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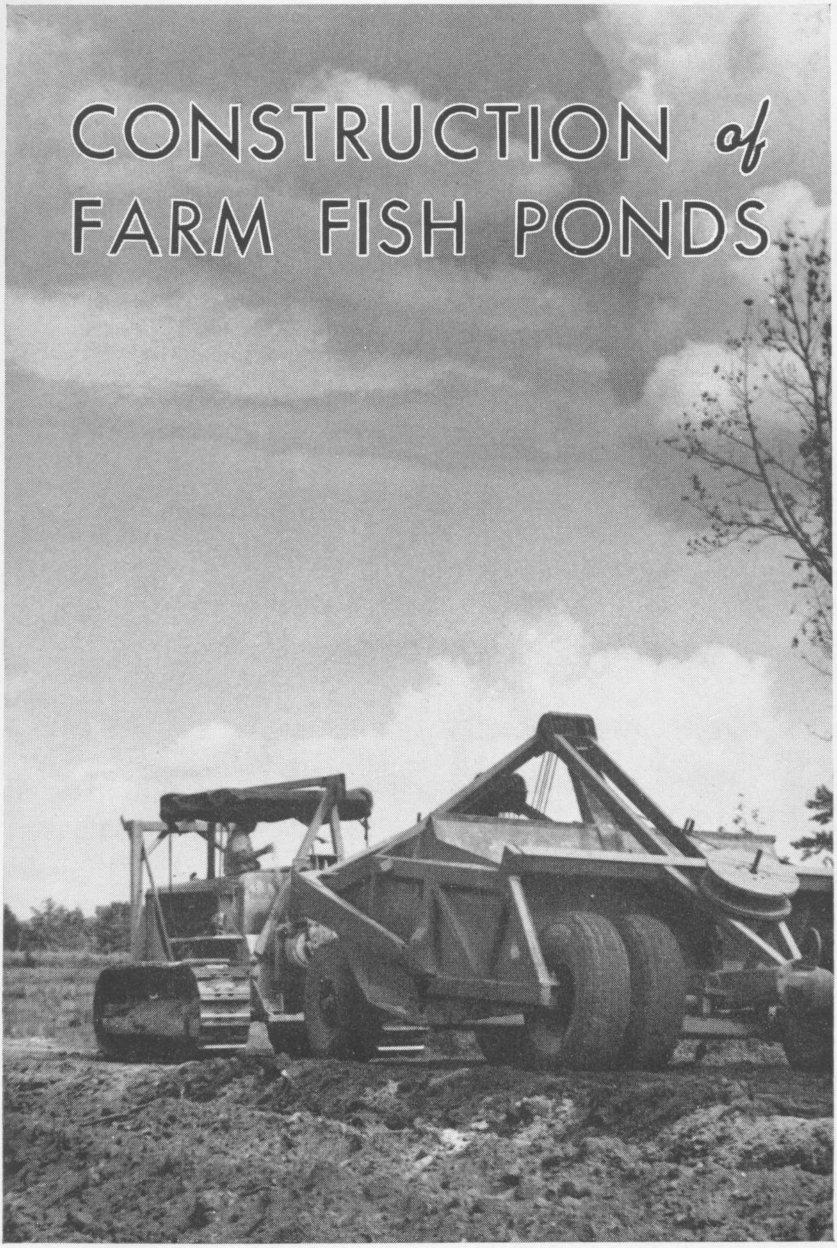
CONSTRUCTION of FARM FISH PONDS



AGRICULTURAL EXPERIMENT STATION
of the ALABAMA POLYTECHNIC INSTITUTE
M. J. Funchess, *Director* Auburn, Alabama

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CONSTRUCTION *of* FARM FISH PONDS

J. M LAWRENCE, *Assistant Fish Culturist*

ALABAMA had 6,388 ponds in operation according to a survey made in 1946. During the last 5 years, new ponds were built at the rate of 500 to 1,000 per year with a total of between 1,000 and 2,000 acres of water. This is a mere start in the development of an estimated 140,000 suitable sites available on the more than 200,000 farms in the state. This development rate should increase in the next few years as farmers become more conservation minded and as they use more of the water that falls on their land. The farm fish pond program is only in its infancy and as the knowledge of how to raise fish and use ponds for other purposes becomes more generally known, it will encourage the establishment of many more small ponds.

Farmers and sportsmen have been building small ponds for fish production and other purposes for many years. However, within the last 20 years pond construction has been greatly expanded due to several reasons. Notable among these are the more recently developed methods for pond fish culture that give excellent fishing in small ponds. In addition to fishing, small ponds already constructed are serving a number of other useful purposes on the farm today. In those sections of the state where livestock is the major business, ponds are widely used for stock-watering purposes. A few of the larger truck farmers have begun to use small ponds as a source of water to irrigate vegetable crops. On many farms water is pumped from small ponds to supply the needs of the barn and the home toilet. In several instances, ponds located near the farm buildings have been used to fight fires. Several large timber growers have used small ponds scattered over their holdings as a water supply for forest fire fighting, as well as a place to store their logs from the time they are cut until the mill can saw them. Numerous small farmer-owned sawmills and gins use small ponds to supply water for their steam boilers. These uses and the recreational facilities afforded the farm family combine to make the small pond an integral part of the progressive farm of today.

For the past 15 years, the Alabama Agricultural Experiment Station has been actively engaged in extensive pond building on its lands near Auburn. To date this Station has constructed 137 ponds for use in its fish production research. During this time a vast amount of information on pond construction has been obtained. Discussed in this publication are size and type of drainage area for a pond; water supply; type of soil necessary to hold water; design of the dam, pond drain, and spillway; and construction methods developed for building a pond.

REQUIREMENTS *for a* GOOD POND

Great care should be taken in selecting a pond site because economy of construction, usefulness, and productivity of the pond depend upon its location. When selecting a pond site, all places on the farm where a good pond might be built should be examined before the final choice is made. If some of the sites examined are questionable, the County Agent or Soil Conservation technician should be called in to help advise with the selection.

A suitable pond site should possess these three characteristics: (1) a topography that may be converted into a pond economically; (2) a subsoil that contains a sufficient amount of clay to hold water; (3) a water supply that will furnish an adequate but not excessive amount of water. In addition, consideration should be given to the location on the farm, especially if the pond is to be used for irrigation or for stock-watering purposes. From the recreational standpoint, ponds that are isolated are generally not as well cared for or used as those located nearer the farm home.

Topography

Topography is the surface features of a watershed, or in everyday terms the "lay of the land." Cost of construction can be greatly reduced if these surface features are used to the best advantage in building the pond.

Most of the existing ponds are built in natural hollows or draws by constructing a dam across the narrow neck and impounding the available water. This is an economical method for building the pond, since use is made of the natural features of the land to form three sides of the pond. On many farms in Alabama, there are hollows or draws that are swampy and stay wet most of the year. These areas are not suitable for farming purposes, but if they meet requirements they may be used for farm ponds. Thus, more land would be brought into productive use and the value of the farm would be increased.

Ofttimes there are no hollows or draws on farms that can be converted into a pond. In some instances, relatively flat bottoms that have a stream flowing through them may be used. In such cases a dam is built around two or three sides of the proposed pond and the water for filling the pond is diverted from the stream. Such construction is expensive, since a long dam has to be built. Also, the stream must have sufficient fall to allow the water to be diverted to fill the pond.

The sides or banks of the hollow or flat that is to be impounded must be sufficiently high to give a depth of water ranging between 6 and 20 feet at the deepest point along the dam. The 6-foot minimum is recommended only for those sites that have an adequate and constant water supply – one that would keep the pond full the year around with little overflow. The 20-foot maximum should not be exceeded for two reasons. First, dams higher than 20 feet are more expensive to build than long, low dams. Second, results of experiments have shown that the bluegill, one of the most valuable pond fishes, seldom feeds in water deeper than 15 feet. The upstream slope of the bottom of the hollow must be flat enough to allow impoundment of a considerable area of water for the size dam that will be constructed, but with an increased slope at the upper end of the proposed pond to give a minimum of shallow water.

Subsoil

Since a pond is nothing more than an earthen vessel for collecting and holding water, its dam and bottom must be composed of a soil material that will reduce seepage to a minimum. Clay soils are best adapted for this purpose. When these soils are compacted and moistened, the clay particles swell, thereby reducing the amount of water that can seep through.

Clay soils, which were formed centuries ago by the weathering of rocks, normally extend for a considerable depth below the surface. Today, in the Limestone Valleys and Piedmont soil regions, clay soils may be found at the surface on badly eroded hillsides or as much as 10 feet or more below the surface in hollows that have silted in. The clays found on the surface in the Black Belt were not produced locally. They were carried by water from the uplands farther north and deposited as sediments on the bottom of what was then an ocean. In the deep sand sections or Coastal Plain of Alabama, there are no true clay subsoils. The coarse soil particles in these sections were transported by water centuries ago from the highlands and deposited as sediments on the ocean bottom. In some of these sandy sections, there is enough sedimentary clay mixed with the sand to enable the soil to hold water. Where these clays are present, ponds may be built. (See Figure 1.)

Water Supply

Some suitable source of water must be available to the pond site. There should be enough water to fill the pond and maintain a water level that does not fluctuate more than 2 feet during the dry months. However, there should not be such a volume of water as to cause a heavy overflow from the pond. All water that flows from a pond is waste, and in addition it carries away the fertilizer that has been applied to make the fish grow. If there is a large amount of excess water from floods or any other source, some method for diverting this excess water around the pond should be devised.

Small ponds in Alabama receive their water from one or more of the following sources: surface run-off from lands, small streams, springs, artesian wells, or underground drainage. The type of subsoil on which the pond site is located will determine which source of water supply will be satisfactory.

Surface Run-Off. Rain water run-off from lands is one of the chief sources of water for many small ponds in operation today. While this is not a continuous source of water, it is usually sufficient to keep the water level of the pond located on a suitable site from fluctuating more than 2 feet during the dry periods.

There are several characteristics of the watershed in each area of Alabama that will affect the amount of run-off. These must be observed and considered when determining the suitability of a watershed for a pond. In addition to determining which water supply is satisfactory for a pond, the type of subsoil will affect the amount of surface run-off that can be expected from a watershed. Also, steepness of the slope will affect the amount of surface run-off, and type of vegetation on the watershed will affect the rate of run-off. While woodlands are recommended as watersheds for ponds, it has been estimated that they reduce the surface run-off approximately 50 per cent below that obtained from pastures because of the forest floor cover and high transpiration rate.

The lower and upper limits of the size of drainage area required to satisfactorily maintain each acre of pond for each soil area in Alabama are given in the paragraphs that follow. The one-acre pond referred to in the foregoing discussion of the size of the drainage area contains from 4 to 5 acre-feet of water. These drainage-area ratios for each acre of pond are based on observations made on a large number of ponds located in all sections of the state.

In the heavy clay soils, such as those found in the Black Belt and adjoining areas (Figure 1, Areas 1), the drainage area required to furnish enough run-off water from rains to fill and maintain satisfactorily the water level in an acre pond varies from about 4 to 8 acres of pasture land and from 6 to 16 acres of woodland. On extremely tight soils, on which water stands for days after a rain, the lower limits will furnish a sufficient amount of water. On the more porous soils in the southern portion of this area, the upper limits for the drainage area may have to be used. If the upper limits of these drainage areas are exceeded, a diversion ditch will be needed to prevent the excessive run-off from entering the pond.

The red clays (Piedmont) and the clay loams (Limestone Valleys) of central and northern Alabama (Figure 1, Areas 2) have fairly impervious subsoils, which may be underlain by decomposed porous rock or crevices. These soils are generally more porous and more variable in permeability than are those of the Black Belt and adjoining areas. In Areas 2 of the state, pond sites with semi-permanent or permanent streams or springs may be used if the ratio of the stream's or spring's watershed is 5 to 20 acres of pasture land or 10 to 40 acres of woodland per acre of pond. On tight clay subsoils in these areas, the

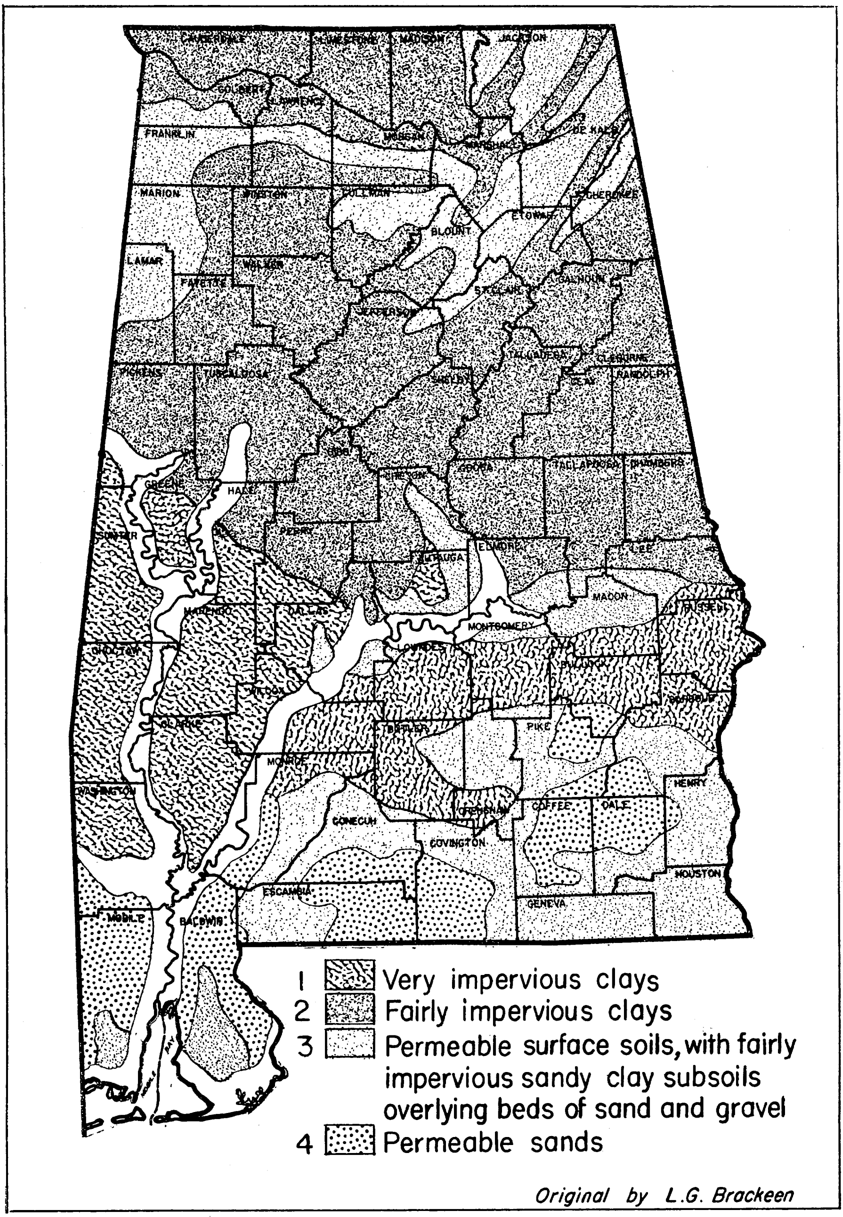


FIGURE 1. Soil areas of Alabama based on adaptability for pond sites.

lower limits of the drainage area may be used. The upper limits of the drainage area should be used on the more porous types of clay subsoils. However, as these upper limits are approached, the danger from excess water following heavy rains is increased. A diversion ditch will be needed to carry the excess water from heavy rains around the pond if these upper limits are exceeded.

