Lagoon Design and Management For Livestock Waste Treatment and Storage

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The trend away from small dispersed livestock production units to larger specialized operations has increased management requirements for manure and wastewater. Utilization systems which conserve fertilizer nutrients often are more sophisticated, expensive and laborious for handling concentrated manure. Systems which pretreat manure for management ease usually result in a loss of fertilizer nutrients. Waste handling systems must meet water quality regulations, i.e., pollutants must not be discharged from livestock operations directly into surface waters. Economically feasible methods for treating livestock manure for stream discharge do not currently exist.

Lagoons became popular for livestock manure treatment as historic interest to utilize fertilizer nutrients by direct land application was replaced by desires to have more convenient systems for manure management. Originally viewed as a total disposal system; it is now recognized that in moisture excess regions, lagoons are one pretreatment process in an overall manure management plan. North Carolina has an annual rainfall surplus of about 18 inches in the mountains, 6 inches in the piedmont and 8 inches in the coastal plain. When the interior surfaces of the lagoon have biologically sealed, lagoons usually fill to capacity with wastewater and rainfall surplus after two or three years. When the filling process is complete, overflow will occur unless the operator is equipped to apply the excess liquid back to field crops, grassland or woodlots.

Definition Table 1 distinguishes lagoons for biological waste treatment from other common earthen waste storage structures. Lagoons act as digesters in which two major types of bacteria decompose organic matter into gases, liquids and sludge. Anaerobic bacteria, present in the intestinal tract of
warm-blooded animals, do not survive in the presence of free oxygen. Aerobic bacteria require free elemental (dissolved) oxygen.

**Advantages** Lagoon systems for treatment of livestock waste are used because of:

- storage and disposal flexibility,
- less land for total treatment system,
- liquid recycling for pit waste removal,
- land application by simple irrigation, and
- lower labor needs and operating costs.

**Disadvantages**

- appreciable loss of nutrient value,
- offensive odors if improperly designed and managed,
- frequent sludge removal if undersized,
- groundwater protection considerations,
- high mechanical aeration costs if used.

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**ANAEROBIC LAGOONS**

Anaerobic lagoons are most commonly used for livestock waste treatment. Anaerobic bacteria can decompose more organic matter per unit lagoon volume than aerobic bacteria and are predominantly used for treatment of concentrated organic wastes. Since the anaerobic process is not dependent on maintaining dissolved oxygen, lagoons can be much deeper and require less surface area. Anaerobic decomposition of livestock waste can result in the production and emission of odorous gases, primarily hydrogen sulfide, ammonia, and intermediate organic acids. An anaerobic lagoon can be properly sized and managed, however, to operate with a minimum of disagreeable odor.

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**Table 1. Characteristics of Earthen Waste Treatment and Storage Structures**

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Earthen Structure</th>
<th>Function</th>
<th>Solids Handling Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-solid</td>
<td>stacking with</td>
<td>temporary storage</td>
<td>10-15% box-beater; side delivery</td>
</tr>
<tr>
<td></td>
<td>liquid drainage</td>
<td></td>
<td>flail; V-box expeller spreaders</td>
</tr>
<tr>
<td>Semi-liquid</td>
<td>earthen basin;</td>
<td>temporary storage</td>
<td>4-12% liquid tank spreaders; hose-drag injection;</td>
</tr>
<tr>
<td></td>
<td>underfloor pit;</td>
<td></td>
<td>slurry irrigation</td>
</tr>
<tr>
<td></td>
<td>(slurry)above ground tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>primary lagoon</td>
<td>biological treatment</td>
<td>&lt;4% sprinkler irrigation</td>
</tr>
<tr>
<td>Liquid</td>
<td>secondary lagoon</td>
<td>temporary storage</td>
<td>&lt;1% sprinkler irrigation</td>
</tr>
<tr>
<td>Liquid</td>
<td>retention pond</td>
<td>temporary storage</td>
<td>&lt;2% sprinkler irrigation</td>
</tr>
</tbody>
</table>
**Design Capacity** Liquid volume, rather than surface area, is the basis for anaerobic lagoon design. Sizing criteria should emphasize major operational needs to control odor, minimize sludge buildup and manage nitrogen. As lagoon capacity increases, odor potential, rate of sludge buildup and pathogenic organisms decrease while nitrogen losses increase. Because bacterial activity increases at higher temperatures, lagoons work best in areas without cold winters. Lagoons in colder areas require more design treatment volume. Table 2 gives suggested livestock lagoon design treatment capacities for North Carolina.

