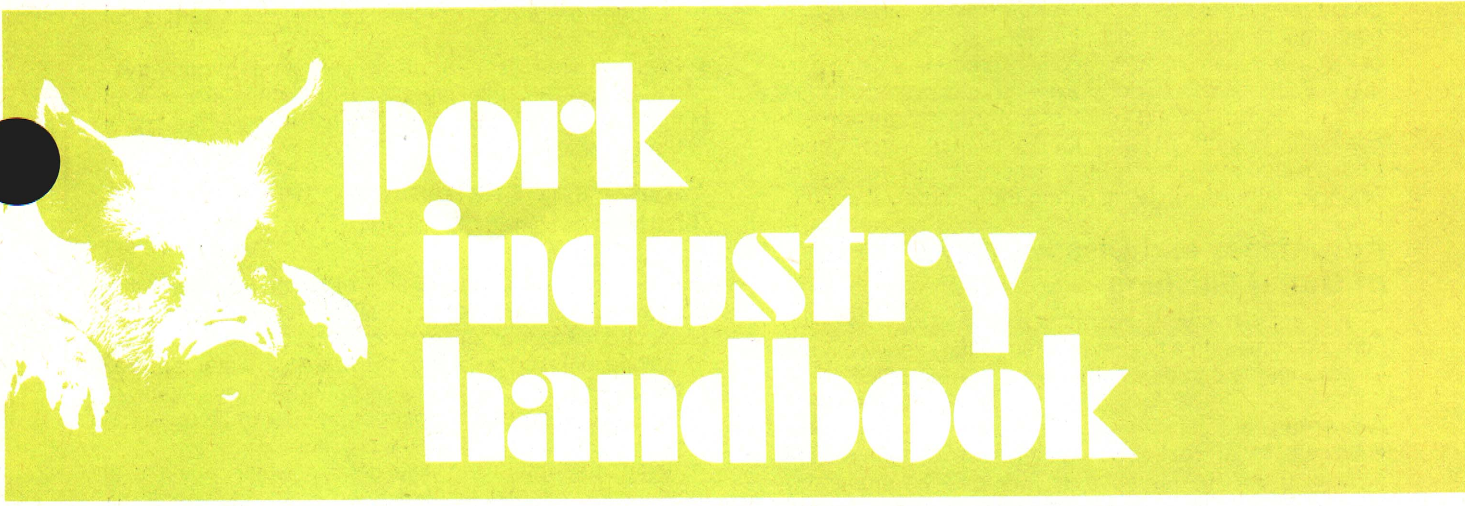
Flushing Systems for Swine Buildings – Pork Industry Handbook
Michigan State University Extension Service

Don D. Jones, Purdue University; Richard Smith, Iowa State University; Robert George, University of Missouri

Issued August 1979
8 pages



COOPERATIVE EXTENSION SERVICE ● MICHIGAN STATE UNIVERSITY

Flushing Systems for Swine Buildings

Authors
Don D. Jones, Purdue University
Richard Smith, Iowa State University
Robert George, University of Missouri

Reviewers
Forest Loudenslager, Marion, Ohio
Ed Miller, Okemos, Michigan

The two types of flushing systems used in swine production facilities are open-gutter flushing, for finishing and gestation buildings, and underslat flushing, which can be used in any swine building. Both systems use a sloped, shallow gutter that is flushed periodically to remove waste from the building to a lagoon. In open-gutter units, the periodic flushing attracts hogs to the channel and induces dunging, helping to "toilet train" them.

Basically, here's how a flushing system operates. A small-capacity pump transports lagoon water to a flush tank at the high end of the gutter in the building. The flush tank periodically dumps the water into the gutter (see Figure 1). Frequency of flush is determined by the rate water is pumped into the tank. The tank is sized to contain enough water to "scour" wastes from the gutter. The spent flush water and waste re-enters the lagoon where it is treated and later reused for flushing. In areas where irrigation is practiced, many producers use fresh water for flushing instead of recycled water.

Who Should Consider Using Flushing Systems?

Flushing systems probably have the greatest appeal to those with farrow-to-finish operations, who feel they must handle swine waste as a liquid, and to those with suitable locations for lagoon construction. Producers who pur-