The sandy surface soils of the Upper Coastal Plain, the Applachian Plateau, and portions of the Lower Coastal Plain (Figure 1, Areas 3) have fairly impervious subsoils underlain by beds of sand and gravel, which make these soils more porous than those in Areas 1 and Areas 2. In Areas 3 it is recommended that only those sites be developed into ponds that have a permanent stream flowing through them or a spring that supplies water the year-round. The ratio of the drainage area of the stream to the size of pond should be from 10 to 20 acres of pasture land or 20 to 40 acres of woodland per acre of impounded water.

In the deep sand region of southern Alabama (Figure 1, Areas 4) there is normally not enough clay in the subsoil to build a pond that will hold water satisfactorily. However, there are natural ponds and some constructed ponds in that area that hold water very well. These ponds are on bottoms that have a thick layer of silt or organic matter, often several feet deep, covering the underlying beds of sand and preventing excessive seepage of water.

Drainage area ratios per-acre-of-pond for all of the areas should be followed closely when selecting the pond site. If the pond is located on a watershed with a lower ratio than is recommended, there is likelihood that there will be an insufficient amount of water to maintain the pond satisfactorily. On the other hand, if the watershed ratio per-acre-of-pond exceeds the recommended ratio, there will be an excessive amount of water passing through the pond, unless an adequate diversion ditch is provided. The maximum amount that the upper limits of the drainage area may be exceeded safely is two times the upper limits recommended.

Drainage areas of open or cultivated lands require different treatments in various sections of the state. In the red clay sections, the land utilized as watershed for ponds should not be in cultivation. If it is cultivated, the ponds will become muddy and remain so most of the year. This condition will give poor fishing regardless of the amount of fertilizer that is applied to the pond. Such red land drainage areas should be terraced and then planted to some permanent soil conserving crop that will hold the soil erosion to a minimum. Any of the perennial legumes such as kudzu, lespedeza sericea, or permanent pasture crops will be satisfactory. Even on the woodland drainage areas in this section, some measure to stop gully erosion must be taken in order to prevent the pond from becoming muddy following a rain. If cultivated or bare land is in the drainage area, a diversion ditch should be constructed to by-pass this muddy water around the pond.

On Black Belt soils, the land should be terraced where necessary and then planted to permanent pasture. Water from cultivated lands in the drainage area should be diverted around the pond. Any erosion occurring in the woodlands that drain into the pond should be stopped.

On sandy soils that contain no red clays in the surface, cropland in the drainage area may be cultivated. However, the fields should be terraced. Although there is little likelihood of the pond becoming muddy, it would be better to plant a permanent crop to reduce the amount of sand entering the pond.

Small streams. Small streams are a satisfactory source of water for small ponds, provided they meet these requirements: (1) the flow is great enough to fill the pond and maintain a fairly constant water level, (2) the stream is not subject to excessive flooding, (3) the watershed is well vegetated, and (4) the stream carries a light silt load and remains fairly clear even during rainy periods.

The flow of the stream should be great enough to fill the pond in a reasonable length of time. This period will vary on different soil types and with different rainfalls. In most sections it should take from 2 to 6 months for the pond to fill if the stream's watershed (acre area) corresponds to the recommended ratio of surface run-off to acre of pond. There are instances where it has taken as long as 2 years for ponds to fill, but these were exceptional cases. If the pond fills in less than a month, the stream supplies too much water. In such cases the pond will have an excessive amount of overflow during rainy periods. A diversion ditch in such a case would be required for best results. It is desirable to have a stream that supplies enough water the year-round so that it will maintain a constant water level in the pond even during the driest months. However, if the stream dries up during the summer and fall months, and if the pond is constructed with a sufficient depth of water, it will retain enough water through these dry periods to maintain the fish.

Some small streams that drain large watersheds are subject to severe floods following heavy rains. If possible, these flooding streams are to be avoided as a water supply for small ponds. They not only furnish more water than is needed for the pond, but they usually carry a considerable amount of mud. Both of these conditions tend to reduce fish production. If this type of stream is the only water supply available for a pond, the possibility of diverting the stream around the pond should be considered. The best method for estimating the suitability of a stream is to use the same ratio of drainage area (per acre of pond) as that for surface run-off.

The watershed that the stream drains should be well vegetated, not only to reduce the amount of mud the stream will carry, but also to aid in stabilizing its flow.

Springs. Small springs when available furnish a good source of water for small ponds. There are two types of springs that are used for the water supply of a pond. One is the open type of spring where the water comes out of the ground in a very small area to produce a rather heavy, constant flow. The other type usually covers a rather large area and the water just seeps out of the ground. This is sometimes called "springy ground." Such seepage water may combine to form a flow that is great enough to support a small pond.

Artesian wells. Artesian wells may be used as a water supply in areas where they may be drilled. Normally, in utilizing this type of water supply, the well is drilled on the side of the pond several feet from the water's edge. The water from the well is flowed over a bed of gravel to aerate it before it enters the pond.

Underground seepage. Underground seepage is often used as the water supply for ponds formed in abandoned strip mines, rock quarries, or "bar-pits." As these are usually deep excavations, the bottom is often below the existing water table. In addition to this permanent water, there is usually a considerable amount of underground drainage that enters the pond during wet periods and helps maintain water level.

SELECTING *the* POND SITE

Actual selection of the site in the field requires that observations and studies of the conditions be made to determine if they comply with requirements. It must be borne in mind that each site examined varies in some way from others. Therefore, judgment is required in making the selection. The more experience a person has, the better will be his decision. The following is a guide for studies that should be made of a prospective site:

Topography

As a rule, one can depend on the eye to determine if the topography is suitable as a pond site. However, if there is any doubt as to whether a sufficient depth or area of water may be impounded, the area should be checked with a surveying level.

Testing the Subsoil

The subsoil should be checked by taking soil samples with a soil auger or posthole digger at frequent intervals in the area where the proposed dam is to be built.

Enough samples should be taken to make certain that there is a 3- to 4-foot layer of clay under the dam site. The test for suitable clay is to take a handful of the moist soil from the hole and compress it into a firm ball. If after a little handling the ball does not crumble, the soil contains enough clay for use in the dam. Otherwise, the soil contains insufficient clay for building the dam.

While taking these soil samples, it may also be determined how much excavation will have to be done in cutting the core trench.

In addition to the test holes in the dam-site area, samples should be taken in the vicinity of this area to determine if enough clay material is available to build the dam. Normally, clay is available much nearer the surface on the hillsides than in the pond bottom. However, it is recommended that as much as possible of the filling material for the dam come from within the pond area, except when the site is in an area where porous rock lies beneath the surface. In such a case, the bottom of the pond should be left undisturbed and the clay for the dam should be taken from the surrounding hills.

Surveying the Water Line

The proposed water level of the pond is established with a surveying level. As a rule, a 10- or 12-foot water level is used for the preliminary survey. This level may later be readjusted to the pond's topography or water supply.

The survey is made by establishing water level stakes at each end of the proposed dam and then projecting this level around the proposed pond area. Complete notes should be made on the direction and distance of each point established from the location of the surveying instrument. These notes may be plotted later to give the area of the pond at that water level.

When all of the points at the water level have been marked, a careful inspection should be made to determine if there are any large areas within the survey where the water will be less than 2 feet deep when the pond is filled. If there is a considerable area of the pond where the depth would be less than 2 feet, the water level should either be raised or lowered to eliminate as much of this shallow water as possible. If this cannot be done, the edges should be deepened while the pond is being built.

Water Supply

The available water supply must comply as nearly as possible with the requirements discussed in the previous section. The ratio of drainage area per-acre-of-pond must be computed and then compared with the recommended ratio for that particular type of soil.

While a good estimate of the acreage of the watershed may be made in the field, it is easily determined from aerial photographs. The area of the pond may be found by plotting the survey notes made when surveying the water level of the pond site. If it is found that the watershed is too large for the size of pond planned, it will be necessary to do one of two things – either enlarge the pond or divert some of the water around the pond. On the other hand, if the watershed is too small for the size of pond desired, the area of the pond will have to be decreased or the existing terraces changed to turn more water into the drainage area.

From the notes on the topography, subsoil, watershed, and pond area, it can be determined if the proposed site is suitable for a pond.

Estimating Yardage in Dam and Cost of Building Pond

Before letting a contract or proceeding with any construction of the dam, it is advisable to estimate the number of cubic yards of fill the proposed dam will contain. Offtimes after computing this yardage, it is found that it would be too costly to build the size of dam contemplated for the area of water to be impounded.

By use of Table 1 and the method described in the Appendix for determining the total volume of dirt, a fairly accurate estimate of the total yardage contained in the above-ground portion of the dam can be made. When estimating yardage contained in the core, the bottom is checked at intervals with a soil auger to determine the depth of the excavation needed to reach the subsoil. The width of the trench is then estimated, using the recommendations given in the section on excavating the core trench. The average width in yards of the core is multiplied by the average depth in yards of the core to give the average cross section, which is then multiplied by the length in yards of the core that is to be excavated. This gives the volume of dirt that has to be removed or excavated and the amount of dirt that will have to be hauled in to fill the core.

Cost of moving the dirt for building the dam can be estimated by multiplying the total number of cubic yards in the fill by the average local price for such work. The costs of the drain pipe and its installation, constructing the spillway, clearing the pond area, ditching dynamite, and other miscellaneous items should be included also in estimating total expense of building the dam.

TIME *to* CONSTRUCT POND

Most people believe a pond should be built anytime the money or equipment for building the pond is available, or when the urge to own a pond becomes so great that the pond must be completed as soon as possible. Unfortunately, this selected time may not be the best. The time a pond is built and filled with water is an important factor in pond management.

Ponds that are completed in mid-summer usually present the greatest problem in pond management. If the pond cannot be stocked with both bass and bluegills immediately, it will become overcrowded with bream or wild fish. Normally bass are not available for stocking after the first of July. If a pond completed in the summer is not filled with water immediately, weeds and brush will cover the bottom before fall. Thus, the bottom will again have to be cleared before the pond is filled by winter rains.

The most desirable time to finish a pond is in the late summer or fall. This is the period during which hatcheries have bluegills available for stocking. A pond finished during this period will fill with sufficient water to allow bluegills to be added in the fall or early winter. The bluegills will make some growth before the bass are added the following spring. Winter is a very undesirable time to attempt building a pond since bad weather hampers the work and much time is lost.

CONSTRUCTION PROCEDURE *for* EARTHEN DAM

The construction features discussed in this circular are for low earthen dams not to exceed 20 feet in height. If a larger dam is to be built, the advice and services of an engineer should be obtained.

Clearing Pond Area

Before any construction is started, all trees, brush, and other litter within the dam-site area must be cut and removed (Figure 2). Trees that are large enough to be used for lumber or firewood should be cut and hauled away. The smaller trees and brush can either be cut by hand and piled or they may be pushed up and piled by a bulldozer or root rake. All of the piles of brush, tree tops, and other trash should be removed from the dam area. Stumps in the dam site must be removed. They may be pushed out with a tractor or blown out with dynamite. No woody material that will eventually rot should be left in the dam area, since it might later cause a leak in the dam.

The clearing operation must eventually be done over the entire pond area. Also, the trees and brush on the banks above water level must be cut at least 15 feet back from the water line to comply with the public health regulations. If the owner intends to fly fish from the bank, it is advisable to cut the trees and brush back 30 feet from the edge. It is not necessary to remove the brush from within the pond area, but it should be piled and burned. While stumps do not have to be removed, they should be cut close enough to the ground so that their tops will not extend above water.

Marking Base for Dam

As soon as the dam site is cleared, the outline of the dam's foundation is marked with stakes. The layout (Figure 3) should show the proposed top width of the dam when it is finished and the area which the foundation of the dam will cover.