The liquid capacity of an anaerobic lagoon (Table 2) should include the appropriate design treatment capacity, storage for accumulated sludge, and temporary storage for rainfall and wastewater inputs. In addition to this liquid capacity, surface storage for a 25-year, 24-hour rainfall (5 to 8.75 inches) and an additional foot of freeboard to prevent embankment overtopping should be provided. Table 2 estimates livestock lagoon liquid accumulation rates. These figures do not include fresh water inputs for flushing or lot surface drainage into the lagoon. Wastewater storage capacity should be figured for 180 days. Average high 180-day rainfall excesses in North Carolina range from 7 - 32 inches. Sludge accumulation rates given in Table 2 should be utilized to design the lagoon life expectancy.

Anaerobic lagoons are not used for treatment of cattle wastes without prior manure solids settling, separation or removal. Cattle wastes have a higher percentage of relatively nondegradable fibrous material which significantly increases the solids buildup rate in a lagoon.

**Shape** Lagoons may be round, square, rectangular, or irregularly shaped to fit existing terrain provided the perimeter does not contain unusually deep bays or pockets. Length-to-width ratios for rectangular lagoons should not exceed 4:1 to encourage even distribution of waste. Sideslopes generally vary from 1:1 in clay soils to 3:1 in sandy soils. A minimum liquid depth of 6 feet should always be maintained in an anaerobic lagoon. Maximum depths are dictated by soil and groundwater site constraints but may range up to 20 feet to minimize the surface area and to encourage dissolution of anaerobic gases. A level lagoon bottom is desirable but not absolutely necessary.

**Site Investigation** A site investigation by an agency with expertise similar to the Soil Conservation Service should be made to determine the soil characteristics and suitability for lagoon construction. Location on highly permeable soils which will not seal or shallow soils over high water tables or fractured or cavernous rock may allow groundwater contamination. Most properly planned livestock lagoons receiving raw manure eventually seal limiting soil permeability to as low as 10-6 cm/sec. The sealing mechanism is mainly physical, i.e., organic solids are trapped within soil pores at the soil surface. Biological mechanisms also help bind manure solids to soil particles thus strengthening the seal. Chemical constituents of manure such as sodium also tend to disperse soil particles. The predominance of professional opinion suggests that with proper initial site selection livestock lagoons have low potential for groundwater contamination.
Table 2. Livestock Anaerobic Lagoon Design Criteria

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Unita</th>
<th>Average Animal Live Weight lbs</th>
<th>Lagoon Contents liquidb gals/day ft3/yr</th>
<th>Lagoon Liquid Accumulation minimum ft3</th>
<th>mean ft3</th>
<th>maximum ft3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>per head</td>
<td>1400</td>
<td>25.5</td>
<td>260</td>
<td>1400</td>
<td>2100</td>
</tr>
<tr>
<td>Beef</td>
<td>per head</td>
<td>800</td>
<td>8.3</td>
<td>110</td>
<td>600</td>
<td>900</td>
</tr>
<tr>
<td>Veal</td>
<td>per head</td>
<td>200</td>
<td>2.5</td>
<td>29</td>
<td>150</td>
<td>225</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>weanling-to-feeder per head</td>
<td>30</td>
<td>0.6</td>
<td>2</td>
<td>30</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>feeder-to-finish  per head</td>
<td>135</td>
<td>2.7</td>
<td>10</td>
<td>135</td>
<td>270</td>
<td>405</td>
</tr>
<tr>
<td>farrow-to-weanling per sow</td>
<td>433</td>
<td>8.8</td>
<td>23</td>
<td>433</td>
<td>866</td>
<td>1300</td>
</tr>
<tr>
<td>farrow-to-feeder  per sow</td>
<td>522</td>
<td>10.6</td>
<td>28</td>
<td>522</td>
<td>1044</td>
<td>1566</td>
</tr>
<tr>
<td>farrow-to-finish  per sow</td>
<td>1417</td>
<td>28.7</td>
<td>115</td>
<td>1417</td>
<td>2833</td>
<td>4250</td>
</tr>
<tr>
<td>Poultry, layer</td>
<td>per bird</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>, pullet</td>
<td>per bird</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a One-time animal or bird capacity.
b Does not include fresh flush water.
c No manure solids removal prior to lagoon input.

