Runoff Control Options

The two basic types of runoff control options are containment and discharge. Containment or nondischarge runoff control systems gather all runoff from the feedlot for application on land owned or contracted by the feedlot operation. Discharge runoff systems are designed to release a portion of the runoff (usually after some treatment) to adjacent land. Federal regulations covering all states require runoff containment systems for operations larger than 1,000 AUs. Most containment systems include a method for separating the liquids and the solids. The solids are deposited in a sedimentation structure that allows the liquid to drain from the solids. The solids are then removed and applied to land as fertilizer. The liquid portion of the runoff drains from the sedimentation structure into a containment structure. The contained liquid is later pumped onto cropland or pasture at proper nutrient management rates.

Regulations for feedlot operations with less than 999 AUs are different for each state. However, feedlot operations should consider a sedimentation structure as a minimum control measure even if there are currently no regulations on runoff control. Regardless of size, new environmental regulations can be imposed if an operation is considered to have a pollution potential. Livestock housed in open lots should not have direct access to a creek or stream for water. Irrespective of size, lots should not drain directly into a road ditch, creek, or other channel without adequate control because of the pollution potential. Frequent cleaning of open lots and proper application of manure onto cropland or pasture can minimize potential pollution problems.

Figures 22-4a through 4e are schematics of the five options available to control the runoff from open lots. Tables 22-3 and 22-4 indicate where these different types of systems may be used.

Table 22-3 is based on the amount of nitrogen (N) expected to enter a vegetative or containment system, and Table 22-4 is based on water surface evaporation. Figure 22-5 shows water surface evaporation rates for the United States.

The two basic types of runoff control options are containment and discharge.

Livestock housed in open lots should not have direct access to a creek or stream for water.

Sedimentation structures

Sedimentation structures are used to separate feedlot runoff solids from feedlot runoff liquids before they are discharged into an infiltration pond, holding pond, lagoon, or grass filter strip. Figure 22-6 shows a sedimentation structure along the lower side of a pen. Often the earth removed to construct a sedimentation structure is used to construct mounds and establish proper pen drainage. Normally, the trapped sediment will contain about 50% of the N leaving the open lots. Unless specified by state regulations, the sediment structure should be sized to contain 1/3 and 2/3 of the runoff volume generated by a 25-year, 24-hour storm for containment and vegetative systems, respectively. A sedimentation structure normally is designed to contain an equivalent of a 1- to 2-inch depth of runoff from all areas draining into the pond plus the pond area. The discharge time from the sedimentation structure should be 30 to 60 minutes for a containment system and 8 to 12 hours for a vegetative system. Sedimentation structures need to be cleaned annually and the sediment applied to adjoining fields at proper nutrient management rates.

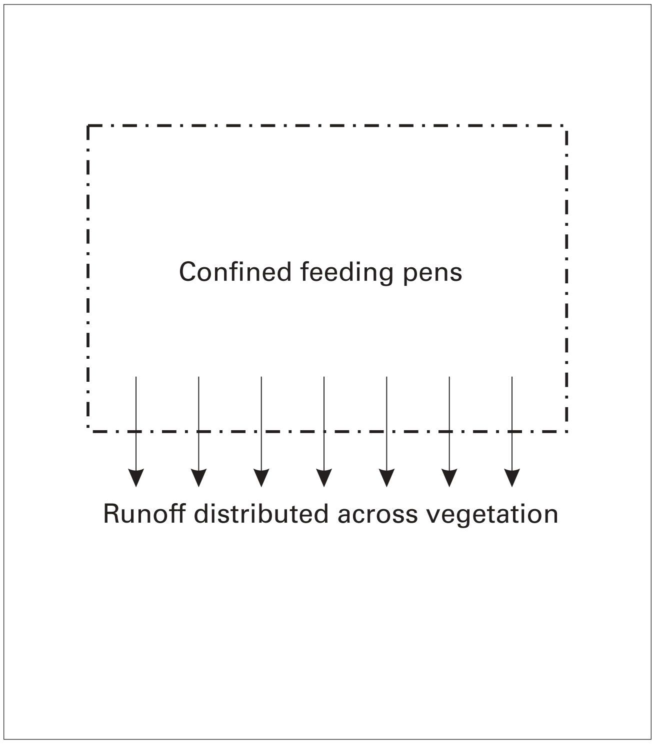

Figure 22-4a. Controlling runoff from small CAFOs using pastures or grassland and existing land terrain.

