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Abandonment Planning for Earthen Manure Storages, Holding Ponds, and Anaerobic Lagoons

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The purpose of this NebGuide is to define some critical issues to be addressed by an abandonment plan of an earthen manure storage, anaerobic lagoon, or runoff holding pond.

A Nebraska construction permit for a Livestock Waste Control Facility (LWCF) requires a written plan defining possible abandonment procedures in the event the operation (and associated LWCF) is discontinued. The plan must be approved by the Nebraska Department of Environmental Quality (NDEQ) prior to permit issuance. Procedures for abandonment of an outdoor lot are discussed in NebGuide G1293, *Feedlot Abandonment Recommended Procedures*.

Current Knowledge

No research specifically targeting closure of earthen manure storage structures exists, although most experts would agree doing nothing incurs an unacceptable environmental risk. However, judgments as to the reduction in environmental risk resulting from a specific closure procedure are, at best, educated judgements. Appropriate procedures for closing earthen manure impoundments can, in part, be based upon our knowledge of ground and surface water issues associated with manure storage and treatment systems. The following knowledge will help define an appropriate abandonment plan.

Structures that are designed, constructed, and managed well pose little environmental risk. Earthen storage structures designed and installed according to accepted engineering standards (such as those defined by NRCS Agricultural Waste Management Field Handbook and ASAE Standard EP 393.3, Manure Storage and ANSI/ASAE EP 403.3, Design of Anaerobic Lagoons for Animal Waste Management) have a proven record of storing livestock manure with minimal risk to water quality. Maintaining structure and liner integrity will continue to limit that risk. A well-maintained structure can be identified by:

- limited erosion of sidewalls due to wave action,
- lack of line erosion in vicinity of manure supply pipe,
- lack of liner erosion near areas used for agitation and manure removal,
- well-maintained sod on berms and exterior sidewalls (weed and tree growth controlled),
- no signs of burrowing animals on berm or sidewall, and
- lack of seepage around pipes through the sidewall and along toe of berm.

Adding manure to an earthen facility further reduces seepage due to the physical, chemical, and biological processes that contribute to the clogging of soil pores. A reduction in seepage by a factor of 100 or more has been documented. NRCS Animal Waste Management Field Handbook (appendix 10D) acknowledges a reduction in coefficient of permeability by a factor of at least 10. This experience suggests maintaining an intact storage structure and liner after abandonment is environmentally sound as long as the integrity of the liner is maintained.

Poorly designed and constructed liners, as well as those badly eroded, may have already allowed significant movement of contaminants into the soil below the earthen structure. Recent field research on an unlined, earthen feedlot runoff holding pond in Nebraska has shown high rates of seepage and movement of pollutants will occur. Extensive efforts may be necessary to evaluate movement of nutrients below improperly sited, poorly constructed, or inadequately maintained structures before an appropriate abandonment procedure can be determined.

The greatest level of contaminant movement below earthen structures is most likely to be observed below the sidewalls, where the potential risk from seepage is greatest. Fluctuating liquid levels combined with shrink/swell properties of clays, activity of rodents, worms, and weeds contribute to this risk. Testing of sidewalls and berms for contaminant movement should define this situation.

Nitrogen is the contaminant from an abandoned earthen storage most likely to impact groundwater. Nitrogen movement below an abandoned storage facility can be determined by measuring organic and ammonium nitrogen. Nitrates are rarely found in stored manure due to anaerobic conditions. Soils with high cation exchange capacity and LWCFs with well-constructed and maintained earthen liners will restrict ammonium and organic nitrogen flow. If a contaminated area becomes aerobic after abandonment, these forms of nitrogen will change to nitrate and become mobile.

It is doubtful that either phosphorus or pathogens would be a concern to groundwater contamination from an abandoned lagoon, unless the water table is very near the bottom of the basin. Soil is an excellent filtering media for pathogens. Phosphorus chemically binds to soil to form a variety of insoluble complexes.

Within an anaerobic lagoon, three distinctly different zones are likely to be found: 1) An accumulation of inert solids, likely high in phosphorus, is often found in the vicinity of the inflow pipe(s) from the animal housing; 2) Above this zone, a moderately viscous sludge high in nutrients, bacteria, and organic matter is commonly found. This material can be handled by pumps designed for high solids applications; and 3) Above the sludge layer is a liquid layer low in solids, moderately rich in nutrients, and easily pumpable with conventional irrigation pumps. While liquid and most sludge can be removed while maintaining the integrity of the liner, solids removal is difficult without incurring damage. Maintaining liner integrity is often of greater value than complete solids and sludge removal.

In the solids and sludge layers of an anaerobic lagoon, a significant accumulation of phosphorus is likely. An approximation of the accumulation can be made from *Table I*. Regular sludge removal limits the phosphorus accumulation, thereby reducing the amount of phosphorus to be managed at the time of abandonment.

