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EC719

Managing Earthen Manure Storage Basins During Drought

Amy Millmier Schmidt, Livestock Bioenvironmental Engineer

Uncovered earthen manure storage basins, runoff holding ponds, and treatment lagoons are designed to contain stormwater and manure from livestock for a specified length of time, while providing volume for sludge to accumulate. Design considerations typically include sizing the basin to contain the average volume of rainfall, minus evaporation during the design storage period, along with emergency storage volume. In this publication, these types of storage structures will be collectively referred to as earthen basins unless otherwise specified.

In Nebraska, average annual rainfall ranges from 34 inches in the southeast corner of the state to 16 inches in the western edge; average annual evaporation is as high as 54 inches along Nebraska's southern edge to 40 inches in the northeast corner (*Figure 1*). In an "average" year, then, an earthen basin on the eastern edge of the state may experience a net evaporation of around 14 inches, while a site in the far western area of the state may experience a net evaporation of around 31 inches. Continued drought combined with high temperatures can increase evaporation rates while significantly reducing the volume of stormwater entering an earthen basin from precipitation.

Although problems may be less obvious as with excess precipitation, drought conditions can pose challenges in managing earthen basins. Even earthen basins that have been properly designed and

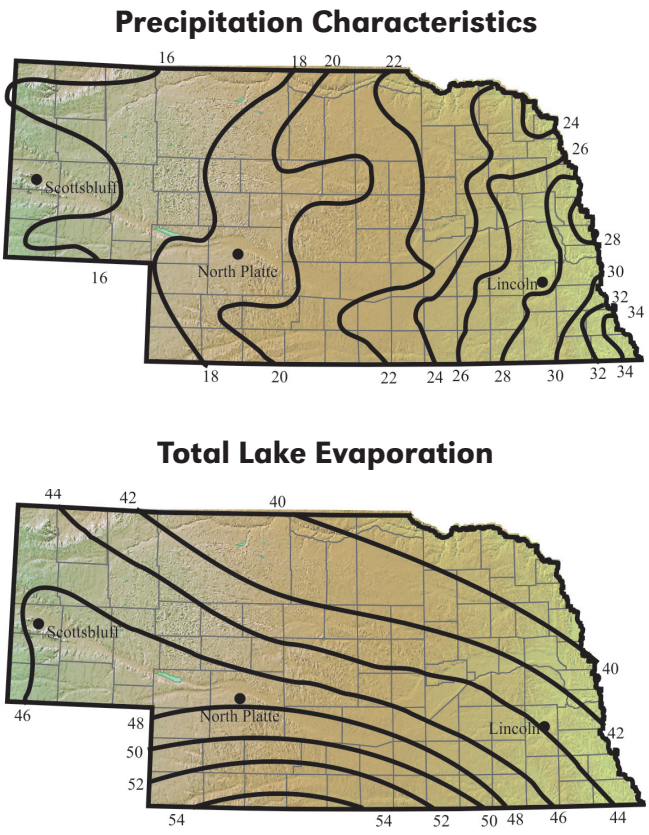

Figure 1. Average precipitation and evaporation for the state of Nebraska. (NAC, Title 124)

Basic Lagoon Management

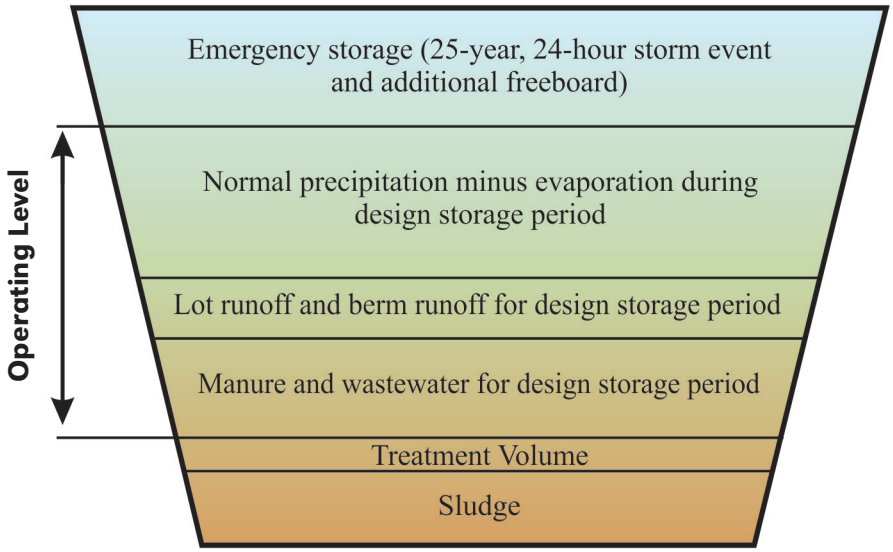

Figure 2. Anaerobic treatment lagoon schematic showing volume fractions.