Marking the top width. One row of the top-width stakes should be set in a straight line from the water-level stake on one bank to the water-level stake on the opposite bank (Figure 4). At this time reference stakes for re-establishing the top line as construction progresses should be set a considerable distance above the water-level stakes on each bank (Figure 4). The other row of top-width stakes is placed opposite the first row of stakes at a distance equal to the width of the top of the dam. In Figure 4 the top width is 12 feet. This width is necessary on dams that are to be built with large tractor equipment. If teams are used to build the dam, the top width may be reduced. However, 5 feet is the minimum top width recommended for an earthen dam. In many instances it may be desirable to have the top width of the dam greater than 12 feet, so that the dam may be used as a roadway when it is completed.

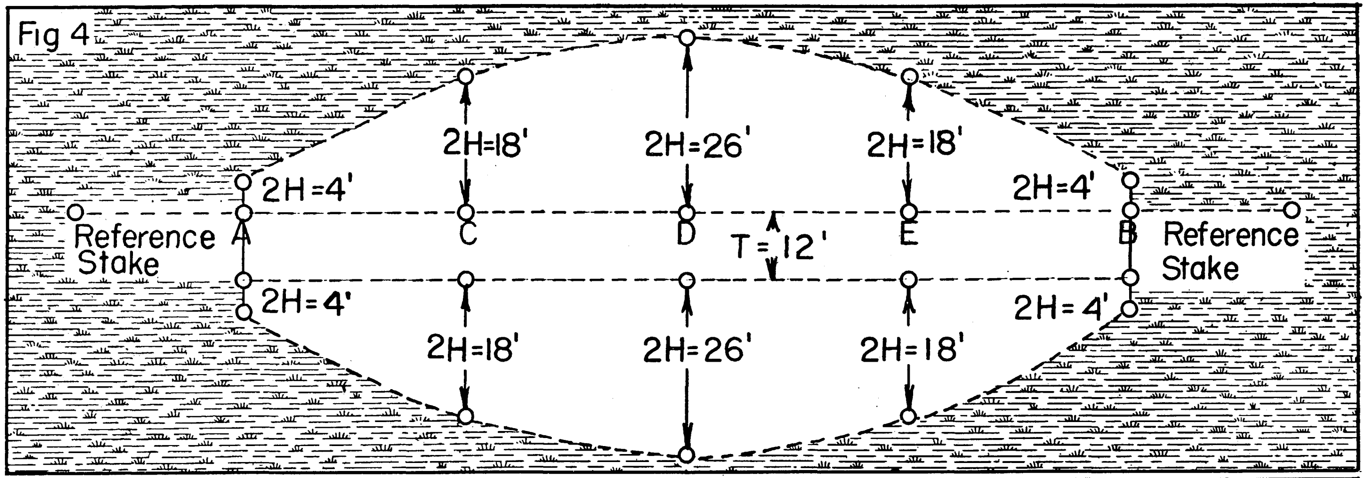
FIGURE 2. Tractors and teams are used to remove the trees, brush, and ground litter from a dam site in preparation for marking off the base of the dam.

FIGURE 3. In the layout of proposed base of dam shown here, the two straight lines of stakes across the hollow outline the width of top of the dam when it is completed. The outside rows of stakes (toe-stakes) outline the area that the base of the dam will cover.

Setting the toe stakes. The sides of an earthen dam must be built to a certain minimum slope if they are to stay in place and not slide when the dam becomes wet. The most economical and satisfactory slope for low dams is 2-to-1 on both the upstream and downstream side. The 2-to-1 slope means that for each foot of height in the dam at a given point the base extends 2 feet on each side. Under no conditions is it recommended that the slope on earthen dams be less than 2-to-1. It is seldom necessary to increase the slope to greater than 2-to-1 on earthen dams of less than 20-foot height when properly packed during construction.

All earthen dams must have some extra height above water level to prevent waves and floods from flowing over the dam and washing it out. This extra height is known as *freeboard*. On low dams that impound small areas of water of 3 acres or less, 2 feet of freeboard is enough. A 3-foot freeboard is recommended on dams that impound larger areas of water where the wind-wave action may be great.

Toe stakes, which outline the edge of the foundation of the dam are set after the top-width stakes are established. The toe stakes are set on each side of the top-width stakes at a distance 2 times as great as the dam is high at that point. In Figure 5 the height (H) of the dam at point C is 9 feet. In Figure 4



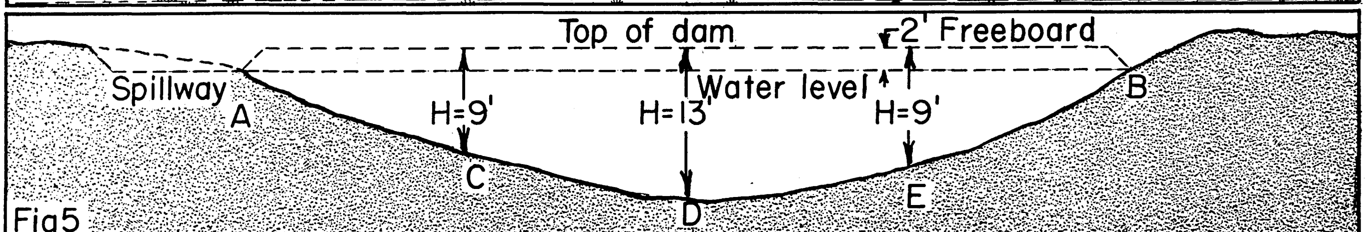


FIGURE 4. From points A, C, D, E and B, measure over 12 feet for top width of dam. The toe stakes, which outline area of dam foundation, are then placed a distance 2 times height (H) of dam at that point on each side of top-width stakes.

FIGURE 5. In laying off dam with a level, first mark points A and B at water level with stakes. Then mark points C, D, and E. Determine distance (H) from points C, D, and E to top of proposed dam, which is 2 feet above water level.

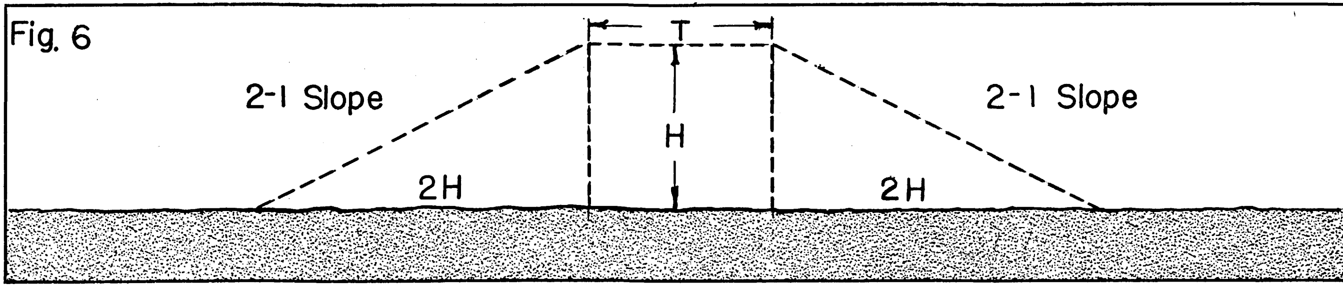
at point C the height (H) is multiplied by 2 to give 18 feet as the base width of the dam on each side of the top width. The width of the entire dam foundation at any point is 4H + T (T = top width of dam), Figure 6.

Setting toe stakes on a slope. There are instances where the slope of the ground varies considerably from the upstream toe of the dam to the downstream toe. In such cases where the difference in height between the two points is 2 feet or more, it will be necessary to establish the distance of the toe stakes on each side of the dam separately to maintain approximately a 2-to-1 slope. In Figure 7, 2H is measured out on each side of T to give points A and B, respectively, as the normal toe stakes for the dam base. The slope on the side from point A to the top of the dam is greater than 2-to-1, because the ground level slopes downhill from this point to the center of base of the dam. To correct this, the height (h) between point A and the top of the dam is determined, and 2h is measured out from the top width to establish the corrected toe stake at point A^1.

The slope of the side from point B to the top of the dam is less than 2-to-1 because the ground level slopes uphill from this point to the center of the base of the dam. The height (h^1) between point B and the top of the dam is determined, and $2h^1$ is measured out from the top width to give the corrected toe stake point B^1. While the slope of the sides on both the upstream and downstream sides of the dam is not exactly 2-to-1 even after this correction, it is close enough for practical purposes.

Removal of Topsoil from Base Area of the Dam

When the toe stakes have all been established, removal of the topsoil within the outlined area is begun (Figure 8). The topsoil is removed for a depth of one foot or more below the surface, since this layer usually contains a large amount of roots and other organic materials that would prevent a good bond between the soil of the pond bottom and the base of the dam. It is permissible to use this topsoil in the downstream toe of the dam, but it should not be used at any other place in the dam. The core trench is cut immediately following the removal of as much topsoil as possible within the base area.



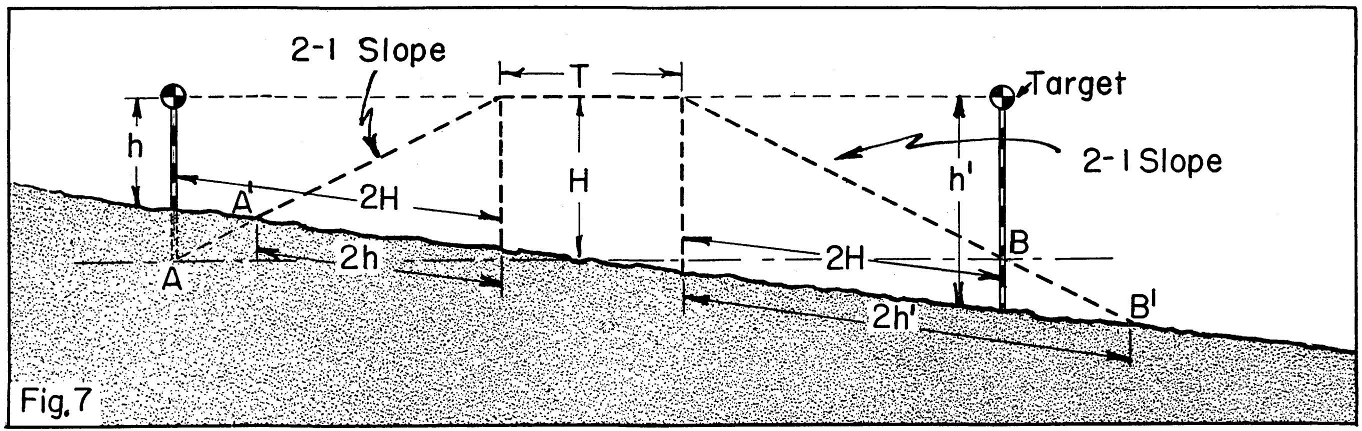


FIGURE 6. Cross-section through center of the dam shows the 2-to-1 slope of the sides. This is on a site that has only slight grade between upstream and downstream toes.
FIGURE 7. Illustrated here is the method for setting toe-stakes of dam on a site having a greater slope than 2 feet between upstream and downstream toes, and described in text, page 19. This procedure is used to obtain an approximate 2-to-1 slope on both sides of the completed dam.

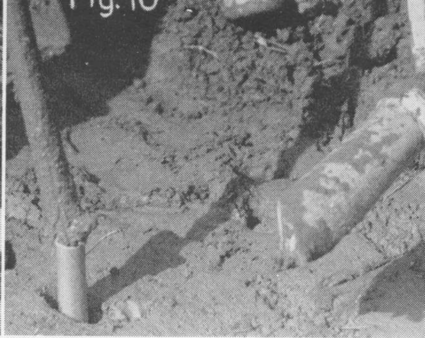
Excavating the Core Trench

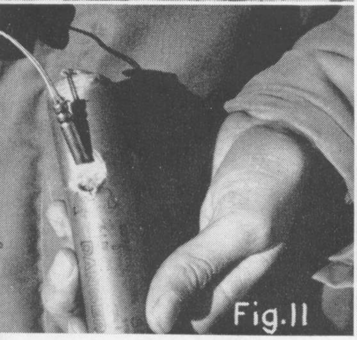
The earthen dam must have a clay core bonding the above-ground portion of the dam to the subsoil of the pond bottom (Figure 6). This is to prevent excessive seepage of water through the porous soils between the surface and the subsoil.

Relatively impervious clay must extend the full length of the dam and reach from the subsoil of the pond bottom to the height of the water level of the dam. The trench for the underground core should be dug approximately 10 feet wide where the soil is a relatively impervious clay. In more porous base materials, the width of the core trench at any point should be approximately twice the proposed water depth at that point. The depth of the excavation will vary depending on the amount of deposits that must be removed. However, it should extend for at least 3 feet or more into the subsoil. This trench may be dug by hand, power equipment, or the boggy area may be blown out with ditching dynamite.

If the hollow is too boggy for heavy equipment to work, it is cheaper and more desirable to blast the core trench with ditching dynamite than to try digging it by hand or with a drag line. If blasting is necessary, it should be done before the tractors start cutting the core trench on the hillsides, since the clay from the hillsides can be used to fill the excavation made by the dynamite.

FIGURE 8. Tractor with bulldozer attachment pushes topsoil from base of the dam to the downstream toe. This operation is done prior to cutting the core trench.





