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Ponds

FOR FARM WATER SUPPLY

AGRICULTURAL EXPERIMENT STATION—AGRICULTURAL EXTENSION SERVICE, Cooperating

CONTENTS

Ponds for Farm Water Supply

By

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The recent period of reduced rainfall extending over several years has brought with it acute problems in farm water supply in some sections of Iowa. This situation has been particularly true in the southern and southwestern parts of the state. In many cases wells which have afforded an adequate supply of water for the farm for many years have failed, and attempts to secure new wells have been expensive and unsuccessful. In those sections the keeping of a desired number of livestock on the farm has been hampered by the lack of a reliable and adequate supply of water.

This bulletin is a review of the problems of using farm ponds and offers suggestions for their location, construction and maintenance.

THE PRACTICALITY OF FARM PONDS

Farm ponds have been used successfully in Iowa and in other states as a source of farm water supply for many years and in many instances have served well also as gully control measures.

In Taylor County a pond was visited by the authors which has been in use for 54 years. The present owner of the farm on which the pond is located stated that to his knowledge it has been in continuous use. Hundreds of ponds have been used for more than a quarter of a century. The history of old ponds reveals that many were constructed during the drouth period of 1894 and 1895. Ponds are generally successful in regions where a tight subsoil prevails but unsuccessful in those areas where the subsoil is open or absorptive. In Iowa the use of ponds is confined for the most part to the southern and southeastern areas. Ponds are not in favor as a rule where good reliable wells can be readily secured.

INFLUENCE OF PONDS ON WELLS

Where wells were located near ponds, inquiry was made specifically concerning the influence of the presence of the pond on the water supply of the well. In every instance the owners of the pond and well asserted that the pond definitely improved the capacity of the well. In some instances the ponds had been constructed for the express purpose of improving the wells.

Generally considered, the influence of ponds on wells will

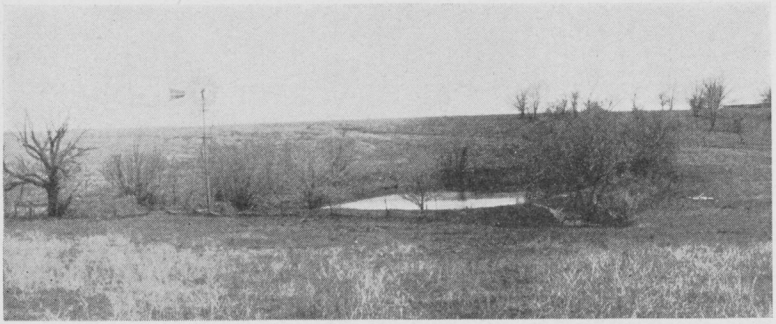


Fig. 1. A well and windmill located near the pond characterize a common and practical water supply layout for many southern and southwestern Iowa farms.

There seems to be common agreement among experienced farmers that the pond in the drainage area favorably affects the well water supply during seasons of scant rainfall. However, that will depend upon the location and depth of well and character of subsurface material.

depend upon location of the well with respect to the pond, depth of well and character of the subsoil material.

ESSENTIAL REQUIREMENTS

Not all ponds have been satisfactory. A study of pond construction, maintenance and use indicates that the essentials of a satisfactory pond are as follows:

1. Convenient location.
2. Adequate storage capacity.
3. Suitable drainage area of proper size.
4. Permanent dam and spillway.
5. Watchful and careful maintenance.
6. Fencing from livestock.
7. Outlet to stock drinking tank.

These essential features of plan and construction are discussed in the following pages.

LOCATION OF THE POND

Whenever possible the pond should be located to receive the drainage from wood lot, pasture land or meadowland. Direct drainage from cultivated land is quite sure to result in the rapid filling of the pond with silt. Drainage from barnyards should never be included in the area. If such yards are in the drainage area, terraces should be constructed to lead the runoff from the yards around the pond.

It is undesirable to locate the pond in a deep gully if it is to be used primarily for water supply, as it will probably fill rapidly with silt unless an adequate program of gully stabilization is adopted at once.

Where it is necessary to locate the pond in a large drainage area, a place often can be found for the pond into which the water may be diverted, avoiding the construction of a large dam directly across the ravine.

