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Gravity Drain Gutter Systems

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A gravity drain gutter is a manure handling system which has no mechanical parts and requires little or no dilution water to remove manure from a building. The liquids and solids are held in a gutter until sufficient depth of manure is available for draining manure out through removable tightly sealed plugs. The drainage interval may vary from one day in narrow gutters for big pigs to a month in wide and deep gutters.

Manure can be removed from a swine barn by: (1) manual or mechanical scraping, (2) flushing with dump tanks, siphons or pumping systems with automatic or manually controlled valves, (3) continuous flushing, and (4) gravity draining. Flushing often requires large amounts of water (over 50 gal./ft. of gutter width per day). Flushing with recirculation from treatment lagoons is not practical in all areas because of odor nuisance potential from associated lagoons and/or soil types which don't seal adequately.

Gravity drain gutter systems can be utilized for handling liquid manure from swine of all ages. Some gutter shapes are a modification of the deep, narrow gutter developed in the early 1960's (Figure 1). Modifications to the original 6-inch-wide gutters include wider top widths, rounded bottoms, flatter slopes to the bottom, and shorter lengths. A new option on gravity drain gutters is a reversing hairpin gutter. This is an 18 in. to 36 in. deep gutter with a divider wall and two plugs which are alternately pulled. It has drastically changed swine manure handling systems.

The "Y" and "V" gutter gravity drain systems have disadvantages when compared to slotted floors over manure storages in that they are more complicated to build, and result in higher total manure system costs.

Research has shown and field experience has verified that corrosive gas production increases with storage time and storage

temperature. To minimize gas production, a gravity drain gutter should be sized to fill and be emptied within four days. If manure will remain in the gutter for more than one week, some form of perforated pit pipe ventilation should be considered unless adequate airflow is available to dilute the concentration. This would be the case with bigger pigs (i.e., 30 lb. plus).

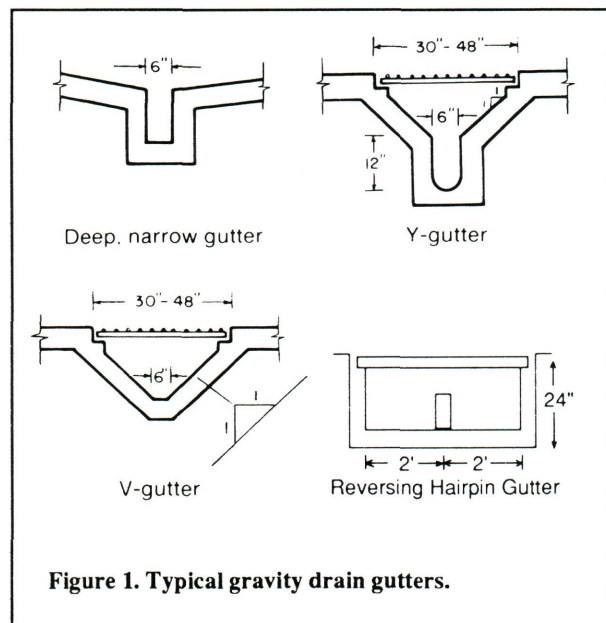


Figure 1. Typical gravity drain gutters.

Design of Gravity Drain Gutters

Designing a gravity drain system involves its shape, slope, length, and outlet.

Gutter shapes may vary considerably (Figure 1), with a trend toward a flat bottom hairpin gutter. Some shapes have in common a narrow section at the bottom of the gutter which receives all the liquids and part of the solids. A minimum accumulated manure depth of 12 in. is adequate to allow the manure to flow toward the outlet when the plug is pulled. The total depth of Y and V gutters varies from 12 in. to 36 in. A common feature in these modified gutters is the bottom section which is narrowed to 6-8 in. This limits the number of days of storage needed to attain the minimum 12-in. draining depth.

Another type of gutter which is quite different is the reversing hairpin gutter. Its depth can vary from 16 in. to 36 in., but the most common depth is 24 in. The width can vary from 2 ft. to 12 ft. Farrowing and nursery gutters should have perforated 6 in. to 8 in. diameter pit ventilation ducts above the divider wall or a central plenum under the service alley which is connected to high RPM (2800) exhaust fans to reduce pit gas levels in farrowing and nursery buildings (see PIH 60 "Mechanical Ventilation of Swine Buildings"). The primary advantage of the hairpin over Y or V gutters is the reduced construction costs.

Two types of side slopes to the Y and V gutter are used. The first is a self-cleaning slope with a minimum of 1 in. rise per 1 in. run for farrowing and 1 in. rise per 3/4 in. run for nursery. These steep slopes work well for nursery pens (4 ft.) housing single litters. However, steep slopes require excavation that is too deep for farrowing crates and long nursery pens with totally slotted floors. The second type has flatter slopes to decrease construction difficulty and cost. Slopes being used in this case are up to 2 in. per foot for farrowing and up to 4 in. per foot for nurseries. Because flatter slopes accumulate manure solids and feed, they should be hosed or scraped off every 1-2 weeks to reduce ammonia levels and fly populations. A combination of the first and second type of slope can be used beneath elevated totally slotted farrowing crates and nursery pens. The self-cleaning steep slopes are placed under the slotted floor sections where manure concentrates the heaviest. The flatter slopes are placed under the remainder of the pens. Gutters should be at least 3-in.

below slats so the manure can fall free of the slotted floor.

