5	698
D (7 - 12 per cent)	---	----	61	12.8	78	14.9	707	66.0	19	43.2	865
E (12 - 18 per cent)	---	----	95	20.0	---	----	54	5.0	12	27. 3	161
F (18 - 30 per cent)	---	----	---	----	---	----	2	0.2	---	----	2
G (over 30 per cent)	---	----	2	0.4	---	----	---	----	---	----	2
Total	283	100.0	476	100.0	524	100.0	1071	100.0	44	100. 0	2398

Table 14

Distribution of Land Use Classes in Each Erosion Group
West Frankfort Reservoir Watershed

Land use class	No apparent Erosion		Slight to Moderate Erosion		Moderately Severe Erosion		Severe Erosion		Very Severe Erosion		Total
	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres
Cropland	153	54. 1	174	36.6	240	45.8	337	31.5	4	9. 1	908
Idle Land	66	23.3	149	31.3	212	40.4	428	40.0	24	54.5	879
Pasture	48	17.0	13	2.7	47	9.0	224	20. 9	15	34. 1	347
Woodland	15	5.3	137	28.8	24	4.6	74	6.9	1	2.3	251
Miscellaneous	1	0.3	3	0.6	1	0.2	8	0.7	---	----	13
Total	283	100.0	476	100.0	524	100.0	1071	100.0	44	100.0	2398