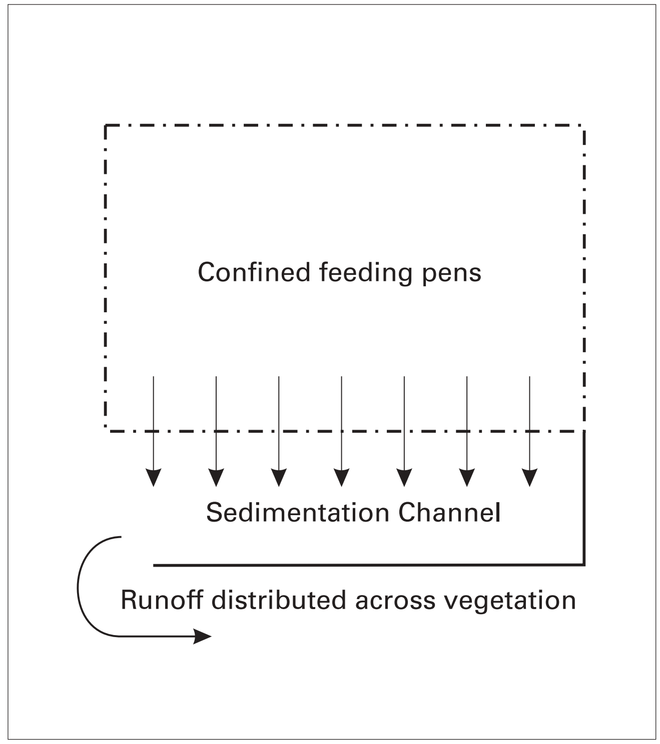

Figure 22-4b. Controlling runoff from small CAFOs using a sediment basin and grass filters.

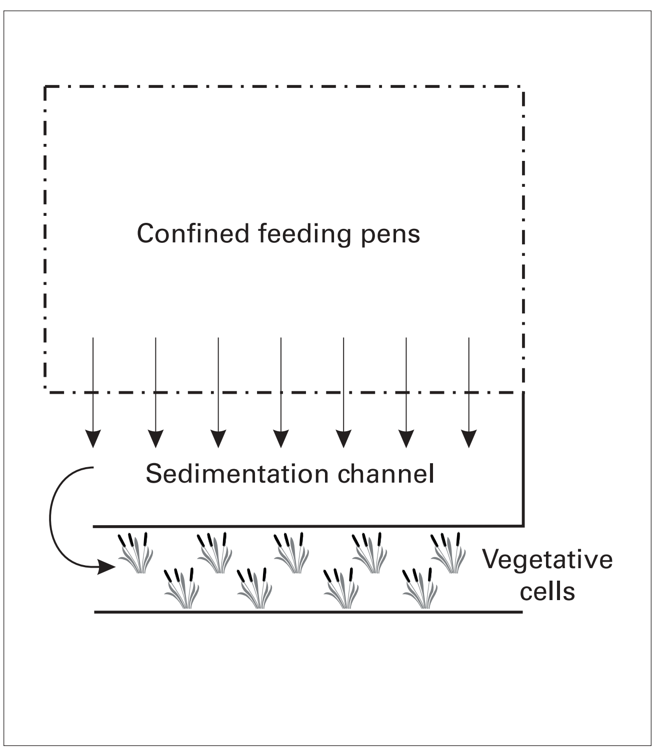

Figure 22-4c. Controlling runoff from small CAFOs using a sediment basin discharging into a vegetative system using filter strips or wetland cells.

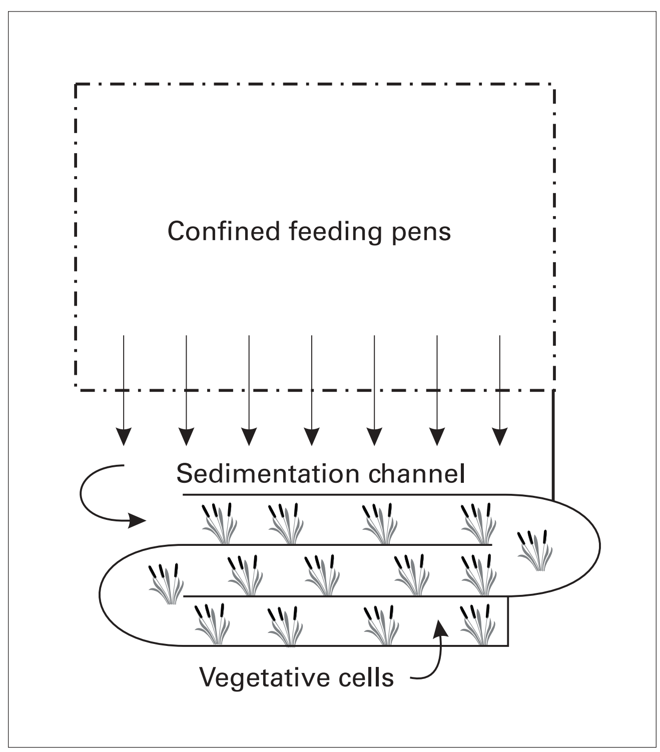

Figure 22-4d. Serpentine terraces as a total containment system for controlling runoff from small CAFOs.

Table 22-3. Potential containment or vegetative system used to control open lot runoff based on pounds of N in the runoff.

	Containment Systems			Vegetative Systems			
Total Annual N in Runoff, lbs	Lagoon	Holding pond	Evaporation pond	Wetland	Infiltration field	Grass filter	Terraces
< 100	X	X	X	X	X	X	X
100-500	X	X	X	X	X	X	
500-1,000	X	X	X	X	X		
1,000-4,000	X	X	X	X			
> 4,000	X	X					

Table 22-4. Potential containment or vegetative system used to control open lot runoff based on water surface evaporation.

