Farm Ponds

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Introduction

Farm ponds can and do serve a variety of uses and may do much to improve the beauty and value of a farm or rural area.

No modern farmstead can be operated successfully without an adequate supply of water for livestock, irrigation, fire protection, spraying and many other farmstead needs. There is ample evidence to prove that a well-planned pond contributes to greater farm earnings and indeed soon pays for itself.

In localities subject to seasonal droughts a good pond can mean the difference between success and failure by providing for crop and livestock needs when wells, springs and other water sources are run dry and are depleted. In areas of heavy rainfall farm ponds are important to soil conservation. By preventing quick runoff, they help check erosion and the formation of land-wasting gullies.

The development of farm ponds for recreation and fish production is also becoming very popular and has stimulated new interests in ponds. In nearly all instances, properly designed ponds can serve each and all these various needs both adequately and simultaneously.

By-pass ponds permit a portion of the water flowing in the stream to be diverted into the pond, while the remainder of the flow continues around the pond within the stream banks. This is shown diagramatically in Fig. 1. With a continuous supply of water from the stream the temperature and quality of the water can be better regulated within the pond.

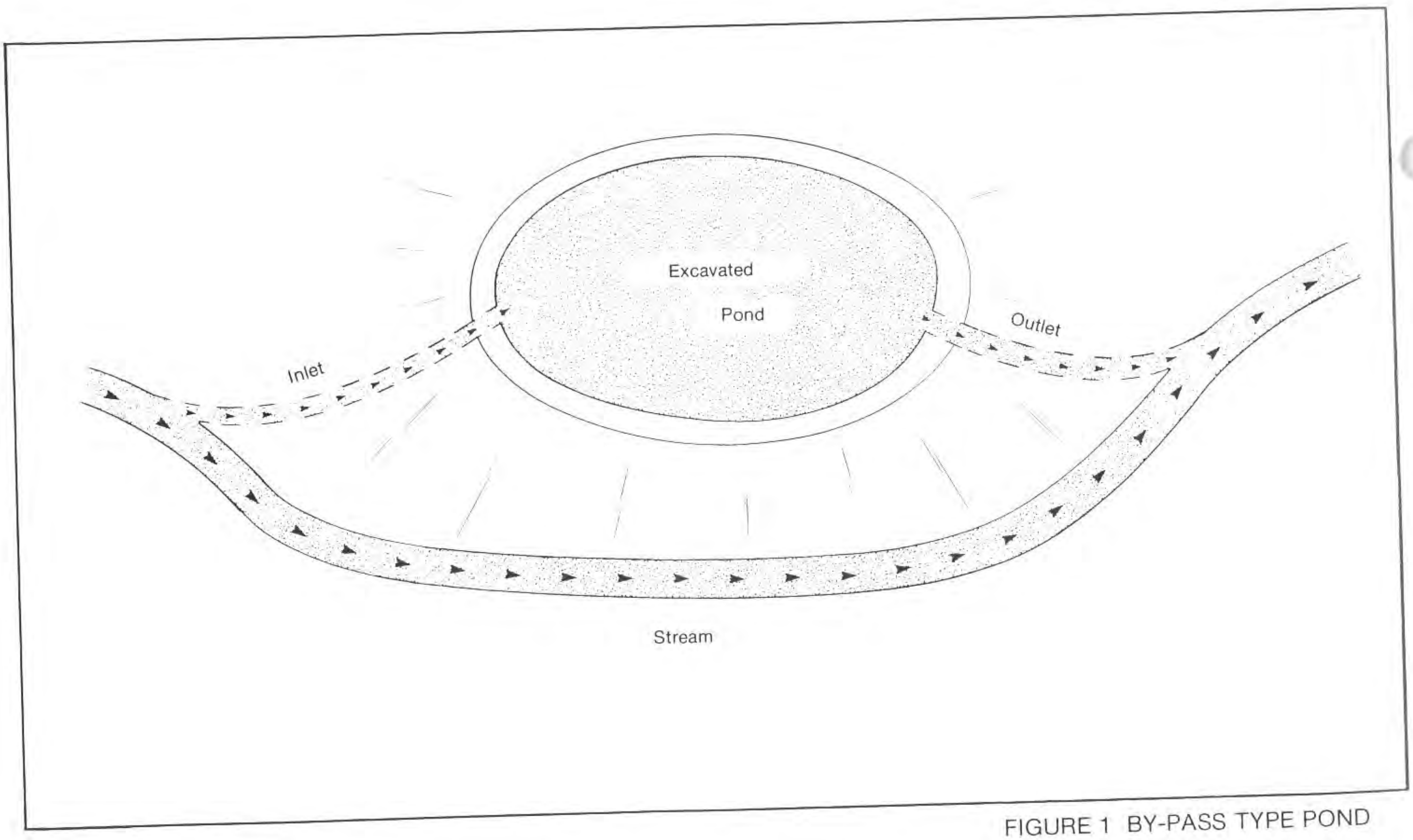

FIGURE 1 BY-PASS TYPE POND

Water Sources for Ponds

The waters of the earth are continuously in circulation. This is known as the hydro- logic cycle, and simply traces the path of the water from the time it reaches the earth in the form of precipitation until it evaporates back to the air and again forms clouds.

Man-made water projects (which includes the construction of ponds) short-circuit the natural circulation pattern of the earth. Water is collected at a time of surplus and is stored for use during periods of low rainfall or high demand.

Springs and **G**roundwater
Where there is groundwater at a shallow depth a large hole can be excavated in the saturated soil to provide a storage structure. This type of pond is similar to an oversize dug well. It is readily replenished by inflow from the water-bearing strata surrounding the pond.

Surface **R**unoff
The surface runoff from small drainage areas will prove to be the best source of water for ponds in gently rolling regions. The water from melting snow or rain will provide large volumes of runoff from pasture land, cultivated areas, or even wooded areas.

Streams
Permanent streams provide a reliable water source for ponds. If the drainage area is small and flooding is not likely to occur, the pond may be constructed directly in the channel of the stream. However, many streams are subject to excessive flooding and this would make construction of a dam too costly for an average farm unit. In such cases it is generally advisable to excavate a pond in the flood plain area adjacent to the stream.

Kinds of Ponds

Embankment **P**ond
An embankment pond is made by building an embankment or dam across a stream or water course. These ponds are usually built when stream valleys are depressed enough to permit storing of 1.8 metres (6 ft.) or more of water. Land slopes range from gentle to steep.

Excavated **P**ond
An excavated pond is made by digging a pit or dugout in nearly level areas. Because their capacity is obtained almost entirely by digging, excavated ponds are used where only a small supply of water is needed. Some ponds are built in gentle to moderate slope areas, and their capacity is obtained both by excavating and by building a dam.

By-pass **P**ond
A by-pass pond can be either an embankment or an excavated pond. Contact your nearest Regulatory Agency for legal restrictions in constructing this type of pond.

Selection of Pond Site

Several factors should be borne in mind when selecting a site for a pond. Some of these factors are:

1 Capability of soil to hold water. Clay or sandy clay soils are usually best.

2 A good portion of the drainage area should be permanent pasture or woodland, to avoid loss of pond capacity through excessive siltation. It is suggested that from one-half to three-quarters of the drainage area should be woodland. Where this is not possible the area should be protected by terracing, strip-cropping or other measures.