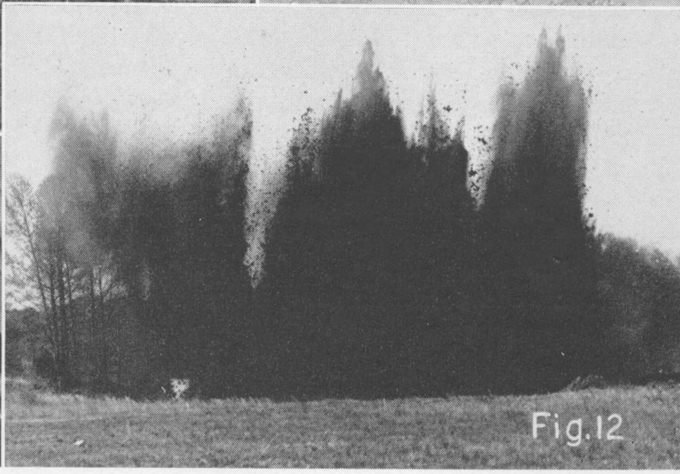


FIGURE 9. Guide stakes are set along center of core preparatory to setting dynamite. FIGURE 10. Close-up of method of punching holes and inserting sticks of ditching dynamite. FIGURE 11. Electric cap is inserted in hole punched in side of dynamite stick. This hole should be about 3 inches deep and one-half inch in diameter. FIGURE. 12. Cap is ignited and entire line of dynamite is exploded. Note the height to which mud and dirt are thrown. Since most of this material falls outside of trench, no one should be nearer than 500 feet.

Use of ditching dynamite. Ditching dynamite is a nitroglycerine explosive specially prepared for open ditch work. Since this dynamite is highly explosive, it can be exploded by shock. Therefore, it must be handled with care. This sensitivity to shock makes it possible to load a series of charges at given intervals in a line several hundred feet long and explode the entire line by a single blasting cap. When the cap is fired, the shock is carried from charge to charge through the soil water and fires each successive charge in the line. The test for sufficient soil water to transmit the shock is when drops of water exude from a lump of soil squeezed tightly in the hand.

Preparatory to blasting the core trench, guide stakes such as are shown in Figure 9 should be set along the center of the core in the wet area. The holes for loading the charges of ditching dynamite are then punched along this established line. An iron pipe 1½ inches in diameter with a pointed end and approximately 6 feet long makes a good punch bar. If the soil is very wet or boggy, the holes may be spaced 15 inches apart and approximately 4 feet deep. On the other hand, the holes should not be more than 12 inches apart if the soil is only moderately wet.

The holes are loaded with 2 or 3 sticks of 50 per cent ditching dynamite, using a *wooden* punch to push the sticks into the holes (Figure 10). Even though nitroglycerine explosives are more resistant to water than are other types, once loading is started it should be completed as rapidly as possible and the charge exploded. For best results, the charges should never be in water for more than 2 hours before exploding.

If stumps or large stones are encountered along the line on which the ditching dynamite is being set, additional holes loaded with 3 or 4 sticks of dynamite should be placed around such objects so that the shock along the line is not broken.

When all charges have been set, one stick of the ditching dynamite is fitted with an electric blasting cap (Figure 11). This stick is then inserted in one of the charged holes near the end of the line and a little mud placed over the hole to seal it. The wire leads from the cap are fastened together and should be left that way until the leads are connected to the blasting cable. The blasting cable, which should be not less than 500 feet long, is laid in a straight line with the charges of dynamite and away from the end of the ditch where the cap is placed. This method gives more protection to the operator, since there is less debris thrown from the ends of the ditch than from the sides. The electric blasting machine is located at the end of the blasting cable, but is not connected to the cable until the cap is connected. The handle for firing this machine should be in the hands of the operator at all times, since he will be responsible for making *all connections.* When all the equipment is laid out, the operator connects the leads from the cap to the blasting cable. The bare joints should be laid on a stick or limb to prevent a ground in the circuit when the current passes through. The operator at this time makes sure no person is within 500 feet of the area to be blasted. He then connects the blasting machine to the cable. The handle is inserted and given a quick turn, thereby exploding the cap and setting off all of the charges of dynamite (Figure 12).

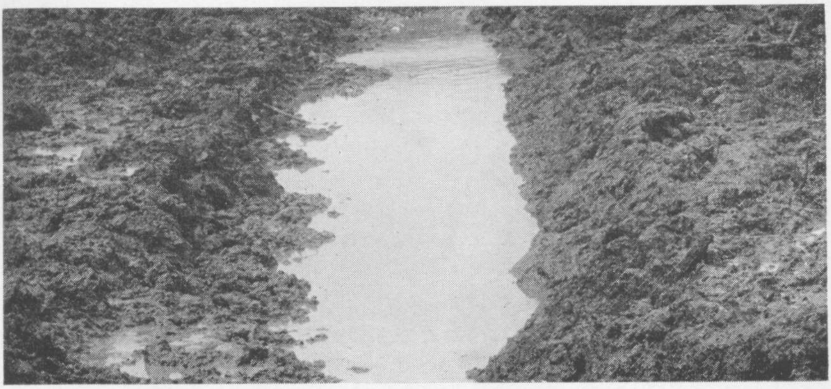


FIGURE 13. The first blast did not remove all porous materials from bottom of trench. Therefore, a second loading will be needed on one bank to widen trench, which then may be deepened by a later blast loaded in trench bottom.

The electric cap is recommended over the fused cap because of its safety and efficiency. When a current is passed through an electric cap and it does not fire, it is safe to disconnect the cable from the blasting machine and then replace the useless cap. However, before discarding the cap, all connections and the entire cable should be checked to make certain that there is no short circuit or broken wires. If, after checking connections and again trying to fire the cap, it does not explode, the cap is probably faulty and should be discarded and replaced. The firing procedure is then repeated.

If a fused cap is used and fails to fire in the allotted time for the fuse to burn down to the cap, it is not safe to check this cap for at least 24 hours. Fused caps have been known to explode 18 hours after the fuse was lighted.

The trench made by the first blast, Figure 13, is usually from 4 to 6 feet deep and 8 to 12 feet wide. While the trench may be fairly uniform in size from one end to the other, more likely it will be wider and deeper in the wet, silty area than on the drier ends where there is clay.

As soon as the smoke and fumes have blown away from the trench, a careful inspection of the soil in the bottom of the trench should be made. If it is found that the clay subsoil has been fully exposed across the bottom and that the trench is wide enough, no further blasting will be necessary. On the other hand, additional blasting should be done if the subsoil has been uncovered only on the ends of the trench and the middle still contains a considerable amount of silt, sand, and gravel, or if the trench needs to be widened.

If a second blast has to be made, the charges of dynamite should be placed 12 inches apart on one bank approximately half way between the top and the bottom of the trench. The second blast is to widen the trench. In the foreground of Figure 14 is shown a portion of a trench that has been blasted the second time. Such widening of the trench in the wet, silty area is necessary to give sufficient space on each side for later charges of dynamite to blow the sand out of the trench bottom.

If sand and muck are still present after the second blast, a third charge should be used. This charge is loaded on the opposite bank if the trench needs to be widened, or in the bottom if the trench needs to be deepened. If this third blast does not remove all of the undesirable materials from the trench, a fourth line of charges may be loaded in the bottom of the trench and exploded. This shot should deepen the trench sufficiently, since there is ample space for the sand to be blown out.

If blasting will not remove all of the sand and silt from the bottom of the ditch, clay pushed into each end of the ditch may be used to force this muck out. When this method is used, a small channel is blasted on the downstream side of the core trench at the lowest point in the hollow. This channel is placed at a right angle or crosswise to the core trench and extends for a sufficient distance below the trench to dispose of the muck that will be forced through it and beyond base of the dam.

The tractors now start pushing clay into the ends of the blasted core trench and as this clay is applied and packed it forces the muck before it into the disposal channel. This operation should be carried on from each end of the dam to force out the muck.

When forcing muck from the ditch with clay, a check must be made frequently with a soil auger to see that the applied clay is forcing the muck be-

FIG. 14. Shown in foreground is a portion of the trench that has been blasted a second time. The men are loading dynamite to complete the second line of charge.

fore it and that the clay is uniting with the clay subsoil across the bottom.

Ditching dynamite accomplishes two things in blasting a core trench for a dam. When the dynamite explodes, it exerts equal pressure in all directions. The downward and sidewise pressure breaks up and packs the soil in the bottom and sides of the trench while the upward force throws the material above it out of the trench. This tremendous pressure in the bottom and sides of the trench collapses and closes small water channels in the subsoil, makes the clay tighter, and reduces seepage of water beneath the core.

Where subsoils are relatively porous, it is desirable to blast the bottom of the core for the dam in order to help seal the seepage channels. This may be advisable even though a deep trench may be cut from end to end by tractor equipment. On moist soils this can be done by punching holes, loading the dynamite, and then filling the holes with water to saturate the soil before the dynamite is exploded. If the soil is dry, it is not practical to use ditching dynamite.

Filling the Core Trench

When the core trench across the wet area has been satisfactorily cleaned out, it is refilled with good clay. Normally, if there is a stream, the trench will accumulate water before it is refilled. This water is desirable since it will aid in flushing out any sand or other debris that is left in the trench when the clay is pushed in. Also the water will allow a greater compaction of the clay and give a better seal in the core. To obtain clay for filling this trench across the bottom, the ends of the trench on the hillsides are now extended to each end of the dam and this clay is pushed into the bottom (Figure 15). Normally enough clay can be obtained from these hillside trenches to completely fill the trench across the bottom. It is advisable to cut these hillside trenches 4 to 6 feet or more into the clay to break up underground seepage channels. The depth of the cut into the clay on the hillside can only be properly determined by examination of the sides of the cut while it is being made. As underground seepage channels are encountered, water will flow from them into the open excavation. Underground channels flowing a 1-inch stream have been uncovered at depths of six feet in Piedmont soils. To reduce seepage to a minimum, excava-

FIGURE 15. All undesirable materials have been blasted from trench in the boggy area. The tractor is now starting to cut the trench on the hillside. This good clay is used to fill the trench across the bottom.

tion should be continued to a point several feet below the lowest encountered underground water channel.

When the tractors have finished cutting the core trench from water level to water level, that portion of the trench that is still open should be refilled with clay from the nearby hillsides. The clay used in filling this trench should be the best obtainable in the area. As soon as the entire core trench is filled, the dam foundation on one side of the bottom is filled to a depth of approximately 3 feet (Figure 16). This filling on one side of the bottom leaves a low space on the other side where water may be diverted while the drain pipe is being installed.

Installation of Drain

A drain pipe should be installed in every pond built so that it may be completely drained. Whenever it becomes necessary, the pond can be emptied and re-established for high fish production. Also, the State Board of Health in Alabama requires that all ponds constructed be equipped with such a drain pipe.

The drain pipe should be installed at the lowest point in the pond so that all of the water may be drained. A check should be made before the pond is filled to make certain that there are no low spots from which the water will not drain. Such holes will fill with fish whenever the pond is drained. This makes removal of all fish from the pond difficult. Such low spots should be filled in and sloped toward the drain.

FIGURE 16. Shown here is base of the dam that has been built to a height of 4 feet above the stream, which is being diverted on the left. The ditch for installing the drain pipe has been dug across fill on the right.

Cutting drain pipe ditch. In cutting the drain pipe ditch through the dam foundation, a bulldozer can be used to push out the bulk of the soil. The final shaping of the ditch is then done by hand, or the entire ditch may be dug by hand. If the dam is being built across a flowing stream, the water should be diverted over that portion of the dam foundation that has not been filled (Figure 16) until the drain pipe and valve have been completely installed and the concrete work allowed to set-up for 48 hours. Subsequently, the stream is turned through the drain pipe and the unfilled portion of the dam's foundation is filled with clay until the top of the entire foundation is level. If possible no water should be present in the ditch while the drain pipe is being laid and the concrete is setting up.

The ditch for the drain should be straight, deep enough to drain all of the water, wide enough in which to work, and should have a slope of about 1 foot per 100 linear feet. Care should be taken to see that this slope is distributed evenly along the ditch.

Size of drain pipe. Size of drain pipe needed depends upon the size of the pond and upon the volume of water running into the pond. A 4-inch drain will empty an acre pond having a maximum depth of 9 feet and an average depth of 3 to 4 feet in about 60 hours if no water is entering the pond during this period. A 6-inch drain will empty the same pond in half of that time, while a 12-inch drain will require a ninth as much time. In a majority of cases, a 4- to 6-inch drain will be satisfactory for ponds up to 3 acres in size; while 6- to 12-inch drains will be necessary for larger ponds up to 15 to 20 acres.

Types of drain pipe. When the ditch is completed, the drain pipe is laid. There are a number of different types of pipes adapted to use as pond drains. The advantages and disadvantages of each type are as follows:

Asbestos-cement pipe, Figure 17, is probably the best type to use for a pond drain. It comes in long lengths, may be obtained in various diameters, and is durable. The main disadvantage is that special equipment is necessary to assemble the rubber ring and collar joint, as shown in Figure 17.

The second best is cast iron pipe, Figure 18. It may be obtained in most any desired length and diameter, is durable, and as a rule is readily available. Its main disadvantages are that the joints and pipe are not flexible, and it is expensive.

Cast iron pipe can be obtained with several types of joints. The common type is the straight nipple on one end and bell on the other. This type is assembled by placing the nipple end of one pipe into the bell end of the next pipe. The joint may then be sealed by packing with oakum and pouring a heavy concrete collar around it, or by filling it with melted lead or an asphalt compound.

Also available is a prepared joint, the bell of which is packed with oakum and equipped with a lead ring poured in place by the manufacturer. To assemble the joint, the nipple end of one pipe is placed in the prepared bell of another. The lead ring is then pounded tight with a punch and hammer to make the seal. This makes a water-tight and rigid joint.

Another mechanical joint available also has bell and nipple ends. The bell, however, has a flange with bolt holes. This joint is assembled by placing a metal ring with matching bolt holes and a tapered rubber ring on the nipple end of the pipe. This assembly is then

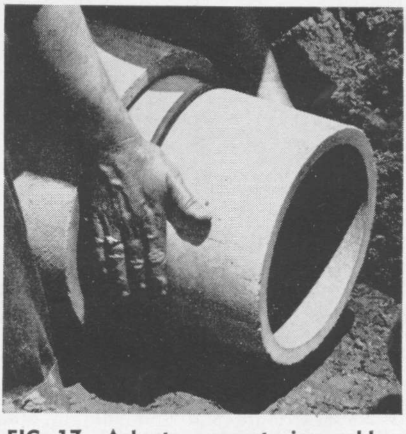


FIG. 17. Asbestos-cement pipe, rubber, rings, and collar used to assemble joint.

placed in the bell. The joint is sealed by bolting the movable flange and compressing the rubber ring between flanges.