Free Water Surface Evaporation, in	Containment Systems			Vegetative Systems			
	Lagoon	Holding pond	Evaporation pond	Wetland	Infiltration field	Grass filter	Terraces
< 60		X	X		X	X	X
45-60		X	X	X	X	X	X
30-45	X	X		X	X	X	
> 30	X	X		X	X		

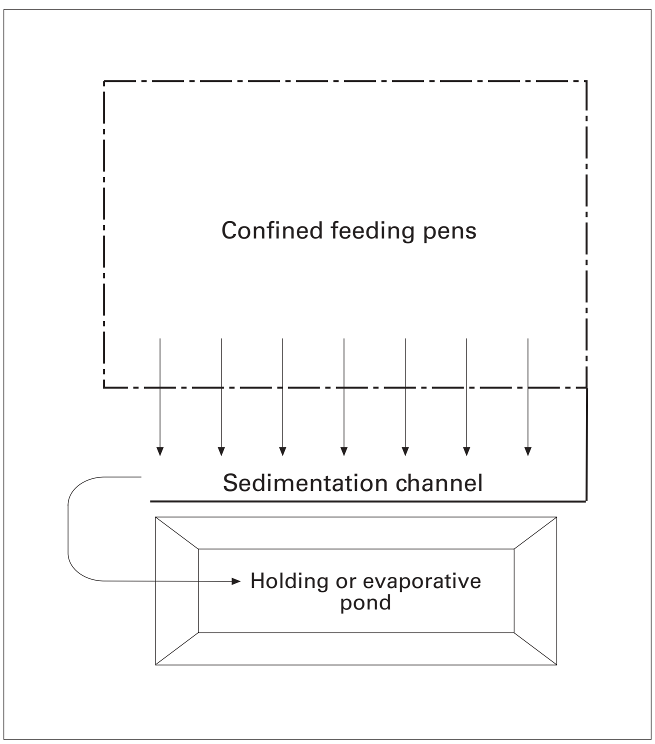

Figure 22-4e. Controlling runoff from small CAFOs using a conventional total containment structure, such as a holding pond, lagoon, or evaporative pond.

Sedimentation structures are used to separate feedlot runoff solids from feedlot runoff liquids before they are discharged into an infiltration pond, holding pond, lagoon, or grass filter strip.

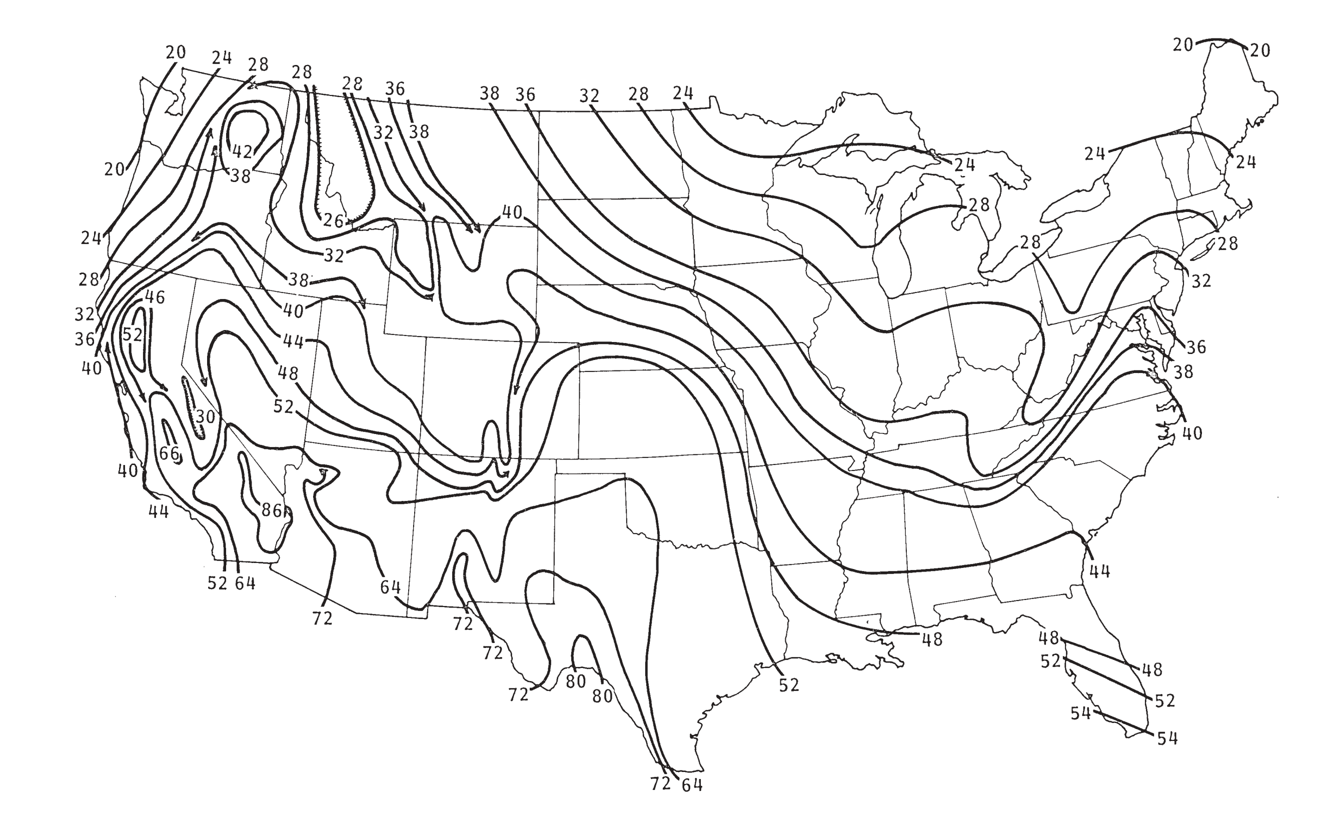

Figure 22-5. Annual water surface evaporation rates, inches.