Gutter length of the Y and V gutters should not exceed 40 ft. for farrowing or nursery barns and 70 ft. for grower and finisher barns. The exception is the hairpin gutter which can be up to 200 ft. long for growing-finishing buildings. The preferred building length is about 100 ft. If center plugs are used, the length can be doubled since the gutters drain from both ends to the middle. The depth should be increased from 2 to 3 ft. to build up more flush force if longer gutters are used. A minimum of one to two inches of water should cover the entire bottom of the gutter before using it the first time. This initial water also helps longer gutters to drain cleaner and helps hold down ammonia levels longer.

The longitudinal slope of the gutter should be about 1 in. of drop in 20-40 ft. for Y or V gutters. The bottom of hairpin gutters should not be sloped. If the gutter slope is steeper, solids remain on the upper end when the liquids flow out. Expect a small deposit of solids on the upper end of the gutter.

The preferred slat type over the Y and V gutters is one with a high percentage open area, such as woven wire. The high percentage open area allows for easy visual checking to see how full the gutter is, and how much manure has built up on the slope above the gutter. This type of slotted floor also allows easier slope cleaning with a hose or a high-pressure washer.

The outlet from the gutter must be equipped with an easy-to-remove water tight plug. Three types are shown in Figure 2. Fit the plugs into a 90-degree elbow or tee (regular or saddle type). It is better to have an overflow as part of the plug, in case a waterer leaks or breaks, especially where hairpin gutters are placed on top of concrete slats (i.e., in an existing building with concrete slats, a thin concrete cap would be poured before adding the gutters). The ones shown have a built-in gas trap to prevent backdrafting of pit gases when the barn has negative pressure ventilation. Locate the plug outside the pen or crate to keep pigs from falling into the gutter unless a permanent guard is used. For a multiple room facility, consider locating the plugs in a common alley outside the rooms (Figure 3). However, the access to the drain must seal tightly to keep air from entering the room over the gutter, and interfering with ventilation system

