EXTENSION Engineering IN KANSAS

KANSAS STATE UNIVERSITY MANHATTAN, KANSAS

R-15

Reducing Pond Water Losses

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Water is lost from ponds by evaporation, evapotranspiration and seepage. Evaporation is the direct loss of water from the pond surface to the atmosphere. Evapotranspiration is the consumptive use of water by aquatic vegetation in or adjacent to the pond and by phreatophytic (high water using) vegetation adjacent to the pond and indirectly taking water from it. Seepage is the loss of water by percolution through the bottom or sides of the pond, through the dam or along the interface between the dam and native materials at the abutments or bottom of the dam.

During dry weather when runoff is low, water losses from ponds become a critical factor. Many ponds disappear during dry periods, which, in some cases, has required hauling water for livestock or domestic use. If losses can be reduced, the carryover storage is more effective and will last longer. Methods for reducing losses are available for each of the losses defined above. The following paragraphs describe the procedures which may be used to reduce losses.

Major Problem Areas

High seepage losses are typically a problem where fractured sandstone or limestone rock is exposed or located near the surface, and anywhere that sandy or gravelly soils are found. In either of these cases, the water generally percolates out the pond bottom and/or sides. The deep loess soils of the state may also be subject to excessive seepage losses because of high permeability of the uniform sized soil particles.

Many times the porous material, such as sand or gravel or fractured rock, is exposed during the construction of the pond. When constructing ponds in areas known to be underlain by sand, gravel, or fractured rock, it is advisable to probe the area prior to making cuts to determine depth of porous materials. A minimum of 2 feet (0.6 m) of soil should be left on top of the porous material. When porous materials are exposed or when most of the soil is removed, rapid seepage may occur through the exposed area.

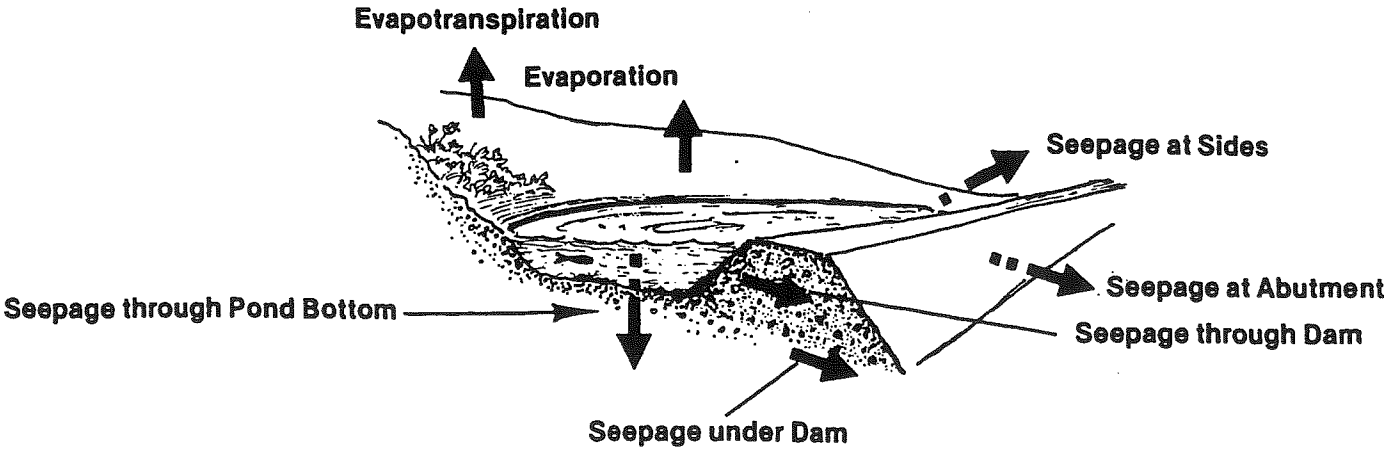


Figure 1. Avenues of Water Loss from a Pond.

Evaporation and Evapotranspiration

The evaporation from ponds in Kansas averages from about 4 to over 6 feet (1.2 to 1.8 m) per year as shown below. During drouth periods, evaporation may be up to 20% greater and during wet periods up to 20% less. Methods for reducing evaporation include reduced surface area, mechanical covers, and surface films. A reduced surface area (increased depth with a smaller surface) is a widely practical method of reducing water losses to the atmosphere in Kansas. Mechanical covers including floating covers, plastic or rubber membranes and roofs have a high initial investment and are costly to maintain but are effective in reducing losses. Surface films are mono-molecular layers generally of long chain (fatty) alcohols which form a very thin, but effective, cover over the water. These films may be useful for some special cases in Kansas where water supplies are limited or water is expensive.