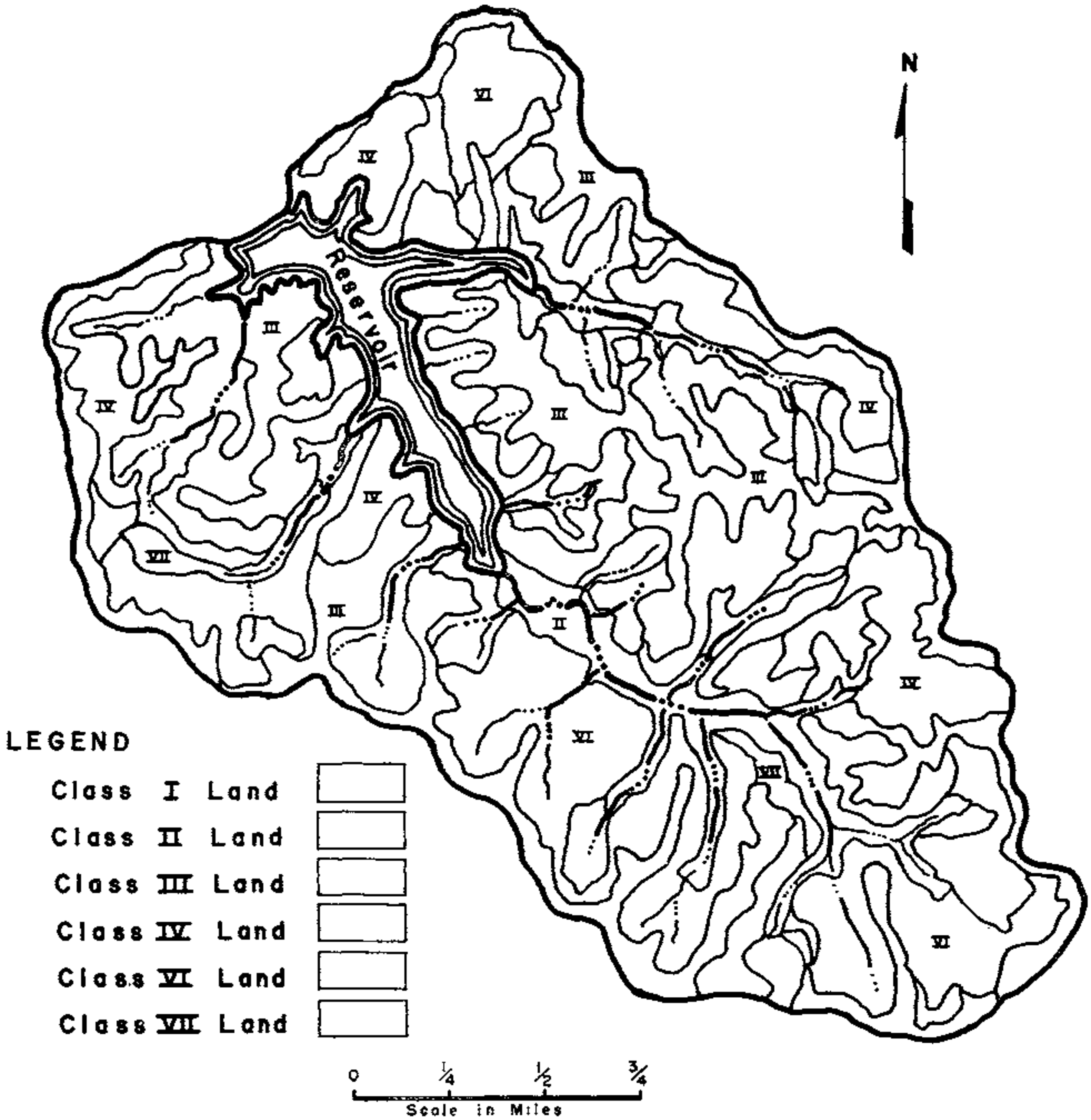

Figure 19. Land Use Capability Map - West Frankfort Reservoir Watershed

U S D.A , Soil Conservation Service, Milwaukee, 1951 most part, the cultivated fields have been planted up and down the slope. Much of the land has been severely cropped for a number of years without the use of recommended soil treatment and has become too poor to economically produce crops. This land has been allowed to grow to broom sedge and briars. In general, the pastures and meadows in the watershed are poor and relatively unproductive. Timber stands in the area are generally fair to poor in quality. 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 siltation in the reservoir.

Figure 19 is a generalized land use capability map of the watershed showing the locations of the various kinds of land. These land classes and their recommendations are the same as those described in Table 9. Land-use adjustments are necessary in order to utilize the land according to its capability and reduce the rate of siltation as well as to provide for a profitable agriculture. As shown in Table 9, one of the important adjustments necessary in the watershed is to crop the land that is suitable for crops and allow the class VI and VII land to remain in pasture or woods.

The first step in a sound watershed treatment program is to classify the land according to its capability. The soil conservation survey maps have been prepared as a basis for land-use adjustments. The soils in this watershed are generally low in fertility and a successful management program is dependent upon the soils being treated according to tests. Past tests have indicated that high rates of lime and fertilizer application are necessary. Without the proper application of limestone and other plant nutrients it is impossible to successfully establish the recommended crop rotations. Rotations allowing grasses and legumes to remain on the land at least 40 per cent of the time would be highly desirable. The poorer, steeper cropland areas should remain in grasses and legumes. Erosion control practices such as contouring and terracing are necessary on most of the cropland areas.

Since a large percentage of the watershed is best suited to pasture a sound pasture-renovation program would be in order. This program would require treating the soils according to soil tests, the seeding of desirable grasses and legumes and proper pasture management. Many water courses in the watershed are in need of shaping, fertilizing, seeding and then should be properly maintained. In some instances earth and concrete structures or flumes may be needed. Timber should be protected and livestock kept out of the woods in order to secure an economic tree growth. There are a number of small, isolated, eroded areas in the watershed that should be protected in order that they will be suitable for wildlife. Multiflora rose and other wildlife plantings would be desirable for these areas. The maintenance of a satisfactory wildlife populatipn in the watershed would be highly desirable from the standpoint of insect control as well as for recreational purposes.

RESULTS

REMEDIAL MEASURES

Practicability. The need for action regarding the silting of West Frankfort Reservoir plus the new Lake West Frankfort has been shown in Figure 11. It is seen that some action will be necessary before 1966 to avert a possible water shortage in that year. Earlier action, prior to 1957, would protect the city from a more severe drought. Since these dates are 6 and 15 years in the future, there exists this "factor of safety" during which time action can be taken to prevent the possible water shortages. Early consideration should be given to possible remedial measures, however, so that necessary provisions can be completed prior to the critical dates.