Steps for Permanent Abandonment

Based upon previous knowledge, it is possible to define closure principles to adequately protect the environment. These procedures assume good design and construction practices were implemented during construction. It also assumes the liner will be adequately protected from erosion and other damaging factors. If these assumptions are not correct, more drastic measures may be needed to assess the abandoned site.

1. *Remove all liquids and pumpable slurry.* A significant portion of the environmental risk is associated with the liquids and slurry within the earthen structure. Removing these from the structure is critical to reduce risk. Agitate and mix the liquids and sludge to maximize solids removal. Agitation may be of limited value on large basins unless multiple access points and agitations are employed. Any agitation activities must be done carefully to avoid damage to the earthen liner.
2. *Protect the integrity of the existing earthen liner.* Low seepage within the liner results from a combination of good engineering design and construction of the liner, maintenance of liner integrity, and sealing by movement of solid manure particles into this interface. For these reasons, maintaining an intact liner is of greater value than its removal in most situations. In situations of poor liner design, construction, or management, or observed movement of contaminants by monitoring wells, removal of soil may be appropriate. This, however, should be the exception, not the rule. When the liner's integrity is suspicious, the need should be determined by deep soil sampling.
3. *Land apply the liquid and pumpable slurry to cropland at agronomic rates.* Both liquids and pumpable slurry are likely to have significant nutrient concentrations. The abandonment plan should define the procedures for a nutrient analysis of both sludge and liquid, estimating desired application rate and field measurement of actual application rate.

   The abandonment plan should define the land requirements for distributing nutrients. The required land for emptying a full manure storage can be estimated using the UNL Extension tool, Manure Nutrient and Land Requirement Estimator, available at *http://water.unl.edu/web/manure/software#WFNB* under the "Nutrient Inventory" heading. Instructions for using the spreadsheet can be found in Extension Circular EC190, *Manure Nutrient and Land Requirement Estimator: Spreadsheet Instructions*, and knowledge of the storage's holding capacity. For an anaerobic lagoon, the accumulated phosphorus will represent the most significant land requirement. Use *Table I* to estimate phosphorus accumulation and *Tables II* and *III* to determine land requirement, assuming phosphorus is applied to meet three to five years of crop phosphorus needs.

It is unlikely that an abandonment plan will define desired application rates because of the difficulty in predicting sludge and effluent nutrient concentration. The plan should acknowledge two methods for estimating application rate:

A. Application rate should never exceed the annual crop nitrogen requirements after appropriate allowances for the crop availability of manure nitrogen (see NebGuide G1335, *Determining Crop Available Nutrients from Manure*).
B. Application rate should not exceed five years of crop phosphorus needs. Soil phosphorus levels should be checked after sludge and slurry application.

At this point, one of two acceptable options should be considered for closure.

Table I. Estimate of phosphorus accumulation in the sludge and settled solids of an anaerobic lagoon that is not agitated during annual pump down. Does not apply to manure storages or runoff holding ponds for outdoor lots.

	Number of animals (average one-time capacity)		*Sludge P_2O_5 accumulation factor (pounds P_2O_5 per year)*		*Years accumulation of sludge and solids*		*Total P_2O_5 in sludge and solids (pounds)*
Example: Finish	*1,000*	*X*	*7*	*X*	*10*	*=*	*70,000*
Swine							
Nursery		X	2	X		=	
Grow/finish		X	7	X		=	
Sows and litter		X	30	X		=	
Sows (gestation) and boars		X	11	X		=	
Dairy							
Lactating cows		X	100	X		=	
Dry cow		X	40	X		=	
Beef feeder		X	30	X		=	
Poultry							
Layer/broiler		X	0.6	X		=	

Assumes 65 percent of the phosphorus excreted by the animals settles into the sludge or settled solids.

Table II. Phosphorus application rate calculation based on estimated phosphorus removal by alternative crops.

Crop	P_2O_5 removal rate		Estimated crop yield (lb/bu or lb/ton)		Years of P_2O_5 (3 years suggested)		P_2O_5 application rate (lb P_2O_5/acre)
Example: Grain corn	*0.4 lb/bu*	*X*	*150*	*X*	*3*	=	*180 lb/acre*
Corn, sorghum, and small grains	0.4 lb/bu	X		X		=	
Corn silage	2.9 lb/ton	X		X		=	
Sorghum silage	2.6 lb/ton	X		X		=	
Alfalfa	11.0 lb/ton	X		X		=	
Most grasses	13 to 18 lb/ton	X		X		=	

Table III. Estimated land requirements for sludge or slurry application at agronomic rates.