Vegetative systems

Generally, state environmental regulations for feedlot operations of less than 1,000 AUs allow runoff to be treated by vegetative systems. Vegetative systems include wetlands, grass filters, infiltration (sorption) fields, terraces, etc. The use of a vegetative system for operations with 500 to 999 AUs depends upon the available filter area, number of days on feed, uniformity of discharge to the drainage area, and proximity of creek, roads, and neighbors. These systems depend on vegetation to remove the nutrients from the runoff. Many of the rainfall events will infiltrate into the soil without causing any discharge from a vegetative system. Intensive storm events, however, will create discharges. For example, monitoring of three vegetative systems in Kansas indicated that discharge occurred in only one out of eight storm events.

A vegetative system includes a sedimentation structure to separate the solids from the liquids. Figure 22-6 shows a typical flow of runoff leaving an open lot. Following sedimentation in a vegetative system, the liquid is then distributed across a grassed waterway, wetland, pasture, or cropped field. Feedlot operations of less than 1,000 AUs that cannot use vegetative systems will probably be required to have a containment type of waste control facility.

The size of a vegetative system is based on crop nutrient use and on the soil's nutrient- and water-holding capacity. Figure 22-7 shows the annual precipitation across the United States, and Figures 22-8 and –9 show, respectively, the percentage of rainfall expected to exit earthen and paved lots as runoff. By using the values of annual rainfall from Figure 22-7 and the percentage rainfall runoff values obtained from Figure 22-8 (earthen) or Figure 22-9 (paved), Figures 22-10 (earthen) and 22-11 (paved) indicate the amount of N released annually, in pounds per acre, from a sedimentation structure. The figures were developed on the assumptions that the runoff will contain 150 ppm of N and 50% of the nutrients will remain in the sedimentation structures.

Figures 22-4a through 4c show examples of vegetative systems. Runoff from an open lot is distributed across grassland in Figure 22-4a. This option requires that land slope perpendicular to the runoff flow be less than 0.25 percent or some land grading be performed to ensure uniform flow. Systems such as those shown in Figure 22-4c should be used when the total N leaving an open lot is less than 100 lbs per year. Most design guidelines require the size of the vegetative systems to first meet the N limitations of the vegetation (crops or grass). In some watersheds, phosphorus (P) may be the limiting nutrient rather than N, and thus the crop uptake of P becomes the design-limiting nutrient. On the basis of land requirements for vegetative systems and the cost of land leveling, operations with lots used year round generally opt to build a total containment system.

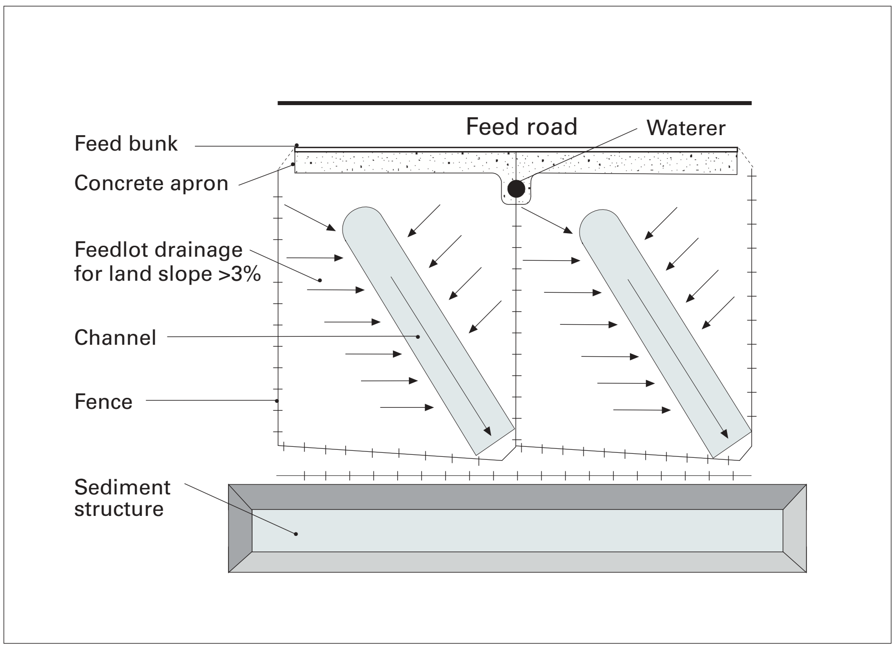

Figure 22-6. Sedimentation structure to receive runoff from feedlot.

The size of a vegetative system is based on crop nutrient use and on the soil's nutrient- and water-holding capacity.

In some watersheds, phosphorus (P) may be the limiting nutrient rather than N, and thus the crop uptake of P becomes the design-limiting nutrient.

Figure 22-7. Annual precipitation of the United States, inches.