Evapotranspiration is the loss from the soil and plants immediately adjacent to the pond. These phreatophytes, high water users, such as trees, cattails, and other growth, use water indirectly from the adjacent pond. A pond with a long shoreline and considerable phreatophytic vegetation in and adjacent to the pond may nearly double total losses to the atmosphere. Removal of these luxurious water users and seeding with low water using grasses can be an effective way of reducing losses. Eliminating shallow areas at the pond edge and reducing shoreline length are also effective in reducing losses to the atmosphere.

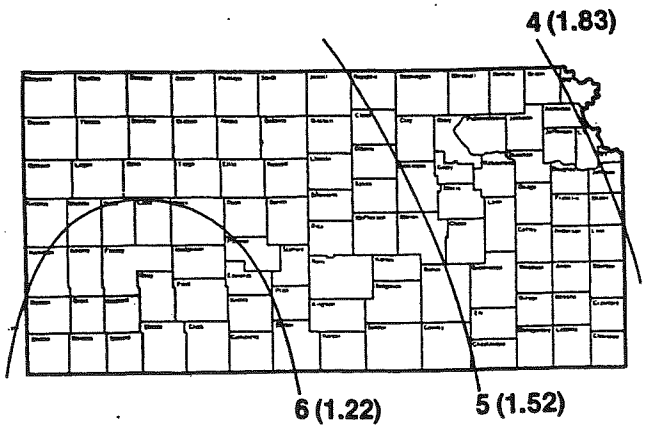


Figure 2. Average Annual Pond Evaporation Feet (meters)

Correction of Exposed Leaky Materials

Pond leakage is often caused by exposure of leaky materials such as sand, gravel or a fractured rock layer in the pond bottoms or sides. This type of leakage is characterized by a rapid water loss down to the lowest level of the leaky material. Most often the leaky material will be exposed at the surface but in some cases may be within a few inches of the surface. Gravel, sand, or rock fragments at the surface in the bottom or along the sides especially in cut areas are evidence of a leaky material. Many times the area responsible for the major leakage is small in relation to the total pond size.

Covering the area of the leaky material is the most common method of correction. Common materials include earth blanket, bentonite clay, organic materials, flexible membranes, and grout. Selection of materials to use depends on the size of leaky area, soil conditions, cost, and materials available. Brief descriptions of the characteristics of each of the materials and procedures for placing them are given in the following paragraphs.

Earth Blanket. Locally available materials which can be compacted to form a slowly permeable layer are suited for an earth blanket. A compacted layer of up to a foot thick is adequate for shallow ponds (less than 10 feet (3 m) deep) where it is not subject to freeze-thaw action. When depths are greater than 10 feet (3 m), the compacted layer should be increased accordingly. On the sides of the pond or on the dam face where it is subject to freeze-thaw action, the compacted soil layers should be 2 feet (0.6 m) thick. The soil used for the earth blanket should have a wide range of particle sizes with sufficient fines to fill the pore spaces and produce an impermeable layer. Clay loam, sandy clay, loam, and clayey materials are usually ideal. The soil is placed in layers of 4 to 6 inches (10-15 cm) and wet to optimum moisture content (often approximated by a condition when an earth ball can easily be formed with light pressure that retains shape on release) so a maximum density can be achieved. Compaction should be done with a heavy machine that exerts considerable pressure (high weight per unit area). A large tractor with heavy wheel weights and narrow tires works well or a sheepfoot roller is ideal if available. The pond should be filled as soon as possible after placing the earth blanket to prevent shrinkage cracks caused by drying. If the pond cannot be refilled soon after placing the earth blanket, a minimum layer of three feet is recommended to prevent shrinkage cracks from negating the effects of the compacted layer.

Bentonite Clay. Bentonite is a special clay material that readily expands on absorption of water to 10 to 15 times the original dry volume. It is also impermeable to water flow. It can be placed in a thin layer and covered with other soil to form a impermeable barrier protected from erosion. Bentonite can also be incorporated with 4

to 6 inches (10-15 cm) of top soil to form an impermeable blanket. One to 1½ pounds of bentonite per square foot (5-7.5 kilograms per sq. meter, kgsm) of soil is used for either method when water depths of 10 feet (3 m) or less are present. If water depths are over 10 feet (3 m), the bentonite application should be increased proportionately.