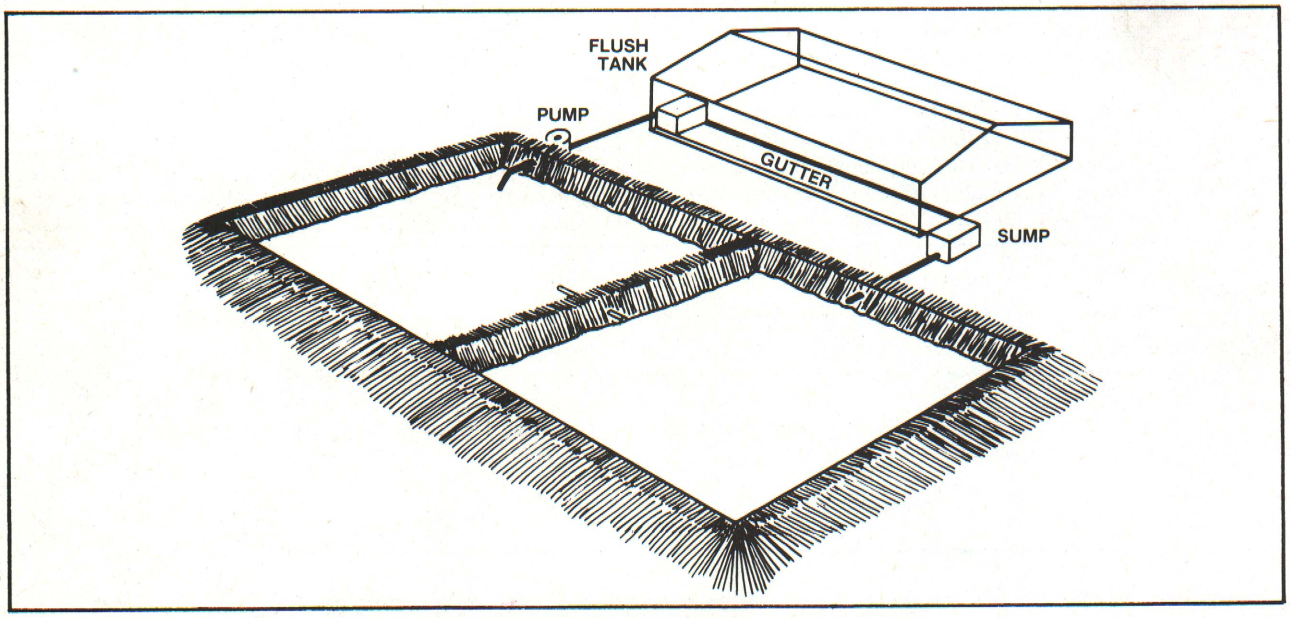


Figure 1. Perspective showing the components of a flush gutter system.

This information is for educational purposes only. Reference to commercial products or trade names does not imply discrimination or indorsement by the Cooperative Extension Service. Cooperative Extension Service Programs are open to all without regard to race, color, or national origin. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

1P-3M-8:79-UP, Price 25 cents.

Michigan State University Printing

0-11655

chase feeder pigs for finishing may have some reservations about open-gutter flushing because of the possibility of disease transmission. In addition, producers using certain sulfa drugs should not use open-gutter systems for finishing hogs during the recommended drug withdrawal periods because of the potential for ingestion of drug residues from the lagoon water. It is often possible to use fresh water or underslat flush systems during the withdrawal period.

Advantages and Disadvantages of Gutter Flushing

Assuming that your present or proposed hog operation can accommodate a flushing system, what specifically are its advantages and disadvantages?

Advantages

- Lowers initial cost. Open-gutter flushing can reduce building cost by as much as 30% over a comparably sized, fully-slotted deep pit facility. However, the large lagoon required will reduce this savings to 10-15%. An underslat flushing system is usually comparable in construction cost to a conventional deep pit building.
- Can reduce odor problems. Frequent flushing of the waste can significantly reduce the characteristic "clinging" odor inside the confinement building.
- Adapts to building conversion. Some older buildings, especially dirt floor poultry buildings, are easily converted to include gutter flushing systems since a deep pit is not required.
- Saves fuel. Compared to deep pit systems requiring a tractor hauling system, flushing gutters with lagoon irrigation can use significantly less energy.

Disadvantages

- Greater nutrient loss. Lagoon-treated animal waste analysis shows a greater nutrient loss than for manure stored in a liquid manure pit under a slatted floor.
- Requires a relatively large land area. Using a lagoon for a flushing system takes up to 4-6 times more land area than the building itself. Many producers might have reservations about using land in this way.
- Interruptions to give medication. If medication is occasionally added to the drinking water, open-gutter flushing systems may have to be turned off for extended periods to force hogs to drink the medicated water, since they can and do drink some of the flushing water.
- Subject to mechanical problems. A flushing system has at least 2 mechanical components—flush tank and return pump—that must operate continuously. Like all mechanical devices, they are subject to breakdown.
- Lagoons are a potential odor source, particularly if not designed and operated properly.
- Possibility of disease transmission in open-gutter systems. Consider that lagoons with 2 cells are several times more effective in destroying disease organisms than single-cell lagoons.

Basic Parts of a Flushing System — Their Design and Operation

Gutter Design

How completely the waste is removed from the gutter depends on velocity, depth, duration, and frequency of the flush; and these factors are determined by the dimensions and slope of the gutter and by the rate flush water is added to the gutter. To adequately clean gutters, a flush velocity of at least 2.0 ft. per sec. is needed in open-gutters and at least 2.5 ft. per sec. in underslat gutters.

In an open-gutter, the initial depth of water should be at least 1½ in. with at least a 10 sec. flush duration. In an underslat gutter, a minimum of 2 ½ in. depth of flow with at least a 10 sec. flush is recommended. For channels longer than 125 ft. or with flushing devices which have a longer flush duration, such as siphons, increase the flush volume by at least 50% to provide the needed cleaning ability.

In most cases, the flush device determines the depth of water flow. For instance, a 3-in. siphon provides only water for about a 1 in. depth of flow in a 30-in. wide gutter, whereas larger siphons provide greater depths and can flush wider gutters. Most siphons release water to give a flush duration of about 30 sec. A "tipping bucket" flush tank can deliver a 3 in. depth of flow in almost any width gutter with a 5-10 sec. release, while the door opening and volume of a "trap door" tank can be designed to provide almost any depth of flow and flush duration.

Consider depth of flow in selecting gutter slope. Table 1 presents the recommended slopes for gutters of various widths and initial water flow depths. To achieve the same

Table 1. Minimum percent slope for flushed gutters.