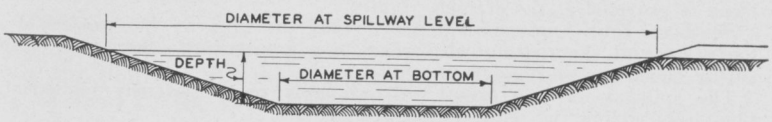
Furthermore, it is important to locate the pond where the water in storage may be used conveniently.

STORAGE CAPACITY NEEDED

The size of a pond required to meet any particular situation depends upon the amount of water needed, the length of storage period and the loss of water while in storage through seepage and evaporation. As these factors depend upon a number of variable factors, it is necessary to decide upon certain quantitative requirements to meet the adverse situation of an extended period of scanty rainfall. In Iowa a supply of water to last 4 months might be considered adequate, although in 1934 and 1936 a supply for a longer period would have been desirable in some instances. With the storage period determined, the amount of water used during that period may be estimated from the daily consumption. The water consumed daily by a mature horse is about 7 gallons, a mature cow 6 gallons, a hog or sheep 3 gallons and by poultry about 1/12-gallon for each bird; thus, 6 head of horses, 25 head of cattle and 70 head of hogs would require about 400 gallons of water a day, or 50,000 gallons for 125 days. If water is used for domestic sup-

TABLE 1. CAPACITY OF ROUND PONDS HAVING BANKS WITH A SLOPE OF 3 TO 1.

Depth at spillway level, feet	Diam. at spillway level, feet	Diam. at bottom, feet	Capacity of pond, gallons	Water available for use 54% loss, gallons	Drainage area 25,000 gallons per acre, acres approx.
8	50	2	49,360	25,500	1
8	75	27	163,557	75,000	3
12	75	3	184,148	84,700	3½
8	100	52	281,225	129,000	5
12	100	28	320,048	147,000	6
16	100	4	328,210	151,000	6
12	150	78	949,176	436,000	17
16	150	54	1,054,828	485,000	18
20	150	30	1,095,637	504,000	20



ply, it is customary to estimate a consumption of 20 gallons per person per day where sanitary plumbing is installed.

To provide the water needed throughout the year, allowance must be made for losses from storage due to seepage and evaporation. These losses will vary much with soil condition and the area of the pond, deep ponds having a smaller loss from evaporation. For average conditions it is assumed that these losses are somewhat greater than the water retained in storage. For a 50,000-gallon seasonal requirement, the pond should have a capacity of about 125,000 gallons.

The shape of a pond will depend largely upon natural topography. A careful survey with a level is required to estimate the capacity of a pond, although a rough estimate may be made from the area and the average depth. Since ponds are most frequently saucer shaped, the capacity of a round pond of this shape may be conveniently used to estimate the capacity of the pond under consideration. The preceding table (table 1) for capacities of ponds circular in shape and having sides with a slope of 3 feet horizontal to 1 vertical has been prepared for this purpose.

SIZE OF DRAINAGE AREA

A review of run-off data for southern Iowa indicates that the rate of run-off varies widely with the various conditions encountered. Furthermore, the run-off in drouth years should be recognized as the most accurate basis for determining the run-off area or watershed. It would appear from study that an arbitrary basis of an annual run-off of 2 inches of water over the drainage area

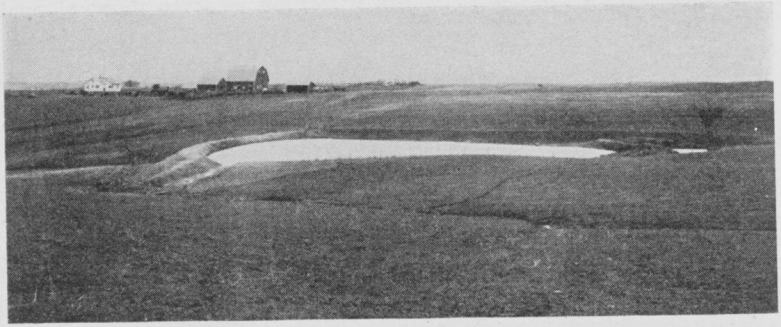


Fig. 2. A watershed of more than 20 acres of cultivated fields supplies this Taylor County farm pond. It can be noted that a silt catch basin is provided at the extreme right.

