UNIVERSITY OF KENTUCKY

COLLEGE OF AGRICULTURE

Extension Division

THOMAS P. COOPER, Dean and Director

CIRCULAR NO. 317

EARTH DAMS FOR FARM RESERVOIRS

Lexington, Ky.
August, 1938

Published in connection with the agricultural extension work carried on by co-operation of the College of Agriculture, University of Kentucky, with the U. S. Department of Agriculture, and distributed in furtherance of the work provided for in the Act of Congress of May 8, 1914.

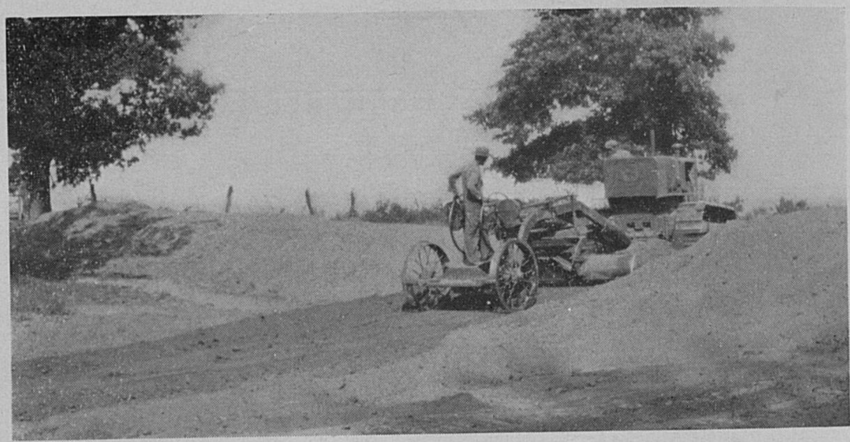

FIGURE 1. Crawler type tractor and two-wheeled terrace grader used for building farm reservoirs.

Circular No. 317

EARTH DAMS FOR FARM RESERVOIRS

EARL G. WELCH and JOHN L. McKITRICK

THE NEED FOR FARM RESERVOIRS

On many Kentucky farms, an inadequate source of water limits livestock and crop production. In limestone areas of the state, deep wells are rare and can only occasionally be drilled at reasonable cost. Springs, small streams and shallow-wells frequently fail in dry periods, even in years when the total rainfall is normal. Farm reservoirs properly located, built and maintained are satisfactory sources of water for livestock and are frequently the most economical that may be provided.

TYPES OF FARM RESERVOIRS

Farm reservoirs in Kentucky may be divided into three types, depending on their locations, as follows:

Hilltop Ponds. Many small ponds have been excavated near the top of slopes, with little or no drainage area above them. This location decreases silting due to erosion and eliminates the necessity of providing for overflow. They are partially filled by direct rainfall and by soil water during wet seasons. Because of limited storage capacity and drainage area, these ponds are frequently dry during periods of drouth when water is most needed or the small amount of water they hold becomes unfit for livestock.

Reservoir in a Stream. A reservoir may be constructed in an intermittent stream by use of a masonry dam. The initial cost of such a dam is usually high, silting of the reservoir is rapid, and the hazard of flooding in adjacent bottom land is greatly increased.

Another method of impounding water in a stream is to build a series of dams of loose stones so placed that the center of the dam is lower than either end. The area above the dam is soon filled with sediment but the overflow creates pools immediately below. Usually these dams are placed at intervals of one to two hundred feet.

Reservoir in a Valley. Another method of constructing a farm reservoir is by building a masonry or earth dam across a narrow draw between two hills. This method is the most satisfactory, provided sufficient care is taken in the location, design and construction. Earth dams are usually low in cost, since no special skill is required to construct them and farm labor, power and equipment may be utilized to reduce cash outlay. In some counties in the state, power equipment is available for customs work and many farmers consider its use to be more economical than the use of farm power and equipment.

To be permanently successful in impounding water, a dam must be planned and constructed with considerable care.

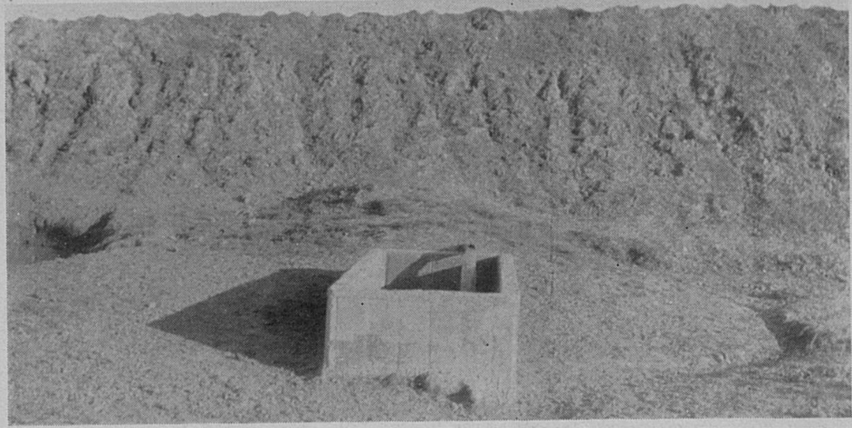

FIGURE 2. A concrete water trough located below an earth dam and filled by gravity from the reservoir.

REASONS WHY A RESERVOIR MAY FAIL

The chief reasons for many farm reservoirs in Kentucky being empty when water is most needed in summer are as follows:

1. Insufficient storage capacity and drainage area.
2. High evaporation and seepage loss resulting from shallow depth and large surface area.
3. Failure of earth fill resulting from an inadequate spillway.
4. Seepage under the earth fill.
5. Silting from cultivated areas.
6. Failure of earth fill due to erosion caused by wave action or direct rainfall.
7. Inadequate allowance for settling of earth fill.

The following suggestions concerning the location and construction of earth dams are intended to aid farmers in planning and constructing farm reservoirs where drainage areas do not exceed 50 acres and earth dams under 15 feet in height are to be built. Where these limits are to be exceeded, an engineer should be employed to design the dam and spillway.

