

Planning And Managing Lagoons For Poultry Layer Waste Treatment

Poultry egg operations, particularly high-density large-volume units, must be planned as total systems. Increasing concerns over water quality and nonpoint source pollution demand that more attention be given to every aspect of planning from site selection to manure management. Location, number of birds, amount of available land for application, soil type, geologic features, crops grown, available labor, and climate must be considered when choosing a waste management system for these operations. The system that works best for one operator in a particular situation may not work well for another operator with different operating circumstances. Systems suited for other parts of the United States may not be suited for Alabama conditions.

Poultry layer waste is normally collected in pits or shallow alleys underneath caged layers or on earthen or concrete floors of high-rise houses. Undercage pits hold waste in liquid or slurry form for a limited time until land application is possible. Shallow alleys may be scraped for direct land application or flushed/scraped into waste storage ponds or lagoons. Poultry wastes under high-rise cages can be periodically scraped, flushed, or stored in place for annual removal. Multi-year high-rise storage is possible with good ventilation and moisture control. Future trends in layer housing may be toward dry handling of manure on belts underneath cage rows.

Each poultry layer waste management system can be properly planned and managed to prevent direct discharge of waste into surface waters or onto neighboring land, improve operational efficiency of the egg production unit, collect and use waste and wastewater as fertilizer, and prevent nuisance conditions.

Anaerobic Lagoons

Anaerobic lagoons are earthen structures that look at first glance like farm ponds but are designed to provide biological treatment and long-term storage of poultry layer waste. Anaerobic treatment of waste occurs without free oxygen to liquify or degrade high BOD (biochemical oxygen demand) organic waste. With proper design and management the anaerobic lagoon can function for years. Odor from a well-designed and well-managed lagoon will be only slightly musty; foul odor indicates a malfunction requiring corrective action.

Advantages of anaerobic lagoon systems are:

- Manure can be handled with water flushing systems, sewer lines, pumps, and irrigation equipment.
- The high degree of stabilization reduces odors during land application.
- High nitrogen reduction minimizes the land area required for liquid effluent disposal.
- Long-term storage is provided at low cost.

Disadvantages of anaerobic lagoons include:

- Public perception that a lagoon is an open container of manure.
- Offensive odors if improperly designed and maintained.
- Limited nitrogen availability if manure is used as a fertilizer.

Location Requirements

Ideally, lagoons should be located downslope from the poultry layer house so that waste can be gravity flushed to the lagoon. Recycled second stage lagoon water is generally used to flush waste from alleys. Flushing has the advantage over scraping by providing an opportunity to separate solids, primarily calcium and feathers, from incoming waste. Prior removal of these contaminants extends lagoon life and efficiency. Settling tanks, with skimmers, should be located between the layer house and lagoons to facilitate solids separation.

Good engineering practice recommends that lagoons be no less than 300 feet from water wells to prevent water supply contamination. Natural Resources Conservation Service (NRCS) recommends 500 feet but will accept 150 feet from an upslope water well.

Location with respect to non-operator-owned residences is an important consideration. American Society of Agricultural Engineering (ASAE) recommends a minimum of 900 feet downwind. In Alabama, however, recommendations are that lagoons

be (1) located at least 1/4 mile from property lines and nonoperator-owned residences and (2) screened from view with a natural or constructed screen. In some situations, especially in north Alabama, the location of a lagoon will be controlled by soil and geological considerations.

Soils Investigation

Although printed county soil survey maps give general guidance, the farm operator planning a treatment lagoon should have an on-site subsurface soils investigation made. Agencies with expertise similar to the NRCS can conduct on-site soils investigations and make appropriate recommendations. Backhoe excavations or soil borings are standard procedures to identify shallow soil over coarse sand and gravel, crevice, limestone, or permeable bedrock. If any of these conditions exist, procedures and materials, such as clay liners, geotextile liners, or concrete, to prevent seepage to ground water must be used in construction.

NRCS currently offers this on-site soils and geologic investigation assistance for animal and poultry waste management structures as part of the animal waste management technical assistance program. They should be contacted for assistance. This process will determine the soil suitability for and final location of a poultry layer waste lagoon.