Raising the Dam. One of the first steps usually considered by lake owners in increasing storage capacity is the raising of the spillway, and possibly the entire dam. Such action is usually subject to limitations as the original dam and spillway were probably designed to give the most economical project available at that site. Limited increase in storage can be gained in this manner under some conditions and should be considered. The spillway of the old lake has already been raised two times and presumably can not be raised further without endangering the dam.

In searching for additional storage space, additional reservoir sites should be considered. In past studies made in locating the present two reservoirs, the most favorable reservoir sites in the area were examined and evaluated. Since future water-supply sources will probably be surface-water developments, these other reservoir sites will probably be utilized in the future as more and more storage space is required.

Dredging. Reservoir owners faced with a silting problem sometimes resort to dredging to remove the silt and regain storage space. The unit cost of dredging is normally high in comparison to other methods of regaining or providing additional storage. Dredging has proven to be worth while in some cases where deltas of sediment, or local "shallows," have been formed within the lake which ruin the esthetic properties of the lake.

Sediment Basins. From a long range planning standpoint sediment basins must be considered as temporary measures. These basins silt up the same as reservoirs and eventually become ineffective. In addition, the cost of constructing such a basin is generally greater per unit of storage than the reservoirs they protect.[8] The building of numerous farm stock ponds properly constructed and located strategically could serve as miniature sediment basins as well as serve livestock needs and fish production.

Vegetative Plantings. Proper soil treatment, adequate crop rotation and a sound pasture renovation and management program are essential. In addition, the planting of trees and shrubs in areas suited for woodland or wildlife is highly desired. The local Farm Advisor or Soil Conservation District personnel should be consulted for the best location for such plantings and the species to be planted.

WATERSHED TREATMENT PROGRAM

Needed Measures. The only way to be reasonably sure that a reservoir will not eventually fill with sediment is to keep the watershed above the dam covered with grass or trees. In addition, all water courses would have to be kept from eroding. This recommendation, of course, is usually impossible to follow unless the entire watershed is owned by the community owning the reservoir. In small watersheds some thought should be given to a comparison of the cost of purchasing the land in the watershed and seeding it to grasses and legumes, as compared to the cost of replacing the reservoir. Revenue for financing such a project could be obtained by renting good grass-legume fields in the watershed either as hay or pasture. It is far more economical to stop sediment at its source than to dredge it from a reservoir or to develop replacement storage.

If the land in the watershed is to be farmed, the treatment program as outlined in Table 15 will materially reduce the rate of sedimentation in the reservoir. This proposed watershed treatment is the most strenuous use to which the land should be farmed. It is questionable if half-way measures, far short of the proposed program, would result in enough benefits to make the efforts worth while. It is estimated from the conservation survey maps and data available from the Soil Erosion Experiment Station 9 that the soil loss under the proposed watershed treatment program would reduce the present loss of 10, 448 tons annually to 1, 556 tons annually. This represents an 85 per cent reduction of the soil leaving the fields. It is reasonable to assume that reducing the soil lost from the fields will also result in smaller amounts of sediment reaching the reservoir.

In comparing the present with the proposed program the greatest reduction in soil loss can be realized on the cultivated land. This is due largely to use of fewer clean-tilled crops on the steeper slopes and the use of supporting conservation practices. The use of supporting practices alone, including contouring, terracing, and strip cropping, can reduce soil losses from a field 30 to 75 per cent. The proposed program actually increases the acreage in cultivation from 907. 6 acres to 1041. 6 acres. This is brought about largely by converting to cropland the idle land suitable for cultivation. The other major adjustment consists of increasing the pasture acreage from 347 acres to 1,063 acres. This too is brought about by converting the idle land and the steep, badly eroded cropland to pasture.