Management Figure 1 outlines a lagoon management scheme. New lagoons should be filled one-half full with water before waste loading begins. Start-up during warm weather and seeding with bottom sludge from a working lagoon will speed establishment of a stable bacterial population. Manure should be added to anaerobic lagoons as frequently as possible, preferably at least daily. Infrequent shock loadings can cause sharp increases in odor production and wide fluctuations in nutrient content. Lagoon liquid drawdown by irrigation should begin when the liquid reaches the maximum normal wastewater storage level. Liquid should not be pumped below the design treatment level so that adequate volume is always available for optimum bacterial digestion.

An anaerobic lagoon in proper balance will have a pH ranging from 7 - 8 (slightly basic). The pH in new lagoons without adequate dilution water or in overloaded lagoons can be reduced to 6.5 or less (acidic), thereby creating odor problems. This condition can be temporarily corrected by evenly distributing agricultural lime (preferably hydrated) to the liquid surface at the rate of one pound per 1000 cubic feet of lagoon volume.

Land Application Lagoon liquid should be land applied through irrigation equipment when it reaches the maximum normal wastewater storage level. Substantial amounts of nutrients can be provided to grassland, cropland, or woodlots, with application rates based on matching the available nitrogen
content of the lagoon liquid to the fertilizer requirement of the crop. Nutrient concentrations vary widely among different lagoons and within individual lagoons seasonally. Applicators are strongly encouraged to periodically have lagoon samples analyzed to more accurately determine the amount of nutrients being applied. The NCDA Plant Analysis Lab analyzes waste samples for primary and micronutrients for a nominal fee. Table 3 gives typical characteristics of anaerobic lagoon liquid in lieu of actual test results.

**Irrigation Equipment** Liquid from lightly-loaded anaerobic lagoons can be applied through sprinkler nozzles 1/4-inch or larger. Single-nozzle, straight-bore sprinklers are recommended. Pump suction intakes should be floated approximately 18 inches underneath the lagoon liquid surface. Liquid from moderate to heavily loaded lagoons can be applied through 1/2- to 3/4-inch nozzles. Larger gun-type sprinklers with 3/4- to 2-inch nozzle diameters should be used for lagoons with high concentrations of solids or liquid sludge irrigation. Low-pressure systems in the 20 psi range with either high-rate or rotary impact nozzles less than 1/4-inch diameter are not recommended.

### Table 3. Livestock Anaerobic Lagoon Liquid Characteristics

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Total Solids %wb</th>
<th>Chemical Oxygen Demand (COD) mg/L</th>
<th>Nitrogen Total</th>
<th>NH₃N lbs/acre-inch</th>
<th>Phosphorus P2O₅</th>
<th>Potassium K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>0.55</td>
<td>4100</td>
<td>137</td>
<td>88</td>
<td>77</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>0.42</td>
<td>3000</td>
<td>72</td>
<td>25</td>
<td>50</td>
<td>122</td>
</tr>
<tr>
<td>Beef</td>
<td>0.55</td>
<td>3200</td>
<td>83</td>
<td>45</td>
<td>77</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
<td>1400</td>
<td>39</td>
<td>16</td>
<td>67</td>
<td>45</td>
</tr>
<tr>
<td>Veal</td>
<td>mean</td>
<td>-</td>
<td>56</td>
<td>34</td>
<td>10</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>std. dev.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Swine</td>
<td>mean</td>
<td>0.37</td>
<td>2100</td>
<td>136</td>
<td>53</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>std. dev.</td>
<td>0.21</td>
<td>1500</td>
<td>70</td>
<td>35</td>
<td>79</td>
</tr>
<tr>
<td>Poultry, layer</td>
<td>mean</td>
<td>0.47</td>
<td>2800</td>
<td>179</td>
<td>46</td>
<td>266</td>
</tr>
<tr>
<td></td>
<td>std. dev.</td>
<td>0.27</td>
<td>1700</td>
<td>92</td>
<td>13</td>
<td>26</td>
</tr>
</tbody>
</table>

For solids contents under 4%, standard centrifugal irrigation pumps are recommended over specialized chopper pumps or cutter attachments. If a lagoon contains an appreciable amount of long-stemmed vegetation or large debris, this material should be removed and efforts made to prevent its recurrence. Pump power requirements for lagoon liquid are similar to those for water provided the solids content is less than 4%.