constructed can have problems when continuing dry conditions reduce the volume of liquid stored in the basin. Relatively small storage basins and those constructed on marginal soils typically are the first to experience problems. At the same time, the reduced elevation of liquid manure in the basin provides an opportunity for maintenance and repair activities. This publication discusses both problems and opportunities that exist in managing earthen manure storage basins, as well as treatment lagoons, during drought conditions.

Basic Anaerobic Treatment Lagoon Management

When properly designed and constructed, anaerobic treatment lagoons have a total volume that provides storage for accumulated sludge, manure and wastewater, runoff, normal precipitation minus evaporation, and emergency stormwater storage. During normal management conditions, manure is allowed to accumulate to the elevation identified as the top of the operating level in *Figure 2*. Pumping to remove manure should be initiated when the liquid in the lagoon reaches this elevation, or before. As manure is removed from the lagoon, it is important to maintain the treatment volume above the sludge layer. The bottom of the operating level in *Figure 2* illustrates the minimum depth of manure that should be maintained in the lagoon. If a lagoon is pumped down to the bottom of the operating level (or very near this level) prior to the onset of a drought, further loss of liquid volume to evaporation could cause significant management and structural issues.

Basic Earthen Manure Slurry Basin Management

Earthen slurry basins differ from anaerobic treatment lagoons in that they are designed to store manure and wastewater, but do not offer addition volume for manure treatment. *Figure 3* illustrates the approximate volume fractions of an earthen slurry storage. Like treatment lagoons, they require a compacted clay liner, so similar management activities are applicable during drought conditions. Complete removal of manure is not recommended as exposure of the clay liner to drying can jeopardize the integrity of the liner.

Slurry Storage Basin Design

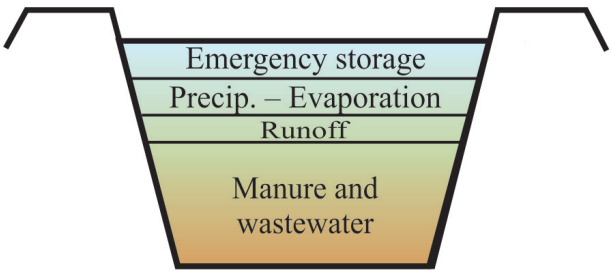

Figure 3. Earthen manure slurry storage basin schematic showing volume fractions.

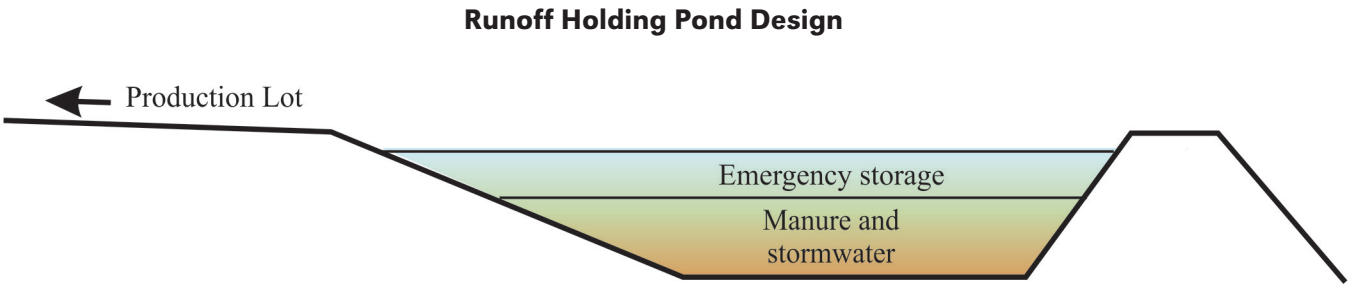

Figure 4. Runoff holding pond schematic showing volume fractions.