Initial depth of flow (In.)	Open-gutter slope (%)	Underslat gutter slope (%)
1.5*	2.0	——
2	1.5	2.0
2.5†	1.25	1.5
3 or greater	1.0	1.25

* recommended minimum depth for open-gutter flushing
† recommended minimum depth for underslat flushing

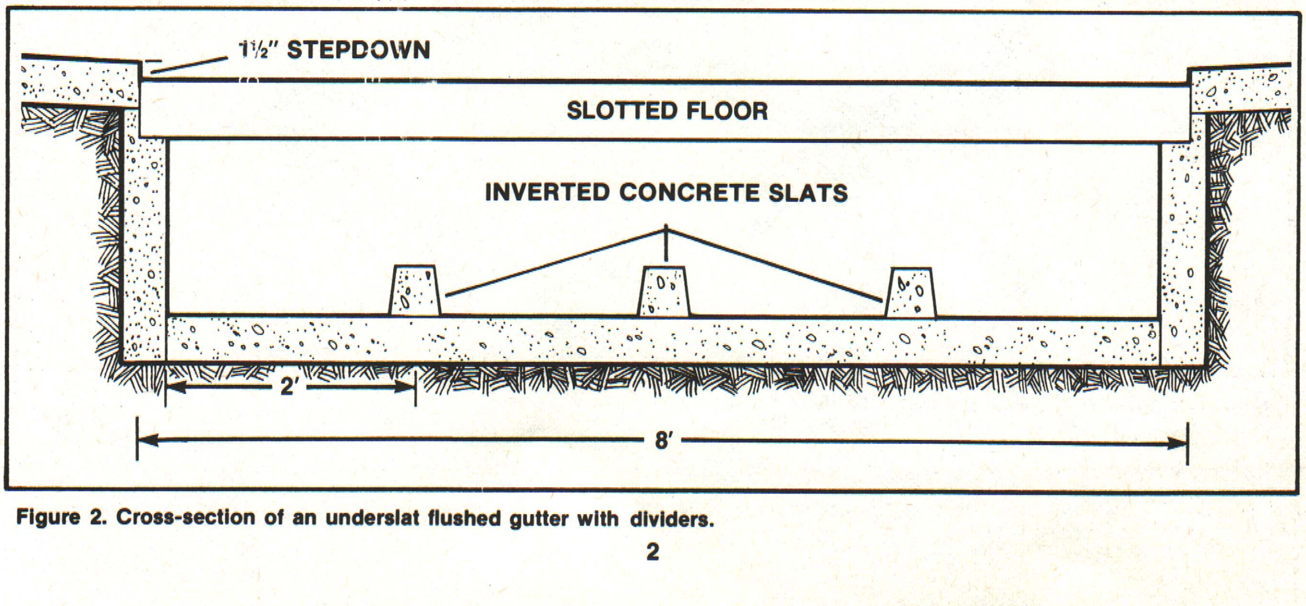


Figure 2. Cross-section of an underslat flushed gutter with dividers.

cleaning action, a steeper slope is required when depth of flow is shallow. Remodeled facilities using open-gutters can be designed for deeper channels (use 2 x 6s as forms) to increase depth of flow (e.g., 3-4 in.), thus permitting a more shallow slope. This minimizes excavation and construction problems in an existing building.

A good recommendation for open-gutter design is to allow a minimum of 1 sq. ft. of gutter area per 150 lb. of liveweight. Most open-gutters are a constant width—usually 30 or 40 in. with a depth of 3½ in. Channel depth should be at least 1 in. deeper than initial depth of flow. Open-gutter depths should not exceed 6 in.; a step that is too deep for the pig causes poor dunging habits.

For underslat systems, at least one-third of the floor should be slotted. Because underslat gutters do not have pig traffic to help suspend and break up the waste particles, slightly crown (¼ in.) the gutter, and give a smooth finish. Gutters wider than 4 ft. should have all but the first 20 ft. of their length divided up into gutter widths of 2-2½ ft. This helps keep flush water from channeling around waste deposits as it moves down the gutter. Inverted concrete hog slats work well for this purpose (see Figure 2).

Flush water picks up solids, causing the water to slow down as it moves through the gutter. This can be a problem in very long gutters. To overcome this, restrict gutters to about 125 ft. in length. Open-gutters can be longer if they are tapered and/or their slope is increased. Research at the University of Missouri showed that in a 132 ft. building, cleaning action was improved when the gutter was narrowed from 6 ft. at the upper end to 3 ft. at the lower end, and when the slope was varied down the length of the channel, instead of remaining a constant width and slope.

For open-gutters shorter than 125 ft., use a constant-slope gutter. For gutters from 125-250 ft., either use a tapered, variable-slope gutter, or slope both ends of the gutter so that they flush toward the middle of the building length. For gutters longer than 250 ft., consult a knowledgeable building engineer.

Wherever possible, use gravity to carry waste to the lagoon. Generally a sewer line 8 in. in diameter with a .5% slope or a line 6 in. in diameter with a 1% slope is sufficient to carry flushed waste to the lagoon. For very large tanks, greater than 500 gal., or where the same sewer must handle several tanks, contact a knowledgeable engineer to see if a larger sewer line is needed.

Locate a sump pit at the discharge (or runoff) end of the flushing gutter if waste must be pumped to the lagoon. Volume of the sump should at least equal the flush tank volume.

Floor and Building Construction

The first step in constructing a swine building with gutter flushing is to establish the approximate grade for the building floor. For a variable-slope gutter, simply average the gutter slopes. Next consider placement of the footings. Using an engineer's level, establish the exact grade of the gutter along the length of the building. It is simplest and cheapest to slope the entire building the same as the gutter slope (Figure 3a). However, if constant ceiling height is desired, the foundation can be poured level at the sill, but with various depths as required by the sloping floor (Figure 3b).