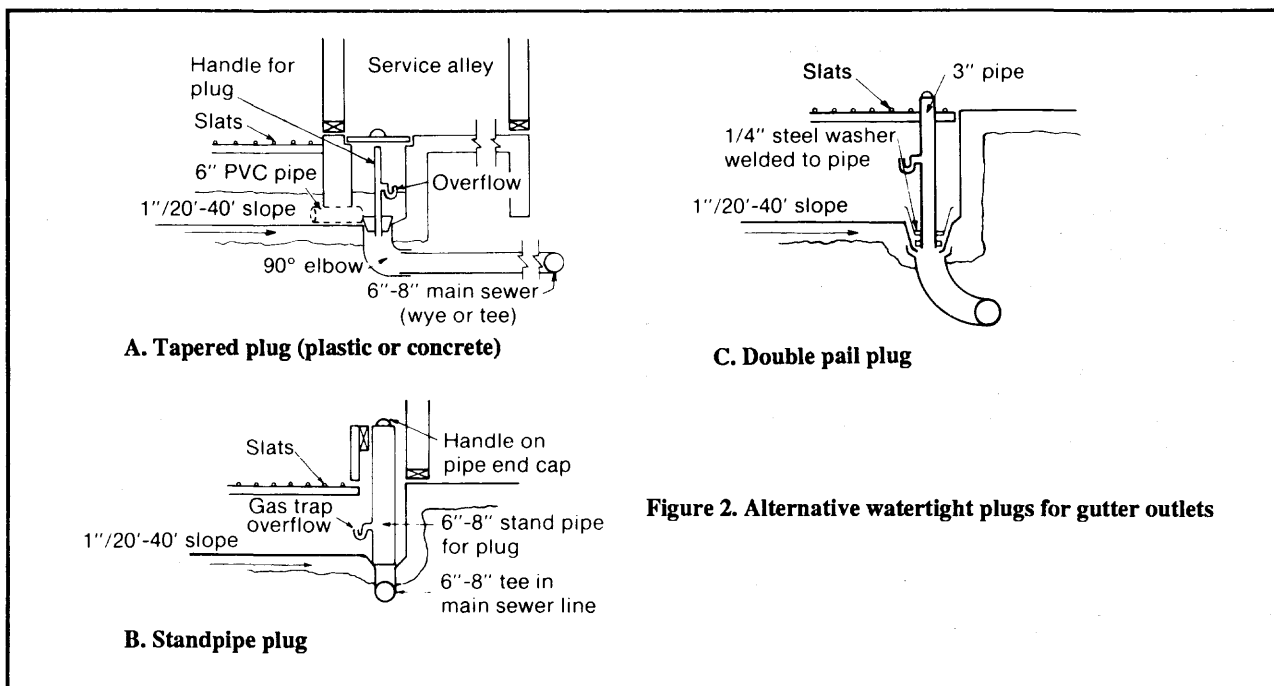


Figure 2. Alternative watertight plugs for gutter outlets

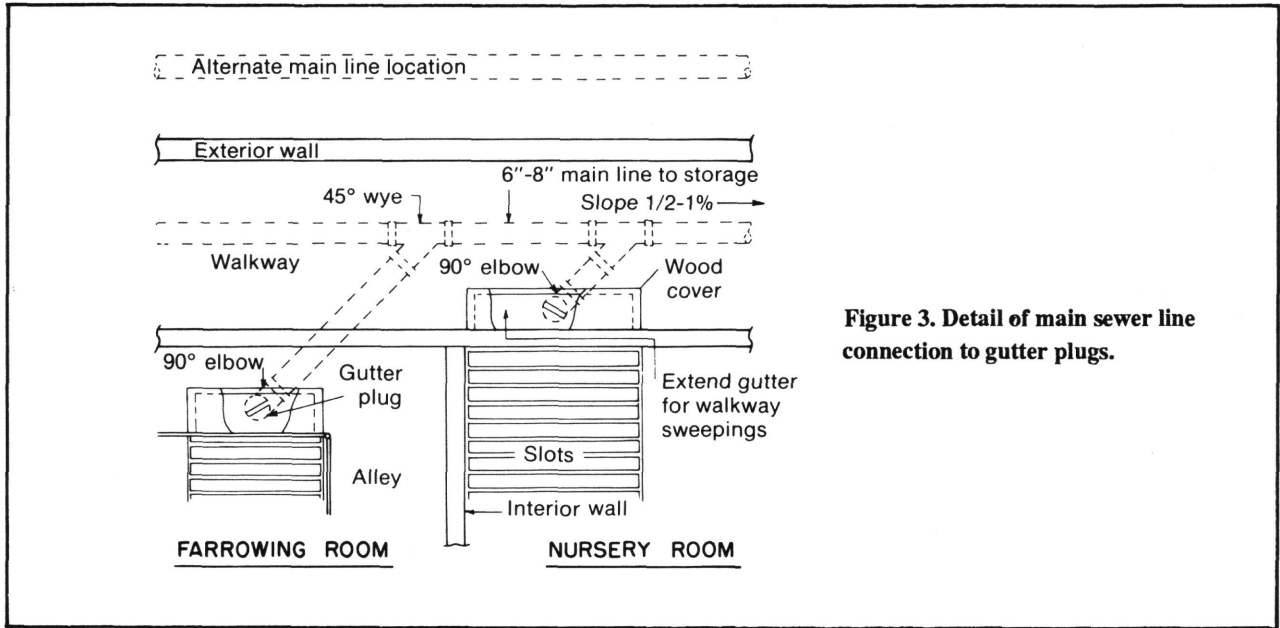


Figure 3. Detail of main sewer line connection to gutter plugs.

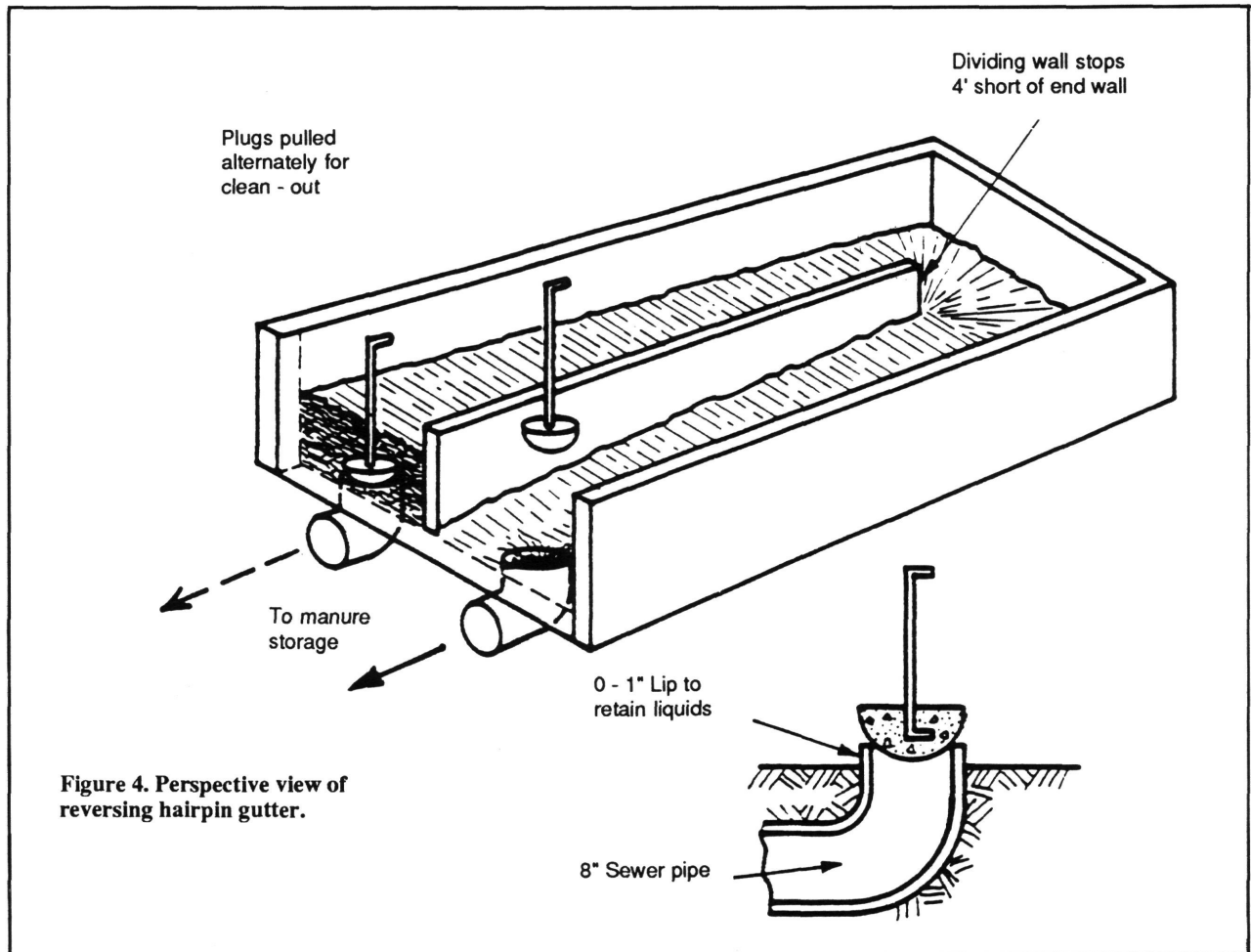


Figure 4. Perspective view of reversing hairpin gutter.