3 Avoid locations where excessive drainage area in relation to pond surface area may occur. That is, for a small pond, do not select a site that has a large drainage area. Large drainage areas naturally have a high capacity for silting and runoff which might exceed normal design estimates.

4 Ponds should not be located near septic tanks or other sources of contaminating drainage such as barnyards.

5 Plenty of depth is important in order to keep evaporation and seepage losses low and to prevent water from stagnating.

6 If an embankment pond is to be constructed, look for sites where dam construction will be easiest. Generally this is where the smallest dam can be placed to form a pond of the desired size. A draw between two hills or a large gully are good examples. In some cases, a crescent-shaped dam can be tied into the side of a hill, or a shallow pot can be hollowed out on relatively flat land, and sides built up to create needed storage capacity.

With these points in mind a preliminary survey of the farm should be made to determine suitable pond locations.

Capacity and Storage Requirements

The pond site selected should provide sufficient storage of water to meet the needs and uses for which it was designed. There will naturally be unavoidable losses due to seepage and evaporation. Seepage losses should be kept to a minimum by selecting a proper site with respect to soil types. Evaporation is harder to control and will be in the order of 0.45 - 0.60 metres (1.5 - 2.0 feet) depth per year.

The following storage capacities are suggested for ponds under various uses.

1 Livestock

a Cattle, drinking only 2770 litres (500 Imperial gallons) /month/animal
Drinking plus sanitation 6810 litres (1500 gallons)/month/animal

b Hogs 454 litres (100 gallons)/month/animal

c Sheep 454 litres (100 gallons)/month/animal

d Poultry 1816 litres (400 gallons)/100 birds/month

2 Household 6810 litres(1500 gallons)/month/person

3 Fire Protection 454,000 litres (100,000 gallons)

4 Irrigation Based on individual crop needs. Note that 1 Ac. in. = 102,650 litres (22,610 gallons)

Drainage Area

Runoff characteristics of drainage areas can vary greatly. In areas where snow contributes to the bulk of seasonal runoff 0.4 hectare (one acre) of hay or pasture land will yield at least 113,500 litres (25,000 gallons) of runoff water per year. On plowed land or stubble land, the runoff yield will be about 168,150 litres per hectare (15,000 Imperial gallons per acre) per year. (See Tables 3 and 4)

Unless very large amounts of water are required for irrigation purposes, the construction of ponds or reservoirs on streams draining watersheds of over 40 hectares (100 acres) should be avoided whenever possible. Construction costs for spillways of such capacity tend to be excessive for ponds intended for private or farmstead use.

Pond Dimensions

A simple rule for determining the approximate capacity of a reservoir with approximately 1:2 side slopes is based on the following formula:

Volume (litres) = 650 d A
A = pond area in square metres
d = maximum depth of water in metres

In English units the formula would be as follows:

Volume (Imperial gallons) - 3.75 d A
A = pond area in square feet
d = maximum depth of water in feet

For example a pond with an area of 1500 square metres and a maximum depth of 3 metres will have a capacity:
Volume = 650 x 1500 x 3 = 2,925,000 litres

The depth of water in a pond should be at least 1.8 metres (6 ft.). If the pond level fluctuates the depth should be 3.0 - 3.7 metres (10 - 12 ft.) so that the pond is never less than 0.9 metres (3 ft.) deep at its lowest level.

The dimensions selected for an excavated pond depend on the required capacity. Of the three dimensions of a pond the most important is depth. All excavated ponds should have a depth equal to or greater than the minimum required depth for a specific location and should conform to the figures above. If an excavated pond is fed from groundwater it should be deep enough to reach well into the water-bearing strata. The maximum depth is usually determined by the kind of material excavated and the type of equipment used.

The type and size of the excavating equipment can limit the width of an excavated pond. For example, if an excavator is used, the length of the boom usually determines the maximum width of excavation that can be made, given proper placement of the waste material.

The minimum length of pond is determined by the required pond capacity.

In order to prevent sloughing, the side slopes are usually no steeper than the natural angle of repose of the material being excavated. This angle varies with different soils, but for most ponds the side slopes are 1:1 or flatter. Figure 2 shows suggested side slopes for excavated ponds. (Note that slope equals "rise — "run").

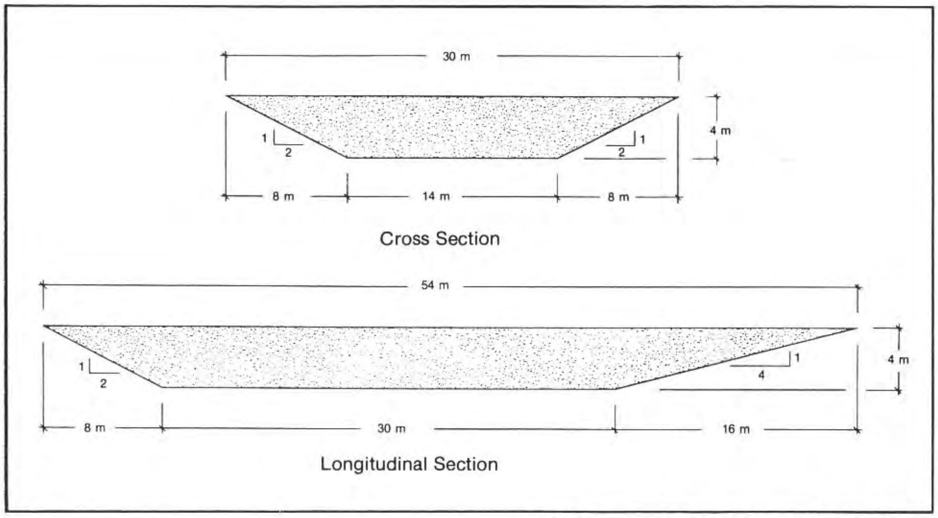

FIGURE 2 TYPICAL SECTIONS FOR EXCAVATED PONDS

Water source is surface runoff or ground water.

FIGURE 3 EXCAVATED OR DUGOUT POND

Construction of Excavated Ponds

After the site has been located and the storage requirements determined, the top dimensions can be indicated on the ground with stakes.

Construction will then proceed in a normal way with earth-moving equipment. The top soil should be stripped and stockpiled for later use. The inside slopes of the pond should be constructed with no less than 1:1 side slopes. More gentle side slopes should be used in loam and sandy loam soil. If the pond is to be filled above the natural ground level the excavated soil can be used to construct a bank around the pond. The inside slopes of this bank should be about 1:3.

In high rainfall areas and in areas where the groundwater table exists within the limits of excavation, the dragline is most commonly used, since it can operate satisfactorily in wet areas. The dragline should be used exclusively for ponds fed by groundwater aquifers.

Upon finishing the job it is advisable to level the earth around the pond with a bulldozer and to do the final finishing job with ordinary farm harrows. The earth should then be fertilized and seeded with grass. This will prevent erosion of the banks and add to the appearance of the pond.

Construction of Embankment Ponds

Earth is the most common material used in constructing an embankment for impounding water in a reservoir. Other materials might possibly be used where the dam is to be very small. However, they will prove to be more costly. In any case, care should be taken in planning the construction of a dam or embankment. Stop-water pipes, seepage control devices, facilities for drainage of the pond, spillways for bypassing excess water both during and after construction are all important parts of the impounding reservoir. The selection of suitable fill material and the careful placement of this material are very important in order to insure the stability of the embankment and the prevention of seepage through or underneath the embankment.

