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Renovating Leaky Ponds

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Water loss from a pond is a serious problem. For the farmer, it can mean little or no water for fish, irrigation or cattle. For the homeowner, a leaking or empty pond is unattractive and detracts from the landscape. Leaky ponds also increase water use, reduce fertilizer effectiveness, and can pollute groundwater.

The most common causes of leakage are:

1) improper pond construction;

2) permeable soils or layers with high sand or gravel content; or

3) thin layers of soil with fractured or layered bedrock or solution cavities (sinkholes) as their substrate.

Known problem locations include areas in north Alabama and Georgia, and parts of Kentucky and Tennessee, where thin soil mantles lie on top of cavernous limestone. Another area where ponds are prone to leaks is the Southern Coastal Plain region, where soils are sandy and usually have a limestone base. In arid parts of Texas and Oklahoma, subsurface caliche high in calcium carbonate or gypsum is associated with leaky ponds.

The keys to repairing a leaky pond are properly identifying the cause of the seepage problem and selecting an appropriate method of sealing the pond. Though some treatments are suggested for undrained ponds, these are generally less effective. In most cases, a pond will need to be drained before repair. The purpose of the pond and the cost that the pond owner is willing to bear will influence treatment decisions. Because effective treatments often require an in-depth knowledge of soil characteristics, the pond owner should consult the Natural Resources Conservation Service (NRCS) or the Cooperative Extension Service for assistance.

Repairing a leaky pond is often expensive (Table 1). When it is a viable option, re-working and compacting a pond is the cheapest alternative at about $300 to 1,000 per acre. Treating a pond with a minimal rate of bentonite (i.e., 1 pound per square foot) will cost $3,500 to 4,000 per acre for the bentonite alone. Other treatments cost still more. The high cost of treating a leaky pond may lead the owner to abandon it, or do nothing in hopes that the pond will seal naturally.

Identify the Problem

In some cases the cause of a seepage problem may be apparent; in other cases, the cause may be unknown (Table 2). When there is excessive seepage, the first step is to carefully examine the pond dam or levees. Seeps, wet spots or wetland vegetation on or below the dam are indicators of leakage through or under the dam or levees. Water also can leak through muskrat or crawfish burrows or through channels left by rotten tree roots. Older ponds can develop leaks around drain or overflow pipes. If the water drops rapidly to a certain level, carefully check the perimeter of the pond at the waterline for holes or discontinuities in the soil.

In addition to inspecting the pond, gather as much information as possible about the pond history, site characteristics, and construction practices used. Important questions include:

- Was the site properly prepared by removing the existing vegetation and topsoil?
- Was the pond levee built properly, in compacted layers of 6 inches or less?

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Table 1. Approximate costs of certain seepage treatments. Prices vary with quantity and location. Cost should not be the only factor in selecting a treatment, as treatments are neither equally effective nor suitable in all cases.

Treatment	Approximate cost per sq. ft.	Approximate cost per acre
Compaction	$0.01-0.02	$300-1,000
Bentonite (cost of chemical alone–compaction is required)	$0.08-0.25	$3,500-11,000
Dispersants (cost of chemical alone–compaction is required)		
salt	>$0.01	$240-395
soda ash ($0.15-0.27/lb.)	$0.02-0.05	$650-2,400
TSSP ($0.82-0.92/lb.)	$0.04-0.09	$1,800-4,000
STPP ($0.61-0.64/lb.)	$0.03-0.06	$1,300-2,800
ESS-13	$0.15	$6,500
Liners (site preparation required at extra cost)		
HDPE (price per roll for liner only—installation is extra)		
12 mil	$0.08	$3,500
20 mil	$0.11	$4,800
30 mil	$0.165	$7,200
40 mil	$0.24	$10,500
Reinforced HDPE—custom shape		
16 mil	$0.27	$11,800
20 mil	$0.38	$16,600
24 mil	$0.55	$24,000
40-mil HDPE (includes professional installation)	$0.35-0.40*	$15,200-17,400
Textured 40-mil HDPE (as above)	$0.37-0.42*	$16,000-18,300
*Price quote for 5.8-acre pond		
Liquid urethane rubber. (60-mil coating, preferably applied over polyester fabric)	$1.24	$54,000

- Were the levee and pond bottom areas adequately compacted?
- Is the area known for sand or gravel lenses or sinkholes?
- How deep is the soil?
- Is there fractured or jointed bedrock in the pond basin?

If possible, ask the person who built the pond about potential problem areas. This may help identify the problem area and reduce treatment costs.