Lagoon Design— Volume

Proper design of an anaerobic lagoon system requires the calculation of volume needed to accommodate waste accumulation over the desired treatment period. Total lagoon volume of either a single stage or two-stage

system is composed of several parts (see Figure 1):

- Treatment volume.
- Manure wastewater volume.
- Surface runoff volume.
- Net rainfall (rainfall minus surface evaporation, including the 25-year-24-hour storm).
- Sludge volume.
- Freeboard volume.

Treatment volume provides enough dilution volume for breakdown of volatile solids by bacteria and is not removed from the lagoon during pump-down operations. This volume is based on volatile solids daily loading rate in pounds per day per thousand cubic feet. Typical recommended primary anaerobic lagoon minimum design treatment volume for poultry layer lagoons in Alabama ranges from 10 to 14 cubic feet per 4-pound bird. The higher values are recommended for layer lagoon installations where odor control is particularly important.

Manure wastewater volume provides for wastewater storage of treated poultry manure volume accumulated over the designed treatment period. Pump-down interval and wastewater treatment period are the same and should be 180 days in Alabama. Storage volume per layer is 2 cubic feet for 6 months. Longer storage time offers greater flexibility in scheduling pumping operations.

Surface runoff volume provides storage for rainfall runoff plus any wash water or other freshwater that may be used for cleaning buildings. This volume is removed from the lagoon during pumping operations. Reducing area where runoff drains directly into the lagoon will reduce pumping volume. Roof and surface water, unless needed for filling or dilution, should be diverted away

from the lagoon. Generally the amount of rainfall and runoff to be collected and stored in the lagoon is figured on the wettest 10 years for net rainfall less evaporation on lagoon surface plus berm runoff.

Net rainfall. The lagoon must provide storage for net gain of rainfall minus lagoon surface evaporation plus berm area runoff plus the 25-year-24-hour storm. In Alabama, typical annual rainfall is at least 12 inches more than evaporates from a free water surface. Service area and berm runoff can add as much as 4 feet per year. This volume from net rainfall less evaporation is held in the second stage of a two-stage lagoon and removed when the lagoon is pumped.

Sludge volume results from manure solids entering a layer lagoon and a portion remaining in the first stage as bottom sludge. Research indicates that approximately 0.0295 cubic feet of poultry layer waste sludge accumulates per pound of total solids added to the layer lagoon. This is 0.67 cubic foot of accumulation per year per bird. Solids separation with a properly operating settling tank can cut sludge accumulation in half. The sludge accumulation rate can be used to determine volume necessary for sludge over any particular chosen design time, most commonly from 12 to 15 years. Recommended sludge volume is 2.0 cubic feet per bird.

Freeboard volume is the minimum extra depth above total full pool level, usually 1 foot, after all other volume requirements are met. Figures 1 and 2 show a cross section of one- and two-stage lagoon designs, which may be used throughout Alabama. Surface area will vary with depth.