**Sludge Removal** Even with good bacterial digestion, significant amounts of sludge accumulate in an anaerobic lagoon. A lagoon can be designed for whatever sludge storage period desired (Table 2 and Figure 1). The rate of sludge buildup can be reduced by mechanical solids separation or gravity
settling of the waste prior to lagoon input. This practice is particularly recommended for cattle wastes containing a high percentage of relatively nondegradable lignin and cellulosic fiber.

At some point the treatment capacity of most lagoons will be severely diminished by sludge accumulation. Table 4 presents some characteristics of livestock anaerobic lagoon sludge. Organic nitrogen compounds and phosphorus tend to accumulate in the sludge causing nitrogen levels up to 13 times higher than lagoon liquid levels and phosphorus up to 55 times higher than liquid levels. In addition to higher nutrient levels, the bottom sludge may also contain significant concentrations of heavy metals, salts and other trace elements. These factors dictate the need to have the sludge analyzed and expert agronomic advice sought prior to land application.

Lagoon sludge solids contents range from 6-13% requiring careful selection of removal equipment. The most frequently used method consists of vigorous mixing of the sludge and lagoon liquid using a chopper-agitator impeller pump or pto propeller agitator. The sludge mixture is pumped through a large bore gun-sprinkler slurry irrigation system onto cropland followed by soil incorporation. Another alternative consists of partial lagoon dewatering followed by sludge agitation and finally pumping the slurry mixture into a liquid manure spreader for field spreading. A third alternative is lagoon dewatering followed by dragline dredging. The sludge may be hauled and applied directly to cropland by spreaders equipped to handle slurries, or stockpiled near the lagoon and allowed to further drain before spreading.

**Solids Separation** Lagoon management is eased by separating solids from raw or flushed manure prior to lagoon input. Removing fiber from cattle wastes and grit from poultry manure significantly reduces the lagoon solids buildup rate and associated pumping problems. Removal of oxygen-demanding solids in swine and poultry manure reduces the lagoon organic loading and lessens its odor potential. Beneficial uses of the recovered solids include bedding materials, supplements to animal feed rations, composting, and soil amendments.

To recover a relatively dry by-product, vibrating-screen, sloping stationary screen or pressure-roller mechanical separators are probably most advantageous. Waste is collected in a sump sized to store 3-4 days accumulation of manure plus dilution and flush water. A submersible or stationary bottom-impeller, agitator-lift pump mixes the waste into a slurry and pumps it across the separator where the liquid drains into the lagoon. Solids are dry enough to be handled by conventional materials handling equipment. Up to 30% of the total solids and 25% of the oxygen-demanding materials are removed.

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Total Chemical Oxygen Solids Demand (COD)</th>
<th>Oxygen Demand</th>
<th>Nitrogen Total</th>
<th>Phosphorus P2O5</th>
<th>Potassium K2O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%wb</td>
<td>mg/L</td>
<td>lbs/acre-inch</td>
<td>lbs/acre-inch</td>
<td>lbs/acre-inch</td>
</tr>
<tr>
<td>Dairy</td>
<td>mean</td>
<td>6.1</td>
<td>23000</td>
<td>398</td>
<td>162</td>
</tr>
<tr>
<td></td>
<td>std. dev.</td>
<td>4.1</td>
<td>16000</td>
<td>311</td>
<td>113</td>
</tr>
<tr>
<td>Beef</td>
<td>mean</td>
<td>11.4</td>
<td>51000</td>
<td>1037</td>
<td>464</td>
</tr>
</tbody>
</table>