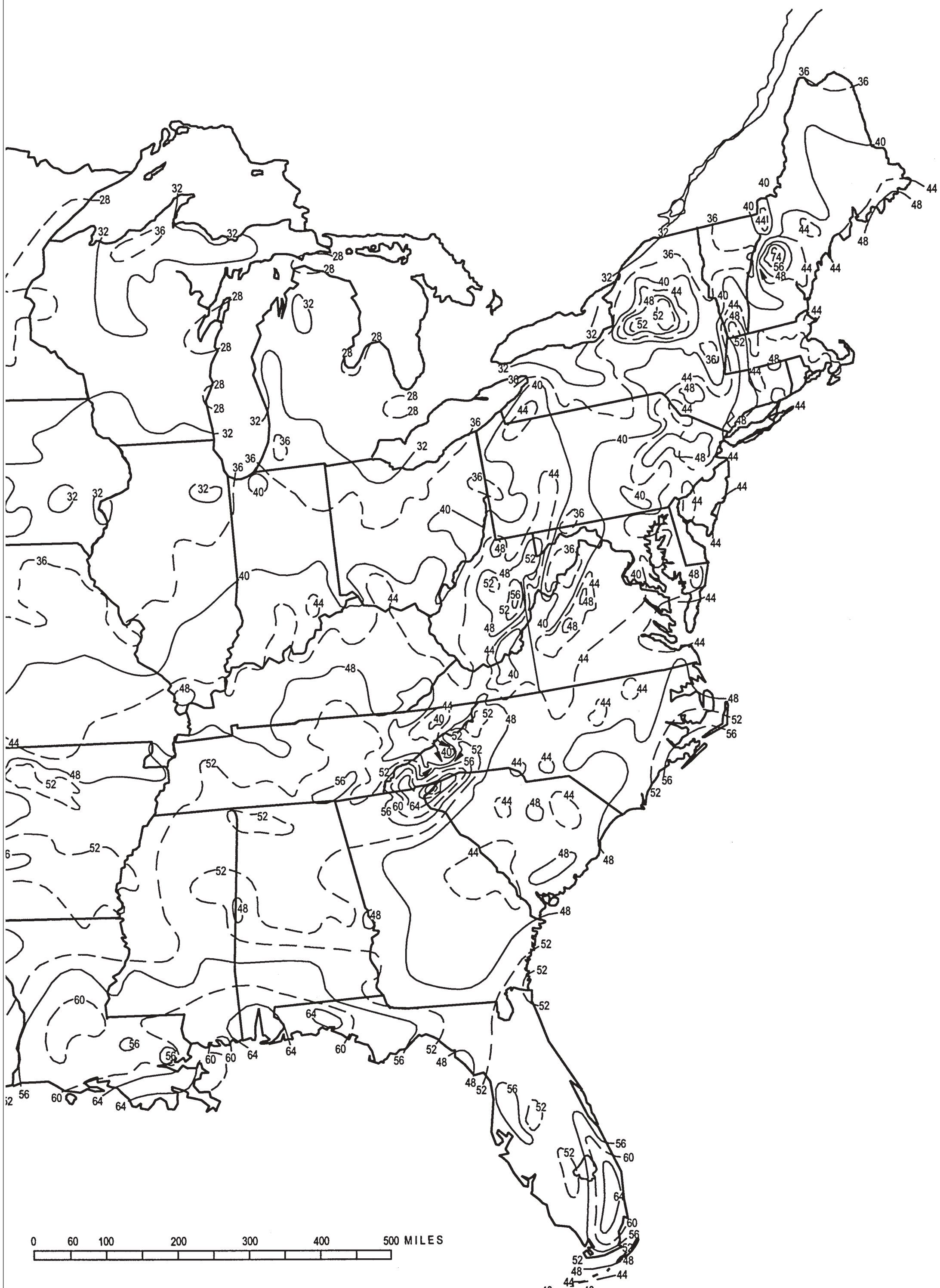
0 60 100 200 300 400 500 MILES

Figure 22-8. Annual runoff from earthen feedlots as percent of mean annual precipitation.