Before undertaking expensive pond renovation, consider that the problem may not be seepage. If the pond's watershed has been altered or reduced in size less water may be flowing into it. This would give the misleading impression that water is being lost from the pond.

Sometimes ponds only appear to be leaking, or they may leak only temporarily. Ponds built in shrink-swell clays will develop deep cracks when dry. As they are refilled water runs through the cracks until the soil swells again. A considerable volume of water may also be lost during the initial filling of a pond as it soaks into the surrounding soil, giving the impression of a leak. It is not uncommon for new ponds to have high initial seepage rates that decrease as microbial activity and the accumulation of fine sediment and organic matter help seal the pond bottom. If ponds that have sealed in this manner are dried or re-worked, they may again leak excessively until the seal re-establishes.

Spot Treatments

If seepage appears localized, dig out the suspect area and cover that section with a 1-foot-thick layer of compacted clay soil. Form the clay blanket with two layers of soil, compacting each layer separately. When repairing leaks in dams or levees avoid making vertical cuts, as they are difficult to seal. Dam or levee cuts should be made in a broad V shape so the new fill will bond with existing soil as it is compacted.

If spot treatment will not work or if leakage cannot be localized, the entire pond basin will require treatment. Methods for complete

Table 2.

Specific problem	Possible reason for leakage	Treatment options	Requirements
Seepage through a well-graded soil (one with a wide mix of particle sizes–sand, silt and clay), more than 15% clay.	Poor initial compaction.	Compaction	Drain; dry pond enough for equipment to enter.
	Sand lenses or other areas of high seepage.	Plow and mix soil, cover suspect areas with fresh mix, compact.	
Exposed layer of porous soil, sand/silt/gravel mixes, usually with less than 15% clay.	Poor initial compaction.	Compaction	Requires at least 10% clay.
	Too little clay (less than 10%).	Clay blanket	Requires local source of clayey soil to be cost effective.
		Bentonite	Requires supporting foundation soil; must be kept wet or will crack and leak again.
		Liner	Requires prepared site, professional installation.
Thin layer of soil on top of undesirable foundation–rock fractures, jointed bedrock, solution cavities.	Poor initial compaction.	Compaction	Requires at least 10% clay and soil thickness of 12 to 18 inches.
	Too little clay; pond bottom soil layer too thin.	Compacted clay blanket	Requires nearby source of suitable clayey material.
		Liner	Requires prepared site, professional installation.
Clayey soil that leaks. Typically high calcium soils.	Seepage through clayey soil because of aggregated soil structure.	Compaction	Requires strong compactive force at near optimum soil moisture to change soil particle structure, reducing permeability.
		Soil dispersant with compaction	Requires dispersants to change soil particle orientation.

pond basin work-overs include simple compaction, compaction aided by additives, or the addition of a liner.

Compaction

For many soils, compaction is critical to reducing leakage. Compaction works well when the soil has a wide and well-graded range of soil particle sizes. With soil containing sand, silt and at least 10 percent clay, water acts as a lubricant and the force of compaction squeezes air from the soil and locks the different size particles into the smallest possible arrangement. This leaves little space for water to move through the compacted layer. For adequate compaction be certain to:

1) compact thin layers;

2) use sufficient compactive force; and

3) make sure that the soil has the right amount of moisture.

Compact no more than 8 to 9 inches of loose soil at a time. This will give a compacted layer about 6 inches thick. This is critical, as the force of compaction diminishes quickly with soil depth. Compacting only the top of a pile does little to reduce the permeability of the soil underneath.

Using specific equipment is essential. A bulldozer alone will not compact adequately, as the broad tracks on a dozer are designed to spread out the weight of the machine to keep it from sinking into the soil. A sheepsfoot roller behind a bulldozer compacts much better (Fig. 1). As the roller makes repeated passes, compacting the soil and making it firm, the roller begins to “walk” out of

Figure 1. Sheeps foot roller.

the soil on the feet extending from the drum. Adequate compaction will require at least four to six passes of the roller over all of the pond bottom and sides. Tractor-drawn wheeled dirt pans also can be used over the dam or levee, although they do not compact as well as a roller.

The amount of water in the soil when it is compacted affects the resulting permeability, especially for clay soils. Though determining the optimum moisture content for a soil requires laboratory tests, a good indication in the field is soil that is too wet for good tilth but not so wet that water oozes out when it is compacted. If the soil is too wet, it can be disked to speed the drying process. If the soil is too dry, spray water over the site and allow it to soak in before proceeding.

When compacting an existing pond, the bottom must be dry enough to support the weight of the equipment. Remove any vegetation, tree stumps, roots and large stones. Disk the pond bottom to a depth of 16 to 20 inches, mixing the soil and ensuring that the soil moisture is near optimum before compaction.