**Table 4. Livestock Anaerobic Lagoon Sludge Characteristics**
A gravity settling basin may be less costly while removing 50% or more of the solids from liquid manure. Solids can be settled and filtered by a shallow basin (2 - 3 feet deep) with concrete floor and walls and a porous dam or perforated pipe outlet. It should allow access by a front-end loader to remove solids every 1 - 2 months. An alternative is an earthen settling basin for 6 to 12 months storage of solids. For flushed swine manure at least 0.55 gallon capacity per 135 pounds animal live weight per day of storage should be provided. The basin top width should be no more than 100 feet with a length-to-width ratio near 3:1 and a liquid depth of 8 - 10 feet. The basin contents should be thoroughly agitated and removed for land spreading either by liquid manure spreader or slurry irrigation. A third alternative consists of a large rectangular metallic or concrete settling tank with a 3:1 length-to-width ratio and an 8-feet liquid depth. Tank volume depends on a peak-flow wastewater detention time of 10 to 30 minutes. Most readily settleable solids in livestock manure settle in about 10 minutes although some additional settling occurs for hours. Tank inlets and outlets are baffled and solids are removed by automated skimmers and scrapers.

AEROBIC LAGOONS

Naturally Aerobic (Oxidation Ponds) The main advantages of aerobic lagoons are that bacterial digestion tends to be more complete than anaerobic digestion with relatively odor-free end products. In naturally aerobic lagoons, oxygen diffusion occurs across the water surface. Algae also generate oxygen through photosynthesis which takes place when sunlight can penetrate the water depths. Water depths are rather shallow ranging from 3 to 5 feet. Because of the need for oxygen transfer, naturally aerobic lagoons are designed on the basis of surface area rather than volume. The USDA Soil Conservation Service recommends a maximum daily loading rate of 50 pounds of biochemical oxygen demand (BOD5) per acre of lagoon surface. Using these design criteria, Table 5 gives the amount of surface area required to maintain naturally aerobic lagoon conditions. Vast amounts of land are required for naturally aerobic lagoons - as much as 25 times more surface area and 10 times more volume than an anaerobic lagoon 10 feet deep. Thus, naturally aerobic lagoons are impractical for primary oxidation and are generally not recommended for treatment of livestock production wastes.

Mechanically Aerated Mechanically aerated lagoons combine the odor control advantages of aerobic digestion with relatively small surface requirements. Aerators are used mainly to control odors in sensitive areas and for nitrogen removal at limited land disposal sites. Aerated lagoons have successfully met these objectives by providing enough oxygen to satisfy 50% of the waste chemical oxygen demand (COD) assuming an aerator oxygen transfer rate of 3 pounds per horsepower-hour. The lagoon liquid surface should not exceed 1000 square feet per horsepower of aeration for floating surface aerators to insure complete surface influence. Liquid depths should be at least 10 feet. Table 5 gives mechanically aerated lagoon design criteria for livestock.
Table 5. Livestock Aerobic Lagoon Design Criteria

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Animal Units</th>
<th>Average Animal Live Weight lbs</th>
<th>Naturally Aerobic Lagoon Surface Area ft²</th>
<th>Mechanically Aerated Lagoon</th>
<th>Horsepower hp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy per head</td>
<td>per head</td>
<td>1400</td>
<td>2030</td>
<td>104</td>
<td>0.10</td>
</tr>
<tr>
<td>Beef per head</td>
<td>per head</td>
<td>800</td>
<td>1150</td>
<td>44</td>
<td>0.044</td>
</tr>
<tr>
<td>Veal per head</td>
<td>per head</td>
<td>200</td>
<td>180</td>
<td>6.3</td>
<td>0.0063</td>
</tr>
<tr>
<td>Swine weanling-to-feeder</td>
<td>per head</td>
<td>30</td>
<td>80</td>
<td>1.7</td>
<td>0.0017</td>
</tr>
<tr>
<td>Swine feeder-to-weanling</td>
<td>per head</td>
<td>135</td>
<td>350</td>
<td>7.8</td>
<td>0.0078</td>
</tr>
<tr>
<td>Swine farrow-to-feeder</td>
<td>per sow</td>
<td>433</td>
<td>745</td>
<td>17</td>
<td>0.017</td>
</tr>
<tr>
<td>Swine farrow-to-finish</td>
<td>per sow</td>
<td>522</td>
<td>900</td>
<td>20</td>
<td>0.020</td>
</tr>
<tr>
<td>Swine farrow-to-finish</td>
<td>per sow</td>
<td>1417</td>
<td>3660</td>
<td>82</td>
<td>0.082</td>
</tr>
<tr>
<td>Poultry, layer</td>
<td>per bird</td>
<td>4.0</td>
<td>11.5</td>
<td>0.32</td>
<td>0.00032</td>
</tr>
<tr>
<td>Poultry, pullet</td>
<td>per bird</td>
<td>1.5</td>
<td>4.3</td>
<td>0.12</td>
<td>0.00012</td>
</tr>
</tbody>
</table>

a One-time animal or bird capacity.
b Loading rate = 50 lbs BOD5/surface acre/day; mean liquid depth = 4 ft.
c 1000 ft²/hp of aeration and a minimum liquid depth = 10 ft.
d 50% satisfaction of waste COD and oxygen transfer rate of 3 lbs/hp-hr.