FACTORS TO BE CONSIDERED IN SELECTING A SITE FOR A RESERVOIR

Capacity of a Reservoir and Drainage Area. The area that drains into a reservoir should not be less than 7 or 8 acres. This area will provide ample water for a minimum-sized reservoir, ¼ acre in area and an average of 6 feet deep, which will hold 1½ acre-feet when filled to capacity. An acre-foot is the amount of water required to cover an acre one foot deep. It is equal to

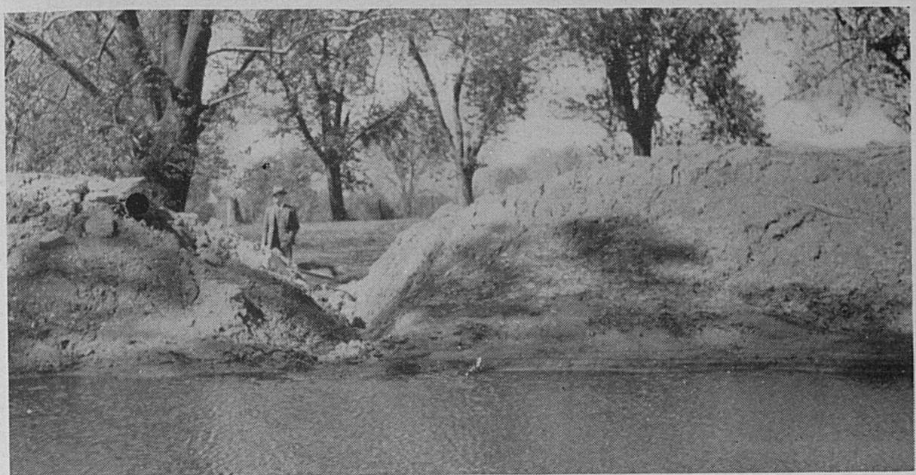

FIGURE 3. Break in an earth dam due to overtopping at a low point caused by excessive settling of the fill.

43,560 cubic feet or 325,850 gallons. The area that drains into the reservoir should equal 5 acres for each acre-foot capacity in order that the normal rainfall during the winter and spring may fill the reservoir before summer. Occasionally, a dam may be located below a spring which will assure a constant water level and provide ideal conditions for fish culture. Care should be exercised, however, not to locate a dam at such an elevation that the high-water level in the reservoir will cover the spring.

A narrow draw between two hills makes an ideal site for a dam and reservoir, especially when the land immediately above the dam site is comparatively level, since the maximum storage capacity may be obtained with a minimum yardage of earth in a dam. Usually such a location provides a suitable site for a spillway to divert surplus water around the dam.

Evaporation and Seepage. In selecting a site for a reservoir, it should be kept in mind that a deep reservoir having the same volume as a shallow one loses less water by evaporation and seepage since smaller areas are in contact with the air and soil. The area to be flooded by a dam of a given height or the necessary height of dam to flood a given area may be determined during a preliminary examination of a proposed site as explained under "Survey for an Earth Dam," on page 8.

FIGURE 4. Break in an earth dam due to inadequate spillway.

Spillway. If possible, a site should be selected which permits the construction of a spillway resembling a wide, shallow water channel, around one end of the dam. Frequently the topography is such that the spillway can be constructed at one side of the pond and be entirely independent of the dam. Overflow pipes of vitrified clay, concrete or iron, placed near the top of the dam, are more expensive, if of sufficient capacity, than open-channel spillways, and because of possible seepage around the pipe and settling of earth are apt to permit loss of water from the reservoir or failure of the dam. Where a dam and reservoir are located so as to add to the appearance of a farmstead or a reservoir is constructed as a feature of a plan for landscaping, the spillway may be directly over the dam. In such cases, the top of the dam and lower slope must be protected by masonry which is expensive and usually requires the services of skilled workmen.

Core Wall. A core trench extending to subsoil and refilled with impervious material should be included in the plan for a small earth dam, otherwise seepage may occur between the earth fill and the original surface of the soil. The trench should run the full length of the dam. The core of impervious material or subsoil should extend from the original ground level to within one foot of the top of the dam, thruout its length, and be not less than 3 or 4 feet in width.

Silting of a Reservoir. Excessive erosion above a dam may cause the reservoir to be filled with sediment. This hazard is reduced to a minimum if the drainage area is permanent pasture or woodland. Terracing the drainage area greatly reduces silting and may be a means of increasing the drainage area by diverting water from an adjoining slope to that draining to the reservoir.[1]

A grass strip 50 to 100 feet wide around the pond, above the high-water mark, helps to prevent silting of the reservoir, since it checks the velocity of the water and causes the soil to be deposited on the grass rather than in the reservoir. In order that the grass strip be maintained, it must be protected from overgrazing and tramping by livestock.

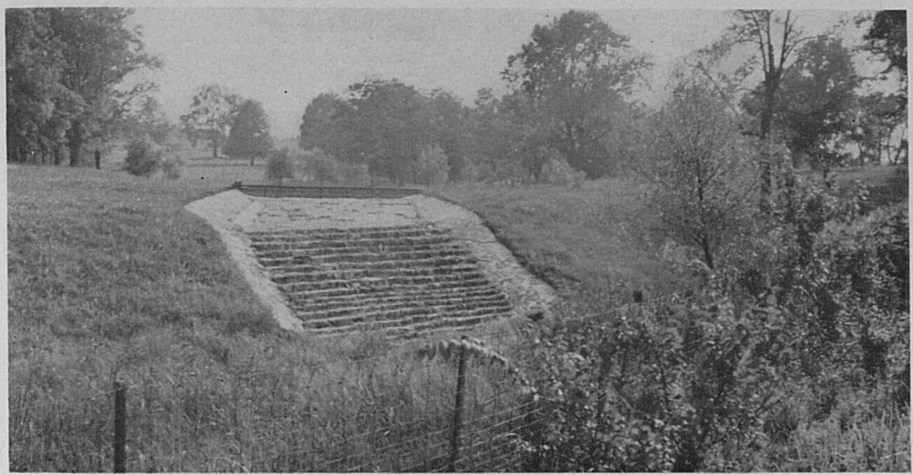

FIGURE 5. A farm reservoir with a masonry spillway directly over an earth dam, as a feature in landscaping.

