Designing Settling Basins for Open Feedlots

All open feedlots should have solids removed before liquids run off during rainstorms. It’s a matter of good environmental stewardship. Proper settling basin design ensures good performance and optimum operator convenience. Good design can help achieve both these requirements. Settling can be accomplished in the lot or outside the lot using basins, terraces or diversions.

Current Iowa Department of Natural Resources (IDNR) rules require all open feedlots (regardless of size) to remove settleable solids before any liquid is allowed to leave. The law specifies the following minimum requirements:

- Basins must be designed to settle solids from a 1-hour, 10-year storm (approximately 2.5 inches per hour in Iowa).
- Liquid velocity must be reduced to 0.5 foot per second or less, for at least 5 minutes.
- Settling basins must have 1 square foot of surface area for every 8 cubic feet per hour of runoff.
- Basins must include adequate capacity to store the settled solids between cleanouts.

Although these requirements sound confusing, some approximations make settling basin design relatively easy, and insure the basin will meet the requirements and be effective. The three most important criteria are storm size, basin surface area, and “cleanability”. Basins should be designed so that they can be cleaned with existing equipment in less than ideal weather conditions.

Design storm size. The 1-hour, 10-year storm varies from 2.1 inches in the northeastern corner of Iowa to 2.5 inches in the southwestern corner (Figure 2). We will use 2.5 inches/hr for all of Iowa. The lot slope, lot surface (earth or concrete), and lot area determine the amount of runoff that occurs from our storm. For such a large, intense storm, however, assume that 100 percent of the rainfall becomes runoff. Using these conservative assumptions ensures adequate basin capacity.
**Surface area.** The second requirement, 1 square foot of surface area for every 8 cubic feet per hour of runoff, coupled with the storm size, determines the minimum basin area. The following example shows a minimum settling basin design for a 1-acre lot using 100 percent runoff and 2.5 inches per hour:

\[
2.5 \text{ inches/hour} \times 1 \text{ acre} \times 3,600 \text{ conversion factor}^* = 9,000 \text{ cubic feet/hour}
\]

Using IDNR’s requirement of 1 square foot of surface area for each 8 cubic feet/hour, the minimum basin size = 9,000 cubic feet per hour divided by 8 = 1,125 square feet. Our basin should have 1,125 square feet of surface area per acre of feedlot. **This is the absolute minimum size** without any solids storage area. It is 1/39 of the lot size. The minimum Iowa State University settling basin size **recommendation** is 1/20 of the feedlot drainage area, to allow extra room for manure solids storage and provide assurance of proper operation.

Now that we have determined the size of the basin, we need to design it to maximize its effectiveness and management convenience. To do so consider the following criteria:

**Slope.** Use a very flat slope at the bottom of the basin so the runoff slows immediately when it hits the basin. Generally use 0.5 percent or less slope.

**Depth.** Settling basins typically should be fairly shallow to allow easy access for cleanout. The shallower the basin is, the more rapidly the solids will dry. Less than 2 feet is normally used, but some situations require settling ponds or tanks rather than shallow basins. Deeper settling tanks or ponds require a cleanout plan and appropriate equipment, such as a backhoe, dragline, or track-type tractor.

**Geometry.** Settling basins below small concrete lots may only be 8 to 10 feet in width. Minimum width is the width of your loader bucket. Basins below larger lots will more likely be 16 feet or more in width. The length will be determined either by the length necessary to intercept all the runoff across the bottom of the lot, or by the minimum surface area as calculated above.

**Cleanout.** Use a concrete pad in the bottom of the basin near the outlet where the majority of the solids will settle. Total concrete basins are recommended, but are more expensive. A concrete apron or driveway that extends the length of the basin is desirable if a total concrete bottom is not economically feasible. Earthen berms along the basin sides are acceptable, but may eventually erode and require more maintenance. A continuous vertical concrete curb along each side of the apron guides the scraper bucket during cleaning and protects earthen sides from erosion.

**Outlet.** Use a restricted outlet to allow the basin to drain. Design the outlet so the top elevation is 6 inches below the top of the containment berm. If the outlet plugs, liquid will still overflow at the outlet location. Various outlet designs include:

- **Slotted Outlets** - Either vertical or horizontal slots from 0.5- to 1-inch work. Horizontal slots constructed from pressure-treated

---

*Solutions*

*1 acre-inch/hour = 1 cubic foot/second.*

3,600 seconds = 1 hour
wood may be easier to build than vertical slots. (Figure 3)

- **Perforated Riser Pipe** - Perforated riser pipes can be used as outlets, however, they cannot be connected to a tile line feeding a waterway or county tile system; they must empty on the ground below the basin berm. They should be protected from cleanout machinery. (Figure 4)

- **V-Notch Weir** - V-notch weirs restrict the flow leaving the settling basin but are less likely to plug than slotted outlets. As the depth of the flow increases, v-notches carry larger flows. (Figure 5)

Location is not critical for the outlet. It can be near the end of the basin or in the middle, but it should not interfere with cleanout or be next to the inlet. A concrete end-wall to push against works well for concrete basins.

**Effluent Management.** Liquids coming from the settling basin should not be discharged directly into waterways. They can be treated a second time before release via passage across a vegetated area.

A grass filtration area, constructed on a 1:1 ratio (grass filtration is the same size as the lot), will help remove both nitrogen and phosphorus from feedlot effluent before it reaches an environmental impact area, such as a surface water source.

**Basin Management.** Any facility can be built to standards, but, if not properly managed, will not work. Basin management includes keeping the outlet unplugged and solids removed. The greater the potential water quality risk, the more frequently solids should be removed. Solids should be removed at least annually but more frequently is better. Removal immediately after every storm is optimum.
General guideline summary for settling basins

- Basin surface area should be 1/20 of drainage area.
- Basin bottom should be nearly flat. Use no more than 0.5 percent slope.
- Wider, shorter designs are better. Minimum width is the width of your loader bucket. Using a 16-foot minimum width often works well.
- Except for very large lots, settling basins should have concrete bottoms to allow easy solids removal.
- Basins should be designed to be cleaned with existing equipment in less than ideal weather conditions.
- Concrete curbs along the side(s) of concrete bottoms make scraping solids easier.
- There are several types of restricted outlets. The outlet should allow dewatering of collected solids and keep plugging at a minimum.
- Outlets should generally be in the side of the basin rather than on the end. A concrete wall to push against facilitates solids loading.
- Settling basins require continuing management and maintenance. They should have solids removed frequently to function properly.

Concrete solid settling basin

SOLUTIONS

File: Environmental 4-1

Written and prepared by:
Jeffrey C. Lorimor, Department of Ag/Biosystems Engineering, Iowa State University
Shawn Shouse, ag engineer, Iowa State University Extension
Wendy Miller, communications specialist, Iowa Beef Center

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Many materials can be made available in alternative formats for ADA clients. To file a complaint of discrimination, write USDA, Office of Civil Rights, Room 326-W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call 202-720-5964.