performance. The main sewer line can be buried outside the perimeter of the barn in case access is needed for maintenance. If the rooms are drained individually, a 6-in. diameter main sewer pipe is adequate. This depends somewhat on room size, pit or gutter size. If the barn has 4 or more rooms, and all gutter plugs will be pulled in a short interval, use an 8-in. pipe. A perspective view of the reversing hairpin gutters with two plugs is shown in Figure 4. All plugs should be at least 8 in. in diameter.

Floor Cross Sections of Gravity Drain Gutters

Farrowing

Nine cross-sections for farrowing crates are shown in Figures 5A through 5J. Figures 5A, 5B, and 5J are examples that can be used in remodeling situations to build above an existing floor. The other cross sections require new sites or the removal of portions of existing floors. Only Figure 5F shows the steep slopes which are self-cleaning; the others require periodic cleaning.

The example in Figure 5A utilizes the reversing hairpin gutter under the entire crate. The divider wall must be anchored to the gutter floor as shown with reinforcing to prevent tipping over. Gutter depth can vary from 16 in. to 24 in. The alleys can be raised higher than the gutter bottom to reduce leakage under the wall into the alley or a keyway (1 in. x 1 in.) can be used to tie the floor and wall together for a better seal. The walls can be 6" concrete block or 4" of poured concrete with reinforcing.

The example in Figure 5B utilizes a formed plastic pan (100-150 mm thick) under the slotted floor. A 3-6 in. clearance is needed between the flooring and the start of the front slope for access to wash down feed and manure solids. Adequate clearance is especially critical if the flooring has only a small percentage of slotted or open area. The alternative of washing the slope directly through the slotted flooring may splash too much water on the pigs unless they are moved out. The crates in Figures 5A, 5B, and 5J generally are raised at least 16 in. if the existing floor is to be left undisturbed. Crates elevated more than 12 in. normally require a portable ramp for the sow to get in and out.

Figure 5C shows the bottom of the rear slope starting about 18 in. from the rear of the crate. Manure solids accumulate mostly in the rear 24 in. of the crate. The steeper 1-in. rise per 1 in. slope helps in washing the solids into the gutter.

The rear section of the gutter shown in Figure 5D is half of a large PVC pipe (generally 24-in. diameter) which collects most

of the manure solids. The minimum slope of the front section toward the half pipe is 1 in. per foot, but 2 in. per foot is preferred. Some manure solids will accumulate on the slope to the pipe.

The gutter shown in Figure 5E is similar to those in Figure 5F but easier to construct. Generally the bottom of the V is 6 in. wide and the top 2 to 2 1/2 ft. The depth is about 12 in. A disadvantage of the V-shape is that it takes about three times as long as the Y-shape for the manure level to reach the 12-in. depth needed for good drainage.

Figure 5F shows two precast concrete gutters side by side. The slope of the sides is about 1 in. rise per 1 in. run which is needed for self-cleaning. These 30-in. deep gutters have a bottom section 6 in. wide and 12 in. deep plus they need to rest on a flat slab as sketched. The high cost disadvantage of the gutters is somewhat offset by their accurate fabrication and by a shorter installation time.

Both cast-in-place gutters in Figures 5G and 5H have a square bottom to simplify construction. Figure 5H requires a minimum of 1 in. per foot slope toward the gutter.

In Figure 5J concrete blocks are used to elevate the crate in order to install a gutter. The deep gutter is a 6- or 8-in. PVC pipe cut in half. A disadvantage of this gutter and Figure 5A is that it