The Subsoil Should Be Examined. The subsoil at a dam site should be tight or nearly impervious to water. A location should be avoided where the impounded water would cover a bed of gravel, sand, or rock containing seams or layers, unless such beds are coverd by five or six feet of impervious soil. The nature of the subsoil should be determined by the use of a soil auger or a post-hole digger.

Relation to Fields. A site may be selected where the reservoir will serve more than one field. Frquently a rearrangement of fences will make it possible to water livestock in several fields, from one reservoir.

[1] Kentucky Extension Circular No. 304, "Soil Erosion and Its Control."

SURVEY FOR AN EARTH DAM

After the site of a dam has been chosen it is advisable to mark the high-water line with stakes and to get data for determining the dimensions of the dam. This information is required for estimating the volume of the dam and determining its probable cost and the length of time required to build it. A farm level or surveyor's level is convenient in making the survey.

FIGURE 6. A farm reservoir protected from silting by permanent sod. Note electric fence to exclude livestock.

Use of Level to Locate High-water Line. The steps to be taken are:

1. Set up the level as shown in figure 7 so that the telescope is about one foot higher than the proposed high-water mark at the site of the dam. The rodman sets the rod on the ground at "A", the proposed water line at one end of the site. The instrument man then directs the rodman to raise or lower the target until it coincides with the horizontal cross hair. The target is fastened in this position.

2. The rodman then crosses the draw and the instrument man motions him to move up or down the slope at the other end of the site until a place is found where the target again coincides with the horizontal cross hair. This is station F. Stations A and F mark the water line at each end of the proposed dam but not the top of the dam, as explained later.

3. The rodman then moves up the draw until the water line is found at the upper end of the proposed pond, as was point F (station G, figure 7). These three stations give an outline of the area in which water will be impounded by the proposed dam. Other

points indicating the high-water line may be located as were points G and F.

Use of Level to Determine Height of Dam. In order that an accurate estimate may be made of the yardage in a proposed dam and to aid in designing the dam before construction work is started, it is necessary that the height of the dam to the high-water mark be determined at those points along its length where there is a change in the slope of the ground. Set the instrument in a position as illustrated in figure 7 and the rod at high-water line at one end of

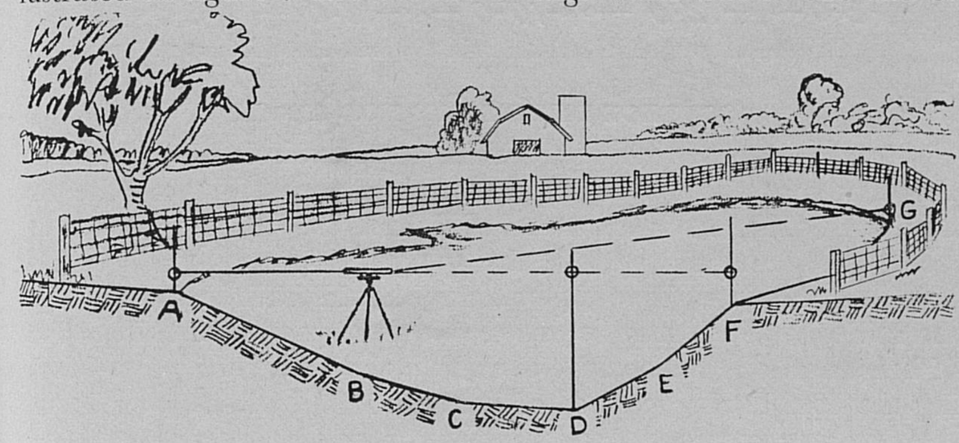

FIGURE 7. Use of level to locate the high-water line of a reservoir.

the dam, with the target set level with the horizontal cross hair of the instrument. Record the height of the target above ground level at this station. Hold the rod at another point such as D and record the height of the target above ground level when its center coincides with the horizontal cross hair of the instrument. The difference of the two readings is the difference in elevation of points A and D, or the height of the dam to high-water level at D. The difference in elevation between high-water level and other points should be determined in like manner.

If no surveyor's level is available and the top of the dam does not exceed 200 feet in length, point F may be located by sighting over a carpenter's level set at A, a string may then be stretched as tight as possible from A to F, to indicate the high-water level. Measurements may then be made from the string to the ground at points A to F. The height of the string above the ground at A and F should be O feet. Besides determining the height of the dam at various points it will be necessary to measure and record the length of each segment of the dam as illustrated in figure 8.

Recording Data. The data taken in the preliminary survey can be most conveniently recorded in the form of a sketch, as shown in figure 8.

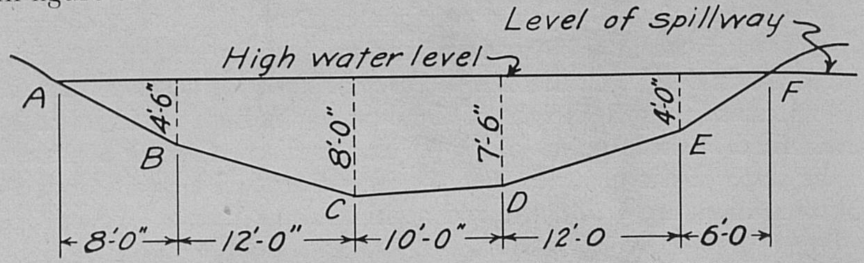

FIGURE 8. Suggested form for recording data taken in survey.

CORRECT DIMENSIONS FOR A DAM

Height. The depth of water in a reservoir is determined by the elevation of the spillway rather than the height of dam. A minimum difference in elevation of six feet between the floor of the storage area and the level of the spillway is recommended. The height of the dam above the spillway should include the depth of the spillway, which may be one to two feet, and an additional foot of height called "freeboard," to reduce the hazard of water breaking the dam during periods of heavy rainfall, when water in the spillway may be running at its maximum depth.

The following example illustrates the method used in determining the height of a dam at various points in its length. See figure 15.

Height of spillway above original ground level	8 feet.
Depth of spillway	2 feet.
Freeboard	1 foot.
Total height of dam	11 feet.