Preparing the **S**ite of the **D**am

The outline of the base of the dam should be indicated on the ground by means of stakes. All materials such as stumps, brush, roots, sod and loose topsoil should be removed from the site. All trees and bushes should be removed from the portion of the pond site which will be flooded after construction.

Construction of the **C**orewall

The purpose of the corewall is to prevent seepage water from flowing under the base of the dam. It consists of a trench dug lengthwise along the centerline of the dam, extending into and up the side slopes of the draw or gully to the normal surface level of the pond. It is backfilled with the most impervious material available. An impervious clay or sandy clay soil, well compacted, is best for this purpose.

Minimum depth of the wall should be 0.9 metres (3 ft.), and deeper if necessary, to contact impervious material underlying the base of the dam. The base of the wall should be 0.9 metres (3 ft.) wide with side slopes of 2:1. The material should be well compacted. If clay cannot be found, some other material such as concrete should be used.

Construction of the **E**mbankment

Fill materials should not contain vegetation, large rocks, frozen soil or any foreign substances. There should be sufficient moisture to insure compaction.

Soil should be added to the embankment in layers of 0.15 m to 0.30 m (6" to 12") and spread over the full width of the dam. This layer of soil should then be well compacted with earth-moving machinery or by means of rollers. If the soil is not damp enough to compact properly, water should be added to insure compaction. At no time should more than 0.30 m (12") of soil be added at once.

Even with compaction, the soil will settle in time. Generally over a one-year period, an embankment will settle 0.30 m (12"). It is usual to add an extra ten percent to the height of the embankment during the initial construction stages to allow for future settlement.

The most satisfactory design for earth-fill dams of the size required has a standard upstream slope of 1:3 and a downstream slope of 1:2.

Recommended maximum slopes for the upstream and downstream faces of a dam built of various materials are shown in the following table.

Fill Material	**Maximum Slope**	
	Upstream	Downstream
Clayey Sand Sandy Clay Silty Clay Silty Sand	1:3	1:2
Silty Gravel Clayey Gravel	1:2½	1:2½
Silt Clayey Silt	1:3	1:3

Portions of slopes not submerged in water should be seeded down to grass upon completion of construction.

The top width of a dam should never be less than 2.5 metres (8 ft.) and should be more if it is to be used as a roadway. The top width should also be increased 0.3 metres (1 ft.) for each 1.5 metres (5 ft.) of height above 4.5 metres (15 ft.). The recommended minimum top width for earth embankments of various heights is shown in the following table.

Height of dam (metres)	(feet)	Minimum top width (metres)	(feet)
Under 3	10	2.5	8
3 - 4.5	10 to 15	3	10
4.5 - 6.0	15 to 20	3.6	12
6 - 8	20 to 25	4.3	14

Stage is the distance between the top of the mechanical spillway and bottom of the emergency spillway. This distance should be between 0.3 - 0.6 metres (one and two feet) (Fig. 4).

Freeboard is the distance between the bottom of the emergency spillway and the top of the dam. A minimum of 0.6 metres (two feet) should be used for freeboard.

Mechanical Spillways

A well-designed dam should have both a mechanical and emergency spillway. No matter how well it has been built, if the capacity of the spillway is inadequate, the dam will probably be destroyed during the first severe storm. The function of spillways is to pass excess storm runoffs around the dam so that the water in the pond does not rise high enough to damage the dam by overtopping. The spillway must also convey the water to the outlet channel below without damaging the downstream slope of the dam. The success of a pond depends on a properly designed and installed spillway.

Earthen Structures

While even on farm ponds most spillways tend to be referred to as mechanical spillways, it is possible to use a natural or excavated earth spillway in some farm pond applications. A natural spillway is one where the topography is such that no excavation is needed to have enough capacity to conduct an overflow to a safe point of release.

An excavated earth spillway may require building an approach channel, a control section, and an exit channel in the earth in order to have an adequate spillway. Extreme care must be taken in designing excavated earth spillways and extreme care also must be exercised in constructing such spillways. This type of spillway is normally not recommended even in farm pond use; however, if this type of spillway is essential, it is suggested that the farmer obtain professional help.

Mechanical Spillways

The mechanical spillway may be one of several types and is generally constructed of metal pipes or concrete structures or a combination of both. At no time is it recommended that wood be used in the construction of a mechanical spillway.

Pipe Spillways

A pipe spillway as seen in Figs. 4 & 5 consists of a horizontal section of pipe extending from the upstream side of the dam below the natural ground level and projecting beyond the dam on the downstream side. This pipe is called the outflow pipe or trickle tube. A drain valve or plug on the upstream end is normally required to permit the pond to be drained for repairs. Alternatively the pond may be pumped dry should emptying be required.

A vertical riser section of pipe should be welded to the horizontal section or attached by a fabricated tee to form a watertight joint. The riser section should extend to the desired water surface level. The diameter of the riser must be somewhat larger than the diameter of the overflow pipe if the tube is to flow full. Recommended combinations of outflow pipe (trickle tube) and riser diameter are shown in Table 5, at the back of this publication. In this table the total head is the vertical distance between a point 0.3 m (12") above the top of the riser and the centerline of the outflow pipe at its outlet end. Since pipes of small diameter are easily clogged by trash and rodents, no pipe less than 150 mm (6") in diameter should be used for the outflow pipe.

Square steel or concrete anti-seep collars with a width approximately 5 times the pipe diameter should be attached to the pipe and a watertight joint assured. Anti-seep collars should extend into the fill a minimum of 0.6 m (24") perpendicular to the pipe. If the dam is less than 4.5 metres (15 ft.) high, one anti-seep collar midway between centerline of the fill and the riser pipe may be sufficient. For higher dams, use two or more collars equally spaced between the fill centerline and the riser pipe.

Pipe and anti-seep collars should then be back-filled with moist soil and thoroughly compacted by hand tools around the bottom and sides.