It must be emphasized that no improved land-use program will succeed in this watershed unless the soil is tested and treated according to tests. It is assumed that this will be done in the recommended program. In general, this will require relatively large applications of limestone, phosphate, and potash. Research data indicate that increased returns in crop yields will more than pay for the cost of treatment.

Table 16 shows the estimated amount of erosion control practices needed on the cropland in the watershed and the suggested rotations. Roughly 33 per cent of the cropland should be contoured and an additional 33 per cent terraced. (See Figure 17.) Of the remaining cropland approximately 20 per cent should be in hayland most of the time (broken up in strips when reseeded) and 13 per cent needs no practices.

The most strenuous rotations on the upland allow the land to be in grasses and legumes 50 per cent of the time. This rotation will be applicable on the better soils in the watershed. The poorer, more eroded soils that are suitable for occasional cultivation should be in grasses and legumes at least two-thirds of the time. In brief the major adjustments necessary to place the proposed watershed program into effect are: (1) treat the land according to its capabilities (Tables 9 and 15), (2) treat the soils according to test, (3) use sound rotations and erosion control practices similar to those suggested in Table 16, and (4) in some cases supply economic assistance for a 5- or 10-year period to cover the initial costs of the soil treatment program. Although the measures shown in Table 15 are designed primarily to re-

8. Brown, C. B., "The Control of Reservoir Silting, " U. S. Department of Agriculture, Misc. Publication No. 521, Washington, D. C. , 1944.

9. Van Doren, C. A. , & Klingebiel, A. A. , "Slope and Practice Limitations for Illinois," mimeograph release, January 1948, Urbana, Illinois.

10. "Effect of Soil Treatment on Soil Productivity," Illinois Agricultural Experiment Station Bulletin No. 516 (1945).

Table 15

Estimated Reduction in Sheet Erosion Annually from a Watershed Treatment Program
West Frankfort Reservoir

Soil	Cultivated		Permanent Pasture		Woodland		Building Lots		Idle Land		Total Annual Soil Loss (tons)
	Acres	Loss (tons)	Acres	Loss (tons)	Acres	Loss (tons)	Acres	Loss (tons)	Acres	Loss (tons)	
PRESENT USE OF LAND											
Upland Soils											
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam soil group.	545. 0	7944. 0	273. 0	163. 9	193.4	121.9	7.0	4.2	663.8	39.7. 1	8,631
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soil. Bluford-Blair silt loam group.	209.4	1671.5	30.6	18.4	49. 3	27. 0	5.2	3. 1	160.0	97.2	1.817
Bottomland Soils											
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam group.	153. 2		43. 4		8.2		1.0		55.4		0
Total	907.6	9615.5	347.0	182.3	250. 9	148. 9	13.2	7.3	879.2	494. 3	10,448
Total acres, 2397. 9; total tons lost annually, 10,448. 3.											
RECOMMENDED LAND USE											
Upland Soils											
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam group.	S35. 6	891.8	917.2	205. 1	222. 4	44.5	7. 0	4.2			1, 145
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soil. Bluford-Blair silt loam group.	352. 8	389.6	47.2	9. 4	49. 3	9. 1	5. 2	3. 1			411
Bottomland Soils											
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam group.	153. 2		98.8		8. 2		1. 0				0
Total	1041.6	1281.4	1063.2	214. 5	279. 9	53.6	13. 2	7. 3			1,556

Total acres, 2397. 9; total tons lost annually, 1556. 8.
Per cent reduction due to watershed program: 85%.

Notes

(1) A soil-loss factor of 0.2 ton per acre per year was assumed on pasture and woods under the conservation program and 0.6 ton under present management. No loss was assumed on level pasture and woods, 0.6 ton per acre per year was assumed on the idle land.

(2) Rotation used as basis for land use without program based on assessor's acreage figures for Cave township. A corn-corn-wheat-3 years of grass-legumes was used.

