ALABAMA A&M AND AUBURN UNIVERSITIES

ALABAMA COOPERATIVE Extension SYSTEM

ANR-953

Using Irrigation To Renovate Livestock Lagoons

Livestock lagoons are designed to store animal waste and to reduce nutrient content of waste. Lagoons became popular when farmers realized how much labor and time are required to fully conserve nutrients in waste and apply them to cropland. Eventually, however, lagoons fill up and must have waste removed to remain useful.

This publication describes lagoon sludge removal and land application with special irrigation equipment. It discusses:

- Advantages and disadvantages of lagoons.
- The lagoon life cycle.
- Analysis of lagoon contents.
- Equipment for renovation.
- The process of renovation and land application.

Advantages And Disadvantages Of Lagoons

Some advantages of operating lagoon systems for treatment of livestock waste compared to waste storage ponds include:

- Flexibility in storage and disposal.
- Less land needed for total treatment program.
- Liquid recycling for pit and gutter waste removal.
- Land application of low solids wastewater by regular irrigation.
- Less labor.
- Lower operating cost.

Disadvantages of lagoons that are not properly designed and managed include:

- Offensive odors.
- Frequent sludge removal.
- Cost of mechanical aeration (if used).

The Lagoon Life Cycle

Lagoon construction takes into consideration two different bacteria—anaerobic and aerobic—that work to decompose livestock waste. Anaerobic bacteria, found in the intestinal tracts of warm-blooded animals, do not survive in the presence of oxygen. Aerobic bacteria require dissolved oxygen to live and operate. Typically lagoons for livestock waste storage and treatment are anaerobic because anaerobic bacteria can decompose more organic matter per unit lagoon volume than aerobic bacteria. Anaerobic lagoons can be deeper, with less surface area required than for aerobic lagoons. This design is less expensive to build and to operate.

Gases, liquids, and inert solids form as livestock waste is broken down by anaerobic bacteria. Through time, the inert solids, called sludge, accumulate in the lagoon. Proper design allows a portion of the lagoon volume for this sludge accumulation; however, the buildup must be monitored regularly. Initial design for a lagoon may provide enough volume for sludge storage of 10 to 20 years. If, however, the number of animals increases or other factors change, the waste load will accelerate, and sludge will accumulate at a rate that fills storage volume more quickly. For a lagoon to operate efficiently and effectively and to have a prolonged life, the sludge must periodically be removed to restore available treatment volume.

The restoring of treatment volume to a livestock waste lagoon is referred to as renovation. The need to renovate is typically indicated by two factors: unusual and prolonged obnoxious odors coming from the lagoon and sludge accumulation equal to about one-third of the lagoon volume.

Analysis Of Lagoon Contents

The usual end use of livestock lagoon contents is application to cropland. As with other soil additives, land application of lagoon contents should be controlled by the guide of beneficial use. Renovated lagoon slurry is applied to a crop with the same care as fertilizer; therefore, timing and amount should be based on expected fertilizer needs of the crop and best time for that crop to take up the applied nutrients. The target area should be soil tested and the nutrient contents of the waste determined so that nutrient application matches need.

Nutrient Analysis Of Waste

Nutrient content (nitrogen, phosphorus, and potassium) of animal waste must be deter-

mined in order to match the target crop and field soil conditions. Collecting samples for laboratory tests has two drawbacks: difficulty in getting a well-mixed sample and delays in receiving results. The entire contents of the lagoon must be thoroughly agitated to get the necessary well-mixed sample. This can be a time-consuming operation, and after samples are sent to the lab results take 3 to 10 working days. Therefore, in general it is impractical for a farmer to rely on actual wastewater lab tests to guide his immediate application process. There are other means of determining nutrient content in a timely way.

When nitrogen is the controlling nutrient in animal waste application, portable nitrogen meters can measure ammonia nitrogen in manure slurries. These meters retail for between $300 and $500 and typically give results within 2 to 9 percent of laboratory tests. The results can be used to determine plant available nitrogen in the agitated lagoon contents just prior to pumpout and thus guide liquid manure application based on nitrogen. There are also electrical conductivity tests that give a reasonable estimate of nitrogen content in lagoon wastewater but may not work as well for agitated lagoon slurry contents.

Soil testing is extremely important when land application of animal waste is planned because some fields may test high or extremely high in phosphorus. Phosphorus then becomes the controlling nutrient.

At no time should animal waste be put on land without regard to the amount of nutrients being applied. If lagoon specific data on nutrient content are unavailable, use Table 1 to determine land application rates based on nitrogen.