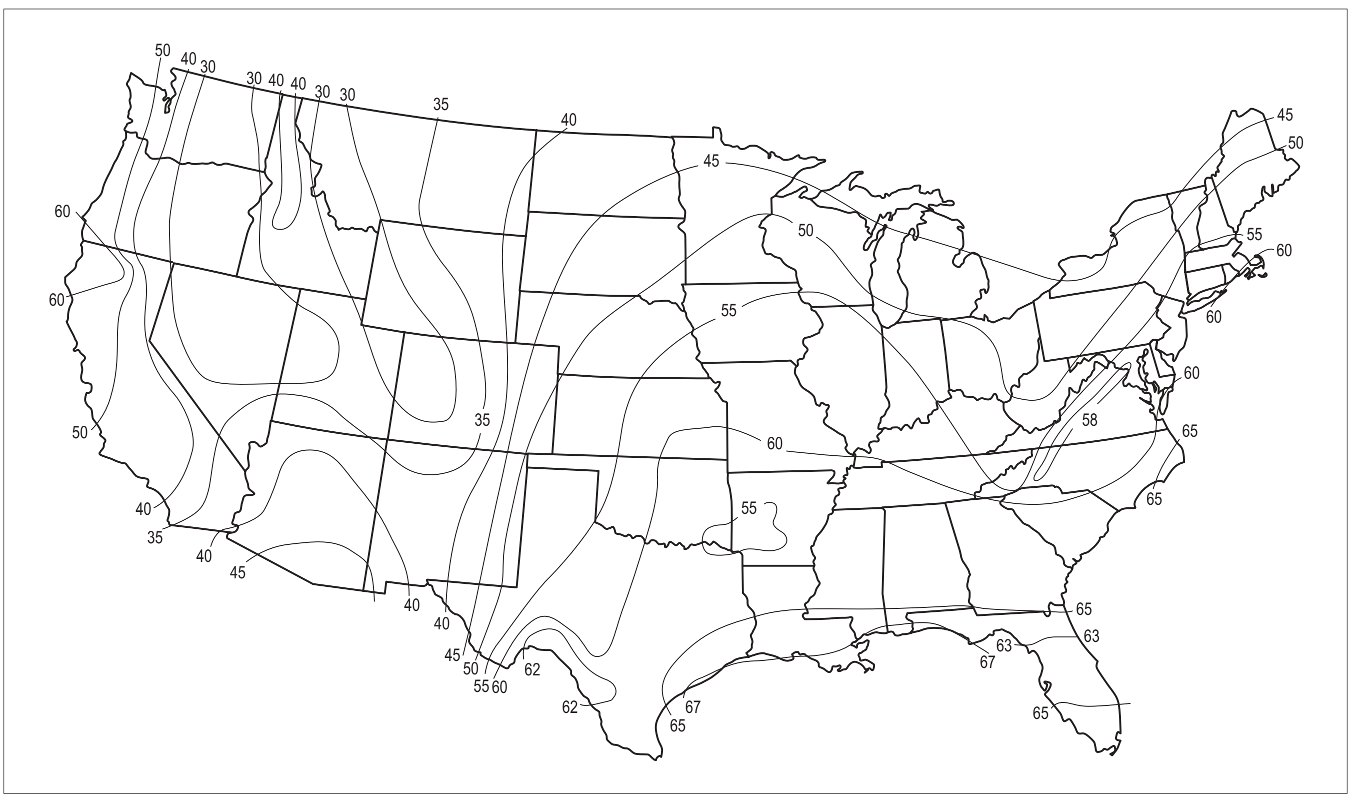

Figure 22-9. Annual runoff from paved feedlots as percent of mean annual precipitation.

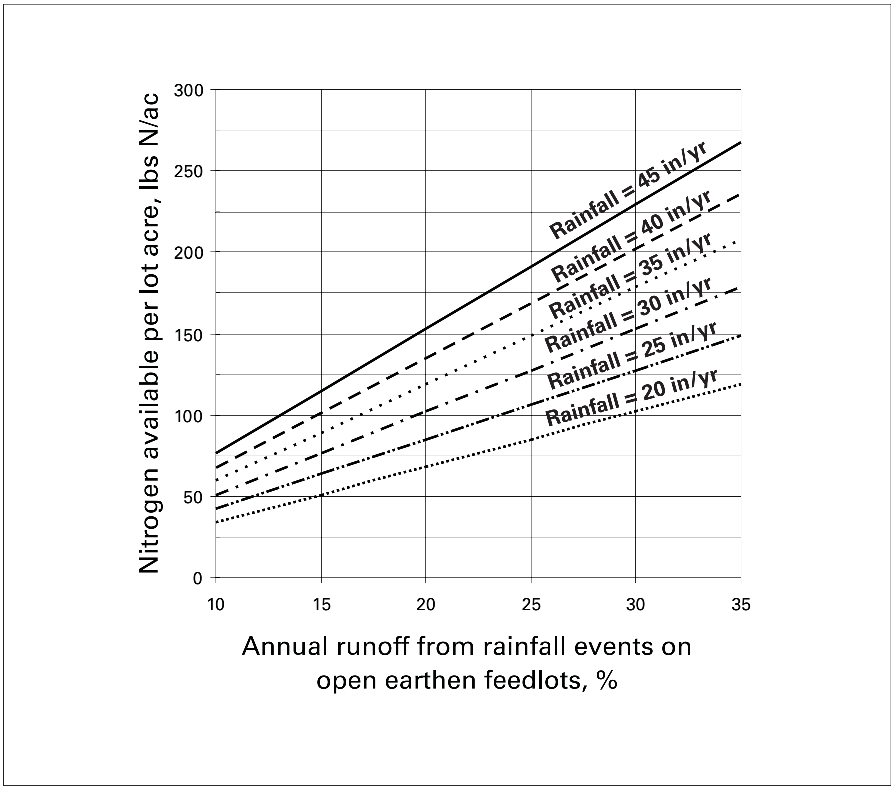

Figure 22-10. Annual N released from earthen feedlots, pounds per acre.