(3) Slope and practice data and land use capability recommendations were used as the basis for the recommendations in this conservation program.

(4) It is assumed all land in cropland and pasture in the watershed will be treated according to soil test. All pastures will be renovated and seeded to desirable grasses and legumes.

Table 16

Estimated Conservation Practices Required
in
West Frankfort Reservoir Watershed

Soils	No Practices (acres)	Contour Cultivated (acres)	Terraces (acres)	Strip Cropping[1] (acres)
	Suggested Erosion Control Practices			
Upland Soils				
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam		154.0	239. 1	142.5
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soils. Bluford-Blair silt loam		198.8	81.8	72.2
Bottomland Soils				
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam	153.2			
Total	153.2	352.8	320.9	214. 7

1. Terraces may replace strip cropping.

Rotations Needed on Cropland
in
West Frankfort Reservoir Watershed

Soils	Corn-beans-wheat-meadow (acres)	Corn-beans-wheat-3 yr. meadow[2] (acres)	Corn-wheat-4 years meadow (acres)	Small grain-4 years meadow (acres)	Corn-wheat-2 years meadow (acres)	Total Cropland (acres)
	Suggested Rotations 1					
Upland Soils						
1. Light-colored, medium-textured, slow to very slow permeability, moderately well drained soils. Ava silt loam		364.9	142. 5		28. 2	535. 6
2. Light-colored, medium-textured, very slow permeability, imperfectly drained soils. Bluford-Blair silt loam		190.2	51.0	21.2	90. 4	352. 8
Bottomland Soils						
3. Light-colored, medium-textured, moderately slow permeability, imperfectly drained soils. Belknap silt loam	153.2					153. 2
Total	153.2	555. 1	193. 5	21.2	118. 6	1041. 6

1. Soils will be tested and treated according to test.
2. If a corn-wheat-2 year meadow were used here, it would further reduce soil losses.

duce sheet erosion, it is estimated that over 90 per cent of the total sediment load entering the reservoir is derived from this source. Therefore, such a program should effect a reduction of approximately 80 per cent of the total sediment load brought to the old reservoir.

Although a detailed study was not made of the new reservoir watershed, generally the same type of soil conservation program is believed to be required.

Costs and Benefits of Soil Conservation. The adoption of a soil and water conservation program by farmers in the West Frankfort Reservoir watersheds would be of definite benefit to the city of West Frankfort by reducing the volume of sediment coming into the reservoirs. In addition, the farmers themselves would benefit from increased farm production and increased net farm income.

The long-time benefits of conservation are certain. In this mixed farming area, fertility improvement, land-use adjustments, erosion control and drainage are some of the major conservation problems. In order to secure a desirable rotation and to obtain good stands of recommended legumes and grasses, most of the cropland requires heavy applications of limestone, phosphate and mixed fertilizers. The costs of the fertilizer application will vary from field to field and from farm to farm. Farm-record studies in an area of comparable soils in southern Illinois show that the cost of adopting a complete soil conservation program, including necessary applications of fertilizer, will cost from $20 to $40 an acre, depending on the present condition of the land. These farm-record studies show that the production level and earnings are low unless a soil conservation and fertility improvement program is applied.

Studies of farms having conservation plans compared with farms of similar soil resources but not having conservation plans in Jefferson County show that the conservation plans made it possible to use the land more productively. The farms with conservation plans spent approximately twice as much for soil improvement as the farms without conservation plans. The farms with conservation plans had a higher per cent of their tillable land in intertilled crops, small grains, hay and rotation pasture than the farms not following conservation plans. They had only four per cent of their farm in idle land compared to approximately 20 per cent in idle land on the nonconservation farms. The soil fertility program, improved land use program, and use of practices such as contouring, terraces, grass waterways and surface drainage resulted in crop yield increases of approximately 40 per cent on the conservation farms as compared to the nonconservation farms.