Top Width. The minimum width of the top of the dam should be 4 feet for dams up to 10 feet in height, and 6 feet for dams from 10 to 15 feet in height. The type of equipment used in moving earth may make it necessary to increase the width of the top over these figures. In some instances, the top of the dam may be conveniently used as a road which would necessitate a width of at least 10 feet.

Base Width. The slope of the lower dry side should be 2 to 1 (2 feet horizontal to 1 foot vertical) and that of the upper wet side, 3 to 1. The base width at any point in a dam having these slopes is five times the height, plus the top width. Steeper slopes are apt to result in slumping of the fill when it becomes wet, and increases the difficulty of establishing vegetation to control erosion.

The following example illustrates the method of determining the base width of the dam at a point where the height is 11 feet (see figure 15).

Base width of slope on dry side—2′ horizontal to 1′ vertical, 2 x 11′	22 ft.
Base width of slope on wet side—3′ horizontal to 1′ vertical, 3 x 11′	33 ft.
Top width of dam	4 ft.
Total base width of dam	59 ft.

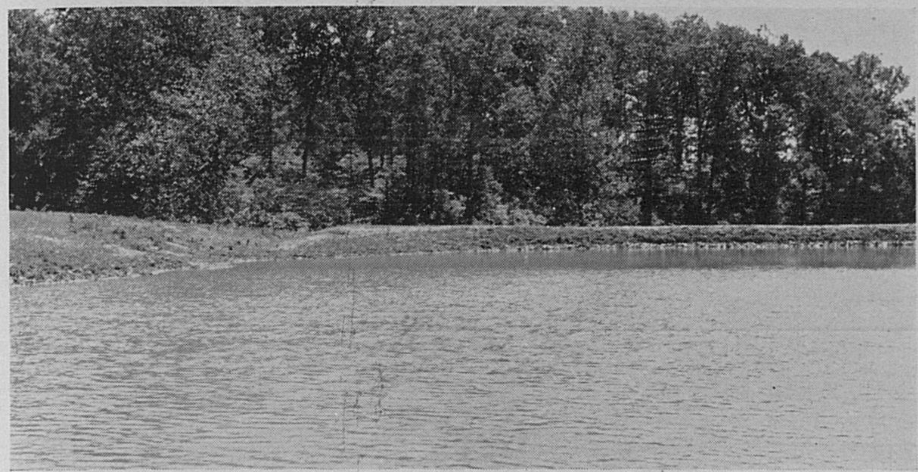

FIGURE 9. The top of an earth dam should be at least one foot above the highest level of water in the spillway. This additional height is called freeboard.

Length. The length of the dam will be determined by the width of the draw in which the dam is located.

Size of Spillway. An open-channel spillway should be large enough to carry water from the reservoir at a rate equal to that at which water may flow in from the drainage area. Heavy rain may occur when the reservoir is filled to capacity and an inadequate spillway causes failure of the dam from over-topping. The size of a spillway depends on the size, topography and ground cover of the drainage area and the grade of the spillway.

The depth of an open-channel spillway may be fixed at 1 ft., 1½ ft., or 2 ft., but the width must vary accordingly, as shown in table 2 which gives the width of a spillway of a given depth. Since a dam, when settled, should have at least 1 foot of freeboard above the high-water level in the spillway, a shallow, wide spillway permits a greater storage capacity for the same height of dam than would a deeper and narrower one. In some locations, the lay of the land determines the depth of spillway. If loose stone or masonry must be used to protect a water channel from erosion, a deep, narrow channel requires less protective material. As a general rule, the depth of the spillway should increase with the drainage area and the run-off. If a drainage area exceeds 50 acres, or unusual conditions exist which would make the success of a simple earth dam doubtful, an engineer should be employed to design the dam and spillway.

To determine the size of spillway:

1st. Determine the area of the body of land above the reservoir, the average slope of the ground, and the vegetative cover.

2nd. From table 1 determine the run-off in cubic feet per second.

3rd. Select the figure in the left-hand colum of table 2 which is nearest to the run-off in cubic feet per second as determined from table 1. The figure in the proper column for depth, opposite the determined figure for run-off is the width to make the spillway.

Table 1. Rates of run-off in cubic feet per second from timber, pasture and cultivated land for Kentucky (based on rainfall frequency once in 10 years).

	Unterraced Areas						Terraced
	Timber		Pasture		Cutivated		Cultivated
Area drained, acres	Rolling 5 to 10% slope	Hilly 10 to 30% slope	Rolling 5 to 10% slope	Hilly 10 to 30% slope	Rolling 5 to 10% slope	Hilly 10 to 30% slope	Rolling 5 to 10% slope
2	2.9	4.5	6.7	8.8	11.9	15.3	9.2
4	5.5	7.5	12.2	15.3	21.0	28.0	15.7
6	8.3	10.7	17.5	21.8	31.0	40.5	21.6
8	11.1	13.6	22.3	27.3	39.4	50.4	26.8
10	13.8	16.3	27.2	33.0	47.2	58.8	32.1
12	16.0	18.8	31.9	38.1	54.2	66.3	37.1
14	18.3	21.3	36.1	43.2	60.2	73.5	41.7
16	20.4	23.7	40.0	48.1	66.0	80.2	46.0
18	22.2	25.8	43.5	51.7	70.1	86.5	50.1
20	23.8	27.4	46.6	55.0	76.3	92.7	54.3
25	26.9	31.5	53.2	62.6	88.3	106.7	64.4
30	29.2	34.7	58.9	69.6	98.7	119.4	73.7
35	31.0	37.9	63.7	75.1	107.0	134.0	83.0
40	32.0	41.0	67.8	80.0	114.5	150.0	93.0
45	35.0	46.0	71.0	85.0	125.0	170.0	105.0
50	50.0	65.0	80.0	98.0	138.0	189.0	122.0

Tabulated from curves prepared by C. E. Ramser, U. S. Department of Agriculture.