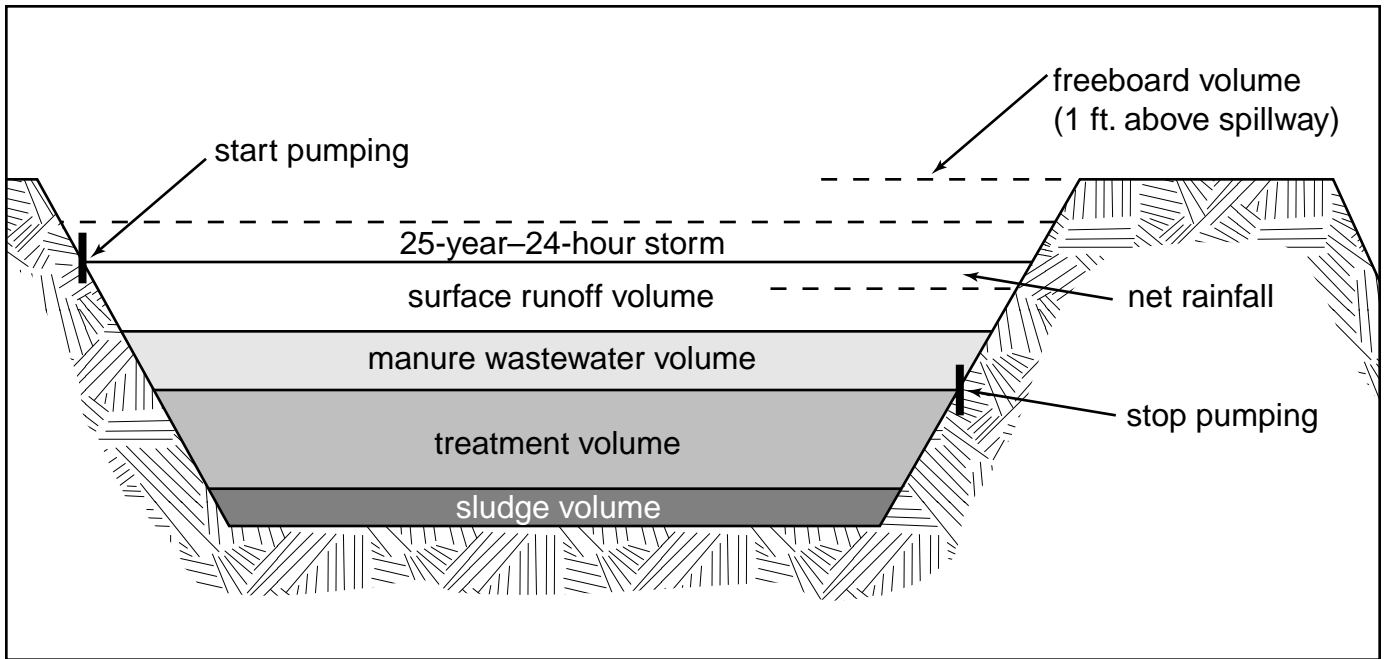


Figure 1. Capacity of single-stage anaerobic lagoon.