Because of the higher production of grains and hay and rotation pastures as well as the higher production on the permanent pastures, the farms with conservation plans produced much more livestock than the farms without conservation plans. They averaged 25 pounds more meat, 43 pounds more milk and three dozen more eggs per acre than the farms without conservation plans.

As a result of their conservation programs, the farms with plans in operation had incomes averaging, in 1945, $7. 03 an acre more than the farms without conservation plans. While the large

Table 17

Annual Water Loss, Yields, and Sheep Production
on Treated and Untreated Pastures
Severely and Moderately Grazed

Item Measured	Treated Plots[1]		Untreated Plots	
	Severely Grazed	Moderately Grazed	Severely Grazed	Moderately Grazed
		(inches)		
Water losses	6. 8	3. 6	7. 3	7.4
		(pounds per acre)		
Desirable forage[2]	2,507	3,448	929	1, 102
Weeds[2]	1, 111	942	2,339	1,919
Sheep gains	49	185	29	82

1. Treated plots received limestone and phosphate according to needs indicated by soil tests.
2. Data for 1947 are not included.

amounts of limestone, phosphate and fertilizer which must be applied in the fertility-improvement program makes the conservation expenses relatively high in this area, benefits of this program are also relatively high. The farm-record studies indicate that increased income from a conservation program will pay for the cost of the program in three to six years in this area. The adoption of a conservation program increases earnings in a relatively few years and puts the farm in condition for sustained profitable production.

Approximately one half of the West Frankfort Reservoir watershed should be in pasture. Proper treatment of pasture land (see Figure 18) can do a great deal to reduce erosion and increase productivity. The value of both treatment and moderate grazing is shown by results at Dixon Springs[7] (see Table 17). Only about one half as much water ran off treated pasture that was moderately grazed as from treated pasture that was severely grazed. Untreated plots, regardless of severity of grazing, lost over twice as much rainfall as the treated plots. The value of good soil treatment and careful handling of pastures is reflected in greatly increased yields of forage and in production of live stock.

In recent years, with improved varieties of legumes and grasses, treated pastures at Dixon Springs have produced 200 to 300 pounds more meat per acre than untreated pastures. Costs of fertility treatment plus seeding range from $30 to $45 an acre, and at present prices for sheep and cattle, the cost of treating these pastures is paid for by increased production in one year after the pastures are established.

<u>Extension of the Life of the Lakes.</u> The effect of a watershed-treatment program on the watersheds of both the old and new lakes is shown in Figure 20. The suggested conservation program would reduce the siltation in the lakes by an estimated 80 per cent as shown earlier in this report. The cost of establishing such a program on the land would be repaid in increased production in only three to six years.

In Figure 20 the decreasing storage capacity of the reservoirs is shown as it will occur in future years if the present rate of silting continues. Also shown are the future demands on the lakes during 50-year and 100-year droughts. These lines cross in the years 1957 and 1966, signifying a water shortage in those years. It is assumed that if the watershed treatment program were begun in 1952 and completed by 1956 the 80 per cent reduction would be accomplished by that year. This reduction in reservoir storage loss after 1956 is shown.

If the present rate of soil erosion on the two reservoir watersheds is allowed to continue at the present rate the reservoirs will continue to fill with sediment. By the year 1970 the combined storage capacity of the two reservoirs will have been reduced to 899 million gallons. This is shown in Figure 11. If the proposed watershed conservation program were in effect by the year 1956, then by 1970 the combined reservoir storage would be 941 million gallons. The conservation program would prolong the total length of time the reservoirs can be used in conjunction with other storage. For this reason as well as the delay of water shortages, the water department of the city should consider means of bringing about the application of this watershed program. The conservation measures needed in the watersheds are measures similar to those needed throughout Franklin County as well as the entire state and nation to provide for a more permanent and productive agriculture. The Franklin County Soil Conservation District has as its objective the application of these measures within the county. Technical assistance is given the district by the Soil Conservation Service, Extension Service, and other federal and state agencies. The district is authorized to accept aid from any source in carrying out its program. Efforts of the city water department to establish the watershed treatment program could very reasonably be carried out through this district.