Basic Manure Runoff Holding Pond Management

Manure runoff holding ponds are designed to store manure and stormwater running off of an open lot livestock production area. *Figure 4* demonstrates the approximate volume fractions of a manure runoff holding pond. Requirements for removing manure from holding ponds vary somewhat based on time of the year, but in general, the contents of the holding pond should be pumped and land-applied any time the pond gets too full to hold the expected runoff from a 25-year, 24-hour storm (NDEQ, 2005). Design considerations for runoff holding ponds in Nebraska are available in Nebraska Administrative Code, Title 130.

Potential Problems

A number of problems can arise as the liquid level in a clay-lined earthen manure storage basin or treatment lagoon drops to a depth that nears the minimum operating level.

Figure 5. Excessive vegetation growth on the inside berm of a lagoon. (Photo credit: Jill Heemstra)

Damage to Basin Liner or Berm

Properly constructed earthen basins and lagoons use either a synthetic or compacted clay liner, with the latter being common in areas where soils have sufficient clay content. Once a compacted clay liner is constructed, water is typically added to a depth of at least two feet to keep the clay wet and prevent shrinking and cracking of the liner. It is unlikely that an anaerobic lagoon will dry out completely during drought conditions; however, liquid level will drop and expose the berm and liner. The exposed berm and liner should be monitored so cracks can be addressed quickly if they occur. Cracks in the berm are more likely to occur as the water level drops. Any cracks that develop should be quickly repaired using available clay soil, or a mixture of soil and bentonite or soda ash when available soil is unsuitable.

Weed growth on the exposed berm (*Figure 5*) can also become an issue during low liquid levels, though this problem is not exclusive to low liquid levels. Regular mowing of the berm is always recommended and may need to be implemented more regularly when more of the inside berm is exposed. Thick-stemmed, woody plants can pose a risk when the roots die and leave porous channels in the berm. Any noticeable holes should be filled in. Plant growth also is conducive to burrowing animals that use the vegetation as habitat. Because burrows can create channels for leakage from the basin (*Figure 6*), control of plant growth and repair of burrows should be addressed promptly. If reducing vegetation does not remedy the problem with burrowing animals, further action may be needed to eliminate these animals from the area around the facility. When addressing burrowing animals, though, bear in mind that some animals may be protected species. Be sure that proper population reduction procedures are followed. Information about

Figure 6. Erosion or animal burrowing on berm of lagoon. (Photo credit: Powell, et al., 2005)

Figure 7. Solids accumulation in a lagoon can present odor problems and in solids buildup in manure collection pits when lagoon effluent is recycled for flushing the manure from livestock buildings. (Photo credit: Jill Heemstra)

endangered and threatened species in Nebraska can be found at *outdoornebraska.ne.gov*.

Concentration of Manure Solids and Nutrients

As the liquid level in a treatment lagoon or earthen basin decreases by evaporation, the manure in the basin will become more concentrated. *Figure 7* illustrates the solids mounds that are visible in a basin with a low liquid level.

The resulting greater solids concentration can lead to more odors as the bacterial population changes. For this very reason, during start-up of a new treatment lagoon or storage basin, fresh water is added before manure is introduced. If odors become problematic, fresh water may need to be added to help reestablish microbial balance of the treatment lagoon and the desired manure treatment.

Bacterial activity may also be inhibited by increased salt concentrations in the liquid, another potential concern due to evaporation. Salt concentrations in the liquid layer of lagoon storage can be monitored by measurement of electrical conductivity (EC). EC can be measured using a handheld meter with a connected probe. Several liquid samples should be collected from the lagoon surface and thoroughly mixed to produce a composite sample. The tip of the EC meter probe can then be submerged in the sample and a reading recorded once the meter stabilizes. An EC concentration greater than 10,000 micromhos per centimeter is likely a sign of solids build-up, decreased microbial activity, and an increase in odors. Again, diluting the manure with fresh water may be necessary to address these issues.

Nutrients will also become more concentrated as liquid evaporates from the lagoon. A significant change in lagoon volume makes collecting and analyzing a representative manure sample prior to initiating land application of manure even more important.