PROTECT A SPILLWAY FROM EROSION

Where the spillway is cut thru one end of the dam, a grade of 6 inches in 100 feet of horizontal distance should be provided to increase the velocity of water. A spillway may be protected from erosion by the use of dense-rooted vegetation, such as bluegrass or Bermuda grass, established by seeding or sodding. Where provision must be made for an abrupt drop in a spillway, or the grade exceeds that recommended in the footnote to table 2, a masonry check dam with apron should be built or the spillway should be protected from erosion by paving it with concrete or rubble masonry.[1]

Table 2. Bottom width of spillway, in feet, corresponding to given run-off and depth.*

Run-off, cu. ft. per sec.	1 foot deep	1½ feet deep	2 feet deep
5	5	—	—
10	5	—	—
15	6	—	—
20	9	—	—
25	11	—	—
30	13	5	—
35	15	6	—
40	17	7	—
45	19	8	5
50	21	9	6
55	23	10	6½
60	25	11	7
65	27	12½	7½
70	30	13½	8
75	—	14½	9
80	—	15½	9½
85	—	16½	10
90	—	17½	11
95	—	18½	11½
100	—	19½	12
105	—	20½	12½
110	—	21½	13½
115	—	23	14
120	—	24	14½
125	—	25	15½
130	—	26	16
135	—	27	16½
140	—	28	17
145	—	29	18
150	—	30	18½
155	—	—	19
160	—	—	20
165	—	—	20½
170	—	—	21
175	—	—	22
180	—	—	22½
185	—	—	23
190	—	—	24

* The grade of a spillway for the dimensions indicated in this table should not be less than 0.5%. If vegetation is used in the channel to control erosion, the grade should not exceed 7, 5 or 3½% for channels 1 ft., 1½ ft., or 2 ft. deep, respectively. Side slope of spillway 3 ft. horizontal to 1 ft. vertical.

[1] See Kentucky Extension Circular No. 304, "Soil Erosion and Its Control."

Illustration. Use of Tables to Determine Size of Spillway

Problem. To determine the width of spillway for a reservoir to be filled from a 16-acre drainage area of rolling land with a maximum slope of 10 percent, or 10-foot drop in 100 feet of horizontal distance, which is in grass but may be cultivated in row crops.

Solution. From table 1, opposite 16 in the column "Area Drained" and under the headings "Cultivated" and "Rolling" the figure 66 is the run-off in cubic feet per second.

In table 2, read down in the left-hand column "Run-off in cubic feet per second" to 65, the figure nearest to 66. Opposite 65, in the columns headed 1 ft., 1½ ft., and 2 ft. deep, will be found the figures 27, 12½ and 7½, respectively. This means that the spillway should have a bottom width of 27 feet if 1 foot deep; 12½ feet if 1½ feet deep; or 7½ feet if 2 feet deep.

FIGURE 10. A spillway of concrete and loose stone.

PLANNING THE DAM

With the sketch of the dam made during the survey as a basis, sketches of the dam to be constructed should be drawn as a guide to the workmen and as a basis for calculating the volume of earth in the structure. These sketches should include a section thru the length of the dam and spillway, a cross section of the dam at its highest point (figure 15), and a sketch of the base of the dam, figure 16.

Section thru Length of Dam. The sketch thru the length of the dam on its center line will be similar to the sketch made for recording data in the preliminary survey except for the following.

1. Additional height above the high-water mark must be provided equal to the depth of the spillway plus freeboard.

2. Length must be added to the end sections because of the additional height and the slope of the bank at the ends of the dam, as illustrated in figure 15.

3. Dimensions of the spillway should be added.

4. The segments of the dam should be numbered to facilitate computation of volume.

FIGURE 11. Upper portion of spillway protected from erosion by vegetation, lower portion by rubble masonry.

FIGURE 12. Farm reservoir with spillway at end of dam, protected from erosion by bluegrass sod.

Plan for Base of Dam. To aid in staking out the dam and building the fill to the desired slopes a plan for the base should be made, as illustrated in figure 16. In this plan the width of the base should be indicated at points where there is a change in the slope of the original ground surface located during the survey as points A, B, C, D, E, F in figure 7. The dimensions should show the top width of the dam and the distance of the foot of the slope from the center line.

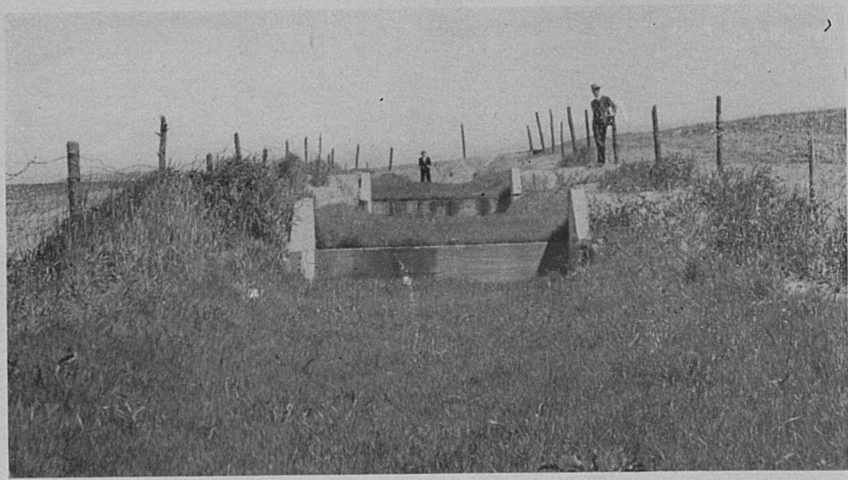

FIGURE 13. Spillway of large reservoir, protected from erosion by concrete check dams and vegetation.

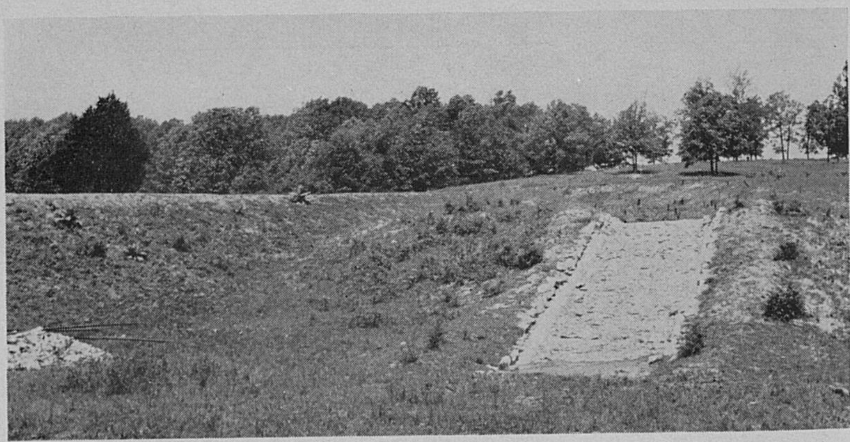

FIGURE 14. Earth dam with spillway on steeper portion of slope, protected from erosion by stones laid in cement mortar.