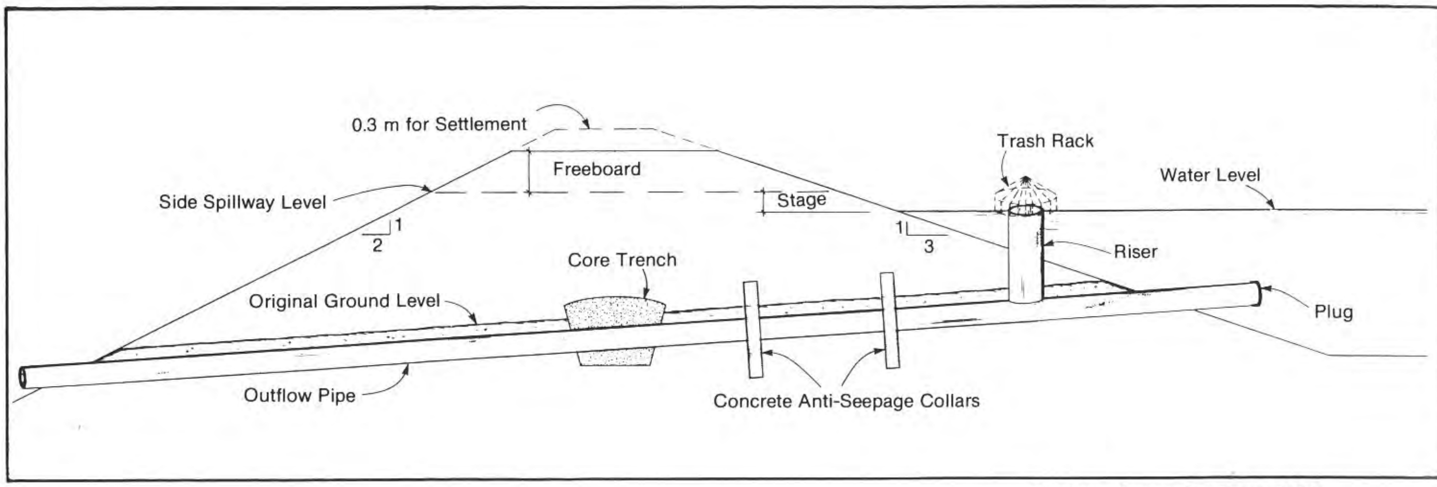

FIGURE 4 PIPE SPILLWAY

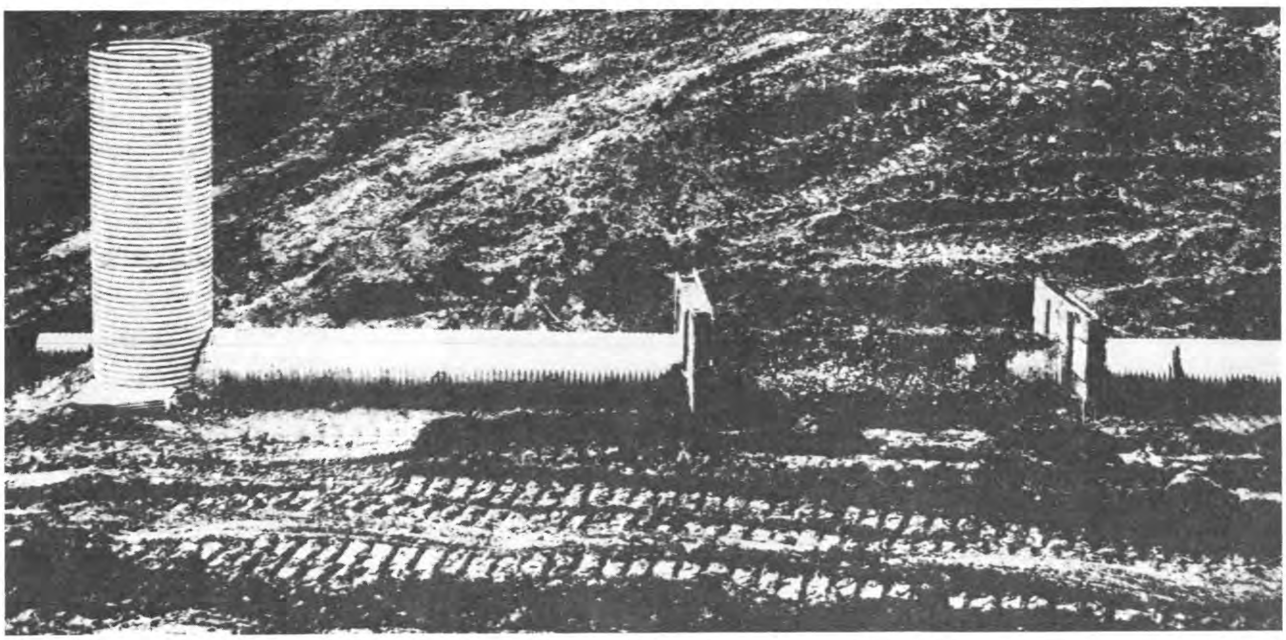

FIGURE 5 CORRUGATED METAL-PIPE SPILLWAY WITH ANTI-SEEPAGE COLLARS PRIOR TO BACKFILLING.