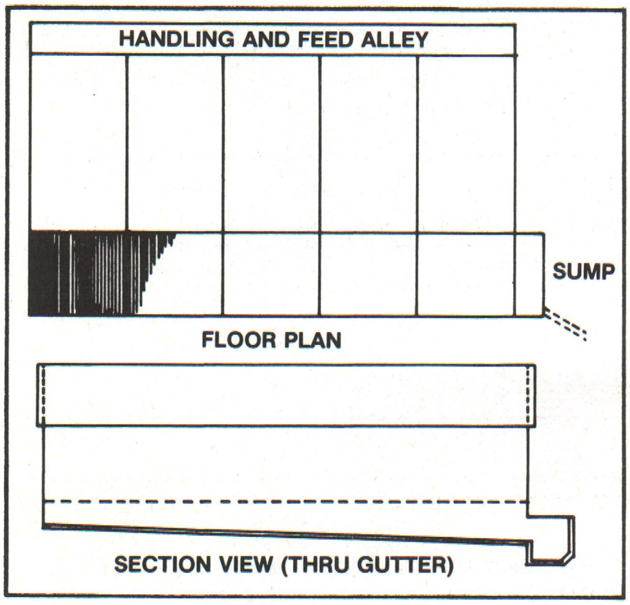


Figure 3b. Section view of building with underslat flushing gutter.

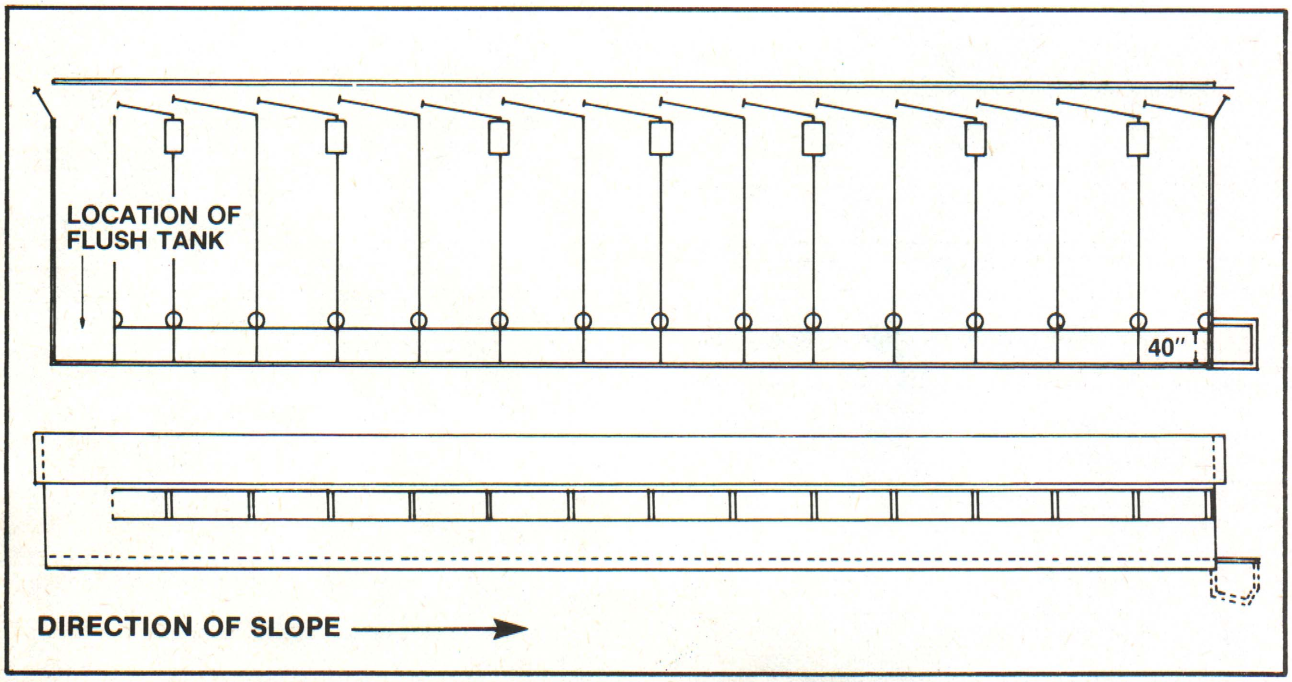


Figure 3a. Side view of finishing building sloped same percent as the flushing gutter.

With pole-type construction, the poles can be set, truss locations marked, and then the girders put in place. If the entire building is set at the gutter slope, the sidewalls are not perpendicular to the poles; however, this should not pose any significant problems since floor slope is not very great.

Flush Equipment Design

Flush Volume

Two flush volumes must be determined: the total volume required per day and the volume required per flush. The smaller the volume of water per flush, the more frequent the flushes should be. When too little water must pick up too much waste, the fluid characteristics change, and a dirty gutter results.

Total volume of flush water required per day for adequate cleaning is about 10 gal. per 100 lb. liveweight (Table 2). Total flush volume is used to size the recycle pump.

The required volume per flush, or flush tank size, depends on gutter width and desired depth of flow. Recommended tank volumes per ft. of flush gutter width are shown in Table 3. If you purchase commercial flush tanks, they may be rated on their discharge rate (see Table 4).

Table 2. Total daily required volume of flush water.

Type of animal	Flush volume (gal.)
sow and litter	35
nursery pig	4
finishing pig	15
gestation	25

Table 3. Minimum gallons of water required to flush gutters (in 10 sec.) at various depths of flow.

Initial depth of flow, in.	Gal./ft. of gutter width
1.5	30
2.0	40
2.5	45
3.0	50
3.5	60

Table 4. Tank discharge rates required to flush gutters at various depths of flow.

Initial depth of flow, in.	Discharge rate* (gal./min.) per ft. of gutter width
1.5	115-180
2.0	150-240
2.5	190-270
3.0	225-300

* Use flush durations longer than 10 sec. for the lower discharge rates.