Southern Iowa experiences indicate that the area of the watershed is too great and that silting will occur on a greater scale than the limited silting basin can well handle.

The spillway in this layout will probably prove seriously inadequate, thus jeopardizing the dam.

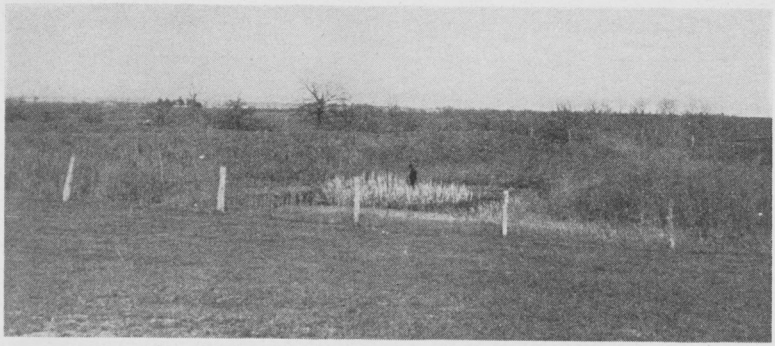


Fig. 3. This 39-year-old pond is well located near the upper end of a permanent pasture ravine on the G. C. Guilliam farm, Madison County. A number of essential features which characterize ponds of long continuous service in southern Iowa may be noted here: (1) The watershed is small and is protected by a permanent vegetative cover, (2) the pond has always been fenced to protect the banks, spillway and water from livestock, (3) the storage capacity is adequate, (4) a satisfactory outlet to a drinking tank has been provided as is shown in the accompanying photos.

This pond has been without water storage only once in the 39 years of its services; in 1934 while supply was at a low level the pond was pumped dry to facilitate the removal of silt. However, only about a wagon load of silt had collected due to the protection of the drainage area by the continuous growing of bluegrass pasture which had never been overgrazed.

should be satisfactory. Two inches of run-off would provide about 54,000 gallons of water per acre of drainage area. If 46 percent of this amount is available for use after seepage and evaporation losses, each acre of drainage area should provide 25,000 gallons of water. This unit figure is suggested as the basis for determining drainage area but to be modified or adjusted to the specific conditions of each pond location.

The drainage area may be so limited that the pond will never overflow, but such a practice is not to be generally recommended, because with a limited area the pond is likely to be dry during a season when most needed. On the other hand, a pond with too large a drainage area offers a serious problem in the disposal of the surplus water and the maintenance of the dam and spillway.

The size of the drainage area may be increased by diverting additional water from terraces and/or diversion ditches.

After the selection of a site for a pond it is desirable to make a survey to mark the high-water line and to determine the size of the dam required. It is desirable to use a surveyor's level if available, although a carpenter's level may be used successfully for small ponds. The high-water mark or water level when the pond is full is determined by the elevation of the bottom or crest of the spillway. With a surveyor's level it is only

TABLE 2. DRAINAGE AREAS, POND CAPACITIES AND LIVESTOCK SUPPLIED WITH WATER.

Drainage area, acres	Water stored, 2-inch run-off	Water available for livestock (46% of storage)	Number of cows which can be watered for 125 days or equiv.*
1	54,300	25,000	33
2	108,600	50,000	66
4	217,200	100,000	132
8	434,400	200,000	264
12	651,600	300,000	396
20	1,086,000	500,000	660
32	1,733,600	800,000	1,056

*Daily water consumption may be estimated by assuming 7 gallons for each horse, 6 gallons for each cow, 3 gallons for each head of swine or sheep and 4 gallons for a flock of 50 hens.

necessary to set the target on the rod by the level when held on the bottom of the spillway, and then points on the boundary of the pond may be determined by carrying the rod to various locations and moving it up the slope until the target is level with the instrument. The depth of the pond at various points may also be determined. If the pond is to be carefully planned, a map of the site should be prepared.