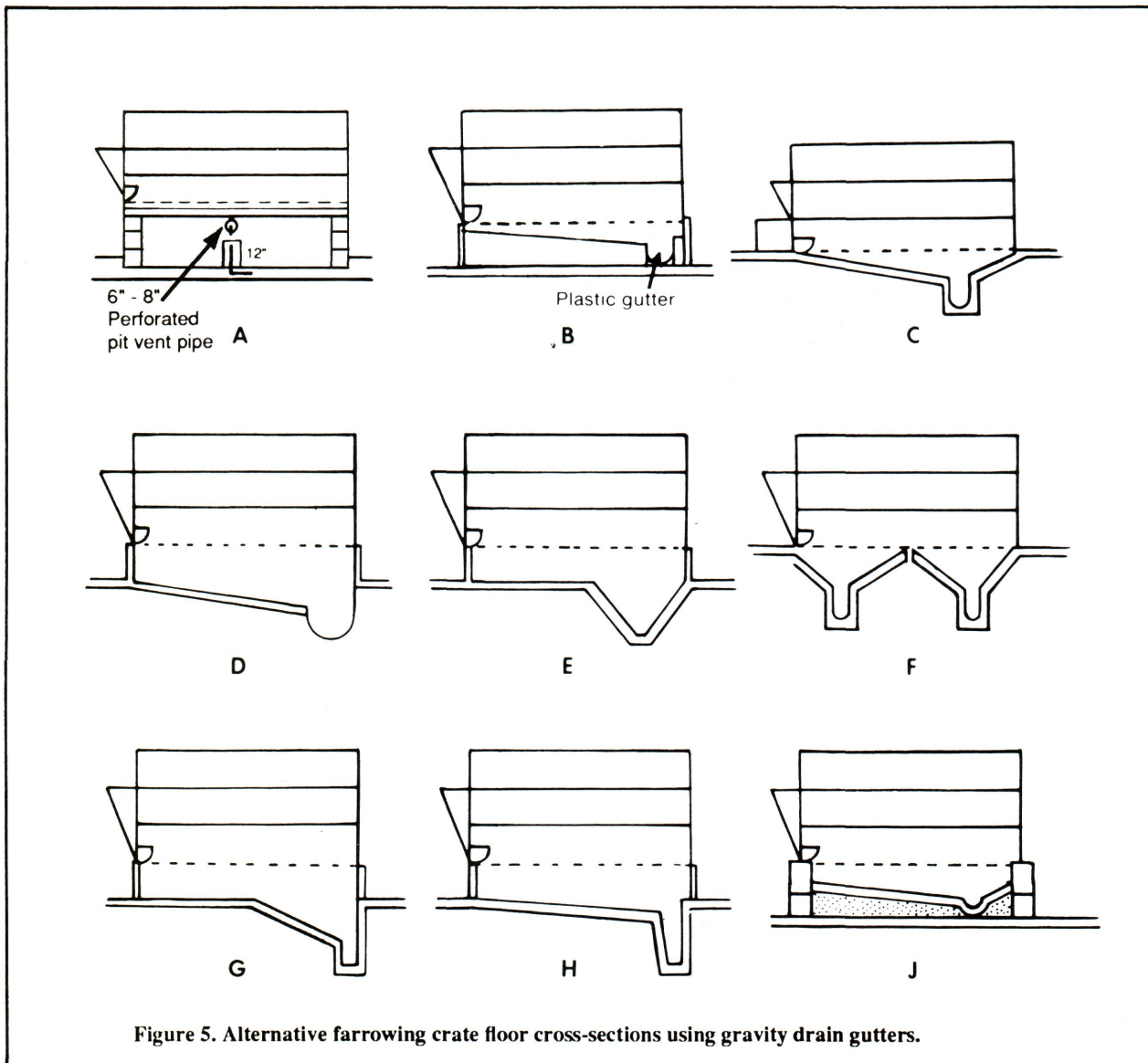


Figure 5. Alternative farrowing crate floor cross-sections using gravity drain gutters.

takes much more time to fill to the needed depth for good drainage than any of the other options.

Gutters shown in Figures 5B and 5F can be purchased commercially whereas all the others must be cast in place.

Nursery Pen Gravity Gutter Design

Five cross-sections for nursery pens are shown in Figure 6. Figures 6A, 6B, and 6E adapt well for remodeling barns where it is desirable to build above an existing floor. The slope toward the gutter should be a minimum of 1 in. per foot, but 3 to 4 in. per foot is preferred. The gutter in Figure 6A is constructed using two 8-in. blocks to form its bottom. It could also be constructed with a round instead of a square bottom for slightly better cleaning. The legs of the pen frame should be 3 in. above the concrete block stands to allow access for cleaning the slopes. The nipple waterers should be located over the gutter to encourage pigs to drop manure there. The sides of the pen toward the alleys should be solid up to 16 in. high to keep manure inside the pen. Prefabricated plastic is shown for the gutter and the sloping area next to it. The plastic should be supported with 2 x 4's unless sand fill is used under the plastic for support (check manufacturer's recommendations).

Figure 6C shows a narrow pen (4 ft.) with a Y-shaped gutter underneath. For self-cleaning, the slope should be 1 in. rise per 3/4 in. run. This would require a 3 1/2 ft. depth to the bottom of the gutter, assuming it has a 12-in. deep bottom section. It is critical that the pen flooring have ample open area when the pen is not elevated above the existing alley floor (for cleaning reasons).

The gutter shown in Figure 6D can be cast in place more easily than the Y-shaped gutter in Figure 6C. A portion of the area nearest the gutter is sloped more steeply because most of the manure solids will fall through the floor at this end of the pen (usually the end opposite the feeder). The 6-in. square bottom is also easier to construct than the rounded bottom Y-shaped gutter in Figure 6C.

The example shown in Figure 6E is similar to the farrowing cross section in Figure 5A. The design and construction are similar. It is a simpler design than the other cross sections to construct and cheaper to build.

Growing-Finishing Barn

Figure 7 shows a sloped solid floor pen with 1 or 2 gutters at the lower end of the pen. Floor slopes, pen partitions, and air flow patterns are critical considerations for keeping pigs resting on the upper end and dunging near the lower end. Dunging generally occurs in the open partition areas where the floor slope is steep (1 in. per foot recommended). It is important to have a 2-4 in. stepdown from the resting area to the dunging area. The dunging section should be a minimum of one-third of the pen length. The depth of the gutter in Figures 7A and 7B should be 24 in. A pipe grating or guard over the gutter in Figures 7A and 7B should be installed to protect small pigs. Square gutters work as well as semicircular gutters in finishing units.

In Figure 7C, the floor between the gutters has a steep slope (1 in. per foot) for self-cleaning. This increases the effective slotted floor area.