Flush Frequency

How often to flush the gutters is determined by two factors—animal behavior characteristics and the solids-carrying capacity of the water. The minimum flushing frequency can be determined by dividing the daily flush volume (determined by the daily manure production) by the minimum volume per flush (determined by channel geometry). In general, open gutter channels are flushed every hour or two to maintain good dunging habits, while underslat gutters are flushed about four times a day. When underslat gutters are flushed manually only a few times per day, the volume per flush is determined by simply dividing the flush volume per day by the number of flushes per day. Odors from underslat floors can be controlled by flushing at least twice a day.

To insure cleaner pens, keep hogs crowded (4 sq. ft. per cwt. of animal), and use solid partitions except at the gutter area so that no other dunging habits are started. The management of an open gutter or underslat flush building is the same as for a partly slotted floor. Producers may need to floor-feed pigs during their first week in the building to help establish good dunging habits.

In summer, hogs lie in the gutter and block the flow of water, but this does not hurt the efficiency of the flushing operation. Underslat gutters should be flushed at least 2 times a day, but preferably every hour. In underslat systems, a 1 ½ in. stepdown to the slats from the bedded area will usually help establish desired dunging habits.

Flush Tanks

Four types of flush tanks have been developed to provide the required flush volumes: the automatic siphon tank, the tipping bucket, the trap door tank, and the manual dump tank.

Automatic siphon tank: Designed and in use at Iowa State University since 1969, this type of tank has the singular advantage of no moving parts (see Figure 4). As the tank slowly fills with water, an air bubble trapped under the bell is forced out the siphon pipe until it triggers the siphoning action. An automatic siphon tank can be placed above the pens, thus eliminating floor space requirements.See AED-17, "Three-Inch, 150 Gallon Siphon Flush Tank," available from the Midwest Plan Service (MWPS) at Iowa State University, Ames, Iowa, for construction details.

Kansas State University has developed an 8 to 24 in. automatic siphon which can handle very large volumes of water. This flush unit uses a small 2-in. siphon to trigger the larger siphon. This large siphon is well suited to flushing wide, underslat gutters.

Tipping bucket tank: Michigan State University has designed a tipping bucket which dumps when it fills to a depth where the center of gravity of the water volume overbalances the pivot point. Because the water discharges all at once, flushing velocity and depth are high and can cover a very wide gutter (8-10 ft.), if necessary (see Figure 5.).

Trap door tank: A University of Missouri innovation, this flush tank has more moving parts than either of the above methods, but allows greater design flexibility because both tank volume and trap door can be modified to meet individual needs. Care and precision are necessary to get a water-tight seal around the door.

Manual flush tank: The manual tank is best suited to twice a day flushing in underslat systems. These are found most commonly in farrowing houses where the operator is present several times a day. Figure 6 shows a simple but effective manual flush tank.

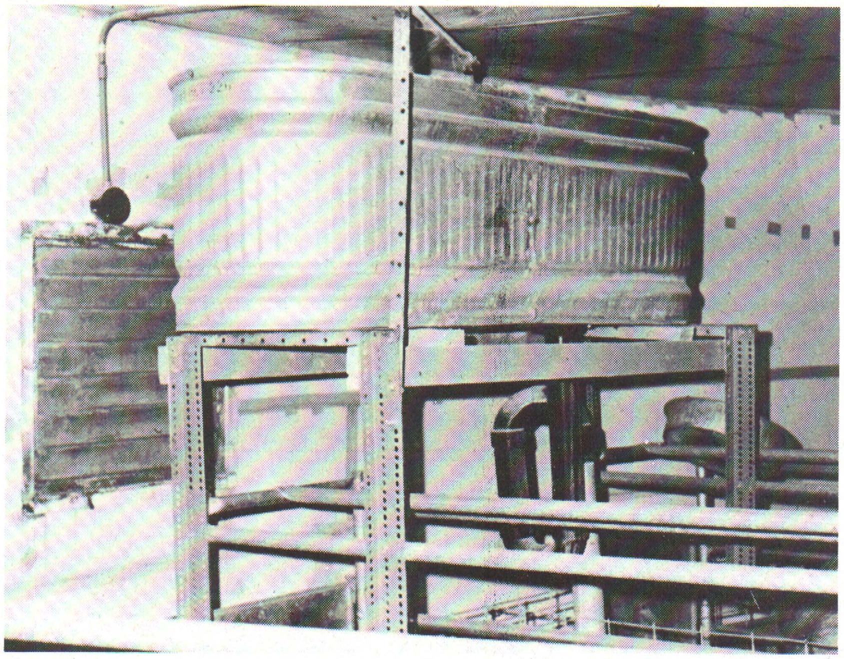


Figure 4. An elevated automatic siphon tank being used in a farrowing house.

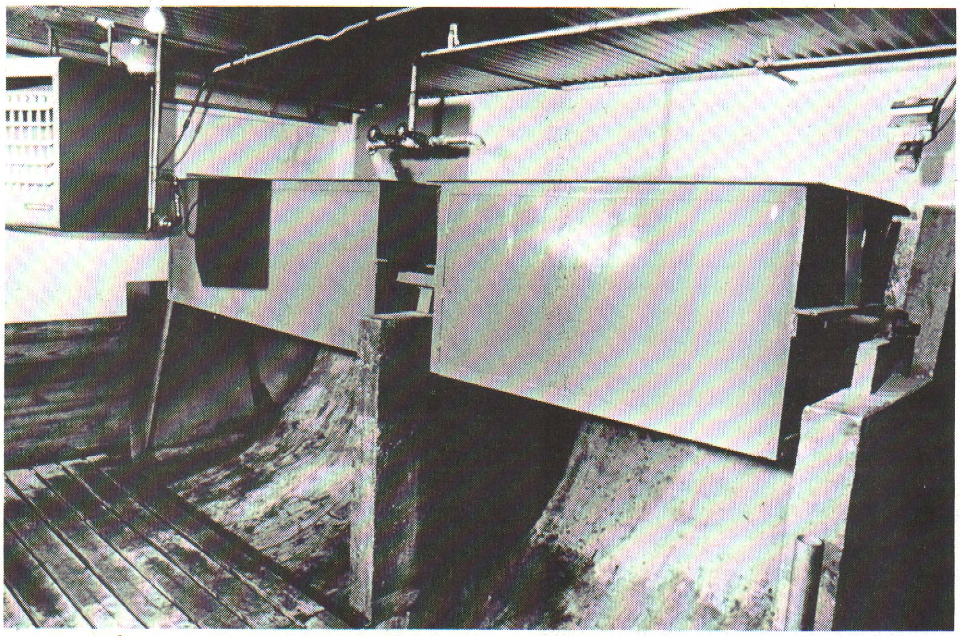


Figure 5. Tipping bucket tank used for flushing underslat gutters.