Galvanized pipe may be used in small ponds and minnow hatchery ponds. While this pipe is very satisfactory, it is expensive. The ends of this type of pipe are threaded, and are assembled with threaded couplings.

Terra cotta pipe is undesirable to use for a pond drain. It cracks under slight pressure or movement, and therefore, should not be used as a drain pipe.

Concrete tile is also undesirable. Not only does this pipe crack easily but some waters will cause the pipe to completely disintegrate.

Assembling the pipe line. Before assembly of the pipe line is attempted, the joints should be laid in the ditch and the location of the valve determined (Figure 18). Assembly of joints should then start at the valve end and work toward the lower end of the drain.

If asbestos-cement pipe is used, the joints are preferably put together with a collar and rubber rings (Figure 17), using a hydraulic jack to pull the collar into place (Figure 19). It is necessary that all dirt, dust, and mud be removed from the ends of the pipe and that the joints be absolutely dry before

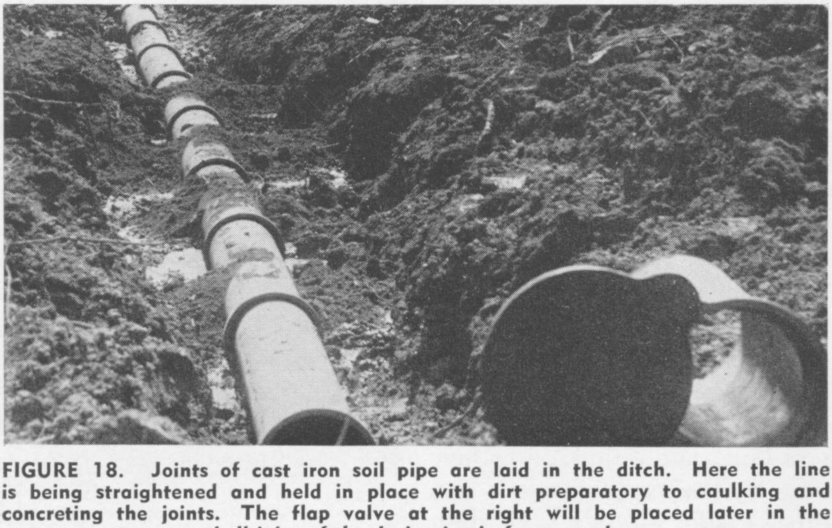


FIGURE 18. Joints of cast iron soil pipe are laid in the ditch. Here the line is being straightened and held in place with dirt preparatory to caulking and concreting the joints. The flap valve at the right will be placed later in the bell joint of the drain pipe in foreground.

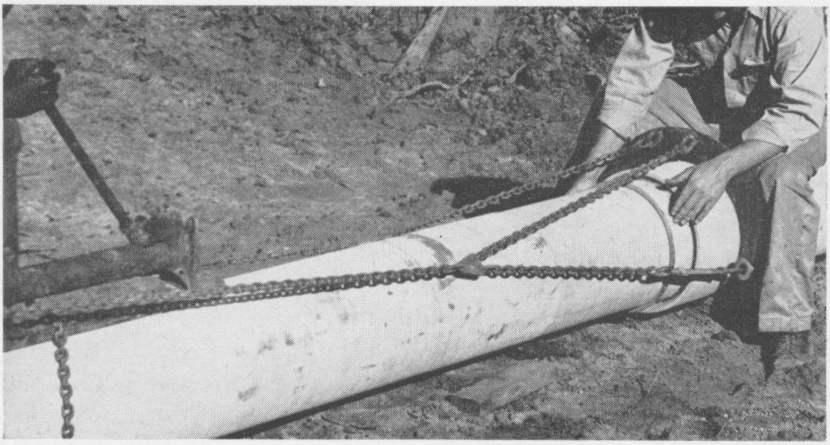


FIGURE 19. A hydraulic jack assembly, as shown, is used to pull the collar in place over the rubber ring to seal the joint of asbestos-cement pipe.

the pipes are pulled together. No other sealing is necessary. However, some concrete cut-off collars, such as those around the bell of the cast iron joints, should be placed along the pipe line at approximately 15-foot intervals to prevent seepage along the sides of the pipe.

If a jack is not available to assemble the rubber rings and collar, the joints of asbestos-cement pipe may be sealed with concrete. In such a case the asbestos-cement collar is placed on one end and the end of another pipe is jammed against the end of the collared pipe. The collar is then slipped over the joint between the two pipes. Each end of the collar is then packed with oakum and a heavy concrete block is poured around the collar. The concrete should extend about 4 inches onto each pipe.

If cast iron or some other type of pipe is used that has no prepared or mechanical joint, a different assembly procedure has to be followed. The pipes are placed in the ditch one at a time, beginning at the valve end and working toward the lower end. As each joint is laid a small trench is dug under the bell of the joint so that this joint may later be sealed with concrete. All joints are then packed or caulked with oakum, which helps to seal and to prevent concrete from running inside the pipe. The pipe line is then ready to be concreted together. To save time and concrete, small earthen walls are built across the trench on each side of the joint to about 4 inches above the

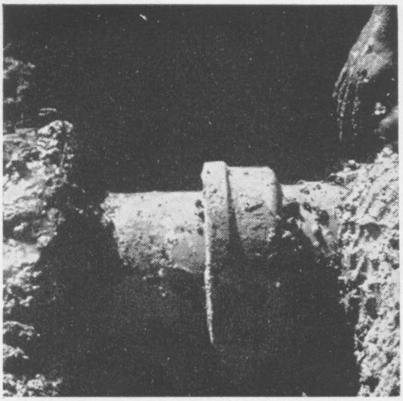


FIG. 20. Shown here is a joint between two cast iron soil pipes. Small clay walls at left and right serve as forms for the concrete joint.

bell (Figure 20). The purpose of these walls is to provide a small form for the concrete collar.

The concrete mixture used for these collars consists of: 1 part portland cement, and 2 parts sand. Only enough water is used to make a stiff, workable mixture.

The mixture is poured in the small form around each joint and then carefully tamped to make sure it flows well around the bell of the pipe. The concrete collars are brought to approximately 4 inches above the top of the pipe and then smoothed. As soon as each of the collars is poured, clay is placed around the entire line and well tamped (Figure 21). The trench is then filled with well-packed clay for at least 4 or more feet above the pipe before the concrete has set. This should be done immediately. If the concrete is allowed to harden before this filling is done, the joints will be cracked by the heavy tractor equipment. No other collars are needed along the pipe of this type of assembly, since these joints break the seepage channels.

There are a number of other ways in addition to the concrete method just described to seal the joints of cast iron pipe. Any of the standard methods of sealing the joints of cast iron pipe is satisfactory if proper care is used to obtain a watertight seal on each joint.

FIG. 21. As soon as the joints are poured, they are covered with thin layers of clay. The clay is then applied along each side of pipe. It is wet and well packed to a height of 4 or more feet over pipe before concrete hardens.

Preventing seepage along drain pipe. Serious trouble from seepage along the drain pipe can result if concrete cut-off collars are not placed along the drain pipe, or if the clay is not packed well around the collars and the pipe as the ditch is being refilled. The cut-off collars, especially on the asbestos-cement and cast iron pipe, which are assembled with mechanical or prepared joints, should be anchored in the sides and the bottom of the drain pipe ditch and spaced at 15-foot or less intervals along the pipe to prevent seepage.

Completing Foundation of Dam

When the drain pipe has been installed, covered, and the concrete allowed to set 48 hours, that portion of the foundation that was left low to take care of the stream and/or flood water is filled in. The entire foundation of the dam should be built to approximately 4 feet above the drain at this time and leveled from end to end.

Installing Valve

All drain pipes in ponds must be equipped with some type of valve that will permit collecting or draining of water when desired.

The size of the valve should be the same as that of the drain pipe. The valve may be placed on the drain pipe when it is laid, or may be installed after the dam is completed.

Location of the valve on either the upstream end of the pipe or the downstream end will depend on the type valve used and how well the drain pipe joints are sealed. If the joints are sealed with concrete collars, it is advisable to locate the valve on the upstream end of the pipe, because water pressure might be great enough to cause the concrete joints to leak if the valve is on the downstream end. A leak along a drain pipe in a pond can cause a complete wash-out of the dam. If mechanical or leaded joints are used on the pipe, it should be safe to locate the valve on the downstream end.

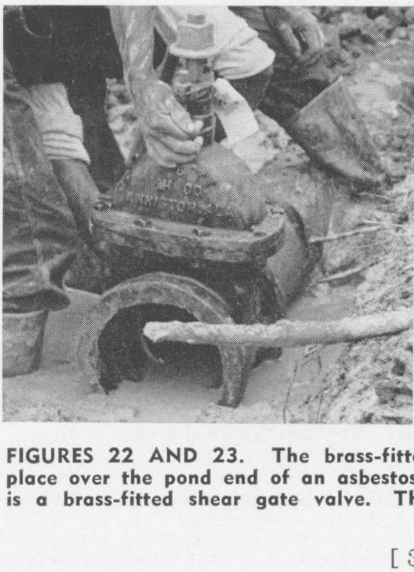
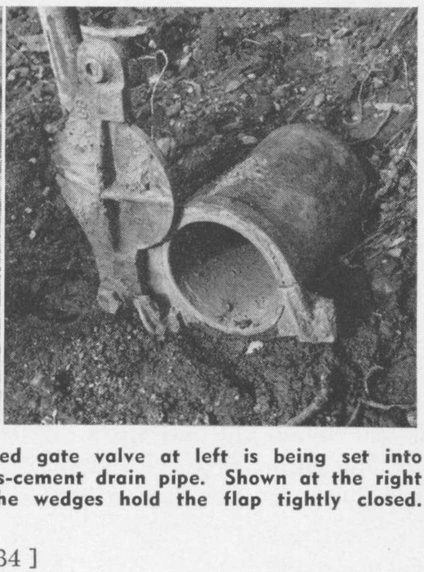
Types of valve. There are a number of different types of valves available that work satisfactorily on pond drains.

The gate valve (Figure 22) is the best and most reliable type to use on a pond drain. These valves are brass fitted, which insures a long, useful life. As this type of valve is mechanically held closed, it may be used on either the upstream or downstream end of the pipe. This type of valve is expensive.

The shear gate valve (Figure 23) is very satisfactory and will last a long time in a pond. This valve is nothing more than a brass fitted flap valve, which is constructed to wedge watertight when it is closed. Because of this construction, it is superior to the flap valve. The shear gate valve is recommended for use on the upstream end of the pipe.

The flap valve (Figure 25) is satisfactory and economical for use on farm ponds. Since this valve is nothing more than a plate that covers the end of the pipe, it depends on water pressure and mud to seal it. It can be used only on the upstream end of the pipe. When installing the valve, it is turned so that the flap will open upward. When closing to collect water, great care must be taken to be sure there is no trash between the plate and the pipe. Mud should be packed against the plate to hold it in place until sufficient water pressure is built up as the pond fills.

If galvanized pipe is used for the drain, an ell with a standpipe may be used inside the pond instead of a valve (Figure 24). This works well on hatchery ponds, but it is not recommended for ponds larger than one acre, since the size of galvanized pipe used is not as a rule sufficiently large to drain the pond.

FIGURES 22 AND 23. **The brass-fitted gate valve at left is being set into place over the pond end of an asbestos-cement drain pipe. Shown at the right is a brass-fitted shear gate valve. The wedges hold the flap tightly closed.**

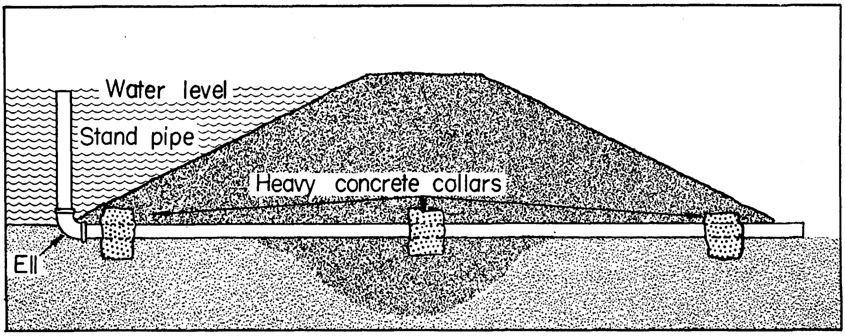


FIGURE 24. Cross-sectional diagram shows how threaded pipe with an ell may be used for a pond drain, eliminating the use of a valve. Heavy concrete collars must be placed at about 15-foot intervals to prevent the pipe from turning and prevent water from seeping along side of the pipe.

Fitting valve to pipe. Most valves are fitted with either a flange, bell, or nipple for attaching them to the pipe. If the valve has a flange or some other mechanical joint, it is fastened to the pipe with a collar and bolts or by whatever other mechanical coupling is provided. If it has a bell or nipple type fitting, the valve is slipped onto the end of the pipe, the joint is packed with oakum, and a heavy concrete collar is poured around the joint to hold the valve in place. A valve larger than 4 inches will require a heavy concrete footing or support. Regardless of the size of the valve, enough concrete must be poured around the collar to withstand the pressure that will be exerted when the valve is opened.

Thirty-degree bend. A variation of the flap and shear gate valve assembly has been used on small ponds at this Station. Instead of installing the valve directly on the end of the pipe, a 30° bend is placed between the valve and the pipe. This assembly places the face of the valve on practically the same slope as the side of the dam. Since the valve rod will have about the same slope as the dam, it is not necessary to build a platform for operating the valve (Figure 25). As this valve is at an angle and there are two joints between the valve and the drain pipe, a heavy block of concrete should completely surround the 30° bend and extend well onto the base of the valve and onto the drain pipe.