Vegetation and organic matter should be removed from the soil surface as should rocks, before incorporating the bentonite. If the surface has large seepage pores, bentonite should be mixed with other sandy or silty soil before placing over the exposed area. In most cases, bentonite will reduce the seepage by 80 to 100 percent if properly mixed and applied. Bentonite is available either in powder or granular form and is used by well drillers, feed processors, and conservation contractors, so generally it is available locally.

Organic Materials. The addition of organic materials such as livestock manure or chopped hay can reduce seepage if the seepage channels are not too large. The organic material causes anaerobic conditions with resulting slime growth which plugs the passages. Usually a heavy application of these materials is required to effectively reduce seepage. The manure contaminates the water so should not be used as a sealant for domestic water supply ponds or for fish ponds. Livestock should not drink from the pond for a few days. Other organic materials could reduce oxygen levels and be detrimental to fish. Addition of organic materials may have to be repeated periodically because of the decomposition process. Manure should be more effective than other organic materials because it has smaller particles and as a result produces anaerobic conditions more readily.

Flexible Membranes. Polyethylene, polyvinyl chloride (PVC) and bulyl rubber membranes are effective in preventing seepage. Proper preparation of the surface and covering is essential to protect the membrane from puncture and thus provides an effective seal. Below is a list of suggested thicknesses for the membrane. The surface should be free of stones, sticks or other materials which could puncture the membrane and should be smooth and firm so it will support men and equipment during installation. If the surface cannot be made puncture-free, a blanket of fine textured material should be placed first to provide a good surface. Slopes should be uniform and no greater than 3 horizontal to 1 vertical when the membrane is covered and 1 to 1 for exposed linings.

The plastic linings are easily punctured and deteriorate quickly when exposed to light so should be covered with soil. The cover should be in two layers consisting of 6 inches (15 cm) sand or silt adjacent to the membrane to protect it and 6 inches (15 cm) gravel, 1 to 3 inches (3-8 cm) in diameter to protect the fines (clay) from erosion. If livestock or people will frequent the pond area, all linings should be covered with at least a foot (0.3 m) of soil to protect the lining. The top edge of the lining should be secured by placing a trench at least a foot wide and 8 to 12 inches (20-30 cm) deep. The back fill of the trench should be compacted to hold the membrane in place.

Seepage Cutoff. If the seepage area is to the side and easily identifiable, the area may be drilled and grouted or trenched and an impermeable barrier placed. This method probably would only be used in larger reservoirs where it is impractical to seal the inside surface. It may also be suited to dams or the dam abutments.

Grouting is accomplished by drilling a series of holes close together into the leaky material so that the pores between holes will be filled by grout as shown on Figure 3. The grout slurry is injected into the holes under pressure to fill the voids and reduce seepage. Bentonite slurry and Portland Cement-sand slurry are commonly used for sealing the leaky strata. If the leaky strata is not too deep, a trench may be dug to the impermeable layer with either a trencher or a backhoe. The trench is filled with a material to reduce seepage such as bentonite, cement or cement-sand slurry. If a bentonite slurry is added to the trench as it is dug to control caving, the trench can be backfilled with soil to form a bentonite-soil mix that is impermeable. Either grout or a cutoff trench can be quite effective in controlling lateral seepage losses.

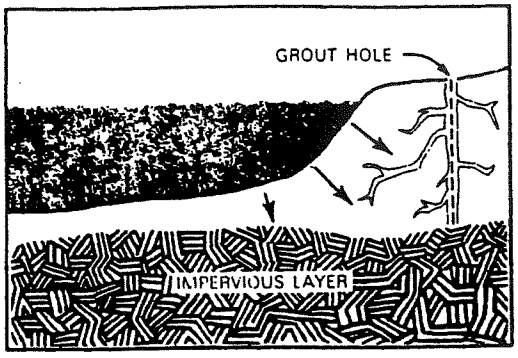
Permeable Soil Conditions

Many ponds leak because of excessive permeability of all soil materials rather than through exposure of leaky material within the pond. This leakage can be controlled by any of the methods discussed previously in the section on sealing exposed porous materials. In addition, other procedures may also be used, such as tramping by livestock and chemical treatment.