Another option is shown in Figure 7D. The manure is held in 2-ft.-deep gutters, which are drained after the manure reaches a 12-in. depth. These gutters are the reversing hairpin type. They can work best in partially slatted pens. The maximum gutter width is 12 ft. This requires a divider wall unless the gutters are recharged with extra water from a two stage lagoon. The recommended maximum length is 100 ft. (200 ft. of draining length). High moisture cracked corn feed can cause these gutters to drain poorly. Wet feeders and gravity gutters do not work well together due to the reduced waterer spillage or dilution water. Grower-finisher gutters fill faster than farrowing-nursery gutters and can be drained more frequently so pit pipe or duct ventilation is not as necessary.

Reversing hairpin gutters can be sealed tighter between rooms than buildings with scraper systems. This is especially

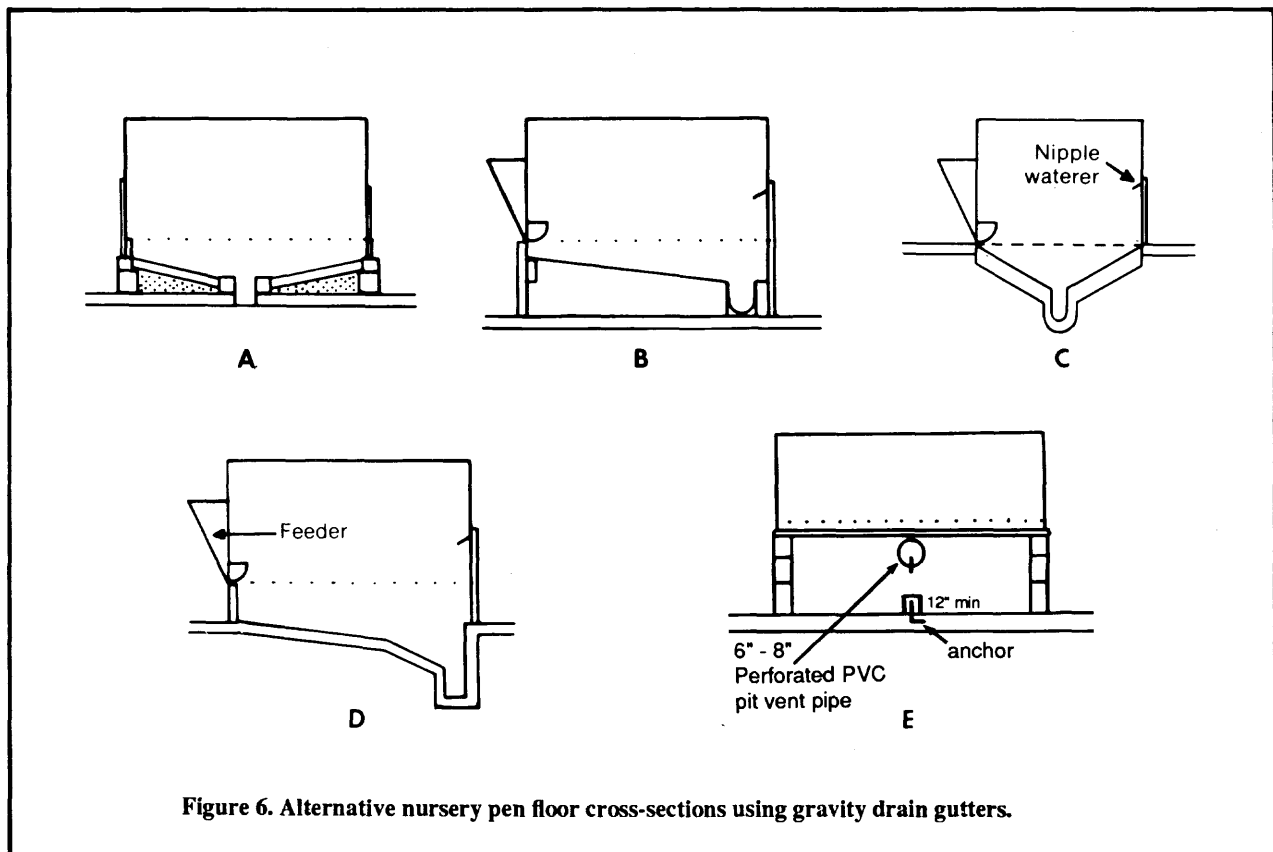


Figure 6. Alternative nursery pen floor cross-sections using gravity drain gutters.

important in naturally ventilated buildings. A pressure treated hinged door works well below room divider walls to minimize air exchange between rooms.

Manure Storage

Manure can be stored in a concrete or glass-clad steel tank, earthen structure, or an earthen treatment lagoon (the latter two should be properly sealed). Note: Storages are overloaded lagoons and smell much worse in warm weather than cool weather. At least 60 days of storage time (180 days is preferred) is recommended. Check state regulations for minimum storage criteria and odor stipulations. Refer to PIH-67, "Swine Waste Management Alternatives," for manure production per day and storage alternatives.

Caution should be exercised when draining or pumping into a storage under another building or in the existing building if the pit is capped since this will agitate that manure and release gases. One of those gases is methane. If the drain plugs are left out during cleaning and if the manure in shallow pits above a deep pit is drained out and if manure in the deep pit is being emptied, the possibility of fire exists from methane gas since most heaters are unvented or have open flames. A negative ventilation system is essential in the pit to reduce gasses released into the building or room connected to the storage via a drain plug or drain pipe.