The city of Decatur, faced with a serious reservoir sedimentation problem, has maintained for many years a trained conservationist to work only on the reservoir watershed. This man, paid entirely from city funds, gives technical help to farmers in the area in a manner similar to that furnished farmers by the soil conservation district. The city of Springfield maintains its own nursery for furnishing seedlings for planting on city-owned property around Lake Springfield, The city of Macomb is aiding the local soil conservation district in an increased effort to apply needed conservation measures on the city reservoir watershed.

Many cities have found it economical to purchase all or much of the reservoir watershed for

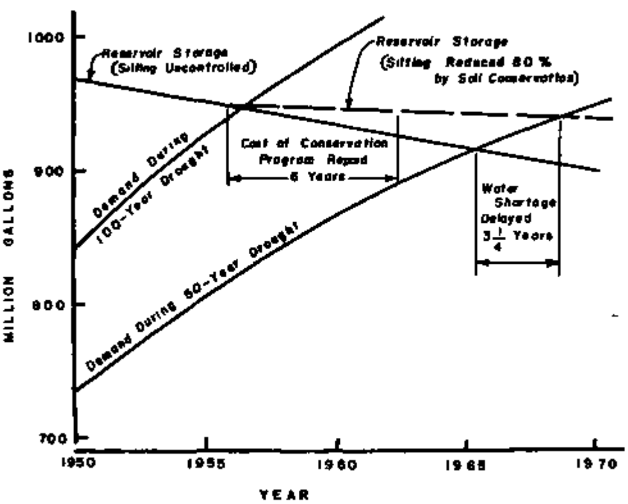

FIG. 20. EFFECT OF WATERSHED TREATMENT PROGRAM ON USEFUL LIFE OF RESERVOIRS.

control. In this manner the city water department can make certain that the control of soil loss is complete. This does not mean that the land is all taken out of cultivation or agricultural use. Such lands are frequently leased to private interests for farming in line with the capabilities of the land. As has been shown, much of the land in the West Frankfort reservoir watersheds is suitable for grassland. After purchase and proper treatment, this land could be leased for pasture. Such programs of watershed control have been found self-supporting and even profitable to the city in many cases.[11] The city of Akron, Ohio, has carried on such operations profitably.

11. LaDue, Wendell R., "Reservoir Lands Pay Their Way - Balanced Use of Reservoir Lands," Journal of American Water Works Association, Vol. 40, No. 8, August, 1948.

RECOMMENDATIONS

It is recommended that the city of West Frankfort undertake immediately the application of a watershed treatment program on the drainage areas of both West Frankfort Reservoir and the new Lake West Frankfort to reduce sedimentation and prolong the ultimate life of these lakes and the length of time they can be used for the public water supply. It is suggested that this program be carried out by: (1) financial assistance from the city to the local soil conservation district for intensified conservation efforts on these watersheds, or (2) purchase of the watersheds, or much of the critical erosion areas, by the city for application of the needed conservation measures.

It is recommended that preliminary consideration be given to possible measures for increasing the raw water supply for the city. Such measures should be put into effect prior to the year 1966 in order to prevent a water shortage in event of a 50-year drought.

REPORTS OF INVESTIGATIONS

ISSUED BY THE STATE WATER SURVEY

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

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

No. 3. Radar and Rainfall. 1949.

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

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

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

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

No. 8. The Silting of Lake Chautauqua, Havana, Illinois. 1951.

No. 9. The Silting of Carbondale Reservoir, Carbondale, Illinois. 1951.

No. 10. The Silting of Lake Bracken, Galesburg, Illinois. 1951.

No. 11. Irrigation in Illinois. 1951.

No. 12. The Silting of West Frankfort Reservoir, West Frankfort, Illinois. 1951.

No. 13. Studies of Thunderstorm Rainfall with Dense Raingage Networks and Radar, (in press)

*Out of print.