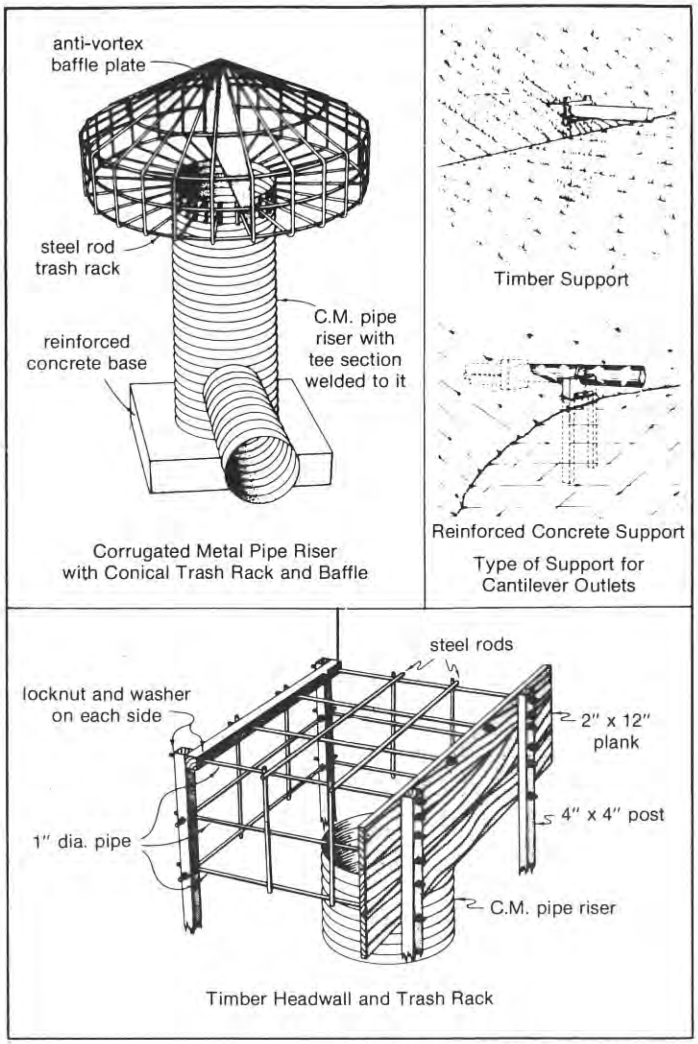

FIGURE 6 TRASH RACKS FOR DROP INLET PIPE SPILLWAYS

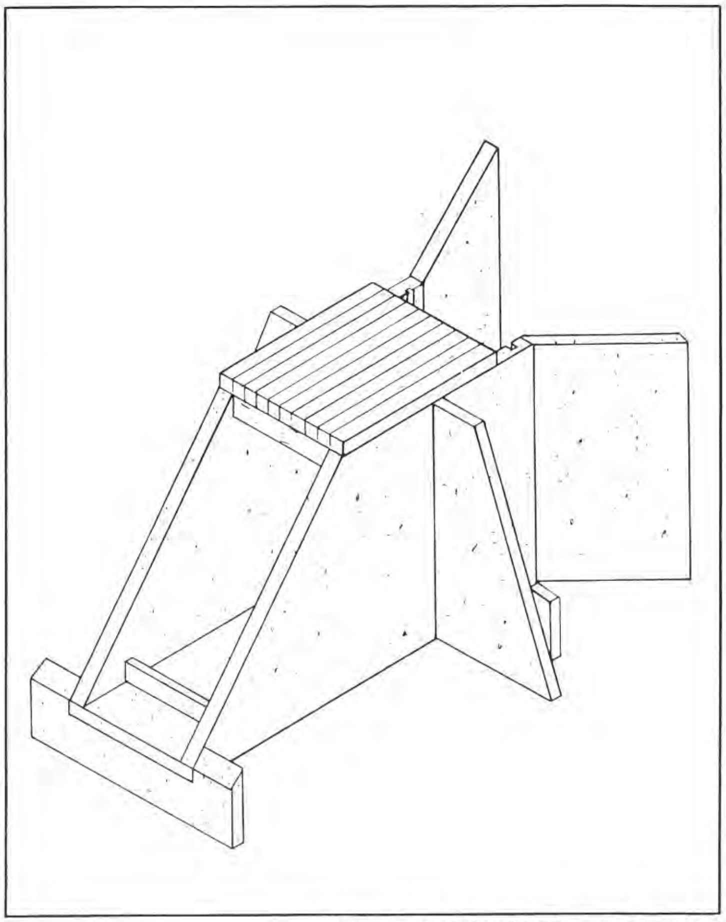

FIGURE 8 CONCRETE WEIR TYPE SPILLWAY

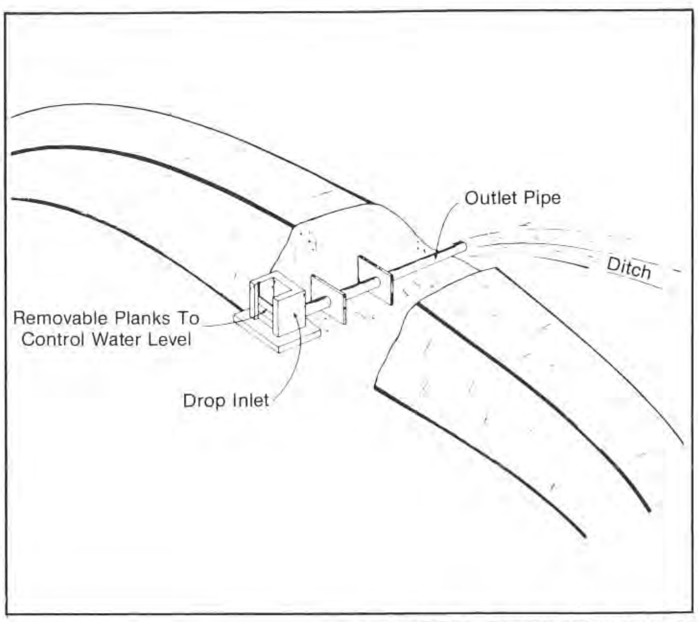

FIGURE 7 DROP BOX INLET SPILLWAY

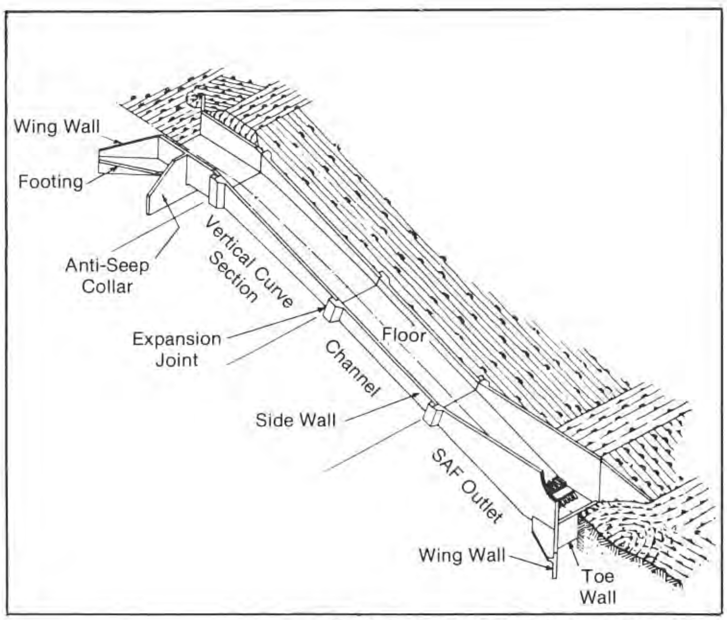

FIGURE 9 CHUTE TYPE SPILLWAY

Top compaction can be carried out by tractor or earth-moving machinery driven along the length of the pipe. Trash racks should be used to keep the trickle tubes or overflow pipes from clogging with trash and debris. There are two types of trash racks which work very successfully in drop inlet pipe spillways. These are shown in Fig. 6.

A spillway of the type seen in Fig. 7 is a modification of the pipe spillway. The riser pipe is replaced by a concrete box inlet. This type of structure is slightly more costly to build and a little harder to construct, but has advantages over the riser pipe. It gives a better control of water level in the reservoir.

Weir Spillways
A concrete spillway of the type shown in Fig. 8 may also be constructed and is very useful in larger dams. It enables the operator to have complete control over the level of water in the reservoir and provides an adequate roadway over the top of the spillway. Care must be taken in the construction of this type of spillway, with special emphasis on adequate seals to prevent leakage.

Chute Spillways
Fig. 9 shows another type of spillway, which may be constructed over an embankment known as a chute spillway.

General Considerations
Before construction of any of these spillways is undertaken a District Agricultural Engineer or Soil Conservation Engineer should be contacted to advise on size of structure to be built in order to insure adequate capacity. At the same time the Engineer should also advise on location and type of construction best suited for the site, and deal with other problems which might be encountered in constructing a spillway. Detailed plans of various spillway types are available from the nearest Extension Agricultural Engineering offices.

Emergency Spillway

This spillway provides protection for the dam during periods of flood flow. The emergency spillway could best be described as a back-up system in the event that peak flow should happen to exceed the capacity of the mechanical spillway. The simplest type of emergency spillway consists of a broad channel constructed from the upstream side of the dam around the end of the dam, with the outlet discharging onto a slope on the lower side of the dam. At no place should it be close enough to the dam to create the danger of washing out the earth fill.

Whenever possible, select a natural channel for the emergency spillway. If this is not possible an earthen emergency spillway should be well sodded to prevent erosion.

The invert elevation of the emergency spillway should normally be 0.3 - 0.6 m (one to two feet) higher than the top of the mechanical spillway, unless a weir type spillway is used. This channel should be capable of providing the necessary protection required during periods of flood flow.

Sealing Ponds and Reservoirs

Excessive seepage losses in farm ponds usually are due to selection of a site where the soils are too permeable to hold water. Seepage losses can also occur because of poor practices followed in constructing embankment or earthern dams. The problem of reducing seepage losses is one of reducing the permeability in the soil to a point where the losses become tolerable or nil.

In areas where ponds must be built on soils with high permeability rates, sealing or reducing seepage losses should be part of the design of the pond itself. No matter how much care is taken in the construction of many ponds, leaking or seepage losses will occur upon completion, even though an analysis of the soil indicates that soil permeabilities are adequate to minimize seepage losses. The problem exists then of how to stop this seepage.

There are a number of methods which can be used to either stop or minimize seepage from a reservoir.

Sealing by Compaction
Pond areas containing a high percentage of a coarse-grained material can be made relatively impervious by compaction alone, if the material is well-graded from small gravel or coarse sand to fine sand, clay and silt. This method of sealing is the least expensive of all methods and really is part of the construction process.