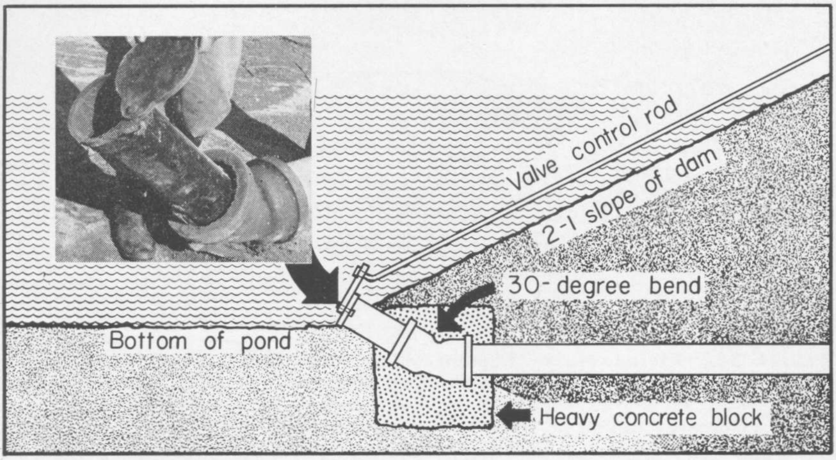


FIGURE 25. Cross-sectional diagram shows the 30° bend in place on pond end of drain pipe. The inset shows the flap valve fitted to the 30° bend.

Platform for Operation of Drain Valve

A post or some type of platform must be provided to hold the rod that operates the valve, if the valve is placed in the inside of the pond and if a 30° bend is not used. The platform

FIGURE 26. Shown here is a wood platform from which the gate valve is operated. Untreated wood is not satisfactory because it rots within 5 years. Pressure-treated, creosote posts or concrete posts are recommended.

must be built before any water accumulates in the pond. When only a post is used as a guide for the rod, it will serve as an anchor for the boat needed to operate the valve. A creosote or concrete post will serve for this purpose.

On larger ponds, a more elaborate platform is necessary to operate the large valve. This is usually made so one can walk out to it from the dam (Figure 26). However, a platform only large enough to stand on and operate the valve rod may be used. These platforms are made of the same materials as previously described. A modification of the concrete post may sometimes be used by taking terra cotta tiles, standing joints end on end, and filling them with concrete. Anchorage for the top is provided by bolts set in the concrete.

Any of the types of supports previously mentioned may be used, but all must have a good footing. This footing is usually made by digging a hole 4 or more feet deep in the pond bottom, filling the hole for about 1 foot with concrete, and then setting the support on this concrete footing. Even when a four-post platform is used, it is best to use this type of footing for the upright supports. All materials used as cross bracing and flooring for the platform should be of creosoted material or tarred steel.

The platform, whatever type used, should extend at least one foot above the water level. Its top should be sturdy enough to withstand heavy pulls that will be exerted on the rod. Also, some method of holding the valve rod in place should be provided.

When the platform is completed, the control rod for the valve is installed. If it is a flap or shear gate valve, the rods are threaded to fasten directly on the flap. If it is a gate valve, the control rod should be keyed to the valve shaft so that it will not be removed accidentally from this seating.

Filling the Dam

Filling the above-ground portion of the dam is the most expensive operation in building a pond. This entire fill should be made, if possible, of the same quality clay as that used to build the core. The clay should be applied in thin layers and well packed before another layer is added. This is to make the dam as seepage-proof as possible. If there is an insufficient amount of good clay available to make the entire dam of the same material throughout, the best clay should be used to extend the center core from the base to the top and the poorer material used to fill the sides.

It is advisable to use some guide to keep the correct slope to the sides as each layer of dirt is applied. One of two simple methods for controlling this slope is generally used.

Grade-stake method. The grade-stake method is recommended when building the dam with tractors and pans. As the clay will not roll to a 2-to-1 slope when it is dumped, it is necessary that the grade stakes be set as each foot of clay is applied to obtain the desired slope.

To set grade stakes, the top-width stakes must be projected in from the reference stakes at the ends of the dam (Figure 4). Using a surveying level, the height of the dam that remains to be built is found. In Figure 27 this remaining height is 10 feet. To determine the height of the top of the grade stake for the next foot of dirt that is to be applied, the distance of 1 foot is subtracted from the remaining height. In Figure 27 the distance from the top of the grade stake to the proposed top of the dam is 9 feet (10′ − 1′ = 9′). The distance to set the grade stakes from the top-width stakes would be two times this difference in height (9′) or 18 feet on each side of the top width (Figure 29).

The grade stakes will be in straight, parallel lines on each side of the fill and approximately 2 feet in from the edge of the dam (Figure 29). In filling this next foot of the dam, the tractor operator drops the dirt as close as possible to these grade stakes and allows the dirt to roll down to form the side slope. If all of this 1-foot fill were applied at one time, the slope of the side

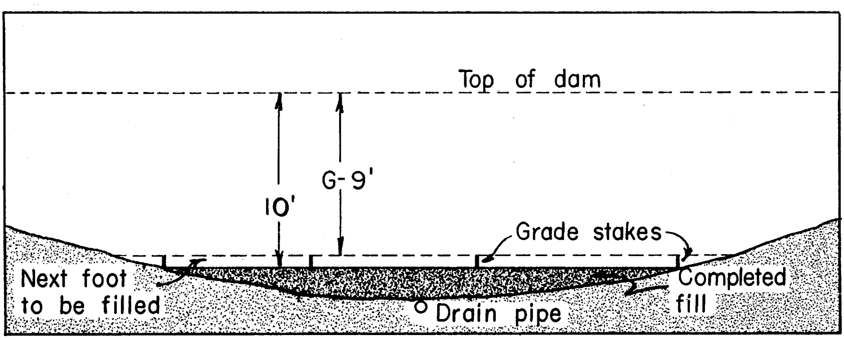


FIGURE 27. Diagram is a side view of incomplete dam, showing grade stakes set for the next foot of fill. "G" is the remaining height of dam to be built above the established 1-foot grade stakes.

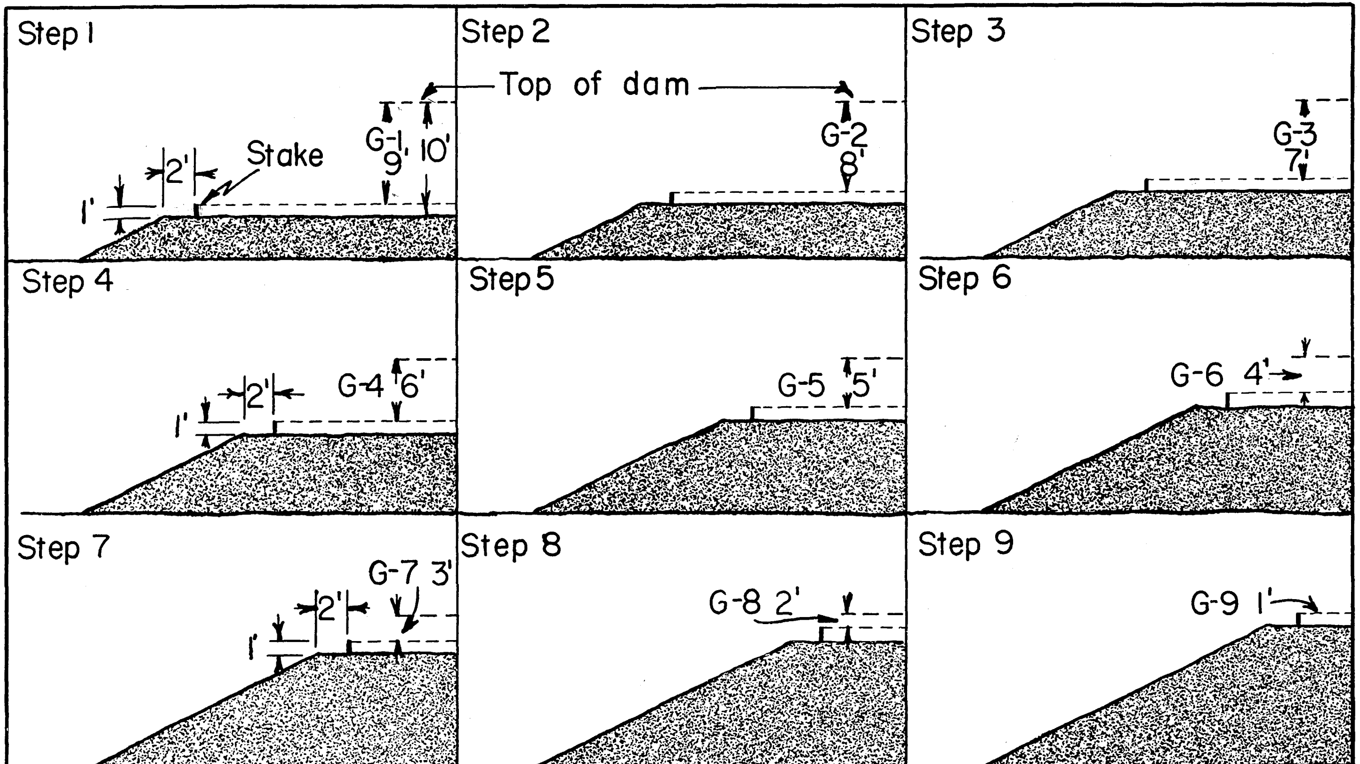


FIGURE 28. **Step-by-step method of setting grade stakes at each foot of fill to maintain desired 2-to-1 slope. The grade stakes are set 1 foot high and 2 feet in from edge of previously completed 1 foot fill until desired height is reached.**

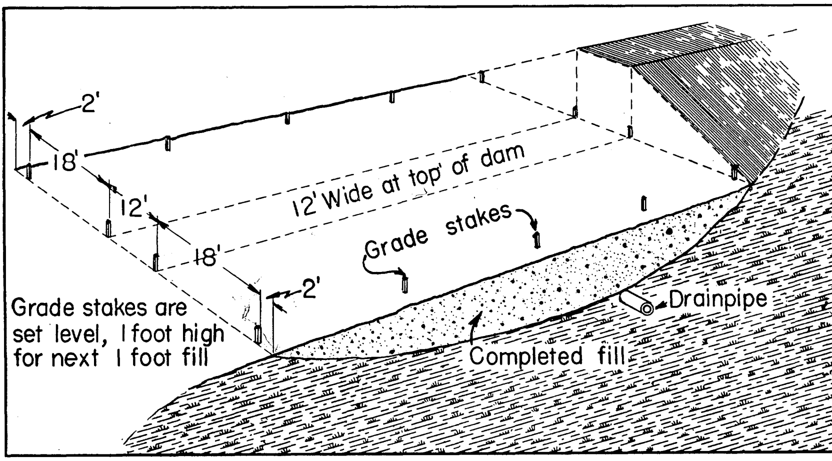


FIGURE 29. Perspective view of Figure 27 shows positions of stakes on fill.

would be approximately 1-to-1. However, if the clay is applied in thin layers and the machinery runs over the clay several times, it will press the clay out until the sides are approximately a 2-to-1 slope. It is extremely important that all clay be applied to the dam in thin layers as it is built and that the tractors run over it to give good compaction. If this is not done, it will be necessary to use a sheep-foot or some other type of roller continuously as the dam is being built to get good compaction.

When the dam has been filled level with the top of the first set of grade stakes, the procedure for setting grade stakes is repeated (Figure 28). This setting of grade stakes for each foot of fill is necessary to keep the slope of the dam uniform as it is built. When the dam has been built up to water level, the ends of the dam are left low to serve as spillways after the freeboard is added.

Triangle method. The triangle method of determining the slope of the sides is much simpler in practice than is the grade stakes method, but the finished dam is not as neat in appearance. This method requires construction of a wooden triangle with a spirit level attachment. This is used for checking the slope of the sides. One side or arm of this triangle is made 2 feet long and another side or arm is 4 feet long. These two pieces of the frame are then fastened together to form a right angle. A third board is then fastened to the free ends of the two joined pieces to complete the triangle. The material used to make this triangle should be sturdy wood approximately 1½ inches square. When the triangle is completed, a small spirit level is attached parallel to the 4-foot side of the triangle (Figure 30).

To use this triangle, the 4-foot arm is held parallel to the ground with the sloping side of the triangle against the slope of the dam. The triangle is then adjusted until the bubble shows that the 4-foot side or arm is level. When this arm is level, the long side of the triangle is at the desired 2-to-1 slope against the side of the dam. If the slope of the dam is correct, the side of the triangle will lay flat against the dam. When the slope of the dam is too steep, the top of the triangle will touch the side of the dam, but the lower end will not. If the slope is greater than 2-to-1, the bottom of the triangle will touch the side of the dam and the top will not. When using this triangle to maintain the side slope of the dam, it will be necessary to make rather frequent checks to see that the filling of the dam is being done correctly.

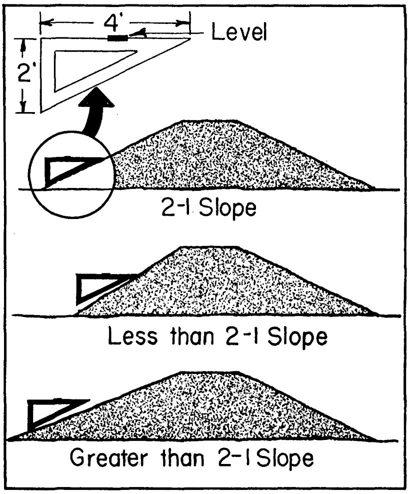


FIG. 30. Diagram shows use of home-built triangle-level that may be used in maintaining the 2-to-1 slope.