Solids Content Of Waste

Solids content varies with livestock species and with waste collection system used. Where solids are allowed to settle (as in a lagoon) or dilution water is added (as rainfall on feed lots or open animal areas), solids content and resistance to flow decrease, resulting in fewer pumping problems. In waste storage ponds, where short-term storage occurs with little waste treatment, and during the lagoon renovation process, where the treatment-generated sludge is agitated and thoroughly mixed with lagoon liquid, solids content will be higher. Table 2 gives some guidelines on solids content for different livestock waste systems. These will vary from installation to installation but are typical.

Equipment For Renovation

Pumping Equipment

Solids content of the pumped solution is one of the most important factors in selecting a pump for use with liquid animal waste. A fluid's resistance to flow (viscosity) is directly proportional to solids content.

Most pumps used in Alabama and the Southeast for liquid animal waste management are centrifugal pumps. These pumps are not positive displacement pumps, which means the impeller can "slip" in the liquid it is pumping. This permits control of flow rates in a centrifugal pump by valving down the discharge side of the pump.

Table 1. Approximate Nitrogen Content In Agitated Animal Waste Lagoons.

Animal Type	Nitrogen Content (lb/ac-in)	Available Nitrogen Using Irrigation (no incorporation) (lb/ac-in)	Maximum Irrigation Per Application (inches)
Swine	320-520	160-260	0.5
Dairy	245-375	123-188	0.7
Poultry	390-815	195-408	0.3

AWMFH, 1992; Zublena, et al., 1993, 1994.

Table 2. Solids Content In Various Liquid Waste-Handling Systems.

System	Solids Content (%)
Waste storage pond or agitated lagoon	
swine	8 to 12
cattle	10 to 15
poultry layer	8 to 15
Holding pond	
pit overflow	1 to 3
feedlot runoff	Less than 1
dairy barn washwater	Less than 1
Lagoon (unagitated)	
single or first stage	
swine	½ to 1
cattle	1 to 2
poultry layer	½ to 1
second stage	Less than ½

Design of the pump impeller (the main internal moving part in a centrifugal pump) determines the pressure-flow operating characteristics of the centrifugal pump. Figure 1 shows common centrifugal pump impeller types. A closed impeller pump is usually highly efficient in moving water but cannot handle liquids containing solid particles. This impeller type is enclosed on both sides by a cover plate or a shroud. It will develop high pressures and is useful in irrigating with relatively clean water or recirculating liquid from a second stage lagoon. A semi-open impeller has a plate or shroud on only one side. This impeller type is used for handling water with limited amounts of solids, such as are typically found in a first stage lagoon. Open impeller pumps have no plates or shrouds attached to the impeller and are used primarily to handle high solids content liquids. Large open impeller pumps can be used to handle liquid at 10 to 15 percent solids content. Where straw bedding or hay is present in the waste, open impeller pumps are sometimes fitted with a sharp rotary chopper blade at the pump inlet to break up large solids and fibers before they enter the pump chamber. One type of chopper-agitator pump is shown in Figure 2.

Both open impeller and semi-open impeller pumps are sometimes called trash pumps. Generally trash pumps can handle liquids with high solids but usually cannot develop the high pressure needed to drive an irrigation system.

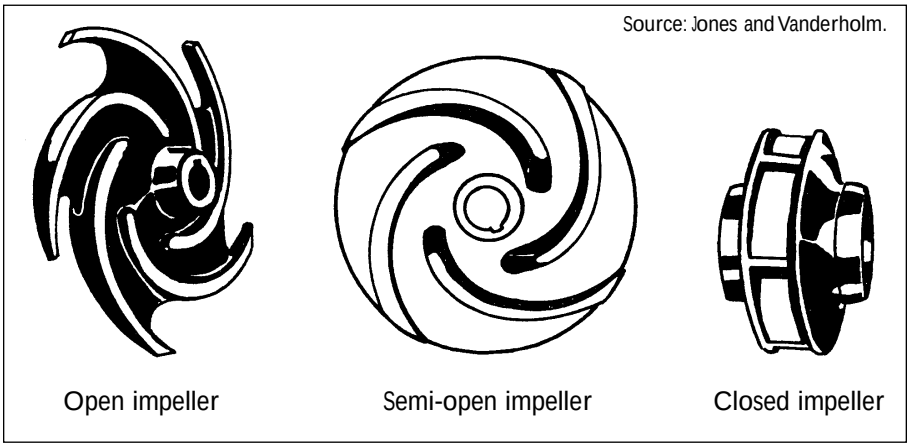

Figure 1. Common impeller types for centrifugal pumps.