The compacted seal should not be less than 0.2 m (8") thick, where 3 m (10') or less of water is to be impounded. Since seepage losses vary directly with the depth of water impounded over an area, increase the thickness of the compacted seal proportionally if the depth of the water impounded exceeds 3 m (10 feet).

Clay Blankets

Pond areas containing a high percentage of coarse-grained soils without enough clay to prevent excessive seepage can be sealed by blanketing. Blanket the entire area over which water is to be impounded, as well as the upstream slope of the embankment. The blanket should consist of well-graded coarse-grained material containing at least 20% clay.

Thickness of the blanket depends on the depth of water to be impounded. The minimum recommended thickness is 0.3 m (12") for all depths of water up to 3 m (10 ft.). Increase this thickness by 0.05 m (2") for each 0.3 m (1 ft.) of water over 3 m (10 ft.).

Bentonite

Adding bentonite is another method of reducing excessive seepage in soils containing high percentages of coarse-grained particles and not enough clay. Bentonite is a fine-textured colloidal clay. When wet it absorbs several times its own weight of water and at complete saturation swells as much as 8 to 20 times its original volume. It fills the tiny voids in porous soil through which water ordinarily seeps. Tests show this method of stopping leakage to be up to 94% effective. However, when dried, bentonite returns to its original volume, leaving cracks. For this reason, sealing with bentonite is not recommended for ponds in which the water level is expected to fluctuate widely. This material does not affect water quality and it can be applied in several different ways.

a. Pure Blanket Method

This is the most efficient method but requires the most care in application. The surface of the area to be treated must be carefully prepared. First, remove the top 0.08 to 0.1 m (three to four inches) of soil from the pond. Then cover the area with a layer of bentonite 0.05 - 0.08 m (two - three inches) in depth. After spreading the bentonite, replace the top soil carefully to avoid disturbing the bentonite.

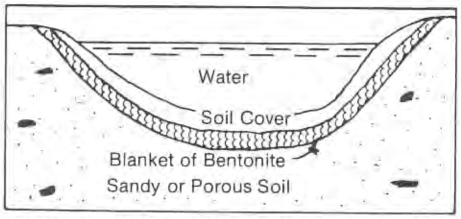

FIGURE 10 PURE BLANKET METHOD

After replacing the top soil, the area should be rolled or tamped to compact the surface. Allow the water to flow gently over the surface because it takes time for the bentonite to become completely saturated and find its way into the permeable voids. The effectiveness of this method becomes complete after several days. If livestock is allowed to wade in the pond the soil coverage should be thicker than 0.1 m (4 inches). Fig. 10 shows how the bentonite should be placed using this method.

b. Mixed Blanket Method

The surface to be treated must be prepared by removing all surface rocks and vegetation. Holes and/or crevices should be filled.

Bentonite should be spread over the surface evenly to a depth of 0.05 - 0.08 m (two to three inches). Then mix the bentonite into the underlying 0.1 - 0.15 metres (4 - 6 inches) of soil with a harrow or tiller, followed by rolling or tamping to compact it, as shown in Fig. 11. Allow water to flow gently into the reservoir.

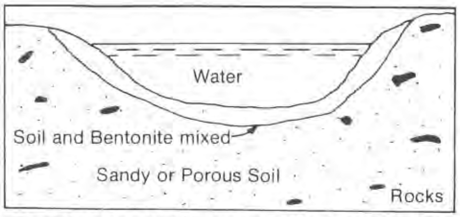

FIGURE 11 MIXED BLANKET METHOD

c. Sprinkle Method

The sprinkle method is used when it is impractical to drain the area to be treated. Coarse particles of bentonite are scattered on the surface of the reservoir and allowed to sink to the bottom. The bentonite is drawn into the cracks and crevices where leakage takes place. Here the bentonite swells and gels, thus closing the holes through which seepage occurs. Crushed or granular bentonite should be used because the particles will drop to the bottom before they complete their swelling and gelling action, whereas fine particles will float. In this method a slight temporary cloudiness of the water will occur, but is not harmful in any way.

Chemical Additives

Because of the structure or arrangement of clay particles, seepage is often excessive in fine-grain clay soils. Such soils are said to be aggregated.

Applying small amounts of certain chemicals to these aggregates may result in collapse of the open structure and rearrangement of the clay particles. This dispersed structure reduces soil permeability. The chemicals used for this purpose are called "dispersing agents".

To be effective, the soil in the pond area should contain more than 50% fine-grain material (silt clay) and at least 15% clay for chemical treatment. Chemical treatment is not effective in coarse grain soils.

There are a number of chemicals or dispersing agents available in the treatment of these fine-grain clay soils. For further information on dispersing agents consult your District Agricultural Engineer.

Waterproof Linings
Another method of reducing excessive seepage losses is the use of flexible membranes of polyethylene, vinyl and butyl rubber.

Thin films of these materials are structurally weak but if kept intact they are almost completely water-tight. Polyethylene films are less expensive and have better aging properties than vinyl. Vinyl is more resistant to impact damage and is readily seamed and patched with a soluble cement. Polyethelene can be joined or patched only by heat sealing. Butyl rubber can be joined or patched with a special cement.

These thin films must be protected from mechanical damage if they are to be serviceable. All polyethylene and vinyl membranes should have a cover of earth or gravel not less than 0.15 m (6"). Butyl rubber membranes need only to be covered in areas subject to travel by livestock. In these areas a minimum cover of 0.25 m (9") should be used over all types of membranes. The bottom 0.01 m (4") of cover should not be coarser than silty sand.

The following table suggests minimum thicknesses of the various types of liners for the various types of soil in question.

Certain plants may penetrate vinyl and polyethylene film. For this reason it is desirable to sterilize the subgrade with chemicals, particularly the side slopes where there are present such plants as nutgrass or quackgrass and other plants having a high penetrating power. Sterilization is not required where butyl rubber membranes are used.

The top edges of the lining should be anchored in a trench excavated completely around the area to be lined at the planned elevation of the top of the lining. The trench should be 0.2 - 0.25 m (8" - 10") deep and about 0.3 m (12") wide.

The lining should be anchored by 0.2 - 0.3 m (8" - 12") in the anchor trench and secured with compacted fill.

An ounce of prevention is worth a pound of cure and the easiest way to control seepage in ponds is to follow the procedures outlined earlier in constructing a pond. If leakage does occur it should be tended to immediately to avoid further erosion and possible failure of the structure. Professional advice should be sought for the best method to overcome specific seepage problems.

Soil Material Not Coarser than:	Polythylene	Vinyl	Butyl Rubber
Sands (Clean or Silty)	200 um (8 mil.)	200 um (8 mil.)	375 um (15 mil.)
Gravels (Clean, Silty or Clayey)	375 um (15 mil.)	375 um (15 mil.)	750 um (30 mil.)

Protecting the Pond

Construction of your pond is not complete until you have provided protection against erosion, wave action, trampling by livestock, aquatic vegetation growth, control of nuisance animals, and any other source of damage. Ponds without this protection may be short-lived and the cost of maintenance is usually high.

Erosion Control
Erosion by wave action may occur along the banks of the pond and upstream surface of the dam, causing the water to become turbid, and it may result in damage to the banks or even lead to failure of the dam. A good grass cover on the margins of the pond may well serve to control shore erosion, but it may be necessary to place stones or rip-rap at water level if erosion cannot be controlled otherwise. Rock or rip-rap should extend from the top of the dam down the upstream face level at least 1 m (3 ft.) below the lowest anticipated water level.