If the nature of the soil is not known, it may be necessary to make some borings to determine whether it is sufficiently impervious to water. Although instances have been found where

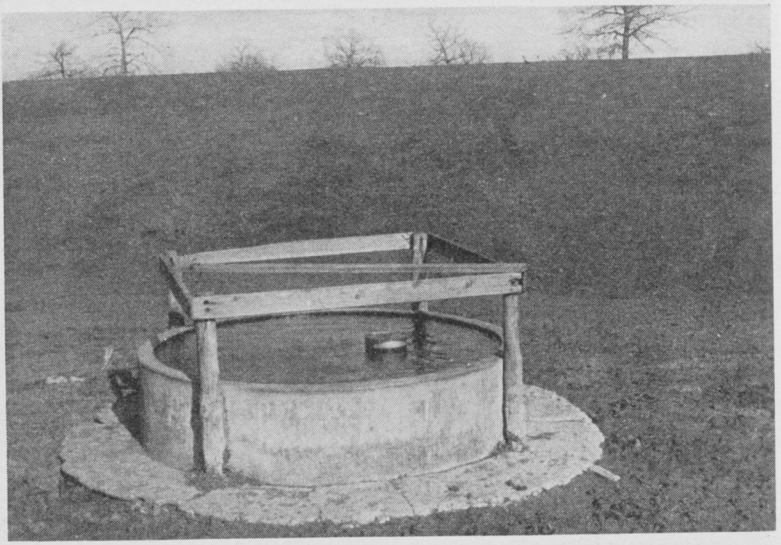


Fig. 4. Below the 39-year-old pond on the Guilliam farm is a permanent livestock watering tank supplied by a pipe from the fenced pond just to the right of the view. It can be noted that the natural waterway is well stabilized by pasture-producing sod.

Fig. 5. This pond on the Charles Stever farm 2 miles west of Fairfield on the south side of Highway 34 was built 25 years ago to provide water supply for 200 to 300 head of cattle and other farm livestock. Its supply has never failed since that time, although it is fed by only 7 to 8 acres of watershed. The extraordinary size gave it the needed storage capacity during the drouth periods of 1934 and 1936. Water is piped to the well and pumped by the windmill located near the end of the barn.

Although this pond is near the barn lots, no water from that area reaches it, since a diversion ditch intercepts that flow and leads it to the natural drainage course below the pond.

ponds on comparatively open soils have become practically watertight after a time from silting, it is generally recognized that a pond will not be satisfactory if located over sandy or gravelly soils. In some instances a layer of clay has been placed over such soils to reduce seepage losses. Puddling of the soil in the bottom of the pond is often done with some success.

THE CONSTRUCTION OF THE DAM

In Iowa, farm ponds as a rule are made by the construction of earth dams across ravines. It has been observed that the majority of failures of farm ponds are due to inadequate earth dams. The most common mistakes are to make the dam too narrow and with too steep banks. It is desirable that the pond side of the dam have a slope of 3 to 1 and the lower side a slope of 2 to 1. The top of the dam should be 6 to 8 feet wide and extend well above the highest water line.

Before placing any fresh earth on the dam site the surface soil should be removed and the soil under the dam plowed so as to form a good bond with the new soil. In some instances a core wall (see fig. 6) of impervious clay should be used. This will call for careful placing of the earth in the embankment.

The earth in the dam should be placed in thin layers and well packed with tractor or horses and scraper during construction. It is undesirable to pull the earth directly to the dam and dump it without the benefits of the packing which is obtained by traveling lengthwise over the dam. Dragline excavators are sometimes used in the construction but are not so desirable, as there is little packing of the earth during construction.

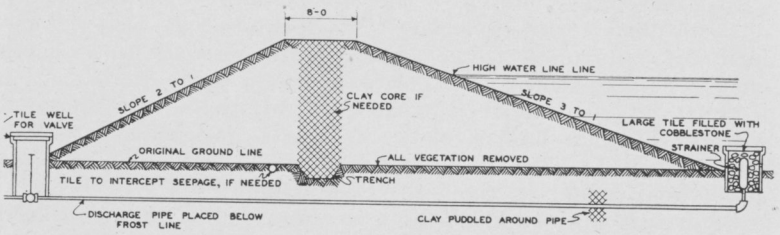
The crest of the dam should be at least 3 feet above the level of the water in the spillway during maximum discharge. Provision must be made for settlement of the dam. About 15 percent should be allowed for settlement where the earth is packed with a tractor or horses during construction. A greater allowance for settlement should be made for dams constructed with dragline excavators. Where an extra deep fill is made, as over a deep ravine, the dam should be built to an additional height, particularly in the center where the fill is deepest, to provide for the greater settlement that will take place.