STAKING OUT DAM AND SPILLWAY

After the dimensions of the dam and spillway have been determined, stakes should be set to mark the following points on the ground surface.

1. The center line of the earth fill.
2. The outside limits of the base of the earth fill.
3. The top of the dam at each end of the fill.

4. The top and bottom width of the spillway at several points thruout its length.

It may not be necessary to cut a spillway channel the entire distance from high-water level to the foot of a slope below the dam if well-established sod is found at the right place. In planning to utilize an established sod, however, it should be determined that water will flow away from rather than towards the foot of the earth fill, otherwise the dam may be weakened by erosion.

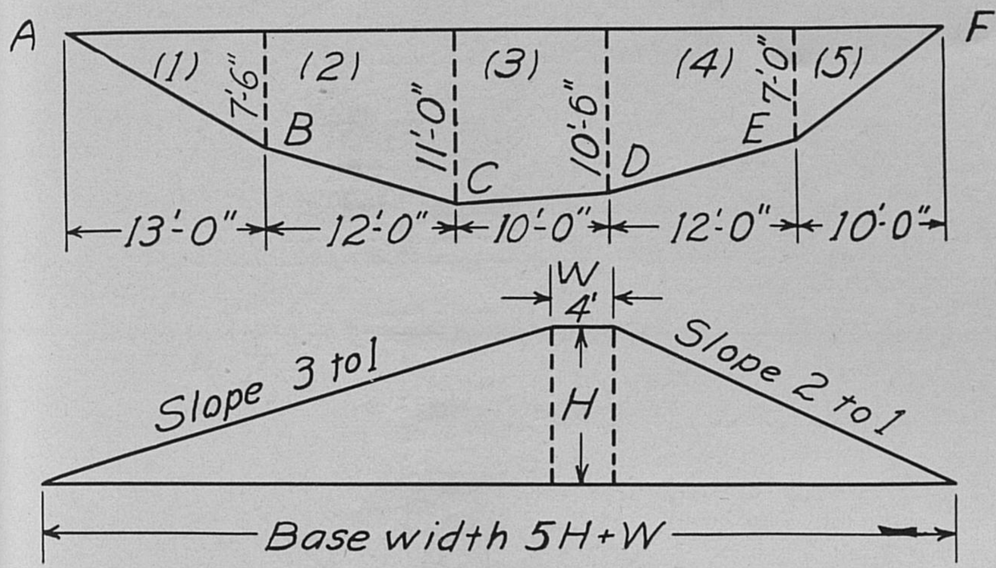

FIGURE 15. Sections thru lenth (upper) and width (lower) of dam to be constructed, showing dimensions.

TO CONSTRUCT THE DAM

The steps to be taken and suggestions for building the dam after plans have been completed are as follows:

Preliminary Work. 1. Clear the ground to be covered by the dam and reservoir of ail vegetation, stumps and tree roots.

2. Plow the area to be covered by the dam so that a bond may be established between the original surface and the earth fill.

Seepage Core. Dig the trench for the seepage core down to impervious subsoil, the full length of the dam, along its center line. The width should be at least 3 feet, but may be more to accommodate equipment such as a slip scraper. If a grader with a steel blade is used a cross section of the core trench may resemble the letter V. Fill the trench with well-packed clay or impervious soil.

Water Line to Stock Trough. 1. Dig a trench about 2 feet deep from the deepest part of the reservoir, across the dam site to the location for the stock trough below the dam.

2. Lay a 1½ inch or 2 inch galvanized pipe in the trench.

3. Pour concrete collars 24 inches square and 4 inches thick around the pipe to prevent seepage lines from developing, figure 15. At least two collars should be used and they should be placed within the limits of the upstream two-thirds of the dam.

4. Fill the trench with impervious soil, well tamped.

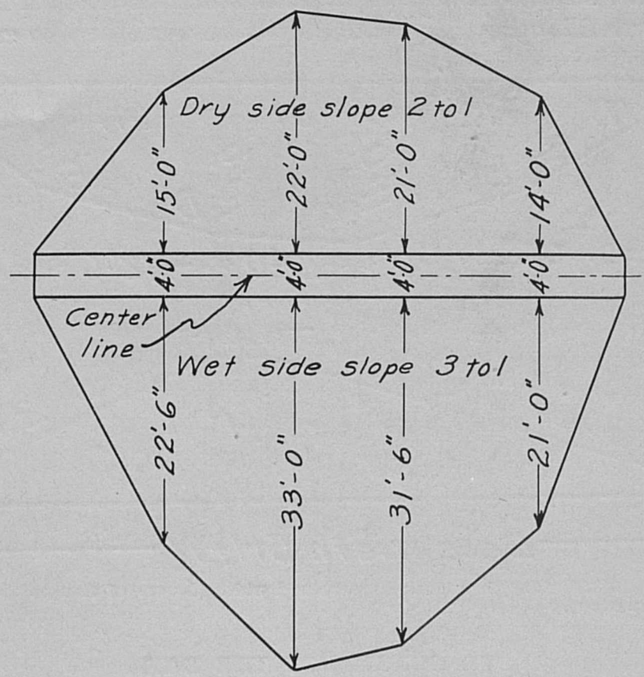

FIGURE 16. Plan of base of dam.

Making the Fill. 1. Work should be started by placing a layer of impervious soil over the entire base width of the dam. As the height is increased the width of the fill should be decreased so as to maintain the desired slopes.

2. Earth should be placed in the fill in layers not thicker than 12 inches and should be well packed by the equipment used in moving the earth.

3. Earth for making the fill should be taken from the area above the dam so as to increase the capacity of the reservoir, and form the spillway.