When basin or lagoon effluent is recycled as flush water for removing manure from animal confinement facilities, the quality of this flush water can be degraded by significant evaporative water loss. Solids contents above 2 percent are often associated with nonfunctional flushing. Greater odors and solids in the flush water will contribute to more odorous emissions from the livestock housing, a buildup of solids in the manure collection pit, and an increase in flies associated with the solids buildup. Should this occur, the temporary use of fresh water for flushing or pit recharge may be necessary to return the lagoon liquid depth to the minimum operating level. When sufficient fresh water addition or precipitation occurs to dilute the lagoon, a return to using recycled effluent for flushing will be appropriate.

Figure 8. Accumulation of solids at lagoon edges. (Photo credit: Jason Gross)

Ideal Conditions for Fly and Mosquito Breeding

As the liquid level in an earthen basin or treatment lagoon decreases, a zone of moist solids will likely form around the inside of the berm where the liquid is receding (*Figure 8*) and on any exposed islands of solids. This moist, nutrient-rich material can be an ideal breeding ground for flies and seedbed for plant growth. Once again, controlling weed growth at this interface can speed drying of the solid material and impede fly breeding.

Concentrated nutrients can lead to increased numbers of mosquito larvae. Total Kjeldahl nitrogen (TKN) concentrations have been shown to have a direct impact on mosquito larvae survivability, with concentrations less than 50 mg per liter (mg/L) or greater than 500 mg/L being detrimental to the larvae (Stringham and Watson, 2002). Lagoon TKN concentration is typically much less than 50 mg/L. However, during drought, it may be advisable to test the TKN concentration in the lagoon to ensure that it isn't approaching or exceeding 50 mg/L. Instructions for sampling liquid manure can be found in NebGuide G1450, *Sampling Manure for Nutrient Analysis*, available at *ianrpubs.unl.edu/sendIt/g1450.pdf*. If the TKN concentration in the basin's liquid layer is found to be greater than 50 mg/L, adding fresh water may lower the concentration enough to impede mosquito production.

Opportunities for Maintenance

While a number of concerns may arise when liquid levels drop during drought, the lower liquid levels also present a number of opportunities for conducting maintenance and repair activities.

Sludge Removal Storage Basins and Treatment Lagoons

The general recommendation is that sludge be removed when it occupies about one-third of a treatment lagoon's total volume. However, if the liquid level in a lagoon is low during drought conditions — making sludge more easily accessible — then removal is certainly justified prior to the sludge building up to one-third of the treatment lagoon volume. Because there is less liquid above the sludge layer, it is likely that the sludge could be removed with less dilution than would be experienced if a lagoon were fuller. A discussion of sludge removal techniques and other information is available in NebGuide G1371, *Sludge Management for Anaerobic Lagoons and Runoff Holding Ponds,* at *ianrpubs.unl.edu/sendIt/g1371.pdf*. Never completely remove all sludge from treatment lagoons, as it is largely responsible for the biological activity that allows an anaerobic treatment lagoon to function properly.

Discharge Pipe Repair

Discharge pipes carrying manure from the livestock production area to an earthen basin or treatment lagoon can become cracked or broken by equipment, poor construction, or freezing and thawing. A pipe that becomes broken at the discharge end can lead to scouring of the lagoon embankment as flushed manure exits the pipe (*Figure 9*). A pipe that becomes broken or separated at a location underground can result in liquid manure seeping around the pipe and eroding the soil where the pipe passed through the berm. Both of these conditions should be remedied quickly.

Figure 9. Erosion of lagoon berm from broken discharge pipe. (Photo credit: Jill Heemstra)

Drought conditions may reveal previously hard-to-see damage and offer an ideal situation for conducting these types of repairs. When lagoon liquid levels are low, the discharge pipe likely will be accessible for inspection and repair. If the pipe has become broken at the discharge point such that the manure discharge is scouring the berm, the pipe should be extended to its original length and the scoured area should be repaired. Riprap may need to be added on the embankment below the discharge pipe to prevent future scouring of the berm.

If erosion around the pipe is noticeable where the pipe exits the inside of the berm, it is likely a break has occurred upstream of the storage basin or lagoon and is allowing liquid to flow around the pipe to the basin or lagoon. If this is the case, the drainage line should be uncovered to identify the broken section(s), which should then be replaced or repaired. Once the pipe repair is completed, the eroded berm should also be repaired and returned to its original grade and finish.