Care should be taken to guard against the destructive action of a heavy run-off due to rains which may come during the construction of a dam.

In certain sections of the state where the ground water line at certain seasons may be above the base of the dam, tile lines embedded in the soil under the dam to intercept and carry the seepage water away have been found necessary. These drains remove excess water from under the "toe" of the dam. Such drains are usually placed lengthwise of the dam near the center with an outlet below the base of the dam. (See fig. 6.)

SPILLWAY

It is essential that an earth dam be protected by a spillway of sufficient size and proper cross section to care for the heaviest run-off. It must be located at such an elevation below the crest of the dam that at no time will there be any tendency for the water to flow over the top of the dam, and it must be protected with vegetation or masonry material to prevent erosion.



A TYPICAL EARTH DAM

Fig. 6. The cross section of a typical earth dam, showing most desirable slopes, pipe outlets, etc.

Fig. 7. A broad-base bank or dam providing a top width of about 8 feet is essential for pond stability.
This Madison County dam reconstructed in 1940 exemplifies broad-base dam construction. The fill on the pond side of the dam should have a slope of 3 to 1 and the side below the pond a slope of 2 to 1.

Many ponds have failed because adequate and sufficiently permanent spillways were not provided.

Wide crests, sometimes called wide-bottom spillways, carefully sodded, are the best for most farm ponds. Shallow, wide spillways are more desirable than deep, narrow ones, because the velocity of the discharge is less and the height of water in the pond will vary less. In some instances it is desirable to build the spillway a year or so in advance of the construction of the dam in order to give the grass on the bottom of the spillway a chance to get a good start.

Where a satisfactory sodded spillway cannot be built, it may be necessary to line the spillway with concrete or rubble masonry. Such a spillway to be successful must be constructed with aprons or check dams to insure that it will not be undermined by the overflow water.

Where large drainage areas lead into the pond, a tile outlet which gradually lowers the level in the pond may be used to supplement the spillway. Such tiles if laid to a steep gradient must have outlet protection of masonry.

The size of the spillway is determined by the rate of run-off, usually measured in the number of cubic feet of water per second discharged from the pond's drainage area. The following table indicates the run-off from areas up to 20 acres with various vegetative coverings, calculated from the general equation $Q = CIA$ [1] where Q is the critical run-off in cubic feet per second, C is the run-off coefficient representing the ratio of the rate of run-off to the rate of rainfall, I is the rainfall intensity

[1] Equation from Ramser, C. E., Jour. Agr. Research, Vol. 34, No. 9. 1937.

in cubic feet per second per acre, and A is the watershed area in acres.

After the rate of run-off from the drainage area to the pond has been estimated, the size of spillway may be determined from a table of discharge capacities for broad-crested spillways of various widths under various heads of water above the crest.

MAINTENANCE OF PONDS

It has been the common experience of those responsible for the maintenance of ponds that constant care and watchfulness must be exercised to insure continued and satisfactory use. When erosion starts in the spillway, particularly if it is sodded, repairs must be made or the entire spillway will be eroded. There must be a constant vigilance that small animals do not burrow through the dam and start a washout. The pond should be kept free from debris. The wave action on ponds covering an acre or more may be very destructive of the earth embankment.

FENCING

Frequently where ponds are used as a source of water supply for livestock, the livestock are given direct access to the pond. It is preferable, however, from every standpoint except the expense involved, to have the pond fenced and have the water piped to a stock tank below the pond. If the pond is used as a source of water supply for domestic uses, fencing is imperative. Where the pond is located in a pasture, the fenced area including the pond should be large enough to retain a grass strip several rods wide around the water at all points.

TABLE 3. RUN-OFF FROM DRAINAGE AREAS IN CUBIC FEET PER SECOND.