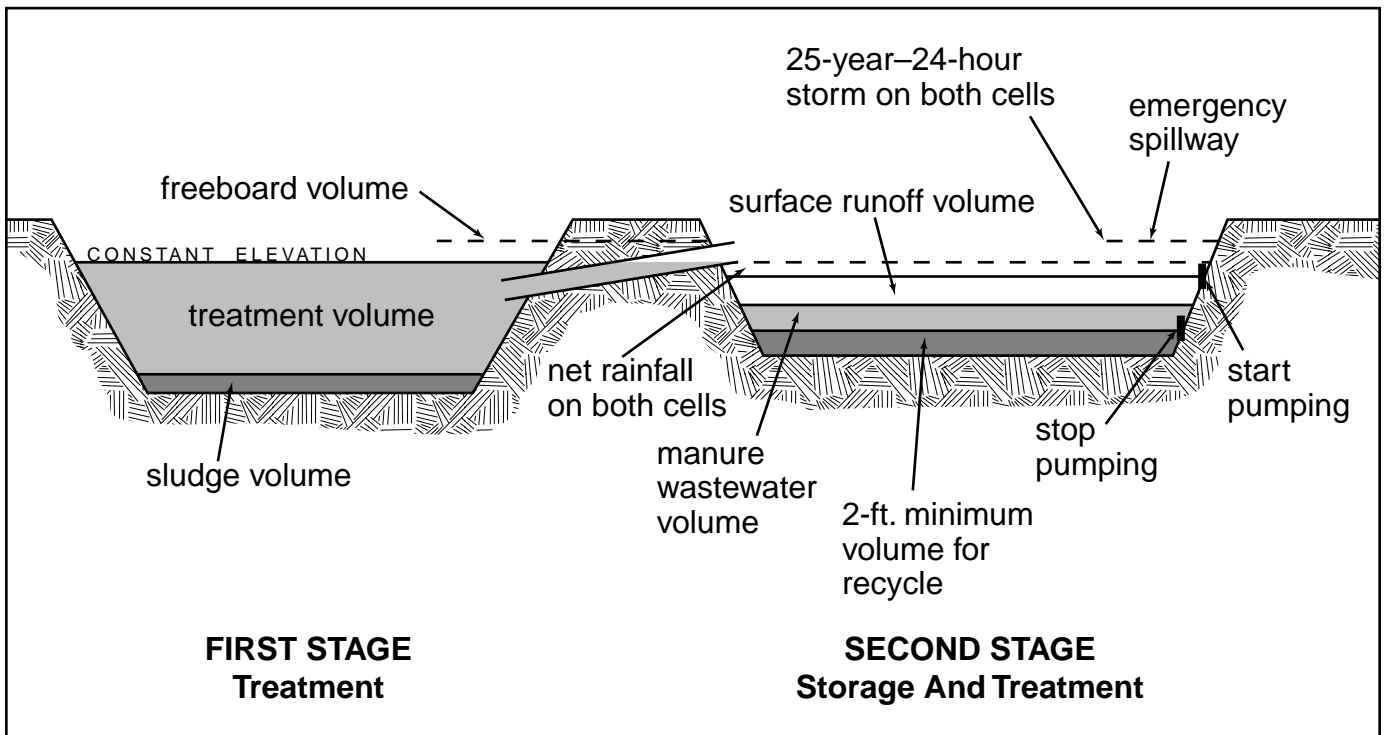


Figure 2. Capacity of two-stage anaerobic lagoon.

Two-Stage Lagoons

Where space is available, a two-stage lagoon should be constructed to improve wastewater treatment and management flexibility. A second stage lagoon, usually anaerobic, should allow for a permanent volume that cannot be pumped (2-foot minimum), the wastewater volume for the desired treatment period (180 days minimum), net rain on both stages, surface runoff volume, and space for the 25-year-24-hour storm for both stages (see Figure 2).

The first stage contains only the treatment (permanent) volume and sludge volume. The second stage lagoon not only stores treated wastewater for irrigation but also provides additional treatment, which produces a higher quality effluent for recycling as flush water. Small diameter sprinkler nozzles can be used to irrigate this treated wastewater.

Lagoon Design—Geometry

Poultry layer lagoons can be designed in a variety of shapes. However, circular or square lagoons allow easier mixing with propeller or pump type agitators and are usually less expensive to construct. When rectangular lagoons are constructed, a 4:1 length to width ratio should not be exceeded to encourage even distribution of manure.

Typical lagoon depths range from 8 to 20 feet, with a minimum depth of 8 feet. The specific footage depends on bird numbers, runoff area slope, and underground geology. Deeper lagoons offer several advantages, including less land needed because of smaller surface area requirement, more thorough mixing of lagoon contents by rising gas bubbles, efficient mechanical aeration, and minimum odor.

The dike for a lagoon must be a minimum of 8 feet wide. Slopes on earthen dikes and banks generally range between 2:1 and 3:1. To establish good grass covers and for safe mowing, slopes of 3:1 or better are recommended. Generally, slopes below the waterline are 2:1 though this depends on soil type and structure design.

An emergency spillway must be provided in the second stage of a two-stage system to protect the dam from extreme flooding. The spillway should be placed a minimum of 1 foot below the top of the berm with allowance for settling. It should be located as close to natural ground as possible and as far as possible from a corner location. The spillway is intended for use in flood conditions and is not to be used as a drain instead of pumping down the lagoon.

Construction Techniques

Proper lagoon construction is essential to ensure protection of ground water resources as well as to provide a system that will operate effectively for many years. Most guidelines for accepted lagoon construction techniques include:

- Site preparation.
- Excavation.
- Embankments.
- Cutoff trench.
- Sealing.

Site preparation requires that all trees, grass, and organic material be removed. Topsoil should be stockpiled close to the construction site for later placement on the top and exposed sides to allow good establishment of grass. After stripping, the foundation area should be prepared to bond with the fill. Loose dry material should be re-

moved, and the foundation area scarified, disked, adjusted for moisture, and compacted as necessary.

Excavation requires the removal of rocks, sand pockets, gravel, and other materials not suitable for sealing. The excavation should be deep enough for both proper volume and seal construction.

Lagoon embankments should be constructed to allow for usual settling of 5 percent. The embankment should be planted with a cover grass to prevent erosion and must be large enough to accommodate mowers. Suitable fill materials should be free of sand, roots, stones more than 6 inches in diameter, and other objectionable material. The minimum moisture content of the fill material and foundation should allow the formation of a ball that will not separate when squeezed by hand. Experience has shown that with suitable soil material (with enough clay content), three passes of a sheepsfoot roller per 6-inch fill lift on the embankment or bottom seal will provide adequate compaction for sealing.

A cutoff trench may be required to remove sand, gravel, or other water-conducting materials to prevent leakage under the embankment.