Pumpdown Marker Installation, Repair, or Replacement

Pumpdown markers are installed in earthen basins and lagoons to give an operator a reference for the depth of liquid in the structure. A simple, durable, and easy-to-read marker helps an operator decide when pumping should begin and end, what fraction of the storage capacity is full at any given time, and how much emergency storage is available. It can also indicate to regulatory personnel that a manure storage structure is being well-managed.

If a pumpdown stake is already installed in a lagoon, drought conditions offer an excellent opportunity for repairs to the stake, if needed. For lagoons and basins without a pumpdown stake, this can be an excellent time to install one.

Many designs have been developed for lagoon pumpdown stakes. In general, the stake or stakes should be durable with easy-to-read marks visible from the lagoon berm. A 6" x 6" treated wood post with notches cut or drilled at graduated distances along it fits this requirement well (*Figure 10a*). Other materials that have been used with varying levels of success include PVC pipes and steel fence posts. As long as the marks on them are not painted or applied with anything that can fade or wash off, they should work fine. Another option that is sturdy and easy to install is a series of posts or stakes set such that the top of each stake represents an important liquid level measurement (*Figure 10b*). A group of four stakes could be used to mark the upper pump-down level, 50 percent storage volume remaining, 25 percent storage volume remaining, and the lower pump-down level. Further information about pumpdown stake design and pumpdown monitoring can be found on the eXtension website, *extension.org/mediawiki/files/b/b0/L21_sec8.pdf.*

Overflow Spillway and Berm Maintenance

Storage basin and lagoon berms and overflow spillways should be inspected monthly to identify erosion, seepage, excessive weed growth, or animal burrows (as shown in *Figures 3* and *4*). Though these repairs can be done almost any time when the berm is relatively dry, drought conditions that lower the liquid level provide an excellent opportunity for more diligent repairs.

Berms that were built with a berm slope steeper than 3:1 (horizontal:vertical) can be sculpted to produce a slope that is easier to mow and maintain. Following any soil movement, the exposed ground should be reseeded to establish grassy vegetation as soon as possible. Bare