4. Do not remove more than one or two feet of soil from the area that will eventually be the deepest part of the basin immediately above the dam, otherwise seepage may occur under the dam.

This is especially true in sections of Kentucky where gravel or limestone are found in banks or layers beneath the top soil.

5. Continue to fill the center of the dam with impervious soil. The last 10 or 12 inches of fill on the top and lower slope of the dam should be of top soil in order that vegetation may be established quickly to prevent erosion.

6. Allow for settling according to the amount of packing the earth receives during construction. If a tractor is used in making the fill or the earth is well packed otherwise, add ½ inch for each foot of depth. If the soil is not packed well during construction, add 1 inch for each foot of depth. Since the depth of the fill is usually greatest midway between the ends, the top of the completed fill will not be level but will be slightly higher in the middle.

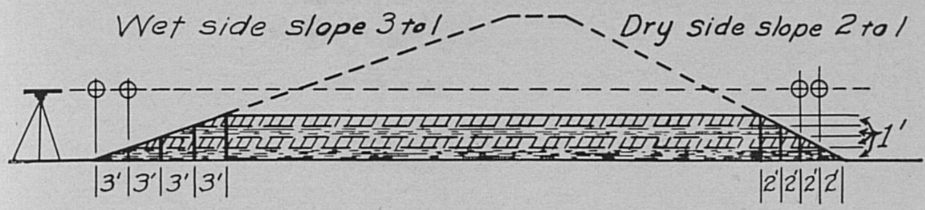

FIGURE 17 Cross section of dam showing method of setting grade stakes to obtain proper slopes of fill.

Maintain Proper Slopes During Construction. Some method should be used to maintain the desired slopes on the wet and dry sides of an earth dam. This can be done most conveniently by using a surveyor's, or farm, level and target rod and grade stakes. The steps to be taken are as follows (figure 17):

1. Level the area covered by the base of the dam by placing soil in low places, paying particular attention to the outside limits. The tops of stakes used to mark the boundry of the base of the dam should be driven level to assure accuracy in grading.

2. After the dam has been raised to the height of the stakes set, place another series of stakes two feet towards the center of the dam from the last stakes set on the lower side of the fill and three feet towards the center of the dam from the last stakes set on the upper side. Drive these stakes to a level one foot higher than the tops of the previous set of stakes.

3. Repeat the setting of stakes for each one foot height of fill until the desired height of the dam is reached. Under certain conditions, it may be desirable to set grade stakes at intervals of two feet vertically rather than one foot. In such cases, the horizonal interval for setting stakes on each side of the dam should be doubled.

Use of Soda Ash to Prevent Seepage. Recently, treatment of the basin of the reservoir and the upper side of the dam with soda ash (crude anhydrous sodium carbonate) to decrease the permeability of the soil to water, has been tried by a few farmers. When thoroly disked into the upper three inches of soil, it tends to deflocculate the clay, producing much the same effect as puddling the soil. The Soils Department and the Agricultural Engineering Department of Ohio State University concluded from their experiments that at least 25 percent of the soil should be clay, where soda ash is to be used. Most soil in Kentucky contains 25 percent or more of clay. Soda ash should ordinarily be applied at the rate of 1 pound to 3 square yards. Any chemical company can supply it.

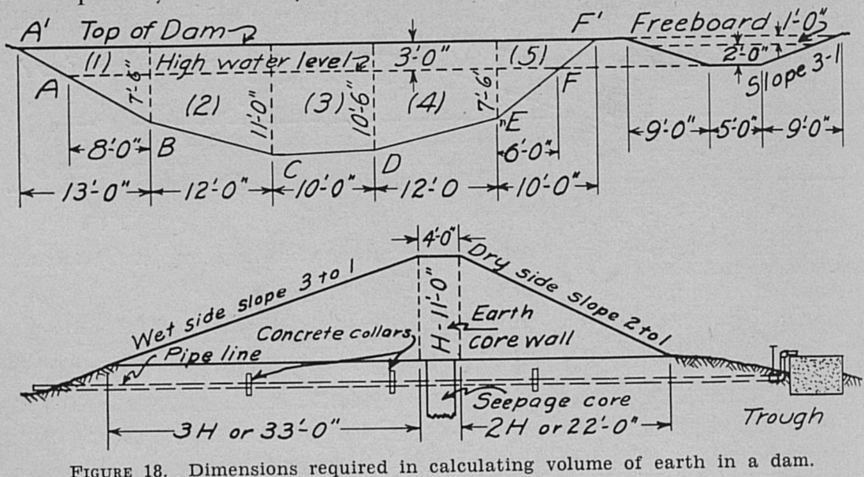

FIGURE 18. Dimensions required in calculating volume of earth in a dam.

Protect the Fill from Wave Action. The upper, or wet, side of the dam should be protected from the action of waves by stone paving laid without mortar, especially if the area of the reservoir exceeds one acre. If stone is not available, satisfactory results may be obtained with coarse gravel, provided that at least a 3 to 1 slope has been constructed. On farms where timber is available, it is possible to construct a boom by tying timbers together and placing them in such a manner that they rise and fall with normal variations in the water surface. The boom should be fastened so that it floats four or five feet from the top of the dam.

Seed the Slopes. The slopes of the dam not covered by water should be seeded to a mixture of grasses and legumes, to reduce erosion. Especially should the top and lower or dry side of the dam be so treated. Fertilizer may be used to advantage to hasten the forming of a sod. The seeded areas should be fenced to prevent livestock from destroying the grass before it becomes well established.

TO ESTIMATE THE VOLUME OF EARTH IN A DAM

The following method for determining the amount of earth in a small dam is accurate where the dam is constructed on ground of uniform slope.