Waste Treatment Lagoons

A properly designed and operated lagoon is essential to the success of a flushing system (see Figure 7).

Although a single stage lagoon can operate satisfactorily in a flushing system, a two-stage lagoon is preferred to minimize odor and disease potential.

The design criteria for lagoons used with flushing systems are the same as for conventional swine waste lagoons. See PIH-62, "Lagoon Systems for Swine Waste Treatment," or MWPS-18, "Livestock Waste Facilities Handbook," available from Midwest Plan Service, for design information on lagoons for your area.

Pumps and Pipes

Pumps transport effluent from the lagoon to the flush tank and, if needed, from the sump at the end of the gutter to the lagoon.

Lagoon-to-Flush-Tank-Pump

The pump used to fill the flush tank is generally very small. For example, a 10 gal. per min. pump is sufficient for two 300-gal. tanks with hourly flushing.

A plastic fitted, nonclogging type of pump with high quality seals that can be easily serviced is recommended. Slower-speed pumps (1725 rpm or less) cost more initially but usually last longer than high-speed pumps (3450 rpm). Because of their seemingly short service life (6-12 mo.), it is a good idea to keep several spare replacement impellers on hand.

Do not use pumps with metal impellers or any metal parts in contact with the water being pumped. Salts in lagoon water precipitate on the metal and eventually plug the pump. Avoid sharp turns in the supply pipe because they add to pressure drop and create turbulence conducive to salt precipitation. Regular addition of dilution water to the

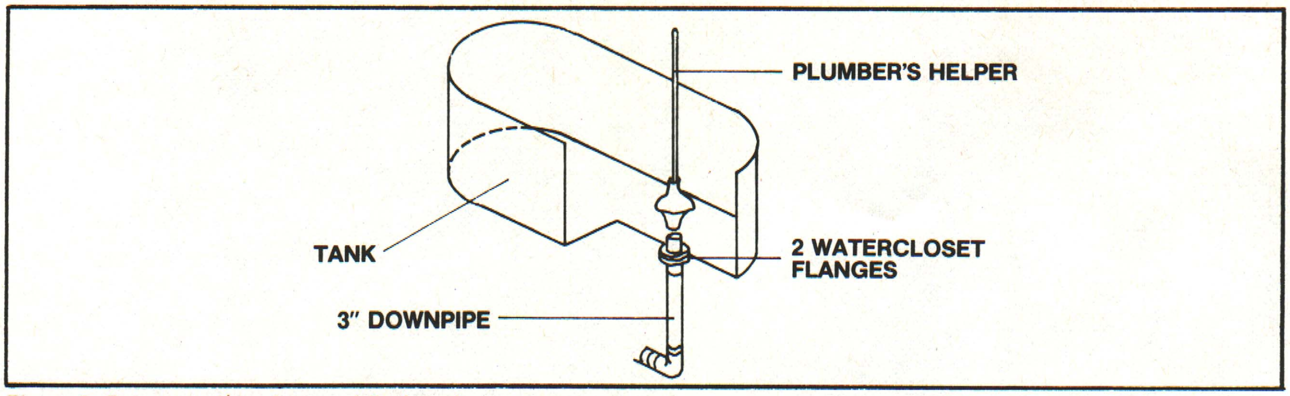


Figure 6. Cut-away view of manual flush tank.

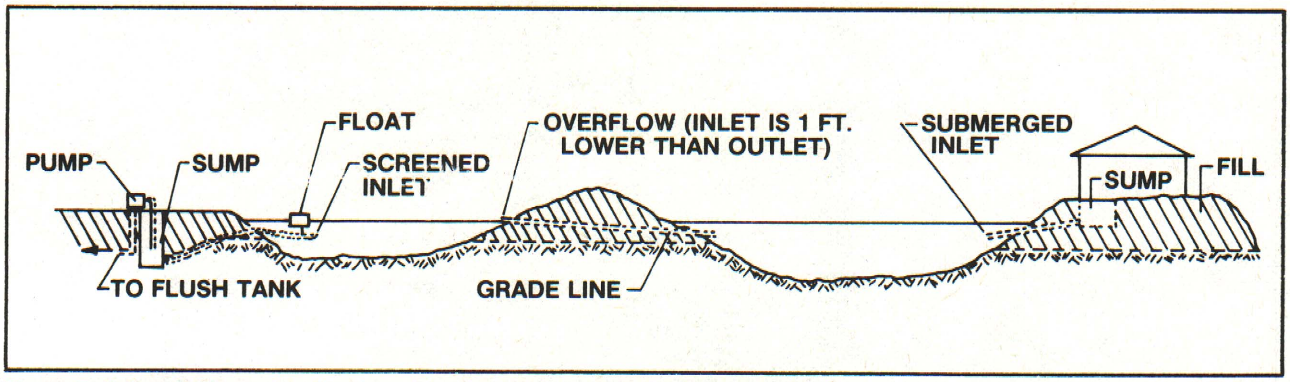


Figure 7. Cut-and-fill construction for a two-stage swine waste lagoon system.