The outlet of the mechanical spillway and emergency spillway is particularly vulnerable to erosion, due to high water velocities. The discharge from the pipe spillways should drop into a stilling pool protected by flat stones on the bottom and sides of the embankment.

The flow from the emergency spillway should form a uniform sheet of water on the slope on which it discharges.

Livestock Protection
Complete fencing of areas on which embankment ponds are built is usually recommended if livestock are grazed or fed in adjacent fields and are using the pond for their water source. Fencing provides the protection needed to develop and maintain a good plant cover on the dam and bank of the pond. It also provides clean drinking water and eliminates damage or pollution by livestock.

If complete fencing of the pond is impractical, fencing critical parts of the livestock watering ponds, particularly the earth fill and the spillway, is usually advantageous.

Aquatic **V**egetation **C**ontrol
Excessive growths of aquatic vegetation in ponds present an undesirable appearance and interfere with both recreational and agricultural uses, particularly where water is pumped for irrigation and fire protection. Certain species of algae are toxic to cattle.

When dealing with control of aquatic vegetation, the importance of pond depth and properly-sloped shorelines cannot be over-stressed.

Shallow water at the edge of the pond promotes water weed growth, provides a breeding place for mosquitoes, and also makes such operations as fish management very difficult. These problems can be overcome to a large extent by deepening the shallow edges around the pond. This can be done by deepening the pool edge during construction or by cutting and filling the pool edge as shown in Figure 12.

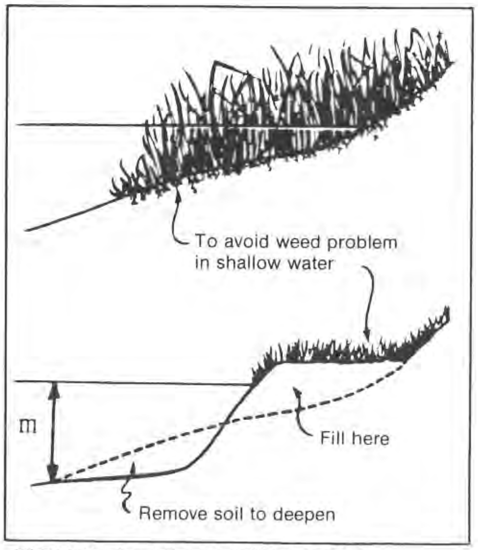

FIGURE 12 DEEPENING POND EDGES TO CONTROL VEGETATION

When all precautions are taken certain species of vegetation may appear in the pond in excessive amounts and may require control. The owner has a choice of either mechanical or chemical treatment or both. Mechanical control involves labor, but is very effective and should be considered seriously before undertaking the more dangerous method of chemical control. If used improperly, chemicals can have an adverse affect on fish, birds and mammals. If chemical means of control are to be used, professional advice should be sought before work is undertaken.

Control of **N**uisance **A**nimals
The presence of certain animals may become a problem in pond management. Dam failures are often attributed to the burrowing activities of muskrats and, occasionally, woodchucks.

Removal of cattails, shrubs and aquatic vegetation makes a pond less attractive to these animals. A strip of wire mesh located in the upstream face of the dam above and below the waterline will discourage burrowing. However, trapping is often the only successful means of control.

Other animals such as beaver, raccoon and mink may be bothersome, and water birds as well. These can be eliminated by trapping or shooting, but should be done in conjunction with local game laws.

Fire Protection

Ponds can serve a very useful purpose in that they can be used for fire protection. Several points should be kept in mind if a pond is to be used for this purpose.

1 Be sure that the pond is of adequate size. In no case should the pond have a capacity of less than 450,000 litres (100,000 Imp. gallons). It should be larger if possible.
2 Be sure that the pond is accessible to fire trucks at all times. A good road should be constructed to the pond's edge.
3 Make sure that water is available the year round. To insure the availability of water in winter, a dry hydrant can be installed.

Pond Safety and Liability

Ponds, like any other body of water, attract people so that there is always a chance of injury or drowning. Although the farmer may be planning to build a pond for watering livestock, for irrigation, or any other farmstead purpose, family and friends may want to use the pond for such recreational purposes as fishing, swimming, boating, or skating.

Fencing is recommended to keep livestock out of the pond. However, to prevent injury or drowning to people, and to protect the owner financially, some of the following steps should be taken.

Contact your local Justice Department to become familiar with the laws governing small farmstead ponds in your own local municipality.

There are other safety measures which should be taken during pond construction. All trees, stumps, and brush should be removed from the site. Remove all rubbish, wire, junk, machinery, and fences which might be hazardous to any activities after the pond is constructed. Minimize or eliminate any sudden dropoffs and deep holes.

After the pond is completed the owner should mark safe swimming areas and place warning signs at all danger points. If swimming and/or boating is permitted, lifesaving devices should be placed at swimming areas to facilitate rescue operations, should the need arise. If the pond is to be used for skating or other winter activities, long planks or ladders should be placed near the pond to facilitate rescue operations. As stated above, however, the owner should consult with his own local Justice Department and become familiar with his own municipal laws pertaining to farmstead ponds.

Regulatory Agencies

While the various provincial departments of agriculture can assist in planning and designing a farm pond from a technical point of view, ponds constructed in the Atlantic Region must also meet any specifications and regulations laid down by various regulatory agencies. Following is a list of the agencies in the Atlantic region.

Nova Scotia Dept. of the Environment
P.O. Box 2107
Halifax, N.S.

New Brunswick Dept. of Environment
Water Resources Branch
P.O. Box 6000
Fredericton, N.B.

Prince Edward Island Dept. of Environment
P.O. Box 2000
Charlottetown, P.E.I.

Newfoundland Dept. of Prov. Affairs & Environment
Elizabeth Towers
100 Elizabeth Ave.
St. John's, Nfld.

Helpful Hints on Planning and Building Farm Ponds

1 Select the best possible site from the standpoint of convenience, water supply, soil, topography and cost.
2 Ponds should contain at least 275 sq. m (3,000 sq. ft.) of surface water area and should be at least 1.8 m (6 ft.) over one-third of the area.
3 Clean off all vegetation from the pond area and do not use this material in the dam construction.
4 Install proper facilities, mechanical spillways, trickle tubes, and grass spillways to take care of excessive water.
5 Build the dam high enough and wide enough to withstand the pressure of the water.
6 Have the normal water level 1 m (3 ft.) below the top of the dam and 0.15 m (6") below the bottom of the spillway.
7 Fence the pond area if possible and do not allow livestock to trample the dam. Deepen the edges of the pond so that the area having a depth of 1 m (3 ft.) or less is kept to a minimum. This helps prevent weed growth.
8 If the pond is to be used for fire protection, an all-weather road should be built to the pond to provide a quick entrance for fire trucks in case of fire.
9 Inspect the pond frequently to see that leaks have not developed or the outflow pipe has not become clogged.
10 If failure develops on any part of the pond, repair the faulty section immediately to avoid further damage.