Sealing is required on the bottom and sides of the lagoon to protect ground water. Seal construction guidelines generally call for overexcavation and then backfilling and recompaction of seal materials in thicknesses not exceeding 6 inches compacted depth (not more than 9 inches deep for compaction).

The lower 6 inches of the bottom seal may be scarified and compacted in place to eliminate removal and replacement. In general, a minimum of 1-foot thick clay seal must be provided

on the bottom and sides of a lagoon. The deeper the lagoon, the thicker the required seal, up to or beyond 4 feet for a water depth of 25 feet.

Some soils require soil amendments such as bentonite, soda ash, or artificial liners to obtain a proper seal. Most properly planned poultry waste lagoons receiving raw manure eventually seal, limiting soil permeability to as little as 10^{-6} cm/sec. Immediately after construction, the lagoon seal should be covered with water (at least 2 feet deep above the highest bottom elevation) to prevent drying and cracking.

Solids Exclusion And Agitation

Feathers, some manure solids, and feed residuals break down very slowly or not at all in the lagoon. A settling tank (preferably two in parallel) should be installed between the laying house and the lagoon system to exclude as much of these solids as possible. This will require solids handling equipment and a drain pad to handle separated solids. Solids separation may exclude as much as 50 percent of layer manure solids. Much of the balance of the solids entering the lagoon is nondegradable. Over time, the accumulated solids will reduce waste treatment volume and cause "overloading" of the lagoon. This "overloading" causes increased odor and reduced waste treatment function.

As solids accumulate into the waste treatment volume they should be removed to prevent overloading by a special pump-out procedure called **lagoon renovation**. This requires continuous agitation with specially designed propeller or chopper pump agitators during the pump-out procedure. For further

information see Extension Circular ANR-953, "Renovating Livestock Lagoons Using Irrigation."

Management Procedures

Proper management is essential to ensure that a lagoon functions effectively and efficiently during its expected lifetime. Good design and well-executed construction are worthless if the lagoon is not properly managed.

For a lagoon system to operate successfully, start-up procedures must be followed carefully. A new lagoon should be filled with water to 60 percent of treatment volume before manure is introduced. This assures sufficient dilution for the establishment of bacterial activity and will also minimize start-up odors. Starting a lagoon in late spring or early summer will allow a good bacterial population to be established during the warm season.

After initial start-up, lagoons perform best when they are loaded continuously. Flushing systems provide ideal loading conditions for lagoons.

If foul odors develop in an anaerobic lagoon, the pH level should be checked. A pH reading can be made using soil testing equipment or litmus paper. The addition of hydrated lime will increase a pH that is too low (less than 6.5). A higher pH will increase the activity of methane bacteria and decrease the acid concentration. If this treatment does not greatly reduce and control foul odors, the lagoon is probably overloaded.

Lagoons usually fill to design capacity within 2 to 3 years of start-up with the accumulation of wastes and the rainfall on the open lagoon surface. To prevent lagoon overflow, excess lagoon liquid should be pumped and

land applied. This lagoon liquid should be applied to grassland, cropland, or woodland at rates within the soil infiltration capacity and the fertilizer requirement of the vegetation. Lagoons should be pumped during the growing season to allow enough storage space for wastewater accumulation through winter when crop growth and nutrient requirements are low.

The lagoon liquid should be sampled and analyzed to determine its nutrient content. Table 1 gives information on average lagoon liquid accumulation rates and estimated available nutrient contents. Table 2 estimates application rates and minimum land areas needed for poultry layer lagoon liquid irrigation application for different crops.

Wastewater irrigation using regular irrigation equipment is the easiest and most cost-effective way to apply lagoon liquid to land. Lagoon liquid should be irrigated on days with low humidity and when winds are not blowing toward neighboring residences. Irrigating early in the morning and early in the week will reduce offensive odors.

For more information on land applying poultry layer waste from lagoons refer to Extension Circular ANR-925, "Calibrating Traveling Guns For Slurry Irrigation." Procedures described apply to wastewater irrigation from lagoons.