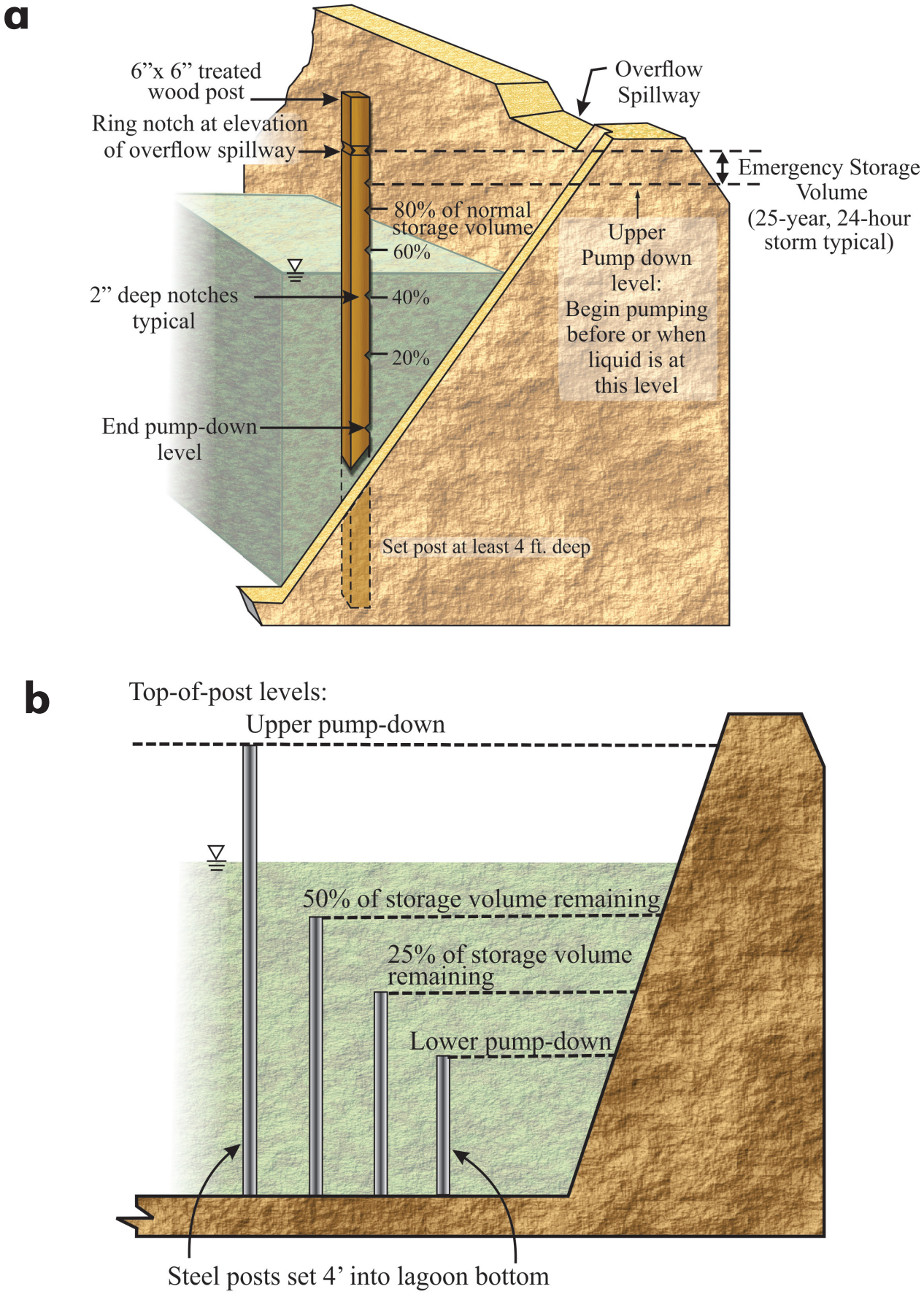

Figure 10. Pump-down markers in an earthen manure storage can be a single post with graduations (a) (adapted from Pfost et al., 2007) or a series of posts set at graduated depths (b).

spots, erosion rills or gullies, channels created by the roots of woody vegetation, and animal burrows in the berm should be repaired and reseeded. When reseeding bare spots on the berm, the seeded area should be covered with straw and irrigated, if needed, to quickly establish a good stand of grass.

The emergency spillway of an earthen basin or lagoon is intended to provide an emergency path for overflow from the structure, should it occur, to avoid liquid topping the entire length of the berm or cutting into the berm and causing a berm failure. The bottom elevation of the overflow spillway is typically one foot below the top elevation of the berm. However, over time the spillway may fill in with sediment or settle and become lower than the original elevation. In either case, it should be reshaped and/or regraded to meet the design specifications of the facility. After earthwork is completed, the area should be reseeded, covered with straw, and watered, if necessary.

Summary

- Observe your earthen storage basin, holding pond, or lagoon regularly, looking for problems that may become visible or arise during a drought.
- Establish a plan for how you will address various problems so that you can quickly take corrective action when a problem is identified.
- Maintain at least 2 feet of liquid in earthen manure storage basins and treatment lagoons to protect the clay liner.
- Consider adding fresh water if odors become an issue.
- If mosquito breeding is a concern, test the basin liquid for TKN to ensure that it is still below 50 mg/L. If it is near or about this concentration, consider adding water to dilute the liquid.
- Take advantage of low storage levels in earthen manure storage basins, holding ponds, and treatment lagoons to conduct maintenance activities on the berm, emergency spillway, and discharge pipe, to install or replace a pumpdown marker, and to remove accumulated sludge.

Resources

Nebraska Administrative Code Title 124, Chapter 18, Section 015. *deq.state.ne.us/RuleAndR.nsf/Pages/124-Ch-18*.

Nebraska Administrative Code Title 130, Chapter 8, Section 002.01, p. 8-1. *deq.state.ne.us/RuleAndR.nsf/Pages/130-Ch-8*.

Nebraska Department of Environmental Quality. 2005. Basic holding pond operation. Environmental Guidance Document 05-134a, February 2005. *deq.state.ne.us/Publica.nsf/0/31f4340ca403beaf06256d350062ba08/$FILE/ATTRJ8ZE/05-134a.pdf*.

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Title 124, Ch. 18, Nebraska Department of Environmental Quality. *deq.state.ne.us/RuleAndR.nsf/Pages/124-Ch-18*.

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