(Computed from equation Q = CIA, where the value of I is 6 for areas of 5 acres or less and 5 for larger areas and C is as indicated.)

Acres	Rolling land, 5 to 10% slope		Hilly land, 10 to 30% slope	
	Cultivated fields C = .60	Pasture or meadow C = .36	Cultivated fields C = .72	Pasture or meadow C = .42
1	3.6	2.2	4.32	2.5
2	7.2	4.3	8.64	5.0
3	10.8	6.5	12.96	7.6
4	14.4	8.6	17.38	10.1
5	18.0	10.8	21.60	12.6
7½	22.5	13.5	27.3	15.8
10	30.0	18.0	36.0	21.0
15	45.0	27.0	54.0	31.5
20	60.0	36.0	72.0	42.0

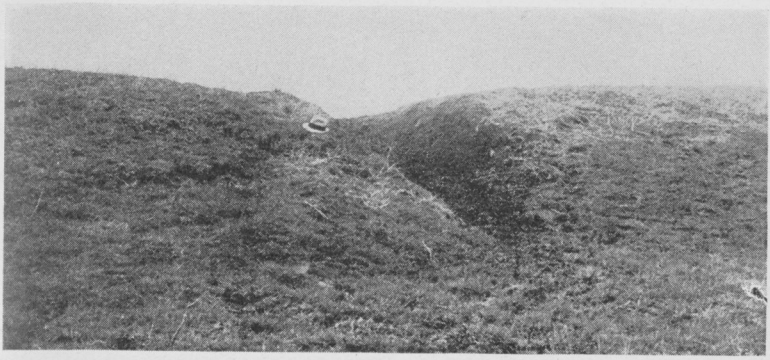


Fig. 8. Because of lack of proper height of bank fill over that of the spillway channel, ponds often fail, as has this Madison County pond constructed many years ago. Many such ponds are being reconditioned to meet the water emergency needs of the drouth seasons. The bank elevation should be at least 3 feet above the bottom of the spillway.

PIPE OUTLET TO TANK

When the farm pond is fenced it is necessary to carry the water from the pond to a stock tank below the pond. A screen or a section of perforated pipe should be fitted to the discharge pipe. In some instances the screen end is placed in a concrete box or metal barrel filled with cobblestone to act as an additional filter. The flow of the water to the stock tank may be controlled by a float, but it will be found convenient to have a shut-off valve in the pipe line. The discharge pipe filter and valves should be installed at the time of construction. One-inch pipes are usually installed.

TABLE 4. DISCHARGE CAPACITY IN CUBIC FEET PER SECOND OF BROAD-CRESTED SPILLWAYS*

Head on crest, feet	Width of spillway, feet							
	2	4	6	8	10	12	16	20
0.5	2.3	4.5	6.8	9.1	11.3	13.6	18.1	22.6
1.0	6.4	12.8	19.2	25.6	32.0	38.4	51.2	64.0
1.5	11.8	23.5	35.2	47.0	58.8	70.5	94.1	117.6
2.0	18.1	36.2	54.3	72.4	90.5	108.6	144.8	181.0
2.5	25.3	50.6	75.9	101.2	126.5	151.8	202.4	253.0
3.0	33.3	66.5	99.8	133.0	166.3	199.5	266.0	332.5

Computed from the equation $Q = 3.2\ LH^{3/2}$
where Q = discharge in cubic feet per second
L = width of spillway in feet
H = head of water on crest of spillway in feet.

*Ayres, Q. C. Soil erosion and its control. 1936.

Fig. 9. A well-sodded, broad-bottom pond spillway on the State College Pasture Improvement farm near Albia. It can be noted that the spillway is about 4 feet below the lowest elevation of the crest of the dam and that pond and spillway are fenced.

DOMESTIC USE OF POND WATER

If a pond is to be used as a source of domestic water supply, special care should be taken to protect the water from contamination. The drainage area should be woodland or preferably meadowland. To guard against contamination, a farm residence with an outhouse should never be included in the watershed. Possibility of any drainage whatsoever from feedlots should be guarded against. Great care must be taken in installing the pipe inlet, and a gravel and sand filter with a strainer is desirable.