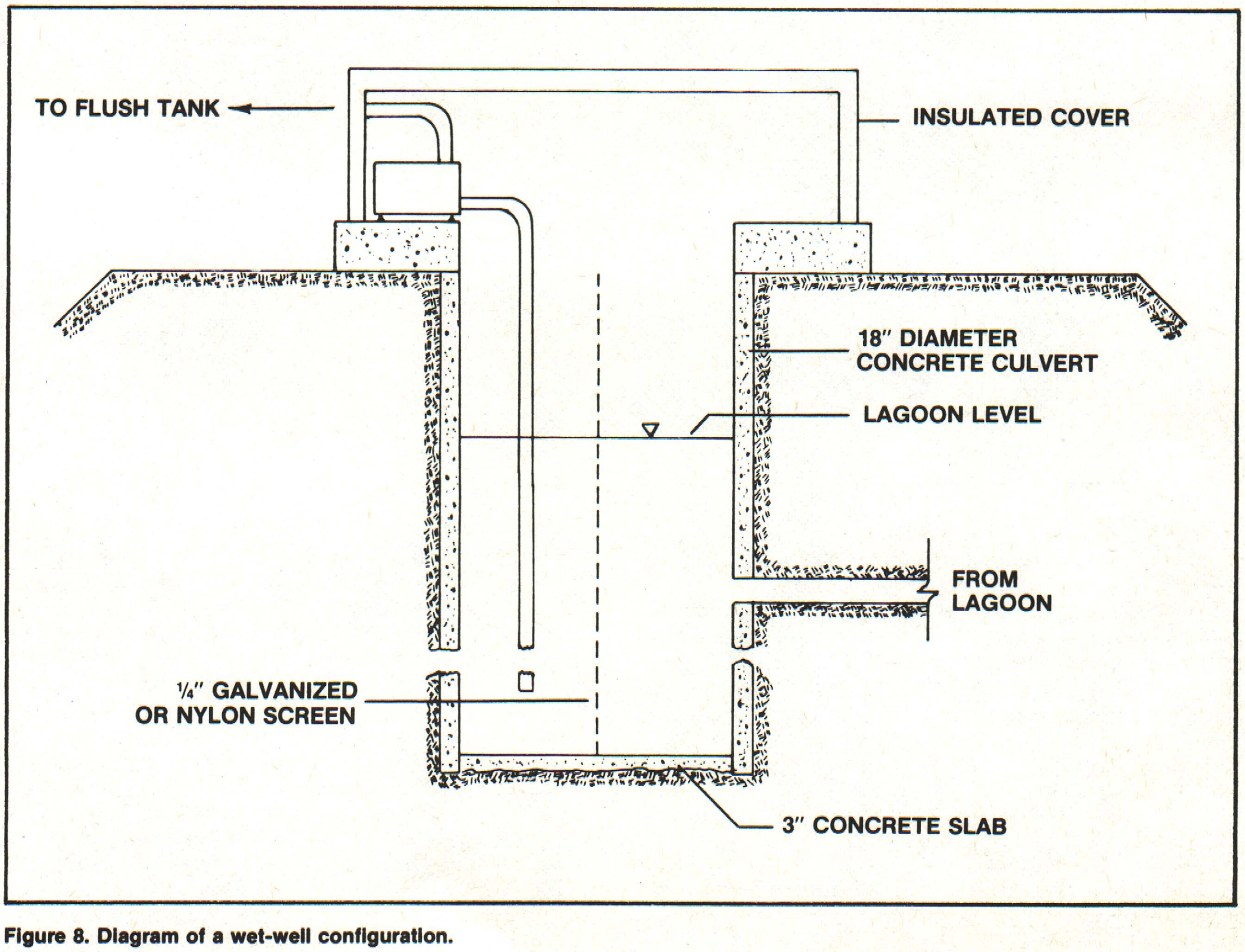


Figure 8. Diagram of a wet-well configuration.