Protecting the dam from flood during construction. While building the dam, the drain pipe should be open at all times. However, ofttimes the drain pipe cannot handle all of the flood waters that may run off the drainage area into the proposed pond. In many cases such flood waters have over-topped an incomplete dam and caused serious damage. Such damage can be reduced by leaving at one end of the incomplete dam a space 2 feet or more lower than the rest of the dam to handle flood water. This should be followed on all dams, but it is especially desirable on sites that have permanent streams or where a diversion ditch is to be constructed.

Finishing the Dam

The last 3 or 4 feet of filling to complete the dam presents a special packing problem. Since the top width of the dam at this stage of construction is narrow the tractor treads pack only the outer edges of the dam, leaving the center portion relatively loose. If this condition is not corrected, the dirt along this center will settle within a few months and the freeboard of the dam will be reduced. Such a condition will not occur if a sheep-foot roller is used to pack the last few feet of fill that is added. If a roller is not available, a farm tractor may be run back and forth over the dam as the last few feet of fill is added.

When the dam is completed, the top should be left level. The ends of the dam should be sloped to the ground level, leaving low spots on each end to protect the dam from floods until the spillway is installed.

Deepening Pond Edge

As weed control is difficult and fishing is poor in shallow water, steps should be taken while constructing the pond to deepen the edge, especially in the upper end. This is done by staking the water line and then cutting the dirt away from inside of the stakes until it is a foot and preferably 2 feet deep. This excess dirt may either be used to fill other areas where it is too boggy for the tractors to work or it may be spread above the water line to give a higher bank. When this operation is completed, the rough bank should be graded to give the edge a smooth slope.

In small ponds a considerable portion of the pond edge may be shaped by the tractors while building the dam. If possible all of the dirt used in the dam should come from within the pond area, unless the pond is underlain by sand or porous rock. In such a case, the clay in the pond bottom should not be disturbed. In addition to giving a good edge, deepening the edges will often increase the pond's area as well as its volume.

Shaping and Sodding Pond Edge

In addition to deepening the inside edge of the pond below water level, the area immediately above water level should be approximately 1 foot higher than water level and smoothed for at least 15 feet back from the pond edge. It is important to have the edge around the pond sufficiently high to allow good surface drainage and management. Boggy, wet pond edges, even though the depth of the water is 18 inches or more within the pond, encourage the growth of undesirable water weeds along the bank. These weeds afford refuge for snakes and also make that portion of the pond unfit for bank fishing. Eventually such weeds will spread into the pond and make mosquito control difficult. A dry, relatively smooth bank will allow the entire border to be sodded with a desirable grass that can be managed with a minimum of effort.

Considerable research has been conducted by the Alabama Station to find a grass that will produce and maintain a good sod with a minimum of effort. The results of this research show that centipede grass is best (reduced upkeep of pond edge 60 per cent); Bermuda grass is second best, and Zoysia grass is a poor third. Kentucky bluegrass may be used in northern Alabama, but it is not recommended.

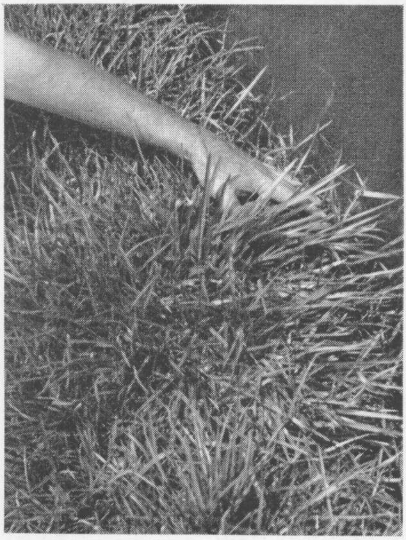


FIG. 31. Shown here is a pond edge sodded with centipede grass.

Centipede grass is a low-growing, thick sod grass that spreads by runners and does well on moist to dry soils (Figure 31). It is especially good for erosion control. The sod is thick and will smother out other undesirable grasses and weeds. This grass cannot stand heavy applications of nitrogen but needs light applications of 6-8-4 at frequent intervals until the sod is well established. Light applications of 6-8-4 are then made at less frequent intervals to keep the grass in good condition. This grass is commonly set by sprigging. It takes approximately one year for the grass to cover the area. The range of centipede grass in the Southeast is from Florida to northern Alabama. Because of its low-growing habit, centipede requires little mowing and will not send runners into the pond. It can be destroyed by heavy cultivation.

Bermuda grass is a hardy grass that spreads by runners and does well on moist, fairly fertile soils. The sod of Bermuda is not as thick or low-growing as centipede. Therefore, it requires more attention to keep out undesirable weeds and to maintain the sod. Bermuda grass will send runners as far as 2 feet from the bank into the pond. Its range extends over most of the southern states. This grass requires applications of 6-8-4 fertilizer to maintain a good sod.

Zoysia grass is a very dense sod lawn grass that requires a fertile soil and considerable attention to establish and maintain. It is not a desirable grass for use on pond edges.

Kentucky bluegrass is an evergreen grass that does well on heavy soils of northern Alabama and farther north. Sod of this grass is obtained by sowing seed in October or November in Alabama. This grass needs basic slag as well as applications of 6-8-4 fertilizer.

Sodding the Dam

As soon as a dam is completed, some type of grass should be planted on it to prevent erosion. A permanent grass such as centipede or Bermuda, should be sodded as soon as possible and kept well fertilized until it covers the entire dam. If these sods are planted thick and kept well fertilized, they will cover the dam in one year and crowd out undesirable weeds, thereby reducing considerably the maintenance cost of the dam. However, if the dam is completed in the late summer or fall, it will not be possible to establish a sod of either centipede or Bermuda on the dam before the winter rains start. In such cases, the dam should be planted to a fast growing winter grass, such as Italian rye grass. As soon as this grass has sprouted, it should be fertilized so that it will produce a good cover for the dam and prevent any serious erosion from winter rains. The following spring the dam should be sodded to a permanent grass.

The Spillway

The main cause of failure of earthen dams is the over-topping of the dam by flood water due to inadequate spillway capacity. The finished dam needs some protection from the floods that may produce more run-off water than is required to fill and maintain the pond. Such protection is provided by a spillway at one or both ends of the dam. Therefore, it is important to build a spillway large enough to take care of the maximum amount of flood water that can be expected.

Caring for permanent overflow. Ponds that have a constant overflow of water will need a permanent concrete or stone spillway, or a concrete overflow slot plus a spillway.

A simple, cheap overflow drain of 12-inch pipe and concrete will take care of the overflow from a pond up to 30 acres in size and will reduce the cost of constructing an elaborate spillway.

The overflow slot (Figure 32) is built at water level some place near the center of the dam so that the discharge may be emptied below into the old stream bed. As soon as the dam is completed, the overflow slot should be installed. The ditch for the overflow is dug across the dam to a depth that will allow the upper end of the pipe to be 12 inches lower than the water level of the pond. A 12-inch drop is recommended, since the more fall given at the lip the greater volume of water the pipe will carry. The ditch is sloped evenly toward the back of the dam with a fall of about 1 foot per 10 linear feet of ditch. The pipe is then laid and the joints are caulked and concreted. Care must be taken that all joints are well sealed so that there will be no leaks in the line. Large concrete cut-off collars should be poured around

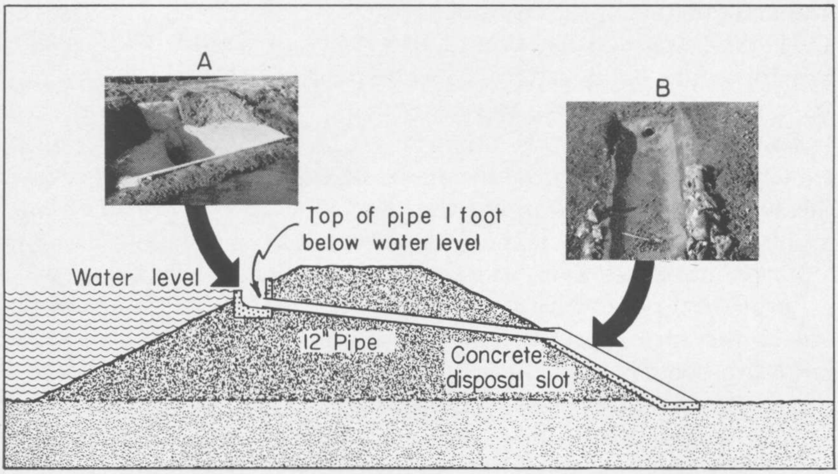


FIGURE 32. Cross section through completed dam shows location of the permanent over-flow slot. "A" is the concrete slot and lip; "B" is the concrete trough that carries the water away from the dam.

the pipe to prevent seepage and possible damage to the dam. The pipe is then covered with clay, which is well packed as it is placed around the pipe.

When laying the pipe line, the pond end of the line should be placed about 3 feet from the water's edge. This is to allow space for the inlet slot (Figure 32-A), which is nothing more than a concrete trough with a wide lip and sloping sides that funnels the water into the pipe.

The water should never run deeper than 1 to 2 inches over the slot in order to prevent the escape of small fish. For a 12-inch pipe, the width of the slot to give this 1 inch depth is 9 feet. The slot is shaped in the soil and covered with concrete 4 or more inches thick.

A concrete trough, such as is shown in Figure 32-B, is made on the back side of the dam to dispose of the water coming through the pipe. The sides of this trough should be 12 inches high and the width between these sides should be 3 feet. Thickness of the concrete should be 4 or more inches in order to prevent cracking from freezing. The concrete in each of these troughs may be reinforced with hog wire fencing for added strength.

If the concrete slot is used to take the constant overflow from the pond, a spillway for handling flood water should be placed at one end of the dam. This spillway should be graded 0.3 foot higher than the lip of the slot.

The size and construction of this spillway should be adequate to handle the flood water. (See following section.)

Size of spillway. It is important that the spillway be large enough to handle adequately the flood water not only to prevent the water from over-topping the dam, but also to prevent large numbers of fish from leaving the pond during a flood.

As an example, over 95 per cent of all fish left a half-acre experimental pond during one heavy rain when the water flowed out of the spillway to a depth of 2 feet. Practically no loss of large fish occurred in a nearby pond where the spillway capacity was large enough to spread the overflow water into a thin sheet of only a few inches deep.

Various ways of screening spillways have been tried to prevent loss of fish. However, screens are not recommended because they invariably become clogged with trash during heavy downpours. Usually the flood water either overflows or tears out the screens. In some cases clogging of the screens during downpours has caused flood water to over-top and wash out dams. Providing adequate width in the spillway is a much safer and more satisfactory solution to this problem.

Results of many experiments conducted by the Alabama Station indicate that, to prevent serious losses of fish from ponds, spillways should be constructed wide enough so that the heaviest floods will not pass over the spillway more than 3 to 6 inches deep. The width of spillway necessary to insure such a shallow flow during floods may be estimated by the following methods:

One method is to observe the driftwood and trash on the stream's banks for indications of the highest flood in the area. The distance between the highest deposits left by the flood on each bank is then measured and the average depth of water that produced this drift is estimated. From these measurements, the width of spillway necessary to handle this volume of water in a thin sheet is estimated. Suppose for example, after extremely heavy rains, a stream flooded and left deposits of driftwood on the banks that were 10 feet apart. The average depth of water across this area during the crest of the flood was 1 foot. This 1-foot depth is divided by 3 inches (desired depth of flow) to give a workable factor of 4. The 10-foot width is then multiplied by 4 to give a spillway width of 40 feet, which will be sufficiently wide to handle water from a flood of the size estimated. This is an approximation method that often can be used on small ponds. It works satisfactorily only if the height of drift deposits from exceptionally heavy rains can be located along the stream banks.

Another method is based on the size of the drainage area supplying the pond. This method is recommended only on drainage areas of less than 50 acres. On larger drainage areas, the method results in an overestimate of the size of spillway needed. Using this method, the total number of acres in drainage area is divided by 2 to give an arbitrary spillway width. To this arbitrary width is added 10 more feet as a safety margin. For example, it is found that the drainage area for a pond is 28 acres. Dividing the 28 acres by 2 gives 14 feet as the arbitrary spillway width. Adding the 10 feet of safety margin to the 14 feet gives a spillway width of 24 feet.

On larger ponds that have drainage areas in excess of 50 acres, the size of the spillway may be computed from the amount of run-off from the drainage area. The following figures are given as a guide to the width of spillway needed on pasture watersheds to maintain less than 1 foot of head over the spillway following the heaviest rainfall to be expected in 25 years. A pond with a 100-acre watershed should have 82 feet of spillway space, with 200 acres of watershed 146 feet of spillway space, and with a 300-acre watershed 172 feet of spillway space. For ponds with watersheds between these given areas, the size of the spillway necessary to obtain a 1-foot or less head may be found by figuring the difference between the given spillway widths.

Location of spillway. Since most ponds are built in natural hollows or draws, the hillsides at ends of the dam are natural places to locate spillways. Often these sides are steep and much grading has to be done to give a spillway sufficient capacity to handle the estimated amount of flood water. However, this grading is well worth its cost in providing protection to the dam. The spillway may be located at one or both ends of the dam, or at a convenient point along sides of pond.

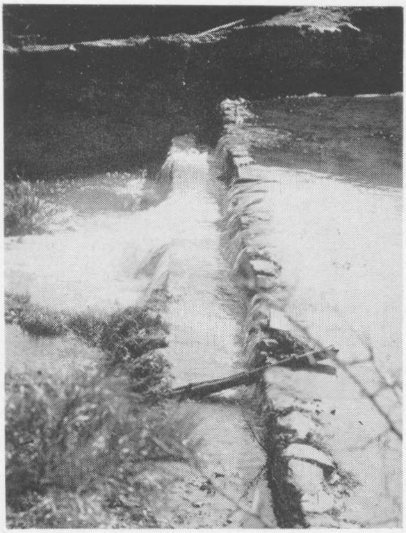


FIG. 33. Shown here is a masonry or rock spillway used on a 12-acre pond. The disposal channel below this spillway is graded to solid rock.