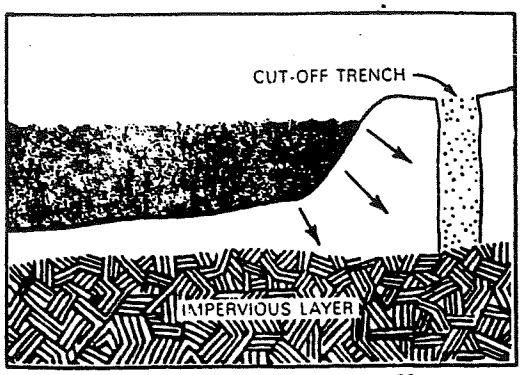
	Buried	Exposed Rubber Sheeting*	
Not Coarser Than:	PVC or Polyethylene	Reinforced	Non-Reinforced
Clay, silt, fine sand	8 mil (0.2 mm)	20 mil (0.5 mm)	30 mil (0.8 mm)
Sands and gravels	12 mil (0.3 mm)	30 mil (0.8 mm)	30 mil (0.8 mm)

*If rubber membranes are covered, thicknesses may be reduced to those used for plastic.

Figure 3.



Grout hole used for seepage cutoff.



Trench used for seepage cutoff.

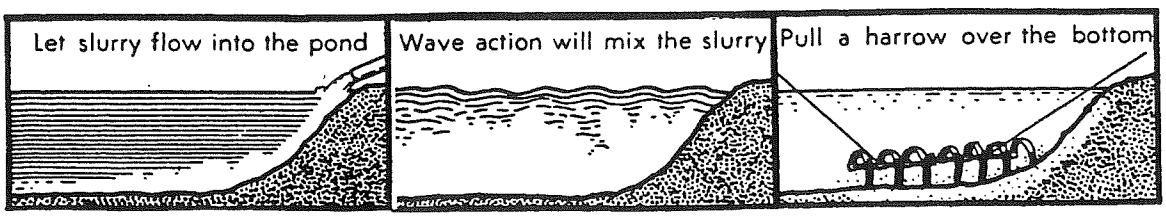
Tramping by Livestock. Tramping the edges and bottom of the pond by livestock is often an effective way to puddle the soil and compact it, thus reducing the seepage. Small hooved animals such as hogs are usually more effective, but any hoofed animal should work. In order for this procedure to be successful, the soil needs to have sufficient fines (clay) to fill the small pores and must be wet to the optimum moisture content as explained previously. Sometimes the pond is emptied and livestock are fed in the pond bottom for a period of time. The combined effect of compaction and manure is usually effective in producing a good seal of the pond. A sudden rain or snowmelt may cause runoff into the pond that could endanger livestock or damage feeding equipment. Steps should be taken to prevent damage to the dam surface when livestock tramp the pond area.

Chemical Additions. Chemical treatment may be used in soils with moderate to considerable clay content. The clay often forms strong aggregated soil particles and an open, porous or honeycombed soil structure may be produced which may have excessive seepage. Chemical treatment can effectively disperse the clay and cause a sealing action. Chemicals commonly used for dispersing are the mono-valent cations such as sodium or lithium. Soda ash (tech. grade—99 to 100 percent sodium carbonate), sodium polyphosphates and sodium chloride are most often used. Of the sodium compounds, sodium tripolyphosphates and tetra sodium pyrophosphate are usually most effective and are applied at rates of 0.05 to 0.1 lbs. per square foot (psf) (0.24-0.5 kgsm). Sodium chloride is applied at 0.2 or 0.33 psf while soda ash is applied at 0.1 to 0.2 psf (0.5-1.0 kgsm). A laboratory analysis of the soil is required to determine which dispersing agent will be most effective and at what rates it should be applied.

The chemical is thoroughly mixed into a 6-inch layer and compacted to maximum density. A more effective seal is obtained if the soil is treated in two 6-inch (15 cm) layers by first removing a 6-inch (15 cm) soil layer and stockpiling it. The next 6 inches (15 cm) is then treated and compacted and the stockpiled soil is then replaced, treated and compacted.

Bentonite. Bentonite can be used to treat the entire pond surface as described previously either as a blanket or mixed with the surface soil. It is also possible to treat a full pond with bentonite by pouring granular bentonite directly onto the pond in a criss-cross pattern or pumping in a slurry of powdered bentonite. Once the bentonite has covered the bottom, it is mixed with the surface soil layer by dragging a narrow, spring tooth chisel or other implement across the bottom as shown in Figure 4.

Figure 4. Bentonite Treatment of a Full Pond.



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