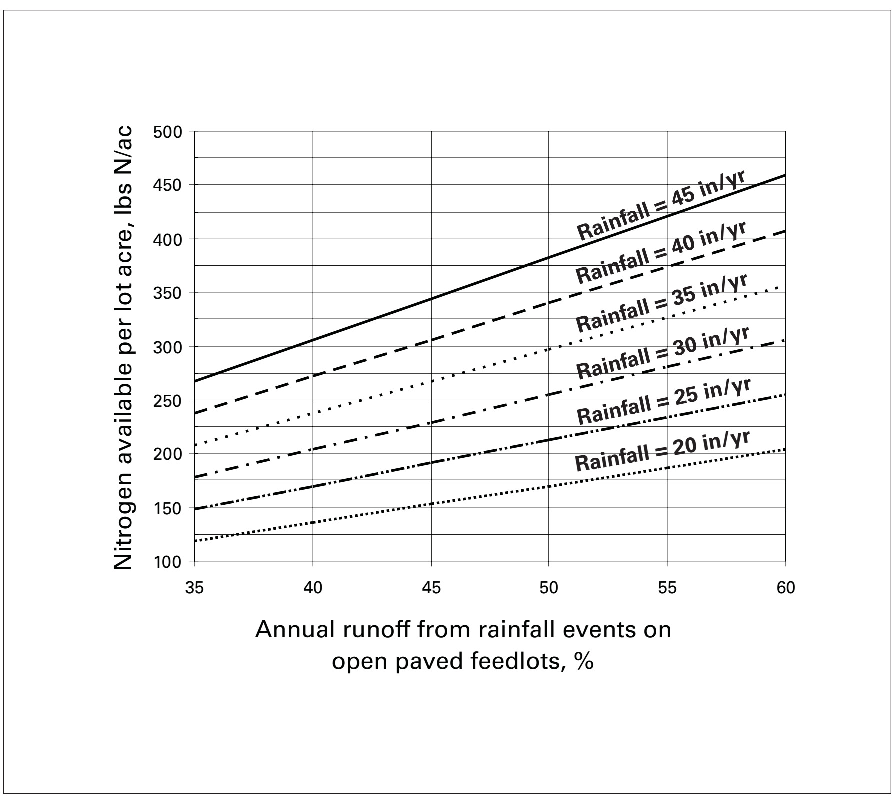

Figure 22-11. Annual N released from paved feedlots, pounds per acre.

Wetland vegetation...offers this advantage: it removes more nutrients per unit area.

The infiltration area must be able to receive the liquid volume as well as use the nutrient loading.

Grass filters

Design guidelines suggest that the drainage area below the pens have a uniform slope between 1 percent and 4 percent, and that the recommended length of the filtering area be 200 feet per 1 percent slope (Figure 22-4b). Therefore, if the drainage area has a 2 percent slope, then a 400-foot filtering area is recommended from the feedlot fence line to the nearest waterway. With this type of system, it is important that runoff from the pens be uniformly dispersed across the filtering area. Thus, the construction of a grass filter strip often requires laser-guided, earth-moving equipment. Guidelines first require the size of the grass filter to meet the N limitations of the grass filter acreage and then meet the minimum filter length based on the terrain slope. Due to the requirements for filtering area, year-round feeding or finishing feedlot operations generally use other alternative runoff controls.

Wetlands

Many states are developing guidelines for using wetlands to reduce nutrient discharges and to support wildlife. Lot runoff first enters a sediment basin to separate the solids from the liquids. Then a controlled release drains into a holding pond before moving through the wetland cells. To obtain maximum nutrient uptake, the wetland cells need about two to three years to establish plants. For example, the vegetative filter system shown in Figure 22-4c could be replaced by a wetland cell. Normally, daily uniform loading of the wetland cell is preferred to the slug loading that occurs with open lots. Wetlands, however, may perform better with seasonally used lots than with lots used year round. Generally, seasonal lots are operated from October to March when the total rainfall is significantly less than from April to September and limited runoff events occur. If the lots are maintained, then the wetland cell is predominately used to handle the rainfall events during the time when livestock are not present. This period coincides with the wetland vegetation's peak time of nutrient uptake. Studies of cattle feedlots have shown that nutrients enter a vegetative filter even when the cattle are not present. Wetland vegetation also offers this advantage: it removes more nutrients per unit area. Therefore, the wetland treatment area is often significantly smaller than grass filters with a similar nutrient load.

Infiltration areas

An infiltration, or sorption, field is another type of partial containment system. Infiltration systems are most practical for smaller lots with 100- to 400-AU capacity. These alternative systems require that a 12 to 24 inch high berm be placed around the drainage area below a small confined animal feeding operation (CAFO) to contain the runoff from the drainage basin. Rather than use pumping equipment, the runoff is moved by gravity and infiltrated into the soil, much like a border irrigation system. Level land below the drainage basin is needed for uniform infiltration of the liquid.

The design of an infiltration/sorption area is based on infiltrating the feedlot runoff from a 25-year, 24-hour storm. The infiltration area must be able to receive the liquid volume as well as use the nutrient loading. To ensure the vegetation's survival, the soil should be able to infiltrate the water in less than 30 hours. A cool season grass is most commonly used as a cover crop in an infiltration pond. In drier climates, the infiltration area is treated as an irrigated field where crops are grown. In all cases, a sediment structure is needed prior to the infiltration/sorption field. Infiltration ponds can be

PROBLEM 1

Determining the annual amount of N released from an earthen feedlot

Farmer Bovine is trying to determine if a grass filter will work below his animal feeding operation (AFO), which he uses year round. He has two acres of brome grass below the AFO and annually applies 80 pounds of nitrogen (N) per acre. Bovine's AFO consists of 200 head of cattle in a two-acre earthen lot. His operation is located in north central Missouri. Estimate how many pounds of N are leaving his AFO.

Step 1. Determine the N annually used by the vegetative area (brome field).

Answer: 160 lbs of N (2 acres x 80 lbs/acre)

Step 2. Using Figure 22-7, determine the annual rainfall for north central Missouri.

Answer: 36 inches

Step 3. Using Figure 22-8, determine the annual runoff from unsurfaced feedlots as a percent of mean annual runoff for north central Missouri.