TABLE 1
Pond Storage Capacity

Size and approximate capacity of rectangular excavated ponds with 1:1 side slopes

Top Dimension (metres)	Depth (metres)	Capacity Cu. Metres	Capacity Litres
30 x 15	2.4	864	864,000
	3.0	1000	1,000,000
30 x 22	2.4	1340	1,340,000
	3.0	1680	1,680,000
36 x 18	2.4	1288	1,288,000
	3.0	1568	1,568,000
30 x 30	2.4	1900	1,900,000
	3.0	2296	2,296,000
45 x 18	2.4	1680	1,680,000
	3.0	1988	1,988,000
60 x 30	2.4	3975	3,975,000
	3.0	4815	4,815,000

Depth refers to depth of water.
Top dimensions at water surface.
Capacity figures rounded to nearest thousand
For 1:2 side slopes, reduce capacity by 20%

TABLE 2
Pond Storage Capacity

Imperial Equivalents of dimensions in Table 1

Top Dimension (feet)	Depth (feet)	Capacity Cu. Feet	Capacity Imp. Gal.
100 x 50	8	32,000	200,000
	10	37,000	230,000
100 x 75	8	48,000	300,000
	10	60,000	370,000
120 x 60	8	46,000	290,000
	10	56,000	350,000
100 x 100	8	68,000	424,000
	10	82,000	512,000
150 x 60	8	60,000	374,000
	10	71,000	443,000
200 x 100	8	142,000	886,000
	10	172,000	1,073,000

SEE NOTES — TABLE 1

TABLE 3
Runoff Producing Characteristics of Watersheds

Designation of Watershed Characteristics	Runoff Producing Characteristics Relief	Soil Infiltration	Vegetal Cover	Surface Storage
Extreme	Steep, rugged terrain, with average slopes generally above 30 per cent	No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	No effective plant cover; bare or very sparse cover	Negligible; surface depressions few and shallow; drainageways steep and small; no ponds or marshes
High	Hilly, with average slopes of 10 to 30 per cent	Slow to take up water; clay or other soil of low infiltration capacity, such as heavy gumbo	Poor to fair; clean cultivated crops of poor natural cover; less than 10 percent of drainage area under good cover	Low; well-defined system of small drainways; no ponds or marshes
Normal	Rolling, with average slopes of 5 to 10 per cent	Normal, deep loam with infiltration about equal to that of typical prairie soils	Fair to good, about 50% of drainage area in good grassland, woodland or equivalent cover; not more than 50% of area in clean cultivated crops	Normal; considerable surface depression storage drainage system similar to that of typical prairie lands; lakes, ponds and marshes less than 2 per cent of drainage area
Low	Relatively flat land, with average slopes of 0 to 5 per cent	High; deep sand or other soil that takes up water readily and rapidly	Good to excellent; about 90 per cent of drainage area in good grassland, woodland or equivalent cover	High; surface-depression storage high; drainage system not sharply defined; large flood-plain storage or large number of lakes, ponds, or marshes

TABLE 4
Peak Flow Per Second From Watersheds
of Various Sizes and Characteristics

Drainage Area		Runoff Producing Characteristics							
		Extreme		High		Normal		Low	
Ha	Ac.	L	Imp. Gal.	L	Imp. Gal.	L	Imp. Gal.	L	Imp. Gal.
2.02	5	217.9	48	181.6	40	81.7	18	22.7	5
4.05	10	381.4	84	304.2	67	131.7	29	36.3	8
6.05	15	544.8	120	431.3	95	186.1	41	49.9	11
8.09	20	703.7	155	544.8	120	236.1	52	59.0	13
10.12	25	862.6	190	658.3	145	290.6	64	68.1	15
12.14	30	1021.5	225	771.8	170	340.5	75	81.7	18

TABLE 5
Discharge Values, Q, Per Second for Various Sizes of
Drop Inlet Trickle Tubes of Corrugated Metal Pipes*

Total Head		Ratio of Trickle Tube Diameter to Riser Diameter in Inches											
		6:8		8:10		10:12		12:15		15:21		18:24	
metres	feet	L/s	cfs	L/s	cfs	L/s	cfs	L/s	cfs	L/s	cfs	L/s	cfs
1.8	6	24.0	0.85	49.0	1.73	87.7	3.1	144.3	5.1	249.0	8.8	399.0	14.1
2.4	8	25.5	0.90	52.4	1.85	93.4	3.3	152.8	5.4	266.0	9.4	424.5	15.0
3.0	10	26.6	0.94	55.5	1.96	99.1	3.5	161.3	5.7	280.2	9.9	450.0	15.9
3.7	12	27.7	0.98	58.6	2.07	104.7	3.7	169.8	6.0	294.3	10.4	472.6	16.7
4.3	14	28.9	1.02	61.4	2.15	107.5	3.8	175.5	6.2	305.6	10.8	495.3	17.5
4.9	16	29.7	1.05	62.5	2.21	110.4	3.9	181.1	6.4	314.1	11.1	512.7	18.1
5.5	18	30.3	1.07	64.0	2.26	113.2	4.0	186.8	6.6	322.6	11.4	526.4	18.6
6.1	20	30.8	1.09	65.1	2.30	116.0	4.1	189.6	6.7	331.1	11.7	534.9	18.9
6.7	22	31.4	1.11	66.2	2.34	118.9	4.2	192.4	6.8	336.8	11.9	546.2	19.3
7.3	24	31.7	1.12	67.0	2.37	118.9	4.2	195.3	6.9	342.4	12.1	554.7	19.6
7.9	26	32.0	1.13	67.9	2.40	121.7	4.3	198.1	7.0	348.1	12.3	563.2	19.9

* Length of trickle tube used in calculations is based on a dam with a 3.5 m top width and 1:2.5 side slopes. Discharge values are based on a head on the riser crest of 0.3 m 100 L/s = 3.53 cfs = 1320 Igpm

TABLE 6
Width of Spillway and Pipe Sizes
Based on Size of Drainage Area

Drainage Area		Max. Depth of flow through Emergency Spillway		Min. Bottom Width of Emergency Spillway		Size of Pipe Under Fill		Size of Riser Pipe	
Ha	Ac	m	in	m	in	m	in	m	in
0 - 1.2	0 - 3	.15	6	.25	10	.10	4	.15	6
1.2 - 2.0	3 - 5	.23	9	.51	20	.15	6	.20	8
2.0 - 4.0	5 - 10	.30	12	.56	22	.15	6	.20	8
4.0 - 6.1	10 - 15	.38	15	.61	24	.20	8	.25	10
6.1 - 8.1	15 - 20	.38	15	.66	26	.20	8	.25	10
8.1 - 12.1	20 - 30	.46	18	.66	26	.25	10	.30	12
12.1 - 16.2	30 - 40	.53	21	.66	26	.30	12	.38	15
16.2 - 20.2	40 - 50	.53	21	.76	30	.30	12	.38	15

TABLE 7
Metric — Imperial Conversion Chart of Measurements Used in Text

Linear

1 meter = 3.2802 feet
1 micron = 3.937 x 10^5 inches
1 micron = 0.03937 mils
1 hectare = 2.471 acres

Volume

1 $meter^3$ = 35.3144 ft^3
1 $meter^3$ = 1000 litres
1 $foot^3$ = 6.229 gallons (Imp.)
1 litre = 0.22 gallon (Imp.)
1 acre-foot = 271,322 gallons (Imp.)
1 acre-inch = 22,615 gallons (Imp.)
1 acre-inch = 102,672.1 litres
1 acre-inch = 10.11 hectare millimeter

Flow

1 litre/sec = 13.2 gal/min. (Imp.)
1 litre/sec = .035 ft^3/sec
1 ft^3/sec = 373.2 gal/min.