Seepage increases proportionally with water depth. For ponds less than 10 feet deep, a 1-foot-thick layer of compacted soil is usually sufficient. This layer should be composed of two separate layers, each compacted separately. Soil will need to be stockpiled to one side or "borrowed" from a nearby site in order to apply a second layer to a compacted pond bottom. For each foot of water depth beyond 10 feet, an additional 2 inches of compacted fill is recommended.

Clay Blanket

Compacted blankets of clay soil have been used successfully to seal areas of exposed, fractured rock or other permeable material. The best soils are those with a wide range of soil particle sizes and with 20 percent or more clay. Again, a minimum thickness of 1 foot is recommended. When suitable soils are available nearby, it is relatively inexpensive to cover the pond bottom with compacted soil layers. Hauling in soil from a distant site adds greatly to the cost. The failure of clay blankets is often associated with on-site application problems. If the soil is dry, clods should be broken apart and water worked into the soil to achieve proper moisture content.

Bentonite

Sodium bentonite is a highly plastic clay that expands 8 to 20 times in volume when wet. It is used to fill in voids in porous soils. Bentonite has been used successfully on relatively sandy soil (at least 10 to 15 percent sand) where there is adequate support for the bentonite-treated layers. Calcium bentonite does not swell to the same extent as sodium bentonite and should not be used.

The amount of bentonite needed varies with soil type and laboratory testing is recommended to determine optimum application rates. Given its high cost, bentonite is more suited to spot treatments or small ponds. Typical application rates are:

Soil type	Application rate lbs./ sq.ft.	Application rate tons/acre
sandy silt	1.0-1.5	22-33
silty sand	1.5-2.0	33-44
sand	2.0-2.5	44-54

For best results, spread bentonite over the pond bottom at the recommended rate and mix it in with a disk or tiller to a depth of 6 inches. Moisten the soil if necessary, and compact the pond bottom as described in the section on compaction. Seepage will not decrease immediately because the clay swells slowly. Once treated, the pond bottom should be kept moist to prevent the clay from cracking and shrinking.

If a pond cannot be drained, granular bentonite can be used as a spot treatment over a suspected seepage area. The granular form allows the bentonite to sink to the pond bottom before dispersing. The proprietary compound ESS-13 (Seepage Control, Inc.), a resinous polymer emulsion, also can be applied to undrained ponds to reduce seepage.

Soil Dispersants

There is a common misconception that soils with adequate amounts of clay will not leak. In fact, not all clays are alike, and the arrangement of clay particles in a soil greatly influences permeability. Dispersants can be added to soil to reduce aggregation and permeability. As the name implies, dispersants aid in changing the soil structure from the open, aggregated form to a dispersed form that is less permeable to water. They work best on calcium-saturated clay minerals; therefore, soils derived from limestone are the likeliest candidates for the effective use of a dispersant. Dispersants will work only with aggregated soils (with an open, honeycomb arrangement of soil particles) with more than 50 percent silt and clay-sized particles and at least 15 percent clay. Because of the technical nature of soil dispersants and clay mineralogy, pond owners should seek expert advice in selecting an appropriate dispersant, if the use of one is indicated.

Common salt is recommended as a dispersant only for soils with a high cation exchange capacity (CEC), typically montmorillonite clays. Soda ash (sodium carbonate) is also used as a sodium-based dispersant. For kaolin clays (low CEC), sodium polyphosphates are more effective than plain salt because of the additional reaction of clay with the phosphate. Three commonly used polyphosphates are tetrasodium pyrophosphate (TSPP), sodium tripolyphosphate (STPP), and hexametaphosphate (SPP). The proprietary compound ESS-13 also functions as a soil dispersant.

A field test for the effectiveness of a polyphosphate dispersant is to add a pinch of the dispersant to a handful of moist soil. If the soil becomes noticeably wetter as it is rolled between the fingers, the dispersant should be effective.

Dispersants are applied in the same way as bentonite. Disk the pond bottom and spread the dispersant evenly over the surface. Mix the soil and compact it as outlined in the section on compaction. Again, a minimum of two, 6-inch-thick compacted layers is recommended. Adequate compaction is an important part of the treatment, as the dispersants work with the force of compaction to change the soil structure.

Typical application rates are:

Dispersing agent	Application rate lbs./ sq. ft.	Application rate tons/ acre
salt	0.2-0.3	4.4-7.2
soda ash	0.1-0.2	2.2-4.4
sodium polyphosphates	0.05-0.1*	1.1-2.2

*Higher rates are indicated for high CEC montmorillonite clays.