Answer: 25%

Step 4. Using Figure 22-10, determine the N (lbs/acre) released from the unsurfaced feedlot. Locate the annual rainfall (36 inches [determined from Figure 22-7]) on the right axis and the percent annual runoff (25% [determined from Figure 22-8]) along the lower axis. Follow the rainfall line downward until it intersects with the percent annual runoff. Then follow horizontally to the left axis for an estimate of the N released per acre.

Answer: 150 lbs/acre

Step 5. Multiply the unsurfaced feedlot acres by the N available per acre to determine the N leaving the lots.

Answer: 300 lbs of N (2 acres x 150 lbs/acre)

Step 6. Compare the N used by the grass filter (Step 1) to the answer obtained in Step 4.

Answer: Farmer Bovine must consider another option since the N from the feedlot is more than the N used by the brome field. He would need (300 lbs N/80 lbs per acre) 3.75 acres of brome grass to use the available N.

designed as discharge or nondischarge structures. Each state's guidelines specify the infiltration area required for proper nutrient loading and infiltration rate. The nutrient loading rate is usually determined by the N and P uptake rate of the vegetation in the infiltration area. To avoid soil compaction and reduced infiltration rates, these areas should not be grazed when wet.

Terraces

Much like an infiltration area, terraces can be used to contain the runoff on a sloping area. Two types of terraces are overflow and serpentine terraces (Figure 22-4d). Overflow terraces are constructed to allow runoff to overflow or cascade from the top of one terrace into the next lower terrace. Plastic tile outlets can also be used to transfer runoff from one terrace to another. In a serpentine terrace, the runoff drains toward one end of the upper terrace and then overflows to the lower terrace, using a drop structure or a terrace riser and pipe. The runoff next drains back the opposite direction and discharges into a lower terrace. The upper terrace can serve as a sedimentation channel. In a terrace system, both rainfall falling on terraced areas as well as pen runoff must be considered. In some states, the total terrace capacity is normally increased 40% to provide storage for consecutive storms. Specific design of the terrace holding capacity varies with each state's regulations. The water depth in the terraces resulting from larger rainfall events determines the expected use of the terraces. Shallow water depths can be suitable for crops or grass that withstand wet conditions.

Containment systems

Holding ponds or lagoons are commonly used for larger operations (greater than 1,000 AUs) or where space is limited. The holding pond is required to have the capacity to store the runoff from the feedlot and the pond created by a 25-year, 24-hour storm plus an allowance for sediment. In some states, additional storage may be needed to handle runoff from normal rains if surface evaporation will not offset a normal rainfall event or if pond removal amounts are low or infrequent. After the holding pond size is determined, an additional freeboard (about 2 ft) is added to the top of the pond, enabling it to retain the runoff from two consecutive storms if the pond cannot be pumped before the second storm occurs. The minimum allowed storage period is generally 120 to 180 days.

A holding pond or lagoon should be constructed according to state regulations. Guidelines to follow if regulations are not available include side slopes of 3 to 1, minimum berm width of 10 feet, and a minimum of 12 inches of clay around the sides and in the bottom. Earthen structures have to meet each state's seepage rate. State and EPA guidelines for separation distance, flooding frequency, distance to water, etc. should be followed during the planning stages.

Holding ponds or lagoons are commonly used for larger operations (greater than 1,000 AUs) or where space is limited.

PROBLEM 2

Determining Runoff Capacity for a Terrace

The owners of Terrace Acre Farm have a five-acre animal feeding operation (AFO) and would like to continue their tradition of using terraces when addressing environmental issues. The farm is located in southwest Tennessee, and the terraced area is equal to the feedlot area. In cubic feet, estimate the terrace volume required to handle the runoff from their AFO.

Step 1. Using Figure 22-1, determine the 25-year, 24-hour storm for southwest Tennessee.

Answer: 6 inches

Step 2. Determine the runoff from the lots.
Answer: 108,900 cubic ft (5 ac x 43,560 sq ft/ac x 6 in x 1 ft/12 in)

Step 3. Determine the rainfall on the terraced area.
Answer: 108,900 cubic ft (The terraced area with the same area as the feedlot also receives the same volume of rainfall.)

Step 4. Determine the total volume of rainfall to be delivered to the terrace system.
Answer: 217,800 cubic ft (2 x 108,900 cu ft)

Evaporation ponds

Small operations or those located in low rainfall areas (20 inches or less) may be able to use evaporation ponds (Figure 22-4e). Evaporation ponds normally require an area equal to one to two times the confined feeding area and should be limited to a storage depth of 2 feet or less plus the required freeboard. If the pens are concrete, then an evaporation area two to four times the feeding area is required. Figure 22-5 shows the free water evaporation amounts for the United States. An earthen evaporation pond may have to be lined with compacted clay to limit the seepage rate to the rate required in each state. Runoff flowing into the pond is a combination of normal and high-intensity storm runoff, daily manure production, and other sources such as flow from overflow waterers or wash water. Losses from the pond occur as a result of normal evaporation and seepage. Evaporation ponds are more feasible when the yearly evaporation amount exceeds twice the rainfall amount. Evaporation ponds are not practical when the annual rainfall is nearly equal to the annual evaporation. It is desirable to have a

Evaporation ponds are more feasible when the yearly evaporation amount exceeds twice the rainfall amount.