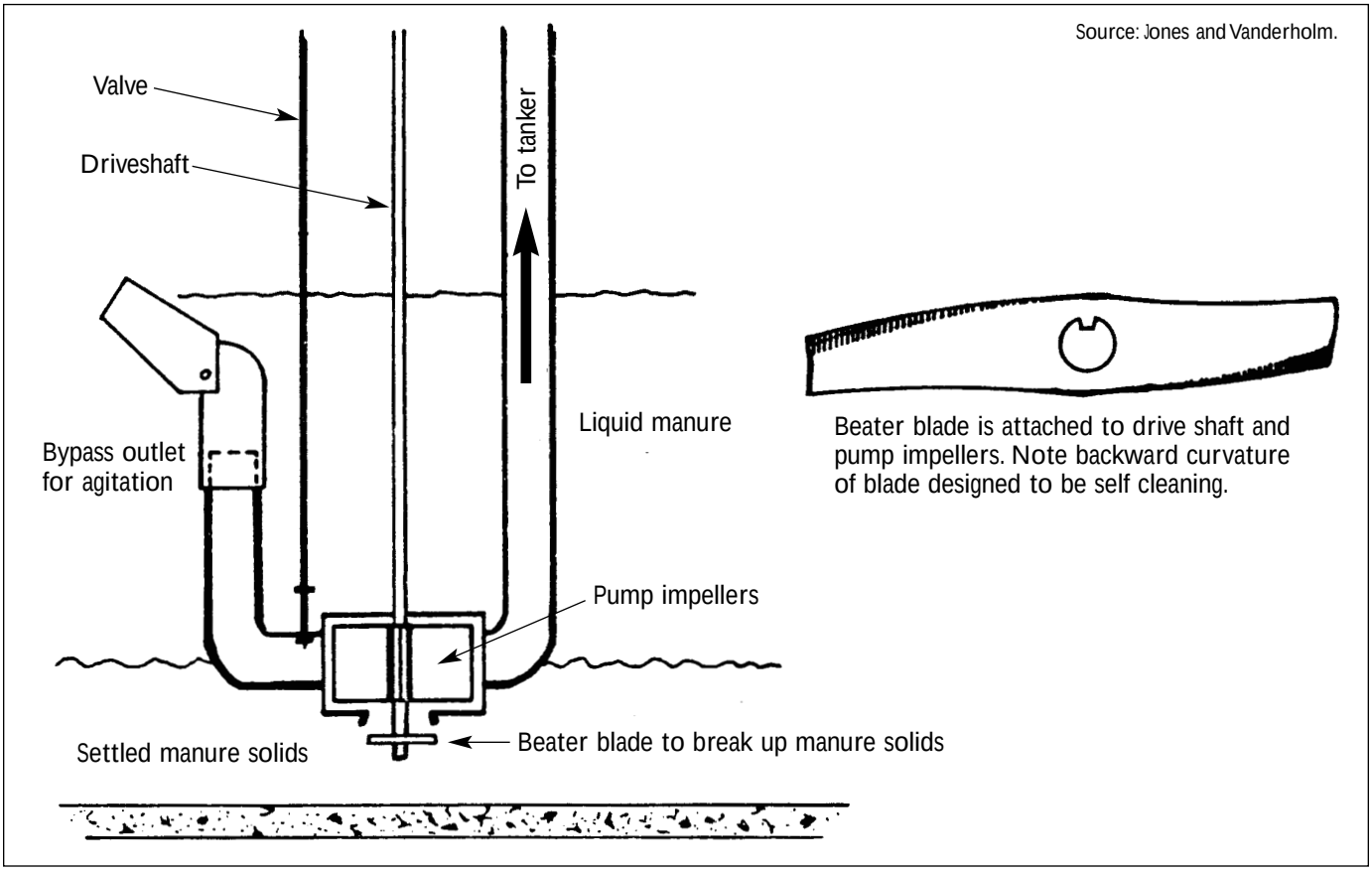

Figure 2. Chopper-agitator pump.

Pump Selection

The solids content of the liquid being pumped determines the type of impeller selected, but there is no hard and fast rule since pump size also affects the size of solid particles that can be passed through the pump.

The second most important thing in selecting a pump, after solids content of the pumped solution, is the pressure needed to operate the pumping system. Some situations require high pressures, as in a sprinkler irrigation system, while others need to lift waste only 10 to 20 feet. Table 3 and Figure 3 summarize the characteristics of waste-handling centrifugal pumps.