When ponds treated with dispersants are filled, the water will probably become muddy and may take weeks to clear. (Alum or lime should not be used to treat for this turbidity, as they will counteract the effect of the dispersants.) Dispersant salts might also leach out into the water and affect its suitability for use as a water source.

Liners

Properly installed, a liner is 100 percent effective in stopping seepage. For soils with high gypsum content, a liner is the only option. Because of the relatively high cost, liners have been used primarily for ornamental ponds, water storage, fish hatcheries, and research facilities. However, advances in liner technology achieved through their widespread use for landfills, hazardous waste, and water storage facilities have caused prices to fall.

Proper liner installation is important. A liner's edges usually are anchored into a trench built around the pond perimeter.

Many factors influence the selection of a liner material, and consumers have a wide choice of products. Modern plastics are environmentally safe, withstand freezing, and are UV-stabilized for long-term exposure to the sun. With care, a pond liner can last 20 to 25 years.

Liner thickness is measured in thousandths of an inch (mils). Twelve- to 20-mil liners can be used in sandy soils, while thicker liners are required to prevent punctures in rocky soils. In some cases, an inexpensive geotextile mat is applied under the liner to protect against punctures. Liners 20 mils or less in thickness are more suitable for temporary uses. For permanent aquaculture facilities, 30- to 40-mil liners are recommended. Thin liners will be punctured by plant sprouts along pond edges unless a sterilant is applied before the liner is installed. Obviously, even thick liners must be protected to a reasonable degree. For example, cattle should not be allowed to trample lined ponds.

Liners can be made from high-density polyethylene (HDPE) or low-density polyethylene(LDPE). LDPE is more flexible and is used where there is more shifting or movement of the soil, while HDPE is more resistant to chemicals. Polyethylene is both economical and durable and can be fiber-reinforced for greater strength. Seams on polyethylene liners are best sealed by heat welding or extrusion, which calls for custom fabrication for smaller ponds or professional installation on larger ponds. Vinyl can also be used for liners and, though less resistant to aging than polyethylene, it can be sealed and patched with solvent adhesives.

For smaller, ornamental ponds, butyl rubber is typically used as a liner material. A proprietary, liquid urethane rubber product is also available. It conforms to any pond shape and seals around pipes and other structures. Professional installation is recommended but gallon kits and an instructional video are available to homeowners.

Liners will become slippery with time, which can create a safety hazard where pond slopes are steep. Using a textured plastic liner, or embedding small stones in the liner's sides with a liquid urethane rubber product will provide a non-slip surface.

Other Treatments

Other methods of sealing ponds include the use of animals, puddling, and gley (organic matter).

A traditional remedy has been to fence pigs, cattle or other animals in the pond basin. Livestock manure aids in sealing the pond bottom, and animals trampling the pond bottom compacts a deeper layer of soil. This method gives mixed results and can cause nutrient pollution of surface or ground water until the pond seals up.

Puddling refers to the deliberate churning of soupy wet soil. Fines released from the soil during the mixing form a barrier of low permeability as they settle out on top of heavier particles. Soils must contain some clay and silt particles in order for puddling to work. Puddling forms a seal that has little strength, so it is not suitable for thin soil layers over rock. Puddling is used primarily in small dugout ponds or to create zones of low permeability within larger dams that are otherwise constructed to structurally support the weight of impounded water.

Burying a 6-inch-thick layer of organic matter, typically straw or a manure-straw mixture, in a pond bottom has been used as a sealing method. Once the organic matter is spread over the pond basin, it should be covered with soil and compacted firmly. Microbial action converts the material to a "gley," an organic layer of low permeability. This method does not form a seal quickly and unwanted nutrients might flow into surface waters until a seal is formed.

Prevention

Proper site selection and pond construction methods will help prevent pond leakage. Landowners should consult with the Natural Resources Conservation Service before building a pond. The Service has soil surveys with valuable information on soil properties and their suitability for water management. Taking core samples from a proposed pond site will help identify areas of high permeability and prevent future problems.

Cutting too deeply during construction is a common cause of leaky ponds. As adequate compaction and suitable moisture content are critical, a pond basin should be in the middle layer of a soil profile. This middle layer is called the B horizon and typically has the maximum accumulation of clay. The parent material underneath the B horizon may have little clay.

Finally, pond maintenance is important in preventing leaks from developing. Levees should be mowed to prevent tree growth and to discourage burrowing animals. Trees growing on levees are a frequent cause of leaks in older ponds. However, once trees with substantial root systems become established it is better not to cut them down, as leaks typically develop where dead roots decay.

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