Manure Transfer Systems

If possible, design the system so that manure flows to the storage by gravity. The drain pipes for the plugs should be at least 6 in. for farrowing and nursery buildings to prevent plugging, with the exception being the reversing hairpin gutters which should have a minimum 8 in. diameter pipes. Eight-inch drain pipes are suggested for finishing barns and gestation/breeding buildings. Slope the 6-inch and 8-inch pipe at least 1% (1/8 in./ft.) to 2% (1/4 in./ft.) to achieve good cleaning velocities. The maximum distance between cleanouts in the drain pipe should not exceed 300 ft. The storage inlet should be at least 3 ft. above the bottom since solids tend to settle out at the point where the manure enters the storage.

To obtain sufficient slope for gravity transfer of manure, it may be necessary to construct the barn floor on extra fill; otherwise, storage capacity is lost by not using all of the available height. Another alternative is a collection sump with a pump to lift the manure into the storage (for sump information, see PIH-91, "Pumping Liquid Manure from Swine Lagoons and Holding Ponds"). Use a pump large enough to handle 1 1/2 in. diameter solids.

Gutter Construction

The gutters can be (1) assembled from commercially available prefabricated plastic, fiberglass, or precast concrete sections; (2) cast-in-place concrete or (3) a combination. The Y and V gutters are more costly to construct than the reversing hairpin gutters because of the steeper slope involved.

Prefabricated and Precast

The plastic gutter sections are joined together with a sealing tape or caulking compound and bolts or channel brackets at the joints. Installation of below-floor plastic gutters requires inner bracing to prevent the sand backfill or fresh concrete from pushing in the form, and weights or temporary bracing to keep the gutter in place.

Precast concrete gutters also are used in below-floor applications. Minimal excavation is needed with the precast concrete sections. They are set on a sloped footing and are stable without bracing or anchoring. The sections are mortared together to prevent leaks.

Cast-in-Place

Commercial steel forms, which are available for Y-gutters, can be set in excavated trenches and anchored to the surrounding concrete floor with lag bolts or weighted with sandbags. Concrete for the alleys is placed before the trench is excavated with a small backhoe. Commercial plywood forms can also be set in excavated trenches. They are temporarily braced to the roof

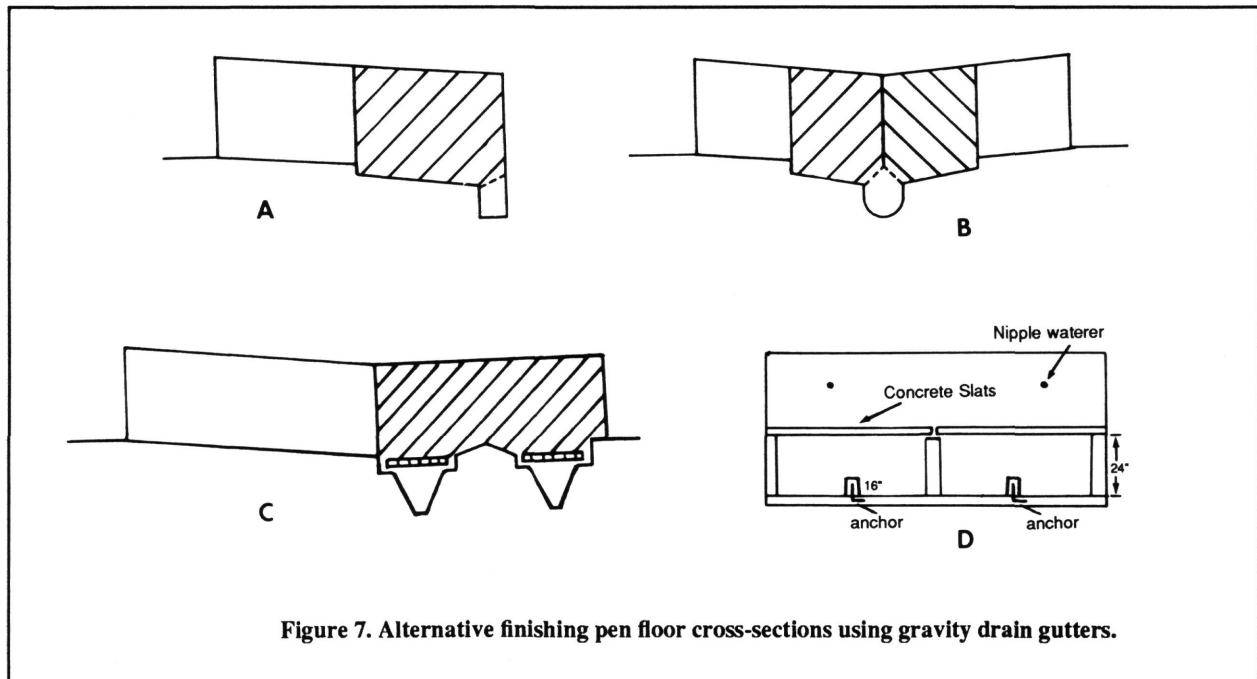


Figure 7. Alternative finishing pen floor cross-sections using gravity drain gutters.