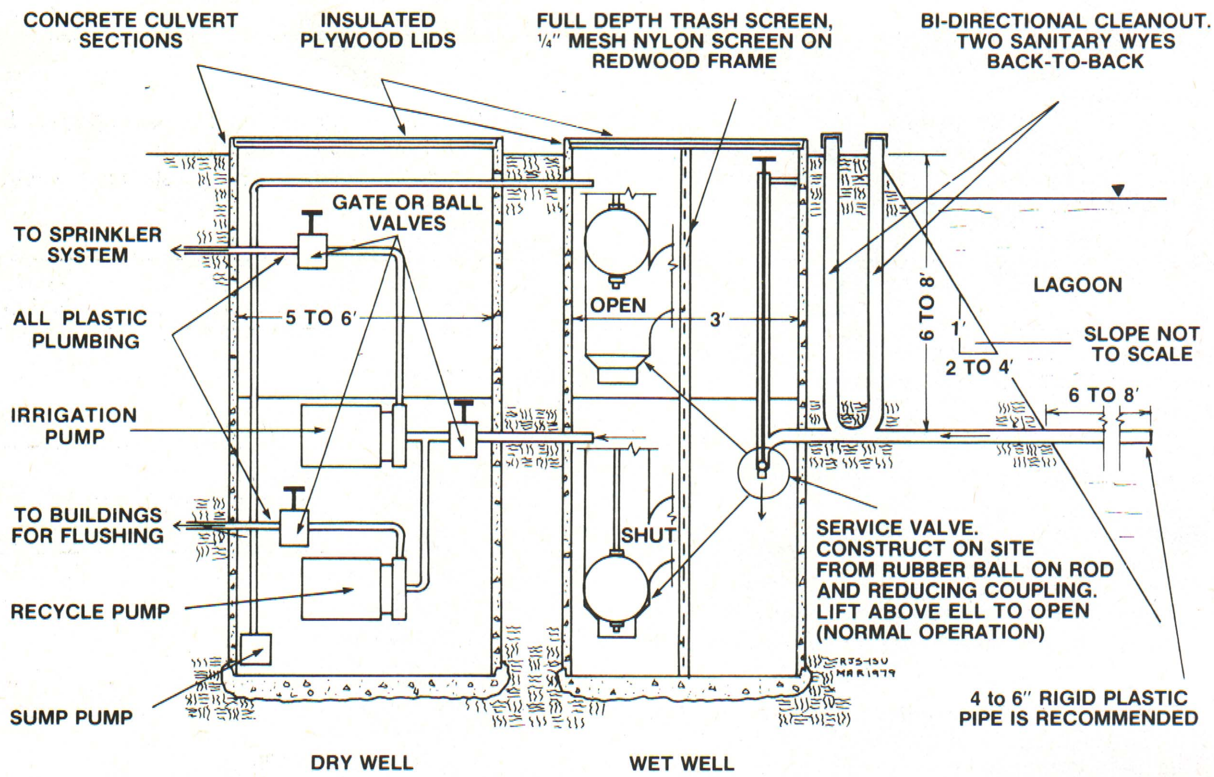


Figure 9. Pumping from a lagoon using a wet well and dry well configuration.

lagoon and removal of salts by irrigation will reduce problems. In most areas of the U.S., the volume of dilution from water wastage and rainfall runoff should equal the volume of waste added. Various treatments (dilute acetic or hydrochloric acids) have been used to dissolve salt deposits, but the best solution is to avoid the problem through proper design and dilution. Mixing and use of acids is hazardous and must be done with caution.

A lagoon-to-flush-tank pump can be placed on the lagoon bank in an insulated enclosure or in a wet well sunk in the bank (see Figures 8 and 9). The pump must be protected from freezing weather.

The intake pipe from lagoon to wet well should be at least 1 in. greater in diameter than the outlet on the return pump. The intake should be at least 18 in. below the lagoon surface, with inlet openings placed several feet from the bank and as far away as practical from where the waste enters the lagoon.

Sump-to-Lagoon Pump

If the pump is needed to lift effluent from building to lagoon, it should be a commercial grade sewage lift type activated with a float switch.

A 3 in. pump should be satisfactory for most operations. Size of the line from pump to lagoon should be the same as the pump discharge to prevent solids from settling in the pipe. Size the sump no larger than the largest flush tank to avoid solids settling.

Piping

The pipe from lagoon to flush tank can be relatively inexpensive polyethylene and, if possible, should be one continuous piece. See Table 5 for determining the size you will need.

Table 5. Recommended pipe sizes for various flow rates.

Pump capacity Gal./Min.	Pipe diameter In.
5	.75
10	1.0
20	1.5
30	2.0
40	2.5

Reference to products in this publication is not intended to be an endorsement to the exclusion of others which may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer.

Worksheet For Designing and Equipping A Gutter Flushing System For Swine

Example Situation

A farmer wants to construct a 250 head hog finishing unit to accommodate open-gutter flushing. The building will be 28 ft. wide x 84 ft. long with constant-width gutter on one side. Pen size will be 8 ft. x 24 ft. with about 25 pigs per pen.

From the above assumptions and the information given in this publication, design his open-gutter system and determine types and sizes of flushing equipment needed.

Calculations		*Our example*	**Your situation**
1. Determine dimensions of gutters.			
a. Gutter width: Minimum gutter area per hog (1 sq. ft.) x no. hogs per pen (25)/pen width (8 ft.). This is a minimum; to insure better cleaning, the farmer decides on a 40 in. width. (Or gutter width in ft. = 40 in.÷12 in./ft. = 3.33 ft.)	=	*40 in.*	______
b. Initial depth of flow: See Table 1 for recommendations.	=	*1.5 in.*	______
c. Gutter slope: From Table 1.	=	*2.0%*	______
2. Determine flush volume and tank capacity:			
a. Required daily flush volume: No. finishing hogs (250) x gal. of flush water per head per day (15 gal. from Table 2).	=	*3750 gal.*	______
b. Minimum flush volume (determined by channel geometry): From Table 3 (30 gal./ft. of gutter width); if channel is longer than 125 ft., increase volume by 50%. Total flush volume: gutter width (3.33 ft.) x 30 gal./ft. = 100 gal.	=	*100 gal.*	______
c. Flush volume for flush intervals longer than 2 hrs.: If time between flushes must be longer than 2 hrs., size tank accordingly. For example, if tank can be flushed only four times a day, tank capacity should be 1/4 the total flush volume (step 2 a.): e.g., 3750 ÷ 4 = 937 gal.	=	*937 gal.*	______
3. Determine size of return pump (lagoon to flush tanks).			
a. Pump capacity to supply required flush volume: Step 2 a. (3750 gal. ÷ 1440 minutes per day. If a flexible impeller pump is used, match the pump speed to the desired flow rate with a belt drive. Driving such pumps at 500 rpm or less improves the lifetime significantly.	=	*2.6 gpm**	______
b. Minutes between flushes: Step 2 b.[(100 gal.) x no. tanks per pump (1)] ÷ Step 3 a. (In this example, 2.6 gpm. However, assume a 5 gpm. pump is available and will be used.)	=	*20 min.*	______
4. Determine size of return pipe (lagoon to flush tanks).			
a. Select from Table 5 using pump flow rate from Step 3 a.	=	*¾ in.*	______

*Use nearest pump size available.