WATER FOR IRRIGATION

A pond of adequate capacity may be used to supply water for supplementary irrigation to the farm garden or truck patch. If the pond is not located above the garden so that the water may be piped to it by gravity, a pumping plant should be installed. High lifts make for expensive operation. A larger discharge pipe, 3 to 6 inches, should be installed if water is to be used for irrigation, because the water should be supplied rapidly.

If water is to be used for irrigation, provision should be made for the extra capacity required. Under most conditions two to five irrigations during the season will be all that is desired. An inch of water, or 27,152 gallons per acre, applied by irrigation will be a normal irrigation to supplement rainfall. If the soil is light and open, more water will be needed.

FARM PONDS FOR FISH AND WILDLIFE

If farm ponds are sufficiently deep, they may be stocked with fish. Such a practice will insure against the pond becoming a breeding place for mosquitoes. In some instances the pro-

duction of fish in farm ponds may become a worthwhile secondary enterprise.

The farm pond lot may be made into an interesting and profitable wildlife refuge. Crops such as wild rice and protective shrubs may be planted to attract wildlife.

Persons interested in obtaining information concerning fish and wildlife in connection with farm ponds should write the Iowa State Conservation Commission, Des Moines, Iowa.

COST OF CONSTRUCTING FARM PONDS

The largest item of cost in constructing a farm pond is that of building the dam. The cost of moving earth is greatly affected by hardness of soil and the efficiency of the equipment used. Although small ponds can be built by teams and slip scrapers, large ponds are constructed with heavy power units. A number of contractors in Iowa are prepared to construct dams for farm ponds according to plans and specifications. The basis of the contract is usually the number of yards of earth to be placed in the dam. In order to insure a clear understanding of the work performed, a plan giving the location and size of the dam, together with the source of the earth is necessary. The methods and special provisions in the construction should be set forth in the specifications. The number of yards of earth

Fig. 10. A "V"-shaped spillway channel is not as stable as one with a flat bottom. Water velocity in the former type is much greater and therefore more destructive. While the channel here pictured has adequate capacity due to both its great cross section and steep grade, even a light discharge has eroded the partially sodded spillway because of the concentration of flow in the center of the V-notch cross section. Care should be taken that the channel grade is kept to the minimum.

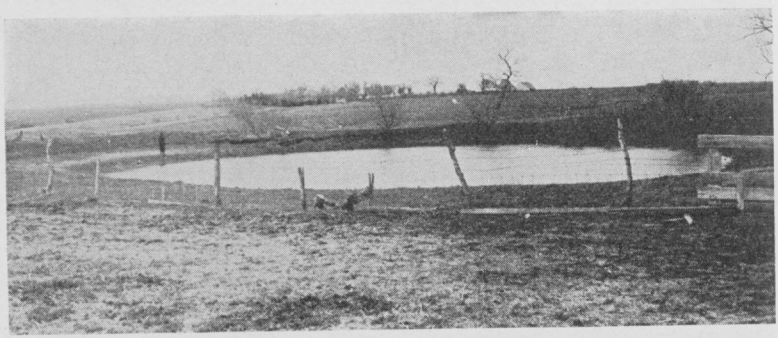


Fig. 11. A 54-year-old pond on the Charles Weller farm near Gravity, Taylor County, has provided livestock drinking water without interruption since its construction in 1886. Among the features which have made for this pond's adequacy are a small, well-sodded drainage area, ample storage capacity, wide spillway protected by dense vegetative cover and a well-placed drinking tank below the fenced-out area.

in any dam may be easily estimated by dividing the dam into sections, the volume of which may be estimated separately.

A study of the cost of dams built in 1939 revealed that the cost per yard of earth moved varied from 6 to about 20 cents per yard. In some instances the ponds were built with an hourly charge.

As criteria of cost of the smaller ponds used only as a supply of water for livestock, it may be mentioned that an insurance company owning a number of farms had 12 ponds built in the fall of 1939 which averaged $140 each. This included cost of dam, spillway construction and discharge pipe with valve. In other locations small ponds were constructed at a cost of $100 each. In most instances the ponds would have been improved and made more durable if more earth had been placed in the dams.

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