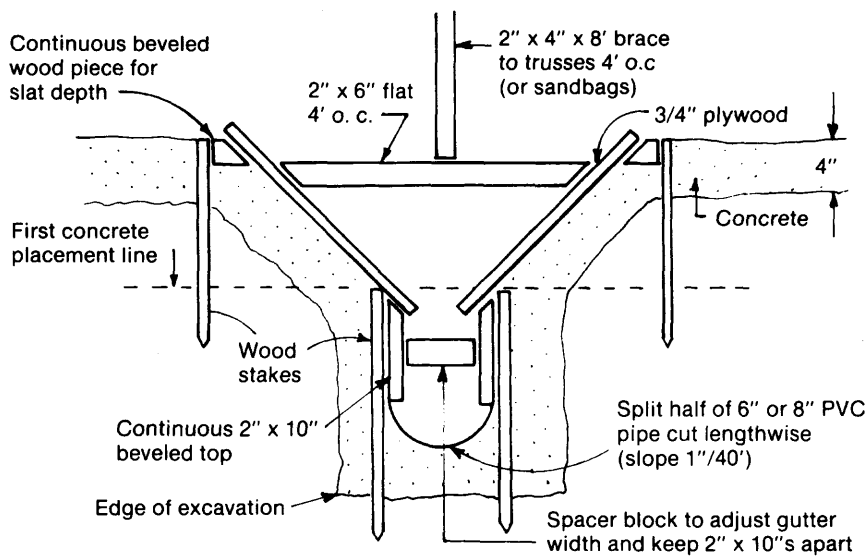


Figure 8. Cross-section of a Y-gutter form for cast-in-place (two stage process)

trusses to prevent uplift. When gutter forms are used, the concrete is generally poured in one step and should be well vibrated to ensure a smooth finish without voids.

Generally, the bottom of cast-in-place concrete gutters is constructed first, using the excavated soil as the outside form (Figure 8). An inner frame with short spacer blocks will form the inner wall. The wood grain should run vertically so that blocks can be split and removed. Fresh concrete should be vibrated to fill the space beneath the inner frame, to prevent water leakage from the gutter, and to provide a smooth surface. A semicircular bottom can be constructed by cutting a 6- or 8-in. PVC pipe in half lengthwise and nailing the half-pipe in the bottom of the inner frame.

Two methods have been used to form the steep slope in the V- or Y-shaped gutters (3 in. to 12 in. per foot). The first method utilizes reinforcing bars (3/8 in.) placed vertically every 4 ft. in the gutter and extended up the sideslope. The soil forms the sideslope for the underside of the concrete form. If the concrete is very stiff and reinforcing mesh is placed over the rebar (above the soil), then the concrete sideslope can be troweled in place. This is a time-consuming method, but it requires no forms.

The second method for the steep slope construction is to use existing soil or fill for the underside form. Stakes are driven as shown in Figure 8. A piece of wood is nailed to the top of the stakes to form a slat ledge (make it the same as the depth of the slats). Then, plywood is nailed to this piece of wood. The plywood is braced to the roof trusses or weighted to prevent uplift. After the concrete has set 1-2 hours, the plywood is taken off and the concrete steel troweled. Another way to give a quick, smooth finish with little troweling is to line the plywood with 4-6 mil polyethylene plastic or its equivalent.

Remodeling

When remodeling requires new concrete on top of existing concrete, the minimum thickness of the new concrete should be 2 1/2 in. if reinforcing wire mesh is used or 3 1/2 in. without reinforcement. Use seven bags of cement per cubic yard, and pea gravel (1 in. maximum) for the thinner concrete.

Foundation Insulation

When gutters are placed next to an outside wall foundation, insulation is needed to minimize freezing in the gutters in cold climate areas. At least 2 in. of a water-resistant foam insulation along side the foundation or in the foundation wall is recommended (see PIH-65 on "Insulation for Swine Housing").

Management of the Gravity Gutter

Start-Up

A biological slime must form on the Y and V gutter sides and bottom to get good cleaning action when the gutter contents are emptied. This will naturally occur in 3-4 weeks. If solids remain in the upper end of the gutter during this initial period, they should be removed manually or hosed down.

Draining Gutter

It is important to have the gutter filled to at least an 8 in. to 12 in. depth before emptying the contents in order to scour solids from the upper end. When replacing the plug or gate, wiggle it in the slot or seat to be sure the outlet is tightly closed. The Y and V gutters should be drained at least every week to ensure lower barn odor levels and good bottom scouring action in the gutter. The hairpin gutters which are drained at 2-4 weeks will

have more odor than Y and V gutters unless pit ducts are used above or on the side of the gutters. With adequate airflow in larger pig buildings (grower and finisher) the odor is very minimal especially with partial slat building where insulated sidewall ventilation doors or insulated curtains are used. The reversing action of pulling alternate plugs keeps solids buildup minimal. If the producer wants to completely clean the gutter of manure, he will need to be able to add water on the end opposite the plugs. There should not be a lip at the plug.

Water in Gutter

Adding one inch or more of water to the gutter after draining will facilitate better drainage of the gutter next time, particularly if it is greater than 40 ft. long. A nipple waterer over each gutter ensures having extra dilution water in the gutter. This is especially critical in reversing hairpin gutters. This can be done by staggering the waterers in the dividers between pens. "Wet" feeders where nipple waterers are over the feed trough minimize waterer spillage. Wet feeders and gravity manure systems do not mix! The manure will be too thick to flow unless extra water is always added initially.

Safety

Do not enter collection sumps, manure storages, or hauling tanks, unless they have been and are being well-ventilated. Also, do not enter these structures without a self-contained breathing apparatus or an air line. In addition, a body harness with a lifeline should be used, with two people standing by who are capable of lifting a person from the storage.

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