Source of nutrients	*Total P_2O_5 in sludge and solids (Table I)*		*Portion to be removed (Between 0 and 1)*		*Desired P_2O_5 application rate (Table II)*		*P_2O_5 application rate (pounds P_2O_5/acre)*
Example: Swine lagoon *sludge from 10 year accumulation*	*70,000 pounds*	*X*	*0.5*	÷	*180 pounds/acre*	=	*190 acres*
		X		÷		=	

Option A. Elimination of earthen storage structure

4A. *Divert all surface water runoff away from the storage.* Runoff from building roofs, abandoned lots, or cropland should be directed away from storage. Plug storage basin pipe inlets.

5A. *Allow remaining sludge to dry.* Fill the lagoon with soil. If significant solids remain, remove them to the original structure's depth while making every effort to maintain liner integrity. Fill the lagoon with soil by pushing in existing dams or berms or bringing in additional fill dirt. Sufficient fill is needed to facilitate rapid surface runoff of stormwater from the lagoon site after allowing for settling of fill soil. Do not allow ponding of stormwater on top of the old lagoon site.

6A. *Establish a growing crop or sod.* Till the final surface and establish growing vegetation. Alfalfa is a desirable crop because of its deep root zone, which may allow recovery of some remaining soil nitrogen.

Option B. Establishment of a farm pond

If the basin will be used as a farm pond, this is a good time to reshape and repair any berm damage. Reshaping berms will make mowing easier and safer. Repairing cracks and erosion will help maintain berm integrity.

4B. *Set maximum water level.* A spillway (if one does not currently exist) or a standpipe should be added to set a maximum water level at least 2 feet below the lowest point in the berm or dam and facilitate the controlled release of water if the storage volume is exceeded. An engineer may be needed to design for sufficient flow through a standpipe if the structure is used to manage runoff water.

5B. *Flush the lagoon with water.* Refill the empty basin with water and allow to set until the next growing season. Pump out the lagoon during the next growing season and apply the water to crops based on their needs. Completely empty the facility.

6B. *Refill lagoon with water.* Dissolved oxygen concentration may be checked after the second refill. If concentration exceeds 3 mg/liter, pump water onto crop and flush the basin with water. If not, manage the basin as a farm pond. Allow runoff to enter the structure or provide additional water to maintain the pond level near its capacity. A full pond will prevent liner damage due to burrowing animals and vegetation growth. Until stable water quality is achieved ($0.0 \leq 3$ mg/L), the basin should be managed as a manure storage with adequate storage volume maintained and effluent removed and land applied as needed.

Principles for Temporary Abandonment

Facilities often are temporarily closed with the intention of restarting livestock production at a later time. While the abandonment plan requirement for a NDEQ permit should focus on permanent abandonment, it is appropriate to have a temporary closure plan in mind.

The first three steps identified for permanent abandonment continue to be relevant. They are:

1. Remove all liquids and pumpable slurry.
2. Protect the integrity of the existing earthen liner.
3. Land apply the liquid and pumpable slurry to cropland at agronomic rates.

For temporary closure, include the following steps:

4. Refill the storage with water. Leave at least 18 inches of unfilled depth to provide at least 1 foot of freeboard and sufficient depth to contain a 25-year, 24-hour storm (ranges from 6 inches in southeast Nebraska to 3.5 inches in the Panhandle). The water should limit damage to the sidewalls from weed growth, erosion, and burrowing animals during temporary abandonment.
5. Monitor the storage water depth regularly. If precipitation and runoff reduce the freeboard and emergency storm volume, pump this water onto crop or pasture land to re-establish the 18 inch emergency storage volume. The water should not be discharged into a stream, ditch, or drainage.

Conclusion

By defining the steps necessary to implement facility abandonment, a plan meeting NDEQ review requirements can be assembled. If abandonment occurs, the plan provides a way of preventing environmental damage. It also provides a procedure for limiting environmental liability due to its preapproval by NDEQ.

Abandonment Plan Worksheet

Describe anticipated procedures, types of equipment, and appropriate measurements for each of the following principles.

Abandonment Plan Principle	*Individual Producer's Plan: Describe actual procedures, types of equipment, appropriate measurements, and other procedures specific to individual plan.*
1. Removal of liquids and pumpable slurry.	
2. Protection of the integrity of the existing earthen liner.	
3. Land application of the liquid and pumpable slurry at agronomic rates (land requirements, manure analysis, method for estimating application rates).	

Identify selected option:

_____ Option A: Elimination of earthen storage structure _____ Option B. Establishment of a farm pond

4A. Divert all surface water runoff away from the storage. OR 4B. Set maximum water level.	
5A. Fill the lagoon with soil. OR 5B. Rinse the lagoon with water.	
6A. Establish a growing crop or sod. OR 6B. Refill lagoon with water.	

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