As lagoons age, salt concentrations may increase to levels that can inhibit bacterial activity. Salt buildup in lagoons should be monitored yearly to ensure a safe level. Electrical conductivity (EC) is a convenient field measurement that indicates salt content. Before the salt content reaches 2,000 to 3,000 milligrams per liter (electrical conductivity of 3 to 5 millimhos per centimeter), the lagoon should be

Table 1. Fertilizer Nutrients In Poultry Layer Lagoon Liquid.

Total Anaerobic Lagoon Liquid Capacity, Ft ³ /Bird		Total Lagoon Liquid To Be Irrigated ^a / 1,000 Birds/ Year		Plant Nutrient	Total Nutrients	Plant Available Nutrients ^b			
						Irrigated		Soil Incorporated	
One Stage	Two-Stage 1st + 2nd	Gallons	Acre-Inch		Lbs./ Acre-Inch	Lbs./ Acre-Inch	Lbs./ Bird/ Year	Lbs./ Acre-Inch	Lbs./ Bird/ Year
15	12 + 3	25,373	0.93	N	179	90	84	128	120
				P ₂ O ₅	46	34	32	37	34
				K ₂ O	266	199	186	213	199

^aEstimated total lagoon liquid includes total liquid manure plus average lagoon surface rainfall surplus; does not account for seepage.

^bIrrigated: sprinkler irrigated liquid, uncovered for 1 month or longer.

Soil incorporated: sprinkler irrigated liquid, plowed or disked into soil within 2 days.

Table 2. Land Application Rate For Irrigated Poultry Layer Lagoon Liquid.^a

Rate-Limiting Nutrient	Cereal Grain	Corn	Fescue ^b	Tifton44 ^b	Tifton44 Bermuda ^c	Bermuda Hay
Maximum Pounds Per Acre Per Year						
N	100	150	200	275	325	400
P ₂ O ₅	50	60	75	75	85	100
K ₂ O	80	100	100	225	260	300
Inches Per Acre Per Year						
N	1.1	1.7	2.2	3.10	3.6	4.5
P ₂ O ₅	1.5	1.8	2.2	2.20	2.5	2.9
K ₂ O	0.4	0.5	0.5	1.13	1.3	1.5
Minimum Acres Per Animal						
N	0.84	0.56	0.42	0.30	0.26	0.21
P ₂ O ₅	0.64	0.53	0.43	0.43	0.38	0.32
K ₂ O	2.30	1.90	1.90	0.83	0.72	0.62

^aN leaching and denitrification and P205 soil immobilization unaccounted for.

^bOpen grazing.

^cControlled grazing.

pumped down and fresh water added. This will reduce the chance of bacterial inhibition and formation of magnesium ammonium phosphate or struvite. This struvite may form on the inside of pipes and pump impellers in the recycled flush system eventually causing breakdown. For information on addressing this situation see Extension Circular ANR-860, "Controlling Salt Buildup In Wastewater Recycling Systems."

Pumping operations should be started before the lagoon is full to assure space (safety volume) is always available to hold a 25-year-24-hour storm. Good management guidelines call for pumping the lagoon when the water level reaches 1 foot below the design water level (usually marked by a treated post on the inside slope of the last stage).

In a one-stage lagoon, permanent markers should be installed (1) at a mark 1 foot

below design water level to show when to initiate pumping the lagoon and (2) at the lagoon treatment level to indicate when to stop pumping (see Figure 1). In a two-stage lagoon, a permanent marker is needed only in the second stage to indicate when to initiate pumping. Pumping out too much effluent is not a problem in the second stage if the 2-foot minimum depth remains to allow recycle pump operation (see Figure 2).

The first stage is pumped only to remove accumulated solids which reduce permanent treatment volume (lagoon renovation, once every 5 to 20 years, depending on design).

Appearance And Safety

A poultry layer lagoon should be as aesthetically pleasing as possible. Berms and embankments should have good grass cover for appearance and erosion control and be mowed and maintained on a regular basis. A well-maintained lagoon is less likely to attract attention and cause controversy.

The lagoon should be fenced to prevent access of children, trespassers, and livestock. Warning signs (SEWAGE TREATMENT FACILITY—KEEP OUT) should be posted and any access gate locked.

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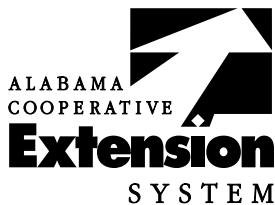
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