A major disadvantage of mechanically-aerated lagoons is the expense of continually operating electrically-powered aerators. One large North Carolina producer determined the cost of aerator operation in 1979 to be $0.70 per feeder pig sold. Larger anaerobic lagoons may provide similar performance with less expense. Aerated lagoons also yield more sludge than anaerobic units because more input organics are converted to biomass. Suspension of bottom sludge by the aerators can cause increased lagoon liquid concentrations and stimulate foaming. Solids traps such as a septic tank type settling chamber between primary aerated and secondary lagoons can provide a convenient mechanism for solids collection and removal. Mechanically-aerated lagoon liquid nitrogen levels are significantly reduced.

**TWO-STAGE LAGOONS**

Two-stage lagoons provide certain advantages over single primary lagoons. More than two lagoons in series is rarely beneficial. Secondary lagoons provide temporary storage prior to land application. Aerobic systems need a second lagoon to provide storage and allow the primary lagoon to function solely for biological treatment. A second stage also allows a maximum liquid volume to be maintained in primary anaerobic lagoons for stabilizing incoming wastes. For livestock operations which recycle lagoon liquid for open-gutter flushing where animals have direct access to flush water,
a second lagoon provides some insurance against disease organisms being returned from the primary lagoon before a reasonable die-off period. Pumping from a secondary lagoon reduces the solids pickup common in primary lagoons due to seasonal water turnovers and biological mixing.

Sizing of secondary lagoons is not clearly defined or critical. North Carolina recommends that the second lagoon have 180 days of wastewater storage generated as indicated in Figure 1 plus enough volume for the combined 25-year, 24-hour rainfall storage from both lagoons.

**LAGOON MANAGEMENT SUMMARY**

- New lagoons should be filled one-half full with water prior to waste input, and the liquid maintained at or above the design treatment level.
- When possible, manure loading of a new lagoon should begin in the spring to permit a good bacterial population to develop during the warm season.
- Lagoons should be loaded on a frequent regular basis avoiding large shock loadings which cause excessive odors and nutrient level fluctuations.
- Apply one pound of agricultural lime per 1000 cubic feet of lagoon volume when the lagoon liquid pH falls below 7 to optimize bacterial digestion.
- Mechanical aeration can be used to control odors, reduce nitrogen content, and reduce surface area but only at high operating costs.
- Solids separation and removal from raw wastes either mechanically or by gravity settling can reduce the sludge buildup and organic loading rate.
- Prevent additions of bedding materials, long-stemmed forage or vegetation, molded feed, plastic gloves, egg flats or other foreign material.
- Remove sludge when 75% of the lagoon design treatment volume has filled.
- Plan lagoon liquid drawdowns such that adequate storage is available during wet seasons.
- Do not lower the lagoon liquid level below the seasonal groundwater table.
- Locate pump intakes approximately 18 inches underneath the liquid surface and as far from the waste inlet to the lagoon as possible.
- Electric pump housings should be adequately grounded to prevent stray voltage from contributing to salt deposits on internal surfaces.
- Irrigate lagoon liquid with equipment selected to handle the particular waste characteristics, whenever the lagoon fills to the top of the normal wastewater storage level, on field crops, grassland or woodlots at agronomic rates.
- Irrigate when odors are apt to be least offensive, on days with low humidity, or when breezes are blowing away from neighboring residences.
- Maintain strict vegetation, rodent and varmint control near lagoon edges.

_Not Included:_

**ANAEROBIC LAGOON PROFILE**

- *Lagoon length-to-width ratio should not exceed 4:1.*
- *Design treatment and sludge storage depth should be at least 6 feet.*
- *Sludge accumulation capacity should provide for a lagoon life of 15-20 years.*
- *Normal wastewater capacity should be enough for 90-180 days storage.*
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