Generally, a semi-open impeller pump is used to pump agitated lagoon contents to a sprinkler irrigation system. Because of the infrequency of the lagoon renovation process, the pump should be portable and tractor PTO powered. Actual pump selection will depend on specific distances, elevations, and sprinkler operating pressure requirements in each situation and may require a tractor in the 85 to 150 horsepower range. Consultants, equipment dealers, or Extension agricultural engineers experienced in using irrigation for waste and nutrient management can make recommendations.

Lagoon Agitation Equipment

For sludge to be effectively removed, the accumulated sludge layer must be resuspended in the liquid portion of lagoon contents. This agitation is best done by either a propeller type agitator

Table 3. Characteristics Of Waste-Handling Centrifugal Pumps.

	Use for Sprinkler Irrigation	Solids Content Possible	Relative Pump Capacity	Applications
Open impeller	no	high	low	sump clean out, pit agitation, transfer
Semi-open impeller	possibly	moderate	moderate	lagoon pumping, lagoon irrigation
Closed impeller	yes	low	high	recirculation, lagoon irrigation

Source: Jones and Vanderholm.

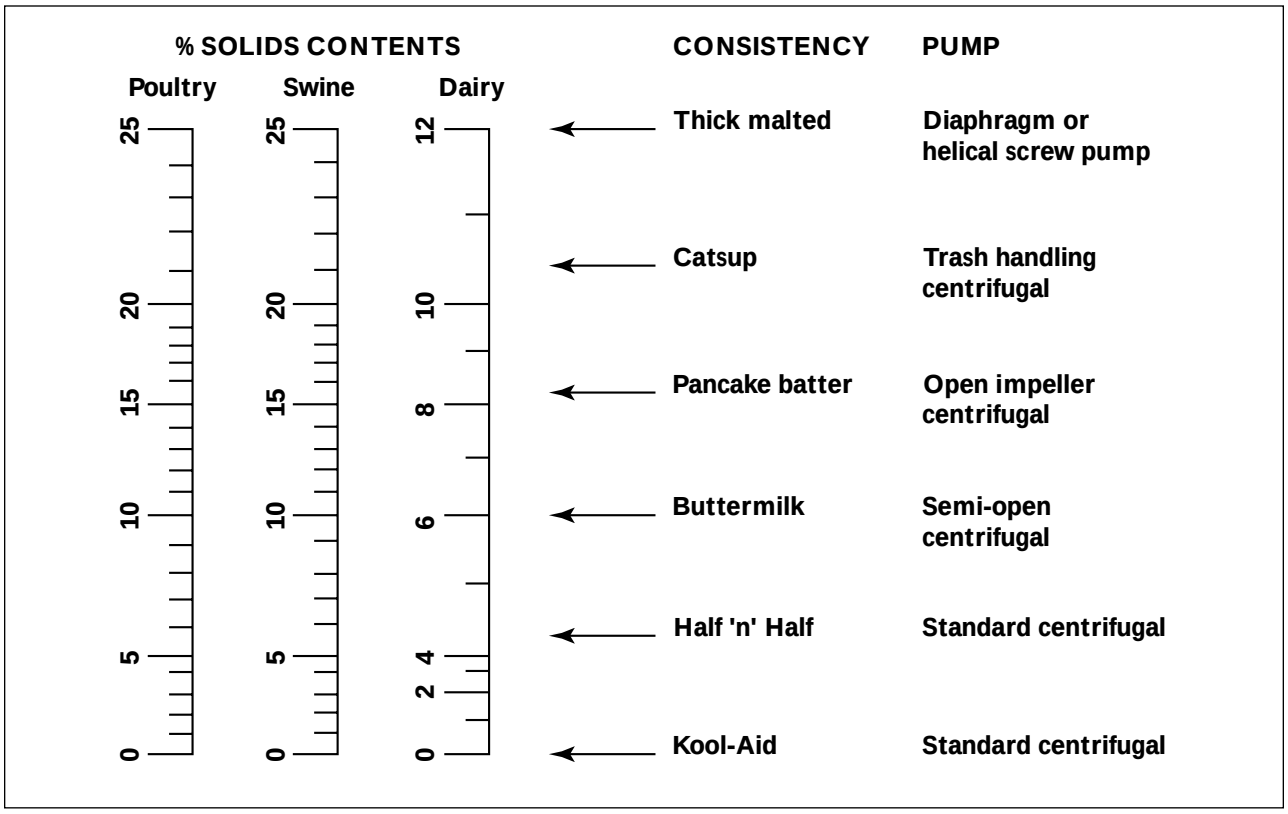

Figure 3. Percent solids content, consistency, and type of pump required for liquid handling of animal and poultry wastes. Source: Jones and Vanderholm.