Construction of spillway. The spillway may be paved with rock, concrete or completely covered with a good sod. The type of construction to use will depend on location of the spillway, type of soil on which it is to be built, and amount of water that it will have to carry. Regardless of the type of construction used, the spillway that is to take care of all overflow should be paved for a sufficient distance to carry the water safely away from the dam.

Rock spillways (Figure 33) may be used when there is an abundance of hard rock available to completely cover the spillway area to a depth of

FIGURE 34. This concrete spillway for a 1.3-acre pond has a low wall across it to obtain desired water level in the pond. The entire floor is paved to prevent erosion and end of dam is faced with concrete to prevent flood water damage.

several inches, or when the area on which the spillway is to be built is solid rock. The latter is the preferred type of spillway and should be used whenever possible. In constructing a spillway on solid rock, all of the dirt is removed not only in the spillway itself but also along the disposal channel below the dam. If necessary, a small concrete wall may be built across the face of the spillway to give the desired depth of water to the pond.

The concrete spillway (Figure 34) is usually made by shaping the spillway form in the soil and then coating this area with a layer of concrete 4 or more inches thick. In areas where there is considerable ground freeze, this concrete should be reinforced with hog wire fencing or quarter-inch reinforcing rods. The surface of the concrete should be well trowled to insure a smooth surface for the water flow. Anchor walls, 12 inches or more thick and extending for at least 1 foot below the ground surface, should be placed along the upper and lower ends of the spillway. The side wall of the spillway next to the dam should extend up a sufficient height to protect the dam from floods. The concrete paving should extend a safe distance beyond the dam before it releases the water. The entire spillway should be poured at one time. If the structure is too large for a single pouring, sufficient reinforcing rods must be used along the seams to tie the entire structure together. The disposal area in which this water is released should be heavily sodded.

The sod spillway is recommended only as an emergency spillway for ponds located on tight clay soils, since more porous soils cannot withstand a heavy flow of water even for a very short period without serious erosion. The sod spillway should be graded to 0.3 foot above the water level of the pond, and then given a 0.2-foot fall per 100 feet until the water may be safely disposed below the dam. The water's edge is then riprapped with stone and the rest of the spillway is sodded with grass. The grass should be fertilized and if necessary watered so that a dense growth will be obtained in a short time. The disposal area below the dam should be thickly planted to lespedeza sericea or kudzu. If there is an old gully or channel below the spillway, it may be used as the disposal area.

Diversion Ditch

Too large a drainage area, cultivated crops within watershed of ponds in the red-land sections, not enough land cover, and excessive amounts of water in the winter cause ponds to become muddy and remain muddy much of the year. Under such conditions, it is impractical to fertilize and manage ponds for high fish production.

Some ponds are built on sites that have too large a drainage area. Such ponds are flooded following heavy rains and often

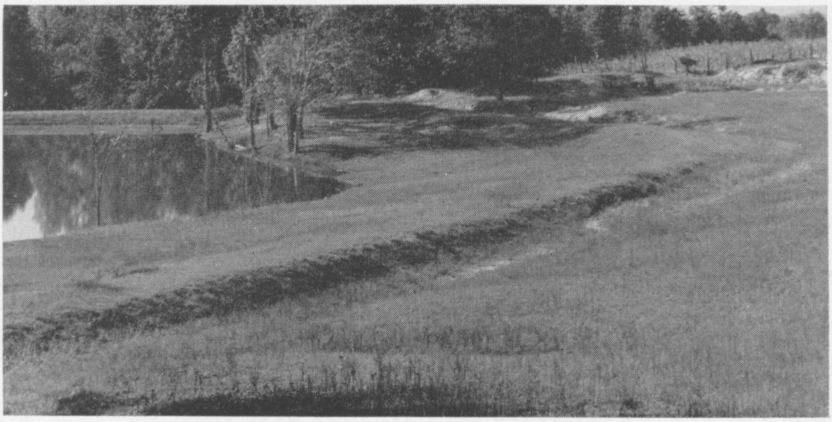


FIGURE 35. A diversion ditch is built on hillside to by-pass excess water around the pond. This ditch is sodded to prevent erosion.

stay muddy most of the year. There are ponds in the red-land sections that become muddy after every rain. These are built on sites where a part of the drainage area is in cultivation and where there is not enough cover to prevent erosion. There are still other ponds that receive too much water from winter rains, and, while such ponds do not become very muddy, practically all of the plant food in the pond waters is lost by the large volume of overflow.

A diversion ditch, such as shown in Figure 35, constructed around one or both sides of such ponds will eliminate these hazards and will allow the ponds to be properly managed.

Layout of diversion dam and ditch. In planning a diversion ditch system for a pond, the first step is to locate the diversion dam for collecting the water in the old water channel before it enters the pond. This dam is placed at a sufficient height above the water level along the old water channel to allow 0.2-foot or more of fall per 100 linear feet of ditch around the side of the pond. The ditch is then laid out beginning at one end of the diversion dam and extending around one side of the pond to a point below the main dam where the water may be safely released. In laying out the ditch, care must be taken to allow the correct fall for each 100 feet of ditch. It is advisable to lay out the diversion ditch prior to constructing the dam, since some of the clay from the ditch may be used in building the dam.

Size of diversion ditch. Size of the diversion ditch and dam must be made sufficiently large to handle the estimated greatest volume of water from the drainage area. An estimate of the size of the ditch can be obtained, using Table 2 in the Appendix.

Constructing diversion ditch and dam. In constructing the diversion dam, it is not necessary to use a clay core to anchor it to the subsoil. Trees, brush, and other ground debris are removed from the site, and the dam is built on this foundation. The clay core is purposely avoided in this dam to allow a certain amount of water seepage under the dam to help keep the pond filled. The soil through which the water percolates before it reaches the pond will filter out the mud, and will allow only clear water to seep into the pond. While building the diversion dam, some type of pipe with a valve should be installed in the dam to supply water to the pond (Figure 36). On ponds less than 5 acres in area, a 4- to 6-inch pipe with a valve should be used; for 5- to 10-acre ponds, a 6- to 8-inch pipe with valve; and for 10-acre or larger ponds, a 12-inch pipe with some type of cut-off valve.

The diversion ditch is constructed from one end of the diversion dam around the side of the pond to a point below the main dam, where the water is released. A tractor and pan or a tractor and bulldozer may be used to remove the soil from the bottom of the ditch channel. The removed soil is piled on the pond side of the cut to form the ditch bank between the channel and the pond. The soil should be spread in thin layers and packed with a sheep-foot roller on this ditch bank to prevent excessive erosion on the sides of the ditch when flood waters pass through it. A frequent check should be made of the dimensions to make certain that the ditch is of adequate size and slope from end to end.

FIG. 36. A pipe with a valve is used for controlling the water entering the pond through the diversion dam.

When the ditch and diversion dam are completed, they should be sodded immediately with some permanent grass. The disposal area below the dam must be planted to thick-growing vegetation and it should be checked at frequent intervals during rainy seasons to make sure that no serious erosion occurs.

The valve controlling water flow from the diversion dam into the pond is left open when the water supply is clear and the water level of the pond needs to be raised. When the water supply becomes muddy from rains or when the pond is full, the valve is closed and all water is diverted through the ditch. Observations should be made from time to time to make certain that the ditch does not become blocked by vegetation or by trash.

Riprapping the Dam

On large ponds the wind often creates waves large enough to severely erode the face of the dam above and below water level. This action on new ponds is often so severe that a foot or more of the dam is washed out in one day. A simple log wall built along the face of the dam will break these waves and prevent this erosion.

Logs 10 to 12 inches in diameter and approximately 20 feet long are floated to their position along the face of the dam and stakes driven along each side to hold them in place. The logs should be lapped so that there are no gaps between the poles. A system of this type allows a certain amount of fluctuation of water level and also gives good protection. Even with such protection, a *constant watch should be kept* on new dams during high winds to see that severe erosion does not occur.

On some large ponds, it is often necessary to provide a more permanent type of riprap than the one just described. Large stones laid along the face of the dam for a foot or so above and below water level will serve to prevent erosion of the dam. In some instances a concrete apron 4 or more inches thick extending above and below water level for the entire length of the dam may be cheaper to build than stone riprap.

On most small-pond dams of 300 feet or less in length, a good heavy sod of grass on the face of the dam will prevent serious erosion from waves.

Filling the Pond

The drain valve is closed as soon as the dam and spillway are completed and sodded, the platform for operating the valve is finished, and the edges of the pond are deepened. Water should be collected in the new pond as quickly as possible to keep the underbrush and weeds from again covering the pond area. Otherwise they will have to be cut again before the pond is filled.

When the pond begins to fill, Gambusia minnows should be added at the rate of 100 or more per acre of water. These minnows may be obtained from neighbors' ponds or from the County Health Officer. They must be added to all new ponds to help control mosquitoes.

Within a week after the pond has filled, the floating trash should be removed. This can be done on a windy day when all the floatage is concentrated on one bank. It then can easily be removed with forks, rakes or with short sections of chicken wire fencing. It is very important that this be done in order to make mosquito control by the fish more effective.

APPENDIX

TABLE 1. CUBIC YARDS OF FILL PER LINEAR FOOT IN EARTHEN DAMS WITH A 2-TO-1 SLOPE ON BOTH SIDES

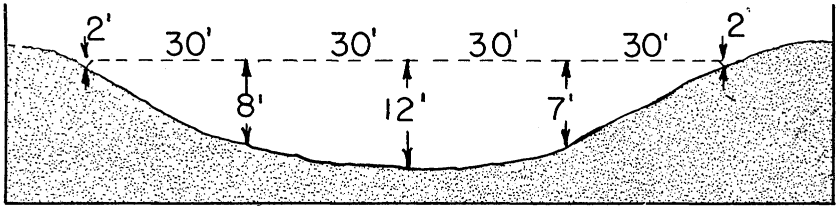
Fill Height (H) Ft.	Cubic yards of earth per linear foot in fills having a top width (T) of:				
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.
1	.30	.38	.45	.52	.60
2	.74	.88	1.03	1.18	1.33
3	1.33	1.55	1.77	2.00	2.22
4	2.07	2.37	2.66	2.96	3.26
5	2.96	3.33	3.70	4.07	4.44
6	4.00	4.44	4.88	5.33	5.77
7	5.15	5.67	6.18	6.70	7.22
8	6.51	7.10	7.69	8.28	8.87
9	8.00	8.66	9.33	10.00	10.66
10	9.63	10.37	11.11	11.85	12.59
11	11.40	12.21	13.03	13.83	14.65
12	13.33	14.22	15.10	16.00	16.88
13	15.40	16.36	17.32	18.28	19.24
14	17.63	18.67	19.70	20.73	21.77
15	20.00	21.11	22.22	23.33	24.44
16	22.51	23.69	24.88	26.06	27.25
17	25.18	26.44	27.70	28.95	30.21
18	28.00	29.33	30.66	32.00	33.33
19	30.96	32.37	33.77	35.18	36.59
20	34.07	35.55	37.03	38.51	40.00

The values in Table 1 were determined by the following formula:

$$\frac{(2H + T)\ H}{27'} = \text{cubic yards}$$

H = height of dam in feet
T = top width of dam

As an example of how to apply Table 1, the profile of a hollow at the proposed dam site is illustrated:



The height of the dam at intervals across the valley and the distance between these intervals is determined. The top width must also be determined. In this example the top width is 12 feet. The approximate volume of the above ground portion of the dam can now be determined.

Referring to Table 1 and reading the 12-foot top width column, it is found that the volume of the cross section where the dam is 2 feet high is 1.18 cubic yards, and the volume of the cross section where the dam is 8 feet high is 8.28 cubic yards. Adding these two cross-section volumes (1.18 + 8.28) and dividing by 2 $\left(\frac{(1.18 + 8.28)}{2}\right)$ gives the average cross-section volume of the section of dam between these two intervals. Multiplying this average (4.73 cubic yards) by 30 feet ([redacted]) gives the volume ([redacted]) of this section of the dam.

This procedure is repeated for each of the other three remaining sections. The volumes of the four sections are then added together to obtain the total yardage contained in the dam.

TABLE 2. DIMENSIONS OF DIVERSION DITCH WITH 0.2-FOOT FALL AND 0.5-FOOT FALL PER 100 LINEAR FEET TO DRAIN MAXIMUM RUN-OFF FROM RAINS ON VARIOUS SIZES AND TYPES OF WATERSHEDS[1]

Area of Watershed	Type	0.2′ Fall		0.5′ Fall	
		Depth	Bottom Width	Depth	Bottom Width
50 Acres	Hilly or rolling pasture	3′	10′	3′	7′
50 Acres	Hilly or rolling woodland	3′	6′	2′	6′
100 Acres	Hilly or rolling pasture	3′	15′	3′	10′
100 Acres	Hilly or rolling woodland	3′	10′	3′	6′
200 Acres	Hilly or rolling pasture	4′	18′	4′	12′
200 Acres	Hilly or rolling woodland	3′	14′	3′	10′
300 Acres	Hilly or rolling pasture	4′	21′	4′	14′
300 Acres	Hilly or rolling woodland	4′	12′	3′	11′

[1] Based on 25-year frequency for central Alabama.

The 0.2-foot fall is recommended to prevent excessive scouring of the bottom of the ditch. The 0.5-foot fall may be used where tight clay or rock is present in the bottom of the ditch to reduce the scouring or where a wider ditch is impractical.