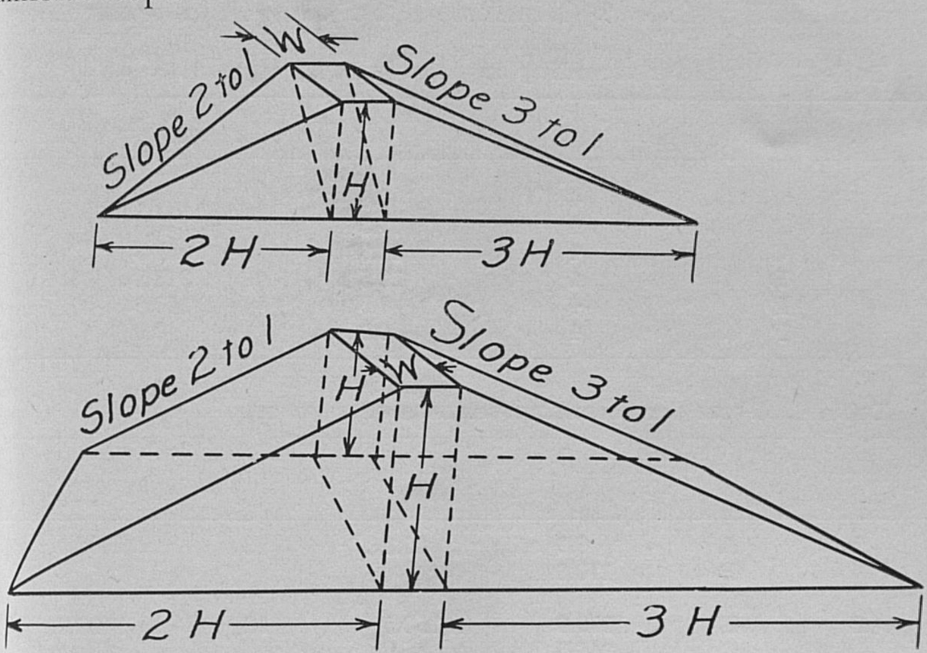

FIGURE 19. Separate segments of a dam. Upper, at end; lower, near center.

Determine the volume of each segment, as 1, 2, 3, 4, and 5, figure 18. The total volume of the dam equals the sum of the volume of all segments. A segment separated from the others resembles one of the drawings in figure 19.

Determine the volume of each segment of the dam as follows:

$$\text{Volume of segment} = \frac{\text{area of one end} + \text{area of opposite end}}{2} \times \text{length}$$

$$\text{Area of end} = (2.5\text{ H} + \text{W}) \times \text{H}$$

If the slopes of the fill are 3 to 1 and 2 to 1, and

H = height of end on center line of dam

W = width of dam at top.

Where slopes of the fill are not 3 to 1 and 2 to 1, the area of the end of a segment may be obtained by adding the area of a rectangle and two triangles, see figure 15. The area of the rectangle will be the height of the dam at the end of the segment times the width of the top of the dam (H × W).

The height of the triangles equals H, the height of the dam at the end of the segment. The base of either triangle will equal the height multiplied by the horizontal distance per foot of vertical distance. If the slope is 2 to 1, 3 to 1 or 4 to 1 multiply H by 2, 3, or 4, respectively, to obtain the base of the triangle. The area of a triangle $= \frac{\text{base} \times \text{height}}{2}$.

FORMS FOR KEEPING NOTES AND CALCULATIONS

A suggestion for procedure and form for keeping records and calculations is as follows (Dimensions are taken from figure 18):

Table 3. Form for recording areas of ends of segments.

Area at station	Top width W	Height H	Area A = (2.5 H + W) H
	feet	feet	sq. feet
A	4	0.0	0.0
B	4	7.5	170.6
C	4	11.0	346.5
D	4	10.5	317.6
E	4	7.0	150.5
F	4	0.0	0.0

Table 4. Form for recording volumes of segments.

Section number	End areas from table 3		Sum of end areas ÷ 2	Length of segment in ft.	Volume in cu. ft. (sum of end areas ÷ 2) × length
1	A	0.0	85.3	13	1108.9
	B	170.6			
2	B	170.6	258.5	12	3102.0
	C	346.5			
3	C	346.5	332.0	10	3320.0
	D	317.6			
4	D	317.6	234.0	12	2808.0
	E	150.5			
5	E	150.5	75.2	10	752.0
	F	0.0			
				Total cu. ft.	11090.9

Since 27 cu. ft. equal 1 cubic yard, 11090.9 cu. ft. = 410.7 cu. yards.

Improving Water in Reservoirs thru Sanitary Precautions. Farm reservoirs are not satisfactory sources of water for household use unless provision is made for treating the water to remove possible harmful bacteria. A reservoir should not be located where the drainage area around the barn or feeding place drains into it.

Contamination of the water is lessened if the entire reservoir including a 50- or 60-foot strip around the high-water mark, is fenced to exclude livestock. If this is done, a trough or pool must be located below the reservoir, to be filled by water flowing thru a pipe from the reservoir, as described previously in this circular (see figure 15). The water level in the trough may be controlled by a float valve or by means of a hand valve. To prevent freezing, the supply pipe from the reservoir to the trough must be buried at least 2 feet below the ground level. An underground stop-and-waste cock line in the line at the trough or a frost-proof hydrant would permit draining the part of the line exposed.

The one-celled algae which cause the water of a pond to appear green and which sometimes form a green scum on the surface, in the summer, can be destroyed or prevented by dissolving bluestone (copper sulfate) in the water, at the rate of 4 pounds to each million gallons. This strength does not injure fish. If fish are not to be protected, 8 pounds of bluestone to each million gallons of water may be used. It is best to apply bluestone early in the season and to repeat the treatment at intervals of 30 to 60 days, to prevent the accumulation of algae.

To apply bluestone, it should be put in a cloth bag at the end of a pole and moved thru the water behind a boat, or the bag may be fastened to a rope and drawn thru the water by men on the opposite sides of the reservoir. The number of gallons in a reservoir can be estimated by computing the number of cubic feet of water from the area and average depth, and multiplying this figure by 7½.

If the accumulation of algae is so great that much can be removed by dragging with a net, this should be done before treating with bluestone.

It is to be noted that a green scum sometimes consists of duckweed (Lemna). These little plants perhaps are not so objectionable as the algae, tho the green scum which they may form is unsightly.

DECREASING MENACE OF MOSQUITOES

The stocking of ponds and reservoirs with minnows is recommended as one of the effective methods of preventing small bodies of water from becoming mosquito breeding places. The destruction of all vegetation (except grass) from low-water level to a point above the high-water level also aids in decreasing the mosquito menace.