or the chopper-agitator pump. The propeller type agitator will move more volume per minute for a given horsepower and is basically a large boat type propeller on an enclosed tractor-powered boom that may be more than 30 feet in length. Both the propeller type and the chopper-agitator pump will require a tractor in the 95 to 125 horsepower range. Both types are wheel mounted and portable. The chopper-agitator pump may be used as a high volume, low head transfer pump to "feed" the main pump. Either type agitator will do a good job. The propeller type is the most common and is generally $2,000 to $5,000 less expensive than the chopper-agitator pump. Constant agitation is required throughout the pumping out procedure.

Irrigation Equipment

Because lagoon renovation should not be an annual procedure, the equipment needs to be portable. The high solids content of the resulting agitated slurry requires a relatively large bore sprinkler nozzle. Special traveling irrigation guns with engine powered travel drives are recommended. The solids content of agitated lagoon slurry will clog up the standard hydraulic drives used on regular irrigation traveling guns. Typical application rate of a traveling gun sprinkler varies from ⅓ inch to ½ inch per hour, even at flow rates as high as 400 to 900 gallons per minute. The wide sprinkler throw of the big gun is the reason for this.

The separate engine powered traveling gun drive system should be capable of towing the traveling gun at speeds necessary to apply total amounts of slurry in the range of ¼ inch to 2 inches. The ability to speed up or slow down irrigation gun travel and control the travel at the selected speed is critical to managing the liquid waste application process. Some agitated lagoon contents may have over 800 pounds of nitrogen per acre-inch. Overapplying this high-strength waste could cause runoff, or in some soil conditions, deep percolation of nitrogen. Either of these situations would allow the waste to move off the target field and contaminate either surface water or ground water. Excellent traveling gun speed control is very important in liquid animal waste application. See Extension Circular ANR-925, "Calibrating Traveling Guns For Slurry Irrigation," for further information on travel speed and application rate.

The Process Of Renovation And Land Application

The following guidelines are best management practices for irrigating land with liquid animal waste—both lagoon wastewater and animal waste slurry from the lagoon renovation process or waste storage pond pumpout.

• **Soil test.** Always get a soil sample for the field and target crop.

• **Determine nutrient content.** Measure or reasonably estimate the nutrient (nitrogen) content of the agitated lagoon contents. Try to apply the liquid waste based on nutrient content, the soil sample, and crop nutrient needs. Apply the waste as near as possible to the time the target crop will use the nutrients. Unless phosphorus is a problem (based on soil test) apply liquid animal waste to the crop based on nitrogen. Agitated waste nutrient content and limited available land could require two annual renovation and irrigation events to completely remove and appropriately apply agitated lagoon contents.

• **Agitate lagoon contents.** Start agitating lagoon contents at least 24 hours before pumping out the lagoon. Relocate the agitation device at least once an hour. Angle the agitator at 45 degrees to the lagoon bank for best circular motion of the lagoon contents and to speed up agitation. Continuously agitate lagoon contents throughout the pumping out procedure.

• **Apply waste appropriately.** Do not apply irrigated waste:

—Within 150 feet of wells or within 300 feet of wells located downslope from the application field.

—Within 100 feet of a water body or stream on field slopes above 5 percent. When field slope is less than 5 percent and good ground cover exists to the water body, this can be reduced to 50 feet.

—Within 300 feet of a water body or stream on clear cultivated ground or ground with poor vegetative cover with slopes above 8 percent.

—On any slopes greater than 10 percent.

—Within 150 feet of public roads.

—Within 300 feet of dwellings or public use areas other than roads.

—Within 3 days of a predicted rain (probability greater than 50 percent).

—Anytime the soils cannot hold the volume of water applied.

—When wind direction and speed might cause drift toward neighbors or public areas.

—On any field where a growing crop will not take up the applied waste (generally after November 1, earlier in North Alabama).

• **Clean up.** Thoroughly wash traveling gun, hose, portable pipe, manure pumps, lagoon agitators, and all related equipment after completing lagoon renovation and land application. A thorough cleanup will help ensure long equipment life and reduce chance of disease transmission between animal facilities if the equipment is loaned or rented.

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